Inflation Targeting in Financially Stable Economies: Has it Been Flexible Enough?

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The international financial crisis and Great Recession of 2008–09 called for a range of significant policy measures by central banks, beyond aggressive interest rate cuts. Measures have ranged from improving international coordination to purchasing local private loan portfolios and direct intervention in both foreign currency forward and spot markets. For formal inflation-targeting (IT) central banks, a natural question has arisen about whether IT frameworks have been flexible enough to accommodate these diverse policy responses in such a challenging environment, or whether IT restricted their room of maneuver. In this paper we explore the experience of nine IT central banks that did not face

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systemic financial problems, to assess the dimensions in which policy responded to global financial turmoil. Our sample includes economies from around the globe, namely the experiences of Australia, Brazil, Chile, Colombia, Indonesia, Mexico, New Zealand, Peru, and South Korea.

The paper presents two pieces of evidence on the policy actions of these central banks. First, we compare actual monetary policy decisions with estimates from conventionally specified Taylor rules for these economies, using data up to the starting point of the crisis period (the Lehman Brothers collapse). We find large deviations from the rule that cannot be reconciled using plausible expected evolutions of inflation and the output gap. Instead, we find support for an interpretation that accounts for a shift in the weight of past decisions on current decisions—namely, lower persistence. This interpretation points towards considerable policy flexibility within the IT framework. Second, we construct a unique daily history of unconventional measures adopted by these nine central banks. These measures include local and foreign currency facilities, swap or liquidity lines with international organizations such as the Federal Reserve or the International Monetary Fund (IMF), and direct exchange rate interventions undertaken in the midst of the financial debacle. We assess the impact of these policy announcements on key money market variables: local currency interest rates, U.S. dollar onshore interest rates, and nominal exchange rates. We also go on to assess the market impact at the time of implementation. In some cases, the immediate impact of unconventional policies is apparent. However, in other cases, the policy mixes and timing effects are too complex to pinpoint the success of individual measures. Taken as a whole though, these non-monetary policy measures were successful in calming market tensions. The heterogeneity of policy choices reveals the evolving concerns of central banks during the crisis.

1. Assessing Monetary Policy Responses During the Crisis

Taylor (1993) suggested that simple linear reaction functions can describe monetary policy actions reasonably well, by relating the policy rate with the output gap and deviations of inflation from the target. Judd and Rudebusch (1998) suggested this basic description could be improved by controlling for persistence or inertia. Persistent interest rate patterns can arise from several

sources, such as forward-looking expectations, uncertainty about data, and uncertainty about monetary policy transmission (Sack and Wieland, 2000). Moreover, Woodford (2003) and others have argued that predictable and gradual monetary policy actions are consistent with optimal monetary policymaking in the framework of dynamic stochastic general equilibrium models with price stickiness.

In this context, inflation targeting—narrowly interpreted as following Taylor-type rules—means that large changes in interest rates, such as those observed in our sample of central banks, arise from major changes in the underlying arguments, from severely reducing its persistence, or from other reasons. We find evidence supporting the second explanation, showing that interest rates that rigorously followed a standard Taylor rule would, by and large, have surpassed actual monetary policy actions during the severe liquidity crisis following the Lehman Brothers bankruptcy into 2009, but that shifting the persistence parameter in the rule allows for a more precise tracking of actual policy.

1.1 Has Monetary Policy Deviated from Previous Patterns?

Let us represent monetary policy decisions with the following Taylor rule:

$$r_t = \gamma + \rho r_{t-1} + (1-\rho)\left[\gamma_\pi(\pi_{t-1} - \pi^*) + \gamma_x(x_{t-1} - x^*)\right], \quad (1)$$

where r_t is the monetary policy rate at time t, π_t is the 12-month inflation rate, and x_t is the 12-month growth rate of the industrial production index.[1] The parameter γ is a constant, ρ is the persistence coefficient, and γ_π and γ_x are the relative weights on the inflation and output gaps, respectively. In this specification, π_t^* stands for the inflation target, and x_t^* acts as a proxy for the natural output growth rate. We proceed to estimate equation (1) for each of our

1. The estimation uses the annual growth rate of industrial production instead of an output-level gap, due to the lack of long historical monthly time series that could be used to confidently estimate the level of these output gaps. This specification follows Walsh's (2003) view that optimal monetary policy can be thought of as reacting to changes in the output gap instead of its level. For this last variable, and unlike the widely used HP filter (or any other filter for that matter), we choose not to use past, current and future values of growth to infer trend growth, x_t^*, but we use the simple mean of annual industrial production growth over the last 24 months, which has performed satisfactorily in this same context (Moura and de Carvalho, 2009).

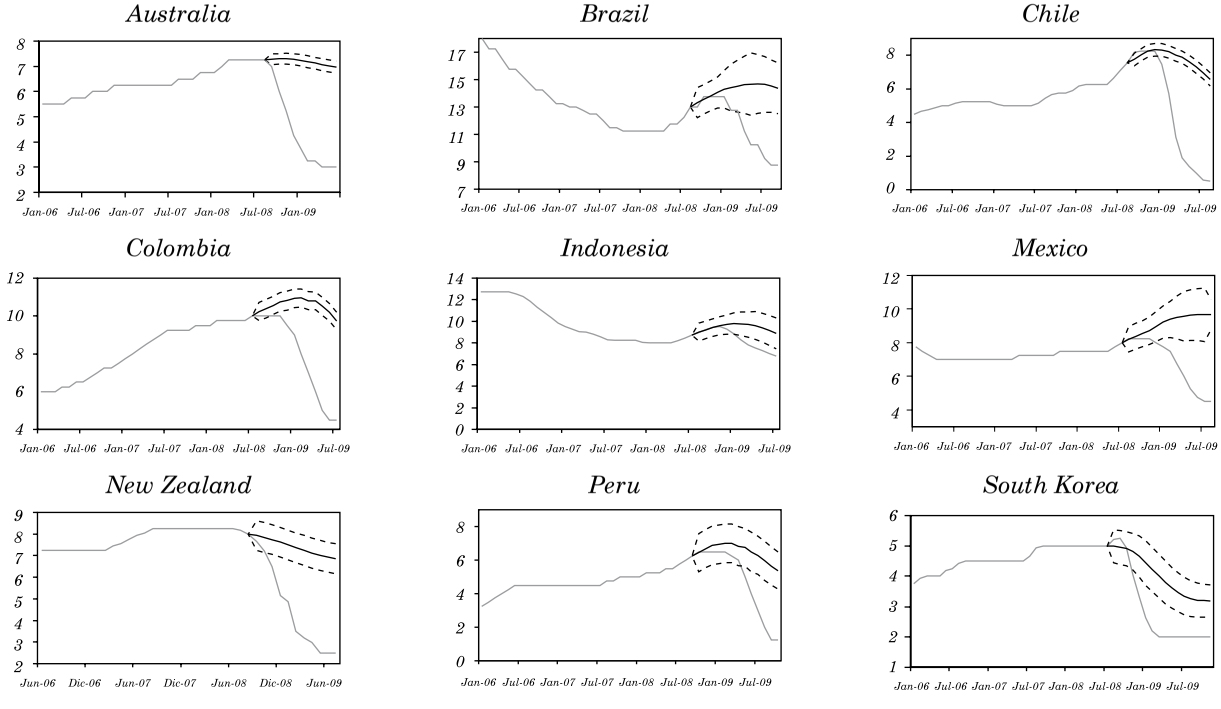
selected economies up to the moment when aggressive monetary policy easing began, typically in the fourth quarter of 2008. Then we dynamically forecast the path for policy rates, given the actual evolution of inflation and industrial production growth, and we compare the resulting policy path with actual policy. Any large and statistically significant deviation of actual monetary policy away from the estimated path after the global financial crisis hit would suggest a break in the way monetary policy reacts to deviations of target variables.

Figure 1 shows the significant deviations from prescribed rule-based policy actions for the nine economies. The gray lines show actual monetary policy response by central banks, while black lines show the conditional point forecasts (solid line) and their 95 percent confidence intervals (dashed lines). It is clear that, all in all, the monetary policy response was significantly different from the predictions arising from simple Taylor rules such as equation (1), estimated for normal times. This result holds qualitatively and—more importantly—quantitatively, if we choose to vary the sample period used for parameter estimation. Note that Australia, New Zealand, Chile, and Colombia post the largest differences between simulated and actual monetary policy rates (MPRs).

Figure 2 summarizes the resulting gaps between the actual path followed by effective MPRs and the ones simulated using the evolution of inflation and the output (growth) gap. A number of observations are in order. First, these gaps are quite large, ranging from 200 to 700 basis points. Second, the timing of the gaps indicates that Australia, New Zealand, and South Korea started to deviate from policy rule prescriptions earlier than Latin American economies (and Indonesia). We confirm this observation estimating a Markov switching model, which allows for two states in equation (1) (explained in detail in the rest of this section), thereby providing an estimated regime shift. Results of this robustness exercise are presented in appendix 1.[2]

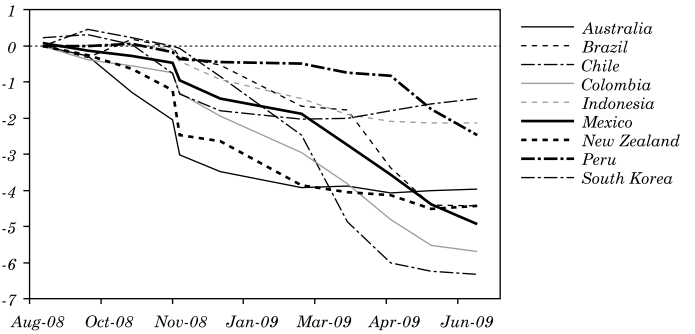
2. We estimate the two-state version of equation (1), $r_t=\gamma+\rho_{S_t} r_{t-1}+(1-\rho_{S_t})[\gamma_\pi(\pi_{t-1}-\pi^*)+\gamma_x(x_{t-1}-x^*)]$, where $\rho_{S_t}=\rho_0 1(S_t=0)+\rho_1 1(S_t=1)$ and ρ_0 stands for high persistence and ρ_1 stands for low persistence. Figure A1 presents the path of actual monetary policy interest rates in dashed lines (left axis) and the probability of being in a high persistence state, $\Pr(S_t = 0)$ in solid lines (right axis). We understand earlier reaction to the financial shock as being an earlier change from a high probability of being in the high-persistence state to one of being in the low-persistence state. Our initial observation is then confirmed, as Australia, New Zealand, and South Korea are the very first countries to be in state $S_t = 1$, followed by Chile, Colombia, Mexico, and Peru, and much later by Indonesia.

Figure 1. Effective and Simulated Monetary Policy Responses in Selected Economies



Source: Authors' calculations.

Figure 2. Gap between Actual and Simulated Monetary Policy Rates



Source: Authors' calculations.

Nevertheless, by the second quarter of 2009 the gaps in Latin American economies had widened significantly more than in the other cases. Third, the shape of the policy deviation indicates a gradual start and a gradual end to the aggressive easing of policy in Latin American economies, whereas in Australia, New Zealand, and South Korea the earlier deviation appeared much more suddenly.[3]

The different policy paths between the latter group and Latin America (plus Indonesia), could be accounted for by the state of the policy cycle at the time. The earlier start for the former group appears consistent with relatively tight policies having been in place, as indicated by flat or falling prescribed policy rates from the conventional Taylor rule at the start of the period under question. In contrast, most of the other economies had rising prescribed rates at the time of the Lehman bankruptcy. Moreover, the shape of the deviations for Latin American economies also reflects a more gradual start and end of the easing cycle than in Asia and the Pacific, likely associated with the earlier recovery in Asia-Pacific economies.

Alternatively, more anxiety about exchange rate fluctuations in Latin American monetary policy making could account for a more gradual initial reaction, which turned aggressive as developing conditions indicated that monetary policy was not worsening turbulence in the foreign exchange market. In contrast, in Australia,

3. This observation is also confirmed in figure A1. Australia, South Korea, and, to a lesser extent, New Zealand and Chile exhibit a reversal in their highly persistent state, $S_t = 0$, after a brief time spent in the low-persistence state $S_t = 1$.

New Zealand, and South Korea, where policymakers were probably less concerned about exchange rate fluctuations, the easing of policy could be—and indeed was—swifter.

Differences in the monetary policy transmission mechanism could also explain the magnitude of the maximum deviation from simulated policy paths. We note that the significance of floating interest rate mortgages in Australia makes for a more potent transmission mechanism, while in Latin America, with less developed mortgage markets, monetary policy would have needed more aggressiveness to achieve similar macroeconomic impact.

1.2 Activism or Dovishness?

Several interpretations could explain the fact that monetary policy has been more aggressive than the standard prescription of a simple policy rule estimated for normal times. In particular, in light of the perception that optimal policy should be predictable, a first take on these results is that monetary policy in these IT countries has deviated significantly from standard monetary policy recommendations and that, therefore, the monetary policy framework itself has deviated from a "pure" IT regime. We argue against this view, on several counts.

First, a specification such as equation (1) is a simple rendering of reality, abstracting many aspects of optimal monetary policy. Although it has been widely shown that simple monetary policy rules lead to economic outcomes—in terms of inflation and output volatility—that do not differ substantially from optimal policy rules, this doesn't necessarily hold true in the event of large shocks.[4] Faced with large shocks, the linearity assumptions that permit the equivalence between simple policy rules and more complex optimal rules break down. It may be the case that under the special circumstances experienced from the last quarter of 2008 onward, the optimal policy response should deviate from a simple policy rule such as equation (1). This deviation would be consistent with the traditional view on optimal policy and Svensson's (2009) view that financial factors play a major role by affecting the transmission mechanism and thus monetary policy needs to react more forcefully when faced with a financial shock.

Second, the assumption that current monetary policy actions do not affect current macroeconomic outcomes—valid in normal

4. See Clarida, Galí, and Gertler (2001), as well as Schmitt-Grohé and Uribe (2006).

times—might not hold under financial distress. Indeed, standard reaction functions such as equation (1) identify the policy reaction by assuming that the arguments on the right-hand side of the equation are not themselves determined by current monetary policy decisions. In normal times, price stickiness and policy lags make this true. However, under financial stress, planning horizons shorten and confidence about the future becomes a paramount determinant of current spending and pricing decisions. This confidence, in turn, becomes largely dependent on policy actions and signaling.

Thus, we can think that the economic counterfactual would have been a smooth and gradually adjusting monetary policy, combined with a much more protracted and severe economic downturn. In a structural sense, the gap between simulated and actual monetary policy paths could actually represent the magnitude of the confidence shock to output and prices, which is currently driving the cycle. Policy, then, has to adjust quickly to prevent this large deflationary shock from affecting economic activity and prices.

A proper interpretation and quantification of the latter channel would require a structural, model-based approach that could help simulate the performance of an economy hit by a large shock, under the assumption of optimal policy versus simple rule-based policy. This goes beyond the scope of this study, but other contributors to this volume touch on this issue. Moreover, it is supported by recent views on optimal monetary policy design amidst financial turbulence or stress, such as those presented in Cúrdia and Woodford (2010), Taylor (2008a), and Taylor (2008b). In the context of our reduced-form analysis, we posit two extreme assumptions about what drives the shift in the monetary policy response in these economies. The first is that monetary policy has become more *activist,* in the sense of reducing the weight of past decisions on current decisions.[5] Hence, this activism can be interpreted as reducing the persistence of the policy rule. The second assumption is that monetary policy became more *dovish*, tending to increase the weight of the output gap on the reaction function.

Returning to our baseline policy rule in equation (1), the stylized fact found in the previous section is that observed monetary policy, ro_t, can be seen as the prescription from the rule plus a shock ε_t:

$$ro_t = r_t + \varepsilon_t = \gamma + \rho r_{t-1} + (1-\rho)\left[\gamma_\pi(\pi_{t-1} - \pi^*) + \gamma_x(x_{t-1} - x^*)\right] + \varepsilon_t.$$

5. We are reluctant to use the term "hawkish," as the literature has related this term to strong inflation aversion alone.

The activist interpretation identifies the shock ε_t as a shift (reduction) in the persistence parameter ρ, while the dovish interpretation implies a shift (increase) in the weight of the output gap γ_x. To obtain a sense of whether our simulations support one or the other, we followed the simple expedient of minimizing the squared deviations of actual policy from a simulated path with either a changing persistence or a changing weight on the output gap. For each country this provides us with a new set of estimates for persistence and sensitivity to the output gap, consistent with a policy path that attempts to closely fit actual events. The result of these exercises for all nine economies is presented in figure 3.

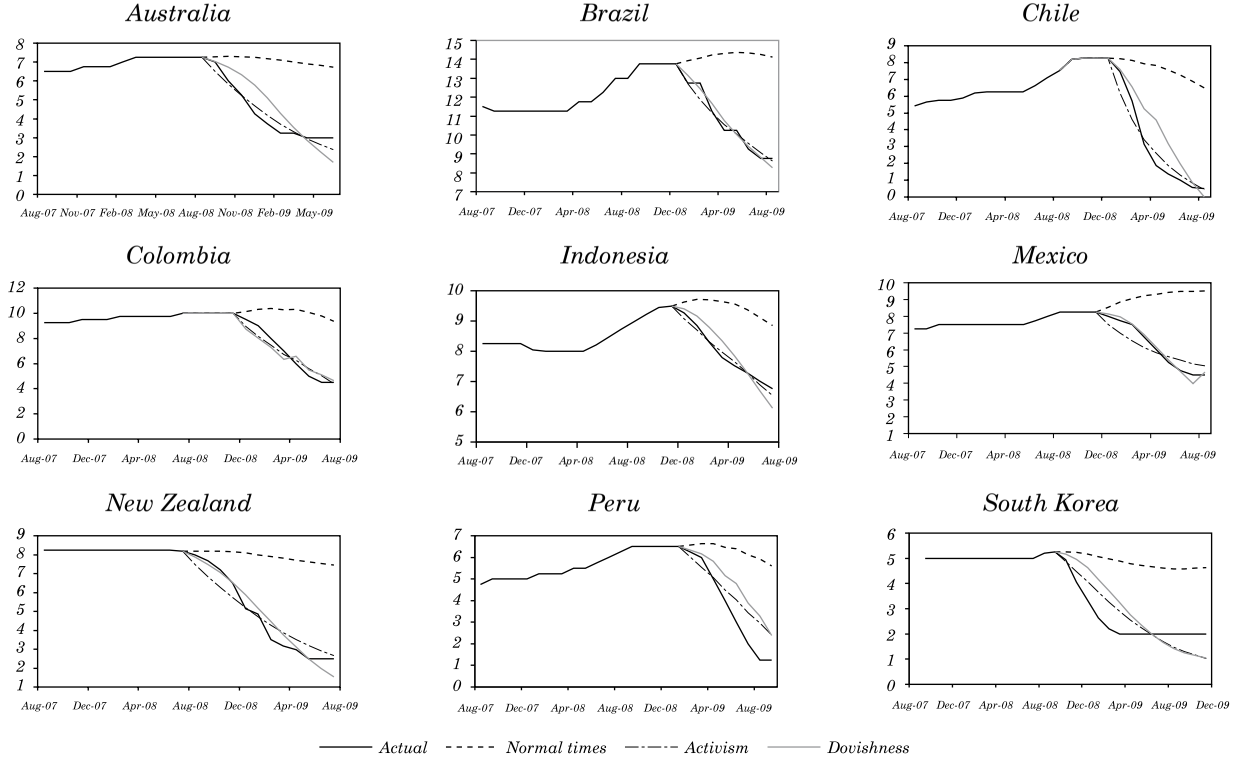
Table 1 presents four columns summarizing this exercise. The first two present the value of the minimized quadratic loss function that penalizes deviations from actual policy by changing either persistence (column 1), or the output gap parameter (column 2). The third column shows the ratio of these last two numbers, and reveals that by changing the persistence parameter in (1), we can approximate actual policy more closely than if we adjust the output parameter for Australia, Chile, Colombia, Indonesia, and South Korea. For New Zealand and Peru the two loss functions are extremely similar, and only for Brazil and Mexico does adjusting the output weight parameter outperform adjusting the persistence parameter. More importantly, columns 5 and 6 show the ratio of the simulated and estimated persistence parameter and output weight parameter, respectively. It is evident that the parameter ρ must be reduced by 6 to 24 percent to approximate actual data. On the other hand, the change in γ_x that is required to approximate actual monetary policy actions is at least an order of magnitude greater. This degree of dovishness is simply too extreme to be plausible.

In a second exercise we take our estimations of equation (1) and compute the values for the change in inflation deviations and/or output growth deviations consistent with both actual monetary policy action and the estimation of equation (1) for normal times. Specifically, we take the long run representation of equation (1) and subtract its lag to obtain

$$\Delta r_t = \frac{\alpha}{1-\rho}\Delta(\pi_t - \pi^*) + \frac{\beta}{1-\rho}\Delta(y_t - y^*). \tag{2}$$

From equation (2) we compute the necessary change of inflation deviation, $\Delta(\pi_t - \pi^*)^{simulated}$, consistent with the decrease in the

Figure 3. Activist (Persistence) and Dovish (Output Gap) Simulated Paths for Monetary Policy



Source: Authors' calculations.

Table 1. Activism versus Dovishness in Monetary Policy

	Loss function			*Required changes*	
	Activism	*Dovishness*	*(1) / (2)*	*Simul. ρ/Est. ρ*	*Simul. β_2/ Est. β_2*
Country	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Australia	1.42	9.26	0.15	0.89	12.00
Brazil	1.15	1.00	1.16	0.90	58.00
Chile	3.84	16.95	0.23	0.74	6.81
Colombia	2.12	3.50	0.61	0.87	6.36
Indonesia	0.16	1.25	0.13	0.93	25.50
South Korea	6.59	11.99	0.55	0.93	3.64

Source: Authors' calculations.

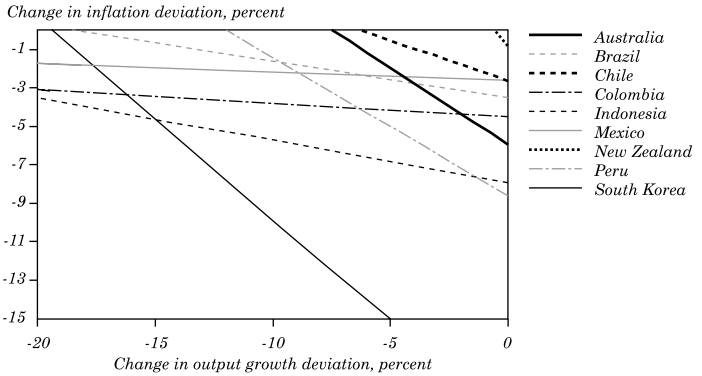
MPR and actual realization of $\Delta(y_t - y^*)$. This inflation deviation is compared to actual $\Delta(\pi_t - \pi^*)^{data}$ and its difference is the intercept with the vertical axis in figure 4. We do the same to compute the difference between simulated and actual output growth deviations consistent with actual change in inflation deviation and the monetary policy rate, which is graphed as the intercept with the horizontal axis in figure 4. The linearity of equation (2) allows us to extrapolate those combinations of exceeding deflationary and contractionary shocks that are necessary for central banks to lower their MPRs as they did, using normal-time Taylor-type reaction rules.

Figure 4 directly suggests that either inflation or output growth should have been radically lower for them alone to account for the central banks' observed reaction, as they aggressively lowered interest rates. All in all, these arguments support our claim that flexibility—that is, temporarily abandoning the persistence of the past—was the most likely and important characteristic of IT implementation in the period of financial stress.

2. Assessing Non-monetary Policy Responses

As discussed above, the central banks included in this study all engaged in a number of non-monetary policy actions. Before addressing the more general issue of whether these measures were consistent with a framework based on inflation targeting (IT), we tackle the more concrete aspect of whether or not these measures

Figure 4. Required Differences in Output (Growth) Gap and Inflation Deviations, Consistent with Actual Monetary Policy Actions



Source: Authors' calculations.

had any measurable and statistically significant correlation with key financial variables.

To narrow the scope of this issue, we focus on the more direct concerns of central banks: money market liquidity and the exchange rate. As mentioned in the introduction, the selection of financially-stable IT economies allows us to avoid the thorny issue of the optimality of central banks' assessments of credit risk during financial crises, the required coordination with the Treasury, and the impact of credit-easing or quantitative-easing policies on a broad set of asset prices, such as house prices, long-term interest rates, and equities.

2.1 Empirical Approach

We compile the daily history of unorthodox non-monetary policy measures undertaken by nine central banks and assess their partial correlation with three variables: short-term (one-month) local currency money market interest rates; short-term (one-month) U.S. dollar local interest rates; and the bilateral exchange rate against the U.S. dollar. Ishi and others (2009) follow a similar line of research to explain the reasons behind implementation of certain measures and their effectiveness. In principle, the outbreak of financial

turmoil affected all three markets, as the tightening of U.S. dollar liquidity worldwide was reflected in onshore U.S. dollar markets, the transmission of financial shocks, high global volatility, and uncertainty regarding authorities' capacity to respond in a timely and effective manner. This, in turn, should have led in varying degrees to higher local currency money market spreads. Finally, the sudden stop of capital inflows, or more generally the prevalence of home-bias effects, stressed the external financing available to several economies. Flight to quality—with the U.S. dollar's role as a reserve currency—only reinforced this phenomenon, depreciating bilateral exchange rates against the dollar worldwide.

Policy responses varied enormously, but can be classified in three groups, corresponding to the three variables discussed above. Some measures aimed to ease U.S. dollar liquidity, such as foreign exchange swaps between central banks and between central banks and local financial or non-financial corporations. Others aimed to ease local money market tensions, such as deposit guarantees, extensions of the tenors of standard repo operations and/or the broadening of eligible collateral. Finally, we can think of the third set of measures as aiming to directly affect exchange rate parities, namely direct foreign exchange reserve sales or purchases.

Most measures targeting a particular market indirectly affected other markets. This can be clarified with a number of examples. Take, for instance, the extension of term lending in local currency. This should, of course, directly impact local money market interest rates, but not necessarily local U.S. dollar money market interest rates. If the magnitude of the impact on local money market interest rates is large enough, then the exchange rate should also react through the uncovered interest rate parity condition. On the other hand, an intervention in the foreign exchange market should affect the bilateral dollar exchange rate, while having an ambiguous effect on local currency money markets, depending on the degree and characteristics of the sterilization of the spot sale. Moreover, the foreign exchange intervention should have opposite effects on local U.S. dollar money market rates, depending on whether the intervention is performed in the spot or the forward markets.

Thus, given the diversity of non-monetary policy measures undertaken by our selected IT central banks, in principle one should allow for specific measures potentially affecting different dimensions. The specifications selected for the empirical exercise follow this eclectic approach. In each case, we allow for the selected extraordinary policy variables (represented by dummies) to influence

all three variables. We control for standard global financial variables, which in some cases are specific to the selected variable, and in other cases are common across variables.[6] Each non-monetary policy measure specific to an economy is identified with a dummy variable. As per the discussion above, we do not exclude the possibility that these non-monetary policy measures could have had an effect on all three variables. Moreover, we allow for an initial announcement effect and a more lasting implementation effect from these measures.

We are also aware of the endogeneity issues involved in this specification: the timing of implementation is indeed endogenous to the tensions in the different financial markets and thus our endogenous variables. We proceed, however, based on three factors. First, we believe that the estimated correlations are informative for policy discussion. Second, the bias, if any, in the estimated coefficients is against finding significant results. Third, the endogeneity problem is to some extent ameliorated by the fact that global developments and not specific local events were at the root of local financial turbulence in the selected economies.

2.1.1 Functional forms

Nominal exchange rate. Equation (3) is the specification for the bilateral nominal exchange rate (NER) against the U.S. dollar. It relates the logarithm of the exchange rate, e_t, to (i) variables that capture international financial market stress: the logarithm of the VIX index, the London interbank offered rate (LIBOR)-OIS spread, and a dummy for the period after the bankruptcy of Lehman Brothers; (ii) the logarithm of the effective nominal multilateral U.S. dollar exchange rate, USD_t; and (iii) the logarithm of the commodity price index, CRB_t, provided by the Commodity Research Bureau.

$$\begin{aligned}\ln(e_t) = {} & \alpha_o + \alpha_{vix}\ln(VIX_t) + \alpha_{USD}\ln(USD_t) \\ & + \alpha_{CRB}\ln(CRB_t) + \alpha_{l-bro}D_t^{l-bro} + \alpha_{lOIS}(r_t^* - OIS_t^*) \\ & + \sum_i (\alpha_d^i D_t^i + \alpha_{d-a}^i \Delta D_t^i) + \vartheta_t.\end{aligned} \tag{3}$$

6. For instance, the commodity price index is used as a control for the nominal exchange rate specification, but is not considered in the local interest rate specification. Controls that are common to all three specifications include a constant dummy that captures the stress that started after Lehman Brothers collapsed, the VIX index, and the LIBOR-OIS spread.

We include specific non-monetary policy variables through dummies that are equal to one during their implementation, as well as their change to capture the initial effect of their announcement. We consider only the initial change, and not the pre-announced lapsing of the measures, in those cases where this was part of the initial announcement.

Local currency money market. Equation (4) presents the specification for the local money market interest rate. It relates the short-term (30-day) local currency deposit rate (or LIBOR), i_t, to the current overnight interbank rate (most often the policy rate), r_t, the expected interbank rate 20 working days ahead (measured by an interest rate swap where available), the local U.S. dollar money market rate, i_t^*, and the same variables used in equation (3) to capture international financial stress. As in equation (3), we include the full set of dummies for exceptional measures and their respective announcements.

$$i_t = \beta_0 + \beta_r r_t + \beta_{re} r_{t+20} + \beta_{i^*} i_t^* + \beta_{vix} \ln(VIX_t) + \beta_{l-bro} D_t^{l-bro} + \beta_{l-OIS}(r_t^* - OIS_t^*) + \sum_i (\beta_d^i D_t^i + \beta_{da}^i \Delta D_t^i) + \varepsilon_t. \quad (4)$$

Local U.S. dollar money market. Several countries in our sample saw large deviations of U.S. dollar interest rates in domestic markets, with respect to those in key offshore financial markets after October 2008. For economies fully integrated into global financial markets, one would not expect this to happen, as domestic U.S. dollar interest rates should exactly match risk-adjusted U.S. dollar rates in international financial markets. Note, however, that in most countries in our sample, financial integration is imperfect due to both regulatory restrictions and underdevelopment of some key financial markets. Moreover, during the recent financial crisis, many of the agents that are able to arbitrage differences between international and local U.S. dollar rates in normal times were unwilling or unable to do so. The severity of the turmoil increased concerns about counterparty risk and made funding liquidity risk paramount, probably hindering these trades. Following the latter idea, Hui and others (2009) document large deviations from corresponding dollar LIBOR rates, and argue precisely that funding liquidity risk (LIBOR-OIS spreads) can explain such deviations.

Equation (5), then, models the local U.S. dollar rate by relating the short-term (30-day) local U.S. dollar rate, i_t^*, to the current local

money market rate, i_t, the 30-day U.S. dollar LIBOR, r_t^*, the financial stress variables, and the policy dummies:

$$\begin{aligned} i_t^* = {} & \delta_0 + \delta_i i_t + \delta_r r_t^* + \delta_{vix} \ln(VIX_t) + \delta_{l-bro} D_t^{l-bro} \\ & + \delta_{l-OIS}(r_t^* - OIS_t^*) + \sum_i (\delta_d^i D_t^i + \delta_{da}^i \Delta D_t^i) + \nu_t. \end{aligned} \tag{5}$$

Equations (3) through (5) are not derived from any optimizing behavior, but offer the great advantage of providing a framework flexible enough to assess the wide variety of measures undertaken by our selection of central banks. Moreover, simple extensions of these equations allow us to, for instance, test whether these policy measures also affected the sensitivity of the interest rates and the exchange rate to global factors, such as the VIX, the multilateral dollar exchange rate, and commodity prices.

In what follows we present the results of estimating equations (3) through (5) for a number of economies that follow IT frameworks: Australia, Brazil, Chile, Colombia, Indonesia, Mexico, New Zealand, Peru, and South Korea. In each case, we provide a brief description of the rationale for the policy measures undertaken in 2008 and 2009, a list of these measures, and how we label these with dummies. We then estimate and comment on the results of these estimations.

2.1.2 The data

Before proceeding to the details of estimations, it is worth discussing the specifics of the selected data set. All data are daily, and the estimation was performed for the period of January 2007 to August 2009. The nominal exchange rate and the macro-financial controls selected—such as the VIX index, the one-month U.S. dollar LIBOR, the LIBOR-OIS spread, and the multilateral nominal value of U.S. dollar commodity prices—were easily obtained from the usual sources. For local money market interest rates and local onshore U.S. dollar interest rates, however, there are no easily available, standard data sets. Money market infrastructure and practices differ widely between economies, such that variables must be selected very carefully. Regarding local currency money market interest rates, we proceeded to select a LIBOR-type interest rate, that is, a term (one-month) interbank interest rate. In some cases, such as Australia and New Zealand, the one-month LIBOR in local currency is readily available, whereas for other economies it is not. For instance, for

Chile we used the prime one-month deposit rate, which in practice is very similar to a money market rate, although more than banks participate in its pricing. Table A1 in the appendix presents the details of the local money market rates selected for each economy, along with their Bloomberg tickers.

The collection of short-term onshore U.S. dollar local interest rate data is a challenge, as it is unavailable for most economies. We proceeded, therefore, by constructing a proxy for local dollar liquidity interest rates using forward prices and the covered interest rate parity condition under the assumption of arbitrage and no transaction costs, expressed as follows:

$$F = S \times \frac{(1+i)}{(1+i^*)}, \tag{6}$$

where F is the forward exchange rate at a given tenor, S is the spot nominal exchange rate, i and i^* are the local currency and U.S. dollar interest rates for the same tenor. Thus, by knowing the spot and forward exchange rates and the local currency interest rates it is possible to infer the implicit U.S. dollar interest rate, which is the onshore U.S. dollar interest rate:

$$i^* = (1+i) \times \frac{S}{F} - 1. \tag{7}$$

In practice, bid-ask spreads and tenor standards for the measurement of interest rates differ. On the one hand, bid-ask spreads can be as high as 10 percent in some economies, while the standard tenors can be calendar days (360 or 365 days) or working days (252 for instance). Hence, the implicit onshore U.S. dollar rate we calculate follows the expression

$$i_b^{on} = \left[\frac{S_a}{F_a}(1+i_b T) - 1\right]\frac{1}{T},$$

where S_a and F_a are the spot and forward exchange rates, i_b is the local currency deposit interest rate and T is a time factor adjusted for the tenor standard. Using this procedure we constructed onshore U.S. dollar interest rates at 1, 3, and 12 months, from January 2007 to the end of October 2009. All data is from Bloomberg, and specific details are presented in appendix figure A1.

It is noteworthy to highlight the situation of certain Asian economies that took a number of measures following the financial crisis of the late nineties that led to the segmentation of onshore and offshore foreign exchange markets. In those cases, we considered the onshore forwards for our calculations.

2.2 Results

2.2.1 Chile

The sequencing of measures is presented in table 2a. Prior to the collapse of Lehman Brothers, the Central Bank of Chile had put in

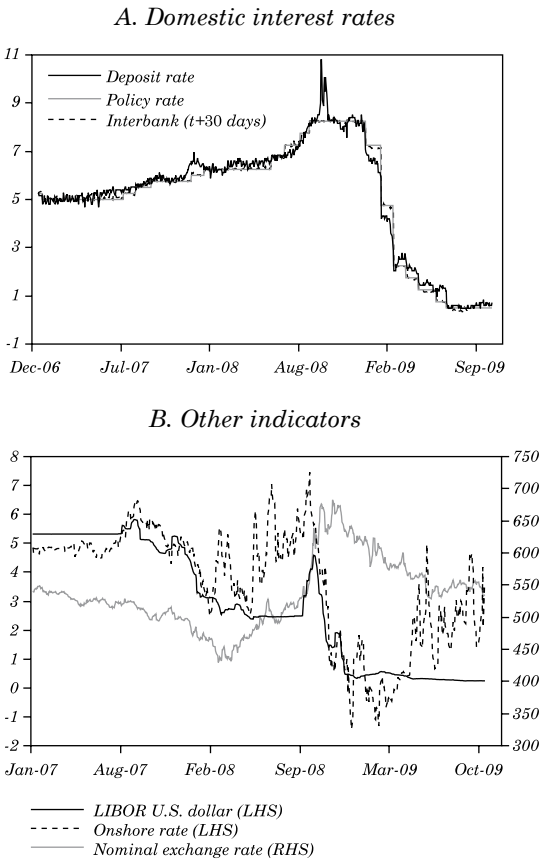
Table 2a. Extraordinary Actions in Chile

Start	*End*	*Extraordinary action*
14-Apr-08	12-Dec-08	Central Bank of Chile decides to increase U.S. dollar reserves by 8 billion dollars: 50 million per day through competitive auctions with sterilization.
29-Sep-08		Interruption of international reserve accumulation process (70 percent of goal achieved).
30-Sep-08		Currency swap auctions.
10-Oct-08		Extension of liquidity-providing operations: extension of currency swaps from one to six months; seven day repo facilities in pesos with bank deposits as collateral.
10-Oct-08	8-Apr-09	Banks' reserve requirement denomination constraint is relaxed for U.S. dollar liabilities.
3-Dec-08		Extension of liquidity providing operations: currency swaps up to 180 days.
10-Dec-08	31-Dec-09	Extension of liquidity providing operations: currency swaps up to 180 days; repo operations to 28 days using central bank bonds as collateral and to seven days using bank deposits.
15-Dec-08	31-Dec-09	Repo operations to 28 days using bank deposits as collateral.
1-Jan-09	31-Dec-09	Eligible collateral assets for 28 day liquidity facility broadened to include government bonds and bank deposits.
10-Jul-09		As of 15 July 2009, term liquidity facility (FLAP) introduced at 90 and 180 days.
30-Dec-08	26-Jan-10	Liquidity credit line in pesos for banking enterprises with collateral. New credit line for banks.

Source: Authors' compilation from Central Bank of Chile reports.

place a reserve accumulation program. This program was cut short on 29 September 2008 as acute dollar liquidity shortages became apparent globally. What followed was a number of liquidity provision measures in both U.S. dollars and local currency. Foreign currency swaps were implemented, in the form of sales of foreign exchange in the spot market with a simultaneous repo of foreign exchange. In terms of domestic currency, term repos in local currency (at a floating interest rate) were implemented, and the set of collaterals broadened to include time deposits. All these measures were in place by October 2008. Moreover, to enhance the monetary policy stimulus in the

Figure 5. Key Money Market Variables in Chile



Sources: Bloomberg and Central Bank of Chile.

Table 2b. Estimation Results for Chile[a]

Deposit rate		
Interbank rate	0.663 [37.13]***	
Expected rate (t+20)	0.245 [12.46]***	
Log (VIX_t)	−0.122 [2.10]**	
LIBOR U.S. dollar	−0.057 [3.55]***	
Onshore rate	0.016 [1.45]	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve accumulation	−0.248 [5.17]***	0.334 [1.46]
Currency swap options	0.721 [5.28]***	−0.237 [0.71]
Currency swap operations extended and repo	−1.187 [11.49]***	1.372 [5.78]***
Term liquidity facility	−0.285 [3.41]***	−0.144 [0.60]
Financial stress		
Lehman Brothers	0.17 [1.95]*	
LIBOR-OIS	0.313 [7.21]***	
Constant	1.049 [5.19]***	
Observations		613
R^2		0.99

Table 2b. (continued)

Onshore rate		
Deposit rate	−0.083 [2.50]**	
LIBOR U.S. dollar	0.629 [11.22]***	
Log (VIX_t)	0.222 [1.00]	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve accumulation	1.034 [5.82]***	−1.134 [1.25]
Currency swap options	0.015 [0.03]	−0.128 [0.10]
Currency swap operations extended and repo	−2.594 [6.86]***	1.126 [1.20]
Term liquidity facility	1.491 [5.90]***	0.726 [0.78]
Financial stress		
Lehman Brothers	0.725 [2.14]**	
LIBOR-OIS	0.52 [3.10]***	
Constant	1.465 [1.88]*	
Observations		649
R^2		0.80

Table 2b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.059	
	[13.06]***	
Log (CRB_t)	−0.357	
	[8.88]***	
Log (VIX_t)	0.004	
	[0.58]	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve accumulation	0.056	−0.063
	[12.74]***	[2.00]**
Currency swap options	0.011	−0.046
	[0.68]	[1.00]
Currency swap operations extended and repo	−0.005	0
	[0.36]	[0.01]
Term liquidity facility	0.028	−0.036
	[3.08]***	[1.10]
Financial stress		
Lehman Brothers	−0.014	
	[1.32]	
LIBOR-OIS	0.046	
	[11.37]***	
Constant	13.201	
	[62.90]***	
Observations		680
R^2		0.90

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets.

context of a binding zero lower bound, a term (six-month) lending facility at the fixed policy rate was implemented in July 2009.

One policy dummy identifies the accumulation of reserves in 2008 prior to the crisis, a second dummy identifies the implementation of foreign currency swaps in late September, and a third identifies the same operations implemented by the middle of October, broadened to include time deposits as collateral for money market operations. A fourth dummy represents term lending at a fixed rate implemented in July 2009. Table 2b presents the results of these estimations. We also include dummies for the announcement of each program.

The specifications yield the expected results regarding the controls for each case. The effective nominal U.S. dollar exchange rate and the commodities index have a large and significant effect on the bilateral peso-dollar exchange rate, the VIX index does not impact the nominal exchange rate and dollar liquidity conditions once the LIBOR-OIS spread is included, while the U.S. dollar LIBOR also affects local dollar liquidity conditions.

On policy measures, the 2008 reserve accumulation program significantly influenced the nominal exchange rate, while increasing the local U.S. dollar rates and local money market rates in the baseline specifications. The more aggressive foreign exchange swap program had an important effect on local money market conditions, reducing peso and dollar rates as expected. Local U.S. dollar interest rates fell by close to 250 basis points while local currency deposit rates fell by close to 100 basis points. Finally, the term lending facility implemented in July 2009 significantly influenced interest rates. Peso rates fell by 30 basis points, while onshore rates rose.

2.2.2 Brazil

The October 2008 financial crisis led to a sizeable increase in capital outflows, and reduced Brazilian companies' access to foreign lines of credit. This prompted authorities to apply significant measures to bolster domestic liquidity and facilitate access to U.S. dollar liquidity. By the end of September, the central bank had already phased out its reverse foreign exchange swap operations—which amounted to the purchase of a forward U.S. dollar position and therefore increased the U.S. dollar position in its balance sheet—and also stopped buying U.S. dollars on the spot market. By early October, the central bank started to unwind its forward U.S. dollar position, as a first reaction to the financial crisis. Moreover, to

further bolster the foreign liquidity buffer, the central bank received authorization to undertake currency swap agreements with foreign central banks on 21 October, paving the way for a 30 billion U.S. dollar swap arrangement with the U.S. Federal Reserve in late October. This was extended for six months into late June 2010, and has not been tapped. In terms of forex intervention, most measures have been implemented through these foreign exchange swaps, and only partially through spot sales.

Table 3a. Extraordinary Actions in Brazil

Start	*End*	*Extraordinary action*
21-Dec-07	29-Sep-08	Central Bank of Brazil (CBB) carries out reverse foreign exchange swap auctions.
6-Oct-09	28-Apr-09	CBB offers traditional foreign exchange swap on a daily basis.
8-Oct-08		Direct U.S. dollar spot purchase.
21-Oct-08		CBB authorized to swap currency with foreign central banks.
30-Oct-08	30-Oct-09	Agreement for up to 30 billion U.S. dollars with the Federal Reserve Bank of New York.
5-May-09		CBB carries out reverse foreign exchange swap auctions.
30-Jun-09	1-Feb-10	Ceiling on foreign exchange swaps with the Federal Reserve raised to 30 billion U.S. dollars.

Source: Authors' compilation from Central Bank of Brazil reports.

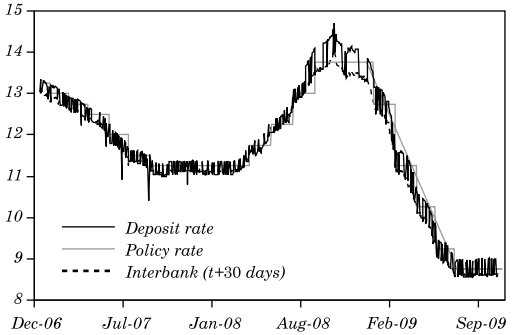
In terms of local financing, the central bank took measures both to facilitate exporting firms' access to credit lines and to ease other strains on local currency liquidity. The former involved implementing credit lines for exporters. The banking system reduced the large reserve requirements on deposits, successfully raising domestic liquidity to 100 billion reales in the last quarter of 2008, that is, two-thirds of base money.[7] To contain financial stress in the most exposed segments of the banking system, incentives were provided to encourage larger institutions to reduce their reserve requirements by acquiring smaller institutions' credit portfolios. Table 3a reveals the sequence of these different policy measures.

7. See OECD (2010).

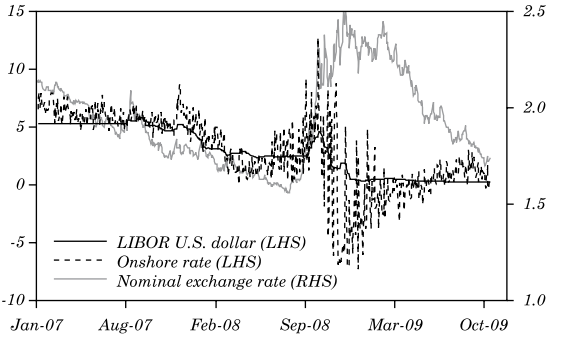
To assess the impact of these measures we identify six policy dummies: reverse foreign exchange swap operations; traditional foreign exchange swap operations; spot interventions in the foreign exchange market; the announcement of the dollar-real swap between the central bank and the Federal Reserve; the implementation of credit lines to exporters; and the reduction in the compulsory reserve requirement. These policy dummies take the value of 1 while the measures are in place. Dummies are also included on announcement.

Figure 6. Key Money Market Variables in Brazil

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Central Bank of Brazil.

Table 3b shows the results of the estimation. With regards to the effects on the exchange rate, the reverse swap operations—for example, increasing the long U.S. dollar position prior to the crisis and after May 2010—seem to have kept the nominal exchange rate weaker, but the traditional swaps do not seem to have stemmed depreciation in any statistically significant way. The swap agreement with the Federal Reserve does appear to have been significant from both a statistical and an economic point of view, appreciating the nominal exchange rate by almost 6 percent. The measures designed to bolster domestic liquidity and access to credit both point to depreciating the currency.

In terms of domestic liquidity, the measures seem less relevant, although policy measures seem to have eased foreign liquidity. U.S. dollar interest rates reacted most significantly to the swap agreement with the Federal Reserve (a reduction of more than 300 basis points), while spot sales also had an impact. This is consistent with the findings of Stone and others (2009), who find that both the announcement and the implementation of foreign exchange easing reduced the local cost of dollar borrowing. Neither foreign exchange swaps nor credit lines to exporters significantly affected this variable.

Table 3b. Estimation Results for Brazil[a]

Deposit rate		
Interbank rate	−0.058 [1.19]	
Expected rate (t+20)	1.12 [23.06]***	
Log (VIX_t)	0.013 [0.25]	
LIBOR U.S. dollar	0.031 [2.88]***	
Onshore rate	−0.005 [1.12]	
Non-monetary policy actions	*Implemented*	*Announced*
Reverse swaps	−0.056 [0.99]	−0.266 [1.27]
Traditional swaps	0.037 [0.54]	0.085 [0.56]
Spot intervention	−0.061 [1.11]	−0.571 [2.68]***
Possibility of foreign exchange swaps with Federal Reserve	0.026 [0.30]	0.052 [0.25]
Credit line expansion	−0.076 [0.95]	0 [.]
Compulsory reserve requirement	0.408 [3.64]***	0.08 [0.37]
Financial stress		
Lehman Brothers		−0.197 [2.69]***
LIBOR-OIS		0.02 [0.53]
Constant		−0.66 [2.67]***
Observations		653
R^2		0.98

Table 3b. (continued)

	Onshore rate	
Deposit rate	−0.106	
	[1.08]	
LIBOR U.S. dollar	1.208	
	[16.88]***	
Log (VIX_t)	−0.044	
	[0.10]	
Non-monetary policy actions	*Implemented*	*Announced*
Reverse swaps	−0.543	0.174
	[1.13]	[0.10]
Traditional swaps	−0.303	0.447
	[0.56]	[0.34]
Spot intervention	−1.065	8.365
	[2.40]**	[4.64]***
Possibility of foreign exchange swaps with Federal Reserve	−3.08	−4.447
	[4.30]***	[2.48]**
Credit line expansion	−0.443	0
	[0.72]	[.]
Compulsory reserve requirement	0.641	−0.396
	[0.68]	[0.21]
Financial stress		
Lehman Brothers	1.817	
	[3.03]***	
LIBOR-OIS	−0.661	
	[2.12]**	
Constant	2.316	
	[1.17]	
Observations	680	
R^2	0.74	

Table 3b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.104	
	[15.13]***	
Log (CRB_t)	−0.586	
	[16.42]***	
Log (VIX_t)	0.012	
	[2.15]**	
Non-monetary policy actions	*Implemented*	*Announced*
Reverse swaps	0.022	−0.001
	[3.23]***	[0.04]
Traditional swaps	−0.006	0.044
	[0.80]	[2.34]**
Spot intervention	0.006	0.103
	[0.96]	[3.93]***
Possibility of foreign exchange swaps with Federal Reserve	−0.059	−0.025
	[5.64]***	[0.95]
Credit line expansion	0.033	0
	[3.76]***	[.]
Compulsory reserve requirement	0.029	−0.004
	[1.98]**	[0.14]
Financial stress		
Lehman Brothers	0.016	
	[1.77]*	
LIBOR-OIS	0.001	
	[0.16]	
Constant	9.125	
	[46.44]***	
Observations	680	
R^2	0.96	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets

2.2.3 Colombia

The impact of the October 2008 financial crisis on the Colombian foreign exchange and short-term money markets was mild compared to other countries in our sample. The interbank overnight interest rates remained close to the policy rate. Indeed, the spread between short-term deposit interest rates and the actual or expected policy rate (as measured by the OIS market) did not increase in late 2008. Similarly, the implied dollar rates in forward contracts rose in late 2008 to almost 100 basis points above LIBOR. It is therefore not surprising that the Central Bank of Colombia did not implement liquidity provision programs in U.S. dollars in response to rising spreads on Colombian U.S. dollar-denominated bonds, and simply eliminated capital controls. In terms of domestic liquidity provisions, in October the central bank reduced reserve requirements on local currency deposits, announced 14- and 30-day repo operations, and an outright purchase of government bonds. In June, the central bank had implemented a reserve accumulation program, purchasing 20 million U.S. dollars per day in competitive auctions. After conditions in international financial markets changed in October, the program was suspended. Finally, in April, Colombian authorities secured a contingent credit line facility from the IMF.

Table 4a. Extraordinary Actions in Colombia

Start	*End*	*Extraordinary action*
20-Jun-08		Modification of international reserve accumulation program to 20 million U.S. dollars per day through competitive auction.
9-Oct-08		Elimination of unremunerated reserve requirement and cancellation of international reserve accumulation program.
24-Oct-08		Reduction of cash position requirements in pesos. Repo operations of 14 to 30 days in pesos. Purchase of treasury bonds worth 500 billion pesos.
20-Apr-09		Contingent credit line petition to the IMF (10.4 billion U.S. dollars).
28-Aug-09		IMF special drawing rights made available worth 890 million U.S. dollars.

Source: Authors' compilation from Central Bank of Colombia reports.

Table 4b. Estimation results for Colombia[a]

Deposit rate		
Interbank rate	0.877 [39.18]***	
Expected rate (t+20)	0.085 [3.53]***	
Log (VIX_t)	0.051 [1.13]	
LIBOR U.S. dollar	0.078 [6.75]***	
Onshore rate	−0.039 [6.27]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	0.186 [7.13]***	−0.146 [1.03]
Repo and reserve requirement	−0.086 [1.86]*	0.042 [0.29]
Contingent credit line with IMF		0.114 [0.81]
Financial stress		
Lehman Brothers	−0.077 [1.59]	
LIBOR-OIS	0.009 [0.38]	
Constant	−0.067 [0.59]	
Observations	576	
R^2	0.99	

Table 4b. (continued)

Onshore rate		
Deposit rate	0.984 [16.83]***	
LIBOR U.S. dollar	1.142 [25.40]***	
Log (VIX_t)	−2.811 [11.33]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	1.46 [8.33]***	−1.102 [1.08]
Repo and reserve requirement	2.821 [9.42]***	−0.197 [0.19]
Contingent credit line with IMF		0.034 [0.03]
Financial stress		
Lehman Brothers	2.486 [7.63]***	
LIBOR-OIS	−1.107 [7.16]***	
Constant	−2.204 [3.03]***	
Observations	626	
R^2	0.72	

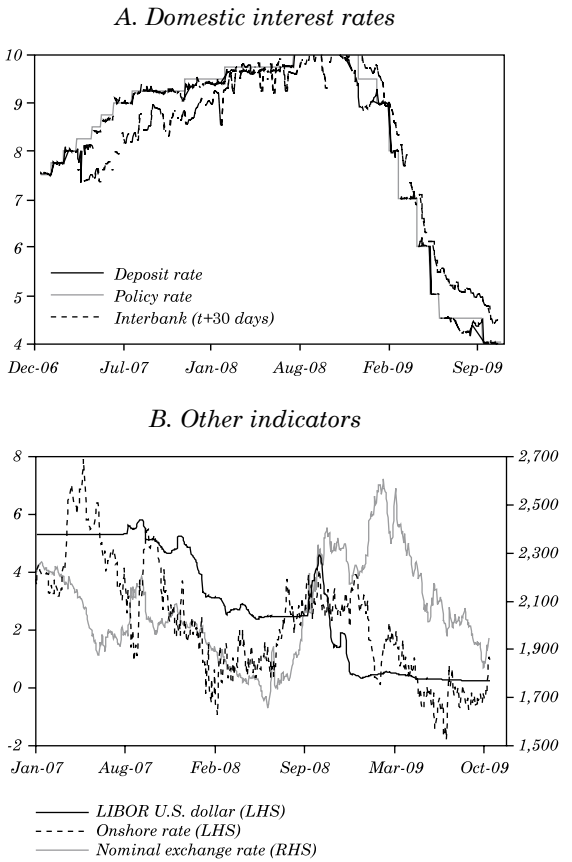
Table 4b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.147	
	[13.83]***	
Log (CRB_t)	−0.405	
	[10.12]***	
Log (VIX_t)	0.033	
	[4.96]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	−0.003	−0.067
	[0.65]	[2.05]**
Repo and reserve requirement	−0.097	0.024
	[9.91]***	[0.71]
Contingent credit line with IMF		0.034
		[1.06]
Financial stress		
Lehman Brothers	0.032	
	[3.39]***	
LIBOR-OIS	0.014	
	[3.60]***	
Constant	15.206	
	[77.98]***	
Observations	680	
R^2	0.90	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets.

To assess the impact of these measures, we identify three policy dummies: (i) the reserve accumulation program; (ii) the changes in reserve requirements and repo operations; and (iii) the contingent credit line announcement. The non-significant coefficients on foreign volatility measures (such as the logarithm of the VIX index) and on the liquidity premium in U.S. interbank rates in the estimation for Colombian interbank rates is consistent with international financial conditions having little impact on domestic money markets. In terms of policies, the domestic liquidity measures correlate with lower interbank rates, as expected. The positive estimated coefficient on the reserve accumulation program dummy, however, is surprising.

Figure 7. Key Money Market Variables in Colombia



Sources: Bloomberg and Central Bank of Colombia.

In terms of onshore dollar rates, these move in line with LIBOR in our sample as expected, rising significantly after the financial crisis deepened (captured by the Lehman Brothers collapse dummy). However, unlike onshore rates in Chile and other countries, we actually find a negative correlation between these rates and the VIX and LIBOR-OIS spread. In terms of policies, domestic dollar rates were higher in the reserve accumulation period.

Results for the exchange rate are closer to our priors. In this period the dollar-peso exchange rate moved due to changes in the dollar's value against other countries, depreciating after the financial crisis deepened in October, as well as in those periods in which the VIX was rising. We find that the announcement—and not the implementation itself—of the reserve accumulation process appreciated the NER, as well as the domestic liquidity provision measures, as arbitrage conditions would predict.

2.2.4 Mexico

The October financial crisis significantly affected peso/dollar markets in Mexico. In Mexico, falling global demand for emerging market assets interacted with rising demand from the corporate sector for dollar-denominated assets, as companies rushed to cover unhedged dollar positions that had built up over the period of exchange rate stability (see Kamil and others, 2009). The result was a significant reduction in turnover in peso-dollar markets and remarkable peso depreciation. Companies' higher demand for U.S. dollar assets also explains why, during the last quarter of 2008, the implicit onshore dollar rate in Mexico fell. Increased demand to buy dollars in future markets pushed up forward rates relative to spot rates, depressing the implicit dollar rate. This led the Bank of Mexico to start selling international reserves through several extraordinary auctions in October and a daily auction program that began in early October and continued through June 2009. This program initially set the minimum price at 2 percent above the previous day's exchange rate, to reduce volatility. This minimum price was eliminated in March.

Lack of a swap market for overnight interbank rates makes it difficult to precisely determine whether Mexico experienced rising tensions in peso money markets in this period. The available data suggests this was not the case. Indeed, 28-day interbank rates actually fell in October, driven by investors reducing their positions in long-term government paper, and switching to short-term debt instruments. In

this context, the extraordinary liquidity facilities implemented by the Bank of Mexico in October (and extended in December) can be seen as a preventative measure to help local institutions manage liquidity.

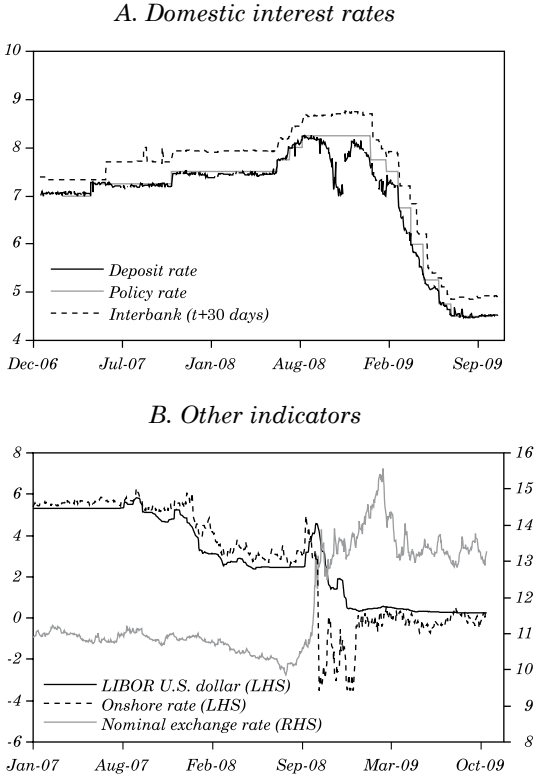
Table 5a. Extraordinary Actions in Mexico

Start	*End*	*Extraordinary action*
8-Oct-08	23-Oct-08	Extraordinary U.S. dollar auction for 11 billion dollars.
9-Oct-08	1-Oct-09	Daily auctions. Initially for 400 million U.S. dollars with a minimum price.
		From March onwards, with no minimum price and in reduced amounts.
27-Oct-08	31-Dec-08	Reduction of the auction program for public bonds for 2008 Q4: replacement with short-term government treasuries (CETES) and later repurchase of bonds.
27-Oct-08	4-Nov-08	Reduction of the auction program for savings protection bonds by the Institute for the Protection of Banking Savings (IPAB): around 140 million U.S. dollars for 2008 Q4; later, announcement to repurchase savings protection bonds worth 10.7 billion U.S. dollars.
8-Oct-08	18-Dec-08	Broadening of admissible collateral for liquidity provision for open market operations.
14-Nov-08	28-Nov-08	Domestic interest rate swap lines of up to 50 billion pesos (around 3.5 billion U.S. dollars).
29-Oct-08	1-Feb-10	Swap lines with foreign central banks extended in May and June.
21-Apr-09		Auction of swap line funds for 4 billion U.S. dollars.
1-Apr-09	1-Apr-10	IMF flexible contingent credit line of 47 billion U.S. dollars.

Source: Authors' compilation from Bank of Mexico reports.

The Bank of Mexico also introduced an interest rate swap facility in mid-November. This facility aimed to reduce bank exposure to high volatility in Mexican government bond prices. In addition to this swap, and in an attempt to reduce long-term interest rates on public debt, the Mexican authorities reduced their issuance of long-term bonds during the last quarter of 2008.

Figure 8. Key Money Market Variables in Mexico



Sources: Bloomberg and Bank of Mexico.

Table 5b reports estimates of the partial correlation of these policy measures with domestic rates, onshore rates, and the nominal exchange rate. For the Mexican interbank offered rate (MEXIBOR), the policy rate has the expected sign and magnitude. Interestingly, the coefficient on the VIX is negative and significant (however small), unlike other countries that saw short-term rates go up relative to the policy rate after Lehman. The estimated coefficients indicate a negative correlation between domestic liquidity measures and the interbank rate, and a negative correlation between the interbank rate and interest rate swaps. The fact that so many programs were announced on 8 October makes it difficult to interpret the positive coefficient on the announcement dummy.

The onshore rate co-moves with the LIBOR, as expected. However, the correlations with the VIX and LIBOR-OIS spreads are negative, due to the unwinding of corporate derivative positions in the last quarter of 2008. Both the announcement and implementation of the Federal Reserve swap line reduced the onshore dollar rate, as expected.

The Mexican peso depreciated after the Lehman Brothers bankruptcy, and further depreciated in those periods of highest volatility (as measured by the VIX index). We did not find the expected impact of U.S. dollar sales (both programmed and extraordinary), probably due to endogeneity in the timing of these measures.

Table 5b. Estimation Results for Mexico[a]

	Deposit rate	
Interbank rate	0.877 [45.47]***	
Log (VIX_t)	−0.075 [2.07]**	
LIBOR U.S. dollar	−0.029 [3.63]***	
Onshore rate	−0.009 [1.10]	
Non-monetary policy actions	*Implemented*	*Announced*
Direct sales of U.S. dollars	0.166 [2.74]***	
Broadening of admissible collateral	−0.494 [8.79]***	0.303 [2.00]**
Interest rate swaps	−0.086 [1.79]*	0.037 [0.50]
Financial stress		
Lehman Brothers	0.063 [1.44]	
LIBOR-OIS	−0.031 [1.19]	
Constant	1.298 [7.51]***	
Observations	628	
R^2	0.98	

Table 5b. (continued)

	Onshore rate	
Deposit rate	−0.64	
	[7.36]***	
LIBOR U.S. dollar	0.648	
	[23.22]***	
Log (VIX_t)	0.588	
	[3.98]***	
Non-monetary policy actions	*Implemented*	*Announced*
Direct sales of U.S. dollars	−0.081	
	[0.29]	
Broadening of admissible collateral	−4.262	4.281
	[19.50]***	[6.17]***
Interest rate swaps	−1.005	−1.048
	[4.85]***	[3.07]***
Financial stress		
Lehman Brothers	1.078	
	[5.41]***	
LIBOR-OIS	−0.976	
	[8.55]***	
Constant	5.405	
	[6.91]***	
Observations	662	
R^2	0.94	

Table 5b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−0.421	
	[6.93]***	
Log (CRB_t)	−0.142	
	[4.64]***	
Log (VIX_t)	0.067	
	[13.27]***	
Non-monetary policy actions	*Implemented*	*Announced*
Direct sales of U.S. dollars	0.023	
	[2.47]**	
Broadening of admissible collateral	0.115	−0.031
	[14.34]***	[1.34]
Interest rate swaps	−0.001	−0.01
	[0.29]	[0.91]
Financial stress		
Lehman Brothers	0.029	
	[3.98]***	
LIBOR-OIS	−0.038	
	[10.51]***	
Constant	4.988	
	[32.65]***	
Observations	680	
R^2	0.96	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets.

2.2.5 Australia

The financial crisis also affected money markets in Australia. Markets for bank funding became particularly stressed and the Reserve Bank of Australia applied several measures to alleviate the situation and satisfy the increased demand for cash balances. The tenor of repo operations was extended, and the frequency of 6- and 12-month repos was increased to daily in early October. Moreover, to confront the increase in counterparty risk, the range of acceptable collaterals was expanded to include residential mortgage-backed securities (RMBS) and asset-backed commercial paper (ABCP) of related parties, in contrast with constraints normally in place on the eligibility of collateral for repo operations.[8] Also, restrictions on the ability to substitute collateral within an existing repo were removed. The average term of repo operations increased significantly in October thanks to these measures. Regarding the provision of U.S. dollar liquidity, the main measure was a bilateral swap arrangement with the Federal Reserve.

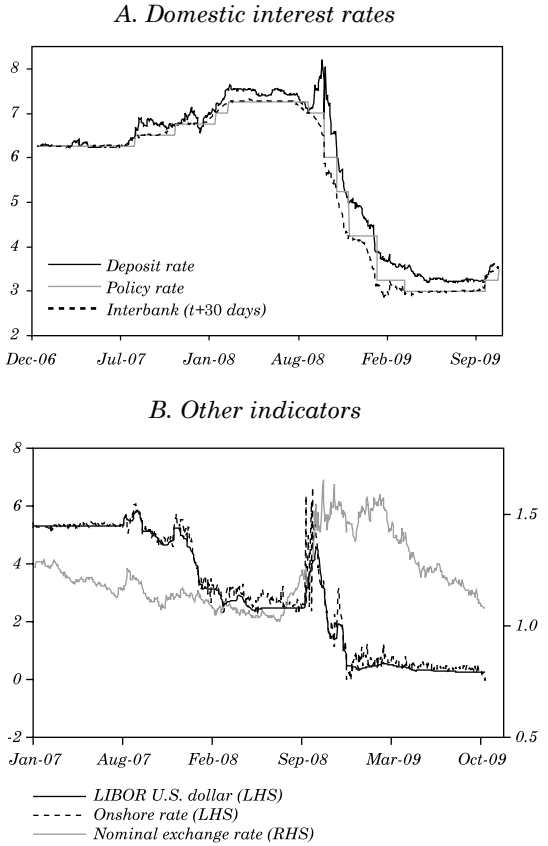
Table 6a. Extraordinary Actions in Australia

Start	*End*	*Extraordinary action*
24-Sep-08		Bilateral swap with Federal Reserve for 10 billion U.S. dollars.
29-Sep-08		Increase of bilateral swap with the Federal Reserve to 30 billion U.S. dollars.
8-Oct-08		Frequency of 6- to 12-month repos increased to daily; acceptance of related parties' RMBS and ABCP as eligible collateral; restrictions removed on substituting collateral within an existing repo; repo operation of 14 to 30 days; and introduction of a term deposit facility with one and two week maturities to absorb liquidity.
12-Oct-08		State guarantee introduced for an unlimited amount for deposits until October 2011 and for debt securities maturing in up to five years.

Source: Authors' compilation from Reserve Bank of Australia reports.

8. See Debelle (2008).

Figure 9. Key Money Market Variables in Australia



Sources: Bloomberg and Reserve Bank of Australia.

What were the effects of these measures according to our empirical specification? We identify two dummy variables, corresponding to the bilateral swap agreement with the Federal Reserve, and the broadening of eligible collateral and term extension for repo operations plus the state guarantees for deposits and other liabilities, respectively. Due to the short time between the latter measures, it is not possible to separately identify the impacts on our selected financial variables. Table 6b presents the results.

Table 6b. Estimation results for Australia[a]

Deposit rate		
Interbank rate	0.137 [4.96]***	
Expected rate (t+20)	0.884 [27.67]***	
Log (VIX_t)	0.007 [0.34]	
LIBOR U.S. dollar	0.04 [2.79]***	
Onshore rate	−0.025 [1.69]*	
Non-monetary policy actions	*Implemented*	*Announced*
RBA-TD and Federal Reserve swap line	0.066 [1.12]	−0.179 [1.65]*
Repo and collateral	0.014 [0.28]	−0.143 [1.34]
Financial stress		
Lehman Brothers	0.286 [6.51]***	
LIBOR-OIS	0.365 [17.04]***	
Constant	−0.284 [2.25]**	
Observations	644	
R^2	0.99	

Table 6b. (continued)

Onshore rate		
Deposit rate	−0.096 [2.63]***	
LIBOR U.S. dollar	0.934 [88.66]***	
Log (VIX_t)	0.092 [1.60]	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	−0.656 [4.30]***	0.503 [1.72]*
Repo and reserve requirement	−0.989 [8.02]***	1.44 [5.11]***
Financial stress		
Lehman Brothers	1.045 [9.59]***	
LIBOR-OIS	0.151 [2.32]**	
Constant	0.697 [2.27]**	
Observations	679	
R^2	0.98	

Table 6b. (continued)

	Nominal exchange rate	
Log (U.S. dollar multilateral exchange rate)	−1.51 [30.63]***	
Log (CRB_t)	−0.267 [11.41]***	
Log (VIX_t)	0.044 [11.13]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	−0.044 [4.44]***	0.018 [0.90]
Repo and reserve requirement	0.004 [0.56]	0.043 [2.18]**
Financial stress		
Lehman Brothers	0.016 [2.11]**	
LIBOR-OIS	0.038 [16.64]***	
Constant	8.546 [74.08]***	
Observations	680	
R^2	0.97	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets.

The bilateral swap with the Federal Reserve and the extensions of repo operations plus the implementation of deposit and other guarantees caused significant currency appreciation, and reduced the onshore rate significantly (from 60 to 100 basis points) and persistently over the period. Interestingly, for local liquidity conditions things were slightly different. The effects were most marked after the announcement, but did not seem to persist, even when we control for other variables. The effects also seem to have been more muted, limited to between 15 and 20 basis points.

2.2.6 New Zealand

In contrast to other economies, the financial and banking system in New Zealand was undergoing a downward credit cycle prior to the October 2008 financial turmoil. Hence, already by June, some precautionary measures had been adopted to expand collateral and assist domestic liquidity. When the crisis hit New Zealand, some finance companies were already under pressure.[9] These measures were further complemented in early October, when RMBS were also allowed as eligible collateral as funding became harder to obtain. By November, further liquidity facilities were implemented through term lending and by December more securities were accepted for domestic liquidity operations, including highly rated corporate bonds.

Table 7b presents the effects of these policy interventions. All three sets of measures (and their announcements) coincided with significantly lower domestic interest rates. Effects of the policy dummies on the onshore rates were mixed. The announcements of all measures coincided with currency appreciations, whereas the measures themselves coincided with a depreciated currency.

9. See Bollard and Ng (2009) and Nield (2008).

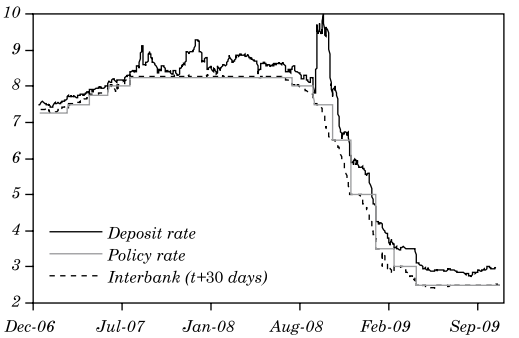
Table 7a. Extraordinary Actions in New Zealand

Start	*End*	*Extraordinary action*
3-Jun-08		Broadening of collateral eligible for acceptance in the Reserve Bank of New Zealand's (RBNZ) domestic liquidity operations: domestically-registered New Zealand dollar AAA-rated securities, including residential mortgage-backed securities, and AA-rated New Zealand government sector debt (including government agencies, state owned enterprises and local authorities). The discount margin applied in the RBNZ's overnight reverse repo facility will be 50 basis points for all eligible securities. Extension of overnight reverse repo facility from one to thirty days.
9-Oct-08		Broaden securities program to residential mortgage backed securities (RMBS).
29-Oct-08	30-Apr-09	RBNZ and Federal Reserve announce U.S. dollar facility of up to 15 billion dollars.
12-Nov-08	26-Oct-09	Term auction facility (TAF) offer raised to 2 billion New Zealand dollars and with three, six, and twelve month maturities.
12-Nov-08	26-Oct-09	RBNZ bill tenders to withdraw liquidity injected via TAF.
17-Dec-08		Extension of the range of securities acceptable in the RBNZ's domestic liquidity operations to include: securities guaranteed by the government, highly rated New Zealand corporate securities, and New Zealand dollar denominated asset-backed securities.
30-Jun-09		Prudential liquidity policy.
22-Oct-09		Prudential liquidity policy deadline implementation is relaxed.

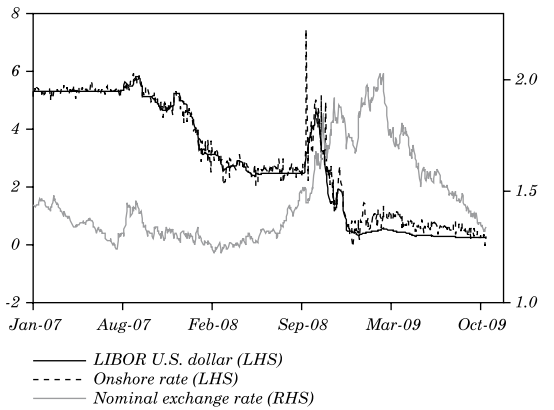
Source: Authors' compilation from Reserve Bank of New Zealand reports.

Figure 10. Key Money Market Variables in New Zealand

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Reserve Bank of New Zealand.

Table 7b. Estimation Results for New Zealand[a]

Deposit rate		
Interbank rate	0.26 [6.82]***	
Expected rate (t+20)	0.802 [18.93]***	
Log (VIX_t)	−0.207 [5.13]***	
LIBOR U.S. dollar	0.136 [5.55]***	
Onshore rate	−0.13 [5.49]***	
Non-monetary policy actions	*Implemented*	*Announced*
Broadening eligible collateral	−0.059 [2.03]**	−0.064 [0.36]
Swap lines with Federal Reserve	−0.196 [6.95]***	−0.616 [3.42]***
TAF and extension of acceptable collateral	−0.113 [1.71]*	−0.346 [1.93]*
Financial stress		
Lehman Brothers	0.884 [14.02]***	
LIBOR-OIS	0.499 [16.70]***	
Constant	0.171 [1.14]	
Observations	677	
R^2	0.99	

Table 7b. (continued)

Onshore rate		
Deposit rate	−0.079	
	[3.74]***	
LIBOR U.S. dollar	0.978	
	[70.38]***	
Log (VIX_t)	0.17	
	[2.64]***	
Non-monetary policy actions	*Implemented*	*Announced*
Broadening eligible collateral	0.075	−0.012
	[1.59]	[0.04]
Swap lines with Federal Reserve	0.17	−0.391
	[3.82]***	[1.33]
TAF and extension of acceptable collateral	−0.582	0.985
	[5.84]***	[3.40]***
Financial stress		
Lehman Brothers	0.246	
	[2.76]***	
LIBOR-OIS	−0.142	
	[2.76]***	
Constant	0.33	
	[1.40]	
Observations	679	
R^2	0.98	

Table 7b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.312	
	[18.02]***	
Log (CRB_t)	−0.077	
	[2.04]**	
Log (VIX_t)	0.02	
	[3.32]***	
Non-monetary policy actions	*Implemented*	*Announced*
Broadening eligible collateral	0.077	−0.046
	[19.85]***	[1.74]*
Swap lines with Federal Reserve	0.035	−0.073
	[6.37]***	[2.72]***
TAF and extension of acceptable collateral	0.072	−0.042
	[9.16]***	[1.59]
Financial stress		
Lehman Brothers	−0.041	
	[5.13]***	
LIBOR-OIS	0.033	
	[7.90]***	
Constant	6.703	
	[37.54]***	
Observations	680	
R^2	0.96	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets.

2.2.7 South Korea[10]

The Bank of Korea initially responded to rising international financial volatility by supplying liquidity to banks and securities companies through long-term repo operations, starting in October 2008. To further ease tensions in funding markets, in November and December 2008 the central bank included bank debentures and certain government agency bonds among the securities eligible for use as collateral in open market operations, which originally included only Treasury bonds, government-guaranteed bonds and monetary stabilization bonds. In November, the central bank supported the creation of a bond market stabilization fund, while in December counterparties for repo operations were expanded to include securities companies in addition to banks.

To facilitate lending, the aggregate credit ceiling was raised in November to boost banks' incentives for lending to small and medium enterprises (SMEs). The aggregate credit ceiling was further increased on 23 March 2009. Moreover, in December 2008, the central bank paid banks a one-off remuneration on their required reserve deposits to help them expand their credit supply capacity by raising their Bank for International Settlements (BIS) capital adequacy ratios.

As in other economies, foreign exchange market tensions grew in the wake of the Lehman Brothers collapse. This is evident from the shift in the level and volatility of the onshore U.S. dollar rate in South Korea in the fourth quarter of 2008, which peaked at over 600 basis points above LIBOR. The central bank undertook a number of measures to alleviate further financial market unrest and to prevent the turmoil from evolving into a full-blown currency crisis. On 30 October 2008, the central bank entered into a 30 billion dollar swap arrangement with the Federal Reserve. In addition, on 12 December the central bank not only entered into a swap arrangement with the People's Bank of China, but also expanded the ceiling of an existing currency arrangement with the Bank of Japan.

Furthermore, the Bank of Korea acted directly to ease corporate access to foreign credit through a number of measures. It directly provided U.S. dollars in foreign currency liquidity to financial institutions experiencing difficulties in overseas fund-raising by way

10. This section is based on Bank of Korea (2009).

of a competitive swap facility between 21 October and 16 December 2008. On 17 November 2008, it introduced measures to heighten the attraction to foreign exchange banks of providing trade finance to SMEs. Meanwhile, for firms which had taken out foreign currency loans or purchased financial derivative products and were facing a widening debt service burden and losses on derivative products, the Bank of Korea allowed domestic banks to extend the maturities of their foreign currency loans made for use as working capital and also permitted export firms to take out foreign currency loans for settlement of currency option contracts such as knock-in knock-out (KIKO) arrangements. Table 8a presents these measures.

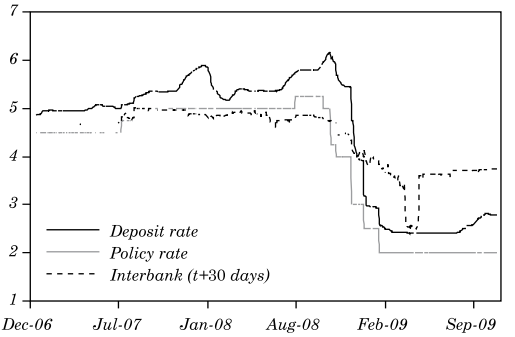
Table 8a. Extraordinary Actions in South Korea

Start	*End*	*Extraordinary action*
30-Apr-08		Specific support to businesses.
1-Oct-08		Specific support to businesses.
17-Oct-08		Foreign exchange swap auctions.
27-Oct-08		Extension of accepted collateral to include bonds issued by banks.
29-Oct-08	30-Oct-09	Swap facility with the Federal Reserve.
1-Dec-08		Specific support to businesses.
3-Dec-08		Interest began to be paid on bank deposits held in the central bank.
9-Dec-08		Extension of accepted collateral to include bonds emitted by public corporations.
11-Dec-08		Twelve more firms made eligible for repo operations.
12-Dec-08	1-Apr-09	Expansion of swap line with the Bank of Japan.
9-Jan-09		91-day repos introduced.

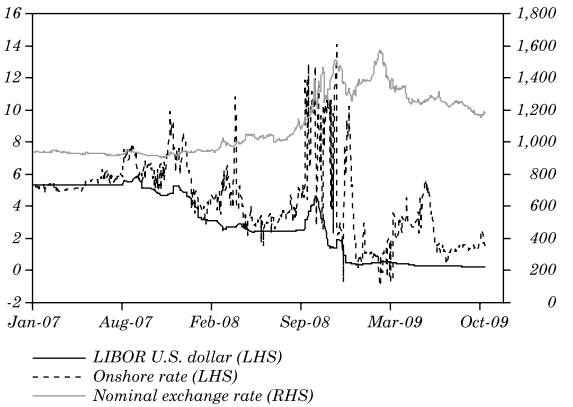
Source: Authors' compilation from Bank of Korea reports.

Figure 11. Key Money Market Variables in South Korea

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Bank of Korea.

Table 8b. Estimation Results for South Korea[a]

Deposit rate		
Interbank rate	−0.498 [10.16]***	
Expected rate (t+20)	1.581 [38.49]***	
Log (VIX_t)	−0.045 [2.28]**	
LIBOR U.S. dollar	0.038 [4.13]***	
Onshore rate	0.003 [1.24]	
Non-monetary policy actions	*Implemented*	*Announced*
Support to businesses	0.086 [3.39]***	
Won-dollar foreign exchange swaps	0.148 [3.38]***	−0.1 [1.18]
Collateral relaxation and central bank remuneration on reserves	0.403 [7.76]***	0.064 [0.79]
Swap facility with Federal Reserve or Bank of Japan	−0.044 [3.00]***	0.084 [1.09]
Financial stress		
Lehman Brothers	−0.179 [6.00]***	
LIBOR-OIS	0.115 [7.84]***	
Constant	−0.452 [5.63]***	
Observations	559	
R^2	0.99	

Table 8b. (continued)

	Onshore rate	
Deposit rate	1.947 [13.38]***	
LIBOR U.S. dollar	0.069 [0.42]	
Log (VIX_t)	1.243 [3.64]***	
Non-monetary policy actions	*Implemented*	*Announced*
Support to businesses	−2.772 [6.01]***	
Won-dollar foreign exchange swaps	−3.319 [4.40]***	3.702 [2.24]**
Collateral relaxation and central bank remuneration on reserves	4.114 [4.84]***	−8.603 [5.45]***
Swap facility with Federal Reserve or Bank of Japan	−2.636 [9.97]***	1.308 [0.85]
Financial stress		
Lehman Brothers	3.726 [7.18]***	
LIBOR-OIS	0.025 [0.09]	
Constant	−7.955 [6.34]***	
Observations	649	
R^2	0.65	

Table 8b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.403	
	[16.80]***	
Log (CRB_t)	0.395	
	[8.74]***	
Log (VIX_t)	−0.01	
	[1.37]	
Non-monetary policy actions	*Implemented*	*Announced*
Support to businesses	0.104	−0.063
	[21.95]***	[2.06]**
Won-dollar foreign exchange swaps	0.072	−0.036
	[4.55]***	[1.07]
Collateral relaxation and central bank remuneration on reserves	0.06	−0.018
	[3.71]***	[0.58]
Swap facility with Federal Reserve or Bank of Japan	0.052	−0.07
	[8.25]***	[2.23]**
Financial stress		
Lehman Brothers	0.082	
	[8.27]***	
LIBOR-OIS	0.047	
	[10.04]***	
Constant	10.896	
	[45.74]***	
Observations	680	
R^2	0.97	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets.

For our purposes, we identify as policy dummies the direct provision of liquidity to businesses, the U.S. dollar-won swap operations by the central bank, collateral extensions and the remuneration of reserves, and the swap arrangement with the Federal Reserve. Table 8b presents the results of the estimation. Two results are the most noteworthy. First, the variable that most reacted to these policy measures was the onshore U.S. dollar interest rate. The liquidity support to businesses, U.S. dollar-won swaps and the swap arrangement with the Federal Reserve reduced this interest rate substantially, by 270, 330, and 260 basis points, respectively. Similarly to other cases, the nominal exchange rate did not seem to react in a significant way to any of these policy measures, in the sense of experiencing an appreciation.

2.2.8 Indonesia

A significant concern in the wake of the global financial crisis in Indonesia was the magnitude of external debt maturing during 2009 as well as the settlement of structured products between a number of banks.[11] Hence, as elsewhere, the implementation of measures to ease short-term funding pressures was key to dealing with the crisis. Most of the measures implemented by the central bank related to the provision of liquidity in foreign currency. By mid-October, the tenor of U.S. dollar-local currency swaps was extended to one month, reserve requirements on U.S. dollar deposits were cut, and limits on foreign borrowing by local banks were abolished. In February 2009, as global financial turmoil continued, Indonesia secured a number of facilities to provide additional foreign liquidity in the form of standby loans from the World Bank, bilateral swap agreements with Japan and China, and an expanded pool of reserves through the Chiang Mai Initiative. In terms of local money markets, also by mid-October, the maximum guarantee for deposits of selected institutions was expanded and longer-tenor repo operations were introduced. In December, the corridor for the overnight rate was narrowed. Table 9a summarizes the timeline of implemented measures.

For our purposes, we identify three policy dummies. First, the introduction of local money market and U.S. dollar facilities in mid-October; second, the narrowing of the interbank rate corridor; and third, the number of credit lines with foreign institutions. Results are

11. See Mulya (2009).

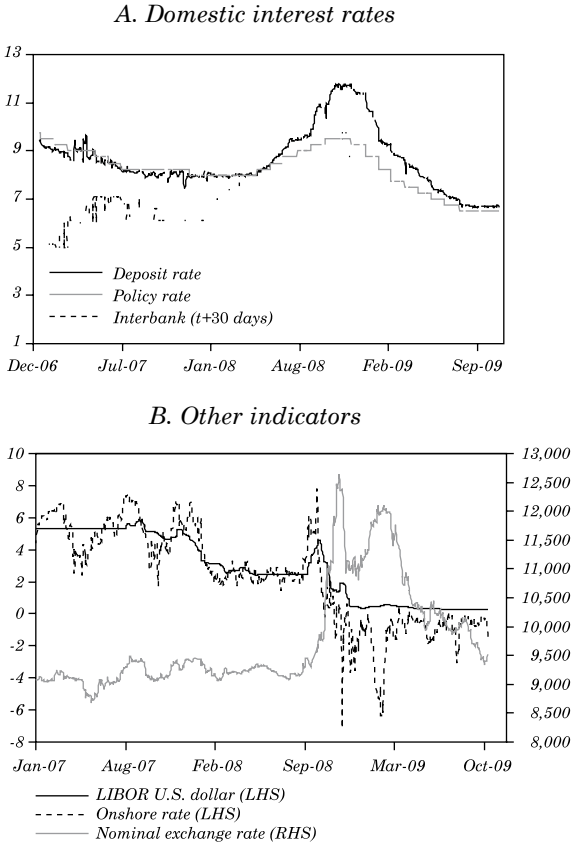
presented in Table 9b, and suggest that several of these measures were indeed effective in easing money market tensions, both in local currency and U.S. dollars. Although the initial implementation of measures in October did not significantly reduce the spread between interbank and policy rates, it did reduce implied onshore U.S. dollar interest rates by close to 300 basis points. The access to a broader set of foreign resources by the first quarter of 2009 significantly affected both local money market interest rates and implied onshore U.S. dollar rates. Interestingly, none of these measures seems to have significantly affected the exchange rate.

Table 9a. Extraordinary Actions in Indonesia

Start	*End*	*Extraordinary action*
9-Oct-08		Introduction of two week repo operation.
14-Oct-08		Foreign exchange market measures: foreign exchange swap maturities extended from seven days to one month; reserve requirements on foreign currency deposits lowered from three to one percent; and limit on foreign currency borrowing by banks is abolished.
4-Dec-08		Corridor for overnight interest rates narrowed from 200 to 100 basis points.
2-Feb-09		Credit lines with foreign institutions: arrangement of 5.5 billion U.S. dollar standby loans from the World Bank, Asian Development Bank, Australia and Japan; and expansion of bilateral currency swap arrangement with Japan from two to six billion U.S. dollars.
23-Mar-09		Bilateral swap line with China.

Source: Authors' compilation from Bank Indonesia reports.

Figure 12. Key Money Market Variables in Indonesia



Sources: Bloomberg and Bank Indonesia.

Table 9b. Estimation Results for Indonesia

Deposit rate		
Interbank rate	1.344 [69.64]***	
Expected rate (t+20)		
Log (VIX_t)	0.417 [9.53]***	
LIBOR U.S. dollar	−0.115 [10.41]***	
Onshore rate	−0.014 [2.01]**	
Non-monetary policy actions	*Implemented*	*Announced*
Repo, swap, or reserve requirement lowered	0.131 [1.93]*	−0.969 [4.86]***
Narrowing of interbank rate corridor	0.013 [0.24]	0.412 [2.09]**
Credit lines with foreign banks	−0.645 [12.59]***	−0.028 [0.15]
Financial stress		
Lehman Brothers	0.849 [12.65]***	
LIBOR-OIS	0.01 [0.33]	
Constant	-3.641 [15.30]***	
Observations	631	
R^2	0.97	

Table 9b. (continued)

	Onshore rate	
Deposit rate	−0.553	
	[7.38]***	
LIBOR U.S. dollar	1.01	
	[21.93]***	
Log (VIX_t)	0.141	
	[0.58]	
Non-monetary policy actions	*Implemented*	*Announced*
Repo, swap, or reserve requirement lowered	−3.726	0.475
	[10.19]***	[0.41]
Narrowing of interbank rate corridor	−0.203	−0.985
	[0.64]	[0.86]
Credit lines with foreign banks	−1.776	1.614
	[5.62]***	[1.42]
Financial stress		
Lehman Brothers	3.69	
	[9.62]***	
LIBOR-OIS	−0.302	
	[1.74]*	
Constant	4.402	
	[4.04]***	
Observations	641	
R^2	0.86	

Table 9b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	0.102 [1.20]	
Log (CRB_t)	−0.372 [9.00]***	
Log (VIX_t)	0.112 [19.19]***	
Non-monetary policy actions	*Implemented*	*Announced*
Repo, swap, or reserve requirement lowered	0.047 [4.94]***	−0.094 [3.20]***
Narrowing of interbank rate corridor	−0.005 [0.58]	0.031 [1.06]
Credit lines with foreign banks	0.03 [4.92]***	0.023 [0.80]
Financial stress		
Lehman Brothers	−0.04 [4.60]***	
LIBOR-OIS	−0.01 [2.26]**	
Constant	10.574 [56.80]***	
Observations	670	
R^2	0.91	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets

2.2.9 Peru

Peruvian authorities did not hesitate to aggressively provide domestic and foreign currency liquidity starting in September 2008. Table 10a summarizes the most relevant actions adopted by the Central Reserve Bank of Peru (CRBP). On domestic liquidity provision, the CRBP reduced reserve requirements for banking institutions gradually but significantly, starting on 26 September 2008, and deepening this incentive into the first quarter of 2009 in six different press releases. On the foreign exchange market, intervention needed to be aggressive since Peru is a highly dollarized economy. The CRBP intervened in the U.S. dollar market by selling almost 7 billion dollars from September 2008 to May 2009, with public announcements by authorities that these interventions were to reduce exchange rate market volatility. From the right panel of figure 13 it is evident that depreciation of the nuevo sol was mild compared to both its own history and other Latin American currencies.

Table 10a. Extraordinary Actions in Peru

Start	*End*	*Extraordinary action*
1-Sep-08	30-Sep-08	Selling auction of 2 billion U.S. dollars to avoid exchange rate volatility.
26-Sep-08		Suspension of reserve requirement for two to seven year obligations (less than twice banks' equity).
		For obligations over seven years, 49 percent of marginal reserve requirement.
10-Oct-08		Establishment of repo operations to provide U.S. dollar liquidity. Accept treasury and Central Reserve Bank of Peru bonds with repurchase agreement.
		Maximum amount previously communicated plus allocation to highest interest rate bids.
20-Oct-08		9 percent unique reserve requirement (national currency) for general liabilities.
21-Oct-08		Reduction of marginal reserve requirement from 49 to 35 percent.
24-Oct-08		New option of currency swaps (soles and U.S. dollars).

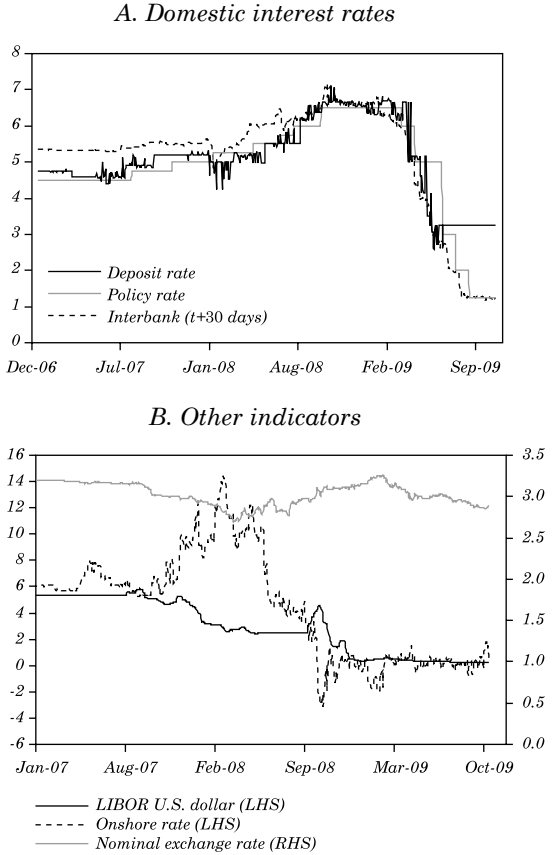
Table 10a. (continued)

1-Oct-08	31-Oct-08	Selling auction of 2.6 billion U.S. dollars to avoid exchange rate volatility.
1-Nov-08	31-Nov-08	Selling auction of 810 million U.S. dollars to avoid exchange rate volatility.
28-Nov-08		Changes to reserve requirements: vindication reserve requirements to 33 percent of liabilities; reduction of reserve requirement for deposits of nonresidents from 120 to 30 percent; reduction of reserve requirement for deposits of nonresidents with investment purposes from 120 to 30 percent; and top mean reserve requirement to short-term foreign loans of 35 percent.
1-Dec-08	31-Dec-08	Selling auction of 289 million U.S. dollars to avoid exchange rate volatility.
30-Dec-08		7.5 percent unique reserve requirement (national currency) for general liabilities.
		Reduction of marginal reserve requirement from 35 to 30 percent.
1-Jan-09	31-Jan-09	Selling auction of 676 million U.S. dollars to avoid exchange rate volatility.
30-Jan-09		6.5 percent unique reserve requirement (national currency) for general liabilities.
1-Feb-09	28-Feb-09	Selling auction of 473 million U.S. dollars to avoid exchange rate volatility.
20-Mar-09		6 percent unique reserve requirement (national currency) for general liabilities.
15-Apr-09		Central bank offers to buy loan portfolios from commercial banks with repurchase agreement.
1-May-09	30-May-09	Selling auction of 77 million U.S. dollars to avoid exchange rate volatility.
24-Jul-09		First currency swap (soles versus U.S. dollars): Central bank sells soles.
14-Aug-09		Currency swap (central bank sells soles).

Source: Authors' compilation from Central Reserve Bank of Peru reports.

The CRBP also implemented repo operations and currency swaps to further ease liquidity in foreign currency. Moreover on 15 April 2009 the CRBP, in a highly unusual policy, offered to buy loan portfolios from commercial banks with a repurchase agreement, thereby moving private sector risk onto the central bank's balance sheet.

Figure 13. Key Money Market Variables in Peru



Sources: Bloomberg and Central Reserve Bank of Peru.

Thus, we identify five dummies for the Peruvian case: (i) liquidity provision through reserve requirement reductions; (ii) direct sales in the foreign exchange spot market; (iii) repo operations in foreign currency; (iv) loan portfolio purchases from commercial banks; and (v) currency swap implementation. Domestic interest rates, as expected, correlated negatively with reserve requirement reductions and the loan portfolio purchase offers, and positively with the VIX index and the policy rate. On the other hand, direct sales of U.S. dollars seem to be positively associated with higher domestic rates, similarly to foreign exchange swaps. Repo operations and currency swaps aimed to enhance foreign currency liquidity tamed foreign exchange interest rates, as expected. Although direct U.S. dollar sales by the central bank do not seem to affect the bilateral exchange rate with the U.S. dollar, the counterfactual scenario would have been one of extensive depreciation of the local currency, as in other economies. Direct interventions specifically aimed to avoid such events. No other policy variable seems to have had a large economic impact on the bilateral exchange rate.

Table 10b. Estimation Results for Peru

Deposit rate		
Interbank rate	0.719	
	[16.91]***	
Expected rate (t+20)	−0.146	
	[4.23]***	
Log (VIX_t)	0.305	
	[5.75]***	
LIBOR U.S. dollar	−0.082	
	[7.69]***	
Onshore rate	−0.027	
	[5.02]***	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve requirement liquidity	−0.449	0.263
	[3.61]***	[1.02]
Direct sales of U.S. dollars	0.417	0.38
	[8.07]***	[2.14]**
Repo U.S. dollar liquidity	−0.05	−0.317
	[0.51]	[1.25]
Buying offer of loan portfolio	−0.51	1.801
	[5.73]***	[7.20]***
Currency swap	0.488	−0.038
	[5.42]***	[0.15]
Financial stress		
Lehman Brothers	0.16	
	[1.61]	
LIBOR-OIS	0.086	
	[2.19]**	
Constant	1.466	
	[5.45]***	
Observations	680	
R^2	0.93	

Table 10b. (continued)

Onshore rate		
Deposit rate	−1.837	
	[8.77]***	
LIBOR U.S. dollar	−0.753	
	[10.56]***	
Log (VIX_t)	1.59	
	[4.23]***	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve requirement liquidity	−1.72	0.631
	[1.96]**	[0.34]
Direct sales of U.S. dollars	−0.262	0.152
	[0.69]	[0.12]
Repo U.S. dollar liquidity	−3.277	−0.956
	[4.70]***	[0.52]
Buying offer of loan portfolio	−3.6	4.796
	[6.83]***	[2.58]**
Currency swap	−0.97	0.326
	[1.67]*	[0.18]
Financial stress		
Lehman Brothers	−4.118	
	[6.00]***	
LIBOR-OIS	0.628	
	[2.45]**	
Constant	14.801	
	[9.30]***	
Observations	680	
R^2	0.81	

Table 10b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−0.988	
	[22.67]***	
Log (CRB_t)	−0.065	
	[2.91]***	
Log (VIX_t)	0.011	
	[2.90]***	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve requirement liquidity	−0.001	0.011
	[0.12]	[0.59]
Direct sales of U.S. dollars	−0.007	−0.002
	[2.02]**	[0.16]
Repo U.S. dollar liquidity	−0.055	0.034
	[7.94]***	[1.94]*
Buying offer of loan portfolio	−0.01	−0.008
	[2.37]**	[0.49]
Currency swap	0.015	0.008
	[2.59]***	[0.43]
Financial stress		
Lehman Brothers	−0.002	
	[0.35]	
LIBOR-OIS	−0.011	
	[4.48]***	
Constant	6.014	
	[52.50]***	
Observations	680	
R^2	0.86	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of t statistics in brackets

2.3 Summary of Empirical Results

The previous subsections highlight the diverse experiences in domestic local currency and U.S. dollar markets. In most cases domestic local currency markets experienced some degree of stress in the second half of 2008, with the average spread between 28-day interbank rates and the expected policy rate rising significantly compared to previous levels and becoming considerably more volatile (see table 12a). Notable exceptions to this were Colombia and Mexico. In Mexico, flight from long-term public debt pushed down short-term rates. In Colombia, although there was no evident pressure in money markets, the central bank expanded its mechanisms for domestic liquidity provision, which in turn pushed down short-term interbank rates.

In those countries which experienced rising rates, central banks expanded their offer and the scope of liquidity facilities, seeking to align short-term bank funding rates with policy rates to ensure an effective transmission of monetary policy. Despite the fact that the interbank-swap spread came down in most countries in 2009, the simple regressions presented in the previous section suggest that the statistical effectiveness of these measures was mixed. Table 11 shows a summary of p-values for a joint significance test on the policy dummies (for implementation and announcement alike). In 10 out of 54 country-policy pairs, parameter estimates were statistically different from zero at the 15 percent significance level. However, for 37 out of 54 country-policy pairs the p-value was lower than or equal to 1 percent. This is broadly consistent with the small but growing empirical literature on the effectiveness of unconventional measures for advanced economies. This literature tends to find that domestic liquidity provision programs tend to reduce LIBOR-OIS spreads (see Aït-Sahalia and others, 2009; Artuç and Demiralp, 2010; McAndrews, Sarkar, and Wang, 2008; Deutsche Bank, 2009; and Christensen and others, 2009).

Table 11. P Values for Joint Test on the Efficacy of Non-Monetary Policy Actions

Country		*Deposit rate*	*Onshore rate*	*Exchange rate*
Australia	Implemented	0.47	0.00	0.00
	Announced	0.11	0.00	0.06
Brazil	Implemented	0.72	0.00	0.00
	Announced	0.06	0.00	0.00
Chile	Implemented	0.00	0.00	0.00
	Announced	0.00	0.31	0.24
Colombia	Implemented	0.00	0.00	0.00
	Announced	0.61	0.75	0.12
Indonesia	Implemented	0.00	0.00	0.00
	Announced	0.00	0.40	0.01
Mexico	Implemented	0.00	0.00	0.00
	Announced	0.11	0.00	0.28
New Zealand	Implemented	0.00	0.00	0.00
	Announced	0.00	0.00	0.01
Peru	Implemented	0.00	0.00	0.00
	Announced	0.00	0.00	0.46
South Korea	Implemented	0.00	0.00	0.00
	Announced	0.36	0.00	0.03

Source: Authors' calculations.

Note, however, that with few exceptions, central banks responded to rising market rates by reducing exceptionally high spreads between 28-day and overnight policy rates, but did not abandon the pre-crisis schemes of primarily targeting short-term rates. Indeed, in most cases the liquidity tools traditionally used to target overnight rates were simply enhanced to extend the maturity and eligible collateral of the central bank's operations.[12]

12. For Mexico and Indonesia, we report spreads between the 28-day interbank rate and the overnight policy rate, because data on interest rate swaps are not available.

Table 12a. Swap Spreads in Local Currency and Spread Volatility

	Swap spread in local currency (basis points)						*Spread volatility (std. deviation)*			
	Jan 07–May 07	*Jun 07–Aug 08*	*Sep 08–Dec 08*	*Avg. 2009*	*Max 2008*	*Last Avg.*	*Jan 07–May 07*	*Jun 07–Aug 08*	*Sep 08–Dec 08*	*Avg. 2009*
Australia	2	18	58	30	205	38	19	22	40	33
Brazil	−8	−4	27	−9	110	−15	16	23	60	46
Chile	4	17	22	0	255	22	15	7	21	21
Colombia	−10	−5	−12	−6	5	−3	25	44	26	73
Indonesia	−19	0	180	67	250	19	2	11	26	8
Mexico	3	−3	−39	−19	28	1	6	20	75	17
New Zealand	25	36	93	42	260	47	8	24	19	84
Peru	−65	−49	−8	81	26	201				
South Korea	18	22	61	27	108	40	4	6	37	21

Source: Authors' calculations.

Several central banks in our sample also participated in some form of public debt policy. In the case of Chile, for example, the central bank shifted the maturity of debt issuance to minimize the impact of higher public sector issuance on the yield curve. Implicit in these policies is a belief that the supply of debt could have significant—if transitory—effects on rates, particularly in times of financial distress. The available information indicates that, in most cases, the objective of these measures was to avoid temporary deviations of rates from "fundamentals" that would impact the transmission mechanism rather than complement traditional monetary policy by pushing down long-term rates.

The impact of the crisis on onshore dollar rates is more heterogeneous. Whether rates rose or fell relative to LIBOR depends on both how financial stress affected external financing costs, and events in domestic forward markets. In several cases, including Brazil and Mexico, agents rushed to unwind short U.S. dollar positions, pushing down domestic dollar rates. In others, the risk-adjusted rate rose in line with rising global uncertainty or illiquidity and pushed up onshore rates (see table 12b). In most cases, however, volatility increased over levels observed in the first semester of 2007.

Here, policies aimed to either complement the private supply of dollar credit directly, via swaps or other mechanisms, or to offset the lack of dollar liquidity on the exchange rate. Many of the measures that provided dollar loans seem to have been relatively successful in reducing domestic dollar rates. The effects of direct one-off or programmed sales of U.S. dollars, as discussed in the previous section, were mixed. For instance, direct U.S. dollar sales in the spot market in Peru appreciated the local currency, while in Mexico this same operation was associated with national currency depreciation, possibly due to an intervention that was less aggressive than required. On the other hand, swap lines with foreign central banks do seem to have been widely effective in those countries that implemented them, taming the depreciation of local currencies both during implementation and at the time they were announced.

Table 12b. Swap Spreads in U.S. Dollars and Spread Volatility

	Swap spread in U.S. dollars (basis points)					*Spread volatility (std. deviation)*			
	Jan 07–May 07	*Jun 07–Aug 08*	*Sep 08–Dec 08*	*Avg. 2009*	*Max 2008*	*Jan 07–May 07*	*Jun 07–Aug 08*	*Sep 08–Dec 08*	*Avg. 2009*
Australia	0	14	26	15	318	79	111	444	174
Brazil	101	28	−116	−26	845	11	118	141	149
Chile	−46	81	112	102	458	140	117	128	112
Colombia	−33	−161	62	11	347	119	91	214	134
Indonesia	−22	10	−105	−153	373	21	111	338	129
Mexico	24	51	−249	−49	177	10	19	68	22
New Zealand	2	2	24	32	426	66	321	234	71
Peru	93	381	−171	−24	1154	0	0	0	0
South Korea	−13	125	513	157	1270	8	32	237	45

Source: Authors' calculations based on data from Bloomberg and national central banks (see table A1 for details).

In general, the period after the Lehman Brothers collapse saw a significant increase in onshore U.S. dollar interest rates. This effect occurred over and above the sensitivity to other risk and volatility measures, such as LIBOR-OIS spreads and the VIX index, and the actual movement of the U.S. dollar LIBOR itself. Local interest rates also reacted to global financial turmoil, although the degree of heterogeneity between economies seems to be larger in this case. Worldwide, local exchange rates followed the gyrations of the U.S. dollar and of commodity prices.

3. Conclusions

Events surrounding the financial crisis and the Great Recession of 2008–09 have required significant policy measures by central banks. Has the inflation targeting framework been flexible enough to accommodate these responses? Or has IT restricted their room of maneuver? In this paper we tackle this question by assessing the policy responses to the crisis of a selection of nine central banks that follow inflation-targeting frameworks and that remained financially stable, in the sense of not facing systemic problems in their banking or financial systems. We find that from the second half of 2008 on, monetary policy responses deviated substantially in all cases from the prescriptions of standard simple reaction functions, a finding that we have reconciled in all cases with a drop in the persistence of monetary policy. We show that neither inflation nor output deviations (actual or expected), were plausibly large enough to account for such severe and swift deviations from past policy actions. We have also constructed a timeline history for the nine economies in our sample, documenting non-monetary policy measures and estimated their impact on local money markets—both in local currency and U.S. dollars—and the exchange rate. We find that although there is a significant heterogeneity in the specific characteristics of non-monetary policy measures and their eventual effectiveness, they were broadly successful in limiting and reducing money market and foreign exchange rate market tensions. The heterogeneity of these types of measures across different IT central banks, along with the general preservation of price stability in the selected economies, suggests that IT frameworks have been flexible enough to accommodate unconventional central bank policies.

APPENDIX

Supplementary Figures and Tables

Table A1. Variable Definitions

Country and variable	*Bloomberg ticker*	*Description*
Australia		
Interbank rate	AU0001M	LIBOR Australian dollar one-month. British Bankers Association fixing for Australia dollar.
Monetary policy rate	RBATCTR	Reserve Bank of Australia cash rate.
Swap rate	ADSOA Curncy	Australian dollar swap OIS one-month.
Nominal exchange rate	AUD Curncy	Spot exchange rate expressed as U.S. dollars per Australian dollar.
Forward contract	AUD1M Curncy**	One-month forward points.
	AUD3M Curncy**	Three-month forward points.
	AUD12M Curncy**	Twelve-month forward points.
Interest rate	ADBB1M Index	Bank bill one-month. Day count: ACT/365.
	ADBB3M Index	Bank bill three-month. Day count: ACT/365.
	ADSWAP1Q Index	Interest rate swap quarterly one-year. Quote: quarterly one to three year use quarterly settlement versus three-month bank bill. Day count: ACT/365.
Brazil		
Swap rate	BCSWAPD Curncy	Real swap Pre-DO one-month. Pre is the fixed rate and DI is the floating rate. Di is the Brazilian interbank deposit average rate.
Interbank rate	BCCDIO Curncy	Brazilian interbank lending rate with no government bonds as collateral.
Deposit rate	BCCDBAE Index	Brazilian retail certificate of deposit quoted as an effective annualized rate (30-day rate).
Monetary policy rate	BZSTSETA Index	Brazilian SELIC target rate.
Nominal exchange rate	BRL Curncy	Spot exchange rate expressed as Brazilian reals per U.S. dollar.
Forward contract	BCN1M Curncy***	One-month NDF points.
	BCN3M Curncy***	Three-month NDF points.
	BCN12M Curncy***	Twelve-month NDF points.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Interest rate	OD1 Comdty	Generic one-day interbank deposit futures contract. Underlying asset: the interest rate of interbank deposits, defined as the capitalized daily average of one-day rates based on the period from the transaction date to the last trade day. Price quotations expressed as a percentage rate per annum compounded daily based on a 252-day year. Day count: DU/252.
	OD2 Comdty	Generic two-day 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD3 Comdty	Generic three-day 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD4 Comdty	Generic 4th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD7 Comdty	Generic 7th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD8 Comdty	Generic 8th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD9 Comdty	Generic 9th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD10 Comdty	Generic 10th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD11 Comdty	Generic 11th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD12 Comdty	Generic 12th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD13 Comdty	Generic 13th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD14 Comdty	Generic 14th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD15 Comdty	Generic 15th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Chile		
Deposit rate		30/90-day banking system average deposit rate.
Swap rate		Swap average camara.
Monetary policy rate		Overnight interbank rate.
Nominal exchange rate	CLP Curncy	Spot exchange rate expressed in Chilean pesos per U.S. dollar.
Forward contract	CHN1M Curncy***	One-month NDF points.
	CHN3M Curncy***	Three-month NDF points.
	CHN12M Curncy***	Twelve-month NDF points.
Interest rate	CLTN30DS Curncy	Nominal average interbank rate 30 days, provided by *Asociación Nacional de Bancos*, observed amongst the local financial institutions. Nominal rates are ACC/30-days and without considering inflation.
	CHSWPC Index	Interest rate swap peso versus camara three-month. Quote: semi-annual settlement & compounding versus camara. Day count: ACT/360.
	CHSWP1 Index	Interest rate swap peso versus camara one year. Quote: semi-annual settlement & compounding versus camara. Day count: ACT/360.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Colombia		
Interbank rate		90-day interbank rate.
Swap rate	CLSWA Curncy	Colombian peso one-month swap.
Deposit rate	CLDRA Curncy	Colombian peso one-month deposit.
Monetary policy rate	CORRRMIN Index	Colombia minimum repo rate.
Nominal exchange rate	COP Curncy	Spot exchange rate expressed as Colombian pesos per U.S. dollar.
Forward contract	CLN1M Curncy***	One-month NDF points.
	CLN3M Curncy***	Three-month NDF points.
	CLN12M Curncy***	Twelve-month NDF points.
Interest rate	DTF RATE Index	DTF 90-day interest rate. This index is released on a weekly basis. It is a weighted average of all financial institutions' deposit rates, calculated by the central bank. This is an annual effective rate.
	COMM1YR Index	Time deposits of banks yield curve one year. Rates are also known as TBS (*Tasa Básica de la Superintendencia Bancaria*). Refers to a 360 day period.
Indonesia		
Interbank rate	JIIN1M Index	Jakarta interbank one-month rate.
Monetary policy rate	IDBIRATE Index	Official overnight rate.
Swap rate	IHSWOOA Curncy	Indonesian rupiah one-month onshore swap.
Deposit rate	IDRE1MO Index	Indonesian rupiah one-month deposit rate (average of 131 banks).
Nominal exchange rate	IDR Curncy	Spot exchange rate expressed as Indonesian rupiahs per U.S. dollar.
Forward contract	IHO1M Curncy*	One-month onshore forward points.
	IHO3M Curncy*	Three-month onshore forward points.
	IHO12M Curncy*	Twelve-month onshore forward points.
Interest rate	IHDRA Index	Deposit three-month. Day count: ACT/360.
	IHDRC Index	Deposit one-month. Day count: ACT/360.
	IDRE12MO Index	Indonesia deposit rate average twelve month. Day count: ACT/360.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Mexico		
Monetary policy rate	MXONBR Index	Official overnight rate.
Interbank rate	MPTBA Curncy	Mexico interbank offered rate (MEXIBOR).
Nominal exchange rate	MXN Curncy	Spot exchange rate expressed as Mexican pesos per U.S. dollar.
Forward contract	MXN1M Curncy**	One-month forward points.
	MXN3M Curncy**	Three-month forward points.
	MXN12M Curncy**	Twelve-month forward points.
Interest rate	MXIBTIIE Index	Benchmark interbank deposit rates TIIE 28 day. The TIIE is an interbank interest rate which is decided by the supply and demand of funds. Calculated by bids provided by Mexican banks, this is the rate which is set when supply and demand reach equilibrium.
	MPSWC Index	Mexican peso-denominated interest rate swaps (TIIE) three-month. Day count: 28/360
	MPSW1A Index	Mexican peso-denominated interest rate swaps (TIIE) thirteen-month. Day count: 28/360
New Zealand		
Interbank rate	NZ001M Index	London interbank offered rate – BBA fixing for New Zealand dollar.
Monetary policy rate	NZOCRS Index	Reserve Bank of New Zealand official cash rate.
Swap rate	NDSOA Curncy	New Zealand swap OIS one-month.
Nominal exchange rate	NZD Curncy	Spot exchange rate expressed as U.S. dollars per New Zealand dollar.
Forward contract	NZD1M Curncy**	One-month forward points.
	NZD3M Curncy**	Three-month forward points.
	NZD12M Curncy**	Twelve-month forward points.
Interest rate	NDBB1M Index	Bank bill one month. Day count: ACT/365.
	NDBB3M Index	Bank bill three month. Day count: ACT/365.
	NDBB12M Index	Bank bill twelve month. Day count: ACT/365.

Table A1. (continued)

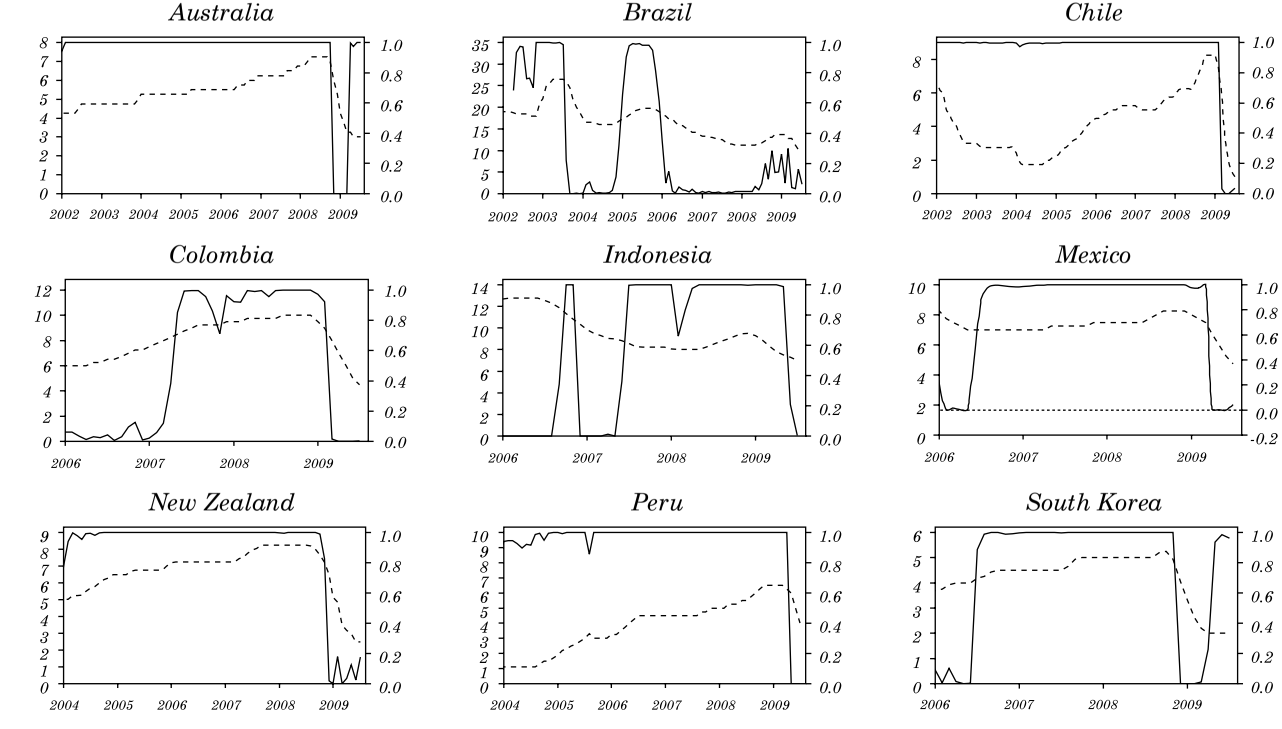
Country and variable	*Bloomberg ticker*	*Description*
Peru		
Deposit rate	PSDRA Curncy	Peruvian one-month deposit.
Interbank rate	PEOPRBI Index	Peru reference interest rate: Lima interbank offered rate (LIMABOR) in local currency.
Monetary policy rate	PRRRONUS Index	Official overnight rate.
Nominal exchange rate	PEN Curncy	Spot exchange rate expressed in nuevos soles per U.S. dollar.
Forward contract	PSN1M Curncy***	One-month NDF points.
	PSN3M Curncy***	Three-month NDF points.
	PSN12M Curncy***	Twelve-month NDF points.
Interest rate	PRBOPRBI Index	Asbanc one-month nominal rate. Reference LIMABOR interest rates in local currency (PES), is the interbank rate to which any bank is available to buy or sell. Day count: ACT/360.
	PRBOPRB3 Index	Asbanc three-month nominal rate. Reference LIMABOR interest rates in local currency (PES), is the interbank rate to which any bank is available to buy or sell. Day count: ACT/360.
	PRBOPRB1 Index	Asbanc one-year nominal rate. Reference LIMABOR interest rates in local currency (PES), is the interbank rate to which any bank is available to buy or sell. Day count: ACT/360.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
South Korea		
Deposit rate	KWCDC Curncy	Korean won certificate of deposit (CD) three-month currency.
Interbank rate	KRBO1M Index	South Korea KFB (KORIBOR) KRW one-month index.
Monetary policy rate	KOCRD Index	Official overnight rate.
Nominal exchange rate	KRW Curncy	Spot exchange rate expressed in Korean won per U.S. dollar.
Forward contract	KWO1M Curncy*	One-month onshore forward points.
	KWO3M Curncy*	Three-month onshore forward points.
	KWO12M Curncy*	Twelve-month onshore forward points.
Interest rate	KRBO1M Index	Korea interbank offered rate (KORIBOR) one-month. Is the average of lending interest rates in the interbank market.
	KWCDC Index	CD three-month. Is a debt instrument issued by a bank that will pay principal and interest when it reaches maturity. Settlement for Korean won-denominated CDs is $T+0$.
	KWSWO1 Index	Interest rate wwap onshore one-year. Quote: quarterly fixed rate versus 91-day Korean won CD. Day count: ACT/365.

Source: Authors' compilation from national central bank reports.

Figure A1. Two-State Markov Switching Estimation of Taylor Rules: High versus Low Persistence



Source: Authors' calculations.

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