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Can Foreign Exchange Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks?

by Olivier Blanchard, Gustavo Adler and Irineu de Carvalho Filho

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I N T E R N A T I O N A L M O N E T A R Y F U N D

IMF Working Paper

Research Department

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Authorized for distribution by Olivier Blanchard

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Abstract

Many emerging market economies have relied on foreign exchange intervention (FXI) in response to gross capital inflows. In this paper, we study whether FXI has been an effective tool to dampen the effects of these inflows on the exchange rate. To deal with endogeneity issues, we look at the response of different countries to plausibly exogenous gross inflows, and explore the cross country variation of FXI and exchange rate responses. Consistent with the portfolio balance channel, we find that larger FXI leads to less exchange rate appreciation in response to gross inflows.

JEL Classification Numbers: E42, E58, F31, F40

Keywords: foreign exchange intervention, exchange rate, capital flows, gross capital flows

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I. INTRODUCTION¹

Large capital flows have dominated the emerging market landscape in recent years, posing sizeable challenges to policy makers as they have tried to cope with the collateral effects of these flows, from asset price inflation, to credit booms, to overheating, to real exchange rate appreciation, and to the buildup of financial vulnerabilities. To lean against capital inflows, policymakers have increasingly relied on macro- and micro-prudential measures, regulation/deregulation of capital flows and foreign exchange market intervention (FXI). However, the effects of many of these policies—let alone their desirability—remain under debate, especially with regard to FXI. This is the focus of our paper.

Two motives have been offered to explain the use of FXI in response to capital inflows and the resulting increase in reserves. The first is a precautionary motive: Emerging market economies built up their cushions of foreign exchange needed in case of liquidity shortages (Aizenman and Lee, 2008; Jeanne and Ranciere, 2011; Ghosh, Ostry and Tsangarides, 2012). The second is a macro-management motive: FXI was deployed to moderate or avoid nominal or real appreciation pressures (e.g. Reinhart and Reinhart, 2008; Aizenman and Lee, 2008; Adler and Tovar, 2014; Gagnon, 2012).²

There is little controversy about the merits of FXI for precautionary motives (although there is still much debate about the optimal level of reserve buffers). On the contrary, whether FXI is effective in stemming exchange rate pressures remains an open question and an empirical challenge (under the precautionary motive, it does not matter whether FXI affects the exchange rate or not).

Most economists agree that unsterilized intervention is effective at influencing the exchange rate (as it entails a change in the monetary policy stance), but the case for effectiveness of sterilized intervention is less obvious on both theoretical and empirical grounds. In theory, sterilized intervention can affect the exchange rate through a signaling channel (FXI informs about the central bank's monetary policy intentions) or a portfolio balance channel (which operates under imperfect substitutability between domestic and foreign assets). While relevant as a mechanism to affect the exchange rate, the signaling channel has received relatively limited attention as it implies that FXI is not an extra policy instrument but, rather, a way to signal intentions regarding other existing policy tools. The portfolio balance channel, on the other hand, has received more attention since the theoretical underpinnings were developed by Henderson and Rogoff (1982), Kouri (1983), and Branson and Henderson (1985).³

¹ This work has benefited at different stages from comments and valuable conversations with Ahuja Ashvin, Tam Bayoumi, Jorge Braga de Macedo, Marcos Chamon, Varapat Chensavadijai, Luca Dedola, José De Gregorio, Sebastian Edwards, Jeff Frankel, Rex Ghosh, Roberto Guimarães, Olivier Jeanne, Sebnem Kalemli-Ozcan, Martin Kaufman, Ruy Lama, Márcio Laurini, Nan Li, Kenji Moriyama, Christopher Neely, Jonathan Ostry, Steven Phillips, Helene Poirson, Ubirajara da Silva and Yossi Yakhin; as well as feedback from participants at various IMF seminars, the 2014 SNB Conference on “Exchange Rates and External Adjustment”, the EMG-ECB 4th Emerging Markets Group Conference, the LACEA 2014 Annual Conference, and the 2015 NBER Summer Institute. We also thank Jair Rodriguez and Mauricio Vargas for their research assistance. Irineu de Carvalho Filho benefited from the hospitality of the Swiss National Bank and Georgetown University School of Foreign Service in Qatar. Remaining errors are ours.

² The specific reasons for intervening in foreign exchange markets have been the subject of several studies (e.g. Canales-Kriljenko, 2003; Moreno, 2005; Neely, 2008), and include influencing the level of the exchange rate, dampening exchange rate volatility, preventing excessive exchange rate movements or overshooting, supplying liquidity during periods of market disruption (Stone, Walker and Yasui, 2009), and leaning against the wind.

³ See Kumhof (2010) and Gabaix and Maggiori (2014) for recent advances in the theory of the portfolio balance channel.

From an empirical perspective, estimating the effect of (sterilized) intervention on the exchange rate has been a major methodological challenge for the literature, as the decision to intervene is often driven by contemporaneous exchange rate developments, and is thus endogenous. See, for example, the extensive work on FXI in advanced economies by Dominguez (1990 and 1998); Dominguez and Frankel (1990, 1993a, 1993b and 1993c), and Ghosh (1992); and more recently on emerging market economies by Tapia and Tokman, 2004; Guimarães and Karacadağ, 2004; Domaç and Mendoza, 2004; Humala and Rodriguez, 2010; Kamil, 2008; Rincón and Toro, 2011; Dominguez, Fatum and Vacek, 2013). Unaddressed, the endogeneity bias tends to conceal the effect of FXI on the exchange rate. Thus, it is not surprising that the evidence about the effect of FXI on the exchange rate remains mixed. Most of the literature has attempted either an instrumental variable approach (seeking exogenous variations of FXI) or relied on high frequency (including minute-by-minute) time-stamped data. In the first case, finding proper instruments has been a major challenge. In the second case, using data that is sampled at a higher frequency than the decision to intervene has allowed researchers to break the reverse causality, and find evidence that intervention does influence the level of exchange rates. However, high-frequency estimates are not informative about the persistent and cumulative effects of intervention, which are of paramount importance for the macroeconomist and the policy maker.

Our paper takes a different approach. Relying on country-specific VAR estimations, our empirical strategy relies on the exogenous nature of global capital flows from the point of view of each small open economy, and exploits the cross-section variation of FXI responses to these exogenous shocks. The evidence suggests that FXI is effective in stemming appreciation pressures arising from global flow shocks. The effect is of economically meaningful magnitude, indicating that—while its relative merits are yet to be assessed—FXI can be a valid policy tool for macroeconomic management.

The paper relates to several strands of research:

It relates, of course, to the growing literature on the role and effects of sterilized FXI in emerging countries, which has taken theoretical, empirical and policy angles. See, for example, the comprehensive reviews of the literature on FXI in Sarno and Taylor (2001), Neely (2005) and Menkhoff (2010 and 2012) and the recent contributions by Benes, Berg, Portillo and Vavra (2012), Ghosh, Ostry and Chamon (2015), Gagnon (2013), and Bayoumi, Gagnon and Saborowski (2014). It relates also to the empirical literature on the effect of global financial conditions on emerging market economies, dating back to Calvo, Leiderman and Reinhart (1993), who study the role of push factors in driving inflows to Latin American countries; Hau, Massa and Peress (2009), who show how exogenous portfolio equity inflows cause exchange rate appreciation in the receiving countries; and Rey (2013), who argues that global financial conditions are transmitted to financially integrated economies irrespective of their exchange rate regime (thus reducing monetary policy independence unless the capital account is managed). A common thread in this literature is that global financial conditions can have pervasive effects on emerging market economies, including through the impact on exchange rates. If effective, sterilized intervention becomes a key policy instrument for managing capital flows.

The rest of the paper is organized as follows: Section II presents a simple model with imperfect asset substitutability to discuss the theoretical underpinnings of the following empirical exercise. Section III explains the empirical strategy, along with the main results and a number of robustness checks. Section IV concludes.

II. A LINEAR MODEL OF THE PORTFOLIO BALANCE CHANNEL

It is useful to start by presenting a simple model with imperfect substitutability between domestic and external assets, which illustrates the workings of foreign exchange intervention—through a portfolio balance channel—in the context of (exogenous) capital inflow shocks. The predictions of this simple model can then be used to interpret the empirical evidence in section III.

We follow the terminology used in recent papers, calling *gross inflows* the net movement in international liabilities of a country, and *gross outflows* the net movement in international assets (note that both “gross inflows” and “gross outflows” can be negative). We interpret gross inflows as reflecting primarily the decisions of foreign investors to change their holdings of domestic assets; and gross outflows as reflecting mainly the decisions of domestic investors to change their holdings of foreign assets.⁴

Let *GPKI* denote gross (private) inflows and *GPKO* denote gross (private) outflows. Let *FXI* be foreign exchange intervention (defined as reserve *sales*), and *CA* the current account balance. The balance of payment identity implies that:

$$GPKI_{j,t} - GPKO_{j,t} + FXI_{j,t} + CA_{j,t} = 0 \quad (1)$$

Assume the following linear functional forms for *GPKI* and *GPKO* respectively, allowing for a departure from uncovered interest rate parity (UIP):

$$GPKI_{j,t} = \alpha(i_{j,t} - i_t^* - e_{j,t} + Ee_{j,t+1}) + z_t \quad (2)$$

$$GPKO_{j,t} = -\beta(i_{j,t} - i_t^* - e_{j,t} + Ee_{j,t+1}) - \rho z_t \quad (3)$$

where $i_{j,t}$ is the domestic interest rate, i_t^* is the interest rate on foreign assets, $e_{j,t}$ is the exchange rate (an increase being an appreciation), and z_t stands for the set of exogenous variables driving global capital flows (e.g., risk appetite). Assume the current account is also a simple linear function of the exchange rate $CA_{j,t} = -\gamma e_{j,t}$ (with $\gamma \geq 0$).⁵

The parameters α and β reflect the sensitivity of gross inflows and outflows to rate of return differentials. The parameter ρ reflects how reactive domestic investors are to global financial shocks (relative to foreign investors, whose sensitivity is normalized to one). As a full-fledged portfolio model would predict, and consistent with the empirical evidence, α and β are expected to be positive, indicating that gross flows move in the same direction when arbitraging deviations from UIP, although possibly with different sensitivities. Theory does not deliver a prior on the sign of ρ . If we think of z_t as reflecting primarily movements in risk appetite, the sign depends on whether lower

⁴ For more on the nature of these gross flows, see for example, Powell et al. (2002), Cowan et al (2008), Rothenberg and Warnock (2011), Forbes and Warnock (2012), Bruno and Shin (2012), Calderón and Kubota (2013), Bluedorn et al (2013), Cavallo et al (2013), Broner et al (2013), and Alberola et al (2013).

⁵ Since we are interested in the short-term impact of capital inflows, our simplified model does not consider the cumulative effect of the current account on the net international investment position. Those considerations would be warranted if we were to focus on medium-term effects.

risk appetite leads domestic investors to move in the same direction as foreign investors, in which case ρ is positive and gross outflows amplify the behavior of gross inflows, or if it leads instead domestic and foreign investors to move in opposite directions, both to ‘return home’, in which case ρ is negative, and gross outflows partly offset the effects of gross inflows. The evidence below, together with other recent empirical evidence, suggests that the second case is the relevant one (that is, for most countries, higher market risk aversion reinforces home bias and leads both foreign and domestic investors to repatriate assets in their own country).⁶

We capture the two key dimensions of the central bank response to flows through the following two equations:

$$i_{j,t} - i_t^* = -de_{j,t} \quad (4)$$

$$FXI_{j,t} = -(1 + \rho)\phi z_t \quad (5)$$

We assume that the domestic interest rate, $i_{j,t}$, responds to the exchange rate, $e_{j,t}$, and that the parameter d can be positive or negative. We model FXI as an offset (proportion ϕ) to the exogenous component of net private capital flows, $(1 + \rho)z_t$.

Finally, we assume global capital flow shocks, z_t , follow an $AR(1)$ process with coefficient ψ .

Then, combining equations (1)-(5) yields the equilibrium conditions:⁷

$$e_{j,t} = \frac{(1 + \rho)(1 - \phi)}{(\alpha + \beta)(1 + d - \psi) + \gamma} z_t \quad (6)$$

$$GPKI_{j,t} = \left[1 - \frac{\alpha(1 + \rho)(1 - \phi)(1 + d - \psi)}{(\alpha + \beta)(1 + d - \psi) + \gamma} \right] z_t \quad (7)$$

$$GPKO_{j,t} = \left[\frac{\beta(1 + \rho)(1 - \phi)(1 + d - \psi)}{(\alpha + \beta)(1 + d - \psi) + \gamma} - \rho \right] z_t \quad (8)$$

$$FXI_{j,t} = -(1 + \rho)\phi z_t \quad (9)$$

Assume $\gamma \leq \bar{\gamma}$, with $\underline{\gamma} \equiv -(1 + d - \psi) \left[(\alpha + \beta) - \beta \frac{(1 + \rho)(1 - \phi)}{\rho} \right]$. That is, the current account

exchange rate elasticity is sufficiently low. It follows, from equation (6), that the domestic currency appreciates in response to a positive gross inflow shock. The central bank can dampen the effect of the shock on the exchange rate in two ways: by decreasing the interest rate (d positive), or by using FXI (ϕ positive).

⁶ See, for example, Adler et al (2015).

⁷ Note that the persistence of the capital flow shock (ψ) affects the contemporaneous response of the exchange rate to z (i.e., the higher is the expected persistence of the capital flow shock, the more the domestic currency appreciates) but not the response of the gross flows.

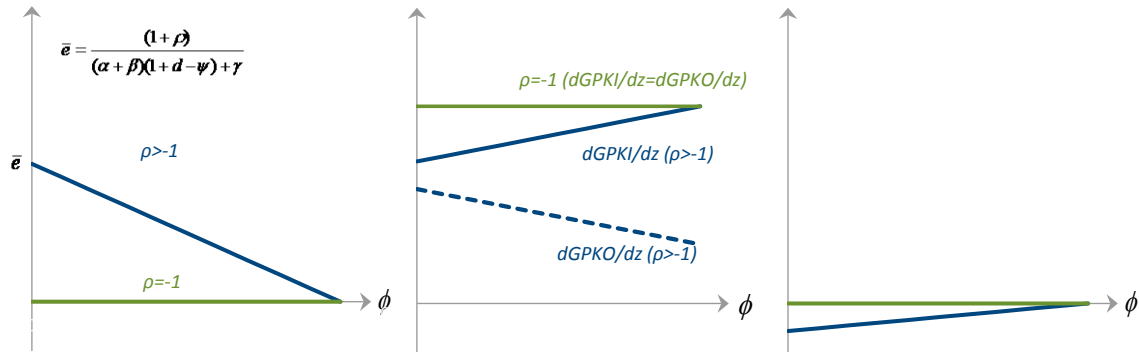
The effect of FXI

Figure 1 presents comparative statics on the effects of the shock z_t on the exchange rate and gross flows, with respect to the degree of FXI (ϕ); focusing on the case of imperfect asset substitutability (i.e., α and β take finite values).⁸

The left panel shows the effect of intervention on the exchange rate. Intervention dampens the effect of the external shock on the exchange rate, so long as private domestic investors do not fully play that offsetting role themselves (i.e., $\rho > -1$). In the limiting case of $\rho = -1$, where domestic investors mirror perfectly the foreigners' reaction to the global shocks, intervention is unnecessary.

The middle panel shows the effect of intervention on gross inflows and outflows. Gross inflows increase and gross outflows decrease with the degree of intervention (and the vertical distance between the two lines gives the extent of intervention). This is because the higher the degree of intervention, the lower the initial appreciation and so the lower the expected depreciation later on. As a result, the more attractive it is for foreign investors to buy domestic assets, and for domestic investors to stay home. In the case of no intervention, the exchange rate moves to induce gross outflows and the current account to offset the response of gross inflows. In the case of full intervention, the exchange rate does not change, and gross inflows and outflows are thus equal to z and $-\rho z$ respectively, with intervention equal to net private inflows $(1 + \rho)z$.

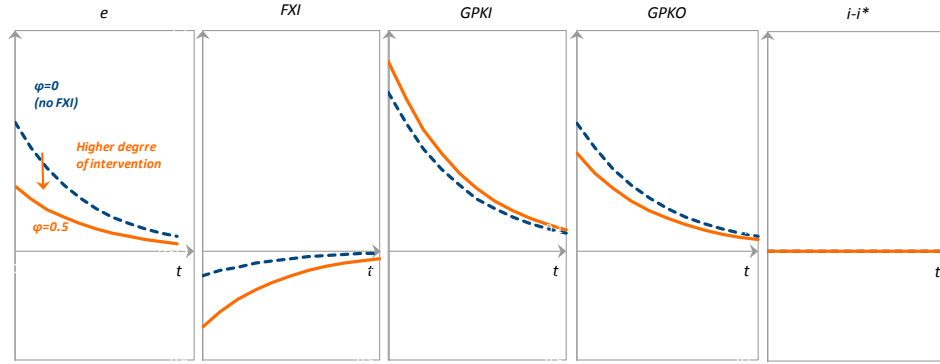
Figure 1. Portfolio Balance Channel—Effect of FXI



Note: comparative statics with parameterization: $\alpha = \beta = 0.5$, $\psi = 0.2$, $\gamma = 0.2$, and $d = 0$, unless indicated otherwise.

With the empirical results below in mind, Figure 2 presents the dynamic responses to a shock to z_t derived from the model, comparing the case of no intervention ($\phi = 0$) and relatively heavy intervention ($\phi = .5$), serving as a benchmark illustration to compare to our empirical findings. For a given value of $\rho > -1$, a higher degree of intervention dampens the impact of the shock on the exchange rate, while inducing a gap between gross inflows and gross outflows, increasing the former and reducing the later. The effects fade away as the external shock z_t does. In this example (consistent with our later empirical findings) interest rates do not respond to the shock, and so the differential impact on the exchange rate can be fully attributed to FXI through a portfolio balance channel.

⁸ The case of perfect substitution between domestic and foreign assets corresponds to the limit case of $\alpha \rightarrow \infty$ and/or $\beta \rightarrow \infty$; and it is straightforward to show that $\lim_{\alpha \rightarrow \infty} de/dz = \lim_{\beta \rightarrow \infty} de/dz = 0$.

Figure 2. Portfolio Balance Channel—Dynamic Responses

Note: comparative statics with parameterization: $\alpha = \beta = 0.5$, $\psi = 0.2$, $\gamma = 0.2$, $\rho = -0.3$ and $d = 0$, unless indicated otherwise.

This simple model illustrates the workings of the portfolio balance channel, pointing to some testable predictions: (i) a positive exogenous global financial (risk appetite) shock leads to an appreciation of the domestic currency; (ii) gross capital inflows increase and so, if ρ is negative, do gross outflows; (iii) FX intervention mitigates the effect of the shock on the exchange rate; and (iii) larger interventions are accompanied by larger gross inflows and/or smaller gross outflows.

Next we contrast these predictions with our empirical findings.

III. EMPIRICAL EVIDENCE

A. Methodological Approach

Our empirical approach relies on the largely exogenous character of global capital flows from the point of view of any one of the small emerging and advanced open economies.⁹ Under the assumption that global capital flows are indeed exogenous to each country, we then estimate the response of FXI, gross inflows, gross outflows, the interest rate and the exchange rate to these flows, on a country by country basis. We can then classify countries into groups based on their de facto FXI reaction function and explore the cross-sectional dimension by comparing differences across country groups.

Specifically, to identify the effect of sterilized intervention on exchange rates, we estimate country-specific VARs linking the key variables identified in the previous section. The specification for each country takes the following functional form:

$$(I - A_1 L - \dots - A_p L^p) Y_{j,t} = \varepsilon_{j,t} \quad (10)$$

where L^p denotes a lag operator of order p , $A_1 \dots A_p$ are 6×6 parameter matrices, and $Y_{j,t}$ is the vector of endogenous variables defined as:

⁹ The existence of global financial flows, sometimes referred to as a “global financial cycle”, has been previously documented in the literature (e.g. Calvo, Leiderman and Reinhart, 1993) and has been used as a working assumption in a variety of studies (e.g. Agénor, Alper and Pereira da Silva, 2012; De Bock and de Carvalho Filho, 2015; de Carvalho Filho, 2014; Rey, 2013).

$$Y_{j,t} \equiv \begin{bmatrix} ER_{j,t} \\ FXI_{j,t} \\ GPKI_{j,t} \\ GPKO_{j,t} \\ INT_{j,t} \\ GKF_{j,t} \end{bmatrix} \quad (11)$$

where $ER_{j,t}$ denotes the log of the nominal exchange rate vis-a-vis the U.S. in the benchmark specification (although we also explore a model with the real exchange rate as an extension later); $FXI_{j,t}$ refers to FX intervention, measured as net reserve sales (so reserve accumulation appears as a decrease in FXI, following the balance of payments definition) plus changes in the central bank off balance sheet FX position. This broad measure of FXI allows us to capture the increasing use of non-spot interventions seen in recent years; ^{10,11} $GPKI_{j,t}$ and $GPKO_{j,t}$ denote country j 's gross private capital inflows and outflows, respectively. All flow variables are normalized by lagged gross domestic product in U.S. dollars for comparability (using lagged rather than actual GDP to deal with the potential endogeneity of actual GDP) and are reported as annualized flows. $INT_{j,t} = i_{j,t} - i_t^*$ is the short-term interest rate differential with respect the U.S.¹² By including the interest rate differential, we control for the effect of contemporaneous changes in the monetary policy stance (unsterilized FXI).

Finally, $GKF_{j,t}$ denotes our exogenous measure of aggregate (global) gross capital flows for country j . For each country j , the measure is constructed as the sum of gross private capital inflows to all non-

¹⁰ Off balance sheet items are composed of short and long positions in forwards and futures in foreign currencies vis-à-vis the domestic currency (including the forward leg of currency swaps), and financial instruments denominated in foreign currency but settled by other means (e.g., in domestic currency), as reported in the International Reserves and Foreign Currency Liquidity Template. Coverage of off balance sheet positions varies across countries, but is sufficiently comprehensive to capture large derivate transactions of recent years. Still, we conduct robustness checks on the proxy of FXI in Section III.C.

¹¹ In the system of balance of payments accounts, a gross inflow, namely the purchase of a domestic asset by a non-resident, may ultimately generate four different outcomes (or combinations thereof): (a) if the resident seller of the domestic asset - she - holds to the foreign currency proceeds of the asset sale or swaps it for a foreign asset, there is an equivalent 'gross outflow'; (b) if she sells the foreign currency proceeds to another resident who uses it to buy foreign assets, there is also an equivalent 'gross outflow'; (c) if she uses those proceeds to consume, or sells the foreign currency to another resident who buys foreign goods, there is an ultimate impact on the current account balance; and (d) if she sells the foreign currency, directly or indirectly, to the central bank, there is a negative net reserve sale or 'reserve accumulation'.

¹² For most countries, the short-term interest rate is the policy rate from *Global Data Source* (GDS), but as dictated by data availability, we used for a few countries the lending rate from *International Financial Statistics* (Bolivia, Croatia, Guatemala, Sri Lanka, Indonesia, Mexico, Malaysia and Romania).

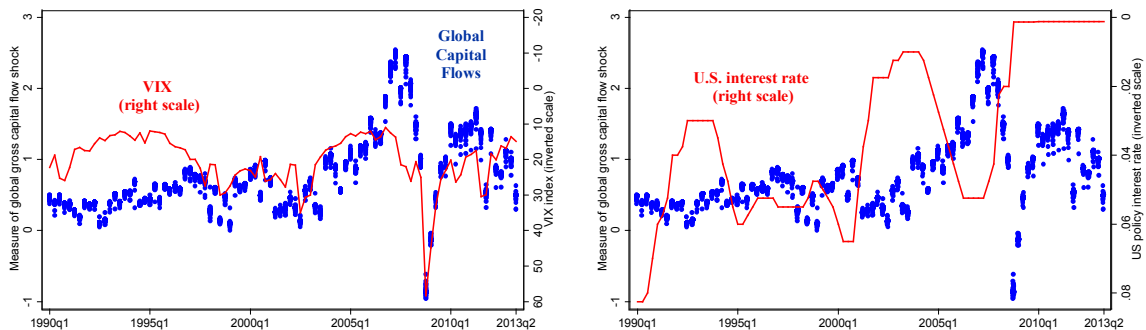
reserve currency countries in our sample leaving out country j , divided by the sum of corresponding nominal GDPs in U.S. dollars.¹³

Data on gross private capital flows come from the Financial Flows Analytics database compiled by the IMF Research department. Gross private capital flows are constructed by adding FDI in the reporting economy and the private elements of portfolio investment, financial derivative transactions and other investment gross flows from the perspective of the originator of the funds. Algebraically, our measure of global capital flows is given by:

$$GKF_{jt} = \frac{\sum_{i \in \Theta \setminus j} GPKI_{it}}{\sum_{i \in \Theta \setminus j} GDP_{i,t-1}^{USD}} \quad (12)$$

where Θ denotes the set of all non-reserve currency countries for which balance of payments and GDP data is available on a quarterly basis (and $\Theta \setminus j$ denotes the set excluding country j); $GDP_{i,t-1}^{USD}$ is gross domestic product measured in U.S. dollars from the IMF's WEO database; and $GPKI_{it}$ denotes the gross inflows for country i , as defined above. Figure 3 (blue dots) shows the time series of this measure for all countries in the sample. While this variable is country-specific, as shown by the vertical (cross-section) variation, there is a clear common global cycle, with pronounced variations especially during the 2008-09 global crisis.¹⁴ This measure of global flows correlates closely with measures of market risk aversion, like the Chicago Board Options Exchange Market Volatility (VIX) Index (chart to the left), suggesting that risk appetite may be the main common factor at play, while it displays little correlation with the U.S. policy interest rate (chart to the right).

Figure 3. Country-specific Measure of Global Capital Flows, VIX and US Interest Rate



Source: Bloomberg and authors' calculations.

Note: Both the VIX index and the U.S. monetary policy rate are reported in inverted scale, as one would expect a negative correlation, if any, between these variables and the measure of global capital flows.

¹³ The United States, United Kingdom, Switzerland, Japan and the members of the Euro Area are excluded as they issue reserve currencies.

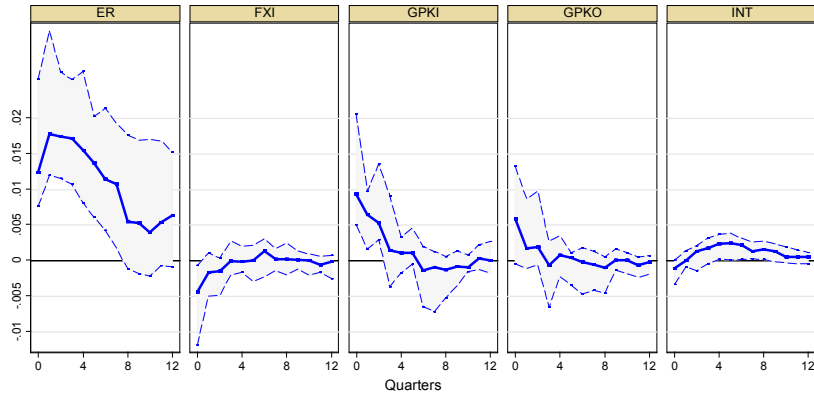
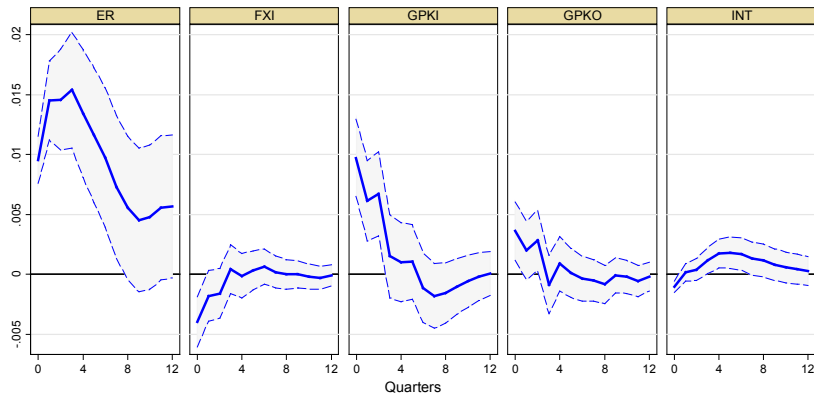
¹⁴ See Milesi-Ferretti and Tille (2011) for a detailed documentation of the latter phenomenon.

The sample includes 35 emerging market and advanced economies, based on data availability.¹⁵ Economies whose central banks issue a reserve currency (US, United Kingdom, Japan, Switzerland and members of the Euro area) are excluded from the sample. The sample covers quarterly data for the period 1990Q1-2013Q4, although it is restricted, on a country-by-country basis, by data limitations. Furthermore, as our empirical strategy relies on classifying countries according to their FXI behavior, as explained in detail below, we also exclude certain country-specific time periods in order to rule out structural breaks related to changes in monetary and exchange rate regimes during the estimation time window (see Appendix Table A1). For each country, the number of lags in the VAR specification, averaging 2.5, is chosen based on the Akaike information criterion (this implies, for a country for which data exist back to 1990, an average of 81 degrees of freedom)

B. Main Results

Our interest lies in the estimated responses of the domestic variables to the exogenous capital flow shock GKF. Figure 4 displays impulse response functions to a one-standard deviation shock to our measure of global capital flows, for all non-peg countries in the sample. Panel (a) displays the median and the interquartile range of individual country impulse responses. Panel (b) displays the weighted average of the point estimates, together with the weighted averages of individual confidence (60%) bands, with weights inversely proportional to the standard deviation of each impulse response.

¹⁵ Those are Australia, Bolivia, Brazil, Bulgaria, Canada, Chile, China: Mainland, Colombia, Croatia, Czech Republic, Denmark, Estonia, Guatemala, Hungary, India, Indonesia, Israel, Korea, Latvia, Lithuania, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russia, South Africa, Sri Lanka, Sweden, Thailand, Turkey and Ukraine.

Figure 4. Responses to a Global Capital Flows Shock*Panel (a). Cross-section variation of individual impulse responses**Panel (b). Weighted average of individual impulse responses*

Note: The figure reports impulse response functions to a one standard deviation shock to the global capital flow variable. The upper panel displays the cross-section variation of responses for different countries, with the median and inter-quartile range. The lower panel shows a weighted average of impulse responses and their (60 percent) confidence bands, with weights that are inversely proportional to the standard deviation of each impulse response.

These general results indicate that:

While there is a relatively wide range of exchange rate responses to the exogenous shocks, both panels indicate an unambiguous appreciation of the local currency, averaging about 1½ percent over the first 2 quarters, and gradually fading away.

As expected, gross private inflows increase in response to the positive GKF shock, reaching about 1 percent of GDP on impact and remaining (statistically) positive for about 3 quarters. Gross private outflows also increase, but less than inflows (suggesting a value of $\rho > -1$).

Most countries in the sample use FXI in response to the increase in gross inflows and accumulate reserves. Finally, short-term interest rate differentials display a fall in response to the shock, at least initially, but the effect is very small.

Figure 5 provides additional information on the individual country estimates for our main variables of interest (*GPKI*, *ER*, *FXI*),¹⁶ reporting cumulative impulse responses (point estimates and confidence bands) estimates on impact and at a 2-quarter horizon. For the exchange rate, non-cumulative responses are reported. The first panel points to the strength of global financial conditions in driving gross inflows to most countries in the sample. Indeed, we find evidence of a negative effect on impact for only one of the 27 non-peg economies (Norway); and there is no country with a negative cumulative impact at a 2-quarter horizon. The impact on exchange rates is also unequivocally positive, with all countries displaying positive effects on impact and 2-quarter horizons. Finally, we find significant heterogeneity in the responses of *FXI*, although a large proportion of countries (20 out of 27) show reserve accumulation on impact, and the proportion increases to 22 out of 27 for a 2-quarter horizon.

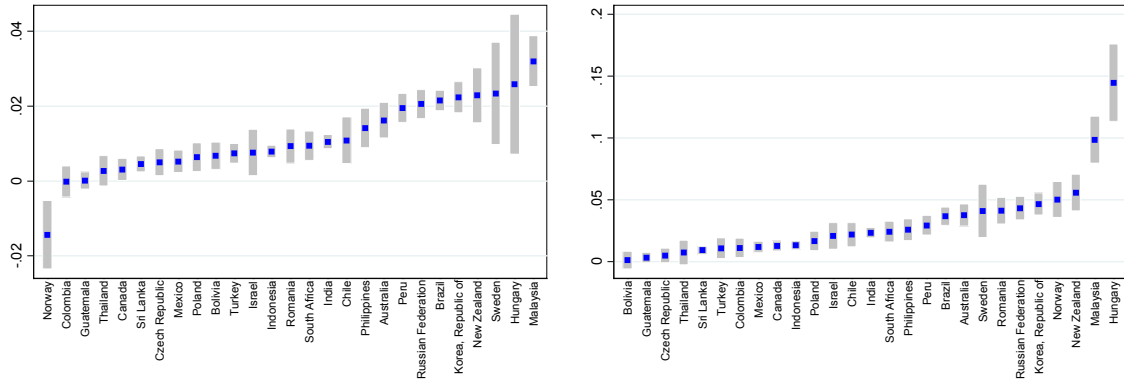
¹⁶ Other variables are reported in the appendix.

Figure 5. Responses to a Global Capital Flows Shock (non-peg economies)

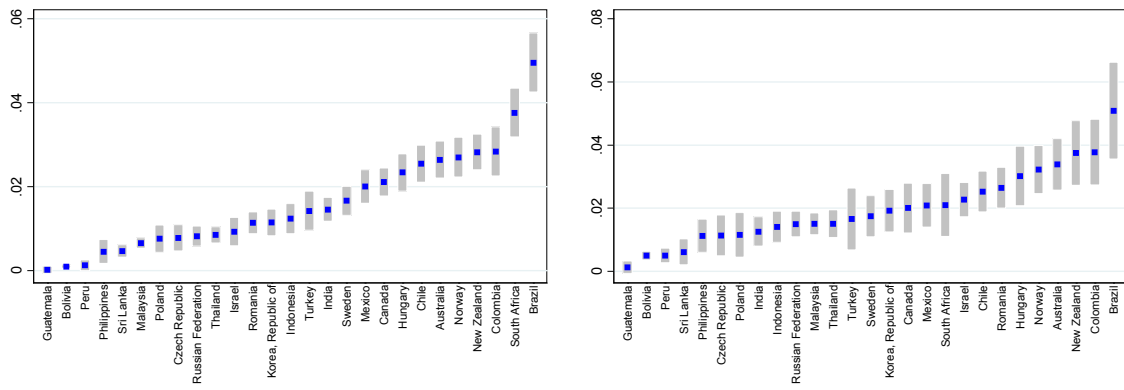
Step $t=0$

Step $t=2$

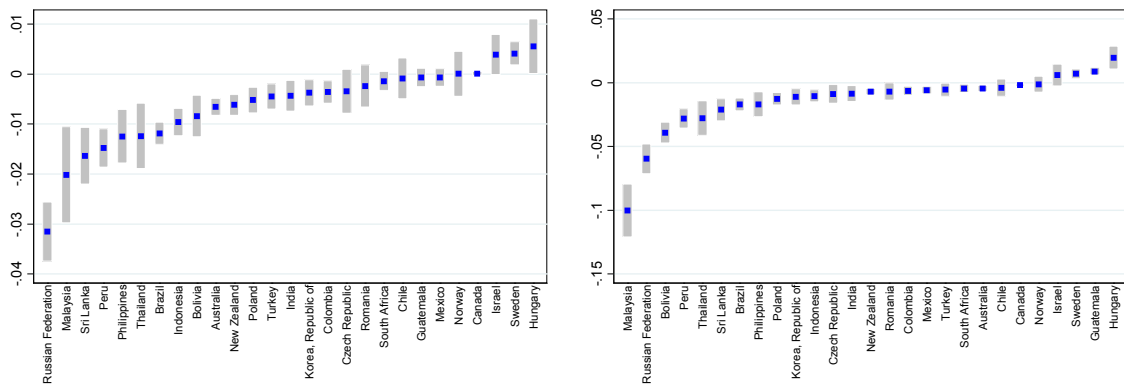
Panel (a). GPKI responses



Panel (b). ER responses



Panel (c). FXI responses



Note: Cumulative impulse (except for ER) responses from individually estimated VAR models, at $t=0$ and $t=2$. One standard deviation bands are reported.

De Facto FXI Regimes

The significant cross-section variation in FXI responses potentially provides us with the evidence needed to look at the impact of these policies on the exchange rate. Specifically, to explore the cross sectional variation of the results, we construct a *de-facto FXI regime classification* by breaking the sample of countries down based on the individual responses to the global capital flows shock, according to the following criteria:

- We continue to exclude countries with de-facto pegs, as in Ilzetzi et al (2011). We include only economies if they show sensitivity to global capital flow shocks, based on whether any of the cumulative impulse responses of *GPKI* or *FXI*; or and the impulse response of *ER* show a statistically significant impact (at a 2-quarter horizon).
- We group the remaining countries (countries with flexible exchange rate regimes and categorized as sensitive to global capital flows) in two groups, *floaters* or *interveners*, based on their cumulative FXI responses (i.e. whether they are smaller or larger than the median) at a 2-quarter horizon.

Table 1 presents the country grouping according to these criteria and the VAR estimations presented before:

Table 1. De Facto FXI Regime 1/

De Facto Pegs 2/	Flexible Exchange Rate Regime 2/		
	Not sensitive to the GFC 3/	Sensitive to the GFC	
		Floaters 4/	Interveners 4/
Bulgaria China, P.R.: Mainland Croatia Denmark Estonia Latvia Lithuania Ukraine	Guatemala	Australia Canada Chile Colombia Hungary Israel Mexico New Zealand Norway Romania South Africa Sweden Turkey	Bolivia Brazil Czech Republic India Indonesia Korea Malaysia Peru Philippines Poland Russian Federation Sri Lanka Thailand

Sources: Ilzetzi et al (2011); and authors' calculations.

1/ Based on FXI responses to a global capital flow shock. 2/ According to Ilzetzi et al (2011). 3/ Sensitivity to global capital flows is determined by the impulse responses of gross private capital inflows (GPKI), exchange rate (ER), and FXI. 4/ Based on degree of intervention, splitting sample in half.

Flexible exchange rate regimes

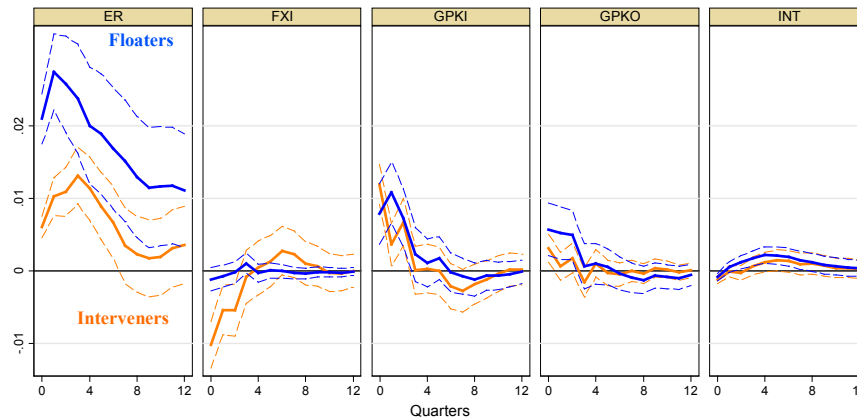
Most countries appear in the expected category, based on their known sensitivity to global financial conditions and their history of FXI during the sample period. It is important to stress that this classification relates to intervention policies in response to global capital flow shocks only. Some of the countries that are found not to respond to those shocks could in fact intervene significantly and frequently in response to other shocks, including idiosyncratic ones.

Next, we analyze the responses of the key variables to a global capital flow shock, by comparing the groups of *floaters* and the group of *interveners* (we still do estimation country by country). Countries with fixed exchange rate regimes are initially excluded, as our benchmark specification focuses on the nominal exchange rate.

Figure 6 reports the weighted average impulse response functions and confidence bands for different variables for each of the two groups.

- The difference in FXI responses between the two groups is sizeable, close to 1 percent of quarterly GDP (0.25 percent of annual GDP) on impact.
- Interveners display a smaller appreciation of their currencies in response to the gross inflows. Specifically, we find a 1.5 percentage point differential in appreciation between interveners and floaters over the first 3-4 quarters. The differential fades afterwards. This difference is significant, both statistically and economically. We see this result—which seems fairly robust as shown below—as the main conclusion of the paper.
- Moreover, comparing the differential between the two groups of FXI and ER responses suggests a large effect of FXI: a quarterly *annualized* intervention of 1 percent of GDP (0.25 percent *non annualized*) leads to about 1.5 percent lower appreciation on impact.
- There is no evidence of a different interest rate behavior between the two groups, at least on average, suggesting that neither interveners nor floaters rely on the interest rate to ‘defend’ their exchange rates in response to exogenous capital flow shocks.

Figure 6. Impulse Responses to a Global Capital Flow Shock



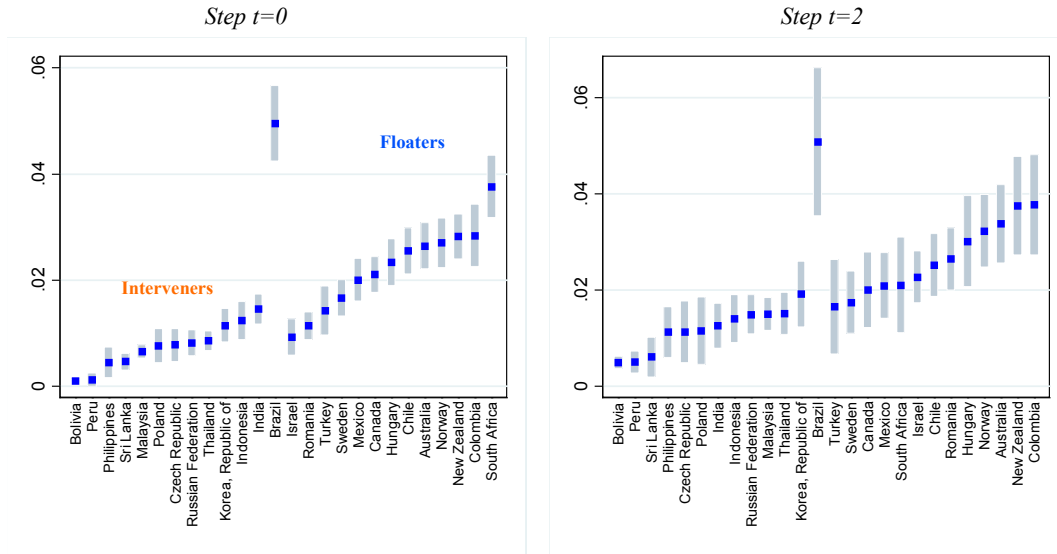
Note: Impulse response functions to a one standard deviation shock to the global capital flow variable. For each group, weighted averages of the impulse responses and confidence bands are reported, with weights that are inversely proportional to the standard deviation of each impulse response.

- Consistent with the predictions of the simple model presented earlier, gross capital inflows respond equally or more markedly in intervening countries, in comparison to floaters. Gross outflows increase for both groups, pointing to an offsetting role by domestic investors (a negative value of ρ), but more in floaters.
- There are two possible causal interpretations of the negative relation between the size of FXI and the size of gross outflows in response to shocks. The first follows from our model, and causality runs from FXI to gross outflows: Sterilized interventions limit the exchange rate appreciation, leading to a smaller expected depreciation, thus making it relatively less attractive for domestic investors to buy foreign assets. The second runs instead from gross outflows to the FXI response. It holds that, if domestic investors are less able or less willing to offset gross inflows, the central

bank partly replaces them by using more FXI. We examined the issue by looking at the relation between various measures of the size and the depth of the domestic investor base, and did not find a robust relation between those measures and the strength of the response of gross outflows. This suggests that the causality runs from stronger FXI to smaller appreciation, to smaller outflows.

Figure 7 shows the cross section of exchange rate responses for each of the countries in each of the two groups, on impact and after 2 quarters. The exchange rate appreciation is in general lower in the case of interveners, with the important exception of Brazil (an outlier within the group).

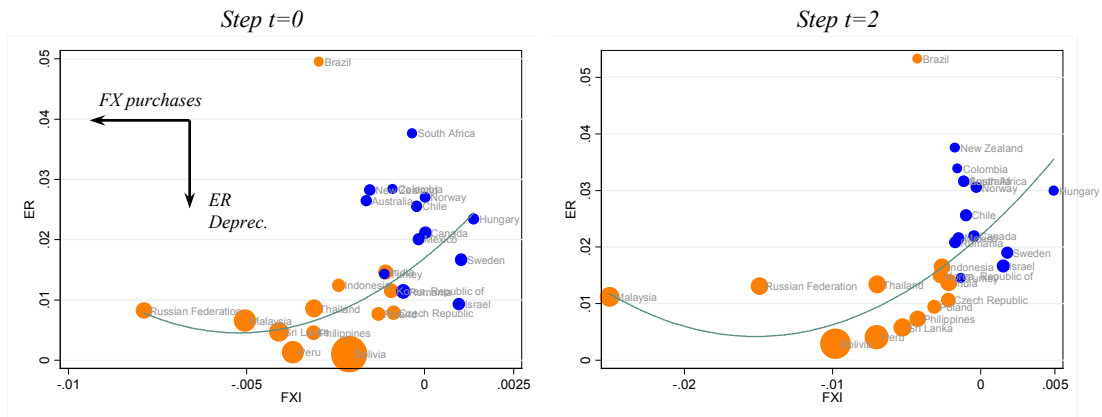
Figure 7. Cross section of Exchange Rate Responses to a Global Capital Flows Shock



Note: Exchange rate impulse responses from individually estimated VAR models, at t=0 and t=2; grouped by floaters and interveners. One standard deviation bands are reported.

Moreover, as shown in Figure 8, there is a clear positive relationship between cumulative FXI and the average ER responses, both on impact and at 2-quarter horizon.

Figure 8. Exchange Rate and FXI Responses to a Global Capital Flows Shock



Note: Cumulative FXI (in percent of annual GDP) and average ER responses at t=0 and t=2; Circles are inversely proportional to the standard deviation of the ER response. Floaters are colored blue; interveners are colored orange. The line illustrates a (weighted) quadratic fit.

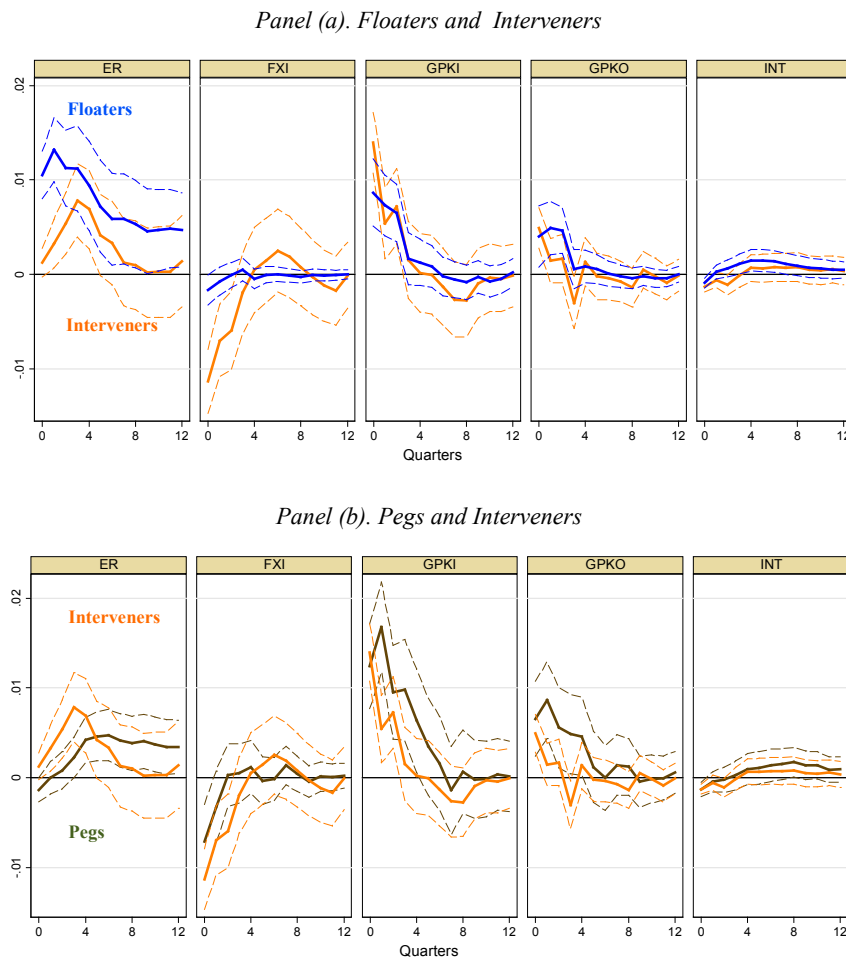
Real exchange rate and fixed exchange rate regimes

The baseline specification focused on the bilateral nominal exchange rates. We now redo the analysis looking at the effects on real effective exchange rates. We look at three categories of countries: floaters and interveners, and, now, pegs. They are compared, two at a time, in Figure 9.

The top panel looks at floaters versus interveners, and thus replicates Figure 6, but using real exchange rates. The results are very similar to those in Figure 6.

The bottom panel looks at pegs versus interveners. Pegs experience a small real depreciation at the start, presumably because of the nominal appreciation of some of their trading partners. They appreciate somewhat afterwards, consistent with lags in inflation. Interestingly, pegs appear to carry out less intervention than interveners within the group of managed floaters (but not less than floaters). Pegs also display somewhat larger volumes of gross flows (in and out) than the other groups.

Figure 9. Impulse Responses to a Global Capital Flows Shock: Real Exchange Rates and Fixed Exchange Rate Regimes



Note: The figure reports impulse response functions to a one standard deviation shock to the global capital inflow variable. For each group, a weighted average of impulse responses and their (60 percent) confidence bands is reported, with weights that are inversely proportional to the standard deviation of each impulse response.

C. Robustness Checks

In this section we conduct a series of robustness checks. While changes in the specification could lead to different country classifications (than those reported in Table 2), the classifications are quite stable, as shown in appendix Table A2. Appendix Figure A2 presents the results of robustness checks discussed here.

Proxy for FXI. In the baseline specification we relied on a proxy for FXI encompassing balance of payments data of changes in reserves and off balance sheet operations (derivatives). However, since the latter is not reported consistently across countries and time, we check the robustness of our results to using a narrower measure of FXI, based only on changes in reserves. The results are qualitatively similar to those of the baseline specification, and most countries remain as classified initially, with the exception of a few cases: Korea and Czech Republic become floaters, indicating that they tended, over the sample period, to rely more than other countries on off balance sheet operations. New Zealand and Romania, on the other hand, become interveners (see appendix Table A2).

Terms of trade. Terms of trade shocks are an important source of exchange rate variations, especially in commodity producing countries; and such shocks may be correlated with global capital flows. We extend the baseline specification to include country specific changes in terms of trade as a control. Results remain roughly unchanged.

Capital controls. A possible shortcoming of the baseline model relates to the fact that the specification does not control for the possible contemporaneous deployment of capital flow measures, due to the lack of sufficient comprehensive and high frequency (quarterly) data on capital controls. This may result in an upward bias in the estimated effect of FXI on the exchange rate (i.e., the seemingly dampening effect of the FXI on the exchange rate could be actually caused by uncontrolled-for capital control measures). To partly deal with such a possibility, we conduct the same exercise as in the baseline but excluding countries with frequent use of capital controls, as indicated by the standard deviation of their Quinn-Toyoda indexes during the sample period. Specifically, economies with indicators above the 70th percentile are excluded. Results are quite similar to the baseline. In fact, we find that excluded countries mostly comprise pegs (Bulgaria, China, Estonia, Croatia) or floaters (Chile, Colombia, Hungary, Israel, Romania), possibly indicating a higher reliance on capital flow control as a substitute for foreign exchange intervention.¹⁷

An additional concern related to capital controls is that the baseline results, especially those on gross outflows being less responsive in economies with heavy intervention, could simply reflect a higher (structural) degree of capital controls, precluding domestic investors from shifting assets across national borders in response to gross inflow shocks. To explore this, we check the robustness of the baseline results by excluding countries with high average levels of capital controls, during the period 1990-2012. In this case, the excluded countries correspond proportionally more to those initially classified as interveners (Brazil, India, Indonesia, Malaysia, Sri Lanka and Thailand) as opposed to floaters (Colombia, Mexico and South Africa). The main results, namely the dampening effect of FXI on the exchange rate and the patterns of gross flows are very similar to those of the baseline specification. The only significant difference is visible in the response of gross outflows, which show a greater differential between interveners and floaters.

¹⁷ The measures of capital controls reflect the average behavior during the full sample period considered for the estimation of the VAR models.

Sterilized intervention. The inclusion of the domestic interest rate in the model should account for the effect of interest rate changes on the exchange rate, thus allowing to disentangle the separate effects of FXI and of the interest rate. To check the robustness of the results, however, we impose a more stringent condition, ruling out possible cases of unsterilized intervention. The latter cases are defined as those displaying a statistically significant negative response of the interest rate differential to global financial shocks (Brazil, Hungary, Indonesia, Philippines, and Russia in the benchmark results). The main results hold.

We also follow this approach with an alternative specification that introduces the domestic and the foreign interest rate separately in the model. In this case, the requirement of not displaying negative responses to a global capital flow shock applies to the domestic interest rate only. Hungary, Indonesia, Russia and Thailand are excluded under this criterion; and results remain similar to those of the benchmark specification.

Sensitivity to the global capital flows. We relax the criteria that exclude countries for not being sensitive to global capital flows shocks, by classifying non-peg countries into floaters and interveners. Again, results remain as in the benchmark classification.

Unconditional FXI regime classification. The baseline classification relies on the behavior of FXI conditional on a global flows shock. Alternatively, we can classify countries based on their unconditional intervention activities. Specifically, we consider as interveners those countries in the sample which satisfy the condition:

$$D_i(\text{intervener}) = 1 \text{ if } \gamma_i \geq \tilde{\gamma}$$

$$\gamma_i \equiv \frac{\sum_{t=1}^T |FXI_{i,t}|}{\sum_{t=1}^T |GPKI_{i,t}|} \text{ and } \tilde{\gamma} \equiv \text{median}\{\gamma_1 \dots \gamma_N\}$$

which is based on the relative degree of intervention in relationship to gross inflows over the sample period. Some countries—several of which were outliers in the baseline classification—change categories. Guatemala, Israel and Norway become interveners, as opposed to not sensitive to the global financial cycle or floater under the conditional classification, reflecting reserve accumulation policies that are less sensitive to capital flow movements.¹⁸ New Zealand and Poland, on the other hand, become floaters. Results are similar to those of the baseline specification, except with regard to the differentiated pattern of gross flows between floaters and interveners, with respect to which the results are weaker than in the baseline.¹⁹

¹⁸ Guatemala and Israel pursued, during part of the sample period, rule-based FXI policies. Norway's reserve accumulation may reflect developments related to oil revenue.

¹⁹ Interestingly, the differentiated response of exchange rates between floaters and interveners is as stark under the unconditional classification as in the classification based on responses to a global capital flow shock. See results in Appendix Figure A3 and A4.

VIX as the exogenous shock. As shown in Figure 5, our measure of global capital flows correlates closely with a standard measure of risk aversion, as captured by the VIX Index.²⁰ Still, to ensure that our results do not depend on our specific measure, we re-estimate the model relying on the VIX index instead as the exogenous financial shock. Although the results are not directly comparable with those of the previous robustness checks since the magnitudes of the VIX and GKF shocks are not of the same magnitude, the results indicate again that intervention is effective in dampening the effects of external financial shocks on the exchange rate.

We also conduct a series of additional robustness checks (not reported), including using the first difference of the exchange rate out of possible concerns about non-stationarity; normalizing flow measures by trend GDP; using a broader measure of net official flows instead of central bank FXI; etc. Results remain quite close to those of the baseline specification.

IV. CONCLUSIONS

We evaluate the effectiveness of sterilized intervention as an instrument to insulate countries from exchange rate pressures stemming from capital flow shocks. To deal with endogeneity issues, we rely on country-specific VAR estimations and exploit the cross-section variation of FXI responses to an exogenous capital flows shock. Consistent with the portfolio balance channel, we find evidence that larger intervention leads to less exchange rate appreciation in response to gross inflows. The magnitude of the effect is relevant from a macroeconomic perspective, suggesting that FXI can be a valid policy tool for macroeconomic management.

²⁰ This is consistent with recent studies (e.g. Rey, 2013; de Carvalho Filho, 2014), which find the VIX to be a good proxy for global financial flows.

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Table A1

Country	Sample period
Brazil	1998Q4 onwards
Bulgaria	1996Q4 onwards
Canada	2002Q2 onwards
Chile	1992Q2 onwards
Croatia	1994Q4 onwards
Estonia	1992Q3 to 2010Q4
Indonesia	1992Q2 onwards
Korea	1998Q3 onwards
Latvia	1994Q4 onwards
Lithuania	1995Q2 onwards
Peru	1994Q4 onwards
Philippines	1998Q1 onwards
Poland	1995Q3 onwards
Romania	2001Q2 onwards
Russian Federation	2000Q1 onwards
South Africa	1995Q2 onwards
Sweden	1993Q1 onwards
Thailand	1999Q1 onwards
Turkey	2003Q2 onwards

Table A2. De facto FXI Regime - Classification of Countries across Specifications

IFS code	Country Name	Excluding Off-			Capital		Sterilized FXI	Sterilized FXI (2)	Sensitivity Criterion	Unconditional Classif.	VIX
		Baseline	BS FXI	Terms of trade	Controls	Controls (2)					
128	Denmark	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg
142	Norway	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Intervener	Intervener
144	Sweden	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Not Sensitive
156	Canada	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater
186	Turkey	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater
193	Australia	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater	Floater
196	New Zealand	Floater	Intervener	Intervener	Floater	Floater	Intervener	Intervener	Intervener	Floater	Floater
199	South Africa	Floater	Floater	Floater	Floater	...	Floater	Floater	Floater	Floater	Intervener
218	Bolivia	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener
223	Brazil	Intervener	Intervener	Intervener	Intervener	...	.	Intervener	Intervener	Intervener	Floater
228	Chile	Floater	Floater	Floater	...	Floater	Floater	Floater	Floater	Floater	Floater
233	Colombia	Floater	Floater	Floater	...	...	Floater	Floater	Floater	Floater	Intervener
258	Guatemala	Not Sensitive	Floater	Not Sensitive	Not Sensitive	Not Sensitive	Not Sensitive	Not Sensitive	Floater	Intervener	Intervener
273	Mexico	Floater	Floater	Floater	Floater	...	Floater	Floater	Floater	Floater	Floater
293	Peru	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Not Sensitive
436	Israel	Floater	Floater	Floater	...	Floater	Floater	Floater	Floater	Intervener	Floater
524	Sri Lanka	Intervener	Intervener	Intervener	Intervener	...	Intervener	Not Sensitive	Intervener	Intervener	Intervener
534	India	Intervener	Intervener	Intervener	Intervener	...	Intervener	Intervener	Intervener	Intervener	Floater
536	Indonesia	Intervener	Intervener	Intervener	Intervener	...	.	.	Intervener	Intervener	Floater
542	Korea, Republic of	Intervener	Floater	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener
548	Malaysia	Intervener	Intervener	Intervener	Intervener	...	Intervener	Intervener	Intervener	Intervener	Intervener
566	Philippines	Intervener	Intervener	Intervener	Intervener	Intervener	.	Intervener	Intervener	Intervener	Intervener
578	Thailand	Intervener	Intervener	Intervener	Intervener	...	Intervener	.	Intervener	Intervener	Intervener
918	Bulgaria	Peg	Peg	Peg	...	Peg	Peg	Peg	Peg	Peg	Peg
922	Russian Federation	Intervener	Intervener	Intervener	Intervener	Intervener	.	.	Intervener	Intervener	Intervener
924	China,P.R.: Mainland	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg
926	Ukraine	Peg	Peg	Peg	Peg	...	Peg	Peg	Peg	Peg	Peg
935	Czech Republic	Intervener	Floater	Floater	...	Floater	Floater	Intervener	Floater	Floater	Not Sensitive
939	Estonia	Peg	Peg	Peg	...	Peg	Peg	Peg	Peg	Peg	Peg
941	Latvia	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg	Peg
944	Hungary	Floater	Floater	Floater	...	Floater	.	.	Floater	Floater	Floater
946	Lithuania	Peg	Peg	Peg	...	Peg	Peg	Peg	Peg	Peg	Peg
960	Croatia	Peg	Peg	Peg	...	Peg	Peg	Peg	Peg	Peg	Peg
964	Poland	Intervener	Intervener	Not Sensitive	Intervener	Intervener	Intervener	Intervener	Intervener	Floater	Not Sensitive
968	Romania	Floater	Intervener	Not Sensitive	...	Intervener	Intervener	Intervener	Intervener	Intervener	Intervener

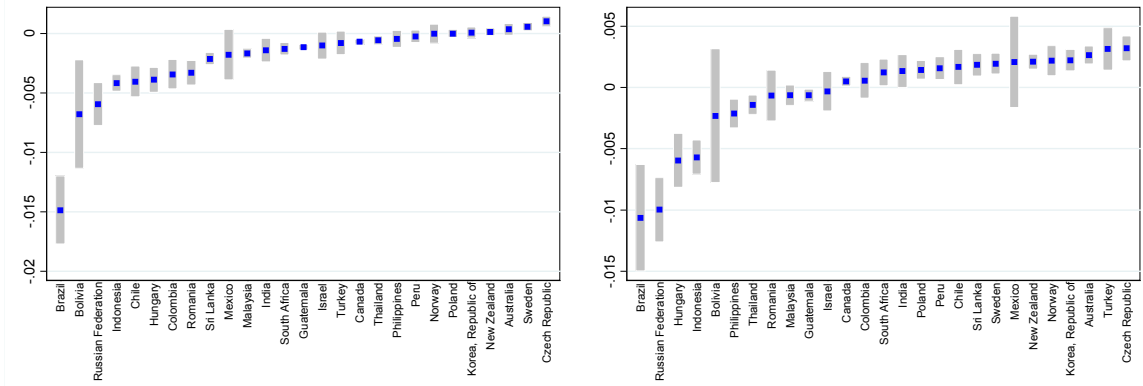
Source: Authors' estimations.

Figure A1. Responses to a Global Capital Flow Shock

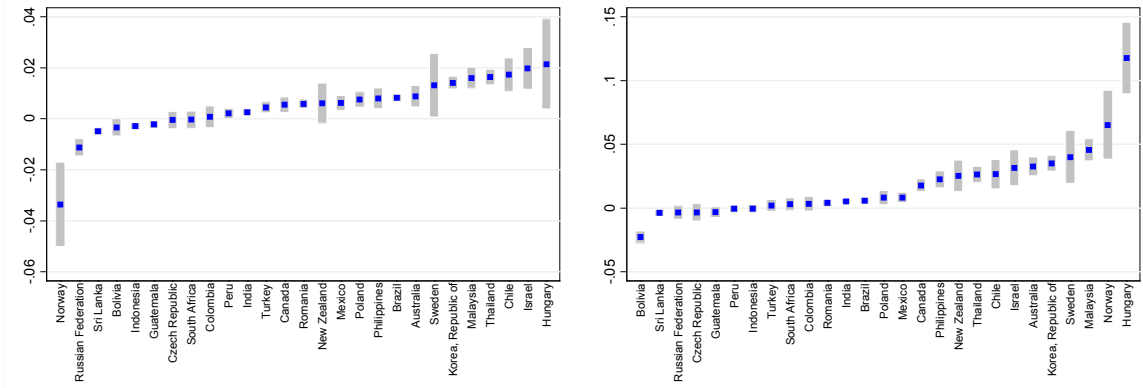
Step $t=0$

Step $t=2$

Panel (a). INT responses to a global capital flow shock

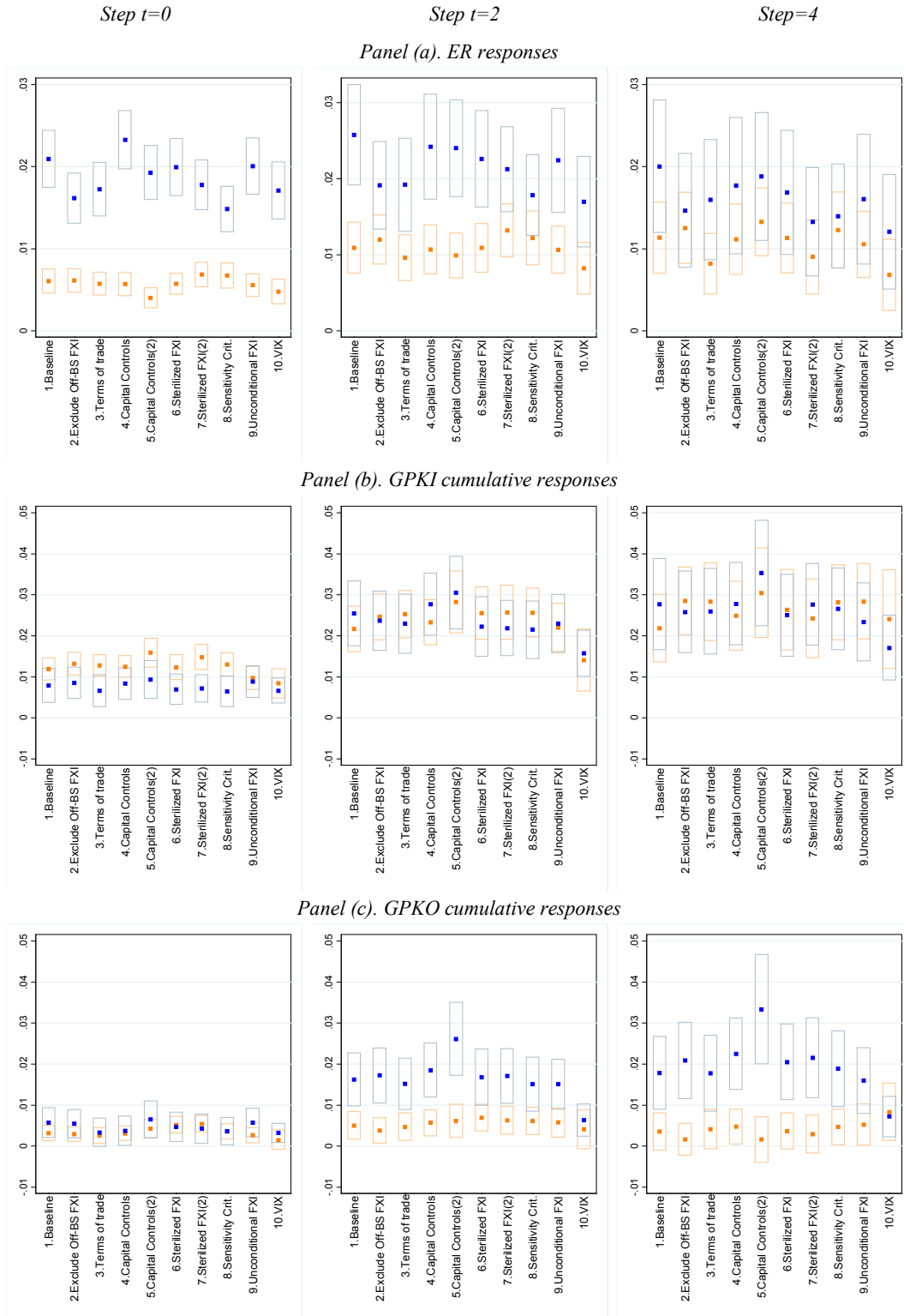


Panel (b). GPKO responses to a global capital flow shock



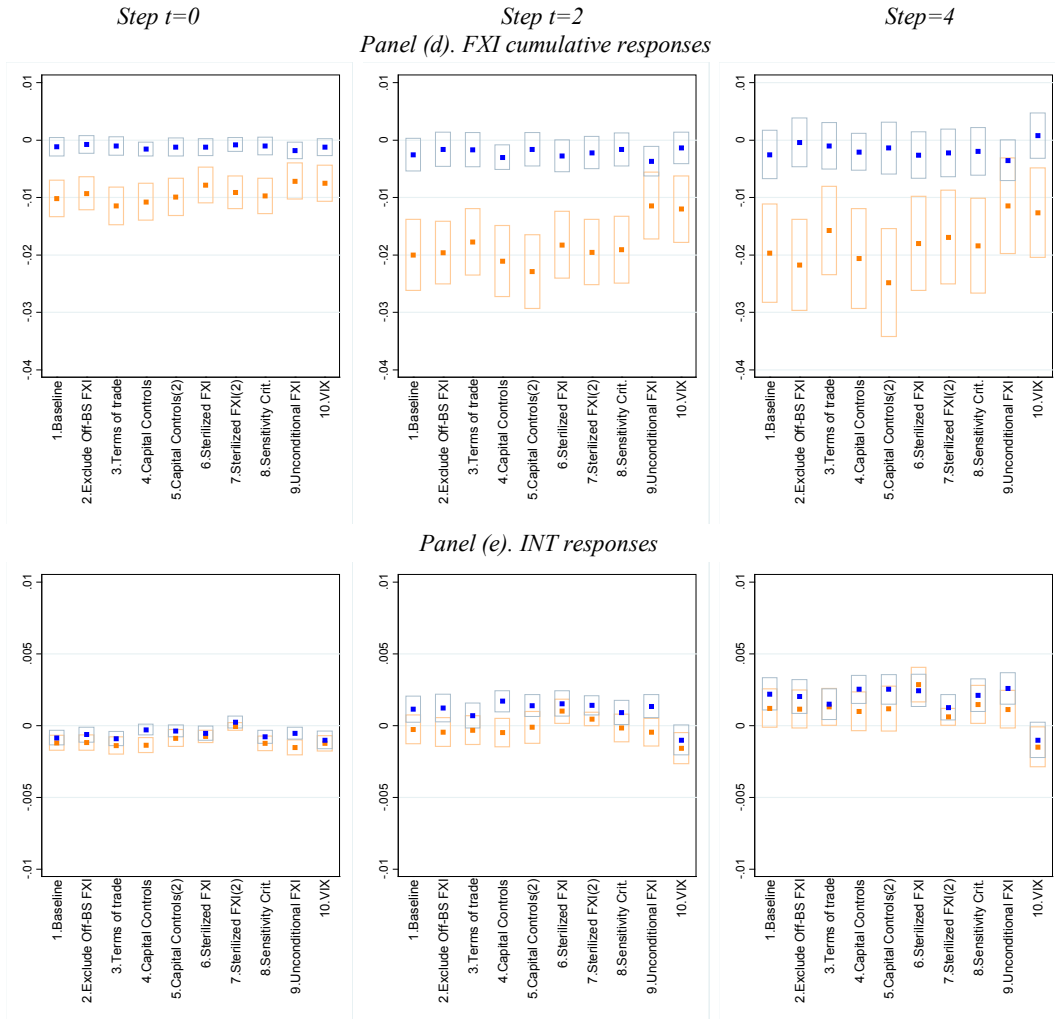
Note: Cumulative impulse responses from individually estimated VAR models, at $t=0$ and $t=2$; except for INT, which is non-cumulative. One standard deviation bands are reported.

Figure A2. Robustness Check. Responses of Floaters and Interveners to a Global Capital Flow Shock (non-peg economies)



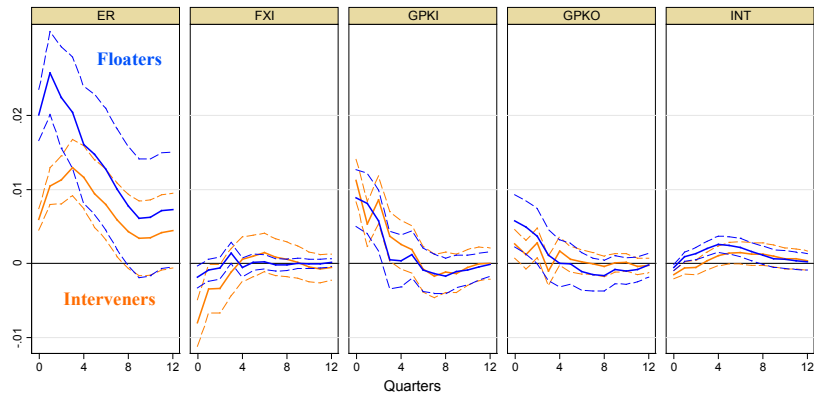
Note: The figure reports results from alternative specifications, as described in the main text, for floaters (in blue) and interveners (in orange). For each of them, the estimated (weighted) average response for *floaters* and *interveniers* are shown, at $t=\{0,2,4\}$.

Figure A2 (continued). Robustness Check. Responses of Floaters and Interveners to a Global Capital Flow Shock (non-peg economies)



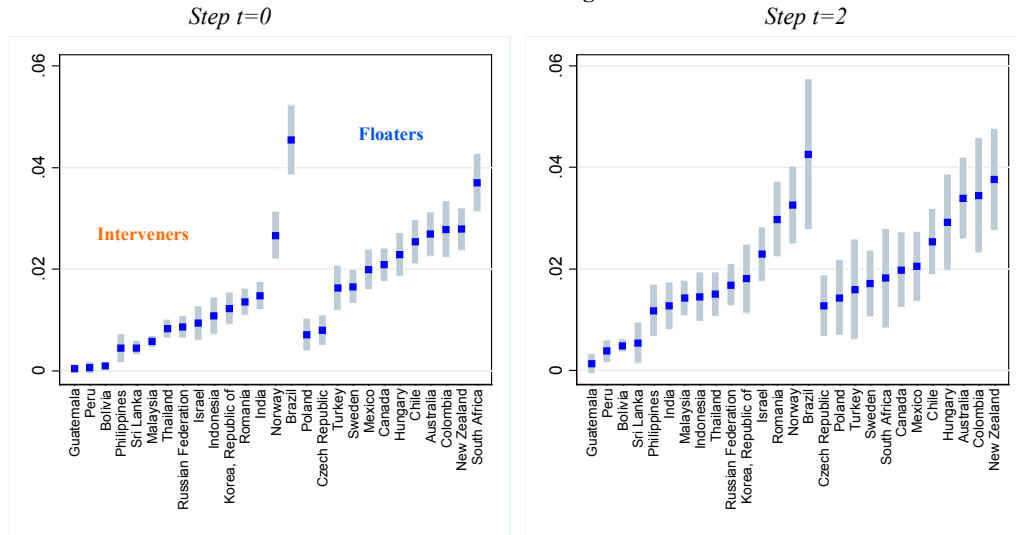
Note: The figure reports results from alternative specifications, as described in the main text, for floaters (in blue) and interveners (in orange). For each of them, the estimated (weighted) average response for *floaters* and *interveners* are shown, at $t=\{0,2,4\}$.

Figure A3. Impulse Responses to a Global Capital Flow Shock—Unconditional FXI Regime Classification



Note: Impulse response functions to a one standard deviation shock to the global capital flow variable. For each group, weighted averages of the impulse responses and confidence bands are reported, with weights that are inversely proportional to the standard deviation of each impulse response.

Figure A4. Cross section of Exchange Rate Responses to a Global Capital Flows Shock—Unconditional FXI Regime Classification



Note: Exchange rate impulse responses from individually estimated VAR models, at $t=0$ and $t=2$; grouped by floaters and interveners. One standard deviation bands are reported.