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Capital controls in Brazil: Effective?

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ABSTRACT

A large theoretical literature emerged in recent years analyzing the positive and normative effects of capital controls, begging for empirical studies to validate it. No emerging market experimented as actively with controls on capital inflows as Brazil did since late 2009. This paper analyzes the impact of those measures. These policies had some success in segmenting the Brazilian from global financial markets, as measured by the spread between onshore and offshore dollar interest rates, as well as ADR premia relative to the underlying local stocks. The measures adopted from late 2009 to mid-2011 did not translate into significant changes in the exchange rate, suggesting limited success in mitigating exchange rate appreciation. However, the exchange rate strongly depreciates after a tax on the notional amount of derivatives is adopted in mid-2011. The last of the three restrictions studied may have depreciated the Brazilian real in the range from 4 to 10 percent. That strong response may have been driven by complementarities with the previous measures, as well as an unexpected easing in monetary policy.

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1. Introduction

Emerging markets have experienced a strong recovery in capital inflows in the aftermath of the systemic sudden stop in late 2008 to early 2009. Flows reached levels comparable to their pre-crisis peak, driven by a combination of relatively favorable fundamentals in emerging markets and low interest rates in advanced economies. These flows should, in principle, bring numerous benefits, helping finance investment opportunities that may otherwise be missed, smoothing shocks to consumption and facilitating technology transfers in the case of FDI. But they may also bring risks. One concern is that massive inflows can lead to a strong appreciation of the exchange rate and loss of competitiveness of the tradable sector. Given large adjustment costs, a strong but temporary appreciation may cause lasting damage to industries which may not recover even after the flows abate and the exchange rate returns to its equilibrium level. Large inflows can also complicate macroeconomic management by further stimulating an already overheating economy, particularly if efforts to control inflation through higher interest rates attract more inflows. On the prudential side, there are concerns that flows may be associated with risky external liability structures, and more generally that the flows may not be directed to productive uses, and end up fueling consumption booms and asset price bubbles instead.

Emerging markets have been aware of these risks from previous surge episodes, but the Global Financial Crisis has heightened these concerns. Recent papers have shown that capital controls may play a useful role in managing the macroeconomic and prudential risks associated with flows (e.g. Ostry et al., 2010, 2012; Korinek, 2011; Engel, 2013; Rey, 2013). There has been a marked change in the conventional wisdom among policy makers, with the IMF recognizing capital controls as a valid component of the policy toolkit under appropriate circumstances (IMF, 2012).

Brazil has been one of the leading countries in this effort to manage inflows, and one of the most vocal against the loose monetary policy in advanced economies that were pushing capital towards emerging markets (the Brazilian finance minister at the time, Guido Mantega, coined the term "currency wars"). It sought to limit inflows in the aftermath of the crisis, adopting taxes on portfolio inflows in October 2009. Over the following two years, Brazil adopted a series of other measures to discourage inflows, starting gradually to dismantle them in 2012.

In this paper, we document that these efforts had some success in segmenting Brazil's domestic financial market from the global one, and analyze the impact of these measures on the exchange rate. We use daily data and estimate the changes around the dates in which capital controls/restrictions were imposed. The controls on capital inflows further segmented the Brazilian from global financial markets, as measured by wedges between onshore and offshore prices of similar fixed and variable income assets. The response of the exchange rate is more nuanced. There is little effect in the aftermath of the first several measures. While the exchange rate seems to revert from an appreciation trend following some measures, we do not find significantly strong effects even on specifications that consider longer time windows around the measures. But the exchange rate seems to respond strongly to the last restrictions adopted, beginning with a tax on the notional amount of derivatives. This pattern is robust across different specifications and time horizons used in the estimation. Our estimates point to a response in the range of a 4 to 10 percent depreciation, depending on the size of the time window in which we measure the effect, even after controlling for other variables that affect the exchange rate. Our preferred estimates are on the top of that range, implying a 10 percent depreciation of the exchange rate. This strong response may be the result of a cumulative effect of the several restrictions. That is, the response may have been large because the last measures finally closed the main remaining channels to bypass the inflow taxes. That result may also have been supported by the unexpected beginning of a monetary policy easing cycle. Unfortunately, the estimates are based on a snapshot around the capital controls events. Therefore, we cannot determine the particular channels or interactions driving the change in the exchange rate.

Our results are much stronger than those typically found in the capital controls literature, which may be largely driven by the broad and extensive nature of the measures adopted in Brazil. There is a vast literature on the effect of capital controls on the exchange rate. Magud et al. (2011) provide an excellent survey and meta-analysis of that literature. The evidence on the effectiveness of controls on reducing the volume of flows, and hence exchange rate pressures, is mixed. The evidence tends to be

stronger for an effect on the composition of flows (e.g. controls on portfolio flows leading to a shift towards FDI or longer maturities for which the control is less burdensome). Part of this shift may just reflect a relabeling of flows. Controls can also have an effect on financial stability (e.g. Ostry et al., 2012). Klein (2012) distinguishes between permanent and transitory controls ("walls and gates"), concluding that the latter are not very effective in affecting macroeconomic variables.

Several studies have focused on specific country experiences with controls. Some noteworthy capital controls on inflows in Latin America include the Chilean Unremunerated Reserve Requirement (URR), adopted in 1991–98,[1] the Colombian URR, adopted in 1993–98 and 2007–08,[2] and the Brazilian capital controls in the nineties.[3]

Benelli et al. (2011) describe some of the recent measures adopted by Brazil to manage capital inflows, discussing the evolution of flows, domestic financial market developments and the exchange rate. Jinjarak et al. (2013) use a synthetic cohort approach to study some of the recent Brazilian controls, and find that the restrictions did not affect flows or the exchange rate. While their approach allows for a counterfactual exchange rate to be constructed based on the evolution of the exchange rate in other countries, it does not allow for other explanatory variables (including Brazil-specific variables) that could affect the exchange rate to be considered.[4] In a contemporaneous paper, Baumann and Gallagher (2012) find that the Brazilian controls had a significant but small effect on the exchange rate. One reason why we find a stronger result than other papers on Brazil is that we take into account the delay in the implementation of the tax on derivatives (whose implementation had a much larger impact on the exchange rate than its announcement).

The recent Brazilian experience provides an ideal context to study the effect of capital controls and restrictions. No other country with a similar level of integration with global financial markets has ever experimented as actively with market-based capital controls, placing Brazil on a category of its own. Our study adds value to the literature on controls for a number of reasons. It provides the most detailed and in depth discussion of the policies adopted and their effect on domestic financial markets. Brazil has very sophisticated capital markets (arguably the most sophisticated among emerging markets), with deep and liquid instruments which we use to document the effectiveness of capital controls in segmenting the domestic and global markets. The measures adopted were transparent and market-based. The inflow tax increases were announced when the market was closed and became effective on the following day, with only one exception. This makes these policies particularly suitable for daily-frequency analysis. We use daily data and control for a host of variables that can also affect the exchange rate, including daily sterilized intervention data (not only through spot interventions but also through futures and swaps), and also test the effect of controls over longer horizons.

The remainder of the paper is organized as follows. Section 2 describes the history of capital controls in Brazil. Section 3 analyzes the effectiveness of these controls in Brazil, since 2009. It shows how the controls create wedges between prices onshore and offshore, both on the fixed income, and on the variable income markets. Then, it analyzes whether or not the controls were able to mitigate the nominal appreciation of the real, which is the main focus of our paper (Section 2.2). Finally, Section 4 presents the conclusions and the policy implications of our findings.

2. Capital controls in Brazil

Controls on capital outflows have a long history in Brazil, since financial repression was the norm until the early 1990s. In 1991, real interest rates were significantly raised to avoid capital flight and to help accumulate foreign reserves. With the low rates prevailing in the US, capital started flowing in the country. So much so that starting in 1993, controls on capital inflows were enacted. Unlike the Chilean or Colombian capital controls, which took the form of unremunerated reserve requirements,

[1] de Gregório et al. (2000), Edwards and Rigobon (2009) and Forbes (2007).
[2] Cardenas and Barrera (1997) and Clements and Kamil (2009).
[3] Cardoso and Goldfajn (1998) and de M. Carvalho and Garcia (2008).
[4] It is also difficult to recover an intuition for the results, since as pointed out in their paper, the country weights on the synthetic cohort have no economic significance or otherwise interpretable meaning.

the capital controls in Brazil took the form of a tax on the exchange rate transaction when capital first entered Brazil. This tax was a particular stance of the IOF tax, which taxes most financial transactions in Brazil with different tax rates (IOF is the Portuguese acronym for Tax on Financial Transactions). Most countries tend to use unremunerated reserve requirements instead of taxes to discourage inflows because the latter typically requires congressional approval. Brazil's case is unique because a general tax on financial transactions (the IOF) already existed, and the Executive was able to extend its coverage to certain foreign exchange transactions, as well as to change its rate, by decree (including setting the tax rate to zero) without congressional approval, with the tax becoming immediately effective.

During the nineties, the top IOF tax rate on capital inflows applied to fixed income (carry-trade) was 9%.[5] With the capital flight caused by the Russian crisis and the LTCM debacle, in 1998, the IOF tax rate on capital inflows was set to zero. In 2008, it was again raised to 1.5% for a brief period as a way (albeit imperfect) to equalize the tax treatment of foreigners (who were not subject to the income tax imposed on domestic investors). This IOF was removed when the capital flight associated with the Lehman crisis began. With the resumption of massive capital inflows, as early as February 2009, capital inflows were again deployed.

Table 1 lists the measures that have been adopted in Brazil since October 2009, which are the subject of the current paper. All the IOF tax increases and restrictions listed in this table were announced when the Brazilian market was closed and became effective at the time of their publication (next business day), except for the tax on the notional amount of derivatives.[6] On October 19, 2009, a tax of 2 percent was imposed on portfolio flows, covering both equities and fixed income. In the past, equity flows were often excluded from such taxes. Unlike the opportunistic and volatile carry-trade, equity flows are typically perceived to be a fairly safe type of flow. Nevertheless, Brazilian equity markets attracted so much capital in the aftermath of the recovery from the Global Financial Crisis that the government, concerned with the exchange rate appreciation, decided to include stocks in the controls. Also, the use of stocks as a vehicle to bring funds in the country aiming to replicate fixed income returns, as had happened in the previous Brazilian experience with controls on capital inflows, in the 1990s (discussed in de M. Carvalho and Garcia, 2008), may have played a role.

One obvious channel, which allowed investors to bypass the controls in the case of equity flows, was the conversion of Depositary Receipts (DRs). DRs are securities issued by a custodian bank, which receives the underlying stock in Brazil, and issues a corresponding receipt that is traded in foreign markets (e.g. ADRs – American Depositary Receipts – in the case of U.S. markets). On November 18, 2009, a 1.5 percent tax was imposed on the issuance of DRs to discourage their use as a way to buy Brazilian equities without incurring the inflow tax. When a foreign investor buys a DR, he has the right to convert that DR into the underlying stock in the Brazilian market. This provided a mechanism to enter the Brazilian financial market without incurring the 2 percent tax on capital inflows. Eventually, a tax of 2 percent was imposed on those conversions (December 30, 2010). There were no other changes targeting equity inflows, and taxes on equity flows were eventually removed (set to zero) on December 2011, although the 1.5% IOF tax on DR issuance still remains.

The fixed income arena has seen much more regulatory action, as a series of measures tightened restrictions on fixed income flows. The tax on fixed income flows, initially set at 2%, was raised to 4% on October 4, 2010, and shortly afterwards to 6% on October 18, 2010.

The controls discriminate against only a subset of capital inflows (portfolio flows), leaving others untaxed, i.e., they are "gates" in the terminology of Klein (2012). If a transfer between a financial institution abroad and its domestic counterpart could fall in the non-taxed subset it would not incur the IOF tax. Therefore, foreign investors wanting to do carry trade could buy Non-Deliverable Forward contracts of Brazilian reals in offshore markets (where they are beyond the reach of the inflow tax), and the banks could take an offsetting position in Brazil. The end result would be banks selling dollars

[5] de M. Carvalho and Garcia (2008) describe several ways through which the IOF tax was avoided at the time. Cardoso and Goldfajn (1998) also measure the effectiveness of those taxes.

[6] The only other restriction in that table that did not become effective on the following business day was the URR on the Bank's Gross FX Position announced on January 6, 2011, which only became effective on April 4, 2011. In contrast, the tightening of that URR announced on July 8, 2011 became effective on the following business day.

Table 1
Major capital control and related measures adopted in brazil since November 2009.

Date	Tighten or Loosen Restrictions?	Measure
10/19/2009	Tighten	Tax of 2 percent on portfolio equity and fixed income inflows
11/18/2009	Tighten	Tax of 1.5% on the Issuance of DRs into local equities
10/4/2010	Tighten	Tax rate raised to 4 percent for fixed income inflows
10/18/2010	Tighten	Tax rate raised to 6 percent for fixed income inflows
12/30/2010	Tighten	Tax of 2% on the cancellation of DRs into local equities
1/6/2011	Tighten	Unremunerated reserve requirement of 60 percent on bank's gross FX positions beyond US $3 billions
3/28/2011	Tighten	Tax of 6 percent on borrowing abroad with maturity below one year
4/6/2011	Tighten	Tax of 6 percent on borrowing abroad extended to maturities below two years
7/8/2011	Tighten	Unremunerated reserve requirement of 60 percent on bank's gross FX positions beyond US $1 billion
7/26/2011	Tighten	Tax on notional amount of currency derivatives
9/16/2011	Tighten	Tax on notional amount of derivatives takes effect
12/1/2011	Loosen	Tax on portfolio equity inflows eliminated
2/29/2012	Tighten	Tax of 6 percent on borrowing abroad extended to maturities below three years
3/1/2012	Tighten	Restricts pre-payments to exporters to no more than one year
3/9/2012	Tighten	Tax of 6 percent on borrowing abroad extended to maturities below five years
3/15/2012	Loosen	Tax on derivatives set to zero for hedging by exporters (up to 1.2 times exports in previous year)
6/14/2012	Loosen	Tax on 6 percent on borrowing abroad restricted to maturities below two years
6/28/2012	Loosen	Pre-payments to exporters can be done by financial institutions
12/4/2012	Loosen	Pre-payments to exporters allowed for horizon above one year but below five years
12/5/2012	Loosen	Tax of 6 percent on borrowing abroad restricted to maturities below one year
12/18/2012	Loosen	Unremunerated reserve requirement on bank's gross FX position applies only after US $3 billion
6/4/2013	Loosen	Tax on fixed income flows eliminated
6/12/2013	Loosen	Tax on notional amount of derivatives eliminated
6/25/2013	Loosen	Reserve requirements on short FX positions held by local banks eliminated
7/11/2013	Loosen	Capital requirements on foreign currency loans raised by subsidiaries abroad eliminated
12/24/2013	Loosen	Tax on Issuance of DRs eliminated
6/4/2014	Loosen	Tax on 6 percent on borrowing abroad restricted to maturities below six months

Note: All tightening restrictions were announced when the market was closed, and became effective on the following business day (the only exceptions were the January 6, 2011 URR on Banks' Gross FX Positions which only became effective on April 4, and the tax on the notional amount of derivatives which was announced on July 26, 2011 and became effective on September 16 of that year).

to the Brazilian Central Bank for reals in order to offset the position (which causes the same pressure on the exchange rate as if the foreigners had come directly). It is difficult to gauge how much such strategies have been used during the last episode of capital controls.

On January 6, 2011, the central bank announced an unremunerated reserve requirement on banks' gross FX liabilities beyond US$ 3 billion (on the spot market only),[7] which limited the extent to which the strategy described above could be used to bypass the controls. This requirement became effective on April 4, 2011. On March 28, 2011, Brazilian firms borrowing abroad became subject to a 6 percent tax on those flows if their maturity was less than 1 year (extended to two years shortly afterwards). Related measures were adopted to prevent firms from borrowing abroad

[7] In Brazil, only banks with a special charter granted by the central bank may trade in the spot exchange rate market. This hindrance has historically stimulated the use of exchange rate derivatives, as discussed in Ventura and Garcia (2012). Also, banks' assets and liabilities in foreign currency have always been closely monitored by the Brazilian Central Bank, and very often controlled. In times of massive capital inflows, restrictions on banks' liabilities are usually deployed, as exemplified by this unremunerated reserve requirement. On the other extreme, i.e., in times of capital flight, limits to FX assets were imposed (to avoid further drain on foreign reserves). This is because increases in banks' FX liabilities bring liquidity, while increases in banks' FX assets drain liquidity from the domestic FX market.

long-term without paying the tax and then converting the loan to a shorter maturity. Foreign investors could use derivatives to leverage their currency exposure, with the inflow tax only being applied to the money they brought to Brazil to meet their margin requirements. Such strategies were somewhat constrained by the earlier measure restricting banks' gross spot FX positions (which was further tightened on July 8, 2011). And on July 26, 2011, a tax on the notional amounts of currency derivatives was announced. The initial tax rate was set at 1%, but the decree allowed for that rate to be increased (although the rate was never actually raised). This tax is levied whenever a currency derivative that shorts foreign currencies is purchased, sold, or at its expiration date (and therefore investors are exposed to the risk that the tax rate increases while they are holding the derivative). This measure became effective on September 16, 2011.

On February and March 2012, additional restrictions were put in place (limiting payments to exporters before actual delivery of goods or services, akin to export credit, and extending the tax on foreign borrowing to loans with maturities up to 3 years, and then up to 5 years). During 2012, capital flows waned. Inflationary concerns, especially after the large reduction of the policy interest rate by the Brazilian Central Bank (from 12.50% on July 20, 2011 to 7.25% on October 10, 2012), made further depreciation of the real less desirable. By the end of 2012, a movement to withdraw some of the capital controls started, aimed at attracting capital inflows. The Brazilian central bank started providing U.S. dollars through repo operations (which has a similar effect to sterilized sales of foreign exchange), so as to manage the exchange rate (which hovered around a relatively narrow band above 2 BRL/USD from May 2012 to May 2013, with relatively small volatility). The tax on foreign borrowing was limited to loans with maturities up to two years on June 2012, and eventually limited to loans with maturities up to one year in December 2012. On June 4, 2013, amid concerns about excessive weakening of the Brazilian real, the tax on fixed income flows was eliminated (set to zero). Eight days later, the IOF tax on the notional amount of currency derivatives was also eliminated (set to zero). As of the time of writing, the only remaining restriction is the 6% tax on short term external loans (eventually limited to loans below 6 months).

3. Effectiveness of measures

Fig. 1 reports the gross capital inflows to Brazil broken down by different types of flows (monthly data). We observe sizable inflows in the period prior to the Global Financial Crisis, with a sharp reversal in late 2008 to early 2009 (with the exception of FDI flows which remained positive even at the height of the crisis). But inflows recover rapidly following the crisis, and by mid-2009 inflows are comparable to their pre-crisis levels. The first vertical line indicates the imposition of the 2 percent tax on portfolio flows. Both portfolio equity and debt flows remain strong after the imposition of that tax. The second vertical line indicates the month when the tax on portfolio debt inflows was raised to 4 and then to 6 percent. While portfolio debt flows decline following the increase in the tax, they remained substantial. Perhaps the most striking pattern in Fig. 1 is the sizable increase in FDI flows during this period. While there was indeed much FDI during this period, this shift could partly reflect a relabeling of flows as FDI so as to avoid the inflow tax. One often hears the argument that intra-company loans are classified as foreign direct investment, thereby avoiding the IOF tax. We checked with the Brazilian Central Bank whether this was the case. According to the explanation given to us, the classification of intra-company loans as FDI is solely for statistical purposes. Intra-company loans were taxed at the same rate as regular (non-intra-company) loan with the same characteristics. According to this explanation, it is very hard to avoid the taxes by relabeling flows.[8] Nevertheless, financial institutions that operate both in Brazil and abroad seem to have more room to avoid the IOF, offering

[8] One viable strategy involves a firm bringing in as FDI more money than it actually plans to invest in its business, keeping the additional funds in fixed income markets. The gains from this strategy seem limited (unless it is done in a very large scale, e.g. with the firm using offshore derivatives to fund their domestic carry trade). Furthermore, as a local firm, it has to pay income tax on the returns on financial investments.

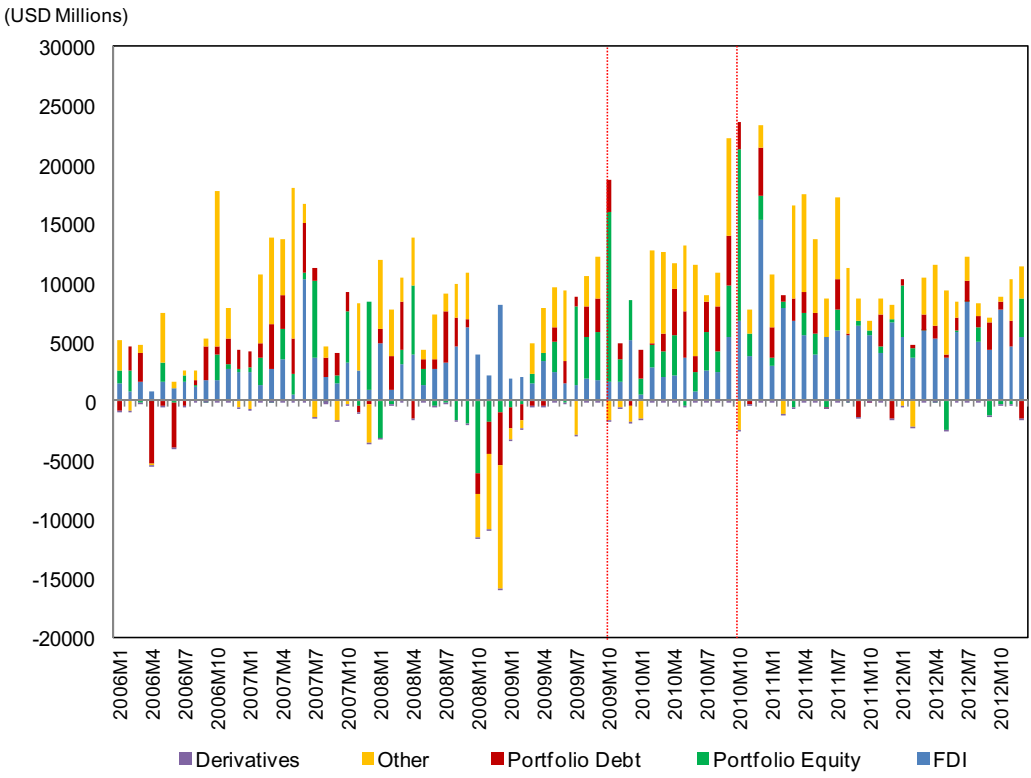

Fig. 1. Gross Capital Inflows to Brazil. Notes: Data from the Central Bank of Brazil. Data correspond to liabilities to foreigners in the capital and financial account. First vertical line indicates the month where the 2 percent tax on portfolio inflows was imposed. Second vertical line indicates the month where the tax on fixed income flows was raised to 4 then to 6 percent.

offshore products that mimic the Brazilian interest rate, e.g., a total return swap or a cross currency swap. These financial institutions use their operations in Brazil to hedge the offshore operations with Brazilian real products.

It is difficult to assess the effectiveness of controls from the volume of flows, since that would involve making assumptions about the counterfactual volumes in the absence of controls. One alternative is to focus on differences between onshore and offshore prices of similar assets. If the measures were successful in discouraging capital flows to Brazil, we should have observed the emergence of wedges in local fixed and variable income markets that would have normally been arbitraged away, but could not under the controls on capital inflows (these wedges will emerge to some degree even if the controls are porous and have a limited effect on the volume of flows).

When it comes to estimating the impact on the exchange rate, we need to estimate a model in order to analyze the impact of the controls (since otherwise we cannot assess what the exchange rate behavior would have been in their absence). Effectiveness is harder to assess along other dimensions. For example, controls on capital inflows can serve a macroprudential role, helping to avoid excessive capital inflows that could inflate bubbles and lead to financial instability. But much of the motivation for the controls was to promote the depreciation of the real. The Brazilian authorities were quite candid about competitiveness concerns. For example, on October 21, 2009 (two days after the first control was announced), Finance Minister Mantega stated: "*We want to prevent an excessive appreciation of the real. When the real appreciates, it makes our exports more expensive and our imports cheaper, and*

we already have an expressive increase in imports while the exports are not growing as they should."[9] Therefore, we will focus on the exchange rate as the main metric for effectiveness.

3.1. Local fixed income markets

The extent to which controls succeed in segmenting fixed income markets can be gauged by the spread between the world interest rate and Brazil's onshore dollar rate. It is illegal to settle contracts in Brazil in any currency other than the Brazilian real (legislation originated in the aftermath of the Great Depression). Banks in Brazil are not allowed to offer deposit accounts in any other currency but the Brazilian real. Nevertheless, there are liquid markets for currency derivatives (currency derivatives did not exist in Brazil when the restrictive FX legislation was created, and were much later used to bypass it). Until 2002, it was common for the government to issue bonds indexed to the exchange rate (while the value of the payment was determined in dollars, it was settled in Brazilian reals at the prevailing exchange rate). But these bonds have been mostly retired. The main liquid instrument with which to obtain a benchmark onshore dollar rate for Brazil is the *cupom cambial*, which is the US dollar (USD) interest rate implied by currency futures. That is, based on the forward exchange rate, the spot exchange rate, and the local currency interest rate (i_t, in the equation), one can easily recover, through Covered Interest Parity, the implied onshore dollar interest rate:

$$1 + Cupom\ Cambial_t = (1 + i_t) * \frac{Spot\ Exchange\ Rate_t}{Forward\ Exchange\ Rate_t}$$

If the onshore dollar interest rate is higher than the world interest rate, gains can be made by arbitrating that difference, without incurring currency risk. But if there are limits to that near-arbitrage, a persistent wedge between the onshore and offshore dollar rates would arise. The evolution of the onshore dollar rate also has major implications for pressures on the exchange rate, since it measures the local cost of funding carry trades (shorting dollars in the onshore market to long the real). It is possible to profit from the appreciation of the real and the positive interest rate differential via the onshore derivatives traded at BM&FBovespa, a Brazilian exchange.[10] The most common trades are to short the US dollar futures contract, to short the contracts on the onshore dollar rate, or to short the onshore dollar rate combined with going long on the domestic interest rate futures (DI × Pre).

Since Brazil emerged from its 2002 crisis, the spread between onshore and offshore dollar rates has been relatively small. For example, in the period between 2005M1 and 2007M6 (during which international financial markets remained tranquil), the spread between the 90 day cupom cambial and the 90-day t-bill averaged less than 50 bps (part of which could be in principle explained by small credit and convertibility risks).

Fig. 2 plots the evolution of the cupom cambial with 90 and 360-day maturities. The vertical bars indicate the days in which different measures were announced (with the announced tax being effective on the following business day). That spread hovered around 1 percent in the months prior to the adoption of the different controls. There wasn't much variation in the world interest rate during this period or in Brazil's credit risk. On balance, there was not much of an impact on onshore dollar rates following the initial controls. There is more suggestive evidence of an effect following the October 2010 round of controls targeting fixed income. The spread spikes shortly after the March–April 2011 taxes on foreign loans, suggesting that those measures were more successful in creating a large wedge between external and internal dollar liquidity, with the more liquid 90-day cupom cambial peaking at over 8 percent. Brazilian banks were borrowing abroad short-term to provide dollar liquidity in the local market. The tax on short-term loans temporarily disrupted that flow. But with the resulting large onshore dollar rates, banks switched to long-term borrowing abroad to restore liquidity in the local market. Indeed, after that spike, the onshore dollar rate gradually declines towards more normal levels (which, while

[9] Translated from http://www.bbc.co.uk/portuguese/noticias/2009/10/091021_mantega_cambio_dt.shtml.
[10] http://www.bmfbovespa.com.br/en-us/intros/intro-about-us.aspx?idioma=en-us.

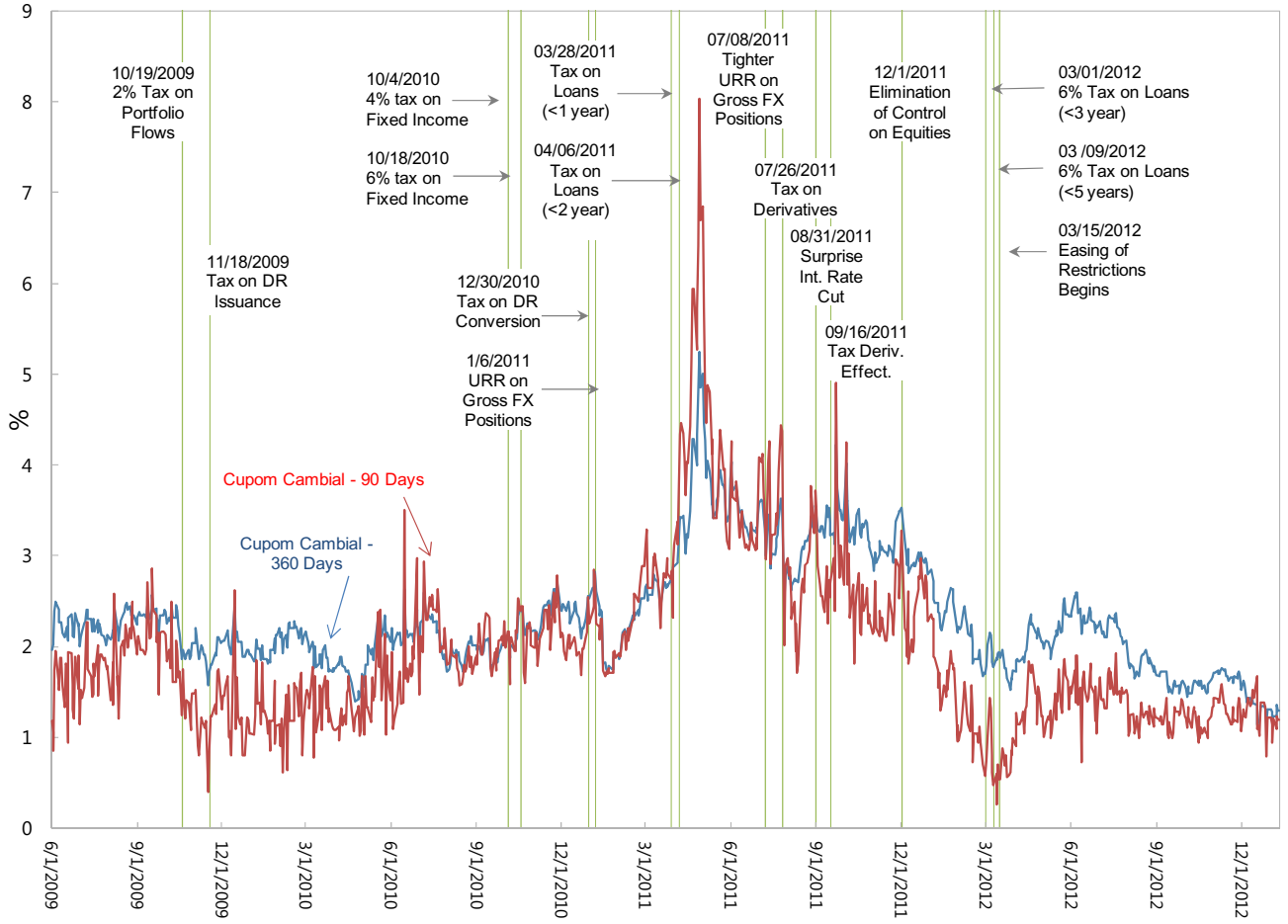

Fig. 2. Evolution of the 90- and 360-Day Cupom Cambial (Onshore Dollar Rate). Source: Bloomberg.

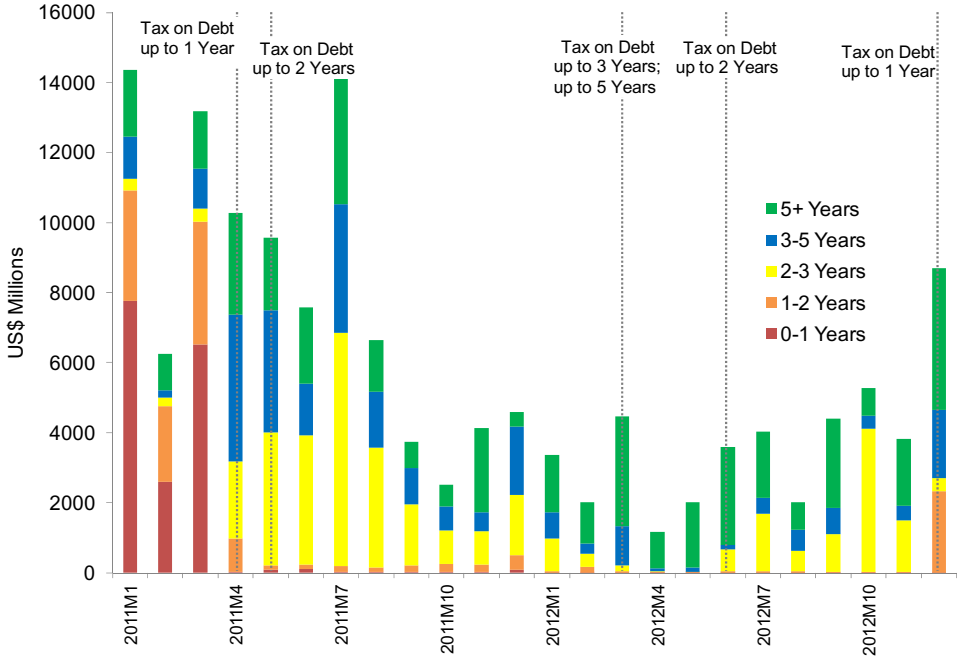

Fig. 3. External Debt Flows by Original Maturity. Source: Central Bank of Brazil.

non-negligible, are nowhere near the 6 percent tax rate on fixed income flows). This is consistent with the view that controls tend to become more porous over time (in this particular case, the high onshore dollar rate lead banks to tap costlier long-term external funding that was exempt from the tax). But we cannot attribute all fluctuations in the onshore dollar rate to the controls becoming more or less effective over time, since these fluctuations can also be driven by the demand and supply of dollar liquidity in the local market. Appendix S1 provides econometric estimates for the impact of the different measures on the cupom cambial.

An active domestic carry trade market emerged in the Brazilian onshore derivative markets, which allowed foreigners to minimize the incidence of the inflow tax (since it applied only to the margin requirements). There was a marked reduction in the foreigners' aggregate net position (open interest) shortly after the tax on the notional amount of derivatives, and beginning of an interest rate easing cycle, as shown in Appendix S1.[11] This suggests that the tax on derivatives (perhaps in combination with a lower interest rate environment) eliminated onshore carry trades by foreigners via the derivatives market.

There were a number of measures related to the taxation of external borrowing. While that is not directly related to the domestic fixed income market, the evolution of the maturity profile of that borrowing illustrates how the markets can adapt to those measures. Fig. 3 plots the external borrowing flows by maturity during 2011 and 2012. Initially, debt with less than one year maturity accounted for half of the flows (and debt with maturity below two years accounted for ¾ of flows). But once the 6% tax is imposed on debt with maturities below one year, those flows disappear almost entirely. Shortly afterwards that tax was extended to maturities up to two years, and virtually all new debt (97%) shifts to maturities above that horizon. Eventually the incidence of the tax is extended to debt

[11] The historical peak for that series was 24.6 billion in early July 2011. On the eve of the surprise rate cut (August 31, 2011), that position was 17 billion. By the time the tax on the notional amount of derivatives became effective (September 16, 2011) that position had declined to 11.2 billion and by the end of September 2011 it declined to 1.1 billion.

with maturity below five years. Flows remain concentrated in the longer-term maturities even after the incidence of the tax is restricted to maturities above 2 years.

The low dollar interest rates made shifting towards longer-term maturities a cheap way to avoid the capital controls. The overall volume of flows is volatile and on average smaller after the imposition of the tax on short-term loans (although there are cases in the post-tax period where it reaches levels comparable to those prior to the tax).

3.2. Local stock market

The different measures adopted to restrict capital flows have also led to the emergence of premia/discount in variable income markets that could not be arbitraged away. The issuance of DRs involves a small transaction cost, but provides foreigners the ability to buy and sell the DR among themselves without incurring the inflow tax multiple times. Historically, DR prices fluctuated very close to that of the underlying stock. But the imposition of the capital control has created a wider band over which those fluctuations cannot be arbitraged away. For example, even if the DR traded at a premium close to 2%, it was still "cheaper" for a foreign investor than paying the 2 percent inflow tax to purchase the stock locally. If a sizable premium were to persist, the custodian bank could create more DRs to increase their supply (although that also involves some transaction costs). On the flipside, if the DR were to trade at a discount, it would be worthwhile to convert it into the local underlying stock. Within that limited-arbitrage band, the premium of the DR can fluctuate, depending on whether or not there is excess demand by foreigners for Brazilian stocks. For example, during times when that excess demand is present, the premium should move towards the upper range of that band. During times when that excess demand is weaker, the premium will decline.

We focus on the stocks for Petrobras (the state controlled oil company) and Vale (a large mining company), which are the largest companies in the Brazilian market (jointly, they account for about a quarter of the Brazilian equity market capitalization), and by far the most liquid stocks.

São Paulo is 1–3 hours ahead of New York (2 hours ahead plus or minus one hour depending on whether it is daylight saving time, in the U.S. or Brazil). We compute the premium by measuring the price of the ADR and the underlying stock as of 12pm EST, a time when both exchanges are always open simultaneously, and drop days when either stock exchange is closed.

Fig. 4 plots the evolution of the ADR premium for Petrobras. That premium used to fluctuate very close to zero before the controls. It immediately rose following the initial control, and spiked to a level close to 2% following the second control (taxing the conversion of ADRs). That premium declines in the first quarter of 2010, but rises again in late 2010[12] and remains high until the tax on equity inflows is eliminated in December 2011 (at which point the premium starts to converge to zero). In principle, only the first two controls should affect the ADR premium, since all the other measures targeted only fixed income flows. It was common for ADRs to be issued and cancelled during that period (as was also the case prior to the controls), but, as expected, issuances tended to occur when the premium was high, whereas cancellations tended to occur when the premium was low. While foreigners could use the cancellation of DRs as a gateway to the Brazilian local markets, foreign accounts for fixed income and stocks are separately maintained and regulated, and it would take some financial engineering to construct a fixed income position from positions in the stock market. However, the other controls could still have affected the ADR premium through other channels. For example, the increasingly tight fixed income controls signaled that the government was serious about trying to restrict foreign access to local markets, and some investors may have feared tighter restrictions were being contemplated for equity flows.[13] Econometric analysis (available in Appendix S1) shows that, as expected, the tax on

[12] In September 2010, Petrobras conducted the largest share sale in history, when US$72.8 billion worth of shares in the company were sold. Upon the sale, Petrobras immediately became the fourth-largest company in the world measured by market capitalization (http://en.wikipedia.org/wiki/Petroleo_Brasileiro_SA).

[13] Forbes et al. (2012), analyzing the Brazilian experience with capital controls from the point of view of foreign investors, conclude that an increase in Brazil's tax on foreign investment in bonds caused investors to significantly decrease their portfolio allocations to Brazil in both bonds and equities.

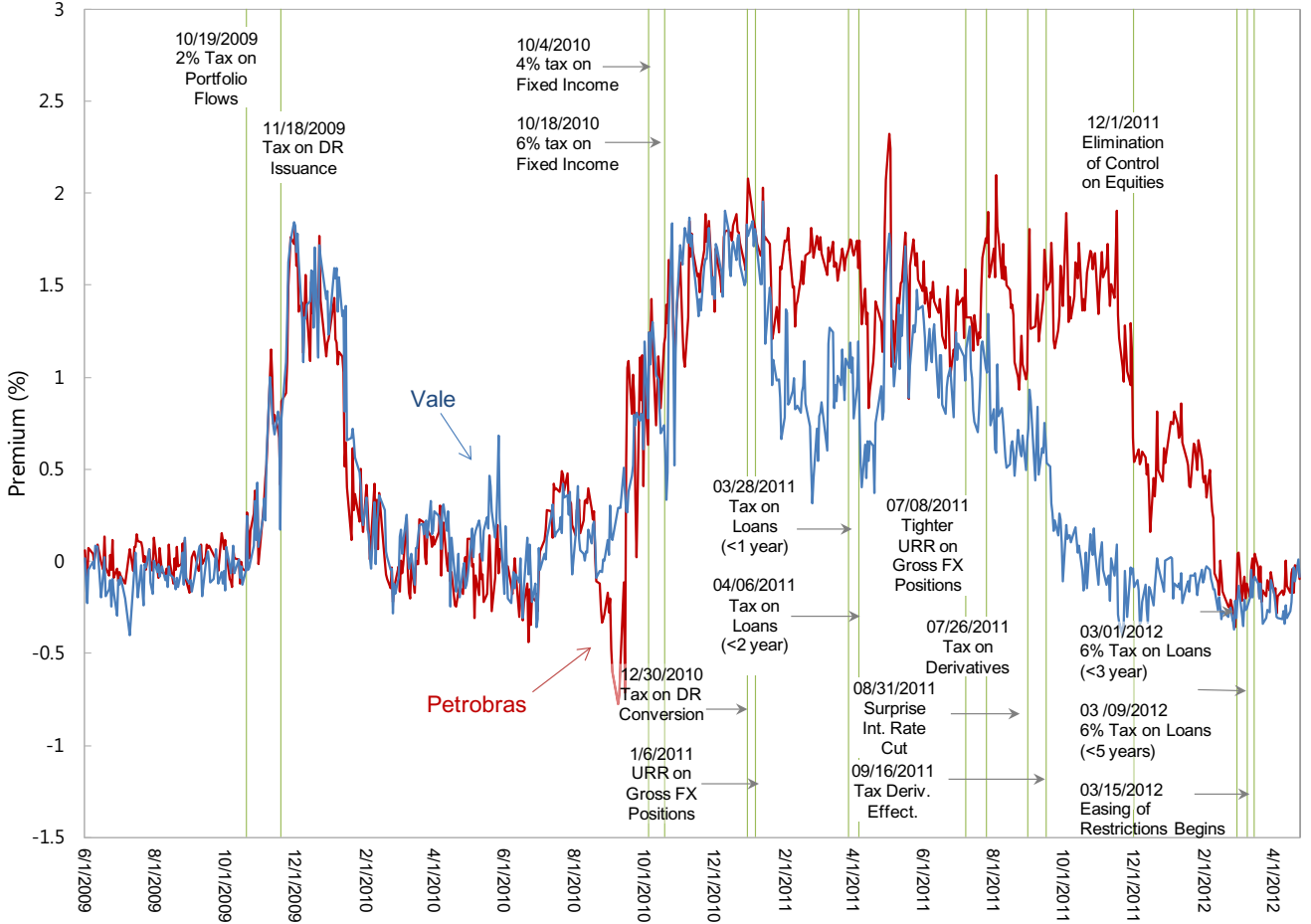

Fig. 4. Evolution of the Premium for Petrobras and Vale ADRs. Source: Bloomberg.

DR issuance is the measure with the most robust impact, increasing the premium for Petrobras by about 0.5 percent, and the premium for Vale by 0.6–0.9 percent depending on the horizon considered. There are a few other measures that have a statistically significant impact, but the results tend to be mixed.

On balance, these results suggest that the controls were reasonably effective in creating at least some segmentation between local and offshore markets. They seem to have been more effective – in the sense of creating spreads commensurate with the inflow tax rate – in the case of equity flows than in the case of fixed income flows. Two factors may have contributed to this pattern. First, the tax on equity flows was kept at 2 percent, which may have limited the incentives to circumvent the controls vis-à-vis fixed income flows, and equity investors usually invest for longer terms (Forbes et al., 2012 survey foreign investors). Second, many of the equity flows are related to institutional investors such as pension funds and mutual funds, which may face regulatory constraints on their ability to trade derivatives and jump through a series of hoops in order to avoid the tax (unlike, say, a hedge fund trying to do carry trade). Reports from the Ministry of Finance confirm that the inflow taxes generated a significant amount of revenues. In 2008 and 2009, the IOF revenues related to currency transactions on inflows was only R$735 million and R$1.368 billion, respectively. Those figures rose to R$5.392 and R$4.797 billion in 2010 and 2011 respectively, and declined to R$2.327 in 2012 (the year when the restrictions began to be removed). In Appendix S1, we provide a plot of the evolution of these revenues.

3.3. Effect of controls on the exchange rate

Fig. 5 plots the evolution of the Brazilian real–US dollar nominal exchange rate during this period. We follow the convention in Brazil, reporting the exchange rate in terms of *reals* per dollar, so an *increase denotes a depreciation of the real*. While appreciation trends seem to halt after some of the initial capital controls adopted, the plots do not suggest sizable discrete responses. In contrast, there seem to be sharp movements in the days following the surprise cut and the last restrictions adopted: the implementation of the tax on the notional amount of derivatives, and the tightening of the restrictions on external borrowing. The dots in the figure indicate the volume of the central bank's interventions in the FX market (right axis). Green (red) dots correspond to interventions where the central bank buys (sells) dollars. There were sizable interventions through most of 2009–11, which the plot suggests failed to stop the appreciation pressures on the real (which is also confirmed in our regressions below).

In principle, the exchange rate is a forward-looking variable that should jump to reflect any changes in expectation as a result of the different measures adopted. But in practice, it may take some time for the market to digest the implications of the different policies, and the extent to which they succeed in discouraging flows. In order to more formally assess the effect of the capital controls and related measures on the exchange rate, we must control for other factors that could have influenced the latter. The first specification we consider is:

$$\begin{aligned}\Delta\log(e_t) = c + \sum_i \beta_i DControl_{i,t} + \gamma_1\Delta(CDI_t - LIBOR_t) + \gamma_2\Delta Onshore\ Dollar\ Rate_t + \gamma_3\Delta\log(Ibovespa_t)\\ + \gamma_4\Delta\log(VIX_t) + \gamma_5\Delta\log(Commodities_t) + \gamma_6\Delta\log(Dollar\ Index_t) + \gamma_7\Delta\log(Dollar - Asia_t)\\ + \gamma_8\Delta\log(Dollar - LA_t) + \gamma_9 FX\ Purchases_t + \gamma_{10} FX\ Sales_t + \varepsilon_t\end{aligned}$$

where e is the dollar–real bilateral exchange rate (an increase in e denotes a depreciation of the real), $DControl_{i,t}$ is a singleton dummy equal to one on the day of a capital control or other measure, and zero elsewhere. We have thirteen dummies associated with the imposition of capital controls/restrictions, one dummy associated with the easing of a restriction, and one dummy for a surprise cut in the policy rate. The dummies are coded as one on the first day of trading after the announcement of the measure (after the close of market on the previous day). All measures took effect immediately after their announcement, except for a restriction on bank's gross FX positions and the tax on the notional amount of derivatives. For that reason, we also include a dummy for the day in which the tax

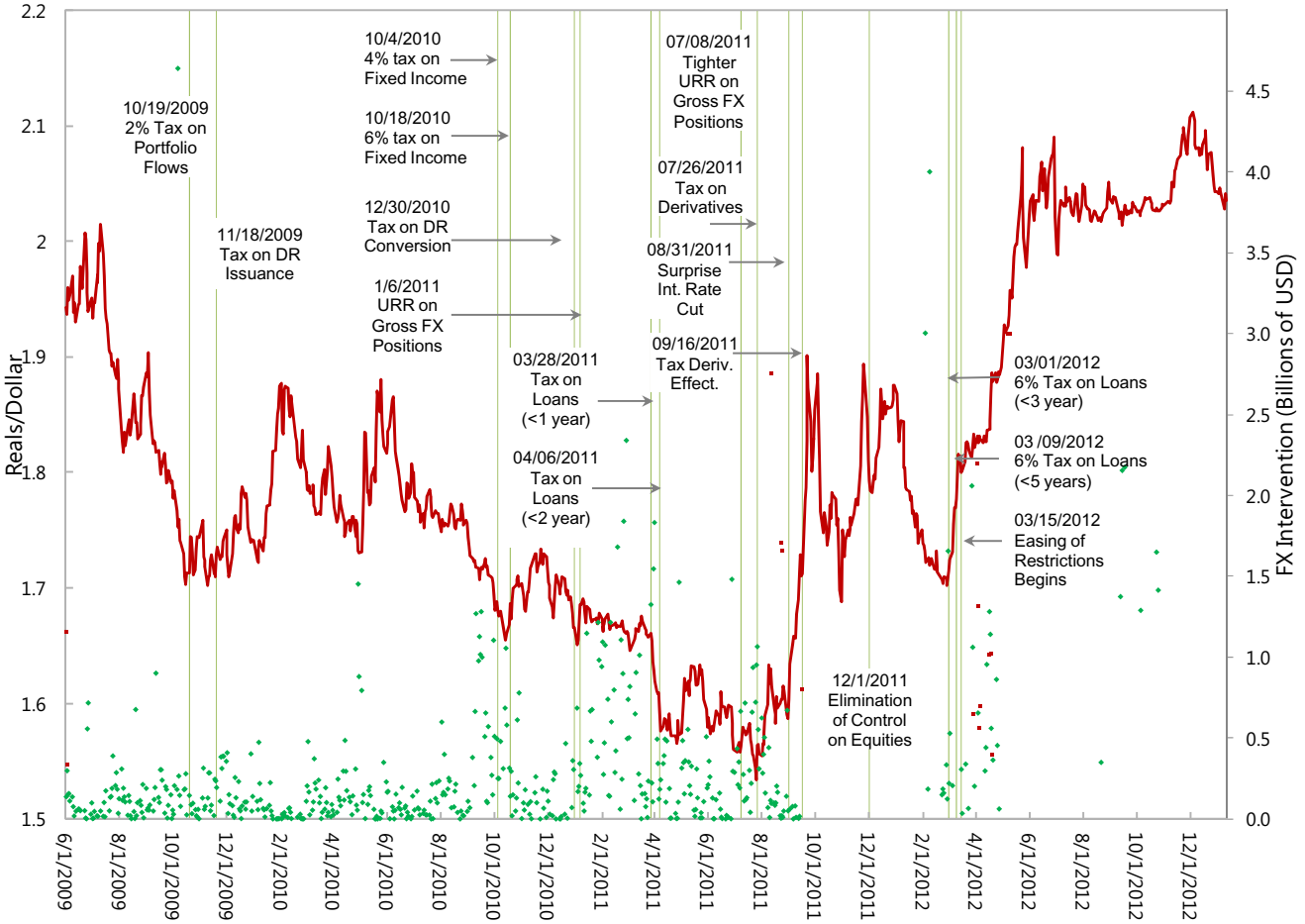

Fig. 5. Evolution of the Real-Dollar bilateral exchange (LHS) rate and FX Interventions (RHS). Notes: Green dots correspond to interventions where the central bank purchases dollars, and red dots to interventions where the central bank sells dollars (magnitudes in the right-hand-side axis). Source: Central Bank of Brazil.

on the notional amount of derivatives took effect.[14] Additional explanatory variables include the change in the spread between the one-month CDI (Brazil's interbank rate) and the one-month LIBOR, the change in the onshore dollar rate (90-day cupom cambial), the change in log of the Ibovespa stock index (Brazil's most used equity index), the change in the log of the VIX, the change in the log of the CRB commodity price index, the change in the log of an index constructed by the Federal Reserve for the value of the dollar relative to major currencies of advanced economies weighted by U.S. trade shares, the change in the log of the Bloomberg JP Morgan Asia and Latin America currency indices (we re-computed the latter, based on published weights, to exclude the BRL), and FX interventions by the Central Bank of Brazil, broken down between purchases and sales. We will also consider specifications where the lagged level of the exchange rate, as well as the variables that enter in changes in the specification above, are included (which provides an error correction feature to the dynamics):

$$\begin{aligned}\Delta\log(e_t) = c &+ \sum_i \beta_i DControl_{i,t} + \gamma_1\Delta(CDI_t - LIBOR_t) + \gamma_2\Delta Onshore\ Dollar\ Rate_t + \gamma_3\Delta\log(Ibovespa_t)\\ &+ \gamma_4\Delta\log(VIX_t) + \gamma_5\Delta\log(Commodities_t) + \gamma_6\Delta\log(Dollar\ Index_t) + \gamma_7\Delta\log(Dollar - Asia_t)\\ &+ \gamma_8\Delta\log(Dollar - LA_t) + \gamma_9 FX\ Purchases_t + \gamma_{10} FX\ Sales_t + \delta_1\log(e_{t-1}) + \delta_2(CDI_{t-1} - LIBOR_{t-1})\\ &+ \delta_3 Onshore\ Dollar\ Rate_{t-1} + \delta_4\log(Ibovespa_{t-1}) + \delta_5\log(VIX_{t-1}) + \delta_6\log(Commodities_{t-1})\\ &+ \delta_7\log(Dollar\ Index_{t-1}) + \delta_8\log(Dollar - Asia_{t-1}) + \delta_9\log(Dollar - LA_{t-1}) + \varepsilon_t\end{aligned}$$

The Central Bank of Brazil publishes data on foreign exchange interventions at a daily frequency. We include central bank interventions (measured in billions of dollars) as an additional control in some specifications. This variable is clearly endogenous, as presumably the interventions are at least partly motivated by developments in the exchange rate market. We instrument FX interventions with the first two lags, as well as with the lagged option-implied 3-month volatility of the exchange rate. The use of lagged interventions as instruments is justified by the fact that once the Brazilian Central Bank decided to intervene, it did so for a long time, irrespective of the short term behavior of the exchange rate (as documented in Vervloet, 2010).

The exchange rate data are based on the PTAX rate published by the Brazilian Central Bank. That rate is based on an average of quotes from foreign exchange dealers in Brazil and is the reference exchange rate typically used for future contracts (including offshore Non-Deliverable Forwards). Using that reference exchange rate also ensures that each set of daily data does not reflect capital control announcements made on that day (since the announcement of restrictions took place after the closing of Brazilian markets). We use Bloomberg as the source for the remaining variables.

Our sample focuses on the period where Brazil was receiving sizable capital inflows and taking measures to discourage these flows. Our estimation sample begins in June 1, 2009 and ends in March 15, 2012 (when the controls/restrictions began to be gradually loosened). For ease of interpretation of the coefficients, we multiply the variables that enter as log changes by 100, and measure the interest rate differential in percentage points.

An obvious issue of concern is the endogeneity of capital controls. Our identification strategy relies on the use of daily data to attenuate this problem. The decision to deploy capital controls was taken after a several-month-long process of exchange rate appreciation, at the close of the 2008 crisis (by February 2009, the Brazilian Central Bank was already conducting sterilized FX purchases). After the decision to deploy capital controls was taken in October 2009, many measures followed. Official statements confirm that the goal was to stop exchange rate appreciation, and many capital control measures were aimed at closing loopholes left by the preceding ones. Our strategy relies both on the fact that it is not the depreciation of the previous few days that prompted the capital control measures (but rather a much longer process), and the fact that when capital controls were enacted, their perceived long-term effects should immediately be incorporated into the exchange rate (a forward-looking asset

[14] We did not include a dummy for the delayed implementation of URR on banks' gross FX position for the sake of conciseness (since it was not as disruptive on implementation as the tax on derivatives). If we include that dummy, it is not significant in any of the specifications considered.

price).[15,16] Finally, please note that endogeneity problems would bias our estimates toward zero (non-significance of the capital controls), similarly to the studies about the effectiveness of sterilized interventions on the exchange rate.

Table 2 reports the results from this regression. The first column excludes the intervention variable. The coefficient on the interest rate differential is not significant (which may strike as surprising, but is in line with previous studies on Brazil, e.g. Vervloet, 2010, and Kohlscheen, 2011). That differential has a significant effect for some specifications in that table, but the point estimate remains very small. The coefficient on the onshore dollar interest rate is not significant either, which may seem puzzling, but is consistent with the fact that periods where the onshore dollar rate was higher (for example, when controls temporarily succeeded in squeezing liquidity) were not accompanied by reduced appreciation pressures.[17] The coefficients on the local stock market, the VIX, and Asian currency index are not significant either (which may be partly due to the presence of many variables that are capturing global risk version and these variables are significant in alternative more parsimonious specifications). The results point to a statistically significant effect of commodity prices, the dollar index, and the Latin America (excluding Brazil) currency index. A one percent increase in commodity prices is associated with a 0.2 percent appreciation of the BRL, a one percent increase in the value of the dollar against advanced economy currencies is associated with a 0.6 depreciation of the real (which is not surprising given Brazil's diversified trade patterns), and a 1 percent appreciation in the Latin America (excluding Brazil) currency index is associated with a 0.4 percent appreciation in the BRL, suggesting strong co-movement with other Latin American currencies.[18] The magnitudes are plausible and in line with previous estimates, and the coefficients in these variables remain comparable across all specifications in Table 1. Since we are interested mainly on the effect of controls, we will not elaborate much on the effects of the variables discussed above.

Turning to the main variables of interest, the capital control/measures with a positive and significant result include the initial control, the tax on the notional amount of derivatives, and the taxation of external borrowing with less than 5 years, with point estimates of 1.2, 1.5, and 2.1 percent, respectively. At the bottom of the table we report the average effect for the thirteen dummies associated with the controls/restrictions adopted. That statistic has a point estimate of 0.34 percent, and is statistically significant. Taking this result at face value, and treating all the changes as permanent would point to a cumulative effect of the measures (that average multiplied by thirteen) of about 4.5 percent on the exchange rate. A similar result (up to the second decimal) is obtained when we consider a single dummy aggregating all the 13 dummies (i.e. a single variable equal to 1 on the 13 observations associated with the different measures, and zero elsewhere, which is reported at the bottom of the table). Note that this result is being driven by the last controls/restrictions, with the average effect associated with the first 9 measures being close to zero and not significant.

In Column 2 we add the central bank's sterilized FX intervention as an additional variable. The estimates suggest that interventions had no effect on the exchange rate, neither when the central bank purchased dollars nor when it sold them (there is one specification where the latter is barely significant). In principle, the capital controls could have increased the traction of FX interventions (since

[15] Fratzscher et al. (2014) make a similar point when analyzing ECB unconventional monetary policies. They argue that the decision to engage in policy actions does not depend on changes in daily conditions, but instead on the "broad" picture. In contrast, daily conditions can respond to a policy change that alters that broad picture, so the use of daily data alleviates the risk of issues related to reverse causality.

[16] We ran a probit model for the imposition of a measure using as explanatory variables the exchange rate and the other variables used in our exchange rate regressions. We considered specifications based on the level, and changes over different horizons (1, 5, 10 or 20 days). The fitted probabilities remain low, even around the actual dates when measures were imposed, suggesting that even if the market expected additional measures, it was very difficult to determine their timing, and that a large element of surprise was present following the measures considered.

[17] The point estimates are compatible with the interpretation that increased onshore dollar rate attracts more funds, thereby appreciating the currency. This result was also true before the controls (Vervloet, 2010).

[18] Please note that the high R-squared in this regression is driven by the co-movement with these contemporaneous asset prices (e.g. value of the dollar vis-à-vis other currencies and commodity prices). That is, despite the relatively high R-squared in this regression we cannot forecast the exchange rate with precision (since we cannot forecast the values of these other exchange rates/asset prices).

Table 2
Regression results for the change in the log of the exchange rate.

Variables	1	2	3	4	5	6
	OLS	OLS	IV	OLS	OLS	IV
Δ Spread CDI – LIBOR	–0.039	–0.041	–0.032	–0.172**	–0.176**	–0.161**
	[0.074]	[0.075]	[0.076]	[0.081]	[0.081]	[0.081]
Δ Onshore Dollar Rate (90d)	–0.056	–0.069	–0.006	–0.022	–0.046	0.026
	[0.075]	[0.070]	[0.109]	[0.077]	[0.072]	[0.113]
ΔLog(Ibovespa)	–0.032	–0.029	–0.042	–0.041	–0.037	–0.048
	[0.026]	[0.027]	[0.029]	[0.026]	[0.027]	[0.030]
ΔLog(Vix)	–0.002	–0.001	–0.005	–0.002	–0.002	–0.004
	[0.006]	[0.006]	[0.007]	[0.006]	[0.006]	[0.006]
ΔLog(CRB Commodity Index)	–0.200***	–0.196***	–0.213***	–0.198***	–0.197***	–0.198***
	[0.042]	[0.042]	[0.046]	[0.043]	[0.043]	[0.044]
ΔLog(Dollar Currency Index)	0.604***	0.596***	0.633***	0.622***	0.610***	0.646***
	[0.063]	[0.064]	[0.069]	[0.062]	[0.062]	[0.071]
Asian Currency Index	0.002	0.004	0.001	0.055	0.06	0.044
	[0.102]	[0.102]	[0.105]	[0.099]	[0.099]	[0.104]
Latin American Currency Index	0.391***	0.384***	0.415***	0.384***	0.376***	0.403***
	[0.094]	[0.091]	[0.104]	[0.098]	[0.094]	[0.103]
Lagged Level of Log(Exchange Rate)				–0.089***	–0.095***	–0.082***
				[0.018]	[0.018]	[0.023]
Lagged Levels of Exp. Variables Above				YES	YES	YES
Intervention (Purchase, Billion USD)		–0.024	0.048		–0.049	0.087
		[0.042]	[0.158]		[0.038]	[0.148]
Intervention (Sale, Billion USD)		0.239	–0.889		0.328*	–0.624
		[0.188]	[0.758]		[0.192]	[0.835]
Dummies for						
Initial Tax on Inflows	1.173*	1.198**	1.077*	1.077*	1.092*	1.053*
	[0.614]	[0.614]	[0.630]	[0.604]	[0.603]	[0.607]
Tax on DR Issuance	0.533	0.542	0.504	0.436	0.436	0.433
4% Tax on Fixed Income	0.484	0.477	0.511	0.478	0.468	0.503
6% Tax on Fixed Income	–0.025	–0.005	–0.098	–0.073	–0.054	–0.114
Tax on DR Cancellation	0.074	0.071	0.096	–0.225	–0.236	–0.206
URR on Bank's Gross FX Position	–0.216	–0.21	–0.233	–0.402	–0.41	–0.395
Tax on Foreign Borrowing up to 1 Year	–0.513	–0.501	–0.555	–0.436	–0.418	–0.473
Tax on Foreign Borrowing up to 2 Years	–0.97	–0.961	–1.004	–1.096*	–1.087*	–1.121*
Tightening of URR on Bank's Gross FX Position	0.153	0.18	0.061	0.18	0.186	0.164
Tax on Notional Amount of Derivatives	1.541**	1.543**	1.566**	1.509**	1.507**	1.521**
Impl. of Tax on Notional Amt. Deriv.	–0.163	–0.158	–0.185	–0.171	–0.149	–0.215
Tax on Foreign Borrowing up to 3 Years	0.142	0.16	0.097	0.076	0.087	0.05
Tax on Foreign Borrowing up to 5 Years	2.136***	2.147***	2.092***	2.256***	2.257***	2.253***
Removal of Tax on Equity Inflows	–0.781	–0.781	–0.785	–0.923	–0.891	–0.986
Surprise Rate Cut	0.871	0.861	0.902	0.549	0.531	0.574
Avg. Effect of 13 Capital Controls/Restrictions	0.335**	0.345**	0.302*	0.278*	0.283*	0.266
	[0.167]	[0.167]	[0.175]	[0.163]	[0.163]	[0.168]
Avg. Effect of First 9 Capital Controls/ Restrictions	0.077	0.088	0.04	–0.007	–0.003	–0.017
	[0.205]	[0.205]	[0.209]	[0.196]	[0.195]	[0.202]
R-squared	0.459	0.461	0.418	0.493	0.497	0.467
Common Dummy for 13 Capital Controls and Restrictions (Alternative Specification)	0.331*	0.341**	0.302*	0.274	0.279*	0.263
	[0.172]	[0.172]	[0.177]	[0.167]	[0.166]	[0.171]
Observations	680	680	679	680	680	679

Notes: Standard errors in brackets (Newey–West HAC standard errors, except for dummies). Sterilized Interventions instrumented with its first two lags, and the lagged 3-month option-implied volatility of the exchange rate in columns 3 and 6. Statistic reported at the bottom of the table for a common dummy corresponds to an alternative specification where the 13 capital control/restrictions are captured by a single dummy that takes the value of 1 on 13 observations. *, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

they further segment the domestic and foreign financial markets, strengthening portfolio effects). But lack of an effect is consistent with the fact that the real steadily appreciated despite frequent and sizable interventions (Fig. 5).[19] There were only 6 instances where the central bank intervened by selling dollars in our sample, which makes it difficult to identify an effect. Sterilized sales became much more common after March 2012 (as shown in Fig. 5).

Columns 4–6 are analogous to Columns 1–3 but also include the lagged level of the log of the exchange rate, interest rate spread, onshore dollar rate, VIX, commodity prices and dollar index as controls. This specification allows the exchange rate to revert to a long-run level that will depend on the levels of these other explanatory variables (an error correction model). The results are fairly comparable to those in Columns 1–3. The coefficient on the interest rate differential becomes significant, but its magnitude remains very small (a 1 percent increase would appreciate the real by only 0.15 percent on impact). The coefficients on the lagged levels of the independent variables are not reported for the sake of conciseness. The coefficient on the lagged level of the log exchange rate ranges from –0.08 to –0.10 (suggesting that in any given day, a one percent deviation from the long-run level is associated with a 0.08 to 0.10 percent correction towards that level, respectively). The results on the capital control dummies are fairly comparable across all specifications in the table. The average effect for the 13 dummies related to capital controls/restrictions ranges from 0.27 to 0.35, which would imply a combined effect, if changes were treated as permanent, of 3.5–4.5 percent, and is significant in all but one of the specifications (column 6). An F-test rejects the null hypothesis of a zero coefficient in all specifications. An alternative specification with a common variable covering the 13 measures (equal to one on those 13 event dates, and zero elsewhere) yields similar results.

Markets may take time to interpret the full implications of an announced measure. Therefore, we ran similar regressions to the ones in Table 4 but spanning longer time windows. Table 3 reports the results when the dependent variable is the change in the exchange rate from $t-1$ to $t+1$ and the dummies still take the value of one at t and zero elsewhere. For the sake of conciseness, we only report the coefficients for the variables of interest. Each column reports the result from a regression analogous to the one from the same column of Table 2 (except for the longer time window for the change in the dependent variable). The dummies for the initial 2 percent tax on portfolio inflows, tax on derivatives, and tax on foreign borrowing with less than 5 year maturity remain statistically significant with a positive sign, with point estimates of about 1.8, 1.4 and 2.4 percent, respectively. The dummy for the implementation of the tax on the notional amount of derivatives is now significant, with a point estimate of 2.8 percent (the highest point estimate of all the dummies). So is the dummy on the surprise rate cut, with a point estimate ranging from 2.4 percent. The dummies on the taxation of foreign debt up to one and up to two years point to a negative and statistically significant effect (with point estimates of –1.4 and –1.6 percent, respectively). The results are fairly comparable across the other specifications. At the bottom of the table we report the average effect of the 13 dummies related to capital controls/restrictions. The average point estimate is statistically significant across all specifications, ranging from 0.40 to 0.51.[20] However, the effect is being driven by the last controls/restrictions, with the average effect associated with the first 9 measures being close to zero (ranging from –0.18 to –0.01) and not significant in any of the specifications.[21]

[19] One possible explanation for why the central bank buying dollars does not affect the exchange rate involves the onshore dollar rate market. As explained before, and documented by Fig. 2, the onshore dollar rate in Brazil runs above the equivalent rate in the US. When the Brazilian Central Bank conducts sterilized purchases of foreign exchange, the onshore dollar rate increases and large banks start bringing short term funds borrowed abroad to profit from the higher interest rate differential, without incurring in currency risk. The increase in the supply of foreign exchange provided by this dollar-interest-rate arbitrage tends to mitigate the effect of the sterilized purchases on the exchange rate. However, the reverse effect does not occur. When the Central Bank conducts sterilized sales of foreign exchange, thereby incipiently lowering the onshore dollar rate, this does not entice banks to borrow dollars in Brazil and invest them abroad, since the onshore dollar rate is still superior to its counterpart abroad.

[20] The common dummy for the 13 measures yields similar results.

[21] Similarly, an F-test rejects the null hypothesis that the coefficients on the 13 dummies are zero, but fails to reject the hypothesis that the coefficients on the first 9 dummies are zero.

Table 3
Regression results for the change in the log of the exchange rate from 1 day before to 1 day after capital control/restriction measure.

Dummy for	1	2	3	4	5	6
	OLS	OLS	IV	OLS	OLS	IV
Initial Tax on Inflows	1.803**	1.811**	1.917**	1.730**	1.709**	1.789**
	[0.805]	[0.806]	[0.808]	[0.782]	[0.779]	[0.875]
Tax on DR Issuance	0.789	0.797	0.826	0.563	0.548	0.504
4% Tax on Fixed Income	0.447	0.438	0.446	0.592	0.564	0.521
6% Tax on Fixed Income	–0.126	–0.112	–0.113	–0.325	–0.315	–0.18
Tax on DR Cancellation	–0.276	–0.274	–0.361	–0.82	–0.84	–1.017
URR on Bank's Gross FX Position	0.312	0.311	0.323	–0.049	–0.078	–0.11
Tax on Foreign Borrowing up to 1 Year	–1.355*	–1.351*	–1.366*	–1.243	–1.247	–1.163
Tax on Foreign Borrowing up to 2 Years	–1.568*	–1.561*	–1.507*	–1.722**	–1.710**	–1.459*
Tightening of URR on Bank's Gross FX Position	–0.303	–0.278	–0.244	–0.282	–0.29	–0.153
Tax on Notional Amount of Derivatives	1.413*	1.391*	1.099	1.443*	1.404*	0.745
Implementation of Tax on Notional Amt. Deriv.	2.734***	2.749***	2.789***	2.766***	2.822***	3.180***
Tax on Foreign Borrowing up to 3 Years	0.394	0.409	0.329	0.159	0.175	0.124
Tax on Foreign Borrowing up to 5 Years	2.359***	2.360***	2.423***	2.469***	2.427***	2.435***
Removal of Tax on Equity Inflows	–0.154	–0.168	–0.1	–0.292	–0.275	–0.128
Surprise Rate Cut	2.371***	2.366***	2.409***	1.924**	1.911**	1.972**
Avg. Effect of 13 Dummies for Capital Controls/Restrictions	0.51**	0.514**	0.505**	0.406*	0.398*	0.401*
	[0.224]	[0.224]	[0.224]	[0.217]	[0.216]	[0.243]
Avg. Effect of First 9 Capita Controls/Restrictions	–0.031	–0.025	–0.009	–0.173	–0.184	–0.141
	[0.269]	[0.269]	[0.27]	[0.26]	[0.259]	[0.293]
Common Dummy for 13 Capital Controls and Restrictions (Alternative Specification)	0.507**	0.512**	0.506**	0.405*	0.397	0.398
	[0.228]	[0.228]	[0.229]	[0.221]	[0.363]	[0.249]

Notes: Each column corresponds to the analogous regression from Table 2. For conciseness, the table reports only the coefficients on the dummy variables. The dependent variable is the two-day change in the exchange rate. Dummies equal to one on the day after measure announced (measures announced after market close on previous day). Coefficient on dummy corresponds to change in the exchange rate from $t-1$ to $t+1$ that can be attributed to measure at time t. Observations where the time window includes a capital control/restriction are dropped from the estimation except when the measure takes place t (unless that results in dropping one of the dummy variables). Intervention variables computed over corresponding two-day periods. Standard errors are in brackets. *, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

Table 4 is analogous to Table 3, but reports the results for the change in the exchange rate from $t-2$ to $t+2$ with dummies that take the value of one at t. This specification provides one extra trading day for the measures to impact the exchange rate. And the base for comparison is the exchange rate at $t-2$, which can also address concerns that the announcement of some measures may have been anticipated at $t-1$. But as discussed previously, the standard errors increase with the horizon considered, which makes it more difficult for a one-off change of a given size to be statistically significant. The dummy for the initial 2 percent tax on portfolio flows remains significant in columns 1–3, with a point estimate that ranges from 2 to 2.2 percent. Only the dummies for the implementation of the tax on derivatives, and for the taxation of foreign borrowing with less than 5 year maturity remain significant across all specifications, with point estimates of 2.1 to 3.0 and 2.2 to 2.5, which are comparable to the ones in the previous table. The dummy on the surprise rate cut remains significant in all specifications, with a point estimate ranging from 2.7 to 3.6. When we compute the average effect for the 13 dummies related to capital controls/restrictions, the point estimate ranges from 0.57 to 0.77. If we take this point estimate at face-value and multiply it by thirteen (treating all the changes as permanent), the combined effect is 7.5 to 10 percent. But again, much of the effect is coming from the very last measures, with the average effect from the first 9 restrictions ranging from 0.12 to 0.43, and is not statistically significant. Extending the horizon from $t-2$ to $t+5$ yield qualitatively similar results (no effect from first several measures but large effect from last measures) with an even larger quantitative effect (a combined effect of about 15 percent).

Table 4
Regression results for the change in the log of the exchange rate from 2 days before to 2 days after capital control/restriction measure.

Dummy for	1	2	3	4	5	6
	OLS	OLS	IV	OLS	OLS	IV
Initial Tax on Inflows	1.996*	2.009*	2.227**	1.318	1.282	1.273
	[1.043]	[1.045]	[1.084]	[0.968]	[0.968]	[1.095]
Tax on DR Issuance	1.063	1.065	1.226	0.683	0.666	0.695
4% Tax on Fixed Income	0.203	0.2	0.201	0.192	0.181	0.194
6% Tax on Fixed Income	1.18	1.163	1.284	0.876	0.872	1.07
Tax on DR Cancellation	0.134	0.129	–0.108	–0.462	–0.488	–0.751
URR on Bank's Gross FX Position	1.296	1.293	1.345	0.596	0.57	0.651
Tax on Foreign Borrowing up to 1 Year	–1.305	–1.346	–1.963*	–1.021	–0.946	–1.299
Tax on Foreign Borrowing up to 2 Years	–1.315	–1.325	–1.137	–1.369	–1.375	–1.026
Tightening of URR on Bank's Gross FX Position	0.574	0.563	0.439	0.635	0.608	0.279
Tax on Notional Amount of Derivatives	0.582	0.558	0.168	0.709	0.739	0.211
Implementation of Tax on Notional Amt. Deriv.	2.099**	2.098**	2.185**	2.550***	2.586***	3.048***
Tax on Foreign Borrowing up to 3 Years	1.327	1.314	1.221	0.646	0.642	0.596
Tax on Foreign Borrowing up to 5 Years	2.161**	2.158**	2.158**	2.396**	2.374**	2.475**
Removal of Tax on Equity Inflows	–0.181	–0.169	–0.026	–0.148	–0.125	0.306
Surprise Rate Cut	3.609***	3.609***	3.645***	2.641***	2.652***	2.971***
Avg. Effect of 13 Dummies for Capital	0.769***	0.76***	0.711**	0.596**	0.593**	0.57*
Controls/Restrictions	[0.291]	[0.291]	[0.302]	[0.269]	[0.269]	[0.304]
Avg. Effect of First 9 Capital	0.425	0.417	0.39	0.161	0.152	0.121
Controls/Restrictions	[0.349]	[0.35]	[0.362]	[0.324]	[0.324]	[0.366]
Common Dummy for 13 Capital Controls and	0.768***	0.762***	0.718**	0.598**	0.595**	0.573*
Restrictions (Alternative Specification)	[0.291]	[0.292]	[0.307]	[0.27]	[0.27]	[0.309]

Notes: This table is analogous to Table 3 (please refer to notes in that table), except that the dependent variable is the four-day change in the exchange rate. Dummies equal to one on the day after measure announced (measures announced after market close on previous day). Coefficient on dummy corresponds to change in the exchange rate from $t-2$ to $t+2$ that can be attributed to measure at time t. Standard errors in brackets. *, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

Since our methodology is similar to an event study analysis, we were encouraged by a referee, to whom we thank, to implement such exercises for robustness. We estimate the regression in column 1 of Table 4 using data from the beginning of our sample up to 20 days prior to the first capital control dummy. We then compute the change in the log of the exchange rate beyond what would have been implied by that fitted model (analogous to the Cumulative Abnormal Returns in a standard finance event study) and the corresponding error bands around that estimate.

We consider a ±10 day window around each of the measures. Since some of the measures took place in close proximity to others, they are grouped into 8 events: (i) Initial Tax on Portfolio Flows; (ii) Taxation of issuance of DRs; (iii) Increase in Portfolio Debt Inflow Tax to 4%; then to 6%; (iv) Tax on Cancellation of DRs; URR on Gross FX Position; (v) Tax on External Borrowing with Less than 1 Year; Less than 2 Years; (vi) Tighter URR on Gross FX Position; Announcement Tax on Derivatives; (vii) Surprise Rate Cut; Implementation of Tax on Derivatives; and (viii) Tax on External Borrowing with Less than 3 Years; Less than 5 Years. Fig. 6 plots the results. Whenever two measures are grouped together, we use a window that ranges from 10 days prior to the first measure to 10 days after the second measure (so if a window ranges from –10 to 18, that is because a second measure was implemented at t = 8).

This analysis corroborates the results found in Tables 2–4: Little response from the first several measures and large and statistically significant depreciations following the last measures. The event based on the surprise rate cut and implementation of the tax on derivatives points to a cumulative depreciation that peaks at a level above 10 percent before declining to around 7.5 percent. The event based on the extension of the tax on external borrowing to 3 and 5 years points to a cumulative depreciation of about 5 percent. Among the earlier events, two of them were close to being significant at the 5 percent level: the increase in the portfolio debt inflow tax to 4% and then to 6%; and the tax on

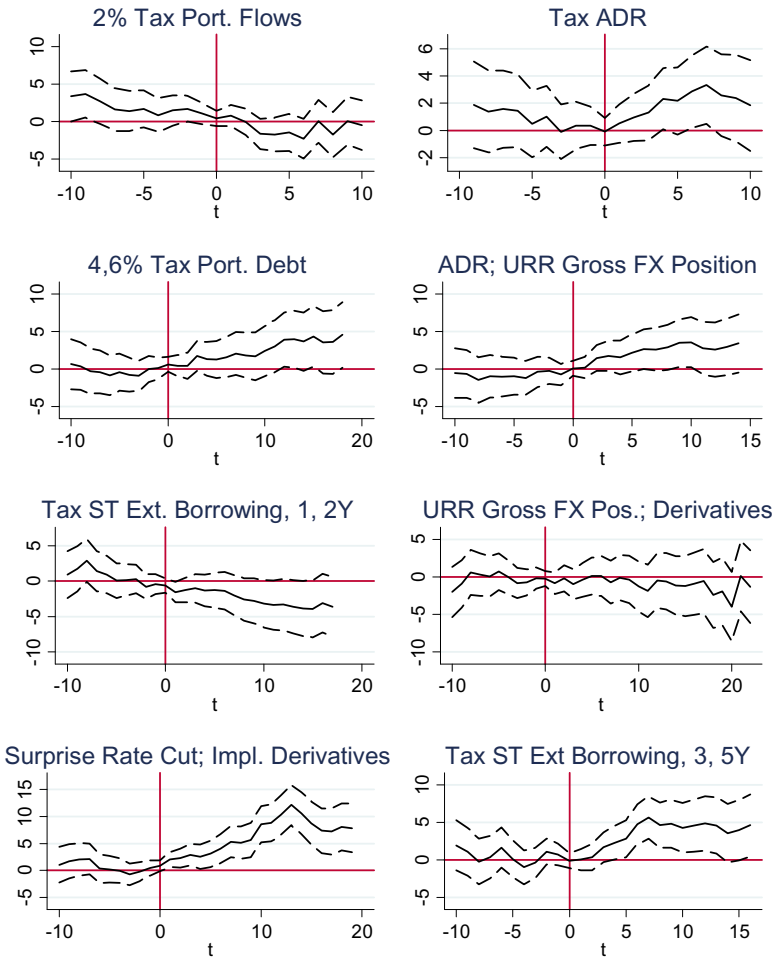

Fig. 6. Cumulative Changes in the Exchange Rate Around Capital Control/Restriction Dates. Notes: Effects based on the regression (1) in Table 4, using a sample that includes observations up to 20 days prior to the first event. Dashed lines correspond to ±2 Standard Deviations. Cumulative changes start at 0 for both before and after period.

cancellation of DRs followed by the URR on the gross FX position. Both had point estimates implying a cumulative depreciation of around 5 percent.

Caution should be used when reading results that are far from the original event date. For example, it may be easier to justify why the market should take a while to digest some earnings news from a firm (as in the standard finance event study) than it is to justify a similar delay in digesting news about the exchange rate. This is one reason why we are cautious in the interpretation of the longer event windows, and our preferred estimates are those based on the change in the exchange rate up to two days following the measures (Table 4), which point to a cumulative depreciation of 7.5–10 percent.

To summarize, the results above do suggest that on average the controls had some success in depreciating the real. But the effect seems to be driven mainly by the last three measures adopted. It is difficult to disentangle whether those measures were particularly effective, or whether it was the accumulation of those measures with the previous ones that made them particularly effective (for example,

if they succeeded in closing the remaining avenues with which to bypass the controls).[22] The change in monetary policy stance at the end of August 2011 has probably interacted with the capital controls that took place afterwards. However, since our results are based on a snapshot around those dates (depreciation tends to be strongest around the capital control events), we cannot determine the particular channels and policy interactions through which the controls impacted the exchange rate.

The regressions above consider the behavior of the exchange rate over relatively short windows. It is difficult to ascertain how much of those changes are temporary and how much proved persistent. Some of our regressions treated the effect of the controls as permanent, while others allowed the exchange rate to revert back to its mean (or more precisely, to the level implied by the levels of the other explanatory variables). But one should be careful when using such features of the specifications to ascertain dynamic behavior, since the models are fitted to explain the relatively short-term changes in the exchange rate. As an alternative approach, Fig. 7 plots the actual exchange rate as well as the fitted exchange rate implied by a regression of the log of the exchange rate on the log of the explanatory variables (excluding capital control/measure dummies and sterilized interventions). This regression is equivalent to the co-integration relationship estimated in an error-correction model, and is estimated in different sub-samples, so we can compare the out-of-sample results with the actual exchange rate. There is a vast literature beginning with Meese and Rogoff (1983), recently reviewed in Engel (2013) that shows how difficult it is to forecast exchange rates. But the goal of this exercise is not to forecast exchange rates. Instead it is just to gauge whether the sustained depreciation of the real in 2012 can potentially be explained by the evolution of these explanatory variables. As expected, the fitted values closely track the exchange rate in-sample, but diverge from actual values out-of-sample. We present results when the estimation sample ends in December 30, 2010, (last tightening of controls on portfolio flows), in July 26, 2011, (tax on the notional amount of derivatives), and March 15, 2012, (beginning of easing of restrictions). In all cases, the fitted values are only systematically below the actual exchange rate beginning around the time of the surprise interest rate cut and start of the monetary policy easing cycle. This divergence becomes more pronounced in the period after March 2012, when the easing of restrictions begins, with the fitted values hovering at a level 5 to 10 percent more appreciated than the actual exchange rate.

A comparison of the Brazilian real with other emerging market and commodity currencies also suggests a break towards the end of 2011, which becomes even more pronounced in 2012. A chart available in Appendix S1 plots the evolution of the Australian dollar, Chilean and Colombian pesos, South African rand, and Turkish lira during 2009–12. The real seems to closely track the South African rand and the Chilean and Colombian pesos during much of this period. But beginning in July 2011 (around the time of the tax on derivatives), the real tends to depreciate substantially vis-à-vis the Chilean and Colombian pesos. It eventually stabilizes at a much more depreciated level, along with the South African rand and Turkish lira (whose depreciation trends started earlier, around mid-2011 and late-2010, respectively).

The different strands of evidence seem to point to an effect of controls on the order of 4–10 percent, but concentrated towards the last restrictions adopted. Cuts to the policy rate also contributed to a weaker currency, and the effect may have been boosted by previous controls. For example, it is possible that a 6 percent tax failed to deter inflows in an environment where the policy rate was 12.5 percent, but that same tax proved more of a deterrent in a lower interest rate environment (the policy rate was cut by 525 bps over the easing cycle that begin with the October 2011 surprise cut). When estimating the effect of a given measure on the exchange rate, our dummy variable captured a snapshot at that particular time. But it is possible that the very same measure may complement follow-up measures down the road. For example, expanding the restrictions on borrowing abroad may have

[22] Please note that it is unlikely that endogeneity concerns could drive this pattern. For that to be the case, we would need the Brazilian authorities reaction function to have changed in late 2011, from setting the controls based on the previous few days appreciation (thereby explaining why the first estimates were not significant), to another, unrelated to the previous days exchange rate movements (which would make it easier to find a statistically significant effect for these measures). This change of behavior seems farfetched and is at odds with the official statements that capital control measures would be pursued until appreciation was reverted, as eventually happened.

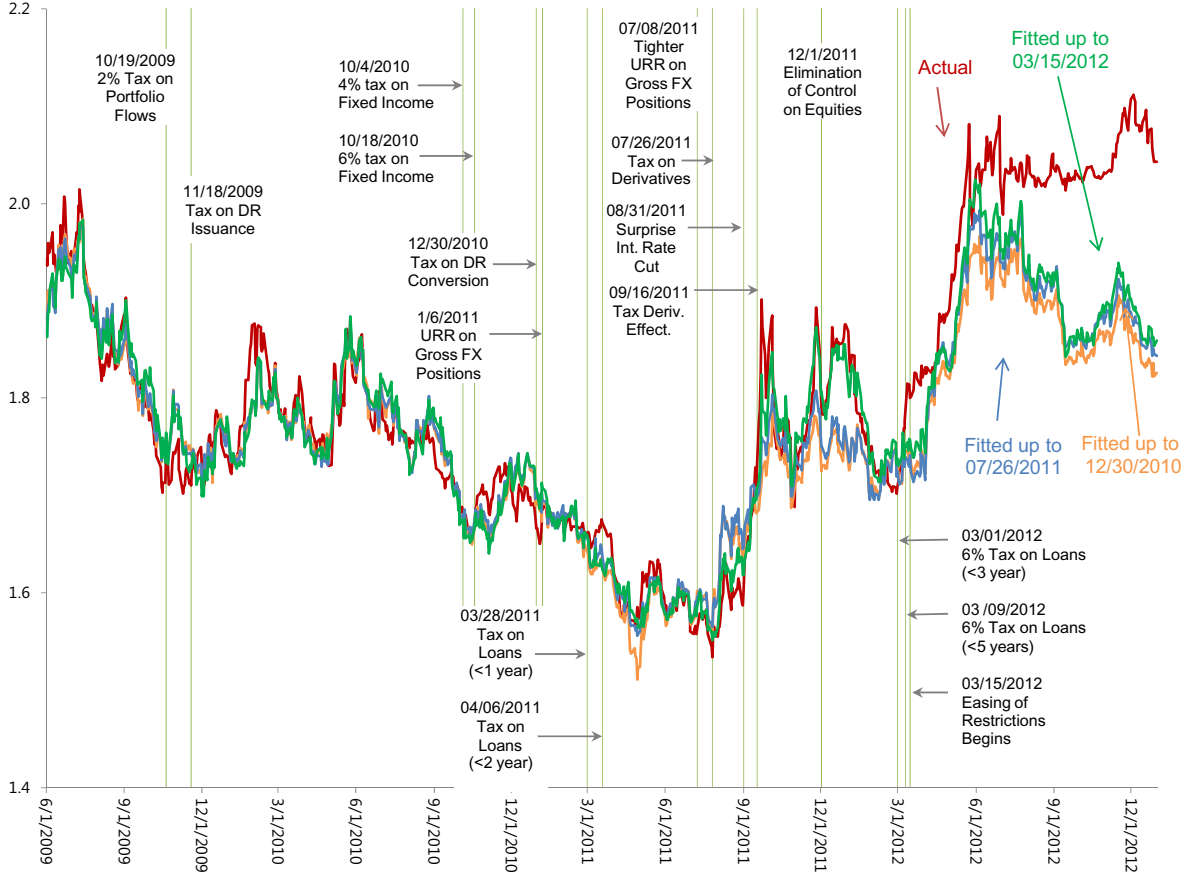

Fig. 7. Real–Dollar Exchange Rate and Counterfactual from Regressions. Notes: Red line corresponds to the actual real–dollar exchange rate (an increase denotes a depreciation of the real); Remaining lines plot the results of a regression of the log of the exchange rate on the log of the interest rate differential, onshore dollar rate, local stock market, commodity prices, dollar currency index and VIX. Orange line is based on a regression sample up to the last tightening of controls on portfolio inflows (Tax on DR Conversion on 12/30/2010); Blue line on a regression up to the announcement of the tax on the notional amount of derivatives (07/26/2011); Green line on a regression up to the end of our sample (when the restrictions begin to be eased on 03/15/2012).

had a more limited impact in the absence of taxes on portfolio inflows. And the effect of measures may have been boosted in an environment with a lower policy rate.[23]

Another institutional detail that must be borne in mind is that price discovery in Brazilian FX markets occur in the futures market, at the first-to-mature contract (Garcia et al., 2014). That is, the exchange rate is formed in the trades of the first-to-mature futures dollar contract at the BM&FBovespa. Those markets are also fairly segmented from world markets because the Brazilian real is a non-convertible currency, meaning that it cannot be traded outside Brazil, unlike, say, the Mexican Peso. This may have contributed to the effectiveness of the derivative tax in depreciating the exchange rate.

The focus of our analysis has been the effect of the controls/restrictions on the exchange rate. But they also had an effect through prudential considerations. For example, there has been a dramatic reduction in short-term external borrowing following the imposition of the 6 percent tax (as shown in Fig. 3). In March 2011 short-term (less than one year) external borrowing amounted to US$ 6.5 billion. In April 2011, following the tax on short-term borrowing, that flow drops to only US$ 26 million. This maturity lengthening may have improved the country's resilience against external shocks.

A full-fledged assessment of the welfare implications of the controls would have to include the costs associated with them. The controls did imply an increase in the cost of funding for Brazilian firms. The amount they were able to raise through equity financing was affected by the 2 percent tax foreigners had to pay to buy that equity. In the case of debt financing, the taxes could be avoided by borrowing abroad long-term. Given how flat the (dollar) yield curve was, borrowing long-term may have been a relatively small cost (which may well pay-off if the crisis were to deepen and global credit markets were to dry). Small firms could not tap foreign markets directly, and their cost of funding may have been more affected by the controls. The taxes on derivative trades were fine-tuned so as to avoid incidence in the case of bona fide hedging by exporters (although taxing "speculators" can still hurt those firms by affecting the liquidity of those markets, as it seems to have happened since liquidity fell substantially). Some market analysts have attributed Brazil's weak growth performance to a self-inflicted "sudden stop" (Volpon, 2013) originating from the combination of economic policy deterioration and capital controls.

4. Conclusion

Controls on capital inflows have gained renewed interest in the last years. Brazil provided the most cited example, both because of its size among emerging markets and because of its active experimentation with many different forms of controls on capital inflows. Our results indicate that the controls were effective in making the domestic assets more expensive, partially segmenting the Brazilian financial market from the international market. The first several measures (from late 2009 to mid-2011) had very limited success in containing the appreciation of the real. But the exchange rate seems to respond strongly in the aftermath of the last restrictions adopted, with several different specifications pointing to a depreciation effect in the range of four to ten percent. It is unlikely that those last measures would have been so effective if taken in isolation. Instead, this strong response may reflect a combined effect, whereby these measures complemented previous ones, closing the main remaining channels to bypass the initial tax on inflows. The response of the exchange rate was also supported by the beginning of a monetary policy easing cycle.

Given the weak state of the global economy together with the diminished interest that foreign investors have been devoting to Brazil recently, capital inflows have waned and most of the controls have been undone. Controls may have helped Brazil to avoid a bubble and perhaps worse.[24] However, given the very low domestic saving rate of the Brazilian economy (16%), constraining access to foreign financing may have contributed to the low investment and growth performance during that period. Overall, the results suggest that capital controls can be effective, but only if they are very comprehensive. One should also bear in mind that the Brazilian real is not a convertible currency, which may

[23] We test for breaks in the coefficients on the interest rate differential and FX intervention following different capital controls/restrictions, but do not find evidence of a significant break.

[24] Even with the controls, the private credit to GDP ratio rose from 44 to 54% from end-2009 to end-2012.

contribute to the effectiveness of capital controls.[25] These characteristics may also explain why the estimated effect is much stronger than the results typically found in the capital control literature. While more comprehensive controls in a non-convertibility environment can be more effective, they may also increase the associated costs, which is a key subject for further research.

Appendix. Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.jimonfin.2015.08.008.

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[25] The configuration of the Brazilian FX markets may have helped: the Brazilian real is a non-convertible currency and the (exchange rate) price discovery occurs at the futures market.