Essays in Open Economy Monetary Policy

by

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Abstract

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International economic integration has risen during the last decades and the interdependence between each economy and the rest of the world has become central for policy decisions. My dissertation contributes to the debate about the conduct of monetary policy in a financially integrated world.

In the first chapter of the dissertation I discuss the relationship between domestic policies and the currency denomination of foreign debt. Foreign debt is a double-edged sword. It allows countries to invest more than what would be possible given their own savings, thereby achieving preferable allocations that would not otherwise be feasible. However, it is the root of several crises. Foreign debt is especially hazardous when denominated in foreign currency; in such cases exchange rate depreciations increase the real value of the debt. An important question then is what determines the currency denomination of foreign debt. I use the adoption of Inflation Targeting (IT) in several economies during the last two decades to evaluate the importance of domestic policies in the determination of the currency denomination of debt. In order to control for possible endogeneity in IT adoption, I use matching and instrumental variables estimators; both generate similar estimates. The results show that monetary policy can have substantial effects on the amount of debt in foreign currency and that a more flexible exchange rate regime increases the use of domestic currency in foreign borrowing.

In the second chapter of the dissertation I investigate the relationship between central banks balance sheets and monetary policy. Heavy foreign exchange intervention by central banks of emerging markets have led to sizeable expansions of their balance sheets in recent years - accumulating foreign assets and non-money domestic liabilities (the latter due to sterilization operations). With domestic liabilities being mostly of short-term maturity and denominated in local currency, movements in domestic monetary policy interest rates can have sizable effects on central bank's net worth. In this chapter I examine empirically whether balance sheets considerations influence the conduct of monetary policy. The methodology involves the estimation of interest rate rules for a sample of 41 countries and testing whether deviations from the rule can be explained by a measure of central bank financial strength. My findings, using linear and nonlinear techniques, suggest that central bank financial strength can be a statistically significant factor explaining large negative interest rate deviations from "optimal" levels.

In the third chapter I investigate whether countries that adopted the IT framework for monetary policy have been constrained by exchange rate consideration when taking policy decisions. I present stylized facts which suggest that exchange rates have been

allowed to float relatively free in IT countries. I employ Bayesian Analysis techniques to estimate a Dynamic Stochastic General Equilibrium (DSGE) structural model for twenty two IT economies and compute posterior odds tests to check whether the central banks systematically respond to exchange rate movements. The main result is that only five central banks directly respond to exchange rate movements; all the other IT central banks do not respond to the exchange rate. I also confirm that IT central banks have been conducting strictly inflationary policies, raising real interest rates in response to increases in inflation.

Dedication

To my Parents, Marcelo, Maiura, Alison, and Juliana.

Acknowledgments

Introduction *

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In the first chapter I discus the relationship between domestic policies and the currency denomination of foreign debt. Foreign debt is a double-edged sword. It allows countries to invest more than what would be possible given their own savings, thereby achieving preferable allocations that would not otherwise be feasible. However, it is the root of several crises, like the Latin America sovereign debt crises of the 1980s, the Mexican, Russian and Asian crises of the 1990s, and the current crisis in advanced economies, particularly in Europe.

The main distinguishing mark of foreign debt is the fact that borrowers and lenders measure their returns in different currencies, making their real returns move in opposite directions when the exchange rate changes. Devaluations of the exchange rate increase the debt overhang for borrowers when it is denominated in foreign currency, demanding large sacrifices in order to repay the debt.

The fact that most countries do not use their own currency when borrowing abroad has led to a growing literature on the determinants of the currency denomination of foreign debt. However, there is no consensus about the role played by domestic policies and, in particular, by monetary and exchange rate policies, on the pattern of foreign borrowing. The first chapter of my dissertation contributes to this literature in two ways. First, I show that domestic policies can influence the currency denomination of foreign debt. I show this using the adoption of the Inflation Targeting (IT) framework in several countries during the past decade. Using a semi-parametric matching technique, I am able to show how this major change in the conduct of monetary policy has affected the currency denomination of foreign debt. Second, I show that the adoption of IT changed the pattern of foreign borrowing due to the increase in exchange flexibility. In particular, countries that adopted IT and allowed their exchange rates to fluctuate more have been able to use their domestic currency for foreign borrowing to a greater extent.

In the second chapter I discuss the relationship between central banks balance sheets and monetary policy. Over the past decade, efforts to manage large capital inflows by many central banks in emerging market (EM) countries have led to a major shift

in the composition and size of their balance sheets. Significant foreign exchange (FX) intervention has been accompanied by large expansions of their net foreign assets as well as domestic (interest-bearing) liabilities - with the latter reflecting large sterilization operations aimed at containing the monetary effects of FX interventions. As a result, currency mismatches in their balance sheets have widened. In parallel, central banks have witnessed a secular decline in their capital - interrupted only temporarily by the effect of the sharp depreciations triggered by the 2008 global financial crises. Such dynamics are particularly evident in emerging Asia, especially when the components of balance sheets are measured relative to the country's GDP. A breakdown between inflation targeting (IT) and non-inflation targeting regimes also reveals that capital losses have been particularly pronounced in the first group, as lower tolerance for inflation led to reduced seigniorage and revaluation losses from currency appreciation.

This transformation in central bank balance sheets (CBBS) has increased the sensitivity of capital to domestic interest rate movements. Indeed, the accumulation of foreign currency instruments on the asset side, along with short-term, local currency-denominated securities on the liability side increases the impact of movements in short-term domestic interest rates (i.e. monetary policy rates) on central banks' capital. This effects operates through two distinct channels: by affecting the amount of interest payments on liabilities - while having no effect on the asset (revenue) side - and via exchange rate movements that derive in capital losses. The magnitude of this potential effect on central banks' capital has grown over time, as balance sheets have expanded while capital shrunk.

This background brings to the forefront of the policy debate the issue of whether central bank's financial strength (CBFS) may affect the conduct of monetary policy. In general, whether a low degree of capital and/or high sensitivity to interest rate movements affects monetary policy decisions remains a relatively unexplored question in the theoretical and empirical macroeconomic literature. In fact, there are (un-tested) opposing views. Some argue that CBBS are irrelevant as central banks have the ability to print money money to recapitalize themselves through seigniorage, or because ultimately what matters are the institutional arrangements in place (i.e., recapitalization agreements with the Treasury) and the consolidated fiscal position (i.e., fiscal ability to recapitalize the central bank). By contrast, others argue that political economy reasons are enough for central banks to care about the health of their balance sheets, as financial weakness may trigger greater oversight and reduce independence, leading central banks to pursue sub-optimal policies in order to minimize the risk of losing independence.

In this chapter I assess empirically whether CBFS constraints monetary policy decisions. Although previous studies have explored the nexus between CBBS and macroeconomic outcomes, such as inflation, this constitutes the first attempt to study empirically and quantify the extent to which CBFS interferes with monetary policy decisions per se. I find evidence that a weak central bank balance sheet can influence the conduct of monetary policy. Quite importantly, the relationship between central bank balance sheets and monetary policy is highly non-linear-i.e., large deviations from optimal policy are associated with very weak balance sheets.

In the third chapter I investigate whether countries that adopted the IT framework for monetary policy have been constrained by exchange rate consideration when taking policy decisions. Despite being a relatively new approach to monetary policy the IT framework

is now fully implemented in twenty seven countries around the world. The framework is known for the public announcement of numerical values of an inflation target and the subordination of all other policy objectives to its achievement. The empirical evidence regarding its success is often positive and there is no evidence that it was harmful for its adopters. Also, its durability and the fact that it has been expanding without any coordination led some to emphasize its relevance in shaping a new international monetary system.

This chapter aims to understand the role of the exchange rate in the IT regimes. IT requires nominal exchange rate flexibility; in an economy with unrestricted capital flows, if the monetary policy is focused on domestic conditions the nominal exchange rate must be allowed to fluctuate. Despite this seemly simple requirement, discussions about the appropriate level and flexibility of the exchange rate are still central in the policy debate of IT economies and economists often disagree on the degree to which IT central banks actually respond to exchange rate movements. This chapter contributes to this debate in two ways. First, I present several stylized facts showing that exchange rates have been floating relatively free in IT economies; whether I compare the exchange rates of IT economies with those of non-IT ones or with their own exchange rates before the adoption of the framework the result is always that the adoption of IT is associated with greater exchange rate flexibility. I also show that interest rates in IT economies have showed lower variability than in non-IT ones. Second, I estimate a structural model and pay special attention to policy responses to exchange rate movements. I find that most IT central banks do not directly respond to exchange rate movements, and confirm the fact that they have been conducting strictly anti-inflationary policies as assigned by the Taylor Principle.

Chapter 01
What is the Role of Monetary and Exchange Rate Regimes for the Currency Denomination of Foreign Debt? *

Abstract

Foreign debt is a double-edged sword. It allows countries to invest more than what would be possible given their own savings, thereby achieving preferable allocations that would not otherwise be feasible. However, it is the root of several crises. Foreign debt is especially hazardous when denominated in foreign currency; in such cases exchange rate depreciations increase the real value of the debt. An important question then is what determines the currency denomination of foreign debt. I use the adoption of Inflation Targeting (IT) in several economies during the last two decades to evaluate the importance of domestic policies in the determination of the currency denomination of debt. In order to control for possible endogeneity in IT adoption, I use matching and instrumental variables estimators; both generate similar estimates. The results show that monetary policy can have substantial effects on the amount of debt in foreign currency and that a more flexible exchange rate regime increases the use of domestic currency in foreign borrowing.

1 Introduction

Foreign debt is a double-edged sword. It allows countries to invest more than what would be possible given their own savings, thereby achieving preferable allocations that would not otherwise be feasible. However, it is the root of several crises, like the Latin America sovereign debt crises of the 1980s, the Mexican, Russian and Asian crises of the 1990s, and the current crisis in advanced economies, particularly in Europe.

The main distinguishing mark of foreign debt is the fact that borrowers and lenders measure their returns in different currencies, making their real returns move in opposite directions when the exchange rate changes.[1] Devaluations of the exchange rate increase the debt overhang for borrowers when it is denominated in foreign currency, demanding large sacrifices in order to repay the debt.

The fact that most countries do not use their own currency when borrowing abroad has led to a growing literature on the determinants of the currency denomination of foreign debt. However, there is no consensus about the role played by domestic policies and, in particular, by monetary and exchange rate policies, on the pattern of foreign borrowing. This paper contributes to this literature in two ways. First, I show that domestic policies can influence the currency denomination of foreign debt. I show this using the adoption of the Inflation Targeting (IT) framework in several countries during the past decade. Using a semi-parametric matching technique, I am able to show that countries that implemented the IT framework increased the share of foreign debt denominated in domestic currency. Second, I show that the adoption of IT changed the pattern of foreign borrowing due to the increase in exchange flexibility. In particular, countries that adopted IT and allowed their exchange rates to fluctuate more have been able to use their domestic currency for foreign borrowing to a greater extent.

The present paper adds to the existing literature on the subject by showing that a particular development in domestic policy, the adoption of IT, caused an expansion of domestic currency use in foreign borrowing. The main advantage is that the IT regime adopted in different countries share similar characteristics, allowing me to explore differences in foreign borrowing patterns in a cross section of countries to identify its effect.

The literature on the currency denomination of foreign debt has proposed a variety of explanations for the fact that most countries borrow abroad largely in foreign currency, despite the risks of doing so. A seminal paper in this literature is Eichengreen and Hausmann (1999), which proposes that the structure of international financial markets favors the issuers of a few dominant currencies, leaving other countries with no option but to use a currency that is not theirs when they borrow abroad. This became known as the "original sin" hypothesis; one of its main implications is that borrowing conditions are exogenous to domestic policies, being determined by the structure of international financial markets. They suggest that, given that financial markets are characterized by the "original sin," developing economies are fragile and debt prone because their favorable economic prospects and open capital accounts tend to make them attractive to international investors.

The literature offers alternative explanations for the predominant use of foreign currency when borrowing abroad. One of them, which has appeared mostly in the form of

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[1]The current crisis in Europe is an exception to this since countries borrowed heavily in euro, which is the common currency of borrowers and most lenders

theoretical models, claims that borrowers do not have incentives to borrow in domestic currency. Jeanne (2002) shows that lack of monetary policy credibility and the expectation of exchange rate devaluations cause interest rates on loans denominated in domestic currency to be much higher than on those denominated in foreign currency. Borrowers then prefer to borrow in foreign currency and default in bad times rather than borrow in domestic currency and default in good times. Other papers propose that the willingness of government to prevent large exchange rate movements creates a moral hazard problem, causing borrowers to underestimate the risks involved in foreign currency borrowing.[2]

A third view focuses on the absence of institutions that enforce debt repayment or that guard against policies, such as inflation or exchange rate depreciation, that benefit domestic borrowers at the expense of foreign lenders. Recently the concept of "debt intolerance" was proposed to describe situations where countries face very unfavorable debt conditions, such as being able to borrow only short term and in foreign currency. In such circumstances the risk premium rises at low levels of debt, levels that lenders would consider sustainable for other countries. Reinhart et al. (2003) suggest that countries' historical records of default and debt repudiation, implicit or explicit, creates a vicious cycle where the countries are forced to borrow on less favorable terms, eventually making them more likely to default again.

This paper also contributes to the literature on IT regimes. I show that IT countries have been able to borrow more in domestic currency and that those with a more flexible exchange rate benefited more from the adoption of IT. This is an important result, particularly for emerging markets, which have a history of recurrent foreign currency debt crises and need foreign savings to sustain economic growth.

Inflation Targeting (IT) changed the international financial system. The twenty seven developed and developing countries currently following IT are generally characterized by relatively open financial accounts, floating exchange rate regimes and monetary policy focused on domestic objectives.[3]

The adoption of IT by emerging markets spurred a debate about whether these economies met the conditions necessary to successfully implement the framework. While adoption of IT tended to be gradual in advanced economies, its adoption in emerging markets often happened after crises that forced the abandonment of currency pegs.[4][5] Large imbalances in the government budgets, possibly leading to "fiscal dominance," and balance sheet currency mismatches, which exacerbated the negative effects of exchange rate fluctuations, required that the public and private sectors adapt to the new conditions under IT. Though critics claimed that emerging markets needed to solve their external and internal imbalances before having an independent monetary policy and a floating exchange rate, the IT experience has been notably durable. No country was forced out of the system, and the performance of emerging markets after the 2008 crisis show that they have been more resilient to external shocks. I show that IT had an important effect on the proportion of domestic currency denominated debt in foreign borrowing as well.

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[2]The moral hazard problem is also related to the existence of implicit guarantees from the government or other countries. See, for example, Obstfeld (1998) and Mishkin (1996).

[3]See Rose (2007) for the role of IT in shaping the international monetary system.

[4]An exception is the United Kingdom, which adopted IT after the 1992 crisis, and Sweden, which adopted IT in 1995 after a financial crisis in the early 1990's.

[5]This was the case for most emerging markets that adopted IT between 1998 and 2001.

In particular, the share of such debt increased most when the exchange rate was given greater leeway to fluctuate.

A concern about IT is that focusing monetary policy on domestic objectives might lead to excessive exchange rate volatility. From the perspective of an optimal response to deviations from the inflation target it is not clear whether an IT central bank should respond to the exchange rate or not; the literature has different views on this. Svensson (2000) suggests that directly responding to the exchange rate can produce welfare gains, but Taylor (2001) claims that, although such gains are possible, the risks and costs of responding too actively to the exchange rate outweigh the benefits.

However, the issue of the optimal response to exchange rate developments goes beyond the conventional debate about how to better control inflation.[6] In particular, in economies with high levels of debt denominated in foreign currency, the fluctuation of the exchange rate can generate negative balance sheet effects. If government debt suddenly increases, it may give rise to "fiscal dominance," which eventually might force the central bank to abandon the target.[7][8] If the debt increase occurs in the financial sector balance sheet, it may precipitate bank runs and capital outflows, causing large depreciations and rendering the target infeasible. Finally, if debt increases in the non-financial private sector, it may generate prolonged recessions due to reduced investment capacity and/or perverse feedbacks to the financial sector.

Caballero and Krishnamurthy (2005) is one of the few attempts in the IT literature to associate the response to exchange rate movements with private sector incentives to hedge against episodes of large depreciations. They show that, although it is optimal for an IT central bank to prevent large depreciations *ex-post*, the central bank can achieve a superior welfare outcome if it commits to allowing the currency to depreciate *ex-ante*. Knowing this commitment, agents hedge their foreign denominated liabilities, reducing the negative effects caused by sudden stops in capital flows.

I find that IT regimes that allowed their exchange rates to float more eventually borrowed less in foreign currency. This is important because one of the primary challenges to countries adopting IT is to live with a flexible exchange rate. This paper shows that exchange rate flexibility is also a key point to guarantee the sustainability of the regime. Over time agents borrow less in foreign currency when the value of the exchange rate fluctuates, avoiding the build up of large foreign currency debts which give rise to currency crises.

In a much debated paper, Calvo and Reinhart (2002) suggest that countries claiming to allow their exchange rates to fluctuate actually do not; they have "fear of floating". They suggest that "fear of floating" is caused by a high pass through combined with an aggressive response to deviations from the inflation target or by currency mismatches in domestic agents' balance sheets. The findings of the present paper suggest that there is more heterogeneity in exchange rate regimes than the "fear of floating" concept suggests;[9] moreover, this heterogeneity has produced different outcomes with respect to the level of

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[6]See, for example, Bernanke et al. (1999) and Mishkin (2004).

[7]See, for example, Blanchard (2004) and Sims (2005).

[8]Implicit guarantees can suddenly increase the public debt if the government is required to rescue the private sector, bringing a government, thought to have a sound budget, to the edge of a fiscal crisis.

[9]The "fear of floating" suggests a convergence of the *de-facto* policies of different exchange rate regimes; at the other extreme of the literature is the "bipolar view" of exchange rate regimes, according to which countries have been moving toward free floating or hard currency pegs.

foreign currency borrowing. Although fear of floating may be justifiable, the main policy recommendation here is that countries should allow their exchange rates to float.

Finally, this paper also relates to the literature on currency crises. By showing that domestic currency debt has increased in IT countries, most conspicuously in those where the exchange rate floats more freely, I am able to propose policy recommendations that can reduce the likelihood of crises. In particular, while these economies would still be subject to sudden stops in international financial markets, they would be better able to cope with them given that balance sheet effects would not be as severe as when all debt is denominated in foreign currency.[10] The interaction between foreign currency denominated debt and exchange rate fluctuations is a focus of this literature.[11] Foreign currency denominated liabilities causes the real value of debt to increase during sudden stops, making debtor countries suddenly insolvent. Since currency crises may be the result of self-fulfilling expectations, policies that maintain lenders' confidence in debtor countries are necessary in order to prevent bad equilibriums.[12] The literature on currency crises has also emphasized balance sheet problems of the private sector, financial and non-financial; the theoretical analysis of Chang and Velasco (2001) suggests that a flexible exchange rate regime is the best in order to avoid runs on the currency when the financial sector is fragile. The results presented here show that a flexible exchange rate is effective in preventing the build-up of large currency mismatches. Strong policy implications are evident.

The paper is structured as follows. Section two presents stylized facts that motivate the paper. Section three discusses the decision to adopt IT. Section four describes the data. Section five presents the empirical strategy and results. Section six investigates why IT countries have managed to achieve a lower level of currency mismatch in foreign borrowing. Section seven concludes.

2   Empirical Facts

In this section I present stylized facts that motivate the paper.

First, I show recent patterns on the currency composition of foreign debt. The dataset on which this analysis is from the *Bank of International Settlements* (BIS), which has detailed information on the currency composition of international debt securities. International securities issues includes all foreign currency issues by residents and non-residents in a given country, all domestic currency issues in the domestic market by non-residents, and domestic currency issues in the domestic market by residents that were specifically targeted at non-resident investors.

In order to evaluate recent developments in foreign borrowing currency mismatches I follow the literature and focus the analysis on the following index:

$$OSIN = max \left[1 - \frac{Securities\ issued\ in\ the\ currency\ of\ country\ i}{Total\ securities\ issued\ by\ country\ i}, 0 \right]$$

[10] For more on currency crises see, for example, Krugman (1999).

[11] For an early case study on the relationship between currency crises and foreign currency debt see Diaz-Alejandro (1985).

[12] For a seminal contribution on the self fulfilling nature of currency crises see Obstfeld (1994). This started the literature on what became known as the second generation models of currency crises.

This index will be the main measure of currency mismatches in this paper and it is based on stock variables; the numerator and denominator correspond to the total value of the outstanding securities in each case. The reason for having all securities issued in the currency of country i in the numerator, rather than only those issued by country i, is that securities issued by other countries in the currency of country i give it more hedging opportunities.

By construction, the "original sin index" (OSIN) runs from 0 to 1, with higher values indicating higher currency mismatch. The analysis of the index shows that some countries have managed to reduce the degree of currency mismatch in foreign borrowing to a great extent during the last decade. Figures 1 and 2 show that, between 2001 and 2010, currency mismatch in foreign borrowing decreased in several countries.

Figure 1: Original Sin in Developing Economies - 2010/2001 change and 2010 level
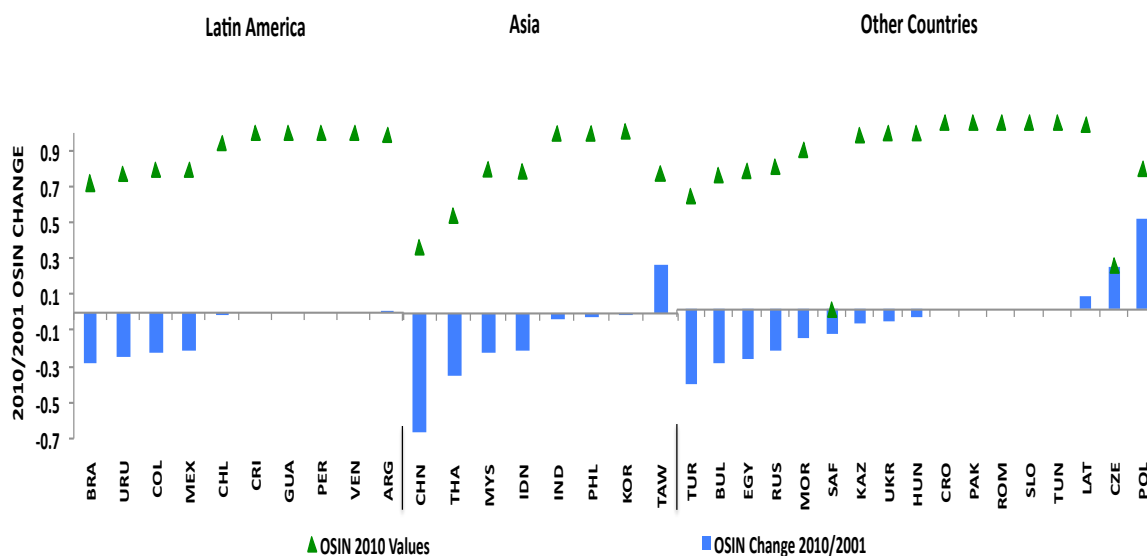
As shown in Figures 1 and 2, original sin reduction was not equal for every country and it is still high in most; therefore, finding policies that increase the use of domestic currency in foreign borrowing is crucial to make it safer. In particular, original sin is still high in most emerging markets (Figure 1), while it varies more in advanced economies (Figure 2). Figure 3 suggests that IT developing countries were able to reduce original sin to a larger extent than non-IT ones.

Exchange rate fluctuations are an important factor when analyzing the currency denomination of debt since they have a direct impact on creditors' and debtors' wealth. The IT countries have been particularly willing to allow their exchange rates to fluctuate. Figure 4 shows that the percentage changes of the nominal and real exchange rates have been larger in IT economies. The top two graphs of this figure compare IT and non-IT emerging market economies; at top left, the two groups' real exchange rate percentage change distributions are plotted while, at top right, the same thing is done but now using the dollar exchange rate.

The bottom graphs of Figure 4 compare the distribution of monthly exchange rate percentage changes in IT economies before and after the adoption of the framework. The bottom-left graph shows the distributions of percentage changes in the real exchange rate

Figure 2: Original Sin in Advanced Economies - 2010/2001 change and 2010 level

Advanced Economies
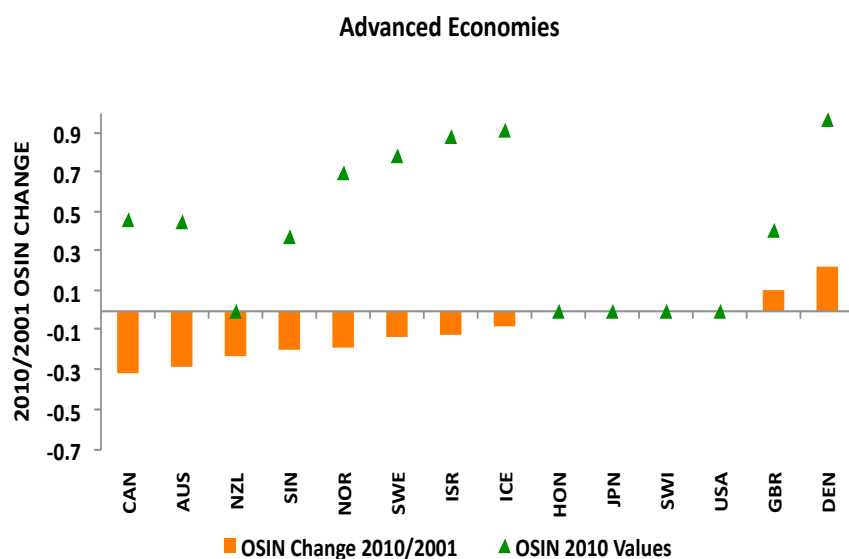
Figure 3: Original Sin in IT and non-IT Emerging Markets Economies - from 1996 to 2011
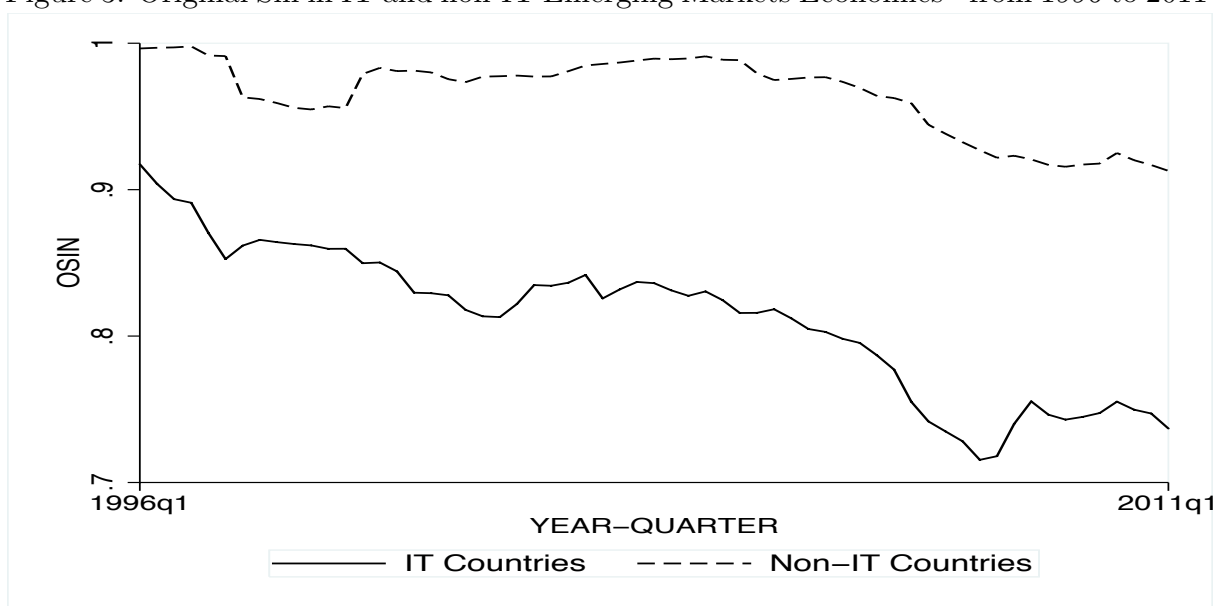
before and after IT adoption, while the bottom-right graph does the same for the dollar exchange rate. The graphs in Figure 4 demonstrate that the exchange rate fluctuates more in IT than in non-IT economies; they also show that the exchange rate has been fluctuating more in IT economies since the framework was adopted.

The hypotheses of equality of the distributions and variances are always rejected at the 1% confidence level, confirming the impression that real and nominal exchange rates have been fluctuating more in IT regimes.

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Figure 4: Nominal and Real Exchange Rate (ER) Depreciation Densities: IT and non-IT
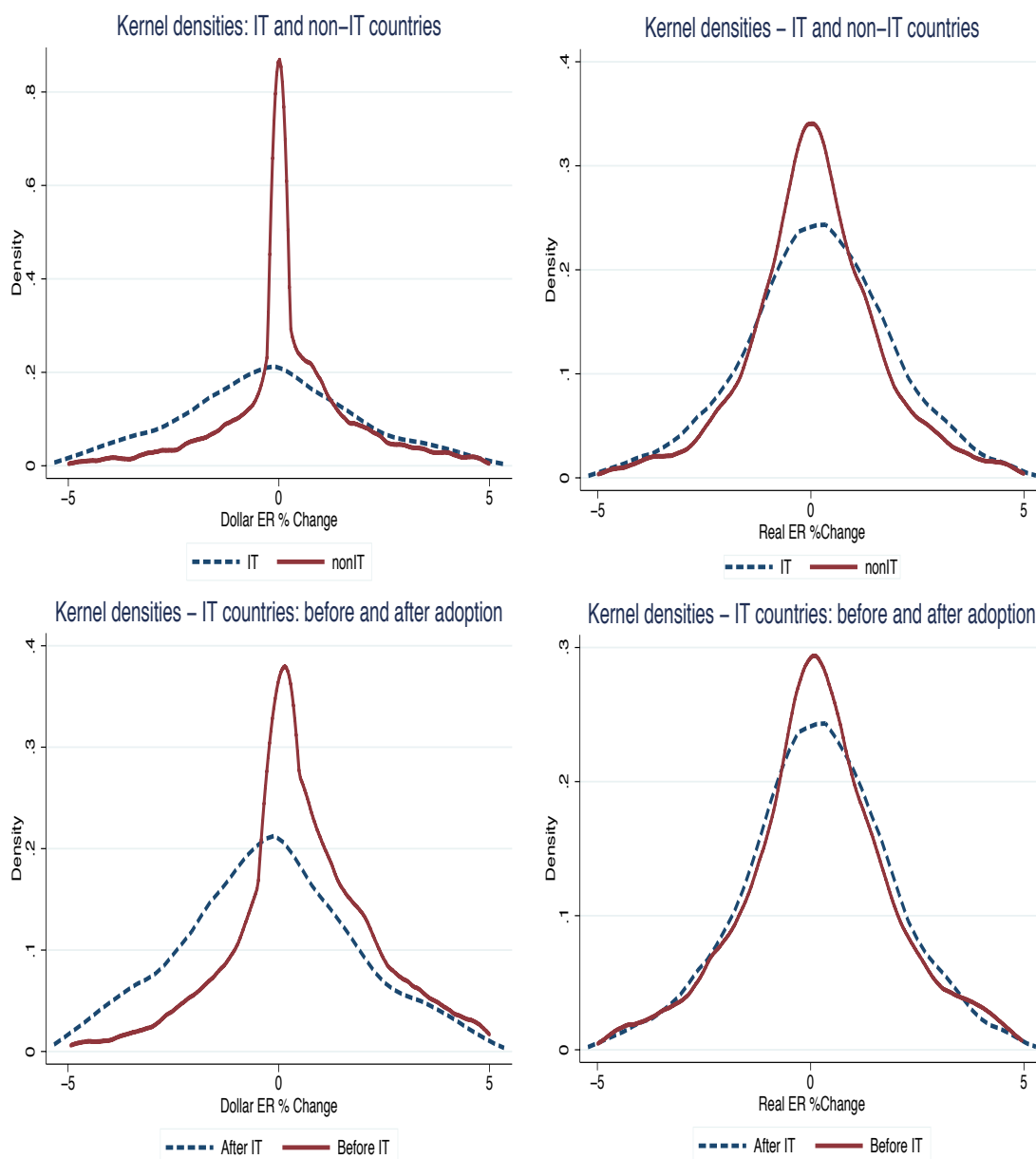
3 Background: Why Implement Inflation Targeting?

In order to assess the impact of adopting IT, it is first necessary to understand why it is adopted. Inflation Targeting is generally viewed as a way to bolster the credibility of monetary policy. Its emphasis on communication is seen as anchoring expectations of future inflation, possibly leading to a more favorable inflation output trade-off.

Bernanke et al. (1999) defines IT as:

"...a framework for monetary policy characterized by the public announcement of official quantitative targets (or target ranges) for the inflation rate over one or more target horizons, and by explicit acknowledgement that low, stable inflation is monetary policy's primary long-run goal."

IT is therefore a framework that assigns monetary policy decisions to domestic goals. An important condition for making domestic inflation the main policy target is to allow for some degree of exchange rate fluctuation. With open capital accounts, monetary policy cannot be focused on domestic objectives unless the value of the currency can change. This is known as the open economy Trilemma.[13]

Bernanke et al. suggests that IT has generated an environment of "constrained discretion" for monetary policy, combining the benefits of rules and discretion. The benefits generally associated with IT include the achievement of lower inflation rates and inflation expectations, lower pass-through into inflation of exchange rate shocks, insulation of policymakers from political pressures, and greater policymaker accountability.

The adoption of IT is therefore determined by the political environment of the country, the potential benefits of adopting the framework, and the costs of adoption. It has been recognized that IT is essentially a democratic framework for monetary policy. It is compatible with democracies by virtue of its emphasis on communication with the public and the accountability of policymakers. Also, since IT is generally associated with a high degree of central bank independence, it is unlikely to be adopted in economies where the monetary policy authority is dominated by strong political interests.

Finally, IT is more likely to be adopted in economies where monetary policy can have significant impact on the domestic economy. In particular, monetary policy is more effective when domestic financial markets are more developed; in this case, changes in monetary policy are more broadly and rapidly transmitted through the economy. Therefore, only countries with reasonably developed financial markets are expected to adopt IT.

4 Data

The dataset used to construct the original sin index was obtained from the *Bank of International Settlements* (BIS) and gives the stock of outstanding amounts of internationally issued debt securities by country and by currency denomination. The main advantage of this dataset is that it provides a detailed description of the currency denomination of international securities. International debt securities issues includes all foreign currency issues by residents and non-residents in a given country, all domestic currency issues in the domestic market by non-residents, and domestic currency issues in the domestic market by residents that were specifically targeted at non-resident investors. The dataset does not include bank loans. The data has quarterly frequency for the period from 1987 to 2011 and covers 61 countries.[14]

The classification of IT economies and the corresponding dates of adoption of the framework were obtained from Svensson (2010). The classification proposed by Ball and Sheridan (2005) was also reviewed. The two classifications tend to agree, but Svensson's classification covers a broader set of countries.

Data for the nominal and the real exchange rates, GDP, and money aggregate M2 were obtained from *International Financial Statistics* (IFS-IMF); this dataset has quarterly

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[13]For a detailed discussion on the monetary policy trilemma see Obstfeld et al. (2005) and Obstfeld et al. (2010).

[14]Countries that adopted the Euro were excluded from the analysis, leaving 61 countries.

frequency. The nominal exchange rate used is the bilateral dollar exchange rate. The real exchange rate is the multilateral real exchange rate; concept *"rec"* from the country tables.

Data for countries' population, trade flows, domestic credit, and fuel exports were obtained from the *World Development Indicators* (World Bank). This dataset has annual frequency.

The degree of capital account openness is measured using the Chinn-Ito capital account openness index.[15] This index ranges from -1.86 (for those with the largest restrictions on capital flows) to 2.46 (for those economies that allow for free cross-border financial transactions) and it is based on the International Monetary fund (IMF) *Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER)*.

Data for the degree of development of democratic institutions were obtained using the *Polity* dataset.[16] From this dataset I used the variable *Polity 2*; this variable ranges from -10 for the least democratic countries (the least democratic countries in the sample are China and Vietnam, their *Polity 2* value is -7) to +10 for the most democratic countries (e.g. United States and Denmark).

Data on the distance from the main trading partner and on countries' areas, as well as a landlocked indicator, were obtained from Shambaugh (2004) and CEPII.[17] Finally, a corruption index was obtained from Transparency International.[18]

5 Econometric Analysis

5.1 Strategy

The objective of this paper is to estimate the causal effect of adopting IT on a country's ability to borrow in domestic currency. Obviously the treatment variable, here the adoption of IT, is not random. Ideally, I would like to compare the amount of domestic currency borrowing an IT country has with the amount of domestic currency borrowing of the same country if it had not implemented IT. Since this is not possible, I use the matching estimator in order to build a control group of non-IT countries that have observable characteristics similar to those of IT countries. A country is part of a control group if it is similar enough to an IT country based on variables which influence the decision to adopt IT. In other words, the objective is to find non-IT countries that are just as likely to adopt IT as those countries that did.

In addition to addressing endogeneity concerns, the matching estimator also allows me to control for possible heterogeneous effects of IT adoption. In particular, the construction of an appropriate control group ensures that only countries that might have implemented IT are used as controls.[19]

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[15] See Chinn-Ito (2008).

[16] See www.systemicpeace.org.

[17] See www.cepii.fr.

[18] See www.transparency.org.

[19] The matching estimator demands less parametric assumptions in comparison with a linear estimator. Linear instrumental variable estimates are shown below; the results are qualitatively the same.

5.2 Matching

Let IT_i be a dummy variable indicating whether a country i adopted IT and let $Y_i(1)$ denote the change in the country's average OSIN level after adopting the IT framework. A country that did not implement IT has its OSIN change denoted by $Y_i(0)$. In particular, denoting by N_b and N_a, respectively, the number of periods before and after IT adoption, if country i adopted IT in period T_i then Y_i is obtained as follows:

$$Y_i = \Delta OSIN_i = \frac{1}{N^a} \sum_{t > T_i} OSIN_{i,t} - \frac{1}{N^b} \sum_{t < T_i} OSIN_{i,t}$$

The interest here is in comparing the change in OSIN for a country that adopted IT with the change that same country would have had if it had not adopted IT:

$$Y_i(1) - Y_i(0)$$

The problem to estimate the impact of IT is that for any given country only one of the outcomes above is observable. For example, $Y_i(1)$ is observable for countries that adopted IT. However, the counterfactual outcome $Y_i(0)$ is not, which creates a problem for the selection of the control group. In general, for each country i only $Y_i(1)$ or $Y_i(0)$ is observable; that is, the problem is essentially one of missing data.

The measure of the treatment effect I want to estimate is the average treatment effect on the treated (ATT), that is, the average effect of IT adoption for IT countries:[20]

$$ATT \equiv E(Y_i(1) - Y_i(0) | IT_i = 1)$$
$$= E(Y_i(1) | IT_i = 1) - E(Y_i(0) | IT_i = 0) - E(Y_i(0) | IT_i = 1) + E(Y_i(0) | IT_i = 0)$$

The researcher interested in estimating the treatment effect would not have great difficulty if she could substitute $E(Y_i(0) | IT_i = 0)$ for $E(Y_i(0) | IT_i = 1)$ but, since the adoption of IT is non-random, these terms tend to be different. In the particular case here, these two expressions are equivalent if the decision to adopt IT is unrelated to the level of OSIN the country would have if it did not adopt the framework. This is a strong assumption for the purposes of this paper.

Fortunately, this assumption is not necessary in order to estimate the ATT. Based on a set of observable country characteristics and pretreatment outcomes that conditions the decision to adopt IT, the ATT can be estimated under a less restrictive set of assumptions. In particular, if $\mathbf{x}$ is a vector of country characteristics and outcomes before the adoption of IT, then ATT can be estimated if, conditional on $\mathbf{x}$, the level of OSIN is unrelated to whether the country adopted IT; that is:

$$E[Y_i(1) | \mathbf{x}, IT] = E[Y_i(1) | \mathbf{x}] \quad and \quad E[Y_i(0) | \mathbf{x}, IT] = E[Y_i(0) | \mathbf{x}]$$

This assumption was introduced by Rosenbaum and Rubin (1983) and became known as the *ignorability of treatment* assumption.[21] They show that in this case the ATT can

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[20]Alternatively one could focus on the average treatment effect, $E[Y_i(1) - Y_{i,t}(0)]$. See Wooldridge (2002) for a discussion on these alternative measures.

[21]Notice that an important implication of this assumption is that, conditional on $\mathbf{x}$, the average treatment effect and the average treatment effect on the treated are identical $ATT \equiv$

be estimated by modeling the probability of treatment given the covariates as:

$$Prob\left(IT = 1|\mathbf{x}\right) \equiv p\left(\mathbf{x}\right)$$

This is known as the *propensity score* function. In the context of this paper, it gives the probability of adopting IT given the covariates in $\mathbf{x}$. Another assumption necessary for the matching estimator, known as the *common support* assumption, is:

$$0 < Prob\left(IT = 1|\mathbf{x}\right) < 1 \ \ for \ all \ \mathbf{x}$$

This rules out the possibility that country characteristics completely determine the decision to adopt IT. In other words, even after controlling for observable characteristics, a country that eventually received the treatment (i.e. adopted IT) had a positive probability of not receiving it. The ignorability of treatment and the common support assumptions combined make the treatment assignment "strongly ignorable" and, in this case, if we have two countries with the same propensity score, where one adopted IT and the other did not, we can show that the expected difference in OSIN for these countries are:

$$E\left[Y|IT = 1, p\left(\mathbf{x}\right)\right] - E\left[Y|IT = 0, p\left(\mathbf{x}\right)\right] = E\left[Y\left(1\right) - Y\left(0\right)|p\left(\mathbf{x}\right)\right]$$

That is, conditioning on the propensity score, the outcome is unrelated to the assignment of the treatment.

Intuitively, the estimation strategy proceeds as follows: The propensity scores are estimated and a comparison (*i.e.*, match) is then made between the change in OSIN of each IT country and the change in OSIN of non-IT countries with similar propensity scores. In particular, when the effect of IT adoption in country i is estimated, the kernel weighting function is applied so that country j receives a higher weight if its estimated propensity score is closer to that of IT country i. Denoting by I_0 the set of non-IT countries, the weight of country j when I estimate the IT effect for IT country i is given by:

$$W\left(\hat{p}_i, \hat{p}_j\right) = G\left(\frac{\hat{p}_i - \hat{p}_j}{b_n}\right) \Big/ \sum_{k \epsilon I_0} G\left(\frac{\hat{p}_i - \hat{p}_k}{b_n}\right)$$

where I used the Gaussian normal function G( ), $G\left(x\right) = e^{-\frac{x^2}{2}}$ and b_n is a bandwidth parameter. The estimator for the causal effect of IT adoption for country i is then given by $\hat{\beta}_i$:

$$\hat{\beta}_i = Y_i - \sum_{k \epsilon I_0} W\left(\hat{p}_i, \hat{p}_k\right) * Y_k$$

Finally, denoting by I_1 the set of IT countries, the estimate of the effect of IT adoption on the level of OSIN is given by:

$$A\hat{T}T = \hat{\beta} = \frac{1}{I_1} \sum_{i \epsilon I_1} \hat{\beta}_i$$

$E\left[Y_i\left(1\right) - Y_i\left(0\right)|\mathbf{x}, IT = 1\right] = E\left[Y_i\left(1\right) - Y_i\left(0\right)|\mathbf{x}\right] \equiv ATE.$

5.2.1 Propensity Score Estimates

The first decision to be made when estimating the propensity score concerns the set of covariates that condition the treatment. I use three covariates: an index of democracy, an index of capital account openness, and the log of the ratio of domestic credit to GDP.[22]

IT is widely recognized as an essentially democratic approach to monetary policy. Given its focus on transparency and policymakers accountability, IT is compatible with democratic institutions. In addition, regimes with high concentration of political power are probably not willing to allow for as great a degree of central bank independence as IT implies. Therefore, more democratic countries are more likely to adopt IT.

Regarding the openness of the capital account it is not clear how greater openness might affect the likelihood of adopting IT. On the one hand, countries with very closed capital accounts are not expected to adopt IT; these countries solved the monetary policy Trilemma by shutting down the economy to capital flows, which gave them the ability to set domestic interest rates and exchange rates. IT countries, by contrast, have been relatively open to capital flows and have accepted at least some exchange rate flexibility. On the other hand, countries with very open capital accounts are often very open economies.[23] From Optimal Currency Area Theory (OCA),[24] we know that a country will gain more from pegging the exchange rate if they have a lot of trade with the country its currency is pegged to. In the dataset used here, several of the countries with high levels of capital account openness are small and have high trade-to-GDP ratios. For these economies the OCA theory suggests it is a better decision to fix the exchange rate than to adopt IT and have monetary policy focused on domestic concerns. Hence, it is unclear how capital account openness would affect the likelihood of adopting IT.

Finally, countries with more developed financial markets are more likely to adopt IT. In these countries, domestic interest rates tend to have a larger influence on the business cycle and therefore they derive more benefit from an independent monetary policy.

The estimated coefficients of the propensity score function are shown in Table 1.[25] The estimates agree with expectations. More democratic countries and countries with more developed financial markets are more likely to adopt IT, while countries with more open capital accounts are less likely to adopt it.

Table 1: Propensity Score Estimates

Variables	Democracy	CA openness	Credit to GDP
Estimates	0.231***	-0.218	0.452*
	(0.069)	(0.147)	(0.248)
Pseudo R^2		0.28	
Sample Size		56	

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; robust standard errors in parenthesis

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[22]I used a larger set of covariates which theory suggests are relevant for IT adoption (*e.g.*, trade to GDP ratio, corruption index, GDP per capita, initial level of OSIN, etc.). The estimates of the IT effect on OSIN were not much affected; therefore, this relatively parsimonious specification was selected.

[23]Offshore centers, for example Singapore and Hong Kong, have the highest levels of current account openness in the sample and are not IT economies.

[24]The seminal reference in the OCA theory is Mundell (1961)

[25]Estimates are based on a probit model; estimates from a logit model and from a linear probability model are very similar.

5.2.2 Propensity Score Matching Estimates

This subsection presents estimates of the causal effect of IT adoption on the change in OSIN. The estimates are shown in Table 2.[26]

Table 2: Propensity Score Estimates of IT effect on OSIN

	PSM 1	PSM 2	PSM 3
$\hat{\beta}$	-0.122**	-0.102*	-0.113*
	(0.057)	(0.059)	(0.066)
Bandwidth	0.13	0.07	0.01
Countries (#)	55	55	55

NOTES: ***, ** and * stand for 1%, 5% and 10% significance; Robust standard errors in parenthesis.

Propensity score matching (PSM) is performed imposing the common support assumption. Therefore I drop non-IT countries for which the estimated probability of adopting IT is outside the support of the propensity score distribution of IT countries. Three bandwidth levels are considered: 0.13, 0.07, and 0.01. The baseline result with bandwidth level 0.13 and Gaussian density shows that the adoption of IT caused a reduction of 12% in the level of original sin. The result is significant at a 5% significance level. The results obtained using different bandwidth levels show that the result obtained here is robust with respect to the choice of this parameter. Decreasing the bandwidth to 0.07 changes the estimated effect of IT adoption to 10% (column 2) while decreasing it to 0.01 changes the effect to 11% (column 3); the effect is always statistically significant. The bandwidth parameter did not affect the estimates.

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[26]In Appendix B I show balancing tests for the Propensity Score Matching. The matching procedure effectively built a group of control countries more similar to the IT economies.

Table 3: Propensity Score Matching Estimates: Robustness

Variables	Estimates					
	(1)	(2)	(3)	(4)	(5)	(6)
Democracy	0.195**	0.250***	0.302***	0.240**	0.224**	0.314***
	(0.077)	(0.083)	(0.106)	(0.094)	(0.090)	(0.100)
CA Openness	-0.320*	-0.263*	-0.162	-0.222	-0.206	-0.307*
	(0.171)	(0.150)	(0.151)	(0.144)	(0.146)	(0.175)
Credit-GDP	0.540	0.774**	0.905**	0.473*	0.447*	1.508***
	(0.347)	(0.327)	(0.384)	(0.257)	(0.250)	(0.566)
OSIN	-	2.825*	-	-	-	4.516**
		(1.720)				(2.040)
Hyperinflation	-	-	1.249*	-	-	0.998
			(0.675)			(0.692)
Gov.-GDP	-	-	-	-0.027	-	-0.036
				(0.039)		(0.046)
Trade-GDP	-	-	-	-	-0.007	-0.011
					(0.006)	(0.006)
Pseudo R^2	0.27	0.31	0.32	0.27	0.29	0.39
Countries (#)	43	55	55	54	55	54
Countries	Emerg. Markets	All	All	All	All	All
$\hat{\beta}$	-0.078*	-0.131**	-0.139**	-0.146**	-0.129**	-0.145**
	(0.042)	(0.058)	(0.058)	(0.060)	(0.060)	(0.064)

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; robust standard errors in parenthesis

A coefficient around 11% means that a country that adopted IT had on average a ratio of domestic currency securities to total securities 11% higher, an economically significant effect. This is a large effect given that OSIN has been found to be very persistent over time and the relatively small time period that my observations cover.[27]

I also do several robustness checks exploring different samples and different sets of covariates. I present the result in Table 3. The first column shows the PSM estimates using the same covariates as before but limiting the sample to developing countries. Columns two to five show estimates where one additional covariate is added to the original set of covariates: the level of original sin before inflation targeting, a hyperinflation indicator for countries that experienced annualized monthly inflation greater than 30% for at least 36 months since 1970, the ratio of government expenditures to GDP, and the ratio of total trade (i.e. imports plus exports) to GDP. Finally in column six I use all covariates. The main lesson from Table 3 is that the effect of adopting IT on the OSIN level is robust to the choice of the sample or covariates used; the adoption of IT led to a reduction in OSIN of 12% according to the baseline estimates.

5.2.3 Covariate Matching

Although Propensity Score Matching is frequently used for the estimation of treatment

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[27]Hausmann et al. (2003) shows that OSIN is very persistent even when considering a 150-years period.

effects, there are other approaches in the literature to match treated and control units. Propensity Score Matching is a regression imputation technique. In this subsection I employ a different methodology to estimate the effect of IT adoption: covariance-adjustment matching (CAM) estimators. I show that the estimated effect of IT adoption on OSIN is robust to the choice of the matching strategy.

In the CAM strategy, a metric of the difference between the covariates is used to match treated and control units. While in the regression imputation approach the match is based on the similarity of the fitted values of a first stage regression (in the previous subsection, the estimated propensity score), in the CAM approach the similarity between two units is evaluated according to the following metric:

$$||x_1 - x_2||_Z = \left((x_1 - x_2)^T Z^{-1} (x_1 - x_2) \right)^{\frac{1}{2}}$$

In the main specification, this corresponds to the Mahalanobis distance, with Z given by the covariance matrix of the covariates. Here, each treated unit is matched with four controls, as suggested by Abadie et al. (2001). In order to check for robustness, I also use the diagonal matrix with the covariates' variances in the main diagonal as Z. The results do not change significantly (see Table 4). With the Mahalanobis metrics, it is estimated that the adoption of IT caused an OSIN reduction of 17% (column 1), whereas using the diagonal variance matrix the estimated reduction is 18% (column 2); in both cases, the estimated coefficient is significant at the 1% level.

I also implement the CAM estimator combined with a bias adjustment term as proposed by Abadie et al. (2001). Abadie et al. suggests that the use of a bias adjustment term improves the small sample properties of the matching estimator. In this case, the adoption of IT is estimated to reduce OSIN by 13%, an estimate that is significant at the 1% level (column 3).

Table 4: Covariance Adjustment Estimates of IT effect on OSIN

	CAM 1	CAM 2	CAM 3
$\hat{\beta}$	-0.176***	-0.181***	-0.128***
	(0.049)	(0.047)	(0.048)
Metric	Mahalanobis	Diagonal Matrix	Maha. and Bias Adj.
Countries (#)	55	55	55
Countries	All	All	All

NOTES: ***, ** and * stand for 1%, 5% and 10% significance; Robust standard errors in parenthesis.

CAM 1, 2, and 3 stands for CAM with Mahalanobis metric, diagonal matrix, and diagonal matrix with bias correction.

Finally I do the same robustness checks as in the last subsection. The results in Table 5 show that considering only emerging markets (column 2) or using a broader set of covariates do not affect the basic result (columns 3 to 6); the adoption of IT led to a reduction in IT. The set of covariates used in columns 3 to 6 is the same used in the corresponding columns in Table 3.

Table 5: Covariate Matching Estimates: Robustness

Variables	Estimates					
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\beta}$	-0.156***	-0.208***	-0.169***	-0.175***	-0.181***	-0.207***
	(0.057)	(0.039)	(0.049)	(0.047)	(0.046)	(0.041)
Countries (#)	43	55	55	54	55	54
Countries	Emerg. Markets	All	All	All	All	All
Metric	Maha.	Maha.	Maha.	Maha.	Maha.	Maha.

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; robust standard errors in parenthesis.

5.3 Alternative Approach: Instrumental Variables

The matching estimator results provide strong evidence that the adoption of IT caused a reduction in the level of OSIN. I showed that this effect is robust for several different matching strategies. In this subsection, an instrumental variable (IV) approach is used to estimate the effect of IT on OSIN. The estimated effect of IT on OSIN using an IV estimator is close to those obtained before. The IV strategy will also be used in the next section, which investigates the reason IT caused a reduction in OSIN.

The inflation targeting dummy, IT_i, is instrumented using the democracy index. The first-stage regression is the following linear probability model (LPM):[28]

$$IT_i = \alpha_0 + \alpha_1 * Democracy_i + \eta_i$$

In the second stage, I regress the change in OSIN on the instrumented IT dummy.

$$\Delta OSIN_i = \beta_0 + \beta_1 * IT_i + \beta_2 * \hat{\eta}_i + \nu_i$$

Two alternative methods are used to estimate the second-stage regression. First I use a simple linear regression model with robust standard errors. In the second specification, since OSIN is bounded between 0 and 1 by construction, I use a double censored Tobit model. Both estimators generate very similar predictions of the effect of IT adoption on OSIN (columns 2 and 3). For comparison, I also show estimates using OLS (column 1).

Finally, I add the index of capital account openness to my instruments list. The two stage least squares (2SLS) estimate show that IT caused a reduction in OSIN (columns 4 and 5). The Hausman test of overidentifying restrictions show that the instruments are valid (i.e. it is not possible to reject the null hypothesis of instruments exogeneity).

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[28]In Table 6 I also show the results when I estimate the first stage using a Probit model.

Table 6: Linear Model and Tobit Estimates

	OLS	IV LPM	Tobit	2SLS	2SLS
$\hat{\beta}_1$	-0.166***	-0.224**	-0.228**	-0.178*	-0.197*
	(0.059)	(0.098)	(0.106)	(0.103)	(0.105)
1st Stage Model	-	LPM	LPM	LPM	Probit
1st Stage F-stat.	-	38.2	38.2	23.11	10.89
$H_0 : \alpha_1 = 0$ (p-value)	-	0.00	0.00	0.00	0.01
Countries (#)	56	56	56	56	56
Overident. p-value	-	-	-	0.30	0.39

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; Robust standard errors in parenthesis

6   Why does IT Adoption Reduce OSIN?

This section investigates a possible explanation for the OSIN reduction caused by the adoption of IT. As documented in section two, IT countries have been allowing their exchange rates to fluctuate more. I will present results showing that the higher degree of exchange rate flexibility played an important role in allowing IT countries to reduce the magnitude of OSIN.

The regression estimated to assess the role of exchange rate flexibility for the currency denomination of foreign debt is:

$$\Delta OSIN_i = \eta_0 + \eta_1 * \hat{IT}_i + \eta_2 * \Delta \hat{ER} + \nu_i$$

where ΔER is the change in exchange rate flexibility after IT was adopted. Different exchange rate measures, over different periods, are used to assess the importance of exchange rate flexibility in reducing OSIN in IT countries. The exchange rate measures employed are, as before, the dollar exchange rate and the multilateral real exchange rate. I compare the standard deviation of monthly percentage changes of these exchange rates after and before IT. I use two possible horizons for the period before IT: one goes back to 1996 and the other goes back to 1990; the final observation is always for 2011:03.

An instrumental variables (IV) approach is used to address endogeneity concerns related to the adoption of IT and the change in exchange rate flexibility. The decision to adopt IT is instrumented using the democracy level (Tables 7 and 9) or the democracy and the capital openness index (Tables 8 and 10), following the strategy from section 5.3.

I use variables often employed in the literature on the choice of exchange rate regimes in order to instrument for the change in exchange rate flexibility.[29] The selection of these variables is based on three main theories related to the exchange rate regime choice literature: the optimum currency area theory (trade to GDP ratio, distance to main trading partner, population, landlocked indicator), the monetary policy trilemma theory (capital account openness), and political economy theories (democracy index, coruption index, GDP per capita). The results are presented in Tables 7 and 8; while in Table 7 I use a LPM to instrument the IT dummy, in Table 8 I use a Probit model.

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[29]See, for example, Klein and Shambaugh (2010) and Shambaugh(2004).

Table 7: Impact of Exchange Rate Flexibility on OSIN

	Estimates			
	(1)	(2)	(3)	(4)
$\hat{\eta}_1$	-0.193*	-0.145	-0.225**	-0.238**
	(0.103)	(0.103)	(0.108)	(0.106)
$\hat{\eta}_2$	-0.021*	-0.020***	-0.071	-0.007
	(0.011)	(0.006)	(0.059)	(0.004)
Exchange Rate	REER	REER	NOMER	NOMER
Period	1996-2011	1990-2011	1996-2011	1990-2011
Countries (#)	53	53	53	53

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; Robust standard errors in parenthesis

REER corresponds to the real multilateral exchange rate. NOMER corresponds to the bilateral dollar exchange rate.

Table 8: Impact of Exchange Rate Flexibility on OSIN

	Estimates			
	(1)	(2)	(3)	(4)
$\hat{\eta}_1$	-0.170	-0.131	-0.206*	-0.211**
	(0.106)	(0.103)	(0.111)	(0.104)
$\hat{\eta}_2$	-0.023*	-0.025***	-0.021***	-0.007
	(0.011)	(0.009)	(0.006)	(0.004)
Exchange Rate	REER	REER	NOMER	NOMER
Period	1996-2011	1990-2011	1996-2011	1990-2011
Countries (#)	53	53	53	53

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; Robust standard errors in parenthesis

REER corresponds to the real multilateral exchange rate. NOMER corresponds to the bilateral dollar exchange rate.

The results show that an increase in exchange rate flexibility played an important role in allowing countries to reduce OSIN. A higher degree of real and nominal exchange rate flexibility led to a expansion in the share of domestic currency denominated debt.

6.1 Alternative Specification

This subsection presents estimates of the equation below:

$$\Delta OSIN_i = \eta_0 + \eta_1 * \hat{IT}_i + \eta_2 * \Delta\hat{ER} + \eta_3 \left(\hat{IT}_i * \Delta\hat{ER} \right) + \nu_i$$

The goal is to check whether the result from the previous subsection showing that an increase in exchange rate flexibility led to a decrease in OSIN is driven by IT countries. Exchange rate flexibility may be more beneficial to countries with credible monetary policies, while it may be related to countries to monetary policy instability in other countries. In particular, I want to check whether the coefficient η_3 is negative; this would

mean that IT countries were especially benefited when they presented higher exchange rate flexibility.

Table 9: Impact of Exchange Rate Flexibility on OSIN

| | Estimates | | | |
	(1)	(2)	(3)	(4)
$\hat{\eta_1}$	-0.307***	-0.276	-0.264**	0.253
	(0.114)	(0.170)	(0.107)	(0.218)
$\hat{\eta_2}$	0.021	-0.006	0.010	-0.005
	(0.017)	(0.013)	(0.011)	(0.015)
$\hat{\eta_3}$	-0.101**	-0.051	-0.069**	-0.003
	(0.043)	(0.034)	(0.029)	(0.032)
Exchange Rate	REER	REER	NOMER	NOMER
Period	1996-2011	1990-2011	1996-2011	1990-2011
Countries (#)	53	53	53	53

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; Robust standard errors in parenthesis

REER corresponds to the real multilateral exchange rate. NOMER corresponds to the bilateral dollar exchange rate.

Table 10: Impact of Exchange Rate Flexibility on OSIN

| | Estimates | | | |
	(1)	(2)	(3)	(4)
$\hat{\eta_1}$	-0.283**	-0.235	-0.244**	-0.179
	(0.112)	(0.176)	(0.108)	(0.188)
$\hat{\eta_2}$	0.020	-0.009	0.009	-0.011
	(0.017)	(0.015)	(0.011)	(0.014)
$\hat{\eta_3}$	-0.099**	-0.041	-0.068**	0.007
	(0.044)	(0.035)	(0.030)	(0.028)
Exchange Rate	REER	REER	NOMER	NOMER
Period	1996-2011	1990-2011	1996-2011	1990-2011
Countries (#)	53	53	53	53

NOTE: ***, ** and * stand for 1%, 5% and 10% significance; Robust standard errors in parenthesis

REER corresponds to the real multilateral exchange rate. NOMER corresponds to the bilateral dollar exchange rate.

Tables 9 and 10 show that it is indeed the case that the relationship between OSIN reduction and exchange flexibility is more pronounced in IT economies. In some cases the relationship do not appear to be statistically significant anymore for non-IT economies. This suggests that while in IT countries exchange rate flexibility has been seen as permanent policy consistent with the maintenance of the domestic currency value, in non-IT economies exchange rate flexibility has not been considered credible or has been related to monetary policy instability.

7 Conclusion

I show that monetary and exchange rate regimes have a role in determining the currency denomination of foreign debt. The adoption of IT in several countries provides an example of a change in monetary policy that caused an increased in domestic currency denominated debt. The main advantage of the approach employed here is that, because the IT regimes adopted in different countries are similar, it is possible to identify the effect of this common change in domestic policy in a cross-section of countries.

Two different techniques - *i.e.*, matching and instrumental variables estimators - are used in order to address possible endogeneity concerns. I show that the the estimated effect of IT adoption on the currency denomination of foreign debt is robust to the specification adopted.

Finally, I show that IT countries whose exchange rates became more flexible after the adoption of the framework were particularly successful in reducing the currency mismatch in foreign borrowing. This is a significant finding because the literature linking exchange rate flexibility and currency mismatches is mostly theoretical. The relationship is here confirmed empirically.

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A Inflation Targeting Countries Adoption Dates

Table A.1: Inflation Targeting Countries Adoption Dates

Country	Adoption Date	Country	Adoption Date
Australia	1994m4	New Zealand	1990m1
Brazil	1999m6	Norway	2001m3
Canada	1991m2	Peru	2002m1
Chile	1999m9	Philippines	2002m1
Colombia	1999m9	Poland	1998m10
Czech Republic	1997m12	Romania	2005m10
Ghana	2007m5	Serbia	2006m9
Guatemala	2005m1	South Africa	2000m4
Hungary	2001m6	Sweden	1995m1
Iceland	2001m3	Switzerland	2000m1
Indonesia	2005m7	Thailand	2000m7
Israel	1997m6	Turkey	2006m1
Korea	2001m1	United Kingdom	1992m10
Mexico	2001m1		

B Non Inflation Targeting Countries

Table A.2: Non Inflation Targeting Countries

Argentina	Estonia	Lithuania	Sri Lanka
Bulgaria	Hong Kong	Macedonia	Taiwan
China	India	Malaysia	Trinidad and Tobago
Costa Rica	Jamaica	Mauritius	Tunisia
Cote d'Ivoire	Japan	Morocco	Ukraine
Croatia	Jordan	Nigeria	United States
Denmark	Kazakhstan	Pakistan	Uruguay
Dominican Republic	Latvia	Russia	Venezuela
Egypt	Lebanon	Singapore	Vietnam

C Balancing Test for Propensity Score Matching

Table A.3: Propensity Score Matching Balancing Test (difference in means test)

Variables	Democracy		CA openness		Credit to GDP	
	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
t-statistic	3.64	0.86	0.39	0.11	1.84	0.50
p-value	0.001	0.393	0.698	0.912	0.072	0.619

NOTE: t-statistic and p-value for the test of difference in means between treated and non-treated countries

Chapter 02
Does Central Bank Capital Matter for Monetary Policy? *

Abstract

Heavy foreign exchange intervention by central banks of emerging markets have led to sizeable expansions of their balance sheets in recent years - accumulating foreign assets and non-money domestic liabilities (the latter due to sterilization operations). With domestic liabilities being mostly of short-term maturity and denominated in local currency, movements in domestic monetary policy interest rates can have sizable effects on central bank's net worth. In this paper we examine empirically whether balance sheets considerations influence the conduct of monetary policy. Our methodology involves the estimation of interest rate rules for a sample of 41 countries and testing whether deviations from the rule can be explained by a measure of central bank financial strength. Our findings, using linear and nonlinear techniques, suggest that central bank financial strength can be a statistically significant factor explaining large negative interest rate deviations from "optimal" levels.

1 Introduction

Over the past decade, efforts to manage large capital inflows by many central banks in emerging market (EM) countries have led to a major shift in the composition and size of their balance sheets (Figures 1 and 2). Significant foreign exchange (FX) intervention has been accompanied by large expansions of their net foreign assets as well as domestic (interest-bearing) liabilities - with the latter reflecting large sterilization operations aimed at containing the monetary effects of FX interventions.[1] As a result, currency mismatches in their balance sheets have widened. In parallel, central banks have witnessed a secular decline in their capital - interrupted only temporarily by the effect of the sharp depreciations triggered by the 2008 global financial crises. Such dynamics are particularly evident in emerging Asia, especially when the components of balance sheets are measured relative to the country's GDP. A breakdown between inflation targeting (IT) and non-inflation targeting regimes also reveals that capital losses have been particularly pronounced in the first group (Figure 3), as lower tolerance for inflation led to reduced seigniorage and revaluation losses from currency appreciation (Figure 4).

This transformation in central bank balance sheets (CBBS) has increased the sensitivity of capital to domestic interest rate movements. Indeed, the accumulation of foreign currency instruments on the asset side, along with short-term, local currency-denominated securities on the liability side increases the impact of movements in short-term domestic interest rates (i.e. monetary policy rates) on central banks' capital. This effects operates through two distinct channels: by affecting the amount of interest payments on liabilities - while having no effect on the asset (revenue) side - and via exchange rate movements that result in capital losses. The magnitude of this potential effect on central banks' capital has grown over time, as balance sheets have expanded while capital shrunk.[2]

This background brings to the forefront of the policy debate the issue of whether central bank's financial strength (CBFS) may affect the conduct of monetary policy. In general, whether a low degree of capital and/or high sensitivity to interest rate movements affects monetary policy decisions remains a relatively unexplored question in the theoretical and empirical macroeconomic literature.[3] In fact, there are (un-tested) opposing views. Some argue that CBBS are irrelevant as central banks have the ability to print money money to recapitalize themselves through seigniorage, or because ultimately what matters are the institutional arrangements in place (i.e., recapitalization agreements with the Treasury) and the consolidated fiscal position (i.e., fiscal ability to recapitalize

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[1]See Adler and Tovar (2001) for a detailed account of FX intervention policies in emerging economies, and their impact on exchange rate dynamics.

[2]While the issue of central bank financial strength has also become relevant in a number of advanced economies - as they expanded their balance sheets with the so called "unconventional policies" - the focus of this paper is primarily on emerging markets, where currency mismatches in central bank balance sheets have become more pronounced and so the cost of raising domestic interest rates. This channel of transmission from interest rates to central bank capital is less clear in advanced market cases, where currency mismatches are not present.

[3]This conceptual issue has been previously discussed in some studies - see Stella (1997) and Stella and Lonnberg (2008) - but there has been no rigorous attempt to test and quantify its importance

the central bank).[45] By contrast, others argue that political economy reasons are enough for central banks to care about the health of their balance sheets, as financial weakness may trigger greater oversight and reduce independence, leading central banks to pursue sub-optimal policies in order to minimize the risk of losing independence (Jeanne and Svensson, 2007).[67]

Figure 1: Dynamics of NFA and NDL of EMEs Central Banks Balance Sheets
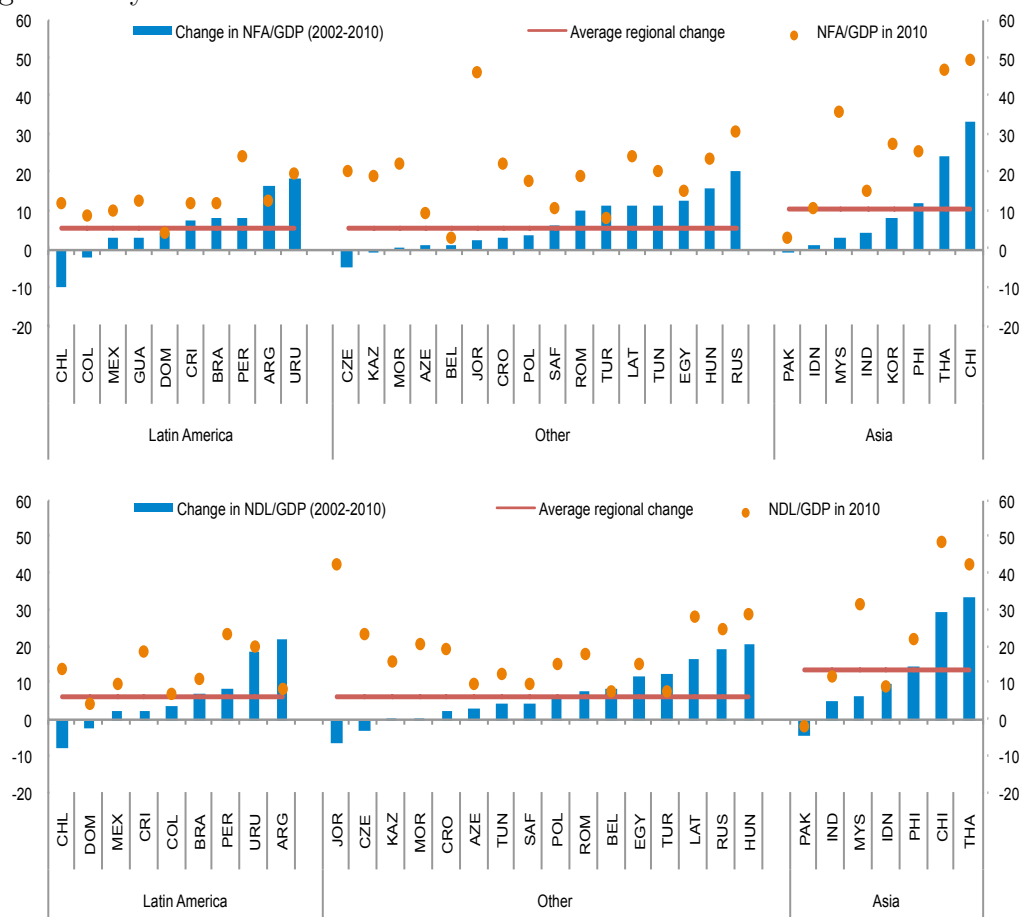
NOTES: Author's calculation based on the *IMF International Financial Statistics*

This paper assesses empirically whether CBFS constrains monetary policy decisions.

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[4]This view is consistent with the notion that negative or low capital does not necessarily mean a negative or low net worth. One obvious counterargument is that losses can be offset by future seigniorage, this strategy could conflict with the goal of domestic price stability.

[5]Those with this view of highlight the Chilean case as an example, arguing that, despite carrying negative capital for several years, the central bank was considered highly credible and successful in maintaining inflation under control. A healthy consolidated fiscal position - which some have called a situation of "good fiscal dominance" - may have helped to make this outcome possible. See Restrepo, Salomo and Valdes (2009). Other central banks have also operated with negative capital for years -see Stella and Lonnberg (2008).

[6]Central governments may pressure monetary authorities to maintain a healthy balance sheet in order to minimize the need for transfers from the Treasury, as the latter would take up budget that could be used for other fiscal purposes.

[7]Moreover, if CBFS becomes a concern for private domestic agents (that normally transact with the central bank), its credibility could be eroded, thus limiting its ability to control domestic interest rates.

Figure 2: Dynamics of Central Bank Capital in EMEs
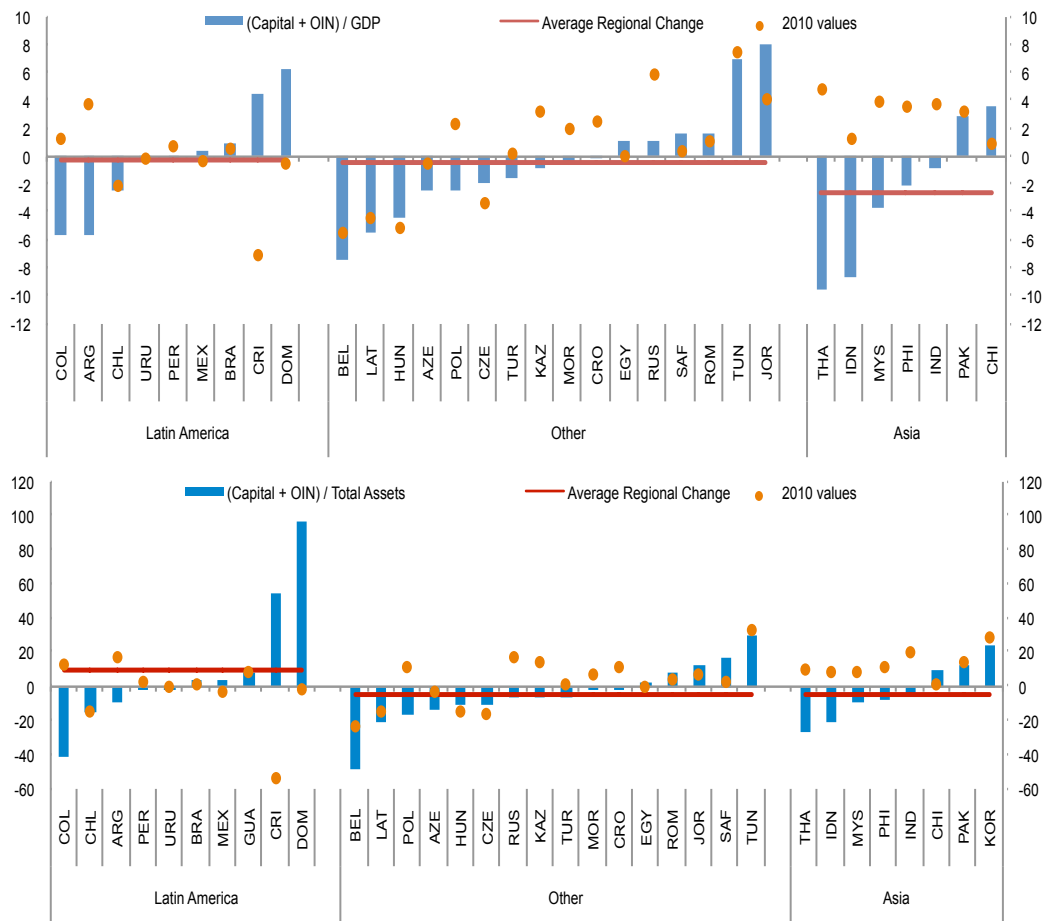
NOTES: Author's calculation based on the *IMF International Financial Statistics*

Previous studies have explored the nexus between CBBS and macroeconomic outcomes. Kluh and Stella (2008) use a panel dataset composed of Latin American and Caribbean countries and show that CBBS conditions have been worsening in recent years. They question the sustainability of current central bank's funding models and propose that policymakers should review the current arrangements between central banks and the respective treasuries. Their main finding is that there is a negative relationship between CBFS and inflation outcomes in the countries considered. Stella (2005) investigate the relationship between policy objectives, CBFS and transparency. He shows that more ambitious policy objectives require a stronger CBBS and that transparency regarding the level of CBFS is fundamental in order to attain policy credibility. Despite these previous investigations in the literature, to our knowledge our work constitutes the first attempt to study empirically and quantify the extent to which CBFS interferes with monetary policy decisions per se. Our approach entails three steps: (*i*) finding an empirical measure of CBFS, (*ii*) constructing a proxy for monetary policy constraints (deviations from "optimal policy"); and, finally, (*iii*) assessing whether CBFS is statistically linked to the latter. To make the methodology operational we rely on an empirical measure for CBFS based on accounting data: the capital to asset ratio (as in Stella and Kluh, 2008). Since there are good reasons to believe that CBFS may only matter beyond certain thresholds,

we consider the possibility of both linear and non-linear effects. Therefore our estimates rely on standard fixed-effects panel regression analysis as well as on a non-linear semi parametric regression analysis: quantile regressions. The study is based on a sample of 41 emerging market countries over the period 2002:M1-2011:M3.

Figure 3: Dynamics of Key Central Bank Balance Sheet Items by Monetary Regime
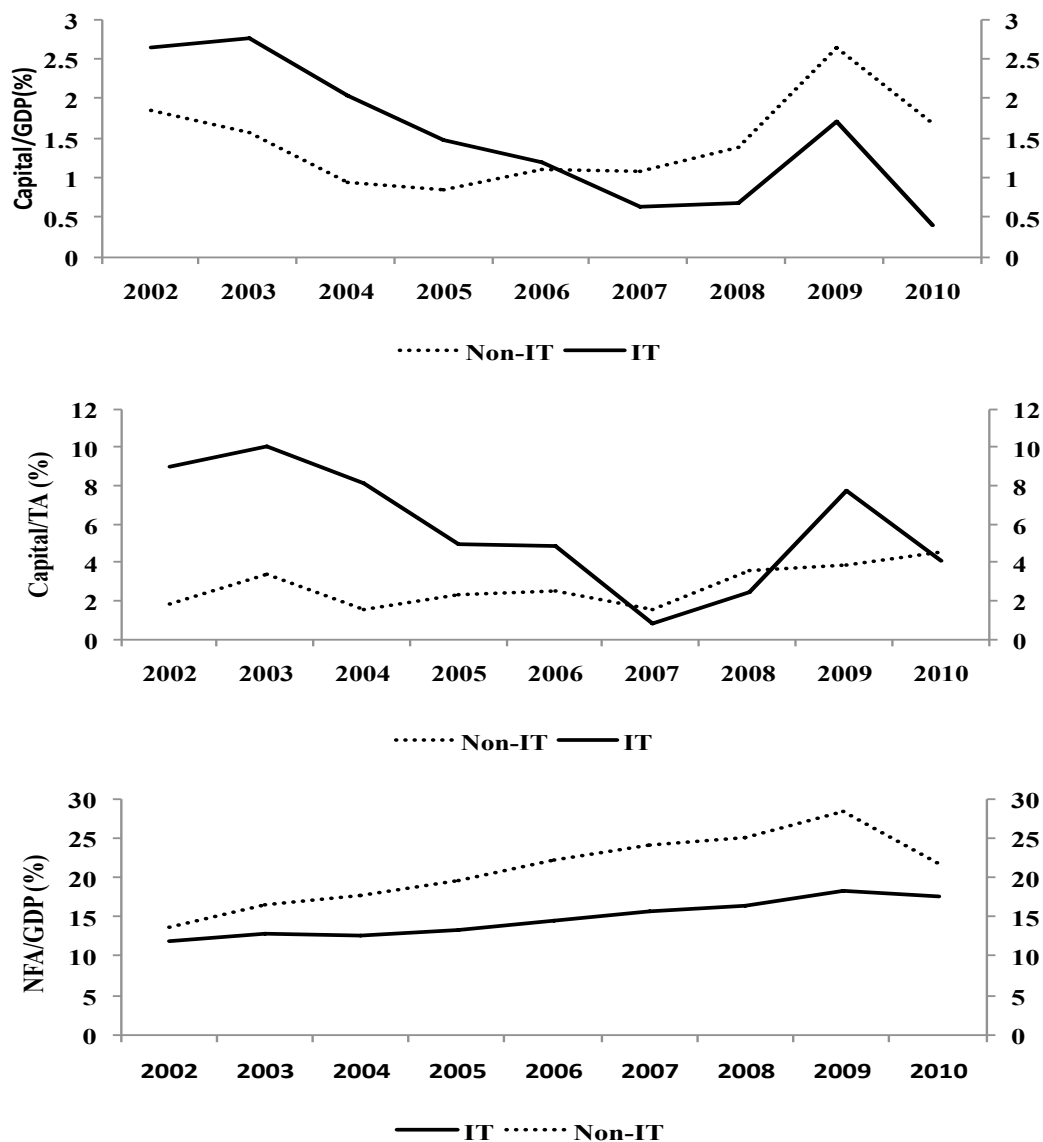
NOTES: Author's calculation based on the *IMF International Financial Statistics*

Our results support the view that CBFS matters for the conduct of monetary policy. We find that large interest rate deviations from optimal policy can be explained to some extent by CBBS weaknesses. Moreover, our results show that such effect is nonlinear, as the impact is statistically significant and economically meaningful in the case of very weak balance sheets (lower deciles of the distribution) but not for moderately weak balance sheets. In fact, low levels of our measure of CBFS explain deviations of up to 72 basis points in the policy interest rate from its "optimal" level. Results are found to be robust.

Figure 4: Average Inflation by Monetary Regimes
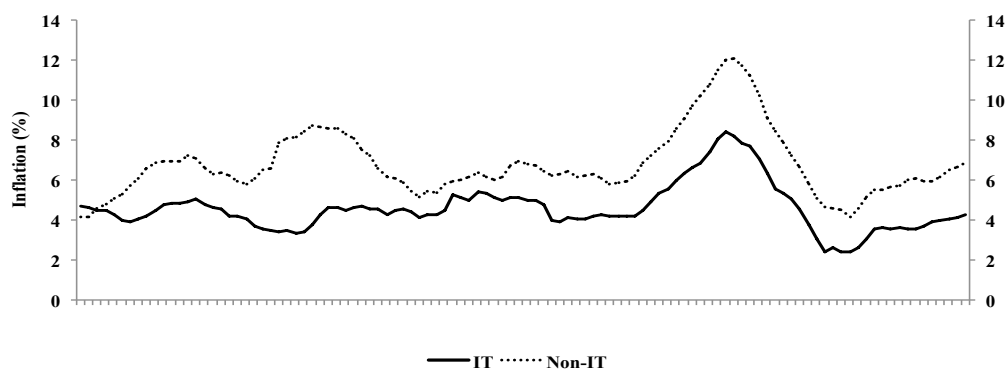
NOTES: Author's calculation based on the *IMF International Financial Statistics*

The rest of the paper is organized as follows: Section II describes the methodology, discussing the measure of CBFS used, the estimation of our proxy for monetary policy constraint (MPC), and how we estimate the relationship between CBFS and the MPC. Section III presents the results along with robustness checks. Finally, Section IV discusses our conclusions, limitations or our analysis, and avenues for future research.

2   Methodology and Data

Our empirical approach involves measuring the financial strength of a central bank and constructing a proxy variable to quantify constrains on monetary policy. This entails defining a measure of central bank financial strength, estimating interest rate rules to derive a proxy for "optimal" interest rate policy, quantifying the constraint on monetary policy, and, finally, putting these elements together to answer the main question of the paper, whether CBFS constrains monetary policy decisions or not.

2.1   Central Bank Financial Strength

The study of the financial structure CBBS has received little attention in the literature. With no doubt this reflects the fact that some analysts and academics consider the issue irrelevant from a macroeconomic point of view on the basis that the issue should be analyzed within the broader context of the financial strength of the consolidated public sector, or because central banks have the ability to generate income through printing money (Stella and Lonnberg, 2008). However, as argued earlier, there are others, who think that CBBS matter. Although in this case the argument is mostly driven around political economy considerations, there is no theoretical guidance as to which is the best way to measure the CBFS.

For the purposes of this paper a key consideration is that the extent to which CBBS interferes with monetary policy decisions will depend, if any, both on the extent of the currency mismatch and the level of capital. But since most emerging market economies display broadly similar balance sheet structures (foreign assets denominated in foreign currency and domestic liabilities in domestic currency) the level of capital becomes the

most relevant measure. Another consideration for the purposes of conducting a cross-country analysis, as that pursued here, is the need to rely on standardized and widely available data set that ensures comparability across countries. With this in mind we define the central bank financial strength (CBFS) as the ratio of a broad measure of capital to assets. Formally, we calculate it as:

$$CBFS_{i,t} = \frac{Capital_{i,t} + Other\ Items\ Net_{i,t}}{Total\ Assets_{i,t}} \qquad (1)$$

This accounting ratio has been employed in previous studies (e.g. Stella and Kluh, 2008) and is widely available on a relatively standardized and high frequency (monthly) basis from the International Monetary Fund's International Financial Statistics (IFS).

Despite its advantages, this measure of CBFS may not capture some subtleties. Although this measure has the advantage of being easily comparable across countries, its accounting nature implies that it may fail to capture the market value of certain assets and liabilities. Moreover, it may also overlook certain financial components, such as contingent liabilities that only materialize with a lag, even though in most cases these tend to be small. Alternatively, we could have considered flow measures (e.g. based on profit and losses or on central bank return on assets), but data availability is much less standardized, which would severely restrict our analysis. Another point to note is that the accounting entry Other Items Net includes idiosyncratic features which might not be fully comparable across countries. The inclusion of this entry is nevertheless desirable because it tends to include valuation changes and reserves that serve as a buffer stock to protect central bank capital.[8] Failing to include such valuation changes could invalidate any relationship between capital and financial strength (Ize and Nada, 2009). Finally, an issue that arises is whether Total Assets is the appropriate scaling factor (i.e. the denominator), or whether other scaling variables (e.g. GDP) would be preferable. We choose Total Assets because it helps to factor in the degree of currency mismatches in the central bank's balance sheet.[9]

2.2   An Indicator of Constraints on Monetary Policy

Deviations of observed policy interest rates from an estimated "optimal" level are used as a proxy measure of monetary policy constraints (MPC). This is a natural candidate as it reflects deviations from what the central bank "should" have done, at least from the perspective of its average historical behavior (i.e., its preferences over inflation and output gap). To obtain this indicator we fit interest rate rules (in the tradition of Taylor (1993)) for each individual country and use in-sample predicted values to derive the "optimal" interest rate level. Moreover, to reduce potential biases associated to the use of a single specification, we estimate different specifications for each individual country, and

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[8]As central banks have started to adopt the *International Financial Reporting Standards (IFRS)* standards it is less likely to find revaluation losses and/or accumulated losses in opaque asset accounts. As a result the risks arising from heightened exposure to foreign exchange revaluation losses have also become more apparent (Stella and Lonnberg, 2008).

[9]Since Capital=Assets-Liabilities, and Assets (Liabilities) are primarily denominated in foreign (local) currency, at least in the case of EMEs, the ratio of Capital/Assets reflects the degree of currency mismatch. This is more evident when re-written as Capital/Assets=1-(Domestic Liabilities/Foreign Assets).

use a selection algorithm to choose the best rule based on its forecasting performance. Constructing the MPC involves three main steps which are discusses next.

Step 1: Estimation of Interest Rate Rules

We estimate different interest rate rule specifications for each country. The baseline specification is as follows:

$$i_t = \alpha + \rho_1 i_{t-1} + \beta_1 \left[E_t \left(\pi_{t+12} | I_t \right) - \pi^* \right] + \beta_2 \left[E_t \left(y_t - y_t^* \right) \right] + \beta_3 \Delta e_{t-1} + \varepsilon_t \qquad (2)$$

where i_t is the monetary policy interest rate in period t, $E_t \left(\pi_{t+12} | I_t \right) - \pi^*$ is the expected 12-months ahead CPI inflation gap (relative to the inflation target[10]), $E_t \left(y_t - y_t^* \right)$ is the 3-month ahead expected output gap, with y^* denoting potential output, defined as the HP-trend or linear squared trend, and Δe_{t-1} is the last quarter observed exchange rate depreciation (vis-à-vis the US dollar). Detailed definitions can be found in Table A.2. In absence of robust measures of output gap for many countries, the model is estimated using different definitions of these explanatory variables. Specifically, we allow economic activity to be captured by the industrial production or the unemployment rate; and proxy potential output using either an HP filter or a linear-quadratic trend. In addition, all the previous combinations are estimated with and without an exchange rate component so as to allow for interest rate policy to respond to exchange rate developments. Overall, eight different specifications are estimated for each country.

The models are estimated using instrumental variable-general methods of moments (IV-GMM) (see Clarida, Gali and Gertler, 1998 and 2000). Lags of all the independent variables and the interest rate, as well as the log of a broad commodity price index are used as instruments.[11] Specifically, we regress in the first stage the forward looking variables (i.e., inflation and output gap) on this set of instruments. The fitted values from these regressions are then used in the second stage to estimate the interest rate rule. This approach deals with possible endogeneity bias problems as forward-looking variables are obtained from a linear combination of lagged variables (i.e. the instruments), and so the dependent variable is not correlated with the error term from the interest rate rule.

Step 2: Selection Algorithm

Interest rate rules for each country are selected based on its out-of-sample forecast performance at different horizons. The algorithm-which is in the spirit of Clark and West (2006 and 2007) and has been applied in the context of interest rate rules by Moura and Carvalho (2010)-estimates an interest rate specification for a subsample period, D, out of the available full sample, T (by definition $D < T$). The fitted interest rate, $\hat{i}_t$, is then used to estimate the following mean-correction equation at different forecast horizons ($k = 1, 3, and\, 6$):

$$i_{t+k} - i_t = \varphi_k \left(i_t - \hat{i}_t \right) + \varepsilon_t \qquad (3)$$

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[10]For non-IT countries, since there is no data on their inflation targets, a constant target is assumed. However, the exact constant target assumed is irrelevant because, econometrically, it will be captured by the constant. For simplicity, we assume a target equal to zero.

[11]The first to sixth, ninth, and twelfth lags were included.

Equation (3) is then used to obtain the out-of-sample forecast for each horizon k, which in turn is employed to calculate the following statistic:

$$f_{t+k} = (i_{t+k} - i_t)^2 - \left(i_{t+k} - i_t - \hat{\varphi}_k \left(i_t - \hat{i}_t\right)\right)^2 + \left(\hat{\varphi}_k \left(i_t - \hat{i}_t\right)\right)^2 \tag{4}$$

Thus we obtain one observation of the statistic f for each forecast horizon k. The algorithm is repeated by rolling the subsample one-period ahead while keeping its size fixed at D to obtain another observation of the statistic f. The process is repeated until we reach the end of the sample. At that point, we have obtained T-D observations of the f-statistic for each horizon k. This allows us to test whether the specification for the interest rate rule provides better out-of-sample forecast performance than a simple random walk.

We select the best specification using sequential criteria. That is, once the algorithm has been applied to every single interest rate rule specification in each individual country, we select the one that beats the random walk at a higher number of horizons. In practice, this means selecting the rule that rejects with the lowest mean p-value the null hypothesis of equal predictive ability to a random walk.

Step 3: Measure of Monetary Policy Constraint (MPC)

The MPC measure is constructed as the difference between the observed interest rate and the predicted value obtained from the selected interest rate rule specification, $\hat{i}_t^*$. Thus formally, our measure of monetary policy constraint is given by the following forecast error:

$$MPC_t = i_t - \hat{i}_t^* \tag{5}$$

We are particularly interested in the cases where $MPC_t < 0$, as these defines cases in which interest rates are set below optimal levels and, therefore, may reflect concerns regarding the central bank balance sheet implications of raising the policy rates.

2.3 Putting the pieces together

Finally, whether CBFS constrains monetary policy is evaluated using a simple bivariate framework. Formally, we estimate an equation in which the MPC indicator is a function of CBFS:

$$MPC_t = \gamma_0 + \gamma_1 CBFS_t + \epsilon_t \tag{6}$$

Equation (6) is estimated using pooled ordinary least squares.[12] However, there are reasons to believe that the relationship may not be linear or may involve discontinuities. In other words, large (negative) deviations from the optimal monetary policy are likely to be associated with low levels of CBFS. With this in mind, we also estimate equation (6) using quantile regressions.[13] An advantage of the approach is its robustness to outliers,

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[12] One of the robustness checks entails exploiting the panel structure of the data by introducing fixed effects.

[13] This semi-parametric approach-in the sense that avoids assumptions about the distribution of re-

in particular, if the dependent variable has a highly non-linear distribution.[14] Intuitively, in a standard regression we would be asking how CBFS affects on average our indicator of MPC. With quantile regressions we are able to inquire whether CBFS influences our indicator of MPC differently for countries where policy rates are far from optimal than for the average country in the sample.

2.4   Sample and Data

Our methodology is implemented using a sample of 41 emerging and advanced market economies with monetary regimes where there is some degree of exchange rate flexibility, over the period 2002:m1 to 2011:m4. The list of countries in the sample is reported in Annex Table A.1. As mentioned earlier, the construction of the CBFS measure is based on central bank balance sheet data reported in the IMF's International Financial Statistics. Interest rates (policy rates or money market rates), CPI index, industrial production, unemployment rates, exchange rates, and the broad commodity price index are from the IMF's International Financial Statistics or Haver Analytics (see Annex Table A.2).

To implement the MPC we estimate the selected interest rate rule over a subsample period, and then construct the dynamic forecast over the remaining sample period. In our benchmark analysis we estimate the interest rate rule over the pre-crisis period (2002:1-2008:8) and, then apply the dynamic forecast for the out-of-sample period (2008:9-2010:4). That is, we focus on deviations from optimal monetary policy during the post crisis period to study the link to CBFS. However, as we show later, our results are robust along different dimensions, including different sample breakdowns. That is, our results are not dependent on the subsample period chosen, which also minimizes concerns associated with a structural break in the conduct of monetary policy after the global crisis (see Section III.C).

3   Econometrics Results

## 3.1   Assessing whether CBFS Interferes with the Conduct of Monetary Policy

Our results suggest that weak CBFS do constrain on monetary policy. Figure 5 displays the coefficient estimates for CBFS (γ_1)-flat red line-obtained from a simple pooled OLS bivariate regression of Equation (6). As shown, this coefficient is positive and statistically significant (regression results are also reported in the Annex). This implies that lower central bank capital is correlated with a wider (negative) gap between the observed and the optimal interest rate (recall $MPC_t = i_t - \hat{i}_t^*$). In other words, improving the financial conditions of a central bank helps ease constraints on monetary policy. Specifically, a 1 percent increase in our measure of CBFS is associated with an average effect of 4 basis points in our MPC measure.

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gression errors-fits a regression at different points of the distribution (e.g. a particular percentile) of the dependent variable, rather than simply fitting the regression to the conditional mean as in an OLS regression.

[14]For a brief introduction on the technique see Koenker and Hallok (2001).

However, we find that the relationship between CBFS and MPC is highly non-linear. Figure 5 also reports the quantile regression estimates with its corresponding 95 percent confidence interval-blue and gray dotted lines-displaying the impact of CBFS for each decile in the distribution of the dependent variable (the MPC indicator). As shown, it is evident that the relationship between CBBS and MPC is non-linear. That is, CBFS appears to play a role when the policy rate is further off from its optimal level. Quantitatively, this means that, for the first decile of the distribution of MPC (i.e. when the indicator is negative, a 10 percent increase in our CBFS measure decreases the size of interest rate gap by 72 basis points (i.e. $\Delta MPC_t = 0.72$).[15] However, as policy rates move closer to their optimal level-i.e. as you move further up in the distribution of the dependent variable- the role of CBBS becomes smaller and mostly statistically irrelevant. This suggests that CBFS plays an important role in cases of large deviations from optimal rates, but less so in cases of small observed deviations.[16]

Figure 5: Baseline Results from OLS and Quantile Regression
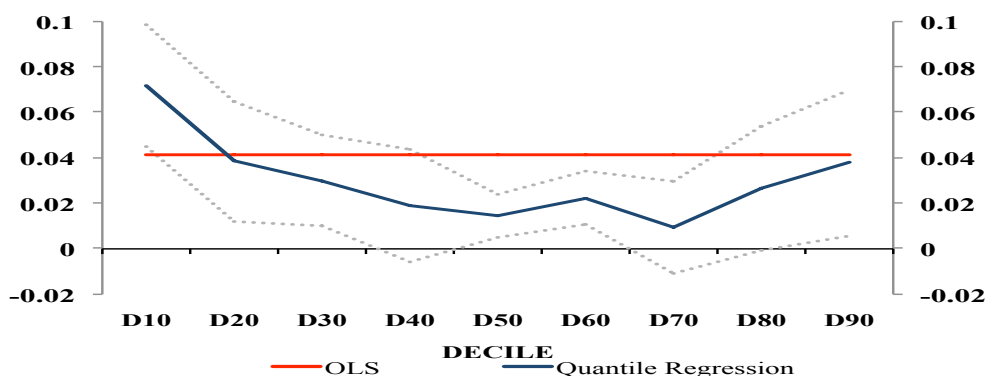
NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

## Monetary Policy Regime and Development Stage

The importance of CBFS does not vary across monetary regimes. One could think of inflation targeting (IT) countries having a more solid framework in place in which the strength of the central bank balance sheet at any point in time may not matter, in particular since the commitment to controlling inflation may be sufficient to ensure that recapitalization would take place if required. We explore this by re-estimating the model only for IT countries (within EMEs). The estimates for this set of countries (Figure 6) display the same pattern as in the benchmark estimation. That is, CBFS is positively related with the measure of MPC and non-linearities matter, suggesting that adoption

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[15]Notice that on average the CBFS indicator equals -1.9 in the lowest decile of the reported distribution in Figure 4, while the sample average for the indicator is 5.7.

[16]Some could argue that there was a structural break in the conduct of monetary policy after Lehman that led central banks to set lower interest rates. Therefore large negative MPCs could be the result of such structural break. However, as shown in the regression results (see annex), the relationship remains statistically significant even if one moves up in the distribution, that is, for example when the MPC is in the second lowest, third lowest deciles or the median of the regressions (see Figure 6 and Annex with regression results).

of an IT regime may not suffice to insulate central bank monetary policy decisions from balance sheet considerations.
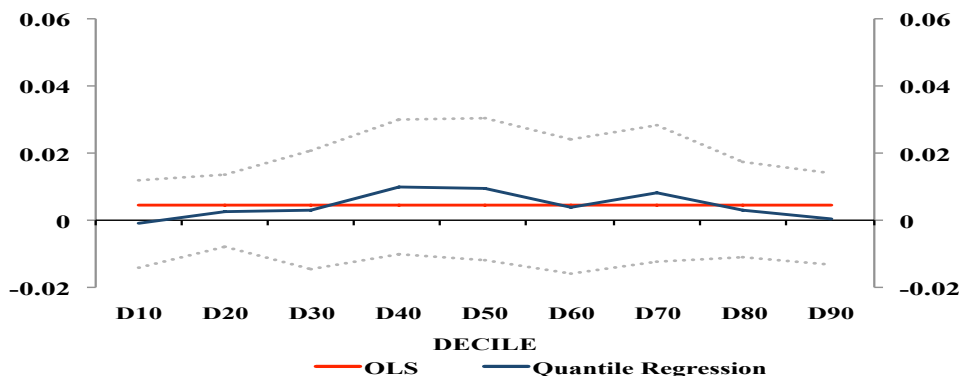
Figure 6: Results for Inflation Targeting Countries
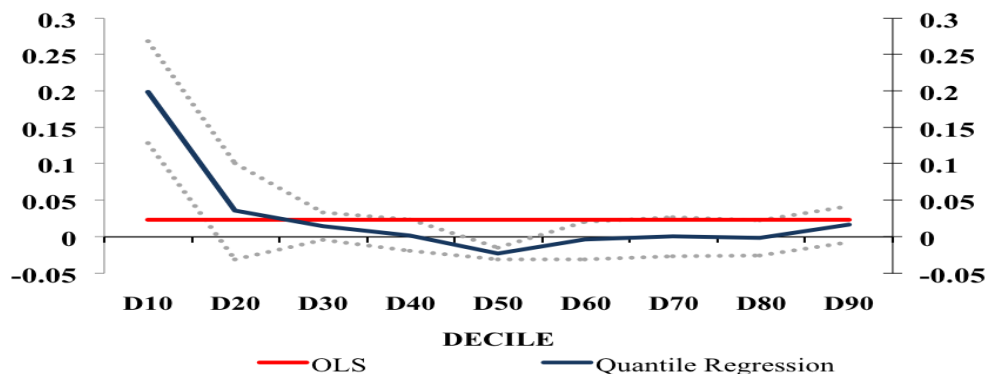
NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

The strength of the general institutional setting does matter. To take this into consideration, we explore the sensitivity of our results to a country's stage of development-used as a proxy for the strength of the institutional setting-independent of whether an IT or a non-IT regime is in place. For this purpose, the sample is split between developed and developing countries. Interestingly, the baseline results do not hold for developed economies, where CBFS appears to have no role even at lower levels Figure 7). This result should, however, be interpreted with caution. It can reflect differences in the strength of the institutional framework (e.g. central bank independence) but it could also capture the fact that currency mismatches are normally not present in CBBS of developed countries, and therefore movements in interest rates do not affect significantly central bank capital.

Figure 7: Results for Developed Countries

NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

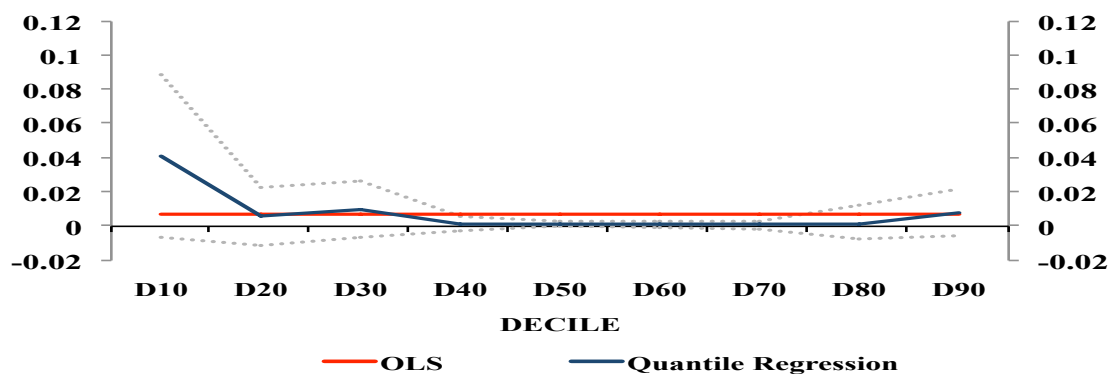Dotted lines show the 95% confidence interval.

3.2 Robustness Analyses

This section examines the robustness of our results across different critical dimensions. Checks include sample variations (both on the time and cross-sectional margins), and adding other controls to the baseline bivariate equation. Notice that unless otherwise indicated, estimates are all based on our benchmark MPC estimates.

Sample Period Employed for the Estimation of the Interest Rate Rule

We first examine the sensitivity of results to the sample period employed in the estimation of the MPC Equation (5). To this end we re-estimate each interest rate rule for the period 2002-2006:12 and forecast the policy rate over the period 2007:1-2008:12. In this manner we aim at assessing whether structural breaks associated with the events that followed the Lehman Brothers' bankruptcy episode in September 2008 may be influencing our results. OLS and quantile regressions results are qualitatively the same to those of our benchmark estimates (Figure 8), but there appears to be a level effect. MPCs tend to be somewhat smaller on average as well as in countries where CBFS is weaker. However, it is worth keeping in mind that a smaller sample size makes our estimates less precise, an effect clearly captured by the wider 95% confidence band.
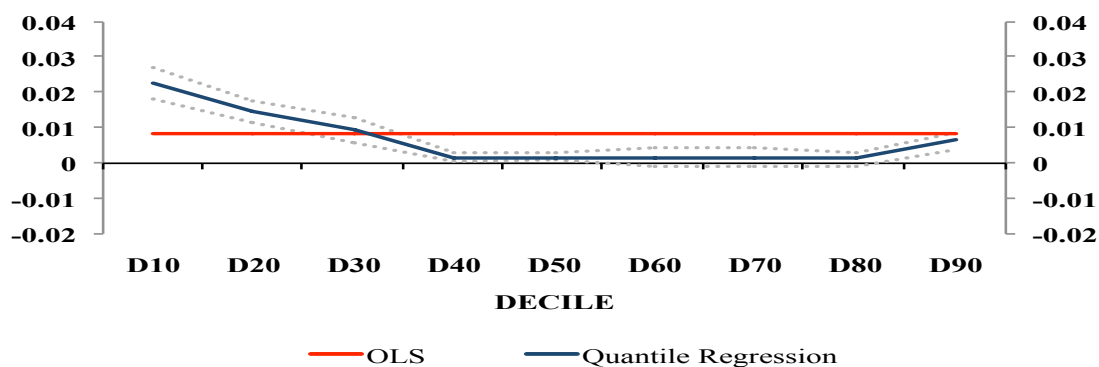
Figure 8: Results under Alternative Sample Period

NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

In-sample versus out-of-sample forecasts

To further assess whether results may be influenced by recent structural breaks we also construct a measure of MPC using in-sample (as opposed to out-of-sample) forecasts. As before our measure of monetary policy constraint is the forecast error-but this time this is estimated in-sample. We then use the new forecast errors series to re-estimate Equation (6) over two different sample periods: the whole sample and the period before August 2008-i.e. prior to the global crisis (as opposed to the post-August 2008 observations in the baseline estimation). Both exercises generate the same qualitative results of the baseline estimation (Figures 9 and 10). Quite interesting, these results confirm the importance of considering nonlinearities, which turn out to be somewhat more pronounced than in the

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Figure 9: Sensitivity to Forecast Sample Period: full sample

benchmark model.

Figure 10: Sensitivity to Forecast Sample Period: pre 2008:8

Sensitivity to the CBFS Indicator

How sensitive are the results to the definition of CBFS? As discussed in Section II.A, the accounting entry Other Items Net may include some idiosyncratic features which might not be fully comparable across countries. Therefore, we examine the sensitivity of results by replacing the baseline definition of CBFS by a simpler ratio, defined as capital-to-total-assets. Our findings indicate that some of the qualitative features do survive, in particular, the non-linearity, but the interpretation is less clear (Figure 11). This is not surprising because the inclusion of Other Items Net is intended primarily to capture valuation changes (and reserves) that, even if being one-off items, tend to affect central bank capital. This confirms, as argued by Ize and Nada (2009), that failing to include such valuation changes could invalidate any relationship between capital and financial strength.
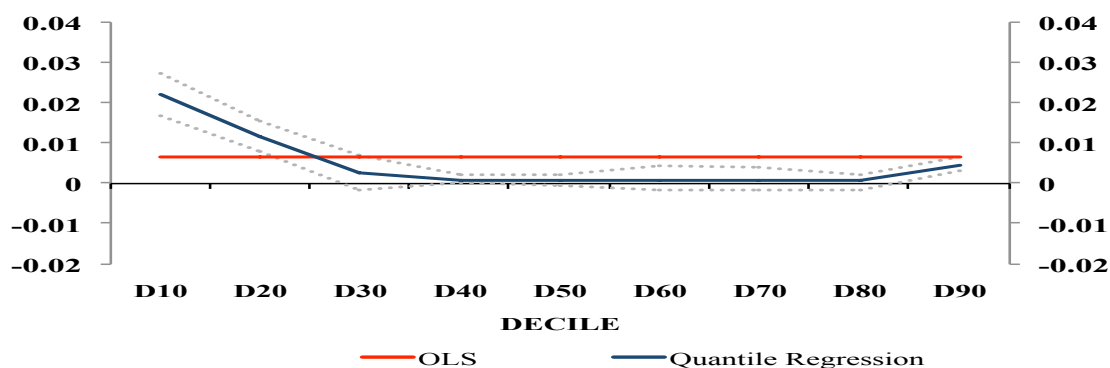
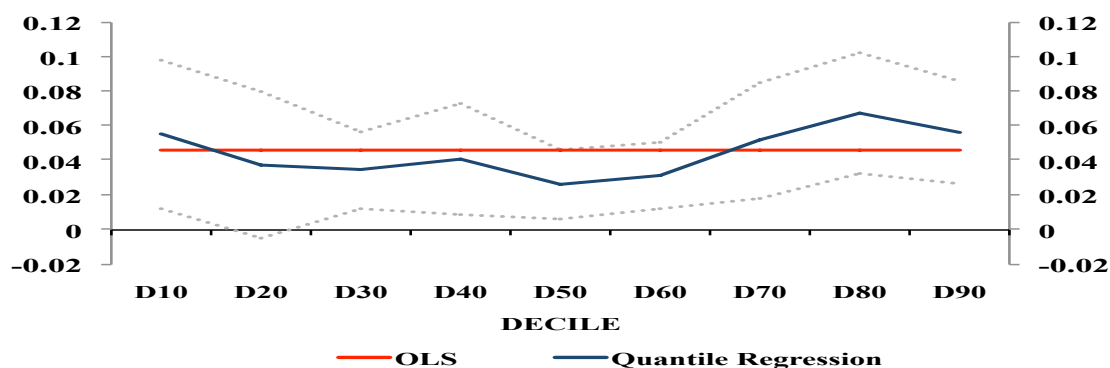Figure 11: Sensitivity to the Definition of CBFS

NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

Exchange Rate Misalignments

Although we allowed monetary policy to react to exchange rate movements in some of the specifications, there is a possible source of bias arising from the fact that exchange rate developments can simultaneously influence the MPC and CBFS measures. That is, our estimates of γ_1 in Equation (6) could falsely signal a statistically significant result, when central banks are reluctant to raise interest rates on concerns about a rapidly appreciating (or overvalued) exchange rate, as the latter would normally cause a weakening of CBFS. To check the robustness of our results against this possible omitted variable bias, we re-estimate the model including the exchange rate as a control. We use two alternative measures proxying the degree of exchange rate misalignment: the deviation from a five-year moving average and the deviation from trend, as obtained from the Hodrick-Prescott filter. Results are qualitatively robust (Figures 12 and 13). Moreover, contrary to what we would expect, CBFS appears to be more relevant in explaining our MPC indicator.

Figure 12: Results Controlling for Exchange Rate Misalignment with 5-years MA
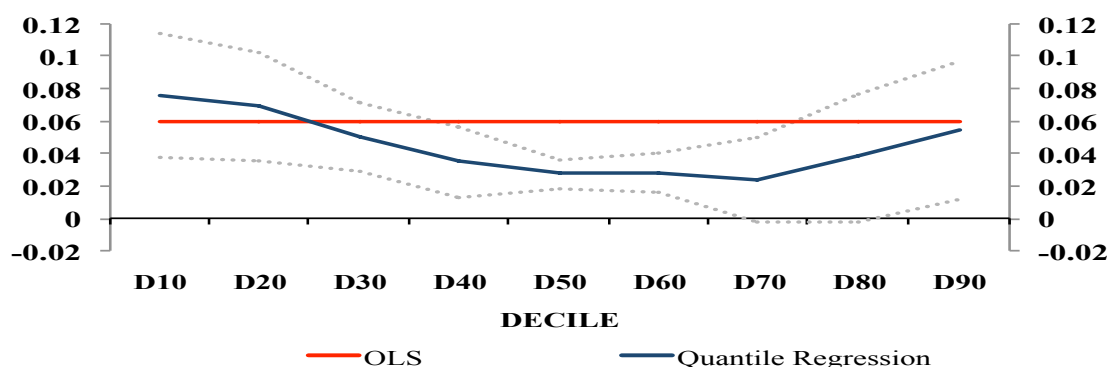

NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

Reverse Causation and Country Fixed-Effects

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Figure 13: Results Controlling for Exchange Rate Misalignment with HP filter

NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

Finally, we consider the possibility of endogeneity bias due to reverse causation in Equation (6)-that is, MPC causing CBFS and not the other way round-as well as whether country fixed-effects could affect the results. To test for reverse causation, we re-estimate equation (6) using a use a three-month lagged value for CBFS. This choice is motivated on the basis that we have an autoregressive (AR-2) term in the interest rate rule (Equation (2)). As displayed in Figures 14, the results are qualitatively robust to this change. Quantitatively, both the OLS and quantile regression estimates appear to be slightly smaller. Similarly, the introduction of country fixed-effects (dummies) does not affect the results (Figure 15).

Figure 14: Results Controlling for Endogeneity Bias

NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

Overall, results suggest that CBBS plays a role in constraining monetary policy decisions. Moreover, quantile regression estimates show that non-linearities matter: large deviations from optimal policy are associated with low CBFS.

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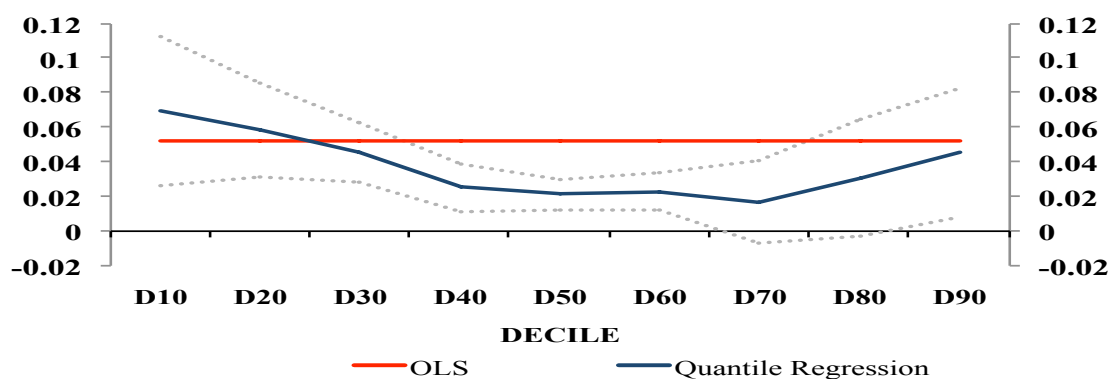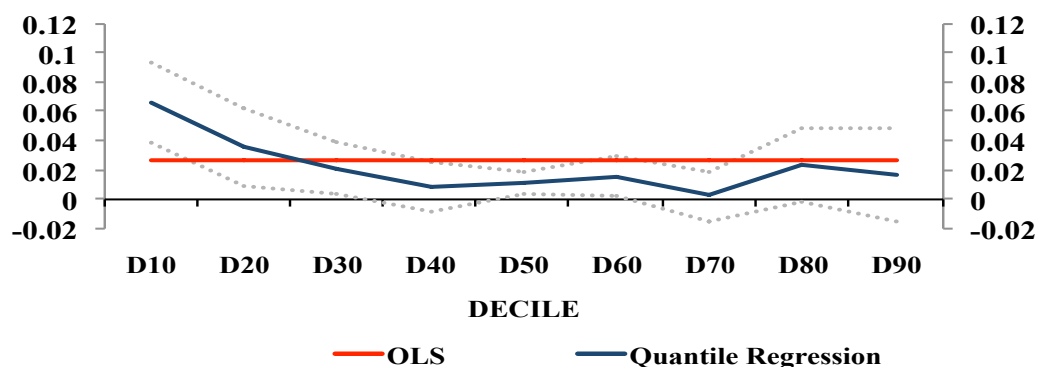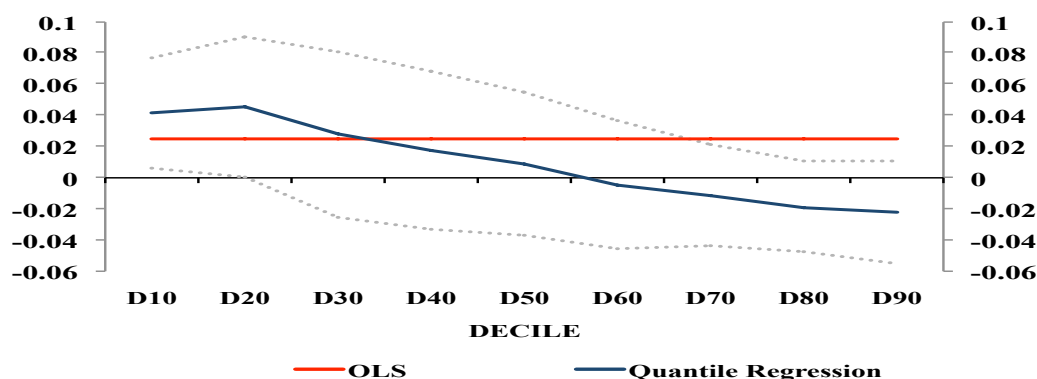Figure 15: Results Controlling for Country Fixed Effects

NOTES: Author's estimates. Horizontal axis: Deciles over the monetary policy constraint (MPC) measure.

Dotted lines show the 95% confidence interval.

4 Conclusions

Over the past decade, efforts to manage large capital inflows by many central banks across the emerging market world have led to a major shift in the composition and size of their balance sheets. Arguably, such a transformation has made their capital sensitive to domestic interest rate movements, and led to increasing concerns about the implications of CBFS for the conduct of monetary policy. Still, research on the importance of central bank capital for the conduct of monetary policy is quite limited. This paper is, to our knowledge, the first attempt to conduct a comprehensive analysis of the issue.

We find evidence that a weak central bank balance sheet can influence the conduct of monetary policy. Quite importantly, the relationship between central bank balance sheets and monetary policy is highly non-linear-i.e., large deviations from optimal policy are associated with very weak balance sheets. In particular, our estimates suggest that weak CBBS (of an order of -1.91 in our indicator of CBFS) can lead to a 72 basis point deviation of interest rates from its estimated "optimal" level.

Certainly, further research in this area is needed. Future work will need to refine our measure of central bank financial strength and examine alternative indicators to assess the degree of monetary policy constraint. The former will require a more in depth analysis of CBBS-for which reliance data on a broad basis is still missing-, or the use of explicit measures of currency mismatches or interest rate risk in CBBS. Equally important is to improve our understanding of the specific mechanisms through which CBFS influences monetary policy. This includes making a careful assessment of how the macroeconomic and institutional environment, in particular fiscal policies, could influence the outcome. Finally, we also believe that our methodology could also be applied to examine problems in advanced economies, where CBBS have been expanding rapidly as a result of the adoption of non-traditional policies.

A   Economic Development and Inflation Targeting Classification

Table A.1: Economic Development and Inflation Targeting Classification

Inflation Targeting		Non Inflation Targeting	
Advanced	Developing	Advanced	Developing
Canada	Brazil	Denmark	Argentina
Iceland	Chile	Japan	China
Israel	Colombia	United States	Costa Rica
Norway	Czech Republic		Croatia
Sweden	Guatemala		Egypt
Switzerland	Hungary		India
United Kingdom	Indonesia		Jordan
	Korea		Kazakhstan
	Mexico		Pakistan
	Peru		Russia
	Philippines		Tunisia
	Poland		Uruguay
	Romania		Venezuela
	Serbia		
	South Africa		
	Thailand		
	Turkey		

B   Taylor Rule Variables Definitions

Table A.2: Taylor Rule Variables Definition

Variable	Definition
Interest Rate	Policy rate or money market rate
12-month Inflation	Difference of log Consumer Price Inflation index in the current month and its value 12 months before, multiplied by 100
Industrial Production	Log of Industrial Production Index
Industrial Production Gap	Difference between Industrial Production and its trend value, multiplied by 100
Industrial Production Gap 3-month ahead	Sum of industrial production gap in the next three months
Unemployment Rate Gap	Difference between unemployment rate and its trend value, multiplied by -1
Unemployment Gap 3-month ahead	Sum of unemployment gap in the next three months
Exchange Rate Depreciation	Difference between log U.S. dollar nominal exchange rate in two consecutive months, multiplied by 100
Exchange Rate Depreciation in the Last 3-months	Sum of Exchange Rate Depreciation in the last three months

C   Main Regression Tables

Table A.3: Benchmark: Pooled OLS Regression

Variables	Coefficients
CBFS	0.0414***
	(0.0091)
Constant	-1.520***
	(0.1660)
Observations	813
R-squared	0.032

NOTES: Robust Standard Errors in Parentheses; *** stands for 1% significance level

Table A.5: Inflation Targeting Countries

Variables	Coefficients
CBFS	0.0235
	(0.0184)
Constant	-2.861***
	(0.249)
Observations	339
R-squared	0.005

NOTES: Robust Standard Errors in Parentheses; *** stands for 1% significance level

Table A.7: Pooled OLS Developed Countries

Variables	Coefficients
CBFS	0.0045
	(0.0052)
Constant	-2.025***
	(0.1201)
Observations	200
R-squared	0.004

NOTES: Robust Standard Errors in Parentheses; *** stands for 1% significance level

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Chapter 03
The Role of the Exchange Rate in Inflation Targeting Regimes*

Abstract

My goal is to assess how Inflation Targeting (henceforth, IT) countries conduct monetary policy and, in particular, how policymakers have reacted to exchange rate movements. I present stylized facts which suggest that exchange rates have been allowed to float relatively free in IT countries. I employ Bayesian Analysis techniques to estimate a Dynamic Stochastic General Equilibrium (DSGE) structural model for twenty two IT economies and compute posterior odds tests to check whether the central banks systematically respond to exchange rate movements. The main result is that only five central banks directly respond to exchange rate movements; all the other IT central banks do not respond to the exchange rate. I also confirm that IT central banks have been conducting strictly inflationary policies, raising real interest rates in response to increases in inflation.

1 Introduction

Despite being a relatively new approach to monetary policy the inflation targeting (henceforth, IT) framework is now fully implemented in twenty seven countries around the world. The framework is known for the public announcement of numerical values of an inflation target and the subordination of all other policy objectives to its achievement.[1] The empirical evidence regarding its success is often positive and there is no evidence that it was harmful for its adopters. Also, its durability and the fact that it has been expanding without any coordination led some to emphasize its relevance in shaping a new international monetary system.[2]

This paper aims to understand the role of the exchange rate in the IT regimes. IT requires nominal exchange rate flexibility; in an economy with unrestricted capital flows, if the monetary policy is focused on domestic conditions the nominal exchange rate must be allowed to fluctuate. Despite this seemly simple requirement, discussions about the appropriate level and flexibility of the exchange rate are still central in the policy debate of IT economies and economists often disagree on the degree to which IT central banks actually respond to exchange rate movements. This paper contributes to this debate in two ways. First, I present several stylized facts showing that exchange rates have been floating relatively free in IT economies; whether I compare the exchange rates of IT economies with those of non-IT ones or with their own exchange rates before the adoption of the framework the result is always that the adoption of IT is associated with greater exchange rate flexibility. I also show that interest rates in IT economies have showed lower variability than in non-IT ones. Second, I estimate a structural model and pay special attention to policy responses to exchange rate movements. I find that most IT central banks do not directly respond to exchange rate movements, and confirm the fact that they have been conducting strictly anti-inflationary policies as stated by the Taylor Principle.

From a perspective of an optimal response to inflation deviations from the target the literature does not offer a definitive answer to whether an IT central bank should respond to exchange rate movements. The literature in this area has advanced both with theoretical models and empirical exercises. Svensson (2000) develops and simulates a small open economy model and suggests that policymakers should directly respond to exchange rate movements. Svensson claims that by responding to the exchange rate the IT central bank can affect domestic inflation with a shorter lag and be more effective in anchoring inflation expectations. On the other hand, Taylor (2001) suggests that, although it is possible to achieve better outcomes by making interest rates respond to exchange rate changes, the gains are often small and it may actually lead to worse outcomes, adding unnecessary variability to interest rates and output.[3] In a case study Jonas and Mishkin (2005)

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[1]The other defining elements of IT enumerated by Mishkin (2002) are: an information inclusive strategy in which all relevant information is used for taking policy decisions; increased transparency of monetary policy by extended communication with the public aiming to make clear the reasoning behind the policy plans, objectives and decisions; and increased accountability of the central bank for its achievements regarding the inflation target.

[2]In this regard see Rose (2007).

[3]Taylor stresses that a monetary authority who follows a policy rule without an explicit reaction to the exchange rate already responds to its changes indirectly, as exchange rate changes will eventually impact the output and inflation. Also, directly reacting to exchange rate movements can add undesirable

analyzed the IT experiences of Eastern Europe economies; they argue that automatic responses to the exchanges rate movements are not desirable and that more attention should be given to the source of the underlying shock.[4] Another case study by Bernanke et al. (1999) suggests that IT central banks have different views on how recent developments of the exchange rate should be incorporated in the decision making processes, but explicitly managing the exchange rate have become increasingly uncommon despite central banks often showing reluctance to allow the exchange rate to free float.[5]

The adoption of the IT framework among emerging markets and transition economies led some economists to question if these countries were apt to deal with the amount of exchange rate flexibility that IT requires. In these economies the exchange rate has been in the very center of the policy debate for decades. Historically many of them used the exchange rate with multiple policy objectives, such as promoting industrialization or generating fiscal revenues by implicitly taxing exports. More recently, exchange rate pegs were implemented in stabilization plans which allowed them to bring down inflation; however, this experience tended to end with exchange rate overvaluation and currency crises. The IT framework was then adopted with the goal to preserve the gains from low inflation while avoiding the crises that forced the abandonment of the peg arrangements.

Lack of monetary policy credibility and high-pass through of exchange rate movements to domestic prices rendered the IT implementation especially challenging in emerging markets. In a much debated paper, Calvo and Reinhart (2002) suggest that countries that claim to allow their exchange rate to fluctuate actually do not; they have "fear of floating". They suggest that "fear of floating" is caused by high pass-through from exchange rate movements to domestic prices, lack of monetary policy credibility and aggressive responses to inflation deviations from the target. The results in this paper show that there is more heterogeneity in exchange rate regimes than the "fear of floating" concept suggests.[6] In particular, the countries that adopted IT have been notably willing to allow their exchange rates to float. Although "fear of floating" might be justifiable, this paper shows that the greater degree of exchange rate flexibility verified in IT countries is a consequence of policy choices, given that for most of IT countries interest rates have been set without any direct response to exchange rate movements.

Another important challenge associated with the IT implementation is that exchange rate movements can generate negative balance sheet effects for countries with foreign currency denominated debt. Eichengreen and Hausmann (1999) document that only few

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volatility to monetary policy if these movements represent departures from purchasing power parity (PPP); in this regard see also Obstfeld and Rogoff (1995b) and Edwards (2006).

[4]Jonas and Mishkin suggest that the lack of attention to the source of exchange rate movements during East Asia 1997 crises led New Zealand and Chile to raise interest rates, "a serious policy mistake", while Australian policymakers recognized that the large negative terms of trade shock called for lowering interest rates despite the large depreciation of the currency.

[5]For example, Bernanke et al. describe the tensions that led New Zealand and Canada to use a monetary conditions index (MCI) "as a means to assess the overall stance of monetary policy". In contrast, Australia tends to pay relatively less attention to the behavior of exchange rates and Israel "gradually de-emphasized strict bands for the exchange rate in favor of a policy that responds to exchange rate changes only when they are deemed likely to affect domestic prices."

[6]The "fear of floating" suggests a convergence of the *de-facto* exchange rate regimes, with the countries practicing some form of crawling peg or managed floating with little difference among them in practice; in the other extreme of the literature is the "bipolar" view, according to which exchange rate regimes have been moving toward free floating or hard currency pegs.

countries are able to borrow abroad in domestic currency. According to the "original sin" view all the other countries have no other option but to borrow in foreign currency, making the real size of their debt contingent on the value of the exchange rate and increasing the likelihood of self-fulfilling crisis.[7] If a significant amount of public debt is denominated in foreign currency a depreciation of the domestic currency can dramatically increase the size of the public debt, leading to "fiscal dominance" and forcing the abandonment of the inflation target.[8] When the financial sector has foreign currency denominated liabilities, an exchange rate depreciation can lead to bank runs and capital outflows, exacerbating the depreciation of the currency and rendering the target infeasible. If the private non-financial sector debt increases with exchange rate depreciations, its investment capacity might become compromised generating prolonged recessions and/or it might have to default on its debt, possibly generating perverse feedbacks to the financial sector. This paper shows that most of IT economies have managed to focus monetary policy on domestic objectives, namely inflation and output levels, without setting interest rates to influence the level of the exchange rate. The result of this paper showing that IT economies have not experienced "fear of floating", with the exchange rate being allowed to play its role as an external adjustment mechanism, gains especial relevance when one considers the rapid growth of gross global financial positions across the world and the increasing relevance of IT for the international monetary system.[9]

Finally, this paper also has implications for the currency crises literature. Caballero and Krishnamurthy (2005) show that the response of IT central banks to exchange rate movements has important implications to the private sector incentives to hedge its balance sheet against episodes of large depreciations. In particular, they show that although it is optimal for an IT central bank to prevent large depreciations *ex-post*, the central bank can achieve a welfare superior outcome if it commits *ex-ante* to allow the currency to depreciate. Knowing this commitment, agents would hedge their foreign denominated liabilities, reducing the disruption generated by sudden stops. My research shows that IT central banks have indeed allowed the exchange rate to fluctuate and, although investigating the implications of this behavior to the accumulation of currency mismatches is beyond the scope of this chapter, the fact that IT experiences have been long lasting suggest that these economies have avoided the build up of imbalances that lead to currency crises.

The chapter is structured as follows. In section two I present stylized facts showing that exchange rate flexibility has been particularly high in IT countries. In section three I discuss the decision to adopt IT. In section four I describe the data. In section five I describe the structural model estimated, the technique used for its estimation and the results. Section six concludes.

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[7]For a case study on the relationship between currency crisis and foreign currency debt see Diaz-Alejandro (1983). For a seminal paper on the self fulfilling nature of currency crises see Obstfeld (1994).

[8]For more on "fiscal dominance" see Blanchard (2004) and Sims (2005)

[9]The build up of gross global financial positions is documented in Obstfeld (2012).

2 Exchange Rate Volatility in IT Regimes

2.1 Frequency Analyses

One of the main criticisms regarding IT is that the exchange rate volatility that it requires to function may outweigh the benefits of focusing monetary policy on domestic conditions. When a country faces a shock which causes exchange rate depreciation, the pass-through of higher import prices into domestic prices and the effect of terms of trade changes into domestic output may require that the central bank responds by changing the interest rate. The critics argue that, since the exchange rate movements will generally affect domestic conditions faster than changes in the interest rate, IT can lead to excessive output and interest rate variability, and IT central banks will end up being forced to prevent the exchange rate from fluctuating.

However, it is not clear that this should be the case. One possibility is that the lower inflation environment and higher policy credibility which the IT framework generates will actually reduce the degree of pass-through from exchange rate to prices. In this case central banks would not respond aggressively to exchange rate movements, and the output and interest rate volatility may not increase.

Therefore, it is important to know how the exchange rate volatility in IT economies compare to that in non-IT ones. There seems to be little consensus about this. As mentioned above, some critics suggest that one of the main costs of IT is associated with higher exchange rate volatility. However, in an influential paper Calvo and Reinhart (2002) showed that countries which announce floating exchange rate regimes actually do not allow their currencies to float; they have "fear of floating". They present a simple model where an IT central bank will display such behavior due to high pass-through and an aggressive response to deviations of inflation from the target.

In this Section I present stylized facts showing that exchange rates have been fluctuating relatively free in IT economies and that there is no evidence that interest rates and reserves have been used to stabilize the value of the currency.

In Table 1 I use an empirical approach similar to Calvo and Reinhart (2002) in order to investigate if exchange rates have been allowed to float in IT countries. For this purpose I divide the sample of 54 countries into two groups: 27 IT countries and 27 non-IT countries. I also present individual statistics for the US, Japan and Australia.

The exercise focuses on the analysis of four variables: the absolute value of the percentage changes of dollar exchange rate $\frac{|\Delta e|}{e}$, the absolute value of the percentage changes of the real exchange rate $\frac{|\Delta \lambda|}{\lambda}$, the absolute value of the percentage changes of the foreign reserves-M2 ratio $\frac{|\Delta H|}{H}$ and the absolute value of the change of the nominal interest rate $|\Delta R|$.[10] Denoting by t the value of some threshold, I calculate the probability that the variable of interest is smaller than this threshold in the sample period; for example, the probability that the absolute value of dollar exchange rate changes is lower than two and a half percent, that is, $Pr(\frac{|\Delta e|}{e} < 0.025)$. The prediction is that countries which allow their currencies to float will have a higher frequency of large changes in the exchange rates and a lower frequency of large changes in foreign reserves and interest rates. Table 1 also shows in parenthesis the standard deviation of the four variables analyzed.

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[10]I also did the same exercises using the absolute value of percentage changes of the foreign reserves; the results were essentially the same and are available upon request.

The statistics for the IT group and Australia (which is itself an IT country) are computed using data since adoption of IT (the specific dates can be found in the Appendix); for the non-IT countries the results were calculated from July 1999 (the average date of implementation of IT regimes) to March 2011. The statistics for the absolute value of the percentage change of the dollar and real exchange rates and foreign reserves - M2 ratio are relative to a two and half percent threshold and for the change in the nominal interest rates are relative to a half percent (or fifty basis points) threshold.

The statistics presented in the Table 1 show that exchange rates have been floating in IT regimes. The likelihood of large percentage changes of the dollar and the real exchange rates is always larger for IT economies in comparison to non-IT ones, even when I consider IT developed economies and IT emerging markets separately. In particular, the exchange rate of IT emerging markets are among the ones which fluctuate the most. Large changes in foreign reserves and interest rates are more likely in non-IT economies, suggesting that IT economies have not been using these instruments to manage the exchange rate. Perhaps surprisingly, the reserves of IT emerging markets have large changes less frequently than in IT developed economies. It is also notable that large interest rate movements occurs as frequently in IT emerging markets and as in IT developed economies. The same results are obtained when I analyze the standard deviation of these variables. The standard deviations of the dollar and real exchange rates are high in IT economies when compared to non-IT ones (this is particularly true for emerging markets) and the instruments used to influence the exchange rate, interest rate and foreign reserves, have lower standard deviations in IT economies, showing that IT central banks have not systematically tried to prevent the exchange rate from fluctuating.

Table 1: Frequency Analyses (Post IT Period)

Country/Groups	Probabilities and Standard Errors			
	$\frac{|\Delta e|}{e} < 2.5\%$	$\frac{|\Delta \lambda|}{\lambda} < 2.5\%$	$\frac{|\Delta H|}{H} < 2.5\%$	$|\Delta R| < 0.5\%$
IT average	0.71 (1.67)	0.82 (1.37)	0.52 (1.34)	0.82 (0.46)
IT emerging markets	0.68 (1.76)	0.78 (1.50)	0.58 (1.32)	0.82 (0.51)
IT developed countries	0.74 (1.57)	0.84 (1.18)	0.44 (1.36)	0.83 (0.39)
non-IT	0.87 (1.38)	0.90 (1.23)	0.48 (1.35)	0.69 (0.83)
Australia	0.66 (1.58)	0.78 (1.30)	0.36 (1.37)	0.96 (0.17)
United States	0.92 (0.91)	0.94 (0.88)	0.70 (1.17)	0.95 (0.17)
Japan	0.72 (1.47)	0.77 (1.59)	0.84 (0.95)	1.00 (0.03)

NOTE: Author's calculations. Standard errors in parenthesis.

The fact that exchange rates have been fluctuating in IT economies is apparent when I use other approaches to analyze the data. Figure 1 below shows the distribution of

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exchange rates percentage changes. In the top two graphs I compare the movements of the dollar and the real exchange rates in IT and non-IT economies; at top left, the two groups' real exchange rate percentage change distributions are plotted while, at top right, the same thing is done but now using the dollar exchange rate.

The bottom graphs of Figure 1 compare the distribution of monthly exchange rate percentage changes in IT economies before and after the adoption of the framework. The bottom-left graph shows the distributions of percentage changes in the real exchange rate before and after IT adoption, while the bottom-right graph does the same for the dollar exchange rate. The graphs in Figure 1 show that the exchange rate fluctuates more in IT than in non-IT economies; they also show that the exchange rate has been fluctuating more in IT economies since the framework was adopted. Overall, IT regimes have been characterized by a great degree of exchange rate flexibility.

Formal statistical tests reject the null hypothesis of equality of distribution and variance in all the cases analyzed in Figure 1. The null hypothesis is always rejected at the 5% significance level (Table 2).

Table 2: Tests of Equality of Distribution and Variance

Groups Compared	ER Definition	Reject Equal Distribution?	Reject Equal Variance?
IT and non-IT	Dollar ER	Yes***	Yes***
	Real ER	Yes***	Yes***
IT: before and after	Dollar ER	Yes***	Yes***
	Real ER	Yes***	Yes**

NOTE: *** and ** stand for 1% and 5% rejection levels, respectively.

Finally, I check whether the results of the comparison between the IT and non-IT economies are driven by outliers from one group or the other. The table below shows how many IT and non-IT economies are in each quartile of the distribution of the countries' (dollar and real) exchange rate percentage changes variances for the period after IT adoption (and after July 1999 for non-IT economies). The main conclusion is that non-IT economies do have lower exchange rate change variances as they are overrepresented in the lower quartiles of the distribution of both the dollar and the real exchange rate changes.

Table 3: Distribution of Exchange Rate Change Variance by Country

	Quartile 1	Quartile 2	Quartile 3	Quartile 4	Total
Real Exchange Rate Percentage Change Variance					
IT	3	7	7	7	24
Non-IT	9	5	5	4	23
Dollar Exchange Rate Percentage Change Variance					
IT	3	5	10	9	27
Non-IT	10	8	3	6	27

NOTES: Author's calculations. Quartile 1 corresponds to the 25% of countries with lowest variances and Quartile 4 to the 25% of countries with highest variances of exchange rate percentage changes.

Figure 1: Real and Nominal Exchange Rate Depreciation Densities: IT and non-IT
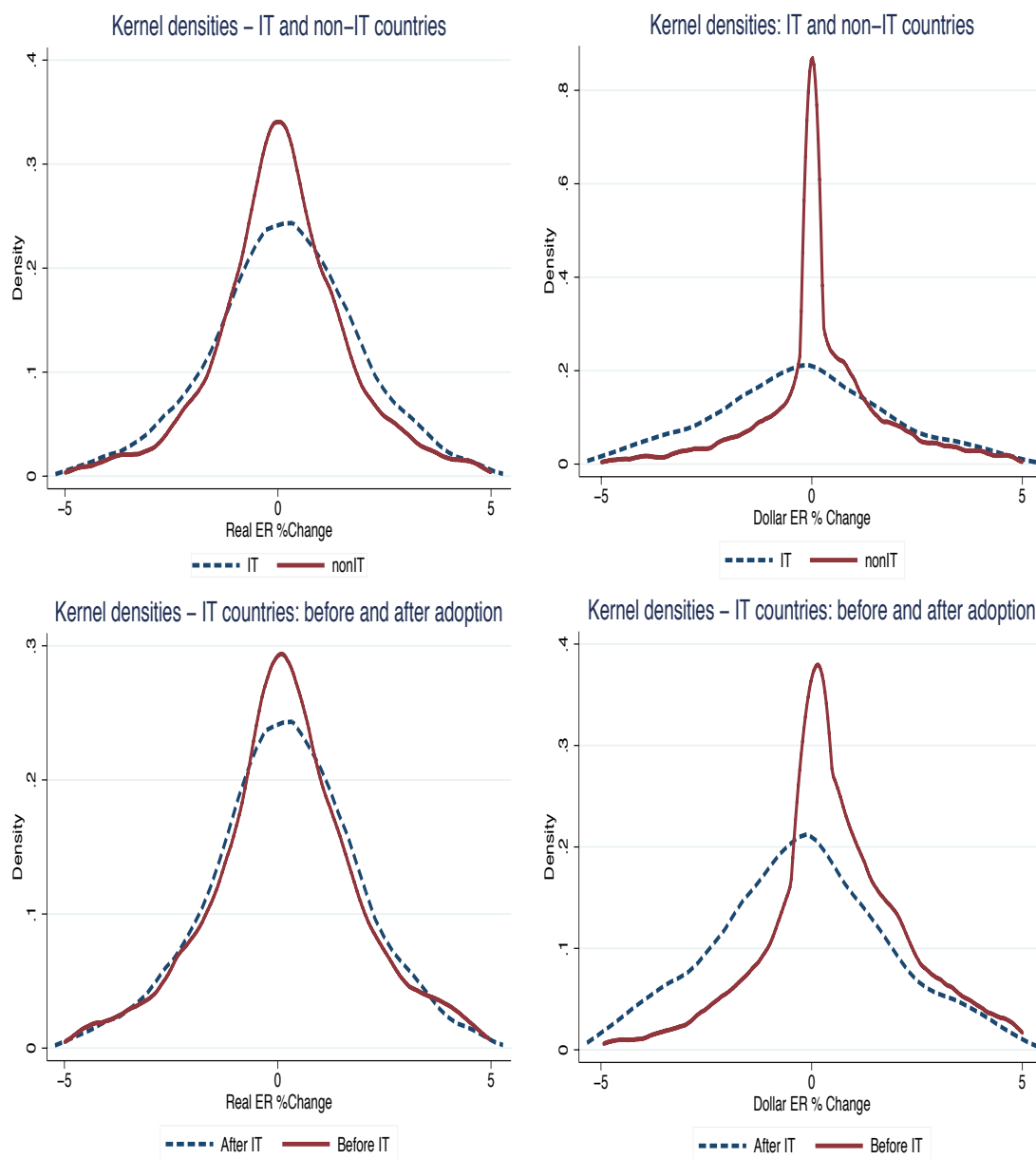
3 Why Adopt IT?

An important question is why countries adopt IT. In this section I briefly make some considerations regarding this decision.

Inflation Targeting is generally viewed as a way to bolster the credibility of monetary policy. Its emphasis on communication is seen as anchoring expectations of future inflation, possibly leading to a more favorable inflation output trade-off.

Bernanke et al. (1999) defines IT as:

"...a framework for monetary policy characterized by the public announcement of official quantitative targets (or target ranges) for the inflation rate over one or more target horizons, and by explicit acknowledgement that low, stable inflation is monetary policy's

primary long-run goal."

IT is therefore a framework that assigns monetary policy decisions to domestic goals. An important condition for making domestic inflation the main policy target is to allow for some degree of exchange rate fluctuation. With open capital accounts, monetary policy cannot be focused on domestic objectives unless the value of the currency can change. This is known as the open economy trilemma.[11] In the other extreme, some countries choose to peg their currencies or to keep tight controls of capital flows. A small open economy closely related to a larger one will have greater benefits by fixing its exchange rate relative to that larger economy's currency. Also an economy with closed capital account will not have much to gain from an IT regime, given that it can control domestic interest rates and the exchange rate simultaneously.

One of the main costs of IT is the requirement of a floating exchange rate regime. Exchange rate volatility tends to generate inflation shocks (in the form of pass-through of imports prices to domestic prices) and terms of trade shocks which may require tighter monetary policy and induce higher output volatility. Some economists have suggested that IT has reduced the costs associated with flexible exchange rates; Bernanke et al. suggests that it has generated an environment of "constrained discretion" for monetary policy, combining the benefits of rules and discretion. The benefits generally associated with IT include the achievement of lower inflation rates and inflation expectations, lower pass-through into inflation of exchange rate shocks, insulation of policymakers from political pressures, and greater policymaker accountability.

4   Data

All the data used in this paper were obtained in the *International Financial Statistics (IFS/IMF)* database.

All variables analyzed in Section 2 above have monthly frequency. The dollar exchange rate is always the nominal exchange rate relative to the US dollar and is given by the nominal "market rate" concept in the IFS data set. The real exchange rate is the consumer price index (CPI) based real exchange rate (*"rec"* concept). The reserves are given by the variable "total reserves minus gold" in the IFS data. The interest rate definition used is the "money market" interest rate.

In Section 5 below I estimate a structural model (described below) for twenty two IT economies. These countries were selected because they have a long enough experience with the IT framework that allowed me to estimate the model. The data used have observations for the real output growth, inflation, nominal interest rates, nominal effective exchange rate changes, and terms of trade changes. The structural model was estimated using quarterly frequency data. The data for each country start in the quarter when IT was adopted and the last observation is always for the 2011:1 quarter.

All data in Section 5 are seasonally adjusted. The output growth rate is the log difference of real GDP, which was multiplied by 100 to obtain quarter-to-quarter percentage growth rates. The inflation rate used is the log difference of the CPI index, multiplied by 400 to obtain annualized rates. The nominal interest rates correspond to the average

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[11]For a detailed discussion on the monetary policy trilemma see Obstfeld et al. (2005) and Obstfeld et al. (2010).

target rate specified by each central bank in a given quarter. The exchange rate change corresponds to the log difference, multiplied by 100, of the average nominal effective exchange rate in a given quarter (positive changes correspond to a depreciation). The terms of trade data were converted into log differences and then multiplied by 100 in order to obtain quarter-to-quarter percentage changes. All series were demeaned prior to the structural model estimation.

5 Structural Model

5.1 Model Description

In this section I estimate a dynamic stochastic general equilibrium (DSGE) model for twenty two IT countries.[12] The model fitted represents a small open economy close to that in Gali and Monacelli (2005) which follows the tradition of the New Open Economy Macroeconomics (NOEM) models. The empirical technique, Bayesian analysis, is based on Lubik and Schorfheide (2007).

Until recently, the most common strategy adopted by economists who sought to investigate whether central banks respond to exchange rate movements was to estimate a Taylor rule expanded to allow for an exchange response, an approach that became popular after the work of Clarida, Gali and Gertler (1998). The reduced form approach was used, for example, by Eichengreen (2004), who investigated if the Bank of Korea responded to the exchange rate in the period from 1998 to 2003.

The structural approach allows the econometrician to avoid the problems related to endogenous independent variables that have been in the center of the criticism to reduced form estimates since it incorporates the model structural restrictions in the estimation. One advantage of the Bayesian estimation procedure is that additional information may be added to the estimation when assigning prior distributions to the parameters. Moreover, the estimates allow the evaluation of the importance of different structural shocks through impulse response functions and variance decompositions.[13]

The Bayesian estimation procedure involves the specification of a prior distribution for the parameters θ to be estimated, $f(\theta)$. The data is then used to construct a likelihood function associated with the model economy, $L(\theta|Y_T)$; where $Y_T = [Y_1, ..., Y_T]$ is a matrix where each column is a vector composed of the observable variables in period t, Y_t. Finally, the Bayes Theorem is used to determine the posterior distribution of the parameters:

$$f(\theta|Y_T) = \frac{L(\theta|Y_T)f(\theta)}{\int L(\theta|Y_T)f(\theta)\mathrm{d}(\theta)}$$

The model is an open economy extension of the New Keynesian model first developed for closed economies. As in its closed economy counterpart the model consists of an IS equation and a Phillips curve, but here expanded to take into account the interaction between the domestic economy and the rest of the world. The exchange rate is introduced

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[12]I estimate the model for twenty two IT countries, instead of doing it for all the twenty seven, because some them adopted the framework recently making the available series too short for the estimation of the model.

[13]For an introduction to the Bayesian analysis of DSGE models see An and Schorfheide (2005).

in the definition of the consumer price index (CPI) and the terms of trade is governed by an exogenous AR(1) process. Finally, the model is closed with an interest rate relationship as in Taylor (1993) expanded to allow for interest smoothing and for policymakers' response to the exchange rate movements.

The open-economy IS equation is obtained by combining the consumption Euler equation, the goods market clearing condition and the assumption of complete securities market:

$$y_t = E_t y_{t+1} - [\tau + \alpha (2 - \alpha) (1 - \tau)] (r_t - E_t \pi_{t+1}) - \rho_z z_t - \alpha [\tau + \alpha (2 - \alpha) (1 - \tau)] E_t \Delta q_{t+1} + \alpha (2 - \alpha) \left(\frac{1-\tau}{\tau}\right) E_t \Delta y_{t+1}^*$$

where $(1 - \alpha)$ is related to the degree of home bias in preferences, (α can be interpreted as openness measure), τ is the elasticity of intertemporal substitution, y^* is the exogenous world output, z is the world productivity growth rate, and q_t is the terms of trade. The endogenous variables are the aggregate output y_t and the CPI inflation rate π_t. The world productivity level evolves according to:

$$\frac{A_t}{A_{t-1}} = \gamma e^{z_t}$$

where $z_t = \rho_z Z_{t-1} + \varepsilon_t^z$. The Phillips curve is derived from the firms' optimal strategy in a Calvo price setting:

$$\pi_t = \beta E_t \pi_{t+1} + \alpha \beta E_t \Delta q_{t+1} + \frac{\kappa}{\tau + \alpha(2-\alpha)(1-\tau)} (y_t - \bar{y}_t)$$

Where $\bar{y}_t = -\alpha (2 - \alpha) (1 - \tau) \frac{1}{\tau y_t^*}$ is the potential output, the slope of the Phillips curve κ is a function of different structural parameters and β is the discount rate.

I now go over the main steps of the derivation of an equation linking movements in the consumer price index (CPI), the nominal exchange rate, the terms of trade and the world price index. The log-linearized CPI equation is given by:

$$p_t = (1 - \alpha) p_{H,t} + \alpha p_{F,t}$$

$$p_t = p_{H,t} - \alpha q_t$$

where p_t is the log of the CPI index, $p_{F,t}$ is the log of the price index of the imported goods, $p_{H,t}$ is the log of the price index for the domestically produced goods, and $q_t = p_{H,t} - p_{F,t}$ is the (log) terms of trade.

It is possible to obtain an expression linking the (log) price index of imported goods, $p_{F,t}$, the (log) nominal effective exchange rate, e_t, and the (log) world price index, p_t^*:

$$p_{F,t} = e_t + p_t^*$$

Then, using the definitions of the terms of trade and of the CPI index, it turns out that the CPI inflation can be described as a function of the exchange rate depreciation Δe_t, the terms of trade change Δq_t and the rest of the world inflation π_t^*:

$$\pi_t = \Delta e_t + (1 - \alpha) \Delta q_t + \pi_t^*$$

The terms of trade growth rate is assumed to evolve according to an exogenous AR(1) process:

$$\Delta q_t = \rho_q \Delta q_{t-1} + \varepsilon_t^q$$

The interest rate rule allows for the possibility that policymakers respond to exchange rate devaluations (i.e., $\psi_3 \neq 0$):

$$r_t = \rho_r r_{t-1} + (1 - \rho_r) [\psi_1 \pi_t + \psi_2 y_t + \psi_3 e_t] + \varepsilon_t^r$$

Where r_t is the interest rate, ρ_r is a smoothing term included to match the persistence of nominal interest rates and ε_t^r is a white noise policy shock. Finally, the world output and inflation are both assumed to follow autoregressive processes:

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_t^{\pi^*}$$

$$y_t^* = \rho_{y^*} y_{t-1}^* + \varepsilon_t^{y^*}$$

The Bayesian estimation method provides a straightforward way to answer the question of how the central banks react to exchange rate movements. In order to do this two versions of the model are estimated; one imposes $\psi_3 > 0$ (model A) and the other $\psi_3 = 0$ (model B). The posterior odds ratio of the two model specifications is then calculated and it is the statistic used to judge which model fits the data better. Formally, the posterior odds ratio is given by:

$$\frac{\pi_{A,T}}{\pi_{B,T}} = \frac{\pi_{A,0}}{\pi_{B,0}} \frac{pr(Y^T|A)}{pr(Y^T|B)}$$

The first factor is the prior odds ratio in favor of model A. The second factor is known as the Bayes factor and corresponds to the sample evidence in favor of model A. The term $pr(Y^T|A)$ is the marginal data density. I impose a prior odds ratio equal to one.

5.2   Estimation

I follow Lubik and Schorfheide (2007) to choose the structural parameters priors. I specify prior distributions for each parameter and assume they are independently distributed. The complete description of the priors is in Table 3.

The prior distributions of the Taylor rule parameters (Table 3) are centered at values commonly found in the literature and allows for a fair amount of parameter uncertainty. The interest rate smoothing coefficient prior has mean 0.50 and standard deviation 0.20. The prior distribution of the steady state interest rate has mean 2.5% and standard deviation 1.00. The slope of the Phillips curve coefficient has mean 0.50 with a relatively large standard deviation. The prior for the preference parameter α has mean 0.20 and standard deviation 0.05. The parameter τ is restricted to be smaller than one, with a mean of 0.50. Finally, the priors of autoregressive coefficients of the foreign inflation, rest

of the world output, technology growth and terms of trade growth are centered at 0.80, 0.90, 0.40 and 0.20, respectively. I choose identical parameters for each model economy.

The policy rule estimated parameters are in line with results previously found in the literature (Table 4). The estimates show that all central banks pursue anti-inflationary policies; with the response to inflation coefficients ranging from 1.08 to 2.82 (United Kingdom and New Zealand, respectively). The response to the output is the highest in South Africa ($\psi_2 = 0.44$) and the lowest in Korea and Thailand ($\psi_2 = 0.04$). There is also a high degree of interest rate smoothing, with all estimates of ρ_r above 0.60. Finally, among the economies for which I found evidence of a policy response to exchange rate movements (see Table 5 below), the response is the highest in Israel $\psi_3 = 0.43$ and the lowest in New Zealand $\psi_3 = 0.13$. It is noteworthy that the parameters estimates fall in a relatively wide range, giving no indication that the prior distributions imposed severe restrictions to the posterior mean.

A question that the literature on monetary policy has been concerned with is whether the coefficients of the Taylor rule are such that determinacy of the equilibrium is ensured. Woodford (2003) shows that, for different classes of models, the determinacy of the equilibrium is ensured for coefficients of inflation and output with magnitudes equal to those presented in Table 4.[14]

Table 3: Prior Distribution of Parameters

Parameter	Distribution	Mean*	Standard Deviation*	Domain
ψ_1	Gamma	1.5	0.5	$[0, \infty)$
ψ_2	Gamma	0.25	0.13	$[0, \infty)$
ψ_3	Gamma	0.25	0.13	$[0, \infty)$
ρ_r	Beta	0.50	0.2	$[0, 1)$
ρ_q	Beta	0.20	0.10	$[0, 1)$
ρ_z	Beta	0.40	0.10	$[0, 1)$
ρ_{y^*}	Beta	0.90	0.05	$[0, 1)$
ρ_{π^*}	Beta	0.80	0.10	$[0, 1)$
α	Beta	0.20	0.05	$[0, 1)$
rr	Gamma	2.50	1.00	$[0, \infty)$
κ	Gamma	0.50	0.25	$[0, \infty)$
τ	Beta	0.50	0.20	$[0, 1)$
σ_r	Inv. Gamma	0.50	4.00	$[0, \infty)$
σ_q	Inv. Gamma	1.50	4.00	$[0, \infty)$
σ_z	Inv. Gamma	1.00	4.00	$[0, \infty)$
σ_{y^*}	Inv. Gamma	1.50	4.00	$[0, \infty)$
σ_{π^*}	Inv. Gamma	0.55	4.00	$[0, \infty)$

*NOTE: For the inverse gamma p.d.f. the values in the mean and standard deviation columns stand for, respectively, the parameters s and v in $p(\sigma|v,s) \propto \sigma^{-v-1} e^{\frac{-vs^2}{2\sigma^2}}$

[14]See Woodford (2003) chapter 4; in particular, pages 252 to 261.

Table 4: Policy Rule Parameter Estimates

Country	ρ_r	ψ_1	ψ_2	ψ_3
Australia	0.90	1.54	0.11	-
Brazil	0.80	2.12	0.17	-
Canada	0.82	1.10	0.27	-
Chile	0.60	1.67	0.05	-
Colombia	0.76	1.86	0.07	-
Czech Republic	0.81	1.22	0.19	-
Hungary	0.80	1.23	0.29	-
Indonesia	0.89	1.15	0.43	-
Israel	0.86	2.25	0.10	0.43
Korea	0.85	1.92	0.04	-
Mexico	0.69	2.26	0.05	-
Norway	0.88	1.38	0.09	0.37
New Zealand	0.83	2.82	0.06	0.13
Peru	0.79	1.75	0.06	0.25
Philippines	0.93	1.84	0.08	-
Poland	0.82	2.24	0.19	-
South Africa	0.80	1.09	0.44	-
Sweden	0.90	2.57	0.05	-
Switzerland	0.79	1.33	0.20	-
Thailand	0.92	1.52	0.04	0.32
Turkey	0.77	2.07	0.09	-
United Kingdom	0.76	1.08	0.21	-

The main result of this chapter is presented in Table 5. In this table I present the estimated policy response to exchange rate movements, the log-density of the restricted model ($\psi_3 = 0$), the log-density of the unrestricted model ($\psi_3 \neq 0$), and whether there is evidence in favor of the restricted or the unrestricted model.[15] Only the central banks from Israel, New Zealand, Norway, Peru and Thailand systematically respond to exchange rate movements, all the other central banks set interest rates without directly responding to the exchange rate.

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[15]See David and Dejong (2007) for more details on the interpretation of the posterior odds ratio

Table 5: Policy Response to the Exchange Rate, Log-Densities and Model Selection

Country	ψ_3	$Log-$ $Density\psi_3 =$ 0	$Log-$ $Density\psi_3 \neq$ 0	$\psi_3 = 0?$
Australia	0.0976	-676.8669	-533.9522	Yes***
Brazil	0.0465	-664.4027	-658.6600	Yes***
Canada	0.0581	-743.0129	-737.9532	Yes***
Chile	0.1518	-581.8380	-580.9195	Yes*
Colombia	0.0542	-477.4347	-472.3211	Yes***
Czech Republic	0.0708	-480.5159	-476.1541	Yes***
Hungary	0.0687	-396.4406	-392.4747	Yes***
Indonesia	0.0973	-284.5699	-280.1239	Yes***
Israel	0.4271	-673.1477	-688.9230	No***
Korea	0.0898	-426.8680	-424.8282	Yes**
Mexico	0.0559	-496.0405	-490.4050	Yes***
Norway	0.3735	-491.7616	-495.8553	No***
New Zealand	0.1279	-854.5488	-856.2787	No**
Peru	0.2518	-415.6549	-416.1012	No*
Philippines	0.2251	-254.9419	-249.9507	Yes***
Poland	0.0845	-625.3021	-619.2816	Yes***
South Africa	0.0273	-473.1856	-460.5712	Yes***
Sweden	0.1114	-645.1576	-643.6892	Yes**
Switzerland	0.0928	-335.6472	-333.7475	Yes**
Thailand	0.3156	-415.1063	-419.8778	No***
Turkey	0.1174	-276.5259	-274.3320	Yes**
United Kingdom	0.1294	-593.3507	-592.4632	Yes*

NOTE: ***, ** and * stand for "very strong evidence in favor of the selected model" , "strong evidence in favor of the selected model",

and "some evidence in favor of the selected model". See Dave and DeJong (2007) for more details.

I also estimate a version of the model where the priors are all assumed to be uniformly distributed. Assigning this kind of priors is potentially useful in detecting identification problems. The parameters posterior means remained stable.

I compute variance decompositions (see Appendix) to check for the relative importance of the different shocks. GDP is always driven mostly by technological shocks and foreign output shocks. The same is also true for inflation but in this case policy shocks also play an important role. Regarding the exchange rate, foreign inflation shocks always plays the most prominent role, followed by terms of trade shocks.

I calculate impulse response functions to better understand the model dynamics; for brevity I only report the result for Chile (see Figure A.1 in the appendix). An adverse monetary policy shock, defined as a one standard deviation increase in the monetary rule error term, leads to lower output, lower inflation and currency appreciation. Better terms of trade lead to exchange rate appreciation and lower inflation, interest rate is reduced and output increases. Higher technology growth increases output and lowers inflation, prompting interest rates to go down and the currency to appreciate.

Regarding the shocks from the rest of the world, a positive rest of the world output shock reduces potential output, increasing inflation and the exchange rate. This causes

output to go down due to an increase in interest rates. In the case of higher rest of the world inflation the exchange rate appreciates leading to a relaxation of monetary policy, which generates higher output and inflation.

6   Conclusion

I show that exchange rates have been fluctuating relatively free in IT countries. The evidence suggests that the adoption of IT regimes is associated with higher exchange rate volatility.

The results from the small-scale DSGE model estimated suggest policymakers in most IT regimes do not try to stabilize the exchange rate. I estimate two versions of the structural model and the posterior odds analyses imply that only the central banks of Israel, New Zealand, Norway, Peru and Thailand do respond to the exchange rate. All the other IT central banks do not respond to the exchange rate.

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A   Inflation Targeting Countries Adoption Dates

Table A.1: Inflation Targeting Countries Adoption Dates

Country	Adoption Date	Country	Adoption Date
Australia	1994m4	New Zealand	1990m1
Brazil	1999m6	Norway	2001m3
Canada	1991m2	Peru	2002m1
Chile	1999m9	Philippines	2002m1
Colombia	1999m9	Poland	1998m10
Czech Republic	1997m12	Romania	2005m10
Ghana	2007m5	Serbia	2006m9
Guatemala	2005m1	South Africa	2000m4
Hungary	2001m6	Sweden	1995m1
Iceland	2001m3	Switzerland	2000m1
Indonesia	2005m7	Thailand	2000m7
Israel	1997m6	Turkey	2006m1
Korea	2001m1	United Kingdom	1992m10
Mexico	2001m1		

SOURCE: Central Banks' websites, Svensson (2010).

B   Non Inflation Targeting Countries

Table A.2: Non Inflation Targeting Countries

Algeria	Croatia	Jordan	Russia
Argentina	Denmark	Kazakhstan	Trinidad and Tobago
Azerbailan	Dominican Republic	Latvia	Tunisia
Belarus	Egypt	Lebanon	United States
China	India	Malaysia	Uruguay
Costa Rica	Iran	Morocco	Venezuela
Cote dIvoire	Japan	Pakistan	

C Variance Decompositions and Impulse Responses for Chile

Table A.3: Variance Decomposition for Chile

Endogenous Variables	Source of Shock (%)				
	Policy	Terms of Trade	Technology	World Output	World Inflation
Output	1.79	0.11	9.03	89.07	0.00
Inflation	21.33	16.82	59.71	2.14	0.00
Interest Rate	16.68	13.26	68.81	1.24	0.00
Exchange Rate	0.13	22.82	0.37	0.01	76.67

Figure A.1: Impulse Responses to a One Standard Deviation Shock for Chile

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