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Does Central Bank Capital Matter for Monetary Policy?

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Does Central Bank Capital Matter for Monetary Policy?*

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Abstract

Heavy foreign exchange intervention by central banks of emerging markets have lead 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 sheet 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, suggests that central bank financial strength can be a statistically significant factor explaining large negative interest rate deviations from "optimal" levels.

JEL Classification Numbers: E43, E52, E58

Keywords: Central bank capital, central bank financial strength, monetary policy.

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Contents Page

I. 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 (Figure 1). 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 crisis. 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 2), as lower tolerance for inflation led to reduced seigniorage and revaluation losses arising 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 denominated 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 effect 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 shrank.[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 a 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 to recapitalize themselves through seigniorage,[4] or

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[1] See Adler and Tovar (2011) for a detailed account of FX intervention policies in emerging economies, and their impact on exchange rate dynamics.

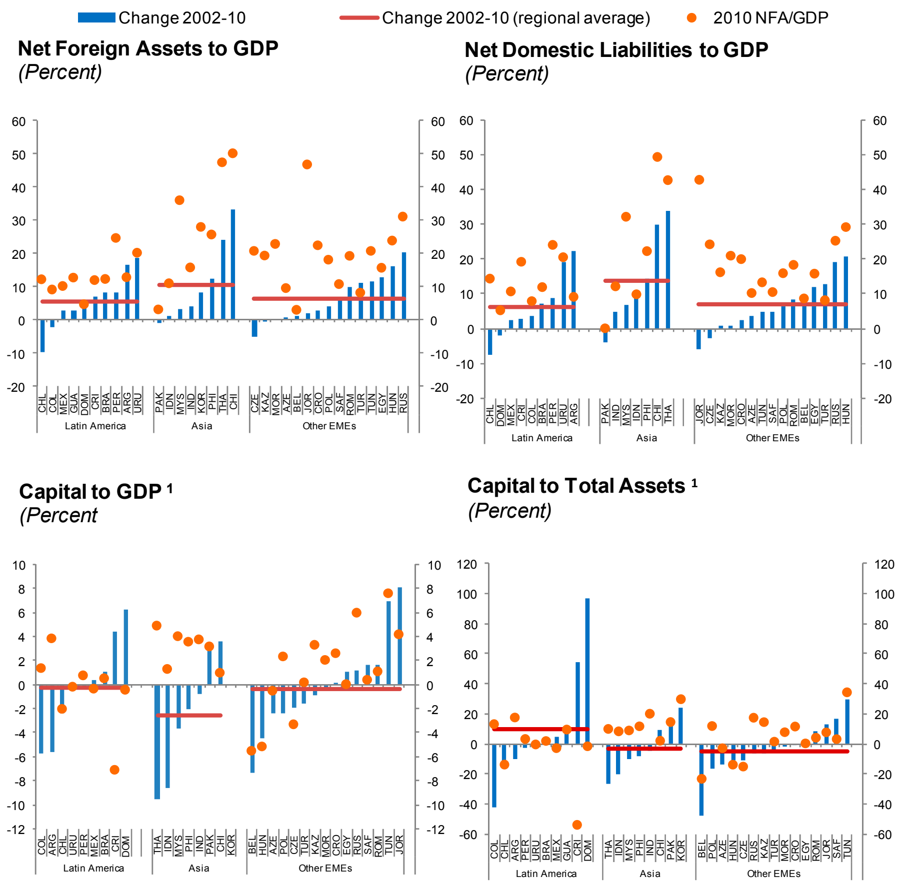
[2] While the issue of central bank financial strength has also become increasingly relevant in a number of advanced economies—as they expanded their balance sheets with the so called "unconventional" policies—the focus of this paper is primarily on emerging markets, where currency mismatches in central bank balance sheets have become more pronounced and so the costs 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.

[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 although losses can be offset by future senioriage, this strategy could conflict with the goal of domestic price stability.

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).[5] 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,[6] leading central bankers to pursue sub-optimal policies in order to minimize the risk of losing independence (Jeanne and Svensson, 2007).[7]

Figure 1: Dynamics of Main Components of Central Bank Balance Sheets in EMEs



Source: Author's estimates on the basis of *IMF International Financial Statistics*.
¹ Includes other items net.

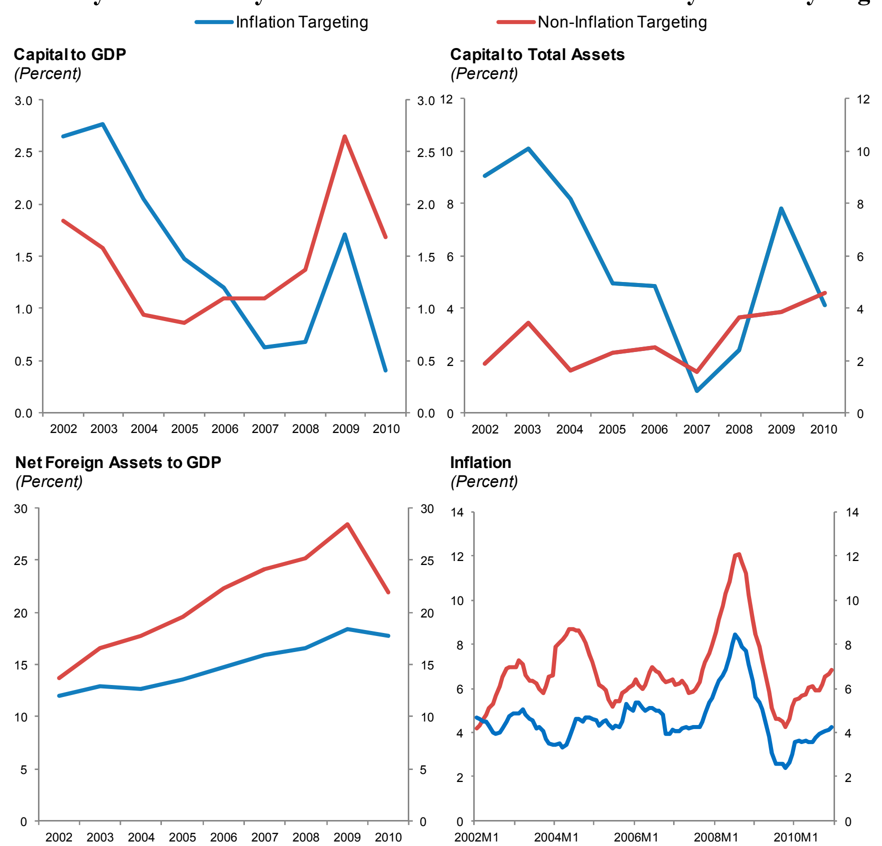
[5] Those with this view often highlight the Chilean case as an example, arguing that, despite carrying negative capital for several years, the central bank was considered highly credible and successful in maintaining inflation under control. A healthy consolidated government fiscal position—which some 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.

This paper assesses empirically whether CBFS constraints monetary policy decisions. Although previous studies have explored the nexus between CBBS and macroeconomic outcomes, such as inflation (Klüh and Stella, 2008; Stella, 2007),[8] to our knowledge our paper constitutes the first attempt to study empirically the extent to which CBFS interferes with monetary policy decisions per se. Our approach entails three steps: (i) finding a suitable 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 and advanced market countries over the period 2002:M1—2011:M3.

Figure 2: Dynamics of Key Central Bank Balance Sheet Items by Monetary Regime



Source: Author's estimates on the basis of IMF *International Financial Statistics*.

[8] A more recent mimeo by Benecká et al (2012) also explores the link between central bank financial strength and inflation, finding weak evidence.

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 sub-optimal monetary* policies (lower deciles of the distribution) but not for *nearly optimal policies*. In fact, our measure of CBFS explains deviations of up to 72 basis points in policy interest rates when such rates are below "optimal."

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 of our analysis, and avenues for future research.

II. Methodology and Data

A. Central Bank Financial Strength

The study of the financial structure CBBS has received little attention in the literature. As a result, there is neither theoretical guidance as to which is the best way to measure the CBFS nor available data on such measures for more than one country at a time.

For the purposes of this paper a key consideration is that the extent to which CBBS interferes with monetary policy decisions may depend both on the extent of the currency mismatch and the level of capital. This follows from the fact that our focus is on emerging market countries. 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 dimension. Another important 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:

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

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 may not fully capture some subtleties. Indeed, although it 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. 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.[9] 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.[10]

B. 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 for each individual country and use out-of-sample forecasted 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 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:

$$i_t = \alpha + \rho_1 i_{t-1} + \rho_2 i_{t-2} + \beta_1 [E_t(\pi_{t+12}|I_t) - \pi^*] + \beta_2 [E_t(y_t - y^*)] + \beta_3 \Delta e_{t-1} + \varepsilon_t \qquad (2)$$

Where i_t is the monetary policy interest rate in period *t*, $E_t(\pi_{t+12}|I_t) - \pi^*$ is the expected 12-months ahead CPI inflation gap (relative to the inflation target[11]), $E_t(\pi_{t+12}|I_t) - \pi^*$ 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

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[9] 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).

[10] 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)*.

[11] 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.

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. 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 ($k = 1, 3, \text{and } 6$):

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

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:

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

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.

C. 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:

$$MPC_t = \gamma_0 + \gamma_1 CBFS_t + \epsilon_t \quad (6)$$

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, 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.

D. 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 derive the measure of 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 the interest rate rule is estimated over the pre-crisis period (2002:1-2008:8) and the MPC variable is measured using 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. Given the possible sensitivity of the results to this choice of sub-periods, we latter explore the robustness of the results to such choice (as well as other dimensions- see Section III.C).

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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 regression 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).

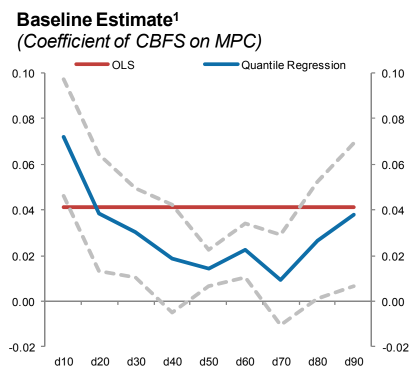
III. Econometric Results

A. Assessing whether CBFS Interferes with the Conduct of Monetary Policy

Our results suggest that weak CBFS does constrain monetary policy. Figure 4 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 $MPC_t = i_t - i_t^*$). In other words, improving the financial conditions of a central bank helps ease constrains 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.

However, we find that the relationship between CBFS and MPC is highly non-linear. Figure 4 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 and therefore suggests that interest rates are below "optimal" levels), a 10 percent increase in our CBFS measure decreases the size of interest rate gap by 72 basis points (i.e. $\Delta MPC_t = .72$). However, as policy rates move closer to their optimal level—i.e. 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.

Figure 3: Baseline Results from OLS and Quantile Regression



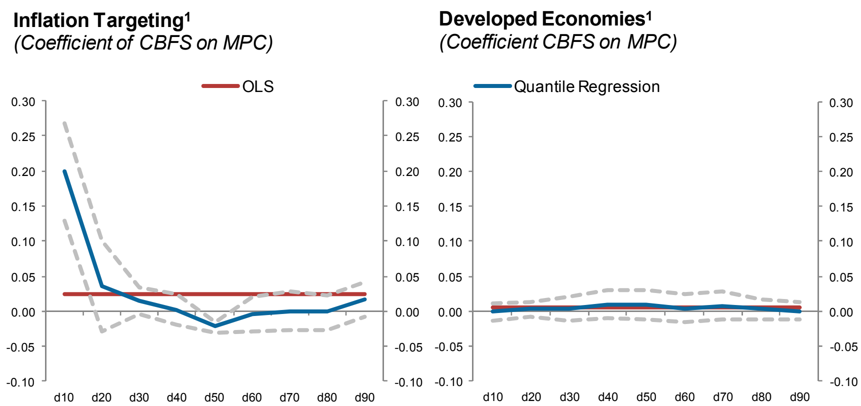
Source: Author's estimates.
[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure. Dotted lines show the 95% confidence interval.

Monetary Policy Regime and Development Stage

The importance of CBFS does not appear to 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 5) 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 of an IT regime may not suffice to insulate central bank monetary policy decisions from balance sheet considerations.

The strength of the general institutional setting, on the other hand, does seem to 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. 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 4: Results for IT and Developed Countries



Source: Author's estimates.

[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure . Dotted lines show the 95% confidence interval.

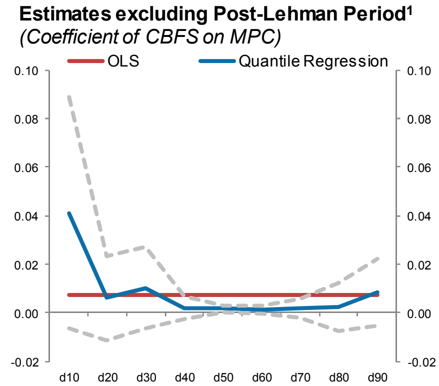
B. Robustness Analysis

This section examines the robustness of the 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 possible 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 similar those of our benchmark estimates (Figure 6), but there appears to be a level effect. At the same time, a smaller sample size makes the estimates less precise, an effect clearly captured by the wider 95 percent confidence band.

Figure 5: Results under Alternative Sample Period

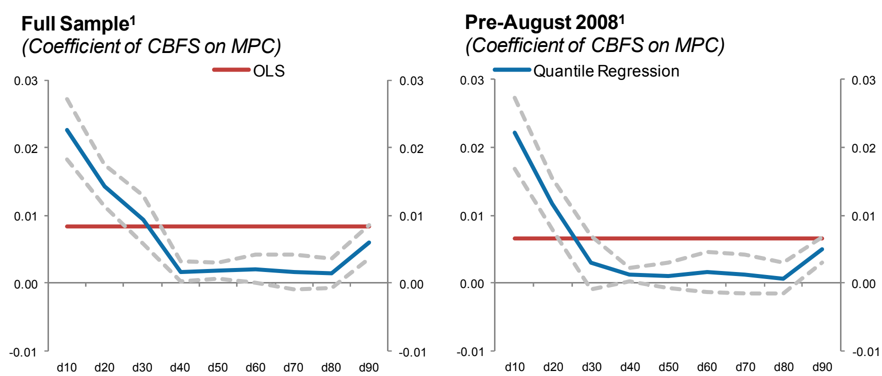


Source: Author's estimates.
[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure. Dotted lines show the 95% confidence interval. Estimation period 2002-2006 and out-of-sample forecasts for the period 2007:1-2008:8.

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 (Figure 7) and confirm the robustness of the results to the choice of sample period estimation. Quite interesting, these results confirm the importance of considering nonlinearities, which turn out to be somewhat more pronounced than in the benchmark model.

Figure 6: Sensitivity to Forecast Sample Period



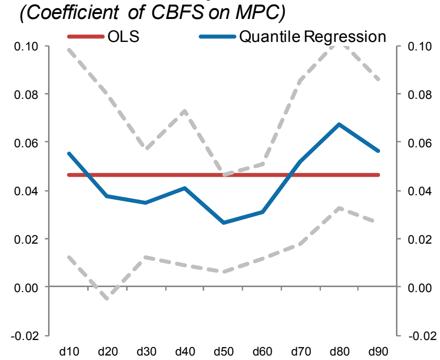
Source: Author's estimates.
[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure . Dotted lines show the 95% confidence interval.

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 8). 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 that failing to include such valuation changes could invalidate any relationship between capital and financial strength (see Ize and Nada, 2009).

Figure 7: Sensitivity to the Definition of CBFS

CBFS defined as Capital to Assets[1]
(Coefficient of CBFS on MPC)

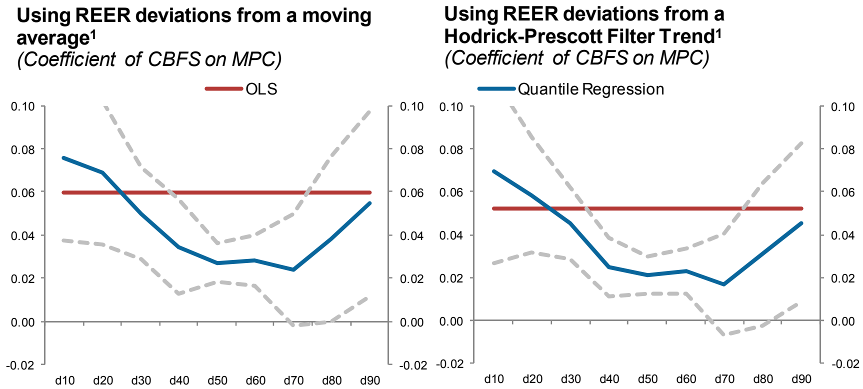


Source: Author's estimates.
[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure. Dotted lines show the 95% confidence interval.

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 (Figure 9). Moreover, contrary to what we would expect, CBFS appears to be more relevant in explaining our MPC indicator.

Figure 8: Results after Controlling for Exchange Rate Misalignment

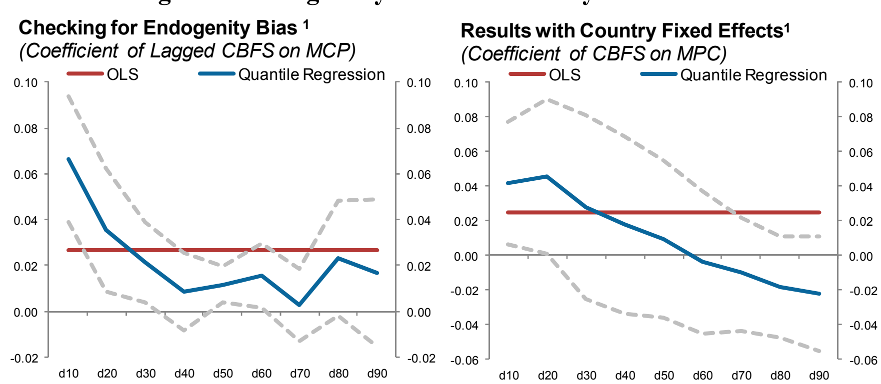


Source: Author's estimates.
[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure . Dotted lines show the 95% confidence interval.

Reverse Causation and Country Fixed-Effects

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 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 Figure 10, 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 9: Endogeneity Bias and Country Fixed Effects



Source: Author's estimates.
[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure . Dotted lines show the 95% confidence interval.

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[1] Horizontal axis: Deciles over the monetary policy constrain (MPC) measure . Dotted lines show the 95% confidence interval.

Overall, results suggest that CBBS plays a statistically significant role in explaining "suboptimal" monetary policies in a nonlinear manner. In particular, quantile regression estimates show that large negative deviations from optimal policy ('undershooting') can be explained, at least partially, by CBFS.

IV. 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 has 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 address this issue in an empirical manner.

We find evidence that a weak central bank balance sheet can influence the conduct of monetary policy. Furthermore, the relationship between central bank balance sheets and monetary policy appears to be highly non-linear—i.e., large deviations from optimal policy are associated with very weak balance sheets.

Certainly, further research in this area is needed. A comprehensive understanding of the relevance of central banks' balance sheets requires refining our measure of central bank financial strength—to fully capture currency mismatches or interest rate risk—while at the same time preserving comparability across countries. Equally important is to improve our understanding of the specific mechanisms through which CBFS influences monetary policy. This includes assessing how the macroeconomic and institutional environment, in particular fiscal arrangements, could influence the link between central bank financial strength and monetary policy decisions. Finally, the methodology could also be applied to examine potential side effects of rapidly expanding central bank balance sheets in advanced economies (as a result of the adoption of non-traditional policies, i.e. quantitative easing).

APPENDIX

Table A.1. Economic Development and Inflation Targeting Classification

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

Sources: IMF Classification, Central Banks web sites, and Svensson (2010)
Note: A country was classified as Inflation Targeting (IT) if it officially followed an IT policy at some point during period. Among the countries in our sample, there was no transition from non-IT to IT, and vice-versa, after August 2008.

Table A.2: Taylor Rule Variables Definitions

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 log 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.

ANNEX: MAIN REGRESSION TABLES

Benchmark: Pooled OLS Regression

	(1)
	reslhs_cbfs1_ols
VARIABLES	reslhs
cbfs1	0.0414***
	(0.00905)
Constant	-1.520***
	(0.166)
Observations	813
R-squared	0.032

Robust standard errors in parenthese:
*** p<0.01, ** p<0.05, * p<0.1

Benchmark: Quantile Regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
cbfs1	0.0718***	0.0385***	0.0300***	0.0188	0.0145***	0.0224***	0.00949	0.0265*	0.0378**
	(0.0137)	(0.0136)	(0.0102)	(0.0128)	(0.00485)	(0.00612)	(0.0104)	(0.0139)	(0.0164)
Constant	-6.020***	-3.797***	-2.906***	-2.160***	-1.340***	-0.786***	-0.0562	1.004***	2.285***
	(0.384)	(0.290)	(0.143)	(0.244)	(0.103)	(0.153)	(0.0812)	(0.198)	(0.257)
Observations	813	813	813	813	813	813	813	813	813

Standard errors in parenthese:
*** p<0.01, ** p<0.05, * p<0.1

Pooled OLS: Inflation Targeting Countries

	(1)
	reslhs_cbfs1_ols_IT
VARIABLES	reslhs
cbfs1	0.0235
	(0.0184)
Constant	-2.861***
	(0.249)
Observations	339
R-squared	0.005

Standard errors in parenthese:
*** p<0.01, ** p<0.05, * p<0.1

Quantile Regression: Inflation Targeting Countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
cbfs1	0.199***	0.0360	0.0144	0.00199	-0.0228***	-0.00418	0.000288	-0.00163	0.0169
	(0.0356)	(0.0330)	(0.00970)	(0.0111)	(0.00408)	(0.0129)	(0.0138)	(0.0124)	(0.0127)
Constant	-9.187***	-4.831***	-3.166***	-2.652***	-1.831***	-1.346***	-0.253	0.161	0.771***
	(0.696)	(0.465)	(0.260)	(0.261)	(0.115)	(0.216)	(0.234)	(0.128)	(0.135)
Observations	339	339	339	339	339	339	339	339	339

Standard errors in parenthese:
*** p<0.01, ** p<0.05, * p<0.1

Pooled OLS: Developed Countries

	(1)
VARIABLES	res_final
cbfs1	0.00453
	(0.00515)
Constant	-2.025***
	(0.120)
Observations	200
R-squared	0.004

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Quantile Regression: Developed Economies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
cbfs1	-0.000898	0.00284	0.00327	0.00986	0.00941	0.00407	0.00810	0.00305	0.000533
	(0.00648)	(0.00546)	(0.00891)	(0.0102)	(0.0106)	(0.0101)	(0.0103)	(0.00714)	(0.00674)
Constant	-3.766***	-3.639***	-3.122***	-2.513***	-2.131***	-1.561***	-1.101***	-0.227	-0.0157
	(0.153)	(0.132)	(0.224)	(0.109)	(0.266)	(0.0981)	(0.265)	(0.200)	(0.0836)
Observations	200	200	200	200	200	200	200	200	200

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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