Two Targets, Two Instruments:

Monetary and Exchange Rate Policies in Emerging Market Economies

Atish R. Ghosh, Jonathan D. Ostry, and Marcos Chamon[1]

Abstract

This paper examines the case for using two instruments—the policy interest rate and sterilized foreign exchange market intervention—in emerging market countries seeking to stabilize inflation and output while attenuating disequilibrium currency movements. We estimate policy reaction functions for central banks, documenting that indeed both instruments tend to be deployed. We show that whether discretionary monetary policy or inflation targeting is preferable depends on the volatility of shocks relative to the central bank's time inconsistency problem. The use of FX intervention as a second instrument improves welfare under both regimes, but more so under inflation targeting. Overall, a regime of (two-way) sterilized intervention-cum-inflation targeting can result in better outcomes in the presence of imperfect capital mobility/asset substitutability—yielding similar gains to a discretionary policy but without jeopardizing the inflation target.

JEL Classification Numbers: F21, F32.

Keywords: emerging markets; monetary and exchange rate policies; inflation targeting; sterilized intervention; capital flows.

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[1] Research Department, International Monetary Fund. Contact information: Ghosh (Corresponding Author): aghosh@imf.org; Ostry: jostry@imf.org; Chamon: mchamon@imf.org. We thank Olivier Blanchard, José de Gregorio, Michel Juillard, Scott Roger, and Mark Stone for useful comments and discussions, and Hyeon Ji Lee for excellent research assistance.

I. Introduction

The global financial crisis elicited an unprecedented degree of policy activism, not only in advanced economies that were at the epicenter of the crisis, but also in emerging market economies (EMEs) that are often on the receiving end of the greater volatility. Intellectually, also, the crisis has also prompted a fundamental re-thinking about the appropriate roles of monetary, fiscal, and financial policies. Traditionally, EMEs have been counseled against activist macroeconomic policies; in the monetary sphere, inflation-targeting (IT) and freely floating exchange rates being the favorite prescriptions. But given that many EMEs have been gaining policy credibility in the years since the financial crises of the 1990s, there is growing recognition that there may be greater scope ("space") for counter-cyclical and activist policies—especially in the face of external shocks such as volatile capital flows. With questions about the adequacy of traditional inflation targeting in advanced economies in light of the global financial crisis, it is natural for EMEs also to wonder whether inflation targeting remains appropriate—or an appropriate goal—for them.

In this paper, we argue that inflation targeting is appropriate for EMEs that lack other nominal anchors (such as a formal peg)—but that it should be supplemented by judicious foreign exchange intervention, especially in the face of volatile capital flows. Such intervention may seem at odds with conventional wisdom about inflation targeting. Early adopters of IT in advanced economies (New Zealand, Sweden, United Kingdom) certainly seemed to take the view that a high degree of exchange rate flexibility was integral to successful inflation-targeting, and allowing the currency to float freely is considered by many to be a litmus test of a country's commitment to a credible IT regime (Masson et al., 1997). Even where there may be high exchange rate pass-through to domestic prices, there are concerns that systematic interventions in the foreign exchange rate (FX) market could undermine the credibility of the IT framework (Mishkin and Savastano, 2001). Analytically, also, most modern open economy models—Benes et al. (2012) being an important exception—imply that FX intervention is neither feasible (because uncovered interest rate parity holds) nor, generally, desirable (because exchange rate fluctuations are equilibrium price movements).[2]

EMEs have reasons to question both the applicability of the standard model and its policy conclusions. In EMEs, borrowing is often in foreign currency, financial markets tend to be

[2] In vintage open economy models (e.g., Meade, 1951), domestic and foreign assets are not perfect substitutes so sterilized intervention can affect the exchange rate. As capital account restrictions between advanced economies began to be dismantled in the post-war period, open economy models (such as Fleming (1962), Mundell (1963), and Dornbusch (1976)) increasingly incorporated the assumption of perfect capital mobility and asset substitutability, which yields the familiar uncovered interest rate parity (UIP) condition.

shallower, and currency markets much thinner. On the appreciation side, the loss of competitiveness can do lasting damage to the tradeables sector, especially if firms do not have adequate access to finance to tide them over periods when the currency is temporarily strong. On the depreciation side, foreign currency exposure of unhedged balance sheets means that sharp exchange rate movements can be highly disruptive, possibly leading to widespread bankruptcies.[3] Individual agents may fail to internalize the aggregate impact of their foreign borrowing, resulting in over-exposure of the economy to exchange rate fluctuations. While the first-best solution may be to prevent such over-exposure in the first place, once it exists (for instance, because the government was unable or unwilling to impose capital controls), exchange rate movements may have amplified effects (Korinek, 2011). Aghion, Baccheta and Banerjee (2001), for example, develop a model in which expectations of currency depreciation can be self-fulfilling, resulting in a severe contraction of the economy because of the balance sheet exposure of unhedged borrowers. As such, benign neglect of the exchange rate is unlikely to be optimal for EMEs (Stone et al., 2009).

Our argument then proceeds in three steps. First, we establish that most EME central banks—even those with formal IT frameworks—appear to care about exchange rate volatility, adjusting the policy interest rate in response to exchange rate movements (beyond their effect on expected inflation) and undertaking sterilized intervention. Surveying existing empirical studies, we also conclude that sterilized intervention is more likely to be effective in EMEs than in advanced economies. Second, using a simple open economy model with imperfect capital mobility, we show in that, while discretionary monetary policy allows the central bank to better respond to domestic and foreign shocks—and this is welfare-enhancing when the central bank cares about exchange rate volatility—it may also impart an inflationary bias to the economy when the central bank is contending with time consistency or credibility problems.[4] Third, we show that FX intervention is fully consistent with the central bank meeting its inflation target under IT, and is welfare enhancing provided the central bank indeed penalizes exchange rate volatility.[5] Indeed,

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[3] Exchange rate fluctuations can be costly even in the absence of balance sheet mismatches. For example, De Paoli (2009) analyzes the optimal monetary policy in a small open economy with monopolistic competition and nominal rigidities. The utility-based loss function for that economy involves a quadratic term on the real exchange rate, in addition to the standard quadratic terms on inflation and the output gap.

[4] In this model, as with many modern macro models, "divine coincidence" (whereby meeting the inflation target also ensures that a zero output gap) implies that there would be no welfare gain from discretionary policies relative to inflation targeting if the central bank did not place any weight on exchange rate stability (as well as its inflation and output gap targets).

[5] As discussed below, the result that having two instruments (the policy rate and FX intervention) yields higher welfare than having only the policy interest rate is not trivial because inflationary expectations of forward-looking wage-setters means that inflationary expectations are potentially

(continued)

adding FX intervention to an EME ITer's toolkit strengthens the case for inflation targeting in the sense that it narrows the welfare gain associated with moving to discretionary monetary policies—even disregarding the time-consistency or credibility problems the latter are likely to engender. Our model further implies that there will be a larger gain to adding FX intervention to the toolkit when the central bank has an IT framework than when it sets discretionary policies, and that the gains from adding the second instrument to an IT framework are larger than the exchange rate stabilization gains of switching to discretionary policies.

We conclude that, with the credibility of most EME central banks not yet fully established, discretionary monetary policies would not be appropriate even though they allow the central bank to better respond to shocks that generate costly exchange rate movements. Rather, by adding FX intervention to their arsenal, EME central banks with IT frameworks can capture much of the currency stabilization gains that discretionary policies afford—without jeopardizing the hard-won credibility about their commitment to maintain low inflation. Indeed, not only is FX intervention fully consistent with inflation targeting, it may actually enhance the credibility of the central bank's inflation target.

The remainder of this paper is organized as follows. Section II examines the behavior of EME central banks, including those with formal IT frameworks, to infer whether exchange rate stability likely features in their objectives. Section III develops a simple theoretical model to establish our main analytical results. Section IV simulates a richer version of the model to confirm key intuitions and explore the dynamics of how monetary and exchange rate policies optimally interact under various policy regimes. Section V concludes.

II. POLICIES OF EME CENTRAL BANKS

What do EME central banks do in practice? Almost inevitably, the exchange rate plays a more important role in EMEs than in advanced economies, for the reasons discussed in the previous section. Therefore, even if they do not set a particular target for the exchange rate, most EME central banks have an implicit "comfort zone" beyond which they would not want to see the exchange rate move (at least not abruptly), and this is reflected in their conduct of monetary and intervention policies (see also the related discussion of the "trilemma" index in Aizenman et al., 2008). That is not to suggest that EMEs should not try to enhance the economy's resilience to exchange rate movements—for instance, by developing and deepening markets—but such structural policies take time to implement, and in the meantime, the central bank may need to be mindful of sharp currency movements.

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different when the central bank has two instruments, and if this exacerbates the central bank's time inconsistency problem, welfare could be lower.

Figure 1 reports the size of reserves relative to different metrics for a sample of IT and non-IT EMEs. Figure 1A reports the ratio of reserves to M2. The ratios are broadly comparable between the IT and non-IT EMEs, particularly if we exclude outliers. Figure 1B reports the ratio of reserves to GDP. The average among the two groups is also comparable. But one striking pattern is that, whereas all IT countries have more reserves relative to GDP in 2012 than they did in 2007, half of the non-IT sample experienced a substantial decline in that ratio over that period. Finally, Figure 1C reports the ratio of reserves to domestic local currency government debt, perhaps the most indicative gauge for the potential strength of a portfolio balance effect of intervention. The median ratio is 68 percent for the IT sample in 2012, up from 48 percent in 2007 (among non-IT countries that median ratio declines from 69 to 64 percent during that period). Reserves correspond to half or more of the stock of domestic local currency government bonds for 9 out of the 12 IT countries in Figure 1C.[6]

At least through the portfolio balance channel, therefore, sterilized intervention is more likely to be effective in EMEs than in advanced economies—a conclusion supported by several empirical studies, including country cases surveyed in Disyatat and Galati (2005).[7] Guimarães and Karacadag (2004), using intervention data from Mexico and Turkey, find that foreign exchange sales have a small but statistically significant effect on the level of the exchange rate in Mexico, but not in Turkey; they also find that such intervention reduces exchange rate volatility in Turkey (but not in Mexico). Although methodological differences across studies makes comparisons difficult, on the whole, evidence that such intervention can affect the *level* of the exchange rate tends to be weaker than evidence that it can affect exchange rate volatility, but for both, most studies find at least some impact (Table 1).[8]

Unlike most advanced economy central banks, therefore, EME central banks are likely to be operating in a (potentially) two-target, two-instrument setting. They have "two targets" in the

[6] Another commonly used metric for the size of reserves is the ratio of reserves to short-term external debt. That ratio is above 100% for all but two of the IT countries in our sample, and all but one of the non-IT countries.

[7] The literature on sterilized intervention in advanced economies generally concludes that the portfolio balance channel is unlikely to be effective because of the magnitude of outstanding assets dwarfs plausible amounts of intervention (Ghosh, 1992; see also Sarno and Taylor, 2001 for a survey, and BIS Paper no. 24, 2005). By contrast, capital tends to be less mobile in EMEs; their assets are less perfect substitutes for advanced economy/reserve currency assets; and the stock of liabilities denominated in their currencies is much smaller.

[8] The effectiveness of sterilized intervention is also likely to depend upon the circumstances; see Kamil (2008), Stone, Walker and Yosuke (2009), Adler and Tovar (2011).

sense that, in addition to the output gap/inflation target (which are simultaneously satisfied because of divine coincidence), they will also want to limit large, disequilibrium movements of the exchange rate. And they have "two instruments" because, in addition to the policy interest rate, they are likely to have at their disposal sterilized intervention.

Interest Rate Rules

A number of studies have found that emerging market inflation targeters often (implicitly) include the exchange rate in their interest rate reaction function (Taylor rule); see, e.g., Mohanty and Klau (2005) and Aizenman et al. (2011). In a textbook IT setting, the exchange rate should only affect an inflation-targeting central bank's interest rate to the extent that it has an impact on expected inflation. But a more pragmatic approach should recognize the importance of the exchange rate in emerging market settings (for the reasons explained above), and provide some room for maneuvering within the inflation target framework. Garcia et al. (2011) present a model of hybrid inflation-targeting regimes. Their simulations support the view that financially robust advanced economies have relatively little to gain by including the exchange rate directly in the policy reaction function, but financially vulnerable EMEs might benefit by doing so in a limited way. These papers do not, however, envisage a systematic role for sterilized intervention in IT regimes (see, however, Benes et al., 2012, who model sterilized interventions as an additional instrument alongside the Taylor rule and affecting the economy through portfolio balance sheet effects in the financial sector).

To see what EME central banks do in practice, we estimate a Taylor rule given by:

$$i_t - \pi_t^* = \beta_0 + \beta_1(i_{t-1} - \pi_{t-1}^*) + \beta_2(\pi_{t+4}^e - \pi_t^*) - \beta_3 \Delta \log(REER_t) + \\ \beta_4 YGAP_{t-1} - \beta\, D_{08:4-09:2} + \varepsilon_t,$$

where the dependent variable is the "target real interest rate" (the policy interest rate, i_t minus the inflation target π_{t+4}^*). Explanatory variables include the lagged dependent variable (since policy rates are adjusted slowly), the difference between expected inflation over the next four quarters (π_{t+4}^e, from Consensus Forecast) and the inflation target, the change in 100 times the log of the real effective exchange rate, the lagged output gap ($YGAP_{t-1}$ obtained from a rolling HP filter), and a dummy variable $D_{08:4-09:2}$ intended to capture the exceptional behavior during the height of the global financial crisis (2008Q4-2009Q2, which had the unusual combination of loosening of the policy rate despite sharp depreciations). Since the regression controls for expected inflation, any effect of the REER on the policy rate will, in principle, be over and above what could be justified by its pass-through to inflation. This Taylor rule is estimated for a sample of 15 EME IT countries using quarterly data from 2000 or the period of IT adoption (whatever is the latest) to end-2012, subject to availability.[9]

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[9] The sample of EME IT countries includes: Brazil, Chile, Colombia, Czech Republic, Hungary, Indonesia, Korea, Mexico, Peru, Poland, Romania, Slovak Republic, South Africa, Thailand and Turkey.

Table 2 reports the results. Column 1 includes only the inflation expectation deviation from its target level as an explanatory variable. Not surprisingly, inflation targeters respond to an increase in inflation expectations by raising the real interest rate; adding the lagged dependent variable (since policy interest rates are typically adjusted sluggishly) still yields a positive coefficient on the expected inflation deviation from target (Table 2, Column 2). The point estimate on the global financial crisis dummy is -0.9 percent (this point estimate would be smaller if other controls could capture the collapse in demand), suggesting extraordinary monetary loosening during the crisis. Table 2, Column 3, adds the lagged output gap and the change in the real exchange rate. The point estimate on the output gap suggest that real rates increase by 0.12 percentage points when output is 1 percentage point above potential (so a 1 percent gap that persists for four quarters would raise the policy rate by about 0.40 percentage points).

Turning to the variable of interest, a 10 percent real appreciation of the currency lowers the policy interest rate by 0.40 percentage points.[10] This is substantial, especially as it represents the reaction of the policy rate to the exchange rate over and above any impact of the exchange rate's movement on expected inflation, and considering that the estimated coefficient is almost surely smaller than the true response because of simultaneity bias.[11]

Our main conclusions from these estimates are that inflation-targeting central banks in EMEs generally conduct their interest rate policy in accordance with the "Taylor principle," tightening real interest rates when inflation is expected to be above its target or output is above its natural level, and—more interesting for our purposes—they respond to real exchange rate movements above and beyond any impact on expected inflation.

Foreign Exchange Intervention

Turning to foreign exchange market intervention, a simple albeit imperfect statistic of the degree of intervention is the standard deviation of the change in reserves relative to the sum of the

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[10] Previous studies had found that policy interest rates of emerging market ITers respond to the exchange rate (e.g., Mohanty and Klau, 2005, and Aizenman et al., 2011). But by controlling for expected inflation, our estimates can rule out the possibility that this is driven by pass-through of the exchange rate to inflation. Of course, this interpretation relies on the assumption that our proxy for expected inflation, namely the Consensus Forecast of expected inflation, captures adequately the central bank's forecast of inflation.

[11] In addition to the interest rate reacting to the real exchange rate (as central banks reduce policy rates in response to appreciation), the exchange rate is likely to respond to the interest rate. But the latter relationship goes in the opposite direction: a higher interest rate will appreciate the real exchange rate, yielding a positive regression coefficient. The finding of a negative coefficient is therefore despite this simultaneity bias, and the true response of the policy interest rate to the exchange rate is larger (more negative) than estimated.

standard deviations of the change in reserves and of the change in the real exchange rate; this statistic ranges from zero (a pure float, no intervention) to unity (all shocks to the REER are perfectly smoothed).[12] For emerging market inflation targeters, the statistic is 0.61, which is not only positive but in fact not even appreciably lower than for EME central banks that do not have explicit inflation-targeting frameworks (whose intervention statistic is 0.76, with the difference not being statistically significant at the 10 percent level).[13]

Table 3 reports the result of a regression of reserves accumulation on the change in the REER.[14] The first column reports the results for our sample of inflation targeters. The point estimate suggests a 10 percent appreciation of the currency would be associated with a 2.5 percent increase in reserves (again, this is probably an underestimate because simultaneity will tend to bias our estimates toward zero).[15] Table 3 (column 2) also reports analogous results for a comparator sample of *non*-IT countries since 2000, which have an even stronger response: 5.6 percent. The bottom line seems to be that inflation-targeting central banks in EMEs do intervene actively in the foreign exchange market (although rather less aggressively than their non-IT counterparts), and certainly do not follow freely floating exchange rate regimes.[16]

While it is not possible to prove definitively the motivations for central bank policies, both their behavior in regard to sterilized intervention and in regard to the policy interest rate is strongly

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[12] Specifically, we calculate $\zeta = \sigma_{\Delta Reserves} / (\sigma_{\Delta Reserves} + \sigma_{\Delta REER})$.

[13] The sample of non-inflation-targeting EMEs used here is Argentina, Costa Rica, Croatia, Dominican Republic, India, Kazakhstan, Malaysia, Russia, Sri Lanka, and Uruguay.

[14] These flows are highly correlated with the change in stocks of international reserves, and help to separate changes in reserves due to new flows from those arising from valuation effects.

[15] In addition to the central bank purchasing foreign exchange reserves in the face of currency appreciation, the exchange rate will react to intervention. But this relationship goes in the opposite direction: central bank purchases of foreign exchange will tend to depreciate the exchange rate, yielding a negative coefficient. The finding of a positive regression coefficient is therefore despite this simultaneity bias, and the true response of foreign exchange intervention to an exchange rate appreciation is larger (more positive) than estimated.

[16] Stone et al. (2009) survey intervention practices as of late 2007, including in 14 inflation-targeting EMEs. Excess volatility is a motivation for intervention in eight of those EMEs, with three others having volatility-related motives (e.g., stabilize foreign exchange markets, maintain orderly conditions, and maintain exchange rate stability). Other common motives include accumulation of reserves for prudential reasons; exchange rate management to help achieve the inflation target; and signaling. Focusing on Latin America, Adler and Tovar (2011) survey intervention motives in 15 economies and find that the most commonly stated reasons are building reserves for country insurance purposes, and containing exchange rate volatility.

suggestive that EME central banks—including those with IT frameworks—place a premium on exchange rate stability. Moreover, the fact that they undertake sterilized intervention presumably implies that at least they believe it to be an effective tool.

III. Optimal Monetary and Exchange Rate Policies

Assuming, as the discussion above suggests, that EME central banks do care about exchange rate volatility (but that nonetheless they do not opt for a fixed exchange rate), what is the best policy regime? We consider two sets of alternatives: discretionary monetary policy versus inflation-targeting; and, under either monetary regime, whether or not to intervene in the FX markets. To explore these questions we adopt the simplest analytical framework available; to wit, a model of a small open economy with imperfect capital mobility, such that capital flows respond positively to the interest differential (taking account of any expected appreciation of the currency), but at a finite pace. Using this framework, we are able to establish three key results.

First, we obtain the traditional rules vs. discretion trade-off. Discretionary monetary policy allows the central bank to react more fully to aggregate demand and foreign interest rate (i.e., capital flow) shocks, which is welfare enhancing provided exchange rate stability is in the central bank's objective function. Conversely, inflation-targeting provides a policy commitment device, which is welfare-enhancing when the central bank faces time consistency problems or lacks credibility. Which regime dominates depends on the importance of the time-consistency problem relative to the volatility of the shocks.

Second, we show that under both discretionary policies and under IT, the central bank is able to achieve superior outcomes when it has both the policy interest rate and sterilized intervention as its instruments compared to when it has only the policy interest rate. The welfare gain associated with moving from one instrument to two instruments is greater for the IT regime than for the discretionary regime. Moreover, at least within our model, the welfare gain associated with moving from one-instrument IT to two-instrument IT is likely to be greater than that associated with moving to discretionary monetary policy—even disregarding the time consistency and credibility problems the latter may engender.

And finally, we show that FX intervention is fully consistent with the central bank meeting its inflation target, and is supportive of the IT regime in the sense that the welfare gain of switching from IT to discretionary interest rate policy (in order to better offset shocks) is smaller when the central bank has both instruments than when it has only the policy interest rate.

The Setup

Aggregate demand is assumed to depend negatively on the real exchange rate, e, where an increase in e is an appreciation of the home currency, negatively on the real interest rate r, and on a demand shock u:

$$y_t = -\varphi_r r_t - \varphi_e e_t - u_t \quad (1)$$

Aggregate supply is given by a Lucas-type "surprise inflation" Philips curve:

$$y_t = \pi_t - \pi_t^e \quad (2)$$

where π denotes actual inflation and π^e its expectation. Importantly (2) implies that the model exhibits "divine coincidence" such that meeting the inflation target also implies that output is at its natural level. The key assumption of the model is that capital flows respond positively to the interest differential (taking account of the expected appreciation of the currency), but at a finite pace:[17]

$$\Delta k_t = \gamma_r (r_t - r_t^* + (e_{t+1}^e - e_t)) \quad (3)$$

In a world without frictions, the capital stock should adjust instantaneously, arbitraging away any expected return differential ($\gamma_r \to \infty$). But we assume uncovered interest rate parity (UIP) does not hold—as is the case in practice, where if anything, a currency tends to appreciate in the presence of an interest rate differential, the forward premium puzzle.

The current account depends negatively on the real exchange rate and negatively on economic activity:

$$ca_t = -\phi_e e_t - \phi_y y_t \quad (4)$$

Finally, the balance of payments identity relates the current and capital accounts to the accumulation of reserves ΔR:

$$ca_t + \Delta k_t = \theta \Delta R_t \quad (5)$$

where $\theta = R_t / k_t$ is a scaling parameter. The monetary authorities are assumed to choose the real interest rate, *r*, and (sterilized) foreign exchange intervention, ΔR. The foreign interest rate, r^* (where a capital inflow shock corresponds to $r^* < 0$) and the aggregate demand shock, *u*, are assumed to be uncorrelated, with mean zero and variance $\sigma_{r^*}^2$ and σ_u^2 respectively. These shocks are assumed to be observed after the wage-setters form expectations about current period inflation (π^e) but before the central bank must set the interest rate and choose the amount of foreign exchange intervention.

Here, to obtain analytical results, we adopt a two-period framework; below we show that the main insights hold in the infinite-horizon setting. Under the assumption that all capital inflows occur in period 1 (and remains in place in period 2), all period 2 variables of interest can be

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[17] From the uncovered interest rate parity condition: $i_t = i_t^* - (s_{t+1} - s_t)$, where *i* is the nominal interest rate and *s* is the nominal spot exchange rate, subtracting domestic inflation rate yields: $[i_t - (p_{t+1} - p_t)] = [i_t^* - (p_{t+1}^* - p_t^*)] - [(s_{t+1} - s_t) - (p_{t+1}^* - p_t^*) + (p_{t+1} - p_t)]$. Defining $r_t = i_t - (p_{t+1} - p_t)$ and $e_t = (s_t - p_t^* + p_t)$ yields (3).

shown to equal zero. Hence, we can focus on period 1. To simplify the algebra, we further assume $\varphi_r = \phi_e = \gamma_r = \theta = 1$ and $\varphi_e = \phi_y = 0$; these assumptions (which are relaxed in the simulation analysis) do not change the model's main intuitions.

As is standard in these models, the central bank is assumed to penalize deviations of output from target, $\bar{y} \geq 0$, which may exceed the natural level of output (here normalized to zero) and of inflation from the target level of inflation (also normalized to zero). When $\bar{y} > 0,$ we say that the central bank has a time consistency problem since the inability of the central bank to commit to low inflation will impart an inflationary bias to the economy, though in equilibrium, this inflation will be anticipated by wage setters and therefore not result in a higher level of output.[18] In addition, the central bank is assumed to penalize deviations of the real exchange rate from its value warranted by medium-term fundamentals (zero) due to competitiveness considerations on the appreciation side, and concerns about balance sheet effects of foreign-currency denominated debt on the depreciation side. Finally, the central bank seeks to minimize its foreign exchange intervention due to costs of sterilization. The central bank's objective function may therefore be written:

$$W = Max_{r,R} - \frac{1}{2}\{(y-\bar{y})^2 + a(\pi)^2 + b(e)^2 + cR^2\} \tag{6}$$

where $a, b, c \geq 0$ are the relative welfare weights, with a 1 percent deviation of output from its target level receiving a weight of unity.

Discretion versus Inflation Targeting—the One Instrument Case

We begin by comparing fully discretionary monetary policy and inflation-targeting when the monetary authority has the policy interest rate as its sole instrument. The objective function therefore becomes:

$$W = Max_{r} - \frac{1}{2}\{(y-\bar{y})^2 + a(\pi)^2 + b(e)^2\} \tag{7}$$

Discretionary monetary policy with one instrument

Under discretion, the first-order condition for the policy interest rate is:

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[18] In the original Barro-Gordon model, this incentive to generate inflation was to reduce real wages and stimulate higher output by "fooling" workers; it could also represent the incentive to reduce real interest rates and thereby cut the real value of public debt by fooling bond holders. As noted below, even if the central bank does not, in fact, have this incentive, so $\bar{y} = 0,$ but the private sector believes that it has, $\bar{y}^e > 0,$ the lack of credibility will have very similar effects in terms of imparting an inflationary bias to the economy and lowering welfare correspondingly.

$$r = \frac{\tilde{b}r^* - (1+a)u}{1+a+\tilde{b}} \quad (8)$$

where $\tilde{b} = b/4$. The policy interest rate therefore responds to the foreign interest rate and (negatively) to aggregate demand shocks, in each case, only partially offsetting the shock.[19] Output, inflation, and the exchange rate are given by:

$$y = \frac{-\tilde{b}r^* - \tilde{b}u}{1+a+\tilde{b}};\ \pi = (\bar{y}/a) + \frac{-\tilde{b}r^* - \tilde{b}u}{1+a+\tilde{b}};\ e = \frac{(1+a)(r^*+u)}{2(1+a+\tilde{b})} \quad (9)$$

Higher foreign interest rates or a (negative) aggregate demand shock lowers output and depreciates the exchange rate. Substituting (9) into (7) yields expected welfare loss under discretion:

$$L_r^D = \frac{E}{2}\left\{\left(\frac{-\tilde{b}(r^*+u)}{1+a+\tilde{b}} - \bar{y}\right)^2 + a\left((\bar{y}/a) - \frac{\tilde{b}(r^*+u)}{1+a+\tilde{b}}\right)^2 + \tilde{b}\left(\frac{(1+a)(r^*+u)}{1+a+\tilde{b}}\right)^2\right\} \quad (10)$$

Inflation Targeting with one instrument

We interpret inflation targeting as a commitment by the central bank to credibly deliver inflation equal to its target (here normalized to zero). Therefore, under IT: $\pi = 0; \pi^e = 0$. From (1) and (2), the policy interest rate must be used to fully offset the aggregate demand shock, which implies:

$$r = -u;\ y = 0;\ e = (u + r^*)/2 \quad (11)$$

Expected welfare under inflation targeting is therefore:

$$L_r^{IT} = \frac{E}{2}\left\{\bar{y}^2 + \tilde{b}\left(r^* + u\right)^2\right\} \quad (12)$$

Comparison of regimes using one instrument

To compare regimes, it is convenient to consider some special cases.

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[19] In response to an inflow shock $(dr^* < 0)$, the policy interest rate is lowered because here (as in the standard Mundell Fleming model) capital inflows, by appreciating the exchange rate, dampen aggregate demand. If the direct effect of capital flows on domestic credit expansion is sufficiently large, it is possible for inflows to be expansionary, in which the policy interest rate would be raised in response to the inflow shock. Our key conclusions about the relative merits of IT and discretion, and the benefits of FX intervention, would be unaltered, however.

Time consistency or credibility problems, no stochastic shocks

We begin with the case where there are no demand or foreign interest rate shocks $(\sigma_u^2 = \sigma_{i^*}^2 = 0)$ but the central bank faces a time-consistency problem $(\bar{y} > 0)$—or, what amounts to the same thing, a credibility problem $(\bar{y}^e > 0, \bar{y} = 0)$. Then:

$$L_r^D - L_r^{IT} = \frac{1}{2}\left\{a\left(\bar{y}/a\right)^2\right\} > 0 \qquad (13)$$

Since the value of discretion lies in the ability of the central bank to deviate from the inflation target in order to offset the effects of shocks on other macroeconomic targets (output, the exchange rate), when there are no shocks (or if these shocks are fully anticipated by the private sector when forming inflationary expectations and setting wages), then discretion has no value. On the contrary, the failure to tie the hands of the central bank imparts an inflationary bias to the economy, resulting in a welfare loss relative to inflation targeting.

Demand or foreign interest rate shocks, no time consistency problems

In the converse case where there are either aggregate demand or foreign interest rate shocks, but no time consistency or credibility problems, discretion dominates:

$$(L_r^D - L_r^{IT})\,|_{\bar{y}=0} = \frac{\tilde{b}(\sigma_u^2 + \sigma_{i^*}^2)}{2}\left\{\frac{(1+a)}{(1+a+\tilde{b})} - 1\right\} < 0 \qquad (14)$$

Of course, if $\tilde{b} = 0$ (the central bank does not care about exchange rate volatility), then there is no gain from discretionary policies relative to IT; this is because the model incorporates "divine coincidence".

In general, therefore, whether inflation targeting or monetary discretion dominates will depend upon the relative magnitudes of the credibility problem the central bank faces and the prevalence of demand or capital inflow (i.e., foreign interest rate) shocks.

Discretion versus Inflation Targeting—Two Instruments Case

Next we consider augmenting the central bank's instruments to include sterilized intervention in the foreign exchange markets. As discussed above, such intervention is more likely to be effective in emerging markets than in advanced economies but it is not costless since there are fiscal costs of sterilization, as well as potential distortions in the allocation of credit in the economy.

Discretionary monetary policy with two instruments

The central bank now maximizes (6) by simultaneous choice of *r* and *R*, yielding:

$$r = \frac{\tilde{b}r^* - (1+a)(1+\tilde{b}/c)u}{((1+a)(1+\tilde{b}/c)+\tilde{b})} \qquad (15)$$

Again, the domestic interest rate responds to the foreign interest rate shock (albeit not one-for-one) and negatively to the aggregate demand shock. Optimal intervention policy requires the central bank to sell reserves in the face of higher world interest rates (which would induce a capital outflow) and to help offset the shock to aggregate demand:

$$R = \frac{-(1+a)(\tilde{b}/c)(r^* + u)}{((1+a)(1+\tilde{b}/c)+\tilde{b})} \qquad (16)$$

Substituting back gives the reduced forms for output, inflation, and the exchange rate:

$$y = \frac{-\tilde{b}(u+r^*)}{((1+a)(1+\tilde{b}/c)+\tilde{b})};\ \pi = \frac{\dot{y}}{a} - \frac{\tilde{b}(u+r^*)}{((1+a)(1+\tilde{b}/c)+\tilde{b})};\ e = \frac{1}{2}\left(\frac{(1+a)(u+r^*)}{((1+a)(1+\tilde{b}/c)+\tilde{b})}\right)$$

The associated welfare loss is therefore:

$$L^D_{r,R} = \frac{E}{2}\left\{ \begin{aligned} &\left(\frac{-\tilde{b}(u+r^*)}{((1+a)(1+\tilde{b}/c)+\tilde{b})} - \bar{y}\right)^2 + a\left((\bar{y}/a) - \frac{\tilde{b}(u+r^*)}{((1+a)(1+\tilde{b}/c)+\tilde{b})}\right)^2 \\ &+\tilde{b}\left(\frac{(1+a)(u+r^*)}{((1+a)(1+\tilde{b}/c)+\tilde{b})}\right)^2 + c\left(\frac{-(1+a)(\tilde{b}/c)(r^*+u)}{((1+a)(1+\tilde{b}/c)+\tilde{b})}\right)^2 \end{aligned} \right\} \qquad (17)$$

Before turning to the two-instrument inflation targeting regime, it is worth verifying that sterilized intervention is welfare enhancing. By inspection of (10) and (17), when there are no interest rate or aggregate demand shocks $(u = r^* = 0)$, and only a time consistency problem, $(\bar{y} > 0)$, the welfare loss will be the same regardless of whether the central bank intervenes in the FX markets. In other words, intervention cannot help with time consistency (or, equivalently, with credibility) problems, it can only help offset demand or capital flow shocks. To see that it does the latter, note that the coefficients multiplying $(u + r^*)$ are smaller in (17) than in (10).[20] Hence, despite intervention being costly, expected welfare will be higher when the central bank

[20] Note that
$[\tilde{b}^2 + a\tilde{b}^2 + b(1+a)^2 + c(1+a)^2(\tilde{b}/c)^2]/[(1+a)(1+\tilde{b}/c)+\tilde{b}]^2 = (1+a)\tilde{b}/[(1+a)(1+\tilde{b}/c)+\tilde{b}]$ and
$[\tilde{b}^2 + a\tilde{b}^2 + \tilde{b}(1+a)^2]/(1+a+\tilde{b})^2 = (1+a)\tilde{b}/(1+a+\tilde{b})$; finally
$(1+a)\tilde{b}/[(1+a)(1+\tilde{b}/c)+\tilde{b}] < (1+a)\tilde{b}/(1+a+\tilde{b})$ because $(1+a)(\tilde{b}/c) > 0$.

has a second instrument—FX intervention—as its disposal, provided the economy is subject to external or domestic shocks, and regardless of the central bank's time consistency problem.

The result that having two instruments is superior to having only the policy interest rate may seem trivial because by revealed preference, when the central bank has FX intervention in its toolkit it, and makes use of it, it must be because it can attain a higher level of welfare (it could always choose not use FX intervention). But in the presence of forward looking wage setters, this revealed preference argument breaks down. In particular, the set of constraints facing the central bank when it has both instruments (and the private sector knows that it could use both instruments) are different—and potentially worse (in terms of exacerbating the time consistency problem)—than when the central bank has only the policy interest rate.[21] That turns out not to be the case here: if the central bank has both instruments, then despite the endogeneity of inflationary expectations, it can attain a higher level of welfare than if it had only one instrument.

Inflation Targeting with two instruments

Again, we assume that, under inflation targeting, the central bank credibly commits to deliver the inflation target so $\pi = \pi^e = 0.$ Monetary policy must therefore be subordinated to offsetting the demand shock, $r = -u,$ and $y = 0; e = (R + u + r^*)/2.$ Optimal FX intervention and the resulting exchange rate are given by:

$$R = \frac{-\tilde{b}(u + r^*)}{\tilde{b} + c}; e = \frac{1}{2}\frac{c(u + r^*)}{\tilde{b} + c} \qquad (18)$$

Thus a positive shock to aggregate demand $(u < 0)$ or a fall in the world interest rate (which would lead to capital inflows) is met by purchases of foreign exchange. Since, by construction, the inflation target is fully met, there is clearly no inherent inconsistency between inflation targeting and management of the exchange rate through FX intervention. In this simple set up where we assumed that $\varphi_e = \phi_y = 0$ there is also a policy assignment rule whereby the interest rate's sole target is internal balance (with intervention used for both), but that is not necessarily the case in more general versions of the model.

The associated welfare loss is:

[21] By analogy, Rogoff (1985) constructs an example (in a very similar framework) whereby international policy coordination lowers welfare. That would appear to be impossible (the global social planner could always choose the same policies as the Nash equilibrium, so it should always be possible to attain at least the Nash equilibrium level of welfare). Again, this "revealed preference" argument breaks down in his set up because forward-looking wage setters behave differently in the coordinated regime, so the planner faces a different set of constraints.

$$L_{r,R}^{IT} = \frac{1}{2}\left\{ \bar{y}^2 + \tilde{b}\left[\frac{c(u+r^*)}{\tilde{b}+c}\right]^2 + c\left[\frac{\tilde{b}(u+r^*)}{\tilde{b}+c}\right]^2 \right\} \tag{19}$$

Again, comparing the terms multiplying $(u+r^*)$ in (12) and (19) shows that FX intervention is welfare enhancing in the face of aggregate demand or foreign interest rate shocks.[22]

Comparison of regimes using two instruments

To compare discretion with both instruments to inflation-targeting cum intervention, it is again useful to focus on a couple of special cases. When there are no shocks, but a time consistency problem, then from (17) and (19):

$$(L_{r,R}^{D} - L_{r,R}^{IT})\,|_{\sigma_u^2=\sigma_{i^*}^2=0} = \frac{1}{2}\left\{ a\left(\bar{y}/a\right)^2 \right\} > 0 \tag{20}$$

which is positive and identical to (13). Thus, when the central bank faces a credibility problem but does not face any shocks, inflation-targeting dominates because of the discipline it imposes. Conversely, when there is no time consistency problem, but there are shocks, the comparison becomes:

$$(L_{r,R}^{D} - L_{r,R}^{IT})\,|_{\bar{y}=0} = \frac{1}{2}\left\{ \frac{-(\tilde{b}c)^2(\sigma_u^2+\sigma_{r^*}^2)}{(\tilde{b}+c)[(1+a)(c+\tilde{b})+c\tilde{b}]} \right\} < 0 \tag{21}$$

which is negative; that is, discretion dominates in the face of domestic or external shocks—unless the central bank does not care about exchange rate volatility, $\tilde{b}=0$, in which case divine coincidence implies that there is no welfare gain from discretionary policies relative to IT.

Comparison of welfare gains using two instruments

Define the welfare gain associated with moving from the one-instrument discretionary regime to the two-instrument discretionary regime as $G_{r\to r,R}^{D}\,|_{\bar{y}=0} = (L_r^D - L_{r,R}^D)\,|_{\bar{y}=0}$ and likewise for the IT regime $G_{r\to r,R}^{IT}\,|_{\bar{y}=0} = (L_r^{IT} - L_{r,R}^{IT})\,|_{\bar{y}=0}$, where in what follows we abstract from time-consistency problems $(\bar{y}=0)$. Also define the welfare gain associated with moving from the one-instrument IT regime to the one-instrument discretionary regime as $G_r^{IT\to D}\,|_{\bar{y}=0} = (L_r^{IT} - L_r^D)\,|_{\bar{y}=0}$. Then it can be established that:

$$\left(G_{r\to r,R}^{IT} - G_{r\to r,R}^{D}\right) = \left(\frac{(\sigma_u^2+\sigma_{r^*}^2)}{2}\right)\left\{\left(\frac{\tilde{b}^2}{(\tilde{b}+c)}\right) - \left(\frac{(1+a)^2\tilde{b}^2}{[(1+a)(c+\tilde{b})+\tilde{b}]}\right)\right\}$$

which may be simplified to:

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[22] $(\tilde{b}c^2 + c\tilde{b}^2)/(\tilde{b}+c)^2 = \tilde{b}[c/(\tilde{b}+c)] < \tilde{b}.$

$$\left(G^{IT}_{r\to r,R}-G^{D}_{r\to r,R}\right)=\left(\frac{\tilde{b}^{2}(\sigma_u^2+\sigma_{r^*}^2)}{2}\right)\left\{\left(\frac{\tilde{b}[(1+a)(\tilde{b}+c)+c(1+a+\tilde{b})]}{(\tilde{b}+c)[(1+a)(c+\tilde{b})+\tilde{b}]}\right)\right\}>0 \qquad (22)$$

Thus there is a larger welfare gain associated with moving from one instrument to two instruments under the IT regime than under the discretionary regime.

What about the gain associated with moving from one-instrument IT to two-instrument IT compared to the gain associated with moving to one-instrument discretionary monetary policy?

$$\left(G^{IT}_{r\to r,R}-G^{IT\to D}_{r}\right)=\left(\frac{(\sigma_u^2+\sigma_{r^*}^2)}{2}\right)\left\{\left(\frac{\tilde{b}^{2}}{(\tilde{b}+c)}\right)-\left(\frac{\tilde{b}^{2}}{(1+a+\tilde{b})}\right)\right\}=\left(\frac{\tilde{b}^{2}(\sigma_u^2+\sigma_{r^*}^2)}{2}\right)\left(\frac{(1+a-c)}{(\tilde{b}+c)(1+a+\tilde{b})}\right)$$

While this expression is potentially ambiguous in sign, for any plausible parameters, it will be positive.[23] Thus, for an inflation-targeting central bank, there would be a larger gain associated with the adoption of FX intervention than with moving to discretionary monetary policy, even when there are no time consistency problems but the economy faces stochastic shocks.

Finally, defining the welfare gain associated with moving from an inflation-targeting to a discretionary regime (when there is no time consistency problem) as $G^{IT\to D}_{r}\,|_{\bar{y}=0}=(L^{IT}_{r}-L^{D}_{r})\,|_{\bar{y}=0}$, and $G^{IT\to D}_{r,R}\,|_{\bar{y}=0}=(L^{IT}_{r,R}-L^{D}_{r,R})\,|_{\bar{y}=0}$ in the one- and two-instrument cases respectively, we have:

$$(G^{IT\to D}_{r}-G^{IT\to D}_{r,R})\,|_{\bar{y}=0}=\frac{(\sigma_u^2+\sigma_{r^*}^2)}{2}\left\{\frac{\tilde{b}^{2}}{(1+a+\tilde{b})}-\frac{(\tilde{b}c)^{2}}{(\tilde{b}+c)[(1+a)(c+\tilde{b})+c\tilde{b}]}\right\}$$

Or simplifying:

$$(G^{IT\to D}_{r}-G^{IT\to D}_{r,R})\,|_{\bar{y}=0}=\frac{(\sigma_u^2+\sigma_{r^*}^2)\tilde{b}^{2}}{2}\left\{\frac{\tilde{b}c(1+a+\tilde{b})+(1+a)\tilde{b}(\tilde{b}+c)}{(\tilde{b}+c)(1+a+\tilde{b})[(1+a)(c+\tilde{b})+c\tilde{b}]}\right\}>0$$

In other words, in the face of shocks, there is a larger welfare gain from moving from inflation-targeting to discretionary monetary policy when the central bank has only the policy interest rate as its instrument than when it has both the policy rate and FX intervention.

This last result has important implications for the dynamics of the choice of regime. As emerging market economies gain greater credibility, they could (optimally) move toward more discretionary interest rate policy. But the benefit of doing so is correspondingly smaller when the central bank also has FX intervention in its arsenal. In other words, far from being inconsistent with IT, FX intervention actually "supports" IT in the sense that the welfare gain from moving to discretionary policies is smaller when the central bank also intervenes in the FX markets. The

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[23] c is the cost associated with sterilized intervention equivalent to a one percent increase in the stock of reserves (for EMEs, reserves are typically 10-20 percent of GDP), where the cost of a one percent output gap is normalized to unity; hence, $c \ll 1$. In the simulations below, we use $c = 0.01$.

point is illustrated in Figure 1, which graphs the welfare losses (for given $\sigma_u^2 > 0$ and/or $\sigma_{r^*}^2 > 0$) under alternative policy regimes as a function of the time-consistency/credibility parameter, $\bar{y}$. Starting with the one-instrument case (dashed lines), when there is little or no time-consistency problem, the welfare loss under discretion (black dashed line) is lower than the welfare loss under IT (red dashed line). But as $\bar{y}$ increases, the time consistency problem worsens, and the welfare loss under discretion rises faster than the welfare loss under IT; beyond the break-even point at $\bar{y}_1$ inflation-targeting is superior to discretion. Adding the second instrument (solid lines), lowers both loss functions, but the shift for IT (red solid line) is greater than the shift for discretion (black solid line). As a result, the break-even point for IT cum FX intervention, $\bar{y}_2$ is to the left of the one-instrument break-even point—and the range over which IT is preferable to discretion is correspondingly larger.[24]

A more subtle argument against intervening in the FX markets under an IT regime is that the dual objective will somehow confuse the public, undermining the credibility of the central bank's inflation target. As shown above, provided the central bank has both instruments, it can perfectly well fulfill its price stability mandate while also limiting exchange rate volatility through intervention. Indeed, explicit recognition of the central bank's preferences over the exchange rate might actually strengthen the credibility of the central bank's inflation target. This is because policy is not made in a vacuum. When the exchange rate moves strongly out of line with fundamentals, the central bank inevitably comes under pressure to do something about it. Obstinately refusing to acknowledge the problem and the need for policy adjustments likely undermines policy credibility because the public realizes that the stance is untenable. By acknowledging that the exchange rate has moved too far or too abruptly, and by openly undertaking foreign exchange intervention, an inflation-targeting central bank's claim that it will respect its inflation target arguably becomes more—not less—credible. At the same time, it is worth acknowledging that aiming for an exchange rate that deviates substantially from that consistent with medium-term fundamentals (itself never easy to estimate) may have consequences for inflation that ultimately undermine the central bank's inflation target.[25] This

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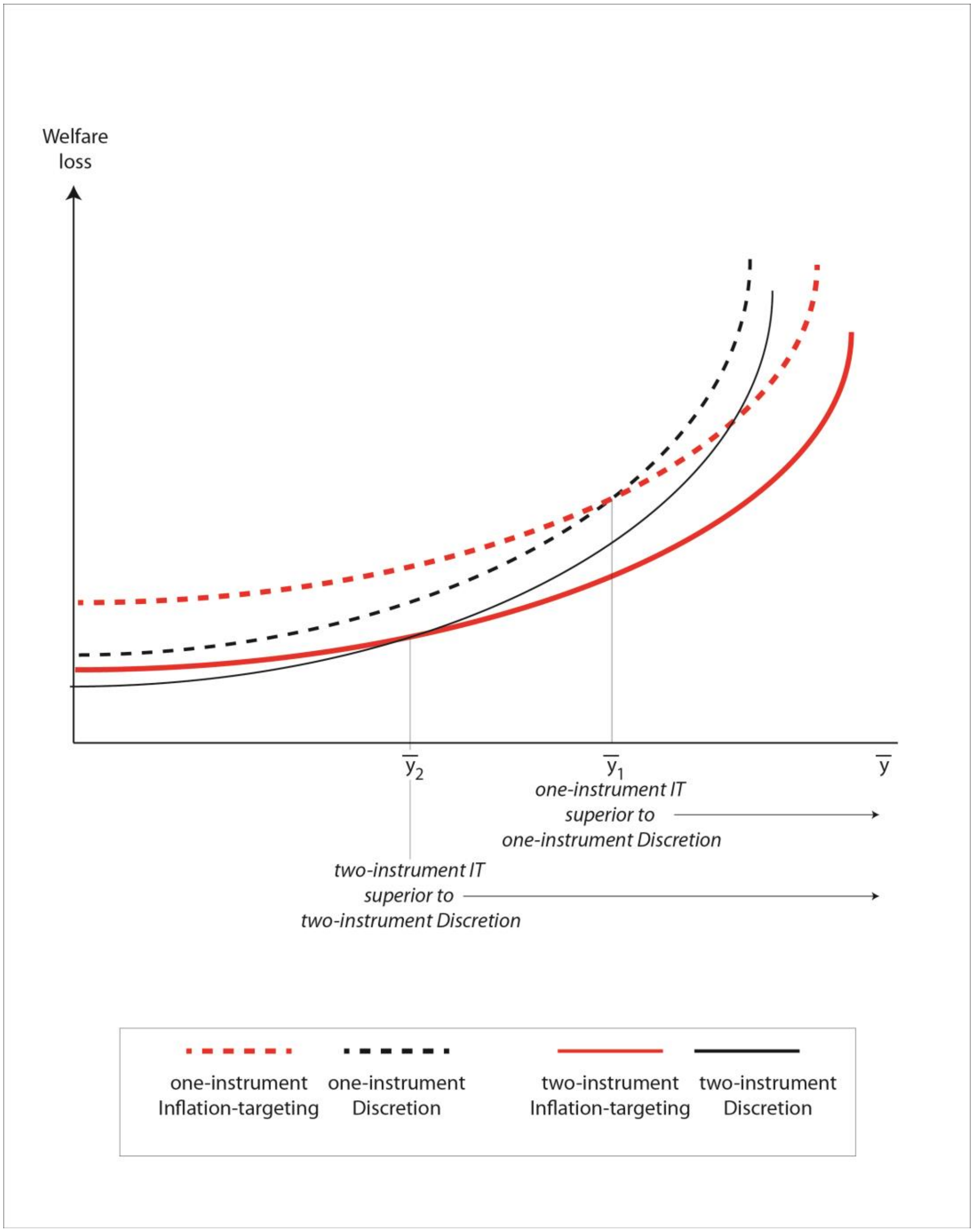
[24] One question is how general is this result. From the mathematics of optimization, it would seem to be quite general, with strict concavity of the objective function (as in quadratic utility) sufficient. This is because, under discretion, the central bank chooses the interest rate optimally given its objective function (and ignoring the time-consistency problem), so the incremental welfare gain from optimizing FX intervention will be smaller than the incremental welfare gain of optimizing FX intervention in the IT regime, where the policy interest rate was not chosen to optimize the central bank's objective function but rather subordinated to meeting the inflation target.

[25] See http://www.imf.org/external/np/res/eba/ for recent IMF methodologies for assessing medium-term equilibrium real exchange rates.

underscores the importance of limiting any intervention to instances where the exchange rate is clearly deviating from its medium-term warranted value.



IV. SIMULATION

The discussion above points to important trade-offs between discretionary monetary policy and inflation-targeting when the central bank cares about exchange rate volatility, but may have time consistency or credibility problems, and faces various shocks. For tractability, however, the discussion was confined to a highly stylized model. Here we simulate a multi-period version of the model to explore more fully how policies compare under different regimes, and flesh out some further considerations in using FX intervention under inflation targeting.

The Setup

The simulated model generalizes the simple two-period framework used above. The key assumption remains a specification whereby capital flows respond positively to the expected return differential, but at a finite pace. We also assume that capital flows depend on the lagged stock of capital (so that flows can eventually disappear even if a return differential were to persist):

$$\Delta k_t = \gamma_r (r_t - r_t^* + E_t \Delta e_{t+1}) - \gamma_k k_{t-1}$$

The remaining equations in the model follow standard assumptions, with the IS curve, current account, and BOP equations given by Equations (1), (4), and (5) respectively. For the simulations, we consider a dynamic specification for the Phillips curve:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t$$

The shocks to aggregate demand also follow an AR(1) process:

$$u_t = \rho_u u_{t-1} + \eta_{ut}$$

Shocks to the foreign real interest rate can "push" capital flows, and these shocks are assumed to follow an AR(1) process:

$$r_t^* = \rho_r r_{t-1}^* + \eta_{r^*t}$$

The central bank's objective function is a dynamic version of (6):

$$\min_{r,R} \sum_t \beta^t ((y_t - \bar{y})^2 + a\pi_t^2 + be_t^2 + cR_t^2)$$

As above, under inflation targeting the central bank is assumed to be constrained to deliver zero inflation at all times. In effect, the central bank commits to a "lexicographical" ordering of objectives such that its inflation target is always met (in the sense that target and expected inflation are equal). This keeps inflationary expectations firmly anchored at π=0 throughout.

We calibrate the model assuming the following initial ratios and parameters:

Capital flow parameters: $\gamma_r = 1; \gamma_k = 0.5; \rho_{r^*} = 0.9;$

BOP parametres: $\phi_\varepsilon = 0.15; \phi_y = 0.3; \theta = 0.5;$

Inflation and aggregate demand parameters: $\beta = 0.99; \rho_u = 0.75; \varphi_r = 1; \varphi_e = 0.25;$

Objective function weights: $\overline{y} = 0; a = 1; b = 0.1; c = 0.01$

Shocks and Policy Responses

With this setup, we can trace through the central bank's reaction to various shocks under alternative policy regimes. We begin by considering the impact of a positive aggregate demand shock, equivalent to 2.5 percentage points of output, which occurs in period 1 and dies out gradually. Figure 2 plots the response under four different regimes: IT with FX intervention (solid red line), IT without FX intervention (dashed red line), Discretion with FX intervention (solid black line), and Discretion without FX intervention (dashed black line). In the face of such a shock, the monetary authorities would naturally react by raising the policy interest rate. Comparing the interest rate response across regimes shows that, for a given set of instruments, the central bank raises rates more under IT (red vs. black lines) than under Discretion, which is intuitive since the central bank must deliver zero inflation under IT, whereas it can accommodate part of the shock by accepting a higher level of inflation under Discretion. Naturally, the central bank must tolerate a large exchange rate appreciation under IT.

Comparing the one- to the two instrument cases (dashed vs. solid lines), the central bank raises interest rates by less when it also intervenes in the FX market, under both Discretion and IT. This is because in the absence of intervention, the only instrument the central bank has to dampen incentives for capital inflows is to lower policy rates. Higher policy interest rates, which help counter the demand shock, also lead to capital inflows, putting upward pressure on the currency. If the central bank can intervene in the FX markets, then it is able to raise interest rates by more than if it does not intervene. Moreover, despite raising interest rates by less when it does not also intervene, the central bank must tolerate a more appreciated currency. Although reserves initially increase, they subsequently decline, eventually returning to their baseline value (normalized to zero). As such, the optimal policy does not imply sustained one-way intervention, but instead both sales and purchases of reserves along the adjustment path, with no net steady-state change in the stock of reserves.

In the face of a capital inflow shock (modeled as a decline in foreign interest rates, which is gradually reversed; see Figure 3), the central bank would lower the policy interest rate, thereby reducing the incentive for capital to cross the border.[26] Again, comparing the interest rate

[26] The model is symmetric in capital inflows and outflows. In practice, there is an important symmetry that in the face of an outflow shock, the central bank could run out of reserves and not be able to intervene further, which cannot happen in the case of inflows.

response across regimes shows that the central bank would cut the policy rate to a larger extent under Discretion than under IT, and when it has one instrument rather than two. This is because in the absence of intervention, the only way the central bank can dampen incentives for capital inflows is to cut the policy rate. But lowering the policy rate threatens the inflation target under IT, and when the central bank has FX intervention at its disposal, it can absorb part of the inflows directly, resulting in less need to adjust interest rates (i.e., greater monetary policy independency).[27] Despite the lower policy interest rate, the central bank is forced to accept a more appreciated exchange rate (relative to that warranted by medium-term fundamentals) when it does not intervene in the FX market. And again, intervention is two-way: initial purchases of FX, followed by sales, with no net steady-state change in the stock of reserves.

Regardless of the shock, the IT framework ensures that the central bank meets its inflation target, so intervention does not prejudice meeting the target. But without FX intervention, the central bank must tolerate a more appreciated currency (and, conversely, with negative shocks, a more depreciated one), lowering welfare relative to its objective of keeping the exchange rate close to its fundamental value. Thus, even though intervention itself is assumed to be costly, the welfare implication is clear: having both the policy interest rate and FX intervention as instruments dominates having only the policy rate.[28] Abstracting from time consistency issues (i.e., setting $\bar{y} = 0)$, welfare (measured in arbitrary but consistent units) under the various regimes are: IT one-instrument, $L_r^{IT} = 1.327;$ Discretion one-instrument, $L_r^D = 1.282$; IT two-instruments, $L_{r,R}^{IT} = 0.89;$ Discretion two instruments, $L_{r,R}^D = 0.876.$ Therefore, consistent with the implications of the simple theoretical model above: (i) Discretion necessarily dominates IT when there are no time consistency issues; (ii) the welfare gain associated with adding intervention to the available instruments is greater for IT than it is for Discretion: $G_{r\to r,R}^{IT} = 0.437 > G_{r\to r,R}^{D} = 0.406;$ (iii) the gain associated with shifting from IT to Discretion is greater when the IT central bank has only the policy interest rate instruments than when it has both instruments: $G_r^{IT\to D} = 0.045 > G_{r,R}^{IT\to D} = 0.014;$ and (iv) the gain associated with adding the second instrument to IT is greater than the gain associated with shifting to Discretion: $G_{r\to R}^{IT} = 0.437 > G_r^{IT\to D} = 0.045.$

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[27] This relative ordering, whereby the policy rate is cut to a smaller extent under IT than under Discretion, and cut to a smaller extent when the central bank also intervenes in the FX market holds under any parameter values. But whether the response under Discretion without intervention is stronger than under IT with intervention will depend on specific parameter values (e.g., how much traction FX intervention has, and the tolerance towards inflation under Discretion).

[28] We do not model the Barro-Gordon type inflationary bias here, so welfare is necessarily higher under discretionary policies than under IT (since the latter adds a constraint to the central bank’s response to ensure the primacy of the inflation target) though as above, if the central bank lacks credibility, then IT may be preferable.

FX Intervention—Benefits and Costs

Both the theoretical model and the simulation analysis suggest that supplementing inflation targeting with FX intervention may be beneficial. But what would the magnitude of the gains depend upon? And what might be the costs of such a strategy?

Beyond the weight on exchange rate stability in the central bank's objective function, the welfare gain from having the intervention instrument depends on the nature and characteristics of the capital inflows. Two parameters are key: the interest rate sensitivity of capital flows (γ_r) and the persistence of capital inflows (which depends on ρ_{r^*}). As capital flows become more sensitive to the return differential, sterilized intervention becomes more difficult (a given quantity of intervention has a smaller impact on the exchange rate); in the limiting case of perfect capital mobility ($\gamma_r \to \infty$), sterilized intervention becomes impossible. Not surprisingly, therefore, greater sensitivity of capital flows to the return differential means that the central bank must tolerate a higher real appreciation and—proportional to the capital flow—undertake less intervention, which is illustrated in Figure 4 under the IT regime. The absolute amount of reserve accumulation is non-monotonic in the return sensitivity of capital flows, γ_r. When this sensitivity is small, the initial change in reserves is also small (since the return differential has little implications for inflows). As γ_r increases, FX intervention initially increases, but eventually starts to decline (since intervention becomes ineffective as $\gamma_r \to \infty$). Conversely, the greater the responsiveness of capital flows to the return differential, the more the policy rate is lowered. In other words, as the economy moves toward the limiting case of perfect capital mobility and asset substitutability, the central bank must increasingly rely on interest rate changes rather than FX intervention to influence the exchange rate.

The other key parameter is the persistence of the shock.[29] The less persistent the shock to the foreign interest rate, the less persistent the inflows that would occur in the absence of any policy response, and the smaller should be the policy response. The key insight of this experiment, however, is that—as a percentage of the initial capital inflow—the initial intervention (i.e., accumulation of reserves) is *greater* when inflows are expected to be *less* persistent. In fact, the degree of intervention (as a percentage of initial inflows) is monotonically decreasing in the expected persistence of the inflows, which is illustrated in Figure 5 under the IT regime. Moreover, when the shock is more persistent, the policy interest rate will be lowered by more, thus playing a larger role relative to FX intervention. This accords with the usual intuition that the central bank should allow the economy to adjust to permanent shocks (including capital inflows) but intervene to absorb temporary shocks that move the economy away from its

[29] On the determinants of capital inflow surges, see Ghosh et al. (2012) and the references therein.

medium-term equilibrium.[30] While the logic is clear, in practice, the central bank may have significant difficulty in judging whether the shock is likely to be temporary or persistent, especially given its likely dependence on a host of factors, including global risk aversion and the behavior of monetary policy in industrial countries.

While the possibility of FX intervention can be welfare enhancing, it is also important to recognize that there may be costs (beyond the sterilization costs, which are already implicitly incorporated in the analysis). Perhaps the most important risk is the possibility that the market interprets the adoption of a second target (the exchange rate) as a softening of the central bank's commitment to IT. We argued above that this need not be the case: on the contrary, provided the central bank really has two instruments, acknowledging that the exchange rate is out of equilibrium and deploying an instrument to deal with it can make the commitment to the inflation target more credible. But this assumes that sterilized intervention is effective and that the central bank can reliably identify the equilibrium real exchange rate for the economy. If that is not the case—or is only the case to a limited degree—then having an exchange rate target could undermine the credibility of the inflation target. An effective communication strategy that stresses the precedence of the inflation target is thus critical.

Another possible drawback of this strategy comes from the possible endogeneity of investor behavior. The simulations take the rate of return sensitivity of capital flows as given and constant across regimes; in practice, it may vary with the policy regime. In particular, greater certainty on the part of investors that they will obtain a higher rate of return would likely increase the sensitivity of capital flows to the return differential. It is noteworthy in this regard that, in most of the simulations (including those depicted here), the response to a capital inflow shock is to allow a jump in appreciation of the real exchange rate (albeit smaller than in the absence of intervention) followed by a gradual depreciation. In other words, the optimal intervention typically does not offer investors a sure expected appreciation—precisely because doing so would induce greater capital inflows, which is what the central bank wants to avoid. Nevertheless, the regimes with FX intervention generally imply somewhat higher and more persistent expected returns compared to the regimes without FX intervention.[31]

It is possible, therefore, that knowing the central bank had adopted a policy regime that included FX intervention (and therefore higher and more persistent returns in the event of capital inflow shocks), investors would become more responsive to the return differential, rendering sterilized intervention less effective (and even counterproductive in a limiting case where flows respond

[30] In practice it is difficult to determine what that equilibrium level is in real time, and there is a risk for over-activism in reserve management.

[31] For example, the expected return (inclusive of the interest rate differential and expected depreciation) over periods 1–10 averages 2.1 percent under IT with FX intervention, and 1.8 percent under IT without intervention.

very strongly to the combination of a significant interest rate differential with a stable exchange rate) To reduce this tendency, some uncertainty in the central bank's intervention policy—when, how much, and at what exchange rate level—may be useful (though in deciding how much "randomness" to incorporate in its intervention policy, the central bank needs to be mindful of its impact on the real economy). In particular, the central bank should not be viewed as defending a specific level of the exchange rate, and should be perceived as willing to let it depreciate when inflow pressures abate. Such short-run volatility in the return to investors can help counteract the perceptions of one-way bets.

V. CONCLUSIONS

The global financial crisis has prompted a fundamental re-thinking about the role of macroeconomic policies in advanced and emerging market economies alike. In this paper, we examine the conditions under which inflation targeting is preferable to discretionary monetary policy, and whether EME central banks, including inflation-targeters, should also intervene in the foreign exchange markets.

Monetary authorities in EMEs often lack the full policy credibility that comes from successfully achieving prolonged periods of price stability. While discretion is a viable option when policy credibility is high, an IT framework can help to anchor inflationary expectations when credibility is imperfect. As such, inflation targeting has proven to be an increasingly attractive option to help anchor expectations and generate low inflation—albeit at the cost of constraining the central bank's ability to respond to shocks, including capital flows, that contribute to exchange rate volatility. At the same time, early adopters of IT and present day inflation targeters among the advanced countries have generally adopted floating exchange rates in part to avoid potential conflicts between price-stability and exchange-rate objectives. Should EME Iters do likewise?

The answer we give in this paper is that, because of well-known structural features of EMEs, benign neglect of large exchange rate movements are unlikely to be the right policy even under an IT framework. If two policy instruments are available (the policy interest rate and foreign exchange market intervention), then they should be used in tandem to achieve both price-stability and exchange-rate objectives. Provided the central bank has sterilized intervention as a viable instrument, stabilizing the exchange rate around its equilibrium value is not inconsistent with achieving its inflation target. On the contrary, FX intervention is supportive of the IT regime in the sense that the gain from moving to discretionary monetary policy is smaller when the central bank also has FX intervention in its toolkit. In response, for instance, to a destabilizing increase in capital inflows, the central bank can both lower the policy rate and intervene in the FX market to limit appreciation, in much the same way as it would do under unconstrained full discretion, but while avoiding the inflationary bias that would otherwise result from discretionary policies. Indeed, given that policies are not set in a vacuum, and the central bank inevitably comes under pressure to respond when the exchange rate becomes too divorced from medium-term fundamentals, supplementing inflation targeting with FX intervention may well enhance the credibility of the central bank’s inflation target.

Table 1. Studies on Sterilized Intervention in Emerging Market Economies

Study	Country	Effectiveness on	
		Level	Volatility
Stone, Walker, and Yosuke (2009)	Brazil	Yes	Yes
Tapia and Tokman (2004)	Chile	Yes	
Mandeng (2003)	Colombia		Yes (mixed)
Kamil (2008)	Colombia	Yes (weak)	Yes
Holub (2004)	Czech Republic	Mixed	
Disyatat and Galati (2005)	Czech Republic	Yes (weak)	No
Barabás (2003)	Hungary	Mixed	
Pattanaik and Sahoo (2003)	India	Yes (weak)	Yes
Rhee and Song (1999)	Korea	Yes	
Domaç and Mendoza (2002)	Mexico and Turkey	Yes	Yes
Guimarães and Karacadag (2004)	Mexico and Turkey	Yes (weak)	Mixed
Abenoja (2003)	Philippines	Mixed	Yes (mixed)
Sangmanee (2003)	Thailand	No	
Adler and Tovar (2011)	Mainly Latin America	Yes	

Table 2. Taylor Rules in Emerging Market Country Inflation Targeters: Panel Regression [1]/

	Dependent Variable: policy rate - inf. target		
	(1)	(2)	(3)
Lagged (policy rate - inflation target)		0.854 ***	0.870 ***
		[0.020]	[0.023]
Expected inflation - inflation target	1.328 ***	0.462 ***	0.441 ***
	[0.209]	[0.059]	[0.047]
Change in REER			-0.040 ***
			[0.012]
Lagged output gap			0.120 ***
			[0.030]
Dummy for Global Financial Crisis	0.820 *	-0.933 **	-0.977 **
	[0.414]	[0.361]	[0.353]
Country Fixed Effects	YES	YES	YES
Observations	654	640	640
R-squared	0.250	0.887	0.899
Number of Countries	15	15	15

[1]/ Standard errors in brackets. *, ** and *** denote statistical significance at the 10, 5 and 1 percent level, respectively. REER is defined such that an increase denotes an appreciation of the currency.

Table 3. Change in Reserves as a function of change in REER [1]/

	Change in Reserves	
	IT	Non-IT
Change in REER	0.252 **	0.564 **
	[0.088]	[0.195]
Dummy for Global Financial Crisis	-1.948	-12.301 **
	[2.167]	[4.454]
Country Fixed Effects	YES	YES
Observations	646	520
R-squared	0.031	0.054
Number of Countries	15	10

[1]/ Standard errors in brackets. *, ** and *** denote statistical significance at the 10, 5 and 1 percent level, respectively. REER is defined such that an increase denotes an appreciation of the currency.

Figure 1A. Reserves to M2 Ratio.

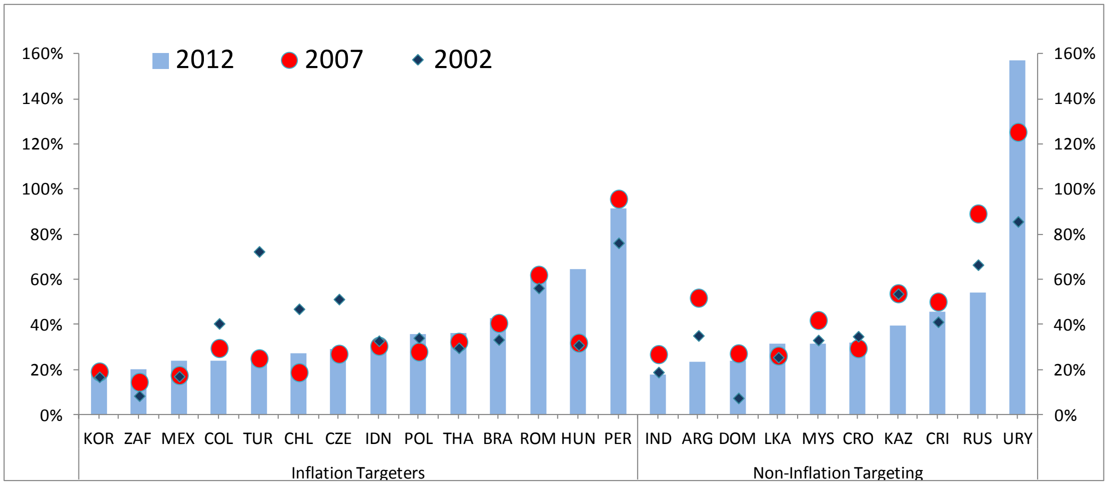


Figure 1B. Reserves to GDP Ratio

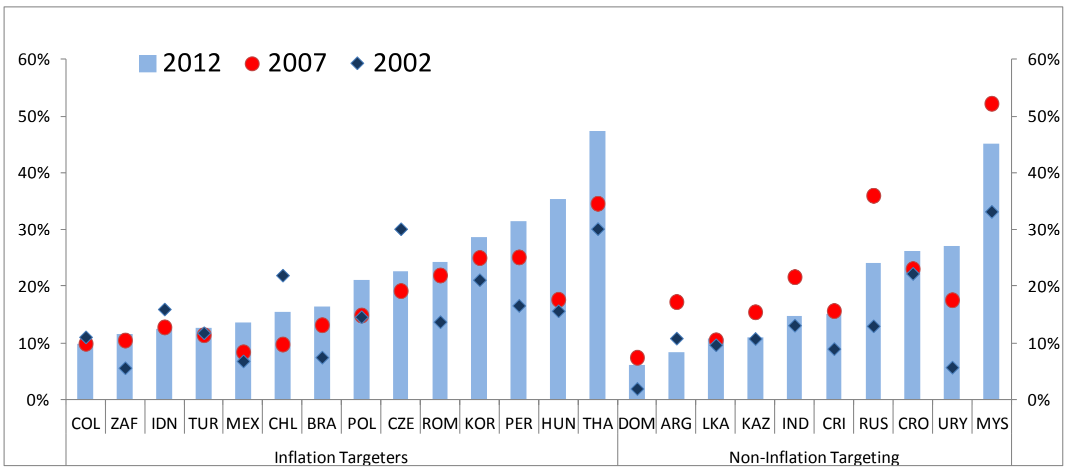
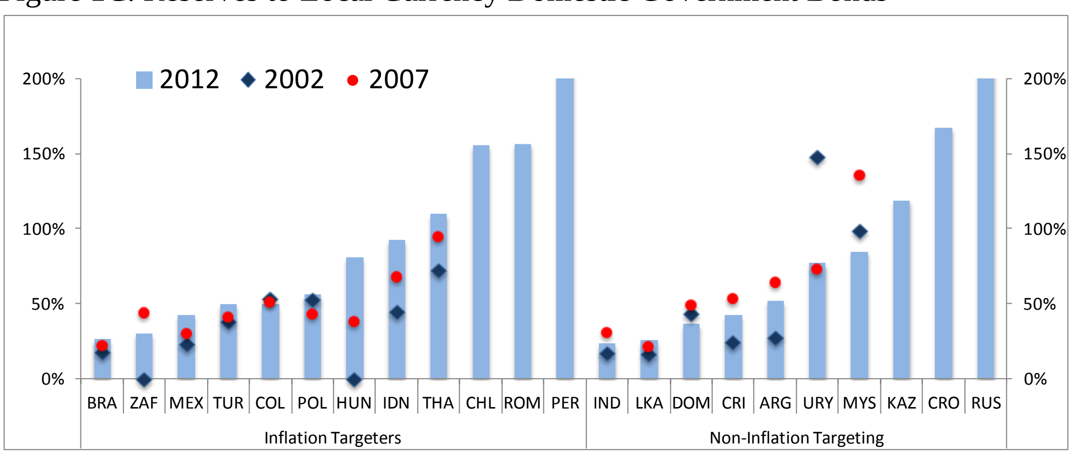


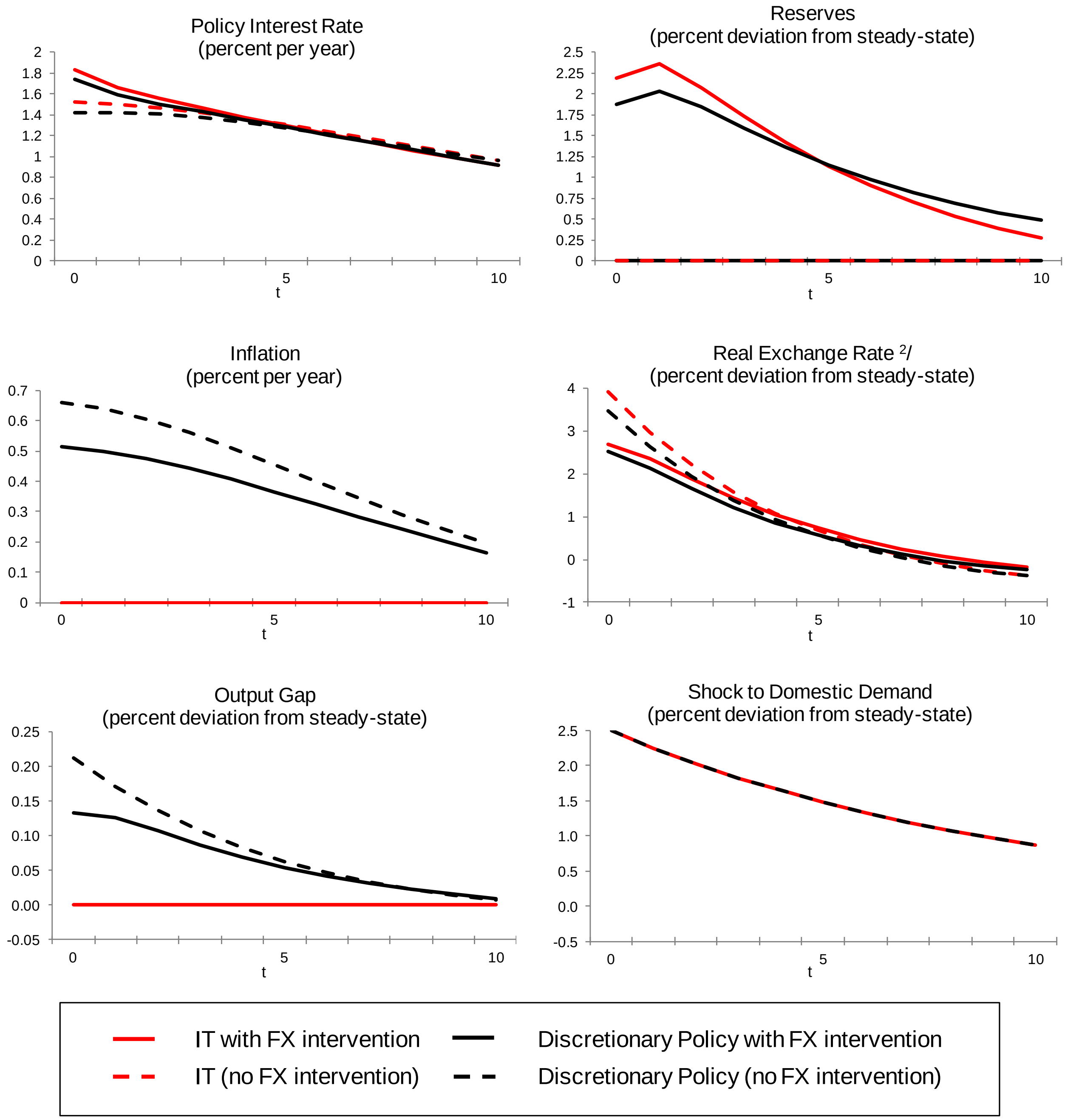
Figure 1C. Reserves to Local Currency Domestic Government Bonds



Notes: The chart scale in Figure 1C was limited to 200 percent for presentation purposes. The Ratio for Peru and Russia were 293 and 364 percent in 2012, respectively.

Sources: IMF International Financial Statistics, World Economic Outlook, and IMF Desk Estimates.

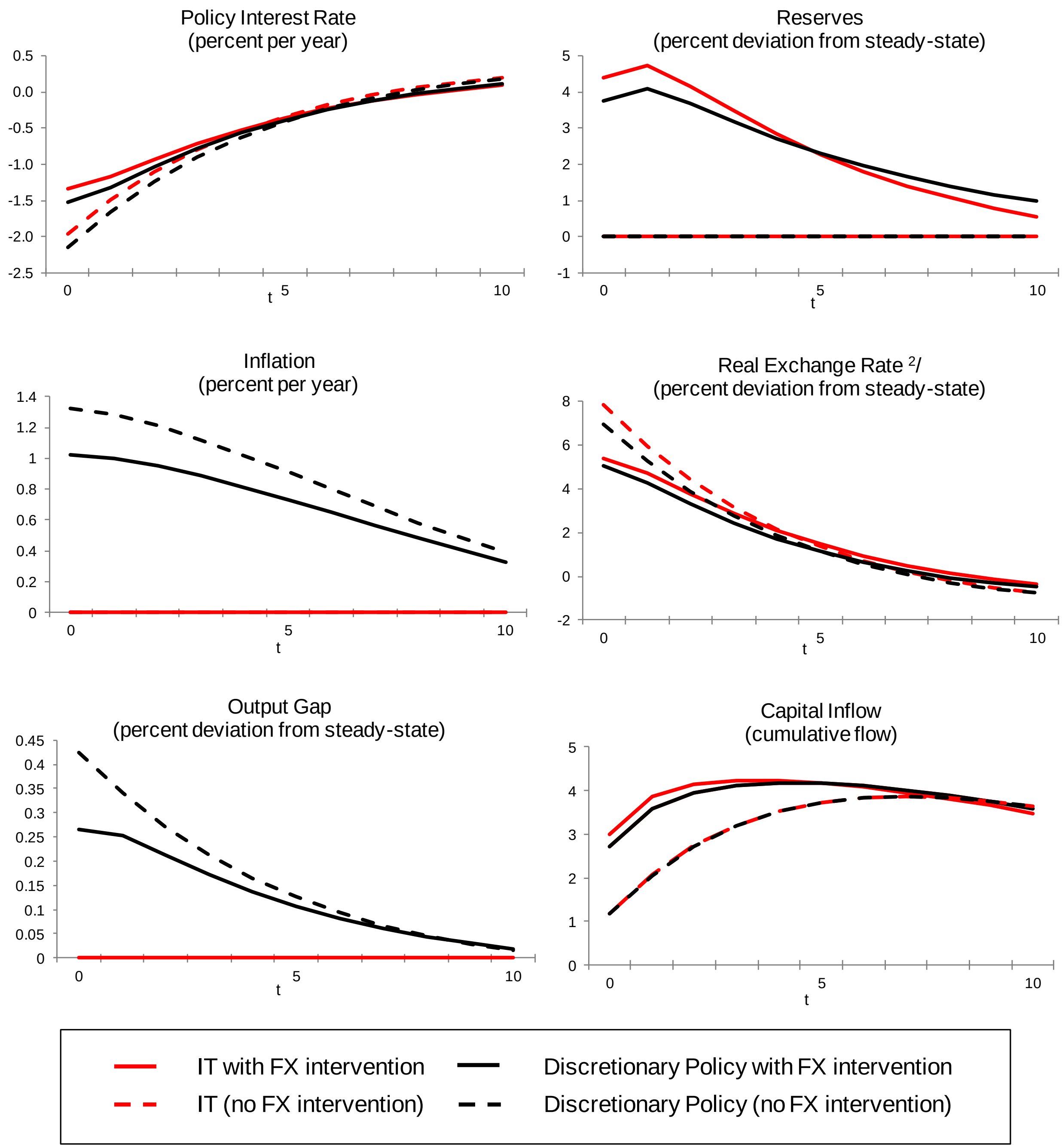
Figure 2. Policy Response to a Demand Shock [1/]



[1/] The shock is based on a 2.5 percentage point increase in domestic demand.

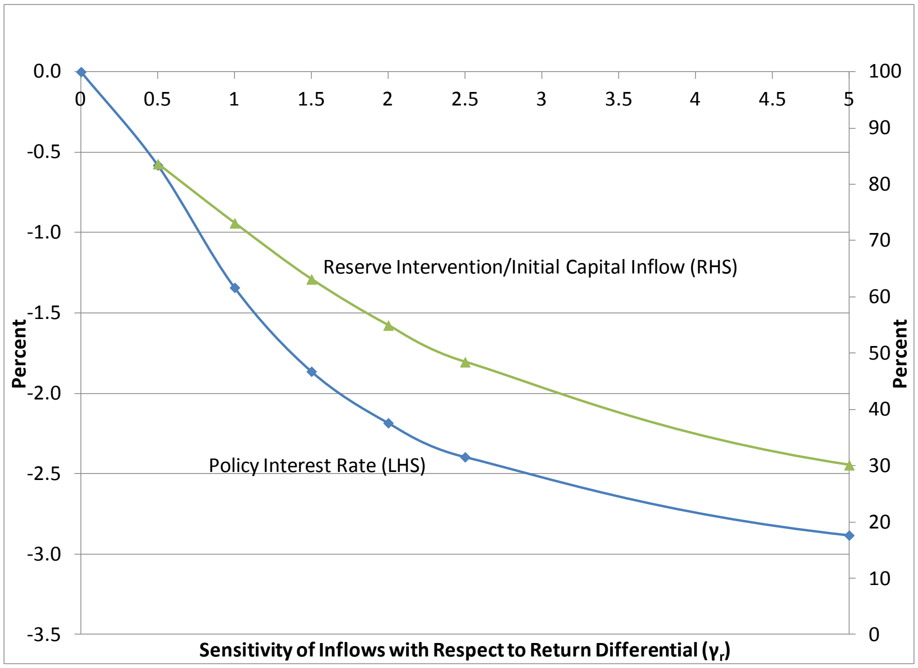
[2/] An increase in the exchange rate is an appreciation of the domestic currency.

Figure 3. Policy Response to a Capital Inflow Shock[1/]



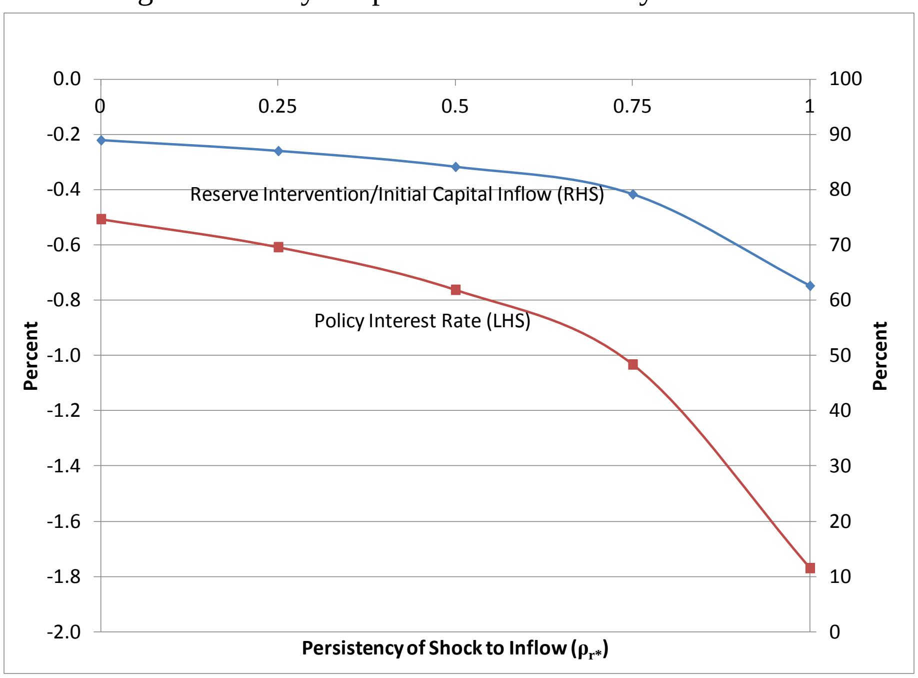
[1/] The capital inflow shock is based on a 5 percentage point decline in the world interest rate.
[2/] An increase in the exchange rate is an appreciation of the domestic currency.

Figure 4. Policy Response and Sensitivity of Inflows with Respect to Return Differential. [1/]



[1/] Response under an IT regime with FX intervention. The capital inflow shock is based on a 5 percentage point decline in the world interest rate. All parameters other than γ_r are kept constant at their baseline values.

Figure 5. Policy Response and Persistency of Inflows.



[1/] Response under an IT regime with FX intervention. The capital inflow shock is based on a 5 percentage point decline in the world interest rate. All parameters other than ρ_{r*} are kept constant at their baseline values.

REFERENCES

Abenoja, Zeno, 2003, "Foreign Exchange Market Intervention: A Short Review of Transmission Channels and Practices," *Bangko Sentral Review*, Vol. V, pp. 1–25.

Adler, Gustavo, and Camilo E. Tovar, 2011, "Foreign Exchange Intervention: A Shield Against Appreciation Winds?" IMF Working Paper No. 11/165.

Aghion, Philippe, Bacchetta, Philippe, Banerjee, Abhijit, 2001. A simple model of monetary policy and currency crises. *European Economic Review* Vol. 44, 728–738.

Aizenman, Joshua, Menzie Chinn, and Hiro Ito, 2008, "Assessing the Emerging Global Financial Architecture: Measuring the Trilemma's Configuration Over Time," NBER Working Paper No. 14533 (Cambridge, Massachusetts: NBER).

————, Michael Hutchison, and Ilan Noy, 2011, "Inflation Targeting and Real Exchange Rates in Emerging Markets," *World Development*, Vol. 39, No. 5, pp. 712–24.

Barabás, Gyula, 2003, "Coping with the Speculative Attack Against the Forint's Band," MNB Background Studies, 2003/3.

Benes, Jaromir, A. Berg, R. Portillo, and D. Vavra, 2012, "Modeling Sterilized Interventions and Balance Sheet Effects of Monetary Policy," IMF Working Paper, forthcoming.

Blanchard, Olivier and Jordi Galí, 2007, "Real wage rigidities and the New Keynesian model," *Journal of Money, Credit, and Banking*, Vol. 39, pp. 5–65.

de Gregorio, José, 2010, "Monetary Policy and Financial Stability: An Emerging Markets Perspective" International Finance, Vol 13, No.1, pp.141–56.

Disyatat, Piti, and Gabriele Galati, 2005, "The Effectiveness of Foreign Exchange Intervention in Emerging Market Countries," in *Foreign Exchange Market Intervention in Emerging Markets*, BIS Paper No. 24, pp. 97–113.

De Paoli, Bianca, 2009, "Monetary Policy and Welfare in a Small Open Economy," *Journal of International Economics*, Vol. 77, No.1, pp. 11–22.

Domaç, Ilker, and Alfonso Mendoza, 2004, "Is There Room for Foreign Exchange Interventions Under an Inflation Targeting Framework? Evidence from Mexico and Turkey," World Bank Policy Research Working Paper No. 3288, April.

Dornbusch, Rudiger, 1976, “Expectations and Exchange Rate Dynamics*” Journal of Political Economy*, Vol. 84, No. 6, pp. 1161–76

Fleming, J. Marcus (1962). "Domestic financial policies under fixed and floating exchange rates". *IMF Staff Papers* Vol. 9, pp. 369–379.

Gali, Jordi and Tommaso Monacelli, 2005, “Monetary Policy and Exchange Rate Volatility in a Small Open Economy” The Review of Economic Studies, Vol. 72, No. 3, pp. 707–734.

Garcia, Carlos, Jorge Restrepo, and Scott Roger, 2011, “How Much Should Inflation Targeters Care About the Exchange Rate?” *Journal of International Money and Finance,* Vol. 30, pp. 1590–1617.

Ghosh, Atish R., 1992, “Is it Signaling? Exchange Intervention and the Dollar-Deutschemark Rate,” *Journal of International Economics,* Vol. 32, No. 3–4, pp. 201–20.

__________, Jun Kim, Mahvash Qureshi, and Juan Zalduendo, 2012, “Surges” IMF Working Paper 12/22.

Guimarães-Filho, Roberto F., and Cem Karacadag, 2004, “The Empirics of Foreign Exchange Intervention in Emerging Market Countries: the Cases of Mexico and Turkey,” IMF Working Paper 04/123.

Holub, Tomáš, 2004, “Foreign Exchange Interventions Under Inflation Targeting: The Czech Experience,” Czech National Bank Internal Research and Policy Notes, No. 1, Czech National Bank, January.

International Monetary Fund Pilot External Sector Report, 2012, (Washington: International Monetary Fund).

Jeanne, Olivier, and Romain Rancière 2011, “The Optimal Level of International Reserves for Emerging Market Countries: New Formula and Some Applications,” *The Economic Journal*, Vol. 121, pp. 905–930.

Kamil, Herman, 2008, “Is Central Bank Intervention Effective Under Inflation Targeting Regimes? The Case of Colombia,” IMF Working Paper 08/88.

Korinek, Anton, 2011, “The New Economics of Prudential Capital Controls,” IMF Economic Review Vol. 59, pp. 523–561.

Mandeng, Ousmène, 2003, “Central Bank Foreign Exchange Market Intervention and Option Contract Specification: The Case of Colombia,” IMF Working Paper 03/135.

Masson, Paul R., Miguel A. Savastano, and Sunil Sharma, 1997, "The Scope for Inflation Targeting in Developing Countries," IMF Working Paper 97/130.

Meade, James, 1951, *The Balance of Payments*. (London, and New York: Oxford University Press).

Mishkin, Frederic and Miguel Savastano, 2001, "Monetary policy strategies for Latin America," *Journal of Development Economics*, Vol 66, pp. 415–444.

Mohanty, Madhusudan, and Marc Klau, 2005, "Monetary Policy Rules in Emerging Market Economies" in *Monetary Policy and Macroeconomic Stabilization in Latin America*, edited by Langhammer et al. (Springer: Berlin Heidelberg), pp. 205–45.

Mundell, Robert, 1963, "Capital mobility and stabilization policy under fixed and flexible exchange rates," *Canadian Journal of Economics and Political Science*, Vol. 29, pp. 475–85

Obstfeld, Maurice, and Kenneth Rogoff, 1995, "Exchange Rate Dynamics Redux," *Journal of Political Economy*, Vol. 103, pp. 624–60.

Ostry, Jonathan, Atish R. Ghosh, Karl Habermeier, Marcos Chamon, Mahvash S. Qureshi, and Dennis B. S. Reinhardt, 2010, "Capital Inflows: The Role of Controls," IMF Staff Position Note No. 2010/04 (Washington: International Monetary Fund).

————, ————, ————, Luc Laeven, Marcos Chamon, Mahvash S. Qureshi, and Annamaria Kokenyne, 2011, "Managing Capital Inflows: What Tools To Use?" IMF Staff Discussion Note No. 11/06(Washington: International Monetary Fund).

————, ————, and Marcos Chamon, 2012, "Two Targets Two Instruments: Monetary and Exchange Rate Policies in Emerging Market Economies" IMF Staff Discussion Note No. 12/04 (Washington: International Monetary Fund).

Pattanaik, Sitikantha, and Satyananda Sahoo, 2003, "The Effectiveness of Intervention in India: An Empirical Assessment," Reserve Bank of India Occasional Papers, Vol. 22.

Rhee, Yeongseop and Chi-Young. Song, 1999, "Exchange Rate Policy and Effectiveness of Intervention: The Case of South Korea," in *Exchange Rate Policies in Emerging Asian Countries,* edited by S. Collignon et al. (Routledge).

Sangmanee, Amporn, 2003, "Central Bank Intervention and Market Expectations of Exchange Rate Regime Shift: The Case of the Thai Baht at the Onset of the Asian Crisis," mimeo.

Sarno, Lucio and Mark Taylor, 2001, "Official Intervention in the Foreign Exchange Market: Is 88it Effective, and If So, How Does it Work?" *Journal of Economic Literature*, Vol. 39, pp.839–868.

Stone, Mark, Scott Roger, Anna Nordstrom, Seiich Shimizu, Turgut Kisinbay, and Jorge Restrepo, 2009, "The Role of the Exchange Rate in Inflation-Targeting Emerging Economies," IMF Occasional Paper 267 (Washington: International Monetary Fund).

————, W. Christopher Walker, and Yosuke Yasui, 2009, "From Lombard Street to Avenida Paulista: Foreign Exchange Liquidity Easing in Brazil in Response to the Global Shock of 2008–09," IMF Working Paper 09/259.

Tapia, Matías, and Andrea Tokman, 2004, "Effects of Foreign Exchange Intervention Under Public Information: The Chilean Case," *Economia*, LACEA, Vol. 4, pp. 1–42.