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The Cost of Foreign Exchange Intervention: Concepts and Measurement

By Gustavo Adler and Rui C. Mano

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Prepared by Gustavo Adler and Rui C. Mano

Authorized for distribution by Luis Cubeddu

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Abstract

The accumulation of large foreign asset positions by many central banks through sustained foreign exchange (FX) intervention has raised questions about its associated fiscal costs. This paper clarifies conceptual issues regarding how to measure these costs both from an ex-post and an ex-ante (relevant for decision making) perspective, and estimates both marginal and total costs for 73 countries over the period 2002-13. We find ex-ante *marginal* costs for the median emerging market economy (EME) in the inter-quartile range of 2-5.5 percent per year; while ex-ante *total* costs (of sustaining FX positions) in the range of 0.2-0.7 percent of GDP per year for light interveners and 0.3-1.2 percent of GDP per year for heavy interveners. These estimates indicate that fiscal costs of sustained FX intervention (via expanding central bank balance sheets) are not negligible.

JEL Classification Numbers: E42, E58, F31, F40

Keywords: central bank balance sheet, international reserves, foreign exchange intervention, currency risk premium

Author's E-Mail Address: gadler@imf.org; rmano@imf.org

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I. INTRODUCTION

Over the last decade, many central banks, both in emerging and advanced economies, resorted to sizeable foreign exchange intervention (FXI) operations in an effort to cope with the effects of large capital inflows and/or positive terms of trade shocks, while trying to maintain monetary policy independence. Despite its widespread use, however, the merits of using FXI, including in comparison to other policy instruments, remain a matter of significant debate. A number of recent studies have delved on the use of FXI as an additional policy instrument, focusing primarily on the effects on the exchange rate (e.g., Adler et al, 2015; Blanchard et al, 2015; Daude et al, 2014; Fratzscher et al, 2015) and the macro-economy (Ostry et al, 2011 & 2015; Blanchard et al, 2015b, Cavallino, 2015). There is also a vast literature on the benefits of conducting FXI intervention, both for mercantilist and precautionary motives. Yet, little attention has been given to the quasi-fiscal costs associated with these policies, despite the fact that gross positions in central banks' balance sheets (Figure 1) have been rapidly increasing as a by-product.

For the most part, there is a belief in policy circles that costs of holding FX positions (often mistakenly equated to the cost of holding international reserves, as discussed below) can be significant; while the academic literature has rarely focused on this aspect arguably because such costs are thought to be of second order importance. Surprisingly, none of these views is based on a thorough empirical analysis of the fiscal costs of FXI, since this remains largely undone. As a result, these costs are poorly understood, particularly from an ex-ante perspective, which is the relevant point of view for decision making.

Conceptually, quasi-fiscal costs were discussed in the early literature on FX intervention. Friedman (1953) argued that interventions could only be effective if they were profitable, involving an arbitrage opportunity for the central bank at the expense of private speculators. However, the subsequent development of the portfolio balance theory—pioneered by Henderson and Rogoff (1982), Kouri (1983) and Branson and Henderson (1985), and extended recently by Kumhof (2010) and Gabaix and Maggiori (2015)—challenged this view by introducing the notion of a risk premium associated with imperfect asset substitutability and incomplete markets.

The empirical evidence, on the other hand, is very scarce and mostly outdated. Early evidence (see Taylor, 1982; Sweeney, 1997; and Neely, 1998) focused only on specific advanced economies, and showed that profit and losses varied widely across countries and time periods.[1] More recent studies have documented these quasi-fiscal costs (IMF, 2011; World Bank, 2013) but only for a limited group of countries and focusing solely on ex-post costs.

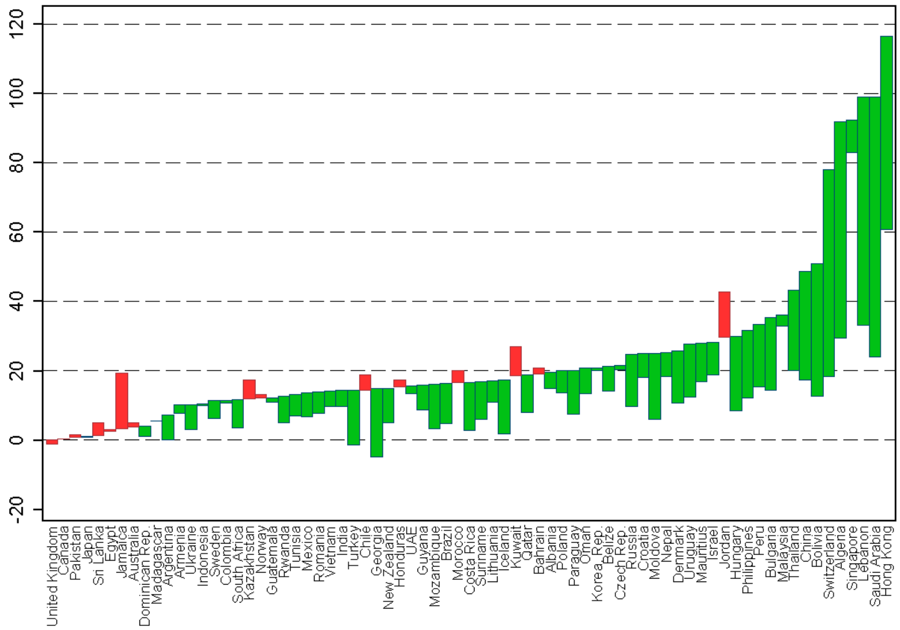
In this paper, we attempt to fill this gap in the literature by clarifying key concepts related to the measurement of the costs of FXI, and documenting them for a large set of countries. In particular, we focus on:

[1] A related strand of the literature focused on the costs of holding reserves, but these are conceptually different from the cost of FXI. See Levy Yeyati (2008).

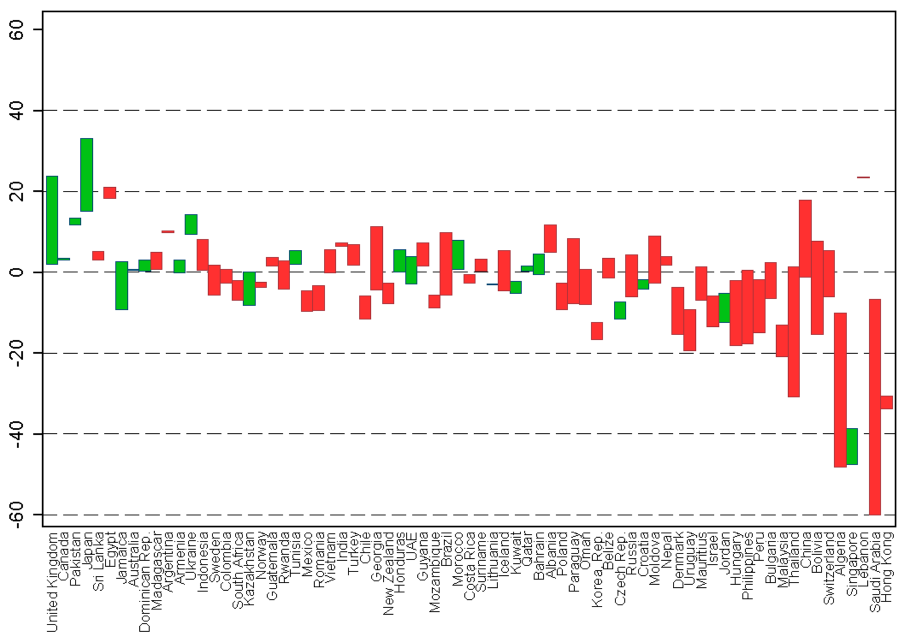
Figure 1. Cross-section of Changes in Central Bank NFA and NDA, 2002-13

(percent of GDP)

Panel (a). Net Foreign Asset Position



Panel (b). Net Domestic Asset Position



Sources: IMF *International Financial Statistics*; and authors' calculations. Green (red) bars indicate an increase; with lower (upper) level corresponding to 2002 and upper (lower) level to 2013.

- The relationship between the cost of FXI and the cost of holding reserves;
- The distinction between book costs and economic opportunity costs.
- The difference between ex-post (realized) costs and ex-ante (relevant for policy decisions) costs.
- The various approaches for measuring ex-ante costs.
- The link between the effectiveness of FXI in affecting the exchange rate and the inherent fiscal costs.[2]

Following the discussion of these conceptual issues, we document the marginal (per US$) and total costs of FXI (i.e., of rolling over FX positions), both from an ex-post and ex-ante perspective, for a set of 73 emerging and advanced economies over the period 2002-13.

We find that *ex-post* costs have been relatively large on account of sizeable deviations from uncovered interest rate parity (UIP) and the elevated central bank FX positions during the sample period.

More importantly, from an *ex-ante* perspective, our estimates indicate non-negligible marginal costs and total costs. We find ex-ante *marginal* costs for the median emerging market economy (EME) in the inter-quartile range of 2-5.5 percent per year, for the full sample period; and ex-ante *total* costs (of sustaining FX positions) in the range of 0.3-0.9 percent of GDP per year. Nearly one fifth of the countries in the sample incurred in costs above 1 percent of GDP per year over the sample period; and more in recent years, as such costs increased significantly during the period of analysis. Heavy interveners (i.e., countries with a heavy degree of exchange rate management) incurred in ex-ante total costs of about 0.3-1.2 percent of GDP per year, compared to 0.3-0.7 percent of GDP by light interveners.

We also find that marginal costs of FXI are significantly larger in EMEs compared to AEs, suggesting that the conjectured greater effectiveness of FXI in EMEs is inherently associated with higher quasi-fiscal costs. [3]

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[2] A common belief is that EMEs tend to rely more on FX intervention than AEs in part because such policies are more effective in the former economies, as their domestic financial markets are shallower and less integrated with global financial markets. A lower degree of financial integration or asset substitutability entails a stronger portfolio balance channel, and thus would lead to greater effectiveness of FXI. However, a lower degree of substitutability would also imply higher costs of FXI, thus indicating that higher benefits of conducting FXI in those economies need to be weighed against their inherent higher fiscal costs.

[3] See comprehensive literature reviews in Sarno and Taylor (2001), Neely (2005) and Menkhoff (2010 and 2012).

Overall, our estimates indicate that fiscal costs of sustained FX intervention are not negligible, and thus should be a factor to consider when conducting FX intervention.

The rest of the paper is organized as follows: Section II discusses key concepts and the definition of the cost of FXI. Section III documents these costs using various approaches. Section IV concludes with the key takeaways.

II. Key Concepts and Definition

In this section we discuss some key concepts that are often used interchangeably in the literature, leading to some misinterpretations.

We consider as FXI any financial operation of the central bank entailing a purchase (sale) of a foreign currency denominated asset—or an equivalent derivatives transaction— and a sale (purchase) of a local currency asset.[4] Such domestic asset can be money or another (interest-bearing) instrument. That is:

$$\Delta NFA = \Delta MB - \Delta NDA \tag{1}$$

where NFA denotes the central bank net foreign asset position; MB stands for base money; and NDA denotes net (interest-paying, normally short-term) domestic assets. Correspondingly, the cost of FXI is defined as the cost for the central bank of carrying the resulting FX position. Whether interventions are conducted for the purpose of affecting the exchange rate, increasing reserves, or other motives is irrelevant (and not observable) for the computation of their costs.

If the intervention is unsterilized, $\Delta NFA = \Delta MB$; and if it is fully sterilized, $\Delta NFA = -\Delta NDA$. In the former case, the expansion of the money supply does not entail larger interest payments, while in the latter case it does. This is why other studies often refer to the 'cost of sterilization', rather than the cost of FX intervention. However, it is important to distinguish between 'book' costs—that would be reflected in the central bank's balance sheet—and economic (opportunity) costs.

Book versus Opportunity Cost

Book costs of FXI depend on the degree of sterilization and the specific instruments used, as these determine the actual amount of interest payments arising from the increased central bank liabilities. On the other hand, the degree of sterilization is irrelevant from the perspective of the *economic* opportunity cost of the interventions, as expansions of the monetary base conducted through (the unsterilized part of) FX operations still carry the opportunity cost of the central bank's domestic liabilities. For example, if the expansion of the monetary base is a response to an increase in the demand for money, such monetary expansion could be undertaken by purchasing local currency assets ($\Delta MB = \Delta NDA$). Not doing so entails an opportunity cost due to the forgone interest on larger holdings of domestic assets. On the other hand, an expansion of base money that is not matched by an increase in money demand entails

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[4] Some countries (e.g., Brazil, Korea, Malaysia, Singapore, Thailand, etc.) have increasingly relied on derivative (off balance sheet) instruments to intervene in FX markets. While these operations have been sizable in terms of flows, overall derivative positions remain relatively small in comparison to on-balance sheet positions. We overlook off balance sheet positions in our computations.

a monetary loosening (lower interest rates) which should be thought of as an additional policy action and not FXI alone.

Thus, we can simply measure the marginal cost of FXI as the economic opportunity cost of increasing the central bank's FX position, determined by deviations from uncovered interest rate parity (UIP). That is:

$$MC_{k,t+1} = \frac{1+i_{k,t}}{1+i_t^*}\frac{S_{k,t+1}}{S_{k,t}} - 1 \tag{2}$$

where $i_{k,t}$ and i_t^* denote country *k*'s nominal interest rate (yield) on the domestic and foreign assets used in the FXI operation, respectively; and $S_{k,t}$ is country *k*'s nominal exchange rate expressed as local currency per unit of foreign currency. In logarithms, equation (2) can be expressed as:

$$mc_{k,t+1} = \ln(1+MC_{k,t+1}) \approx (i_{k,t} - i_t^*) - \Delta s_{k,t+1} \tag{3}$$

where $\Delta s_{k,t+1}$ denotes the (log) change in the exchange rate from period t to period $\mathrm{t}+1$. For simplicity, and given the dominance of the US dollar as a reserve currency, we focus on the US dollar interest rates for i_t^* and the local currency exchange rates per US dollar for $S_{k,t}$.[5] Domestic and foreign yields correspond to short maturity instruments (1-month rates in the inter-bank market or closest available) to minimize issues related to liquidity, maturity and default risk.[6] Additionally, we ignore possible counter-party risk that is generally very small. Therefore, in this formulation the central bank is only exposed to currency risk. The timing convention is such that variables are time-subscripted when they are revealed to agents. Thus, even though the central bank engages in a foreign exchange intervention at t, the actual marginal cost is only realized a month later at $t+1$.

The *total* cost of FX intervention—or cost of rolling over the FX position—is thus given by:

$$TC_{k,t+1} = NFA_{k,t} MC_{k,t+1} \tag{4}$$

where $NFA_{k,t}$ denotes the FX position at time t, expressed in percent of GDP; and $MC_{k,t+1}$ is the marginal cost as defined above. [7]

Cost of FX Intervention versus Cost of Accumulating Reserves

The literature often refers to the costs of FX intervention and the cost of holding reserves indistinctly. This arguably reflects the perception that countries accumulate reserves mostly by intervening in the FX

[5] See discussion below on the case of multiple reserve currencies.

[6] Many central banks purchase long-term foreign securities when conducting FX intervention. While these assets may earn higher interest rates as a result of a term premium, the latter reflects liquidity, maturity and default risk, and thus should be stripped out from the computation of the cost of intervention.

[7] The cost of temporary intervention can, equivalently, be computed as the cumulative marginal cost for the duration of the resulting balance sheet expansion.

market. However, these are two distinct concepts, linked to liquidity and net FX positions respectively, with different associated marginal costs. Consistent with the definition discussed above, a FX intervention should be understood as an operation that changes the net FX position of the central bank, without necessarily changing its net liquidity position (an increase in liquid foreign assets matched by an equal increase in short-term liabilities). This is different from reserve accumulation, which relates to a portfolio reallocation within FX assets meant to increase liquidity (or reduce debt maturity). Thus, the marginal cost of changing the net FX position of the central bank is given by the (ex-ante or ex-post) deviation from uncovered interest parity; while reserve changes entail a marginal cost related to the steepness of the yield curve of the reserve currency—i.e. a term (or liquidity) premium in the foreign currency.[8]

Foreign Currency Composition

Throughout the paper, we assume the US dollar as the single currency of denomination of the net FX position, although in practice, FX positions often include other reserve currencies (mostly the Euro but also Pound, Yen, etc.). The latter would suggest that a measure of the cost of intervention should be based on the return on a basket of reserve currencies. However, to the extent that reserve currencies are close substitutes of each other (i.e., low cross reserve currency risk premia) the composition of foreign currencies in central bank holdings is of secondary importance from an ex ante perspective.[9,10] Operationally, the focus on the U.S. dollar also facilitates the computations as country specific data on the composition of central bank foreign assets is rarely available.[11]

Valuation Gain and Effect on Risk Premium

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[8] See Levy Yeyati (2008) and Jeanne and Ranciere (2011).

[9] In the general case, the ex-ante marginal (log) cost of FXI is given by
$E_{k,t}\left[mc_{k,t+1}\right] = i_{k,t} - \sum_{h\in H} w_k^h i_{h,t} - \sum_{h\in H} w_k^h E_t\left[\Delta s_{k,t+1}^h\right]$ where w_k^h indicate the weight of reserve currency $h\in H$ in country k's reserve holdings; and $s_{k,t+1}^h$ denotes the (log) exchange rate of country *k* vis-a-vis country *h*. The expression can be re-arranged as
$E_{k,t}\left[mc_{k,t+1}\right] = \left\{i_{k,t} - i_t^{US} - E_t\left[\Delta s_{k,t+1}^{US}\right]\right\} + \left\{\sum_{h\in H} w_k^h\left(i_{h,t} - i_t^{US} - E_t\left[\Delta s_{h,t+1}^{US}\right]\right)\right\}$ where the first term is the risk premia of county k relative to the US, and the second term measures the risk premia of all other reserve currencies relative to the US (using triangular equality). Our estimates assume the last term to be of second order importance.

[10] Another aspect often discussed relates to the maturity composition of central banks assets, as most central banks invest a large share of their reserve assets in (liquid) long-term security instruments (e.g., 10-year US Treasury bonds). See for example, Dominguez (2012). While this allows to increase their return on assets, it entails taking additional liquidity and interest rate risk, and thus such extra returns should not be considered when computing the cost of FXI.

[11] The IMF compiles such data in the Currency Composition of Official Foreign Exchange Reserves (COFER) database and reports world and regional aggregates, but country-specific figures are confidential.

Another relevant issue relates to the valuation effects and the possible effect of FXI on risk premia. Operating through a portfolio balance channel, a FX intervention entails two effects: (i) a valuation gain on the pre-existing net foreign asset position arising from the fact that an intervention would lead to a depreciation of the domestic currency[12]; and (ii) the (portfolio balance) effect of FXI on the risk premium. As shown in Annex 1, however, these two effects perfectly offset each other since the contemporaneous valuation effect mirrors the expected appreciation of the domestic currency (which is what creates the higher expected return—i.e., the risk premium). Thus, expression (2) does not need to be adjusted to account for these two effects.

III. MEASURING THE COST OF FXI

A. Data

We proxy the FX position of the central bank using its end of period net foreign asset (NFA) position, as reported in the IMF's *International Financial Statistics*.[13] The monthly series combine data available through the Standardized and Non-Standardized Reporting Forms. The sample encompasses 73 emerging and advanced economies during the period 2002-13, based on data availability. As discussed before, exchange rates are observed at end of period and vis-a-vis the U.S. dollar. Money market or monetary policy rates (subject to availability of the former) are used to proxy for the short-term interest rates.

B. Ex-post cost

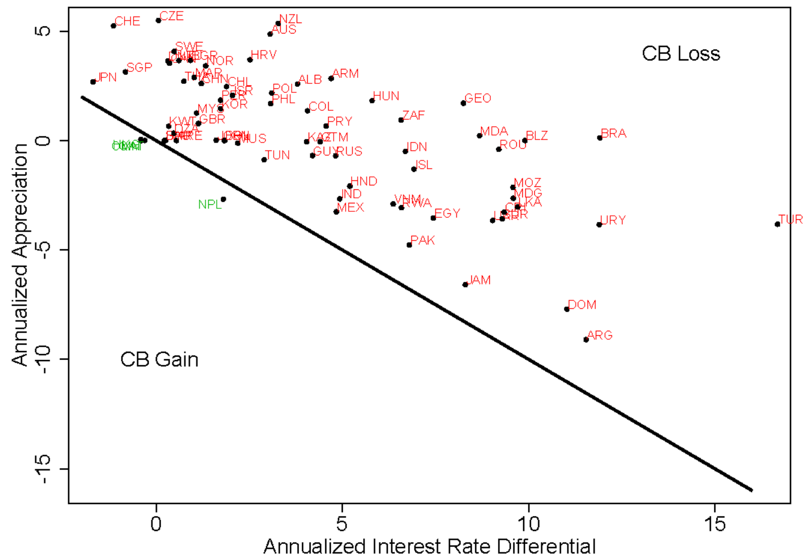
We first document ex-post costs. Figure 2 depicts the average value of the two RHS terms of equation (3)—that is, the annualized (log) interest rate differential and ex-post nominal appreciation—as well as the line consistent with uncovered interest rate parity (UIP) holding on average, for the full sample period. As shown, a large number of countries (70 out of 73) have diverged from interest rate parity generating positive costs (i.e., central bank losses). The median UIP deviation reaches 3.3 percent in the sample. Brazil and Turkey are among the most noticeable deviations, with ex-post log marginal costs in excess of 10 percent per year (see also Figure 3).

[12] For recent studies on the effect of FXI on the exchange rate, see Adler et al (2015), Blanchard et al (2015), Daude et al (2014) and Fratzscher et al (2015).

[13] In countries with a high degree of financial system dollarization, NFA may overestimate the net FX position of the central bank, to the extent that banks' deposits at the central bank are denominated in foreign currency. Cases of high dollarization, however, are rare in the sample of countries and period under analysis.

Figure 2. Deviations from Uncovered Interest Rate Parity, in logs, 2002-13

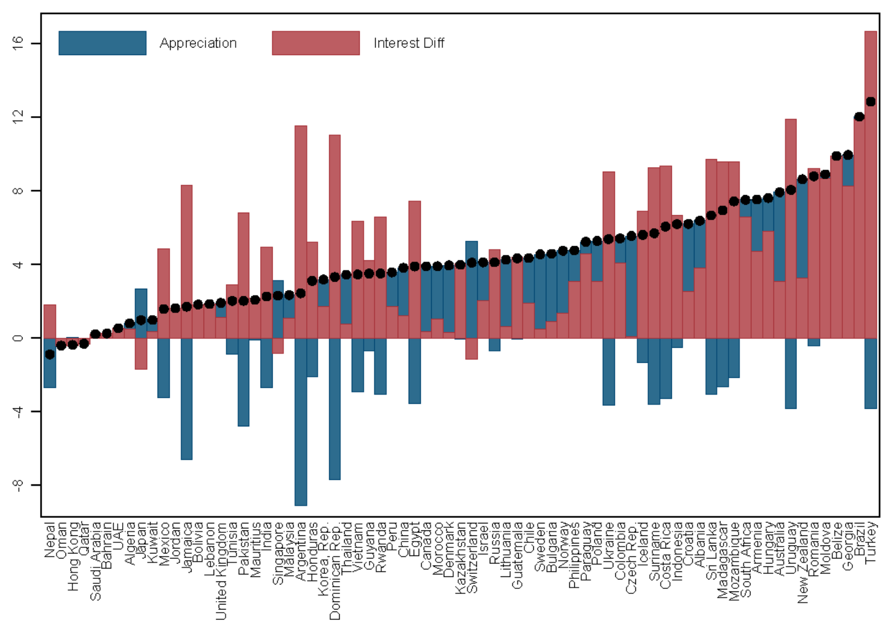
(percentage points, average for the period)



Sources: Datastream, Haver, IMF's *International Financial Statistics*; and authors' calculations.

Figure 3. Decomposition of Deviations from Interest Rate Parity, in logs, 2002-13

(percentage points, average for the period)

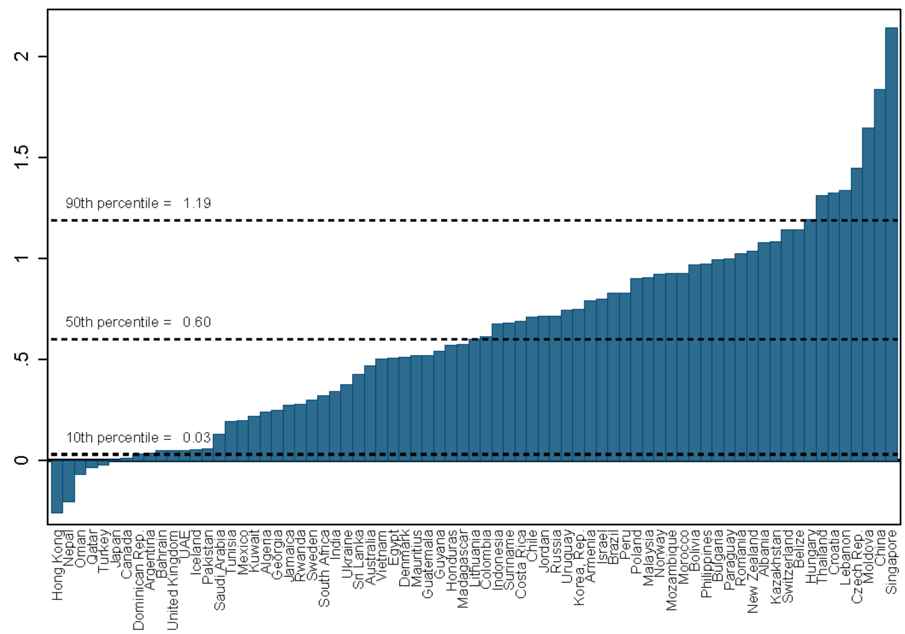


Sources: Datastream, Haver, IMF's *International Financial Statistics*; and authors' calculations.

Figure 4, in turn, displays (country average) ex-post total costs—or the cost of rolling over FX positions—during the sample period, measured in percent of GDP. As shown, such costs reach about 0.6 percent of GDP for the median country in the sample, while at least 10 percent of the countries incurred in costs in excess of 1 percent of GDP on average. Interestingly, the cases of high ex-post marginal costs identified before (Brazil and Turkey) do not appear among the highest total costs, on account of relatively lower holdings of FX during the period; while China and Singapore stand out at the top of the distribution of total opportunity costs, despite being below the median in the distribution of marginal costs. This reflects their much larger FX position during the period of analysis.

Figure 4. Cost of Rolling-over FX Positions, 2002-13

(percent of GDP, average for the period)



Sources: IMF International Financial Statistics; and authors' calculations.

C. Ex-ante costs

While ex-post costs appropriately capture the incurred cost of FXI, they may reflect the effect of unanticipated shocks on the exchange rate (for example, the entire deviation from UIP in Czech Republic's case is due to an appreciation of the currency). Indeed, for many EMEs in the sample, the period of analysis coincided with years of unexpected economic boom and thus with sizeable appreciations of their currencies.

A more meaningful measure, relevant for policy decisions, is given by the (expected) cost of FXI from an *ex-ante* perspective. Thus, taking conditional expectations of equation (3), the ex-ante (or expected) marginal cost would be:

$$E_{k,t}\left[mc_{k,t+1}\right] = i_{k,t} - i^{*}_{k,t} - E_{k,t}\left[\Delta s_{k,t+1}\right] \quad (5)$$

And, analogous to the total ex-post costs computed before, the expected cost of rolling over an existing FX position is given by:

$$E_{k,t}\left[TC_{k,t+1}\right] \approx NFA_{k,t}\{\exp\left(E_{k,t}\left[mc_{k,t+1}\right]\right)-1\} \quad (6)$$

where the only unknown term to be estimated is the expected marginal cost since the NFA position is known at t.[14] The expectation in (5) is a sufficient statistic for a risk-neutral central bank contemplating an intervention at time t and considering only the costs of such operation. The key component of (5) is the *expected* exchange rate change, $E_{k,t}(\Delta s_{k,t+1})$, underlining the need to forecast the behavior or the exchange rate—which is an intrinsically difficult endeavor. For this reason, we will follow various alternative approaches with different underlying assumptions. Note that $E_{k,t}(mc_{k,t+1})$ is also a measure of the expected excess return on currency k expressed in U.S. dollars, also known as currency risk premium. Thus, we rely on existing empirical work on currency risk premia.

1. Nominal random walk

A standard view is that the best predictor of future exchange rates is the current exchange rate. This would imply $E_{k,t}[\Delta s_{k,t+1}] = 0$ and therefore, the ex-ante cost of intervention would simply be the interest rate differential: $E_{k,t}[mc_{k,t+1}] = i_{k,t} - i^{*}_{t}$.[15]This is our first approach for estimating ex-ante marginal costs.

2. Currency risk premia

Alternatively, there is a growing literature that points to a predictable component in exchange rate returns (or currency risk premium). Non-zero expected excess returns can be explained by either risk compensation or limits to arbitrage due to institutional frictions in the micro-structure of currency markets, as discussed in Lustig and Verdelhan (2007) and Burnside (2011). In this paper, we denote the conditional expectation of marginal costs of intervention as risk premia without taking a particular stand on this debate. Risk premia can be measured in two ways: (i) relying on survey-based expectations of exchange rate movements; and (ii) estimating expected returns by linking realized returns to ex-ante observable variables (i.e., model-based risk premia). Both approaches are discussed and implemented next.

Survey-based exchange rate expectations

Our survey-based measure takes exchange rate expectations from Consensus Forecast (CF), as an estimate of the third RHS term in equation (5). We use actual (log) 1-month ahead expectations when available; or otherwise we rely on (log-linear) implied 1-month expectations derived from 3-month (and in some cases 12-month) ahead expectations. Expected exchange rate changes are computed

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[14] We ignore the Jensen's term in computing the total ex-ante cost (i.e. we first estimate the expected log marginal cost and then take an exponential to approximate the expected marginal cost in levels).

[15] An alternative approach would be to assume that nominal exchange rates are expected to behave in tandem with expected inflation differentials (thus the real exchange rate follows a random walk). In this case, the ex-ante marginal cost would be given by the real interest rate differential. However, this approach cannot be easily implemented because inflation expectation data is normally only collected for current and next end-year horizons, thus complicating the estimation of 1-month ahead expectations that are required to match the horizon of short-term interest rates.

relative to the spot rate reported by CF. The sample coverage for this measure is restricted to 54 countries due to CF coverage, though most of the data are available from 2002 onwards.

Model-based risk premia

Model-based estimates of currency risk premia entail finding a link between current observations of some variables and future excess returns; that is, forecasting excess returns conditional on contemporaneously observable variables.

We follow the approach proposed by Hassan and Mano (2014), who estimate risk premia by decomposing them into three dimensions—a pure cross-sectional, a common time series component and an idiosyncratic component—and study how interest differentials drive these different dimensions of risk premia. Specifically, the marginal cost (risk premia) is decomposed into:

$$E_{k,t}\left[mc_{k,t+1}\right] = E_k\left[mc_k - mc\right] + E_t\left[mc_{t+1}\right] + E_{k,t}\left[mc_{k,t+1} - mc_{t+1} - \left(mc_k - mc\right)\right] \quad (7)$$

where mc_k , mc_{t+1}, mc are the time-series sample average for each country, the cross-sectional average at each point in time, and the overall average of the ex-post (log) marginal cost, respectively. Thus, risk premia are decomposed into i) a currency specific component–the first term on the right-hand side—or so called *static risk premium*; and ii) a common component to all currencies at each point in time–the second RHS term–or *dollar risk premium*; and (iii) departures from either static or dollar risk premia– the last term– denoted as *dynamic risk premium*. We now turn to how these three components of FX risk premia can be explained by usual drivers of currency market returns.

First, we focus only on interest differentials, as do Hassan and Mano (2014), and later expand the set of possible drivers to other variables. We estimate the currency-specific component (static risk premium) by running a cross-sectional regression of the form:

$$mc_k - mc = \beta^{stat}\left(\left(\widehat{i_k - i^*}\right) - \overline{\left(i_k - i^*\right)}\right) + \varepsilon_k^{stat} \quad (8)$$

The common time-series component (dollar risk premium) is estimated by running a single time-series regression:

$$mc_{t+1} = \alpha + \beta^{dol}\left(i_t - i_t^*\right) + \varepsilon_{t+1}^{dol} \quad (9)$$

Finally, the idiosyncratic component (or dynamic risk premium) is estimated by running:

$$mc_{k,t+1} - mc_{t+1} - \left(mc_k - mc\right) = \beta^{dyn}\left(i_{k,t} - i_t^* - \left(\widehat{i_k - i^*}\right) - \left(i_t - i_t^* - \overline{\left(i_k - i^*\right)}\right)\right) + \varepsilon_{t+1}^{dyn} \quad (10)$$

where $\widehat{i_k - i^*}$ is an estimate of expected average interest rate differential for each country, $\overline{\left(i_k - i^*\right)}$ is the average of $\widehat{i_k - i^*}$ across all countries, and i_t is the cross-sectional average of interest rates for all countries at time *t*.

All regressors in equations (8)-(10) are known at *t,* except the average expected interest rate differential for each currency, $\widehat{i_k - i^*}$, and its average across all countries, $\overline{\left(i_k - i^*\right)}$. Hassan and Mano (2014) argue against using realized ex-post country averages for $\widehat{i_k - i^*}$, since that implies investors know the ex-post average interest rate differential that will prevail in their investment horizon, which biases estimates of β^{dyn}. Instead, they propose simply estimating the expected average interest rate differential in a pre-sample. They also discuss other methods but settle on pre-sample estimation for its simplicity and ease of interpretation. We follow the same procedure.

We estimate equations (8)-(10) using different cut-off periods and a pre-sample of four years to estimate the average expected interest rate differential for each currency. Appendix Table A1.a reports regression results for different cut-off periods. We focus on the specification with 2003 as a cut-off, striking a balance between restricting excessively the sample period, on one hand, and using a pre-sample period that includes large crises, on the other.[16]

Based on our estimates, we focus on two types of risk premia: a static risk premia, given by

$$\hat{E}_{k,t}\left[mc_{k,t+1}\right] = \beta^{stat}\left(\left(i_k - i^*\right) - \overline{\left(i_k - i^*\right)}\right) + mc \tag{11}$$

and a broader measure that includes the dynamic component which we denote by "time-varying risk premia (interest rate only)".[17]

Finally, we explore possible additional drivers of risk premia—beyond interest rates—allowing for multivariate regressions with additional factors, $\mathbb{F}_{k,t}$, and thus modify (8)-(10) to:

$$mc_k - mc = \beta^{stat}\left(\left(\widehat{i_k - i^*}\right) - \overline{\left(i_k - i^*\right)}\right) + \mathbb{F}_{k,t}\boldsymbol{\delta}^{stat} + \varepsilon_k^{stat} \tag{12}$$

$$mc_{t+1} = \alpha + \beta^{dol}\left(i_t - i_t^*\right) + \mathbb{F}_{k,t}\boldsymbol{\delta}^{dol} + \varepsilon_{t+1}^{dol} \tag{13}$$

$$\begin{aligned} &mc_{k,t+1} - mc_{t+1} - \left(mc_k - mc\right) = \\ &\beta^{dyn}\left(i_{k,t} - i_t^* - \left(\widehat{i_k - i^*}\right) - \left(i_t - i_t^* - \overline{\left(i_k - i^*\right)}\right)\right) + \mathbb{F}_{k,t}\boldsymbol{\delta}^{dyn} + \varepsilon_{t+1}^{dyn} \end{aligned} \tag{14}$$

We focus on factors previously explored in the literature, most importantly Engel and West (2005) and Menkhoff et al (2013). Appendix Table A1.b shows robustness of the benchmark specification to different cut-off choices and Appendix Tables A2-A4 show different specifications for each of the three risk premia dimensions. Factors other than interest rates include: (i) broad money growth differential; (ii) actual real GDP growth differential; (iii) expected real GDP growth differential (from Consensus Forecast, for the current and following year); (iv) expected inflation (from Consensus Forecast); and (v) real effective exchange rate gap, computed as the deviation from an HP filter trend (this variable only enters the dynamic component as the real effective exchange rate is an *index* and, thus, its level cannot be compared across countries).

[16] Estimates for ex-ante marginal costs based on this estimation procedure are only available after 2003, unlike estimates for the other methods presented, which sample goes back to 2002, if available.

[17] The significance of the dynamic component is not robust to alternative sample cut-offs. However, its size is small in all cases, meaning that including it does not change materially the point estimates of risk premia.

Interestingly, we find that none of these other factors explain risk premia in the cross-section or time-series dimensions. However, in the idiosyncratic dimension, both the real exchange rate gap and expected growth rate differentials (for the current year) are significant in explaining dynamic risk premia. Thus, we construct a broader measure of risk premia, which we denote "time-varying risk premia", based on the more-broadly estimated static and dynamic risk premia (Appendix Table A2-column 1; and Table A3-column 10, respectively).

Empirical Evidence for our Sample

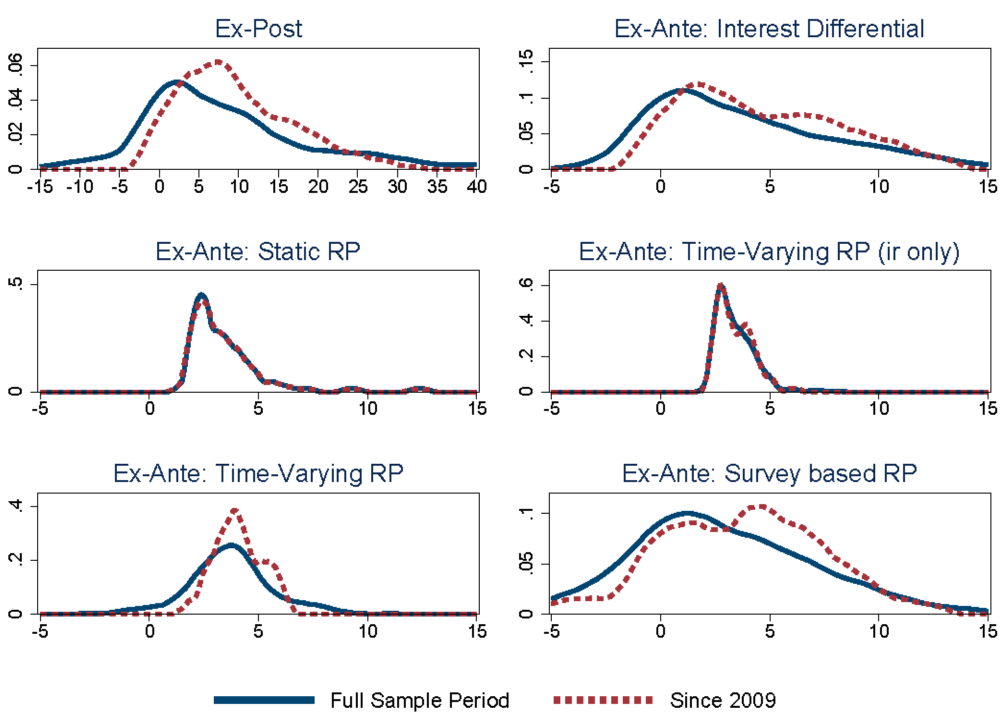
Figure 5 displays the density distribution of the alternative measures of the marginal cost of FXI, both for the full sample period as well as for the post-global financial crisis period. Table 1 presents some summary statistics, and country-by-country results are reported in Appendix Table A1. We find some interesting results:

The different measures of ex-ante marginal costs deliver broadly similar results, with medians in the range of 2.5-3.7 percent; although there are differences in terms of dispersion.

The range of estimates of ex-ante costs is significantly smaller than that of the ex-post costs. This indicates that the ex-post costs reflect, to a large extent, unexpected returns, and thus may significantly under- or over-estimate the relevant (ex-ante) metric of the cost of intervention for policy decisions. Moreover, the median ex-ante marginal cost is about 3 percent; while the median ex-post costs reached 6.3 percent during the sample period, reflecting the widespread unexpected appreciation of EMEs' currencies during the period of analysis.

Figure 5. Density Function of Marginal Cost of FXI, 2002-13

(percentage points, distribution based on annual averages)



Sources: IMF *International Financial Statistics*; and authors' calculations.

Table 1. Average Marginal Cost of FXI, 2002-13 1/

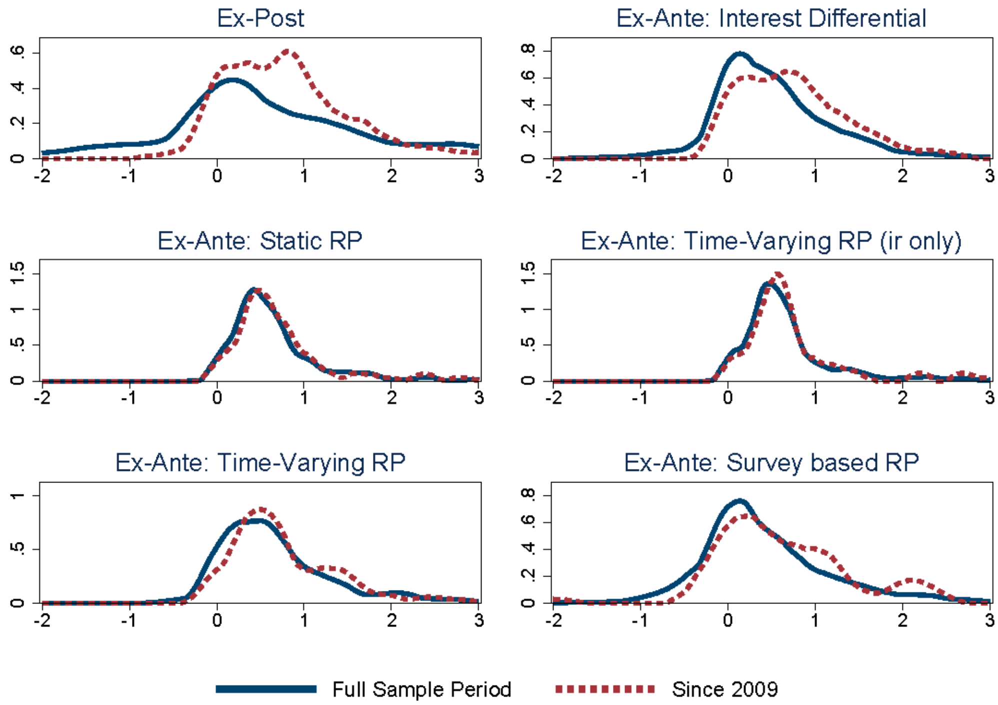
	Ex-Post	Ex-Ante					
		Interest Differential	Static RP	Time-Varying RP (ir only)	Time-Varying RP	Survey based RP	Ex-Ante Average
Full Sample Period							
25th percentile	0.99	0.55	2.27	2.74	2.62	0.06	1.65
median	6.46	2.98	2.95	3.24	3.68	2.45	3.06
75th percentile	14.02	6.74	3.93	3.92	4.72	5.70	5.00
mass > 5%	0.55	0.35	0.11	0.04	0.20	0.29	0.20
Since 2009							
25th percentile	4.87	1.68	2.27	2.78	3.38	0.77	2.18
median	8.56	3.79	2.95	3.11	3.99	3.76	3.52
75th percentile	14.21	7.24	3.93	3.96	4.86	5.71	5.14
mass > 5%	0.72	0.42	0.11	0.04	0.21	0.37	0.23

Sources: IMF *International Financial Statistics*; and authors' calculations. 1/ Statistics of the universe of annual averages (i.e., one observation per country/year).

Not surprisingly, ex-post costs of FXI are larger for the post-2008/09 crisis period, reflecting low returns on foreign assets arising from very loose monetary policy in the US (as indicated by the interest rate differential plotted in the upper right chart of Figure 5), and appreciation pressures from capital inflows in most countries in the sample. Ex-ante measures, on the other hand, display less evidence of a structural break, except for the broad time-varying version. The latter indicates that time-varying variables, like expected GDP growth differential were key temporary drivers of expected excess returns on the post-crisis period.

Figure 6 and Table 2 present similar information, but in this case for the total (rollover) costs. Corresponding country-by-country results are reported in Appendix Table A2. We find, for the median country, ex-ante costs in the inter-quartile range of 0.3-0.5 percent of GDP per year, depending on the method; in comparison to ex-post costs of 0.6 percent of GDP. Similar to the results for the marginal costs, ex-post total costs have been larger (and with higher variance) since the 2008-09 crisis; while ex-ante measures display some, but less evidence of a structural break.

Figure 6. Density Function of Total (Roll-over) Cost of FXI, 2002-13
(percentage points, distribution based on annual averages)



Sources: IMF International Financial Statistics; and authors' calculations.

Table 2. Average Total Cost of FXI, 2002-13 1/

	Ex-Post	Ex-Ante					
		Interest Differential	Static RP	Time-Varying RP (ir only)	Time-Varying RP	Survey based RP	Ex-Ante Average
Full Sample Period							
25th percentile	-0.05	0.05	0.33	0.37	0.21	-0.00	0.19
median	0.40	0.40	0.53	0.54	0.54	0.29	0.46
75th percentile	1.38	0.84	0.78	0.77	0.98	0.79	0.83
mass > 1%	0.33	0.20	0.16	0.16	0.24	0.19	0.19
Since 2009							
25th percentile	0.21	0.21	0.40	0.41	0.44	0.15	0.32
median	0.70	0.67	0.56	0.60	0.61	0.44	0.58
75th percentile	1.14	1.11	0.85	0.82	1.25	1.04	1.02
mass > 1%	0.32	0.30	0.16	0.18	0.31	0.26	0.24

Sources: IMF *International Financial Statistics*; and authors' calculations. 1/ Statistics of the universe of annual averages (i.e., one observation per country/year).

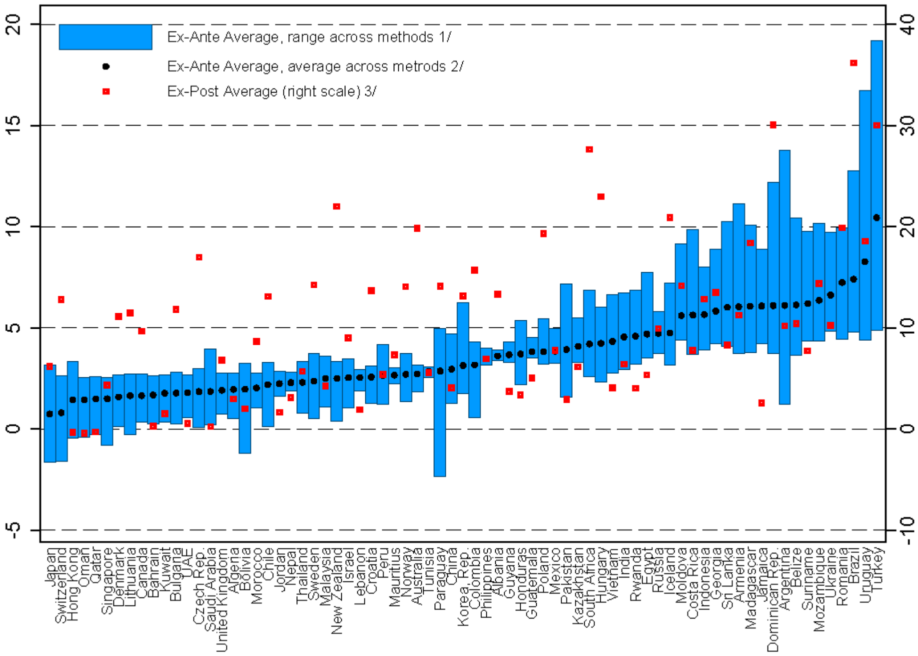
Finally, Figure 7 displays the cross section of estimates for marginal and total costs, respectively, showing the range of risk premia estimates according to the different approaches (blue bars), their means (black dots) as well as the ex-post costs (red dots). As shown, the range of estimates is relatively wide for some countries, especially those with higher average estimates; although the ranking of countries seems to be quite stable across measures. More importantly, except for only about a quarter of the sample, our estimates suggest that the opportunity costs of FXI have been of economically meaningful magnitude even if the lower bound estimates are taken into account. For 9 out of 73 countries, total costs averaged more than 1 percent of GDP per year over the sample period.[18]

[18] In some of these countries (e.g., Saudi Arabia, Russia) large central bank balance sheets reflected fiscal savings associated with commodity windfalls. In these cases, the estimated fiscal costs may not be directly linked to FX intervention. They still reflect the opportunity costs of holding the corresponding FX positions—i.e., investing these (sovereign wealth) savings into foreign assets as opposed to domestic assets—although they may overestimate the true costs in cases where domestic financial markets have limited absorption capacity.

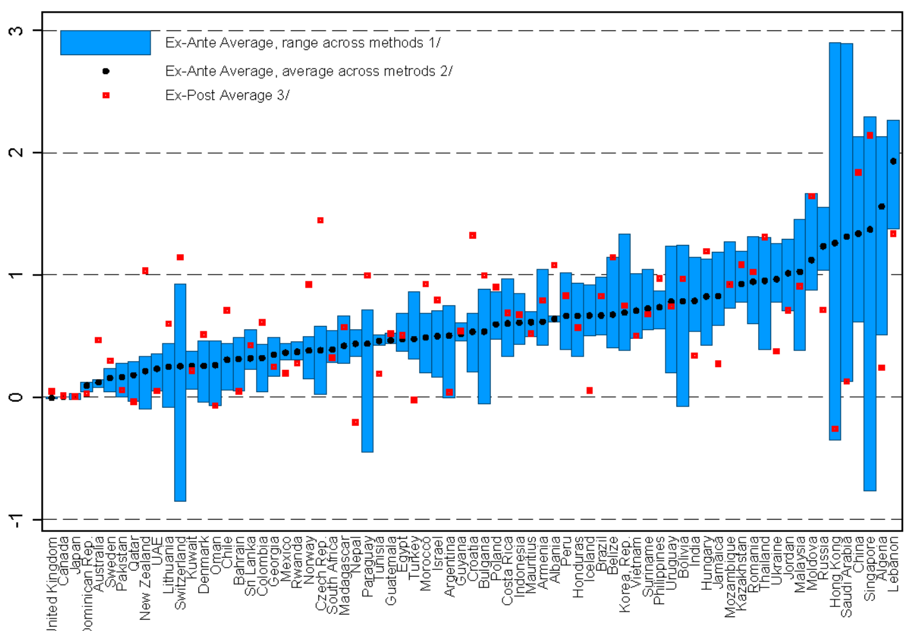
Figure 7. Marginal Cost of FXI per country, 2002-13

(percent of GDP)

Marginal Cost



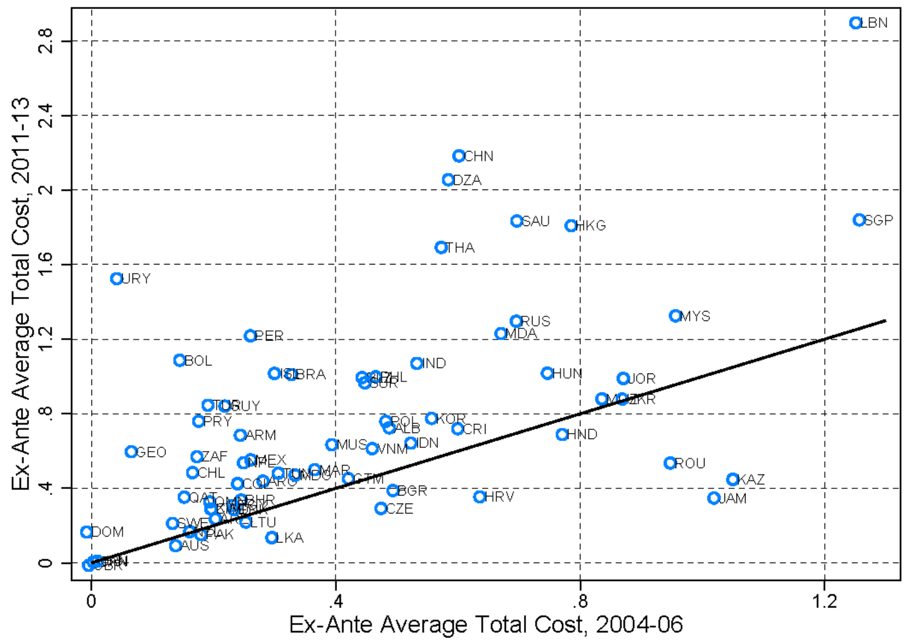
Total Cost



Sources: IMF *International Financial Statistics*; and authors' calculations. 1/ Range between the minimum and maximum estimated ex-ante country-average across different methods. 2/ Average (across methods) of ex-ante measures. 3/ Ex-Post country-average.

Moreover, for most countries in the sample total costs of rolling over FX positions have increased significantly during the period of analysis (Figure 8), primarily on account of increased positons.

Figure 8. Total Ex-Ante Cost of FXI: 2004-06 and 2011-13



Sources: IMF *International Financial Statistics*; and authors' calculations. 1/ Average of ex-ante country-averages across methods.

D. Exchange Rate Management and Cost of FXI

Another relevant aspect relates to whether the degree of exchange rate management affects marginal and total costs of FX intervention. Tighter exchange rate management could reduce risks of large movements in the exchange rate and so the marginal cost of FXI (risk premia). On the other hand, heavier exchange rate management may lead to large central bank FX positions, increasing total costs.

To explore this issue, we construct a simple country-specific measure of the degree of exchange rate management as:

$$\rho_j \equiv \sigma_j^{NFA} / (\sigma_j^{NFA} + \sigma_j^{S}) \tag{15}$$

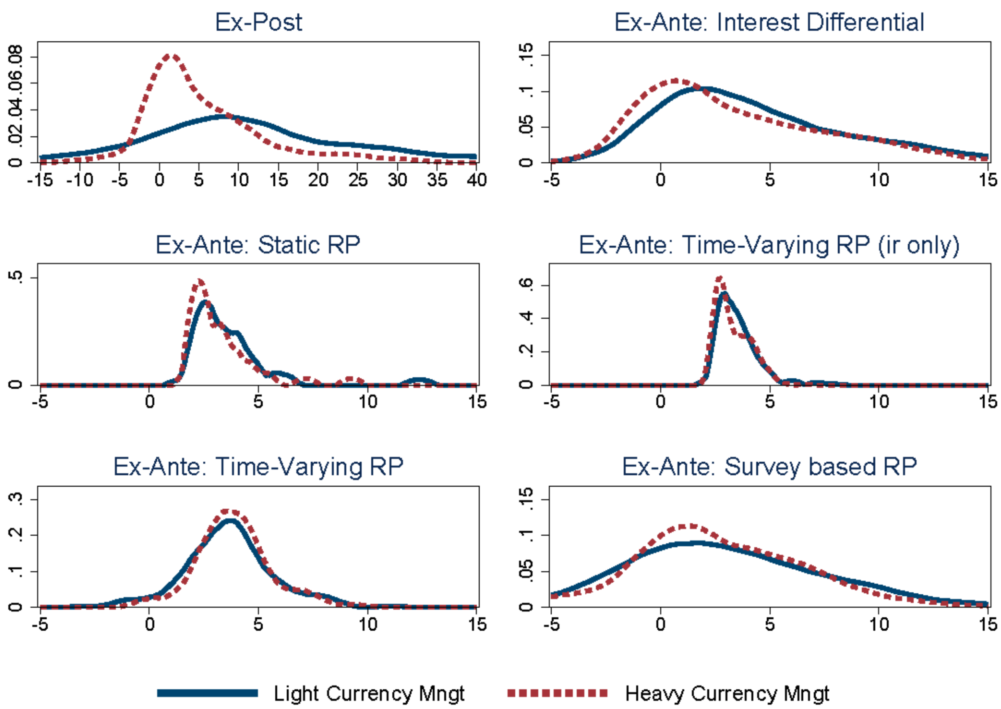
where σ_j^{NFA} and σ_j^{S} denote the standard deviations of changes in net foreign assets (normalized to GDP) and of the nominal exchange rate, respectively. The measure ρ_j varies between 0 and 1, corresponding to a *pure floating* and a *peg* respectively. Subsequently, we divide the sample into light and heavy interveners depending on whether the value of ρ_j is below or above the cross section median.

We find that, while heavy exchange rate management is associated with less dispersion and lower average ex-post marginal costs, there is no clear statistical link for the ex-ante measures (Figure 9).

This suggest that either FXI is immaterial on risk premia, or that FXI is undertaken in countries where risk premia would be higher in absence of FXI. On the other hand, total costs (Figure 10) appear to be meaningfully larger for heavy interveners (in the inter-quartile range of 0.3-1.2 percent of GDP per year), than for light interveners (in the range of 0.2-0.7 percent of GDP per year), as a result of their larger balance sheets.

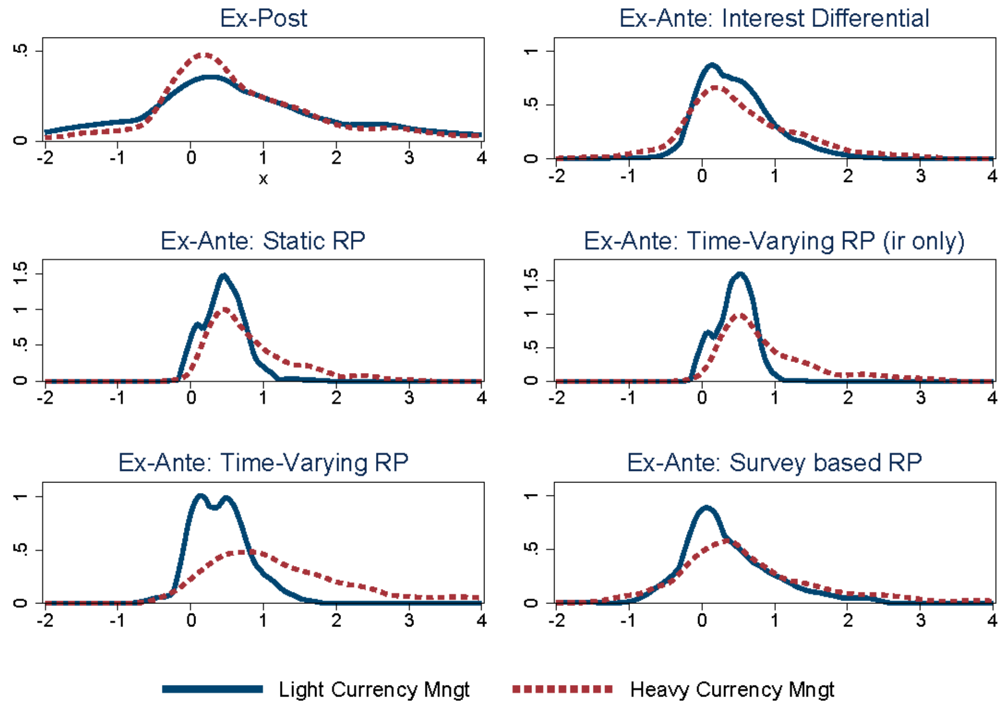
Figure 9. Degree of Intervention and FXI Marginal Cost, 2002-13 1/

(percentage points, average for the period)



Sources: IMF International Financial Statistics; and authors' calculations. 1/ Based on a measure of the degree of exchange rate management is defined as: $\rho_j \equiv \sigma_j^{NFA}/(\sigma_j^{NFA}+\sigma_j^{S})$ where σ_j^{NFA} and σ_j^{S} denote the standard deviations of changes in net foreign assets and in nominal exchange rate, respectively.

Figure 10. Degree of Intervention and FXI Total Cost, 2002-13 1/
(percentage points, average for the period)



Sources: IMF International Financial Statistics; and authors' calculations. 1/ Based on a measure of the degree of exchange rate management is defined as: $\rho_j \equiv \sigma_j^{NFA}/(\sigma_j^{NFA} + \sigma_j^S)$ where σ_j^{NFA} and σ_j^S denote the standard deviations of changes in net foreign assets and in nominal exchange rate, respectively.

E. Other Conditional Costs

Emerging market versus advanced economies

Much of the debate about FXI over the last decade has focused on emerging markets, and it has been argued often that EMEs rely more heavily on FXI because such instrument tends to be more effective in those economies (reflecting lower asset sustitutability and so a stronger portfolio balance channel). Our empirical evidence (see Tables 3-4, and Appendix Figures A1-A2) confirms that, while there is no significant difference between ex-post deviations from UIP in EMEs and AMEs, risk premia are indeed higher (and more dispersed) in EMEs. This indicates that the benefits of a stronger portfolio balance channel (which increases the effectiveness of FXI) may need to be weighed against the higher fiscal costs that the latter entails.[19]

[19] In strict sense, a stronger portfolio balance channel requires the risk premium to be more sensitive to FXI, rather than to be higher; but a higher premium is likely to be an indication of the former (i.e., lower asset substitutability).

Global Risk Appetite and Cost of FXI

Finally, we explore whether risk premia vary with global financial conditions, namely global risk appetite. To this end, we look at the cross section of estimated risk premia at two points in time characterized by significantly different conditions: January 2007—when the VIX index reached a record low value—and October 2008—when the VIX index reached its peak value in the midst of the 2008-09 crisis. Interestingly, we find significantly higher median (twice as high) and dispersion of risk premia in the latter case (Tables 3-4 and Appendix Figure A3).

This indicates that at least extreme global financial conditions (beyond those reflected in interest rates) may have important effects on the cost of FXI.[20] This would argue, from a purely fiscal perspective, for reducing (increasing) FX positions during times of high (low) uncertainty.

Table 3. Marginal Cost of FXI—Conditional Statistics, 2002-13

	Ex-Post	Ex-Ante					
		Interest Differential	Static RP	Time-Varying RP (ir only)	Time-Varying RP	Survey based RP	Ex-Ante Average
Emerging Markets							
25th percentile	0.90	1.20	2.54	2.89	2.87	0.59	2.02
median	5.46	4.09	3.31	3.46	4.03	3.35	3.65
75th percentile	12.65	7.86	4.37	4.08	4.97	6.24	5.51
mass > 5%	0.52	0.42	0.14	0.05	0.24	0.36	0.24
Advanced Economies							
25th percentile	2.31	-0.31	2.16	2.51	2.01	-0.68	1.14
median	9.50	0.64	2.31	2.69	3.11	0.87	1.92
75th percentile	20.26	2.50	2.47	2.95	3.84	2.82	2.92
mass > 5%	0.64	0.07	0.00	0.00	0.10	0.12	0.06
Light Interveners							
25th percentile	3.16	1.13	2.40	2.84	2.51	-0.24	1.73
median	10.13	3.50	3.07	3.33	3.61	2.54	3.21
75th percentile	19.82	7.02	4.20	3.91	4.66	5.78	5.11
mass > 5%	0.68	0.37	0.11	0.05	0.21	0.31	0.21
Heavy Interveners							
25th percentile	0.40	0.18	2.18	2.65	2.81	0.25	1.61
median	3.44	2.56	2.80	3.03	3.80	2.23	2.88
75th percentile	9.13	6.47	3.66	3.94	4.76	5.39	4.84
mass > 5%	0.42	0.32	0.11	0.02	0.19	0.27	0.18
High Vix							
25th percentile	-23.25	1.93	2.27	2.57	3.40	1.12	2.26
median	-0.33	4.47	2.95	3.16	8.09	4.10	4.56
75th percentile	4.74	9.28	3.93	3.96	12.46	11.21	8.17
mass > 5%	0.23	0.48	0.10	0.07	0.66	0.47	0.35
Low Vix							
25th percentile	0.54	-1.35	2.27	2.86	2.91	-1.51	1.04
median	7.06	0.18	2.95	3.27	4.72	0.41	2.30
75th percentile	20.52	3.12	3.93	3.81	5.79	2.48	3.83
mass > 5%	0.56	0.11	0.10	0.00	0.38	0.04	0.13

Sources: IMF *International Financial Statistics*; and authors' calculations.

[20] Interestingly, the VIX index was found to be insignificant in the estimation of the risk premia. This, along with the results mentioned in the text, suggests that only tail events in global risk appetite may have meaningful impact on risk premia.

Table 4. Total Cost of FXI—Conditional Statistics, 2002-13

	Ex-Post	Ex-Ante					
		Interest Differential	Static RP	Time-Varying RP (ir only)	Time-Varying RP	Survey based RP	Ex-Ante Average
Emerging Markets							
25th percentile	-0.04	0.16	0.38	0.41	0.34	0.05	0.27
median	0.43	0.51	0.57	0.57	0.59	0.40	0.53
75th percentile	1.36	0.96	0.80	0.80	1.02	0.90	0.90
mass > 1%	0.34	0.23	0.16	0.16	0.26	0.22	0.21
Advanced Economies							
25th percentile	-0.10	-0.04	0.09	0.11	0.02	-0.07	0.02
median	0.17	0.00	0.34	0.42	0.29	0.02	0.22
75th percentile	1.51	0.22	0.58	0.67	0.82	0.42	0.54
mass > 1%	0.33	0.04	0.15	0.17	0.19	0.11	0.13
Light Interveners							
25th percentile	-0.19	0.10	0.27	0.30	0.12	-0.01	0.16
median	0.39	0.40	0.45	0.47	0.40	0.21	0.39
75th percentile	1.40	0.75	0.64	0.63	0.64	0.66	0.66
mass > 1%	0.33	0.13	0.04	0.00	0.07	0.15	0.08
Heavy Interveners							
25th percentile	-0.02	0.02	0.39	0.44	0.54	0.07	0.29
median	0.42	0.40	0.65	0.70	1.00	0.44	0.64
75th percentile	1.36	1.01	1.09	1.17	1.83	1.09	1.24
mass > 1%	0.33	0.26	0.28	0.32	0.49	0.26	0.32
High Vix							
25th percentile	-5.08	0.27	0.37	0.40	0.52	0.03	0.32
median	-0.05	0.65	0.57	0.56	1.42	0.75	0.79
75th percentile	1.04	1.39	0.81	0.83	2.08	1.70	1.36
mass > 1%	0.26	0.36	0.17	0.21	0.57	0.35	0.33
Low Vix							
25th percentile	0.01	-0.19	0.32	0.37	0.36	-0.27	0.12
median	0.74	0.02	0.49	0.53	0.73	0.02	0.36
75th percentile	2.92	0.46	0.83	0.78	1.10	0.30	0.69
mass > 1%	0.44	0.03	0.14	0.13	0.28	0.00	0.11

Sources: IMF *International Financial Statistics*; and authors' calculations.

IV. CONCLUSIONS

The paper discussed a number of conceptual issues regarding how to measure the costs of conducting FX intervention; and estimated marginal and total associated costs over the last decade; both from an ex-post as well as an ex-ante perspective.

Ex-post costs have been relatively large on account of both sizeable deviations from UIP and the rapid growth of central bank FX positions.

From an ex-ante perspective, we found non-negligible costs of conducting FXI, with *marginal* costs for the median emerging market economy (EME) in the inter-quartile range of 2-5.5 percent per year; and ex-ante *total* costs (of sustaining FX positions) in the range of 0.3-0.9 percent of GDP per year.

Countries that intervene more heavily face a lower variance in ex-post deviations from UIP, but there is no meaningful difference in *expected* excess returns, compared to light interveners. This suggests that a higher degree of exchange rate management does not lead to lower risk premia. However, total costs have been substantially larger in heavy intervening countries, on account of larger FX positions, reaching an inter-quartile range of 0.3-1.2 percent of GDP per year, in comparison to 0.2-0.7 percent of GDP per year in light interveners.

Overall, these estimates indicate that fiscal costs of sustained FX intervention are a relevant dimension to be taken into account when conducting exchange rate policy. There may be valid reasons for conducting FX intervention, especially transitory, when benefits outweigh costs. Our paper does not attempt to shed light on the optimality of these interventions, but rather on how to measure the associated quasi-fiscal costs.

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Appendix

Table A1. Currency Risk Premia Estimation 1/

a. Interest rates only

	Static			Time-Series			Dynamic		
threshold	2001	2003	2005	2001	2003	2005	2001	2003	2005
Average int. diff.	0.128***	0.137***	0.096**						
	(0.035)	(0.034)	(0.043)						
World int. diff.				0.365	-0.755	-1.306			
				(0.914)	(1.370)	(1.615)			
Idiosyncratic int. diff.							0.111	0.123**	0.107
							(0.088)	(0.052)	(0.079)
R^2	0.24	0.26	0.10	0.00	0.00	0.01	0.00	0.00	0.00
N	44	47	47	139	115	91	6113	5402	4274

b. Other factors

	Static			Time-Series			Dynamic		
threshold	2001	2003	2005	2001	2003	2005	2001	2003	2005
Average int. diff.	0.128***	0.137***	0.096**						
	(0.035)	(0.034)	(0.043)						
World int. diff.				0.365	-0.755	-1.306			
				(0.914)	(1.370)	(1.615)			
Idiosyncratic int. diff.							0.119	0.135***	0.122
							(0.090)	(0.052)	(0.078)
Idiosyncratic exp. growth diff.							0.001**	0.001*	0.001*
							(0.000)	(0.000)	(0.000)
RER gap							-0.083***	-0.070***	-0.057***
							(0.013)	(0.012)	(0.012)
R^2	0.24	0.26	0.10	0.00	0.00	0.01	0.02	0.02	0.01
N	44	47	47	139	115	91	6113	5402	4274

Source: authors' estimations. Standard errors reported in parenthesis. *$p<0.10$, **$p<0.05$, ***$p<0.01$. 1/ Follows the methodology in Hassan and Mano (2014). Columns 2001, 2003 and 2005 correspond to the cut-off years for the beginning of the estimation period.

Table A2. Currency Risk Premia Estimation—Static Component 1/

Cross-Section	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Interest diff.	0.14***	0.14***	0.14***	0.13***	0.15***	0.14***	0.17**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.07)
M2 gr. diff.		-0.00					
		(0.00)					
RGDP gr. diff.			0.01				
			(0.01)				
M2 & RGDP gr. diff.				-0.00			
				(0.00)			
Exp. GDP gr. diff.					0.00		
					(0.00)		
Exp. GDP gr. diff.(1y)						0.00	
						(0.00)	
Exp. Inflation diff.							-0.04
							(0.08)
R^2	0.26	0.28	0.27	0.27	0.28	0.28	0.27
N	47	46	47	46	47	47	47

Source: authors' estimations. Standard errors reported in parenthesis. *p<0.10, **p<0.05, ***p<0.01. 1/ Follows the methodology in Hassan and Mano (2014).

Table A3. Currency Risk Premia Estimation—Dynamic Component 1/

Idiosyncratic	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Interest diff.	0.12**	0.07	0.14***	0.07	0.13**	0.14***	0.08	0.07	0.12**	0.14***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.08)	(0.05)	(0.05)	(0.05)
M2 gr. diff.		0.00								
		(0.00)								
RGDP gr. diff.			0.01							
			(0.01)							
M2 & RGDP gr. diff.				0.00						
				(0.00)						
Exp. GDP gr. diff.					0.00					
					(0.00)					
Exp. GDP gr. diff.(1y)						0.00				0.00*
						(0.00)				(0.00)
Exp. Inflation diff.							0.06			
							(0.11)			
EPFR exog. flows								-0.00		
								(0.02)		
RER gap									-0.07***	-0.07***
									(0.01)	(0.01)
R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
N	5402	5199	5402	5199	5402	5402	5402	5268	5402	5402

Source: authors' estimations. Standard errors reported in parenthesis. *p<0.10, **p<0.05, ***p<0.01. 1/ Follows the methodology in Hassan and Mano (2014).

Table A4. Currency Risk Premia Estimation—Common Component 1/

Time-series	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Interest diff.	-0.76	-1.40	-1.40	-1.70	-1.25	-1.73	-1.67	-0.76	-0.96
	(1.37)	(1.93)	(1.48)	(1.87)	(1.40)	(1.42)	(1.67)	(1.38)	(1.72)
M2 gr. diff.		-0.03							
		(0.06)							
RGDP gr. diff.			-0.18						
			(0.16)						
M2 & RGDP gr. diff.				-0.03					
				(0.04)					
Exp. GDP gr. diff.					-0.00				
					(0.00)				
Exp. GDP gr. diff.(1y)						-0.01**			
						(0.00)			
Exp. Inflation diff.							2.11		
							(2.21)		
EPFR exog. flows								0.00	
								(0.01)	
VIX index, in units									0.00
									(0.02)
R^2	0.00	0.00	0.01	0.01	0.02	0.04	0.01	0.00	0.00
N	115	115	115	115	115	115	115	115	115

Source: Authors' estimations. Standard errors reported in parenthesis. *p<0.10, **p<0.05, ***p<0.01. 1/ Follows the methodology in Hassan and Mano (2014).

Table A5. Marginal cost of FXI, by country, 2002-13 1/

	Ex-Post	Ex-Ante					
		Interest Differential	Static RP	Time-Varying RP (ir only)	Time-Varying RP	Survey based RP	Ex-Ante Average
ALB	13.31	3.89	3.57	3.40	.	3.56	3.60
ARE	0.55	0.55	2.17	2.68	.	.	1.80
ARG	10.19	13.78	5.99	4.65	4.88	1.20	6.10
ARM	11.24	4.90	4.44	3.71	.	11.12	6.04
AUS	19.85	3.12	2.40	3.06	3.17	1.82	2.71
BGR	11.81	0.95	2.18	2.70	2.80	0.24	1.77
BHR	0.26	0.26	2.15	2.64	.	.	1.68
BLZ	10.43	10.43	3.66	4.31	.	.	6.13
BOL	1.98	1.89	2.95	2.96	3.24	-1.21	1.97
BRA	36.20	12.78	5.28	4.80	5.05	9.09	7.40
CAN	9.68	0.37	2.21	2.63	2.72	0.32	1.65
CHE	12.82	-1.13	1.80	2.34	2.62	-1.61	0.80
CHL	13.09	1.93	2.65	2.98	3.29	0.13	2.19
CHN	4.06	1.25	2.17	2.76	3.88	4.71	2.96
COL	15.69	4.16	3.39	3.43	4.29	0.55	3.17
CRI	7.79	9.87	4.62	4.34	.	3.71	5.64
CZE	16.97	0.08	2.31	2.61	2.97	1.28	1.85
DNK	11.12	0.33	2.16	2.61	2.67	0.13	1.58
DOM	30.08	12.21	4.59	4.53	3.75	5.40	6.10
DZA	2.95	0.50	2.60	2.76	.	.	1.95
EGY	5.36	7.76	3.51	3.94	4.01	4.22	4.69
GBR	6.81	1.15	2.36	2.77	2.53	0.75	1.91
GEO	13.50	8.87	5.49	4.21	.	4.72	5.82
GTM	5.04	4.53	3.59	3.52	.	3.63	3.82
GUY	3.70	4.31	3.28	3.43	.	.	3.67
HKG	-0.34	-0.41	2.16	2.53	3.35	-0.47	1.43
HND	3.38	5.37	3.67	3.62	.	2.17	3.71
HRV	13.70	2.60	2.91	3.11	2.89	1.28	2.56
HUN	22.98	6.01	3.50	3.68	2.34	5.63	4.23
IDN	12.83	6.96	4.20	3.90	5.21	8.01	5.66
IND	6.40	5.09	2.95	3.47	4.52	6.71	4.55
ISL	20.92	7.22	3.16	3.83	.	.	4.74
ISR	9.02	2.10	3.07	2.99	3.46	1.05	2.53
JAM	2.58	8.90	5.15	4.20	.	.	6.08
JOR	1.66	1.63	2.25	2.84	.	.	2.24
JPN	6.17	-1.66	1.52	2.20	3.17	-1.50	0.75
KAZ	6.16	4.19	3.31	3.33	4.09	5.51	4.09
KOR	13.16	1.76	2.33	2.85	2.52	6.24	3.14
KWT	1.50	0.34	2.32	2.65	.	.	1.77
LBN	1.92	1.88	2.80	2.94	.	.	2.54
LKA	8.31	10.24	4.09	4.43	5.18	6.13	6.02
LTU	11.48	0.63	2.42	2.73	2.72	-0.27	1.65
MAR	8.67	1.05	2.27	2.74	.	.	2.02
MDA	14.16	9.17	4.42	4.41	5.35	4.68	5.61
MDG	18.39	10.08	3.78	4.35	.	.	6.07
MEX	7.79	4.97	3.96	3.68	3.22	3.40	3.85
MOZ	14.36	10.17	4.56	4.35	.	.	6.36
MUS	7.32	2.24	2.74	3.01	.	.	2.66
MYS	4.25	1.10	2.05	2.70	3.02	3.60	2.49
NOR	14.06	1.36	2.61	2.82	3.72	3.00	2.70
NPL	3.11	1.89	2.17	2.82	.	.	2.29
NZL	22.02	3.34	2.47	3.10	3.23	0.36	2.50
OMN	-0.40	-0.40	2.16	2.54	.	.	1.43
PAK	2.92	7.15	2.70	3.78	4.41	1.59	3.92
PER	5.42	1.76	2.99	3.04	4.19	1.21	2.64
PHL	6.95	3.15	3.24	3.22	3.99	3.74	3.47
POL	19.33	3.18	3.77	3.35	3.36	5.46	3.82
PRY	14.10	4.94	3.93	3.47	4.30	-2.33	2.86
QAT	-0.29	-0.30	2.14	2.59	.	.	1.47
ROU	19.90	9.93	9.27	5.33	4.42	7.28	7.24
RUS	9.94	5.03	4.37	3.71	4.67	5.82	4.72
RWA	4.02	6.85	3.21	3.70	.	.	4.59
SAU	0.23	0.22	2.24	2.64	3.94	0.21	1.85
SGP	4.31	-0.82	1.81	2.39	2.54	1.54	1.49
SUR	7.71	9.76	4.46	4.36	.	.	6.19
SWE	14.26	0.50	2.16	2.61	2.78	3.75	2.36
THA	5.68	0.76	2.20	2.72	3.36	2.48	2.30
TUN	5.57	2.96	2.54	3.05	.	.	2.85
TUR	30.04	19.21	12.38	6.73	4.87	9.04	10.45
UKR	10.22	9.73	6.23	4.83	5.42	6.87	6.62
URY	18.57	16.74	7.15	4.40	4.46	8.59	8.27
VNM	4.06	6.65	2.76	3.64	4.54	4.02	4.32
ZAF	27.65	6.84	3.59	3.74	4.25	2.58	4.20

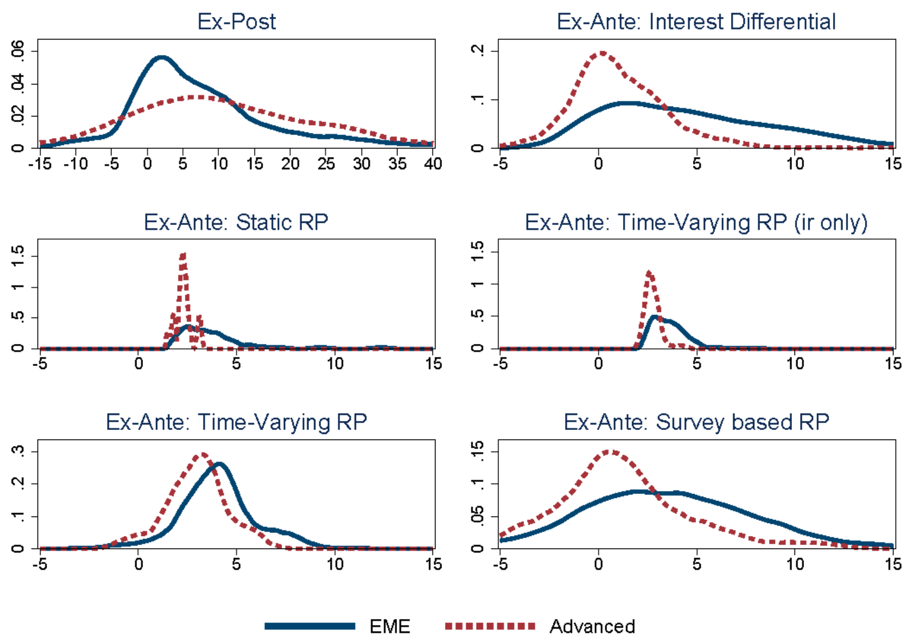
Source: authors' estimations. 1/ Averages for the period 2002-13.

Table A6. Total Cost of FXI, by country, 2002-13 1/

	Ex-Post	Ex-Ante					
		Interest Differential	Static RP	Time-Varying RP (ir only)	Time-Varying RP	Survey based RP	Ex-Ante Average
ALB	1.08	0.66	0.64	0.61	.	0.64	0.64
ARE	0.05	0.05	0.29	0.35	.	.	0.23
ARG	0.04	0.75	0.67	0.54	0.57	-0.01	0.50
ARM	0.79	0.49	0.51	0.42	.	1.04	0.62
AUS	0.47	0.14	0.11	0.14	0.13	0.08	0.12
BGR	0.99	0.31	0.71	0.89	0.82	-0.05	0.54
BHR	0.05	0.05	0.40	0.49	.	.	0.31
BLZ	1.14	1.14	0.40	0.48	.	.	0.68
BOL	0.97	0.55	1.10	1.10	1.24	-0.07	0.78
BRA	0.83	0.98	0.58	0.51	0.51	0.76	0.67
CAN	0.01	0.00	0.00	0.00	0.00	0.00	0.00
CHE	1.14	-0.23	0.62	0.80	0.93	-0.85	0.25
CHL	0.71	0.28	0.36	0.40	0.44	0.06	0.31
CHN	1.84	0.61	0.97	1.23	1.75	2.13	1.34
COL	0.61	0.43	0.35	0.35	0.42	0.05	0.32
CRI	0.69	0.97	0.58	0.54	.	0.33	0.60
CZE	1.45	0.02	0.48	0.54	0.58	0.30	0.38
DNK	0.51	0.05	0.38	0.46	0.42	-0.04	0.26
DOM	0.03	0.12	0.13	0.11	0.08	0.04	0.10
DZA	0.24	0.51	2.04	2.13	.	.	1.56
EGY	0.51	0.68	0.38	0.42	0.46	0.42	0.47
GBR	0.05	-0.00	-0.01	-0.01	-0.01	0.00	-0.01
GEO	0.25	0.17	0.41	0.32	.	0.49	0.35
GTM	0.52	0.53	0.45	0.44	.	0.44	0.47
GUY	0.54	0.61	0.46	0.49	.	.	0.52
HKG	-0.26	-0.29	1.87	2.18	2.90	-0.35	1.26
HND	0.57	0.93	0.71	0.69	.	0.33	0.67
HRV	1.32	0.54	0.65	0.69	0.59	0.21	0.54
HUN	1.19	1.13	0.74	0.78	0.42	1.04	0.82
IDN	0.67	0.74	0.47	0.43	0.56	0.85	0.61
IND	0.34	0.85	0.53	0.63	0.78	1.14	0.79
ISL	0.06	0.92	0.50	0.59	.	.	0.67
ISR	0.80	0.42	0.62	0.60	0.71	0.16	0.50
JAM	0.27	1.19	0.71	0.59	.	.	0.83
JOR	0.71	0.71	1.04	1.30	.	.	1.01
JPN	0.00	-0.02	0.01	0.02	0.03	-0.02	0.01
KAZ	1.08	0.86	0.78	0.79	1.02	1.19	0.93
KOR	0.75	0.38	0.56	0.68	0.51	1.33	0.69
KWT	0.22	0.06	0.33	0.37	.	.	0.25
LBN	1.34	1.38	2.15	2.27	.	.	1.93
LKA	0.43	0.55	0.23	0.25	0.26	0.30	0.32
LTU	0.60	0.10	0.39	0.44	0.40	-0.08	0.25
MAR	0.92	0.20	0.58	0.69	.	.	0.49
MDA	1.65	1.67	0.88	0.88	1.04	1.14	1.12
MDG	0.57	0.66	0.28	0.32	.	.	0.42
MEX	0.20	0.44	0.38	0.35	0.30	0.34	0.36
MOZ	0.92	1.27	0.76	0.72	.	.	0.92
MUS	0.52	0.50	0.64	0.70	.	.	0.61
MYS	0.91	0.39	0.88	1.15	1.26	1.45	1.03
NOR	0.92	0.15	0.39	0.42	0.49	0.46	0.38
NPL	-0.20	0.33	0.43	0.55	.	.	0.44
NZL	1.03	0.33	0.25	0.32	0.24	-0.09	0.21
OMN	-0.07	-0.07	0.40	0.46	.	.	0.26
PAK	0.06	0.27	0.14	0.19	0.22	0.00	0.16
PER	0.83	0.47	0.72	0.73	1.02	0.39	0.67
PHL	0.97	0.56	0.74	0.71	0.87	0.80	0.74
POL	0.90	0.51	0.60	0.53	0.47	0.87	0.60
PRY	1.00	0.66	0.67	0.60	0.71	-0.45	0.44
QAT	-0.04	-0.04	0.28	0.29	.	.	0.18
ROU	1.02	1.15	1.31	0.77	0.60	0.90	0.94
RUS	0.71	1.13	1.22	1.04	1.22	1.56	1.23
RWA	0.28	0.45	0.31	0.35	.	.	0.37
SAU	0.13	0.13	1.58	1.84	2.89	0.14	1.31
SGP	2.14	-0.77	1.68	2.22	2.29	1.43	1.37
SUR	0.68	1.05	0.58	0.55	.	.	0.73
SWE	0.30	0.04	0.16	0.19	0.15	0.23	0.16
THA	1.31	0.39	0.88	1.09	1.31	1.08	0.95
TUN	0.19	0.44	0.43	0.51	.	.	0.46
TUR	-0.02	0.36	0.87	0.46	0.31	0.38	0.48
UKR	0.38	1.25	1.02	0.78	0.78	1.00	0.97
URY	0.74	0.83	1.24	0.80	0.84	0.20	0.78
VNM	0.50	1.01	0.48	0.63	0.78	0.65	0.71
ZAF	0.32	0.54	0.35	0.37	0.40	0.28	0.39

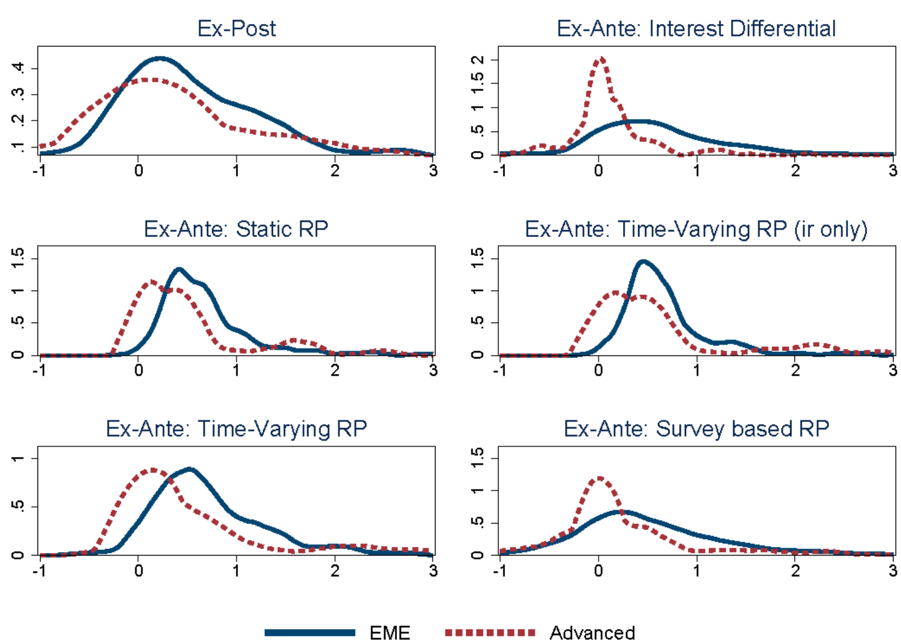
Source: authors' estimations. 1/ Averages for the period 2002-13.

Appendix Figure A1. FXI Marginal Cost in EMEs and AMEs, 2002-13
(percentage points, distribution based on annual averages)



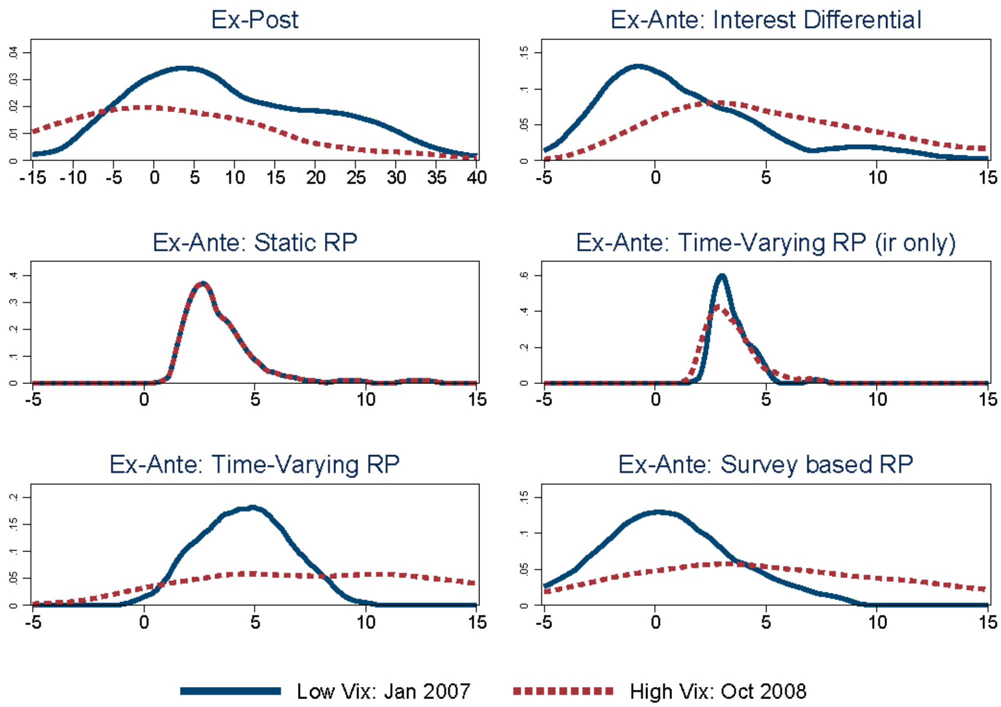
Sources: IMF International Financial Statistics; and authors' calculations.

Appendix Figure A2. FXI Total Cost in EMEs and AMEs, 2002-13
(percentage points, distribution based on annual averages)



Sources: IMF International Financial Statistics; and authors' calculations.

Appendix Figure A3. Global Risk Appetite and Marginal Cost of FXI
(percentage points, average for the period)



Sources: IMF International Financial Statistics; and authors' calculations.

Annex 1

In this annex, we formally derive the measure of marginal cost of FXI, and discuss the relevance (or lack) of the valuation and risk premium effect of FXI.

Consider the central bank balance sheet:

$$S_t NFA_t + NDA_t = M_t + K_t \tag{16}$$

where $S_t NFA_t$ denotes the net foreign asset position expressed in local currency (S_t being the exchange rate vis-a-vis the U.S. dollar); NDA_t stands for the net domestic asset position; M_t is the monetary base; and K_t is the net worth or capital.

The inter-temporal budget constraint is given by:

$$S_t NFA_t + NDA_t - M_t = (1+i_t^*) S_t NFA_{t-1} + (1+i_t) NDA_{t-1} - M_t - \Omega_t^G \tag{17}$$

where i_t^* and i_t denote the interest (return) on foreign and domestic assets respectively; and Ω_t^G stands for transfers to the central government. We assume, for simplicity, that foreign assets and liabilities are denominated in foreign currency; while domestic assets and liabilities are denominated in local currency. Thus, we refer to net foreign assets and net foreign exchange positions indistinctly. From equations (16) and (17) follows that the law of motion of central bank capital is:

$$K_{t+1} = (1+i_t) K_t - S_t NFA_t mc_t + i_t M_t - \Omega_{t+1}^G \tag{18}$$

where mc_t denotes the marginal cost of rolling over the foreign exchange position: given by:

$$mc_t = (1+i_t^*) \frac{S_{t+1}}{S_t} - (1+i_t) \tag{19}$$

The value of the central bank can be defined as the present discounted value of all transfers: $EPV_t \equiv E_t \sum_{j=1}^{\infty} (1+i_t)^{-j} \Omega_{t+j}^G$. Thus, at any point in time t:

$$EPV_t = K_t + E_t \left\{ \sum_{j=1}^{\infty} (1+i_t)^{-j} \left[i_{t+j-1} M_{t+j-1} - S_{t+j-1} NFA_{t+j-1} mc_t \right] \right\} \tag{20}$$

FX intervention

Define sterilized FXI ($dFXI_t$) as an operations that satisfies:

$$dFXI_t = S_t dNFA_t \tag{21}$$

$$\begin{aligned} & S_t dNFA_t + dNDA_t = 0 \\ & dM_t = 0 \end{aligned} \tag{22}$$

Differentiating equations (20) and (16); and combining them with (21) yields:

$$\frac{dEPV_t}{dFXI_t} = \frac{dS_t}{dFXI_t} NFA_t - \sum_{j=1}^{\infty}(1+i_t)^{-j} E_t\left\{mc_{t+j-1}\right\} + \sum_{j=1}^{\infty}(1+i_t)^{-j} E_t\left\{NFA_{t+j-1}\frac{dmc_{t+j-1}}{dFXI_t}\right\} \quad (23)$$

where the first term on the right-hand side reflects the valuation gain on impact associated with the impact of FXI on the exchange rate, arising from the net FX position ($\frac{dK_t}{dFXI_t} = \frac{dS_t}{dFXI_t} NFA_t$), the second term reflects the expected present value of the cost of increasing the NFA position (given the ex-ante marginal cost); and the third term reflects the impact of FXI on the net present value of the cost of rolling over the FX position due to increase in the risk premium:

$$\frac{dmc_{t+j-1}}{dFXI_t} = -\left[(1+i^*_{t+j-1})\frac{dS_{t+j}}{dFXI_t} - (1+i_{t+j-1})\frac{dS_{t+j-1}}{dFXI_t}\right] \quad (24)$$

Consider a general case of FXI depreciating the exchange rate on impact by an amount $\phi$and following an AR(1) path with coefficient ρ . The effect of FXI on the exchange rate is thus given by:

$$\frac{dS_{t+j}}{dFXI^S_t} = \begin{cases} \phi & if \quad j=0 \\ \rho^j\phi & if \quad j\neq 0 \end{cases} \quad (25)$$

Assuming for simplicity that policy rates are constant over time (i.e., $i^*_t = i^*$ and $i_t = i$). Combining equations (23), (24) and (25) yields:

$$\frac{dPV_t}{dFXI^S_t} = NFA_t\left[\phi - \phi\left(\frac{1+i}{1+i-\rho}\right)\left(1-\frac{(1+i^*)\rho}{(1+i\ )}\right)\right] - E_t\left\{mc_t\right\}\frac{1}{i} \quad (26)$$

Without loss of generality, assume that $i^* = 0$. It follows that the first term in equation (26) collapses to zero, and so the full expression becomes:

$$\frac{dEPV_t}{dFXI^S_t} = -E_t\left\{mc_t\right\}\frac{1}{i} \quad (27)$$

This indicates that the expected cost of FXI in terms of the impact of the net present value of the central bank is simply given by the net present value of the ex-ante marginal cost. The corresponding 1-period cost if thus given by $E_t\left\{mc_t\right\}$. This result arises from the fact that the valuation gain on impact and the raise of the risk premium due to FXI offset each other, as the increase in risk premium reflects the expected appreciation of the currency, following the depreciation on impact. The present value of the former cost equals the valuation gain at time t.