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ABSTRACT: We use panel quantile regressions to study extreme (rather than average) movements in the distribution of the real effective exchange rate (REER) of small open economies. We document that global uncertainty (VIX) and global financial conditions (U.S. monetary policy) shocks have a strong impact on the distribution of the REER changes, with larger impacts in the tails of the distribution, and especially in economies with shallower FX markets, lower central bank credibility, and higher credit risk (i.e., weaker macro fundamentals). Foreign exchange intervention (FXI) partially offsets the impact of these shocks, especially in the left tail (large depreciations) and particularly in economies with weaker fundamentals but, more importantly, when FXI is used sporadically. Thus, our results highlight the importance of deepening FX markets, improving central bank credibility, and strengthening macro fundamentals against the potential dynamic trade-offs of overreliance on a policy that would exacerbate the previously mentioned frictions. While our results point to low effectiveness of capital flow management in preventing large REER movements, they seem to enable more impactful foreign exchange intervention in the immediate aftermath of shocks.

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WORKING PAPERS

External Shocks, Policies, and Tail-Shifts in Real Exchange Rates

Prepared by Nicolás E. Magud and Samuel Pienknagura [1]

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I. Introduction

Financial integration can have pro-growth effects, but it can also lead to short-term challenges. Integration eases countries' financing needs, which can foster long-term investment and help smooth domestic and external shocks. It can also help increases exports and imports, which can raise growth prospects. However, globally integrated economies, especially small open economies (SOEs), are exposed to transitory external financial shocks, which can result in excessive movements in key economic variables. In particular, financial integration exposes countries to global uncertainty, as reflected in higher VIX levels, and to changes in global financial conditions, such as those stemming from U.S. monetary policy actions. These shocks can lead to temporary swings in capital inflows, increase funding costs, and result in excessive movements in exchange rates.

The challenges and opportunities brought about by global integration have sparked a lively debate about the appropriate design of policies to sustainably reap the benefits of a more interconnected global economy. One side of that debate, which has garnered growing attention in both academic and policy circles, regards the usefulness and effectiveness of foreign exchange intervention (FXI) and capital flow management (CFM) policies in mitigating the adverse effects of excessive movements of key economic variables in response to temporary shocks. Part of such debate, however, oftentimes lacks a proper definition of the specific objective that such policies aim at achieving—a key consideration in policy design.

In this paper, taking as the policy objective to smooth exchange rate volatility (as SOE typically aim at[2]), first we focus on the impact that financial external (VIX and US Monetary policy) shocks have on the distribution of real exchange rate changes, and especially extreme movements in real exchange rates. Then, we explore the role that FXI and CFMs (both of inflows and outflows) have in mitigating the impact on these shocks. Especially, we care for whether and how these policies mitigate the effects of external financial shocks in the tails of the distribution of real exchange rate movements, what we dub the extremes.

Key to our contribution is that we depart from the existing literature, which mostly focuses on the *average* effect of shocks on real exchange rates, to focus on the extremes of the distribution, where policy becomes more relevant. We care about this because, by definition, the average impact of shocks may hide important tail risks stemming from shocks. To this end, we track the

[2] The real exchange rate is an endogenous relative price not only associated with competitiveness, but also a country's income in the global economy. It is highly correlated with the nominal exchange rate, but unlike the latter, is less contaminated by economic policies such as a country's exchange rate regime, inflation control strategies, and other policies. It may also summarize typical measures of welfare such as GDP or consumption. Theoretically, Lahiri and Vegh (2001) show that under some circumstances intervening in foreign exchange markets to reduce excessive REER volatility may be the optimal policy of a central bank in a small open economy.

dynamic impact of shocks across specific deciles of the real exchange rate distribution by means of panel quantile regressions. For simplicity, and as a broad depiction of shifts in the distribution of the changes in the REER in the aftermath of shocks, we assess the response of the median value, the 10th percentile and the 90th percentile, which allows us to study the behavior beyond the central part of the distribution and, importantly, around the two tails.

Focusing on both the median and the tails of the distribution enables us to show how mitigating policies can be deemed as more effective and less costly at different deciles—such as in collapses or crises, periods during which containment policies may be needed the most. In fact, we show that the mitigating power of FXI and CFM varies substantially across the exchange rate movements' distribution. We stress this point, which, to be the best of our knowledge, has been mostly unexplored, because a large part of the received literature finds FXI to be ineffective. In contrast, we argue that, in part, such lack of statistical significance derives from focusing on averages rather than exploiting the information in the tails of the distribution. In addition, potential asymmetries in the impact of positive vs. negative shocks on different deciles of the REER distribution amplify the previously mentioned considerations.

Specifically, we find that an increase in global uncertainty (as given by the VIX) shifts the three deciles we focus on to the left, suggesting an overall weakening of the REER. However, the effect is stronger at the 10th percentile of the distribution, that is, currencies that weaken relatively more. Therefore, our results imply that, other things equal, a VIX shock increases markedly the probability of observing large depreciations. As an example of these non-linearities, and as is discussed in more details in the rest of the paper, Figure 1 shows the response of various quantiles of the distribution of REER changes to a one standard deviation change to the VIX. Note that although the average real depreciation is about 0.6 percent, the real depreciation of the 1st decile is about 1.1 percent (almost twice the impact), while that of the 9th decile is 0.2 percent. U.S. monetary policy shocks also depreciate SOEs' currencies (left shift in the deciles we study), but the impact is stronger on the median and in the 90th percentile (stronger currencies)—thus, reducing the probability of observing large appreciations.

We also find that negative shocks are more relevant than positive shocks. We observe that only increases in the VIX have a statistically significant impact on the three deciles that we focus on (with no effect from a lower VIX). And only a tightening of U.S. monetary policy results in protracted and substantial depreciations in small open economies (left shift of REER deciles), with only marginal appreciation in response to monetary easing.[3]

[3] Of course, countries' REER do not systematically weaken. We speculate that this could be associated with domestic shocks, policies, and policy frameworks contributing to secularly strengthening REER distributions in the spirit of Balassa-Samuelson. To the extent possible we control for variables plausibly related to such trend. Terms-of-trade shocks, which can potentially impact the real exchange rates, is found not to affect it, however. We show this in the Annex 2.

To understand the transmission of these external shocks to the REER, we study whether the effects of these shocks differ when conditioning by the depth of the foreign exchange market, the credibility of the central bank, and the country's credit risk. We find that in fact all these are key factors. Countries with shallower foreign exchange markets, less credible central banks, or higher credit risk (i.e., weaker fundamentals) all experience larger depreciations when hit by the external shocks, and impacts are particularly stronger in the left part of the REER change distribution.

In terms of policy effectiveness, we find that, in response to an increase in global volatility, as expected, a larger FXI yields a more muted change in the three deciles that we study, a pure volume effect[4] while FXI seems to reduce the depreciation pressures of U.S. monetary policy shocks only marginally, and especially around the median. Additionally, we split the sample in episodes of FXI selling international reserves (in response to depreciation pressures) and FXI purchasing reserves (in response to appreciation pressures)—the typical central bank "received wisdom"—and find symmetry in that, in response to VIX shocks and U.S. monetary policy shocks, selling international reserves mitigates depreciation pressures while purchasing international reserves dampens appreciation pressures.

A key insight is to understand the channels through which these effects operate and whether these happens in a linear or nonlinear manner. To the best of our knowledge, addressing this issue empirically is still missing in the literature, and this paper helps to fill this gap by documenting notorious nonlinearities. We show that, in response to VIX shocks, FXI ameliorates the impact on the real exchange rate distribution more in economies with shallower FX markets, in those with less credible central banks, and those with higher credit risk.[5] This is in part due to a base effect, associated with larger response of real exchange rate changes in economies that lack deep FX markets or with central banks with lower credibility, in absence of intervention. The differential effectiveness of FXI reflects the variation in the degree of FX market shallowness and central bank credibility. In this sense, when external financial shocks hit the economy, FXI helps to compensate financial market and institutional weaknesses, especially in the left tail. Also, FXI is more effective in situations of capital outflows events than in onflows events. This is consistent with anecdotal evidence that policymakers in small open economies are oftentimes more worried about excessive real depreciation than appreciation pressures (e.g., Calvo and Reinhart, 2002)—and reinforces the usefulness of the quantile regression approach used in this paper.

The above finding, however, does not imply that FXI is a silver bullet. In fact, when we split countries into heavy FXI users and non-heavy users, we find that FXI is substantially more effective in mitigating external shocks for non-heavy users of FXI policy. That implies that FXI is a reasonable policy to contain the (negative) effects of VIX and U.S. monetary policy shocks for

[4] The results are qualitatively unaffected when we not only control for contemporaneous FXI, but also for future interventions.

[5] Basu and others (2023) model related non-linearities theoretically for countries that face external borrowing constraints.

countries that do not rely on FXI too frequently. Moreover, we interpret the latter combined results as highlighting the importance of SOEs developing deep FX markets and building central bank credibility. Otherwise, relying on the expectation that the central bank will always be there to smooth FX markets would reduce incentives to invest in improving such macroeconomic fundamental—a typical example of moral hazard. Moreover, not doing it may eventually render the effectiveness of FXI weak, with subsequent real and financial deleterious effects.

In terms of magnitudes and costs (as measured by international reserve losses), we find that a larger and more durable effect of FXI on the 10th percentile of the REER distribution—that is, the weaker extreme. Thus, the arguments for these types of interventions are stronger when the objective is to avoid large depreciations (tail outcomes). Second, our estimates also shed light on the feasibility of achieving a given reduction in the REER decile of interest. Reducing in 10 percent the depreciation of the 10th percentile of the REER in the aftermath of a one standard deviation VIX shock would require a sizeable intervention, of about 2.8 percent of GDP. This is roughly 15 percent of the median holding of international reserves in our sample in 2019, and equivalent in size to the decline in reserves observed for the median country during the GFC. In other words, for the left tail, for each one percent of GDP of international reserves used to intervene in foreign exchange markets, the real exchange rate depreciation is mitigated in close to 3.5 percentage points. This contrasts with results in Blanchard and others (2013), who find, looking at averages, that one percent of GDP intervention renders a 2 percent change in the real exchange rate (almost half). This highlights that the elasticities of real exchange rate movements to foreign exchange intervention differ along the distribution. The latter is especially relevant when designing a policy of foreign exchange intervention, and supports methodologically shifting to panel quantile regressions, as opposed to standard panel (that is, average effects only) regressions.

CFMs do not seem to be effective in reducing the effects of any of these external shocks, regardless of whether those controls aim at stemming excessive inflows (associated with real appreciation pressures) or mitigating capital outflows (in event of rea depreciation). We also explore whether imposing CFMs enable a more effective FXI—under the logic that a relatively closed financial account strengthen the effectiveness of FXI. There seems to be some evidence that restricting the external financial account does contribute to enable FXI to become more effective, albeit mostly in the immediate aftermath of the shock.[6]

We extend the analysis to the impact of these external shocks on three deciles of the distribution of REER volatility. We find that only changes in the VIX affect the deciles we study. A higher VIX results in an increase in all deciles we study, with the 90th percentile of the empirical distribution

[6] A recent literature (e.g., Das and others, 2021) studies ex-ante CFM restrictions. Given the nature of our sample, we do not focus on such CFMs in this paper.

reacting more strongly. This suggests a higher probability of higher REER volatility in the aftermath of shocks. FXI seems to help contain the impact of VIX shocks on REER volatility.

Finally, we show that initial conditions matter. In particular, external shocks affect more net debtor countries compared to net creditor countries. This highlights the importance of strong macro policy frameworks as a way to cope with external shocks.

Related literature. The importance of global uncertainty/financial shocks, such as the VIX, in affecting the dynamics of key economic variables in SOEs has been thoroughly documented, including with Rey (2015), as well as the key contribution of U.S. monetary policy shocks, starting with Calvo and others (1993). Higher uncertainty or tighter U.S. monetary policy result in net capital outflows from SOEs, depreciating the real exchange rate. Our results are aligned with most of the received wisdom in that we take VIX and US monetary policy shocks as exogenous to SOEs. Our contribution (and eventual differences), however, lies in deviating from (previous) average results and analyzing the impact of external shocks on the changes in the distributions of real exchange rates.

Sterilized foreign exchange intervention gained theoretical support starting with Kouri's (1976) contribution to the portfolio balance approach—other channels include the signaling channel (Mussa, 1982) and the microstructure channel (Evans and Lyons, 2002). To the extent that domestic and foreign assets are not perfect substitutes, Kouri (1976) shows that foreign exchange intervention can be effective in affecting the exchange rate (and in a sticky-prices environment, also the real exchange rate). Lahiri and Vegh (2001) provide a theoretical argument for intervening in foreign exchange markets in response to large shocks, but not otherwise, as it is optimal only to mitigate larger shocks. Recent theoretical developments, building on the portfolio balance approach have shown the existence of optimal FXI effectiveness to contain movements in the exchange rate triggered by capital flows (e.g., Cavallino, 2019). Fanelli and Straub (2021) study the mitigating role of FXI in the presence of partial segmentation between domestic and foreign bonds and of pecuniary externalities affecting the volatility of the exchange rate, and Bianchi and Lorenzoni (2022) explore the prudential use of capital controls and foreign exchange intervention.

Despite theoretical arguments, the empirical evidence about the effectiveness of FXI has been mixed. Early contributions found scarce evidence of FXI effectiveness, mostly focusing on advanced economies (see Dominguez and Frenkel, 1993). A recent body of work finds more systematic support for FXI effectiveness. Blanchard and others (2015) find evidence of FXI affecting exchange rates, albeit only in the short run. Daude and others (2016) find FXI affects the level and volatility of the real exchange rate, while Adler and others (2019) find that FXI is effective in impacting the nominal and real exchange rates. Using daily data, Fratzscher and others (2019) find that FXI is a useful tool to smooth the path of exchange rates. Adler and others

(2019) theoretically show the output-inflation volatility trade-off arising from FXI by central banks with low credibility. While our results do not focus on the above-mentioned trade-off, we do find that credibility of the central bank affects the effectiveness of FXI, in line with their results. Recent evidence supporting the effectiveness of FXI lends credence to the fact that it has been a widely used policy tool (see Chamon and others 2019, who document the use of FXI in Latin American central banks that have an inflation target). Our paper contributes to this literature and to the policy debate by distilling conditions under which FXI could be an effective policy tool, under which fundamental macroeconomic weakness it becomes stronger, and how that is contingent on the alternative areas in the REER distribution.

Turning to capital controls, evidence of their effectiveness is quite elusive, and it is not focused on real exchange distributions either. For example, Magud and others (2018) find that only under very country-specific situations can capital controls gain some traction—and most of it achieves extending the maturity of capital flows without affecting the volume of inflows; the effectiveness on the exchange rate and on increasing monetary policy independence is negligible. Acosta-Henao and others (2021) note that changes to capital controls do not occur frequently and have not been systematically used. This is consistent with Fernandez and others (2015), who find that capital flow management policies are acyclical. Ben Zeev (2017), however, finds that the composition of CFMs may be important. De Gregorio and others (2000) find no impact of capital controls on the real exchange rate. Alfaro and others (2017) study the impact of capital controls on firms, as do Andreasen and others (2021), who find welfare losses from capital controls due to misallocation. All this evidence contrasts with theoretical models, such as Fahri and Werning (2014) who present a model in favor of using capital controls. We also find only marginally evidence of CFMs' effectiveness in containing the effects of external financial shocks, even when analyzing this over the REER distribution.

From a policy perspective, our paper contributes to a growing literature stressing potential policy complementarities when dealing with different shocks. For example, Adrian and others (2021) and Basu and others (2020) develop conditions under which the simultaneous use of CFM and FXI can mitigate the welfare costs of shocks.

Methodologically, we follow closely Gelos and others (2022) and Mano and Sgherri (2020). However, Gelos and others (2022) focus on the effects on capital inflows (specifically, portfolio flows) to a country, while we look into the real exchange rate.[7] They also look at external shocks (financial conditions, as given by U.S. corporate BBB yields, and the VIX in their robustness section) and whether some policies can contain the effects on the external shocks on a country's probability distribution of capital flow movements—what they label capital flows at risk. In terms

[7] In turn, Gelos and others (2022) borrow methodologically from Adrian and others (2019) and Adrian and others (2022), the latter focusing on growth-at-risk, which also works as proxy for welfare.

of policies, as we do, they investigate FXI and CFMs, but they also explore the effects of macro-prudential policies and domestic monetary policy. Mano and Sgherri (2020), on the other hand, focus on the response of three policy variables—FXI, policy rates, and NEER—to a capital flows shock.

The paper continues as follows. In the next section we describe the methodology and the data. In Section III we present the results, including robustness exercises and extensions, and section IV concludes.

II. Econometric Approach and Data

This section describes the methodology and the data that we use. Our goal is to quantify the impact of external shocks (VIX and U.S. monetary policy shocks[8]) over the distribution of real effective exchange rates, as well as gauging the effectiveness and complementarities between policies aimed at mitigating the effects of the shocks.

A. Methodology

To track the impact of external shocks on the distribution of the REER over time we estimate panel quantile regressions at different horizons. For practical and presentational reasons, we loosely represent the distribution of a variable by jointly showing the time-series response to a shock in the tenth percentile, the median, and the ninetieth percentile.[9]

Methodologically, we follow Adrian and others (2019), Adrian and other (2022) and Gelos and others (2022). In all cases, the authors track the evolution of the variable of interest in the aftermath of a shock. The methodology and its interpretation can be viewed as the quantile regression counterpart to local projections (Jordà, 2005). Contrary to standard local projections, which track the average response of a variable of interest in the aftermath of a shock, the quantile regression approach allows us to study the response of different deciles of the distribution of the variable of interest, especially those associated with its right and left tails.

To have a sense of quantile regressions, the estimated elasticity of the α^{th} percentile of the accumulated change in *y* between periods *t* and *t+h* with respect to a vector *Z* of variables, ρ_h^{α}, is obtained by minimizing[10]

[8] In Annex 2 we also explore the impact of cyclical deviations of terms-of-trade. However, we find that these shocks do not impact the REER, a result that is consistent with Fernandez, Schmitt-Grohé and Uribe (2017).

[9] We could of course do it for each decile, but that will add no substance and crowd the charts showing the results. Alternatively, presenting the time-series movements of a distribution will be hard to interpret economically.

[10] For the technical details about quantile regressions see Koenker and Bassett (1978) and Machado and Santos Silva (2019), and references therein.

$$\rho_h^{\alpha} = argmin \sum_{t=1}^{T-h} \left(\alpha \times \mathrm{I}_{y_{t,t+h} > \rho Z_t} \left| y_{t,t+h} - \rho Z_t + (1-\alpha) \times \mathrm{I}_{y_{t,t+h} < \rho Z_t} \right| y_{t,t+h} - \rho Z_t \right) \quad (1)$$

in which I is an indicator function, α refers to the percentile of the distribution, and the predicted value that results from the quantile regression that minimizes ρ_h^{α} is given by

$$\hat{Q}_{y_{t,t+h}}(\alpha) = \hat{\rho}_h Z_t \quad (2)$$

Specifically, our baseline specification is as follows:

$$Q\left(y_{i,t}^h; \alpha\right) = \rho_h^{\alpha} Z_t = \gamma_{i,\alpha}^h + \delta_{\alpha}^h + \beta_{\alpha}^h * shock_{i,t} + \theta_{\alpha}^h * X_{i,t} + \varepsilon_{i,t} \quad (3)$$

where $Q\left(y_{i,t}^h; \alpha\right)$ is the α^{th} quantile of the distribution of the variable of interest, *y*, *h* months after the shock that hits the economy on period *t*. The variable that we track is the change between *t-1* and *t+h* of the (log) real effective exchange rate (REER). The shock variable is either the VIX, or a U.S. monetary policy shock (as defined in Ilzetzki and Jin, 2021). In a robustness exercise, we also track the impact of changes in the US financial conditions index constructed by the IMF (IMF, 2017).[11] The quantile function is assumed to depend on a country fixed effect $\gamma_{i,\alpha}^h$, the external shock, $shock_{i,t}$, and on a vector $X_{i,t}$, capturing a number of country-specific, time varying, controls, including lagged values of international reserves to M2, trade openness, inflation, a banking crisis dummy, the exchange rate regime (represented by a dummy that takes the value of one if the country has a less flexible exchange rate), and U.S. inflation. International reserves in terms of M2 points to the solvency of the central bank's international reserves in case agents lose confidence in the domestic currency, thus we would expect to find a positive association with the real exchange rate.[12] Higher rates of inflation and banking crises are typically related with a weaker currency, while the latter can be associated with stronger trade balances. U.S. inflation is needed to control for nominal relative movements coming from the reserve currency. We drop exchange rate regimes that are rigid (including pegs) and collapsing regimes.[13] The exchange rate regime is added to control for differentiated effects of relatively less flexible exchange rate regimes.

[11] The index is a summary statistic of key financial variables including policy rates and the VIX. In this sense, it summarizes the effects of many of the individual shocks of interest.

[12] This is a typical measure of reserve adequacy, as include in the IMF's ARA metric (IMF, 2011 and 2013).

[13] That is, in the Ilzetzky and others (2021) fine classification we drop exchange rate regimes 1-4 (no separate legal tender or currency union, pre announced peg or currency board arrangement, pre announced horizontal band that is narrower than or equal to +/-2%, de facto peg, and pre announced crawling peg; de facto moving band narrower than or equal to +/-1%) and regimes 14-15 (freely falling and dual market in which parallel market data is missing). We consider as less flexible exchange rate regimes those with a regime value 5-8 in the Ilzetzky and other (2021) fine classification (pre announced crawling band that is narrower than or equal to +/-2% or de facto horizontal band that is narrower than or equal to +/-2%, de facto crawling peg, and de facto crawling band that is narrower than or equal to +/-2%) and more flexible regimes as those with a fine classification regime between 9 and13 (starting from pre announced crawling band that is wider than or equal to +/-2% all the way to fully flexible).

Note that the key parameter of interest is β_{α}^{h}. This parameter measures, for example, the percentage change in the REER that results from a one standard deviation shock to the VIX. We also include a dummy variable to capture dynamics that were specific to the global financial crises. Thus, we add a dummy that takes a value of one for the period September 2008-March 2009, and zero otherwise. Finally, we add the lagged cyclical component of the REER (detrended byway of an Hodrick-Prescott filter). This aims at accounting for initial conditions resulting from previous period's deviation of the real exchange rate from its trend—to proxy for over- and under-valuation effects.

In addition to the baseline quantile regressions in (3), we also study the role of policies and country characteristics in dampening/exacerbating the impact of shocks. In particular, we estimate an extension of (3), as follows:

$$Q\left(y_{i,t}^{h};\alpha\right) = \gamma_{i,\alpha}^{h} + \delta_{\alpha}^{h} + \beta_{\alpha}^{h} * shock_{i,t} + \sigma_{\alpha}^{h} * shock_{i,t} * P_{i,t} + \vartheta_{\alpha}^{h} * P_{i,t} + \theta_{\alpha}^{h} * X_{i,t} + \varepsilon_{i,t} \qquad (4)$$

In which $P_{i,t}$ is a state or policy variable that may affect the impact of the shock on the variable of interest. The policies that we consider are foreign exchange intervention (FXI) and capital flow management (CFM). The FXI metric is the size of the foreign exchange intervention in percent of the economy's GDP (both in U.S. dollars).[14] We control for the average intervention in the six months prior to the shock. In the main body of analysis, we use country-specific CFM (cumulative) stocks by coding each tightening CFM event as +1 and each easing CFM as -1, and zero otherwise. Thus, we compare the impact of shocks conditional on having a certain level of CFMs compared to the impact conditional on not having financial account restrictions before the shock (CFM(t-1)=0). It is worth mentioning that our measure of CFM includes restrictions on capital inflows as well as those on capital outflows. For robustness, we also modify (4) to include changes in policies in *t+h* and also consider alternative measures of capital account restrictions (Fernandez and others, 2016, Chinn and Ito, 2006).

Finally, the paper studies the potential country characteristics making interventions effective. For example, we study how market shallowness and inflation anchoring affect the effectiveness of FXI in containing REER movements following shocks. With this aim, we extend the specification in (4) as follows:

$$Q\left(y_{i,t}^{h};\alpha\right) = \gamma_{i,\alpha}^{h} + \delta_{\alpha}^{h} + \beta_{\alpha}^{h} * shock_{i,t} + \sigma_{\alpha}^{h} * shock_{i,t} * FXI_{i,t} + \varphi_{\alpha}^{h} * shock_{i,t} * Z_{i,t} * FXI_{i,t} + \tau_{\alpha}^{h} * shock_{i,t} * Z_{i,t} + \vartheta_{\alpha}^{h} * FXI_{i,t-1} + \omega_{\alpha}^{h} * Z_{i,t-1} + \theta_{\alpha}^{h} * X_{i,t} + \varepsilon_{i,t} \qquad (5)$$

[14] Given that most of the countries in our sample are inflation targeting economies, FXI refers to sterilized intervention. However, for robustness, we run the exercise only for the inflation targeting countries in the robustness section. Results remain unaltered.

In which $Z_{i,t}$ is the country-specific variable of interest. In this part of the analysis will be mostly focused on tracking the statistical and economic significance of the coefficient φ_{α}^{h}.

B. Data

Our empirical analysis uses data from a variety of sources at various frequencies. The REER data comes from IMF's Information System Notice (INS), while trade openness (exports + imports, in percent of GDP), international reserves (in percent of broad money, M2), CPI inflation, terms of trade, and real GDP, are all from IMF's International Financial Statistics (IFS) and World Economic Outlook (WEO). CFM raw data are from IMF data and Magud and others (2018) and FXI is from Adler and others (2021).[15] The de facto exchange rate regime is provided by Ilzetzki, Reinhart, Rogoff (2021) and VIX data comes from the Chicago Board of Exchanges. Banking crises dummies are from Laeven and Valencia (2020), while U.S. monetary policy shocks are from Ilzetzki and Jin (2021) following the approach by Gertler and Karadi (2015). REER, VIX, U.S. monetary policy shocks, CPI inflation are of monthly frequency. We proxy exchange rate shallowness with the ask-bid spread, which is collected from Bloomberg and Refinitiv. The measure of inflation anchoring comes from Bems and others (2021). Sovereign spreads come from Bloomberg. Trade openness, international reserves, and real GDP are of quarterly basis, converted to monthly data using splined approximations—al other data has monthly frequency. In robustness exercises we use the index of capital account openness proposed by Chinn and Ito (2006), the index of capital control measures in Fernandez and others (2016), and the net foreign asset position estimates presented in Lane and Milessi-Ferretti (2018). The balanced panel data spans from 2000M1 to 2020M12 for 28 mostly inflation targeting economies.[16] Tables 1 and 2 present the list of countries and some descriptive statistics.[17]

III. Results

This section presents the results of our quantiles regression estimations. As described earlier, it begins by quantifying the impact of external shocks on key deciles of the distribution of REER changes (which abusing notation, we will interchangeably call REER distribution), then it assesses the role of policies in mitigating the impact of external shocks, it turns to exploring the potential country-specific characteristics affecting the effectiveness of policies, and it concludes by conducting robustness exercises and extensions to the main econometric specification.

[15] It is worth noting that the data on CFMs is based on observation of the implementation of various alternative types of CFMs but does not account for its intensity. In this, we follow the existent literature for a lack of a better, intensity-adjusted metric of CFMs.

[16] Of our 28 countries, 24 are classified as inflation targeting countries in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) as of 2021. The other have crawl-like arrangements, albeit some have explicit definitions of price stability (e.g., Switzerland).

[17] All Figures and Tables are shown in Annex 1.

A. Effects of External Shocks

Recall that our analysis tracks the impact of different external shocks on different deciles of the distribution of our variable of interest (the real effective exchange rate $\boldsymbol{REER_t}$).[18] We normalize the real effective exchange rate such that REER=100 in M1-2000 (first observation).

We start by exploring the effect of global uncertainty shocks, as given by the VIX. Consistent with Figure 1, Figure 2 shows that a one standard deviation increase in the VIX results in a weaker currency throughout the distribution, that is, shifting the entire curve to the left. Yet, the effect is stronger (as measured by a larger reduction) in the left side of the distribution. Intuitively, an increase in global volatility not only weakens currencies in small open economies on average, but it tends to increase the likelihood of more extreme depreciations, as measured by the shift in the left of the distribution.

Shocks to the U.S. monetary policy rate (Figure 3) tend to depreciate SOEs' currencies throughout the REER distribution, albeit timing varies. On impact, US monetary policy shocks increase the likelihood of large depreciations, but this impact on the left tail of the distribution is short-lived. By contrast, these shocks appear to exert more lasting depreciation pressures on the median and on the right tail of the distribution.

So far, we have assumed that shocks have a similar impact on the REER, regardless of whether these are favorable or adverse shocks. Figures 4-5 explore whether positive and negative shocks have symmetric or asymmetric effects. Results suggest that shifts in the REER distribution are driven exclusively by VIX increases, as the impact on different moments of the REER distribution stemming from VIX reductions are not statistically significant (Figure 4). We still observe a stronger effect on the left side of the REER change distribution. As expected, US monetary policy tightening results in large, protracted leftward shifts across the REER distribution (towards weaker currencies), with effects being larger at the left-tail of the distribution. By contrast, the impact of US monetary policy easing is mostly not-statistically significant.

Thus, our results so far suggest that adverse shocks tend to result in increased depreciation pressures, as this is especially driven by shifts in the left-tail of the REER distribution. Favorable shocks leave the REER distribution mostly unchanged.

[18] In the Extensions and Robustness section we also assess the impact on the volatility of the REER ($\boldsymbol{\sigma[REER_t]}$), as given by the 6-month rolling standard deviation of $\boldsymbol{REER_t}$.

B. The Role of Policies: FXI and CFM

Given these external shocks, now we turn to studying the effectiveness of foreign exchange intervention as a tool to smooth REER movements driven by VIX shocks. Following the specification in (4), we allow the impact of the shock to vary depending on the level of FXI at the month of the shock. Figure 6 presents the REER deciles' response for countries pursuing strong FXI (defined as above the 75th percentile of the FXI distribution) and weak FXI (defined as below the 25th percentile of the FXI distribution). Our findings suggest that size matters, as the stronger the FXI, the more FXI mitigates the real depreciation triggered by an increase in global volatility. The mitigating role of FXI is stronger and more durable for the 10th percentile and the median of the REER distribution, as shown in the upper and middle rows of Figure 6.

The above results have two important policy implications. The first is that, given the larger and more durable effect of FXI on the 10th percentile of the REER distribution, the arguments for these types of interventions are stronger when the rationale is to avoid large depreciations (tail outcomes). Second, our estimates also shed light on the feasibility (and cost) of achieving a given reduction in the REER decile of interest. For example, mitigating the depreciation of the 10th percentile of the REER by 10 percent in the aftermath of a (one standard deviation) VIX shock would require an intervention of 2.8 percent of GDP, which is roughly 15 percent of the median holding of reserves in our sample in 2019 and equivalent to the decline in reserves observed for the median country during the GFC. This points to a relatively large "sacrifice" of reserves needed to mitigate the impact on the REER of such shock.

Similarly, Figure 7 explores the mitigating role of FXI following US monetary policy shocks. Results suggest that FXI marginally reduces depreciation pressures stemming from U.S. monetary policy shocks, especially in the central section of the distribution.

Next, we explore potential differences in the response to the REER to shocks, conditional on the direction of the FX intervention. That is, we compare the effectiveness of FXI when it involves selling international reserves to mitigate the impact of shocks that threaten to weaken the domestic currency, and when it involves purchases of international reserves to reduce appreciation pressures. We find that, when hit by a VIX shock or US monetary policy shocks, negative FXI, in the form of selling reserves, is particularly effective in mitigating depreciation pressures around the median and left tail of the REER distribution, while purchases of international reserves are effective in dampening appreciation pressures in the middle and right tail of the REER distribution (Figures 8 and 9).

We turn to the question of whether the frequency of FXI use has any impact in terms of effectiveness. To that end, we create a dummy variable that take the value of one for heavy users

of FXI and zero otherwise. We define heavy users as countries that have an average FXI value over the sample is above the 75th percentile of the FXI distribution.

Our results show that using FXI sporadically enhances its effectiveness. In other words, FXI is more effective in countries that do not rely systematically on FXI—as, presumably, using FXI too frequently, reduces the credibility of a central bank. Figure 10 illustrates this point neatly, when analyzing shocks to the VIX. It illustrates that the depreciation pressures that result from an increase in the VIX are smaller (that is, more muted) when countries intervene and the country is not a heavy-user of FXI, compared to heavy-users that intervene (Panel A). Our results go in the same direction when studying U.S. monetary policy shocks, though with smaller differential effects (Panel B).

We perform similar exercises as those run for FXI, finding that CFM is mostly ineffectual in mitigating external shocks (Figure 11). We also test for the differential effects that may result from imposing CFM for economies that are heavy users of CFMs compared to those that are not. We find little differentiation between heavy users of CFMs and other countries, with CFMs being relatively ineffective tools to dampen the impact of the external shocks that we analyze on the REER (Figure 12).

However, our results show that CFM may complement FXI for some shocks and for some quantiles (Figure 13). Focusing on cases for which results are statistically significant, we find that the effectiveness of FXI is larger in financially closed economies. For example, the marginal effect of FXI in reducing the impact of a VIX shock is stronger if strong CFMs are put in place—but mostly in the median of the distribution and temporarily. Maybe due to endogeneity, we find that for U.S. monetary policy shocks CFMs end up reducing the mitigating effects of FXI—and again having some statistical significance only the median of the distribution. Far from being conclusive, these results highlight the need to further explore the potential complementarities between policy tools and the channels though which these policies interact.

C. When is FXI Most Effective?

So far, we have established the effectiveness of FXI as a tool to mitigate the impact of external shocks on the REER, especially on the left tail of the REER distribution. Yet, the rationale and effectiveness of FXI may depend on country characteristics. For example, Basu and others (2020) theoretically show that FX market shallowness is an important determinant of the optimality of using FXI. Adler, Lama, and Medina (2019) find that FXI can help reduce output volatility in countries with limited central bank credibility. Finally, countries with weak macro fundamentals (for example, those that have higher sovereign credit risk), may suffer more in the aftermath of

external shocks. Given this, this section provides an empirical assessment on how FXI effectiveness varies with these three variables.

Figures 14 and 15 showcase the differential effectiveness of FXI in mitigating VIX shocks along the REER distribution in countries with high and low inflation anchoring, and with high and low FX market shallowness, respectively. The first observation is that, in the absence of intervention, economies that lack deep FX market or with less credible central banks display a larger real exchange rate change across the distribution following shocks, which is in part due to a base effect. Second that, regardless of the degree of inflation anchoring or FX depth, in most cases FXI appears to mitigate the impact of these shocks on the REER. The only exception is in the case of high inflation anchoring countries, where FXI appears mostly ineffectual. Given that most countries in our sample are inflation targetters, this would speak for the credibility of the central bank along with the flexibility of the exchange rate regime, which implies relatively low use of FXI. The third point to note is that FXI appears to be most effective in containing depreciations in countries with either low inflation anchoring or shallow FX markets, albeit with differences along the inflation distribution as, for each percentage point of real depreciation, the effectiveness of FXI becomes stronger in these types of countries. In the case of inflation anchoring, Figure 14 shows that FXI yields a more muted change in the 10th and, especially, 50th percentile of the REER distribution in countries with low inflation anchoring. In the case of FX market depth, FXI is more effective in countries that have shallower markets, but the difference between the two groups of countries is mostly significant in the 50th percentile. The differential effectiveness of FXI in fact reflects the variation in the degree of FX market shallowness and central bank credibility, in that when external financial shocks hit the economy, FXI helps to compensate the existing financial market and institutional weaknesses in these economies, especially in the left tail.

Figures 16 and 17 show that sovereign credit risk is another important factor affecting the impact of external shocks on a country's REER as well as the effectiveness of FXI. Countries with high credit risk (i.e., those with high EMBIG spreads[19]), experience sharper depreciations, especially at the 10th percentile and the median of the distribution (Figure 16). In part due to this larger impact, FXI appears to be more effective in containing excessive depreciations. In all cases, differences are larger in the immediate aftermath of the shock.

The above finding, however, does not imply that FXI is a silver bullet. On the contrary, the problem is relying on FXI to substitute for sound macroeconomic policy frameworks and market development. As shown in Figure 10, the effectiveness of FXI is dependent on the frequency with which this tool is used, suggesting that overusing it can limit (or even reduce over time) its power as a stabilizing tool. Moreover, the use of FXI is likely to exacerbate issues of weak macro

[19] We classify countries with no EMBIG information in a specific month as low EMBIG countries.

fundamentals and financial underdevelopment, as FXI is substantially more effective in mitigating external shocks for non-heavy users of FXI policy. That implies that FXI is a reasonable policy to contain the (negative) effects of VIX and U.S. monetary policy shocks for countries that do not rely on FXI too frequently. Moreover, we interpret the latter combined results as highlighting the importance of SOE developing deep FX markets and building central bank credibility. Otherwise, relying on the expectation that the central bank will always be there to smooth FX markets would reduce incentives to invest in improving such macroeconomic fundamental—a typical example of moral hazard. Moreover, not doing it may eventually render the effectiveness of FXI weak, with subsequent real and financial deleterious effects.

These results are consistent with theoretical work by Adler and others (2019) and in Adrian and others (2021), that show that FXI should be used with caution. As pointed by Adler and others (2019), through the lens of a theoretical model, the use of FXI in countries with low inflation anchoring can generate trade-offs between output stabilization and inflation reduction. This, in turn, could exacerbate the inflation anchoring problem. FXI can also lead to moral hazard and exacerbate problems of currency mismatches, as documented in Kim, Mano and Mrkaic (2020). The frequent use of FXI can also forestall external adjustments when imbalances arise (see Adrian and other, 2021).

D. Extensions and Robustness

To further dig into the impact of shocks and policies on REER behavior, we estimate the impact of external shocks on the different deciles of the real effective exchange rate volatility (Figure 18). VIX shocks have a statistically significant impact on REER volatility, and they are associated with a rightward shift in the distribution, that is, volatility increases. US monetary policy changes exacerbate volatility, albeit in the latter two cases the impact is not statistically significant for any of the deciles of the volatility distribution that we study.

Zooming into the impact of VIX shocks, we study whether the direction of shocks affects the response of the REER volatility distribution. As with the level, our results show that increases in REER volatility are mostly driven by increases in the VIX, and that this impact is stronger on the right tail of the distribution—i.e., VIX spikes amplify high levels of REER volatility (Figure 19). By contrast, reductions in the VIX have a smaller impact in REER volatility, and it is only (marginally) statistically significant for the median.

We also analyze the role of FXI on the volatility of the REER. Since the only shock that has a statistically significant effect in the volatility of the REER is the VIX, we focus only on this shock. We find that foreign exchange intervention has only a moderate impact in terms of mitigating the impact of VIX shocks on REER volatility (Figure 20). In particular, FXI marginally reduces the

median value of REER volatility, but does not seem to prevent large increases in volatility (as it does not affect the right tail of the distribution).

Given the prominence of VIX shocks in explaining REER movements, next we study the role of initial conditions in shaping the response of the REER to these shocks. More specifically, we estimate equation (4) focusing on the role that capital account openness and net foreign asset positions play in mediating the impact of foreign shocks on the REER. In our exercise we use two alternative measures of capital account openness—Chinn and Ito (2006) and Fernandez and others (2016). We differentiate countries according to whether their capital account openness index is above or below the median value. Our results point to mixed evidence regarding the impact of capital account openness. We find that the mitigating/amplifying role of capital account openness is sensitive to the index used (Figures 21 and 22) and the extent to which openness stems from measures affecting inflows or outflows (Figure 22). This is in line with the elusive benefits of capital controls found in the previous section. Our findings show that a country's net foreign asset position affects the impact of external shocks on the REER. Net creditor countries experience more moderate movements in the REER following VIX shocks, and differences are significant through most of the horizon we analyze.

One potential concern about the results stemming from the interaction between shocks and policies, is that they may be contaminated by subsequent interventions or changes in CFM. We tackle this concern by presenting results for FXI where equation (4) is expanded to include FXI in month $t+h$. Figure 23 shows that, while there are quantitative differences, results do not qualitatively change.

Finally, we perform some robustness exercises. The first focuses on real bilateral local currency-US dollar exchange rates (LCUS) and the second uses the US financial conditional index (FCI) computed by the IMF (see IMF 2017). Figure 24 shows that the dynamics of the bilateral LCUS real exchange rate resembles REER dynamics, independently of the shock analyzed. Figure 25 shows that REER dynamics in the aftermath of US FCI shocks follow closely those of VIX shocks. This result is a byproduct of the salience of the VIX in the US FCI. [20]

IV. Conclusions

We study the effects of external shocks (given by VIX and U.S. monetary policy) on the distributions of real exchange rate levels in small open economies using quantile regression analysis. Defining the real exchange rate levels as the policy objective, we also look into the

[20] We also estimated alternative specifications and explored restricting our sample. In particular, we extended the model in (3) to include interest rate differentials between each SOE in our sample and the US, and we estimated the model in (3) for a sample that excluded Switzerland. All results remained unchanged to these robustness exercises and are available upon request.

mitigating effects of foreign exchange intervention and capital flow management policies for the economies that face the external shocks—and whether a less open financial account increases the effectiveness of foreign exchange intervention, that is, the interaction of the policies.

Results suggest that global uncertainty (as reflected in the VIX) and global financial conditions (as given by U.S. monetary policy) impact REER levels and volatility distributions, and not always symmetrically. These results are driven by negative shocks, as only higher levels of the VIX, tighter U.S. monetary policy shift the REER distributions to the left, suggesting a role for domestic policies and shocks to shift the REER distribution to the right. The VIX is the only of these external shocks that also impacts the distribution of the REER volatility, shifting it to the right—that is, towards higher levels of REER volatility, driven especially by the right tail. Notably, we find that countries with shallower foreign exchange markets, less credible central banks, and higher credit risk (that is, weaker fundamentals), experience sharper real depreciations, especially in the left part of the REER distribution.

In terms of policy, foreign exchange intervention seems to partially offset the impact of external shocks (but only if applied in a sizeable magnitude and not very frequently), especially in countries with shallow FX markets, low central bank credibility, and higher credit risk (i.e., weaker fundamentals), while capital flow management appears ineffective in most cases, other than to enable a more effective foreign exchange intervention—as oftentimes assumed from theoretical models. Also, we find that FXI is much more effective in containing the effects of external shocks when used infrequently, highlighting the need to deepen FX markets, increase central bank credibility, and strengthen macroeconomic fundamentals before FXI policy becomes much less effective.

Importantly, the size of mitigation effects of foreign exchange intervention varies over the distribution of the REER, which highlights the importance of moving away from averages into the effects on the distribution, especially when thinking about counter-cyclical policies and extreme (in some case crises) events. And the sacrifice in terms of reserves could be large. For example, we find a larger and more persistent effect of FXI on the 10th percentile of the REER distribution than in other parts if the REER distribution. Thus, the arguments for these types of interventions are stronger when the objective is to avoid large depreciations (tail outcomes). The costs are also high, as mitigating the depreciation of the 10th percentile of the REER in the aftermath of a 10 percent VIX shock would require a sizeable intervention, of about 2.8 percent of GDP, which is roughly 15 percent of the median holding of international reserves in our sample in 2019, and equivalent in size to the decline in reserves observed for the median country during the GFC.

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Annex 1. Figures and Tables

Table 1. List of Countries in Analysis

Western Hemisphere	Europe	Asia	Africa
Brazil	Czech Republic	India	South Africa
Canada	Iceland	Indonesia	
Chile	Israel	Kazakhstan	
Colombia	Hungary	Republic of Korea	
Costa Rica	Norway	Malaysia	
Mexico	Poland	Philippines	
Peru	Romania	Singapore	
	Russia	Thailand	
	Sweden	Vietnam	
	Switzerland		
	Türkiye		

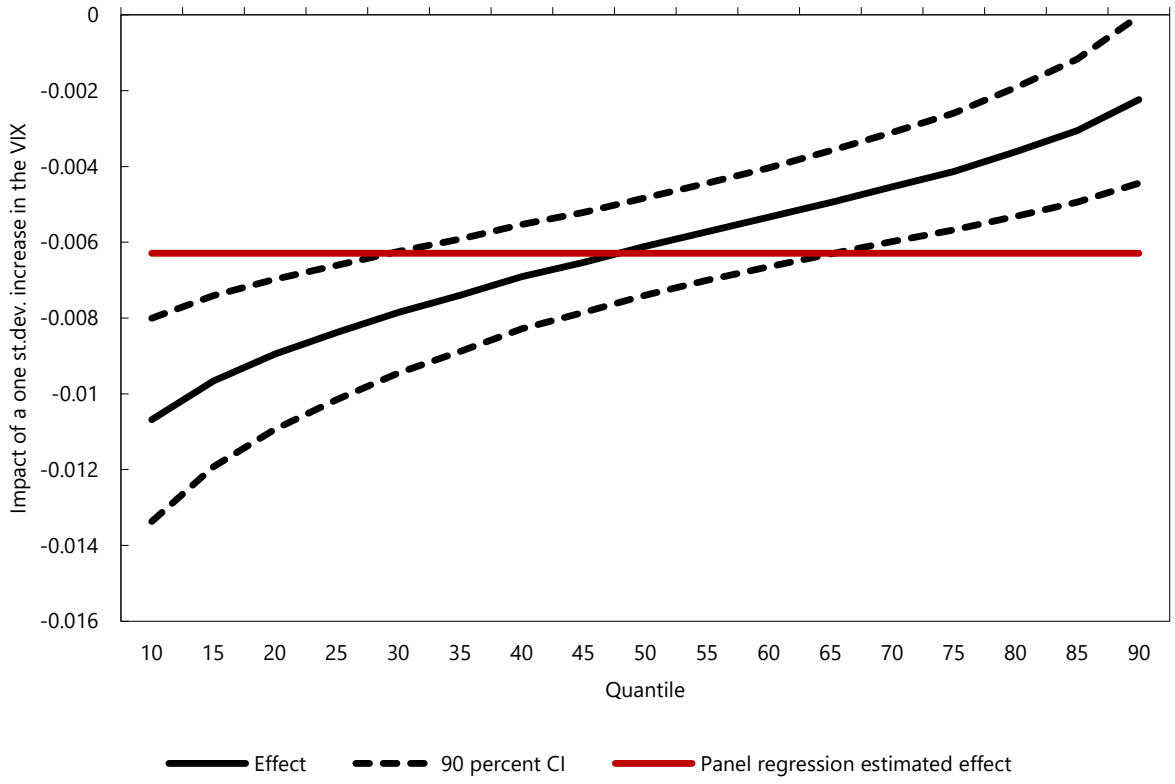
Note: Countries are grouped according to IMF regions.

Table 2. Descriptive Statistics

Variable	average	st. dev.	min	max
ln (REER)	4.56	0.14	3.99	5.11
ln (ToT)	4.60	0.04	4.36	4.75
VIX	19.09	8.10	9.51	59.89
US Monetary policy shocks	-0.003	0.03	-0.17	0.12
Inflation, in percent	4.07	3.35	-2.10	32.93
Monetary policy rate (6 month rolling average, in percent)	5.49	4.33	0.00	37.07
Reserves over M2 (6 month rolling average, in percent)	19.88	15.61	2.61	93.88
Exports+Imports over GDP (annual, in percent)	88.99	66.61	22.11	437.33
US inflation (month-over-month, in percent)	0.17	0.30	-1.79	1.37
FXI over GDP, in percent	0.09	0.82	-8.53	7.44
Cummulative CFM	0.22	2.18	-9.00	13.00

Note: Descriptive statistics are for the 28 countries and months included in the econometric analysis.

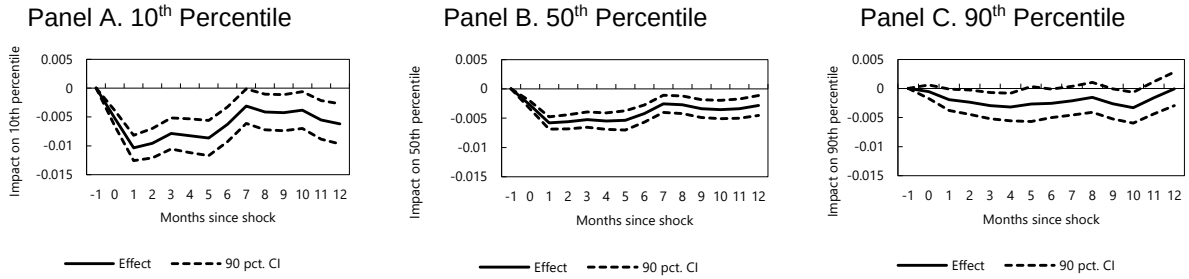
Figure 1. The Heterogeneous Impact of VIX Shocks Along the REER Distribution



Note: The chart presents the estimated impact of changes in the VIX at different quantiles of the distribution of the change in the (log) REER. These are estimated using a panel quantile regression approach described in Section II. It also shows the estimated impact stemming from a fixed effects panel regression.

Figure 2. Impact of VIX shocks

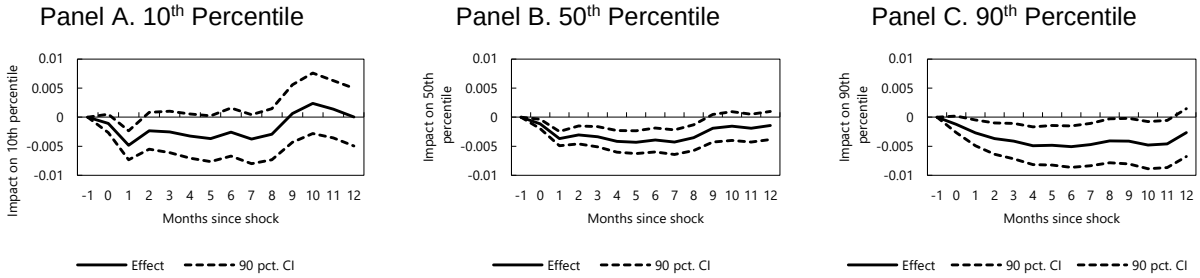
REER change



Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX.

Figure 3. Impact of surprise US MON POL shocks

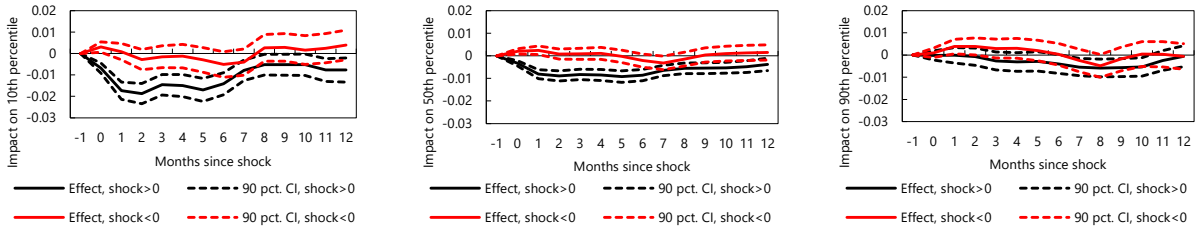
REER change



Note: Each panel shows the response of a specific decile of the (log) REER change distribution with respect to a one standard deviation change in US monetary policy shocks.

Figure 4. Impact of VIX shocks, by direction of shock

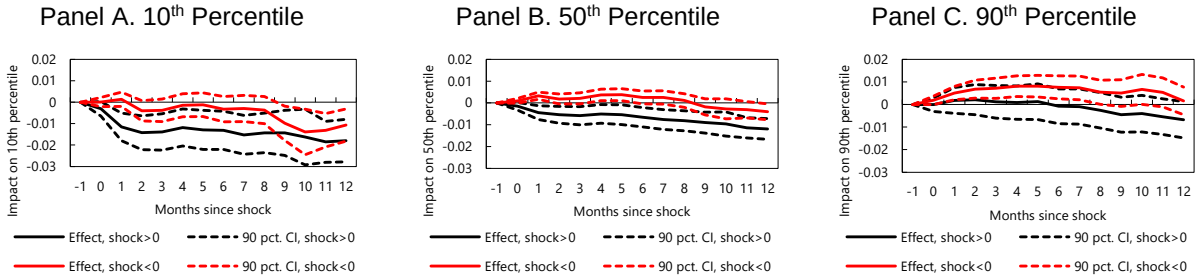
REER change



Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the direction of the shock.

Figure 5. Impact of US Mon Pol shocks, by direction of shock

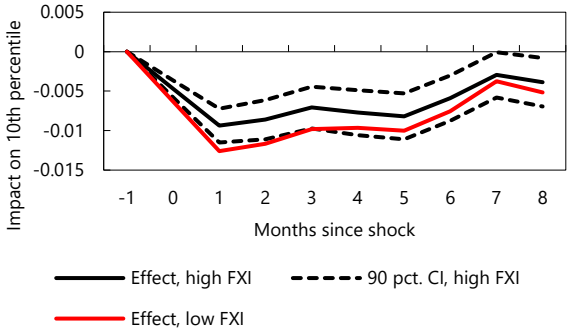
REER change



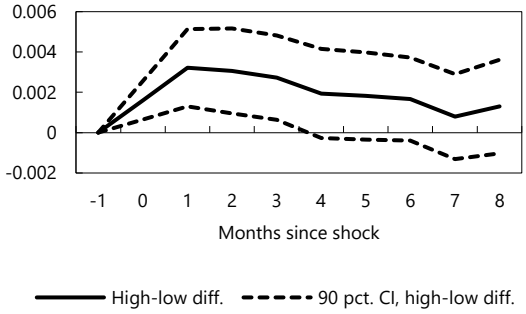
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in US monetary policy shocks, conditional on the direction of the shock.

Figure 6. Impact of VIX shocks on REER—the role of FXI

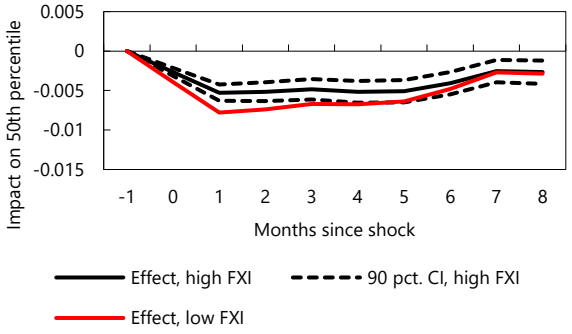
Panel A. 10th Percentile



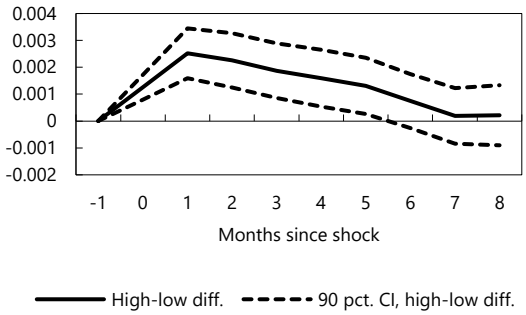
Panel B. 10th Percentile, Strong vs. Weak FXI response



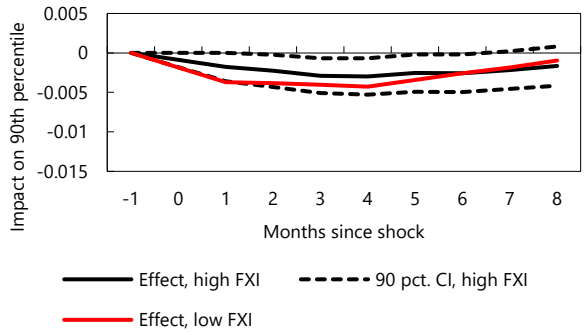
Panel C. 50th Percentile



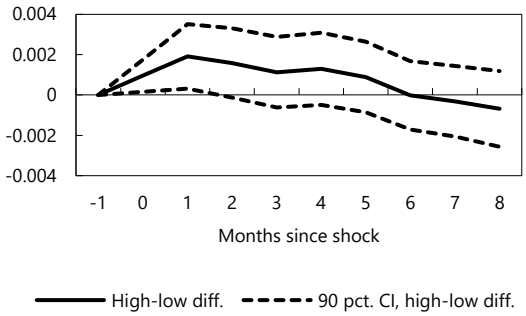
Panel D. 50th Percentile, Strong vs. Weak FXI response



Panel E. 90th Percentile



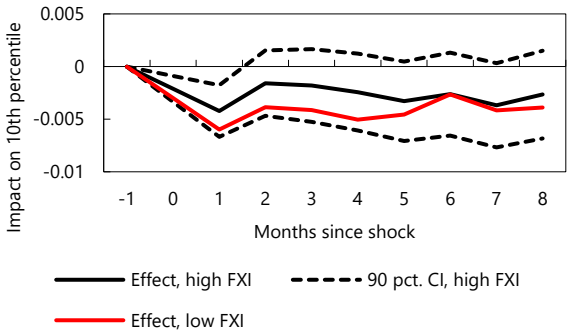
Panel F. 90th Percentile, Strong vs. Weak FXI response



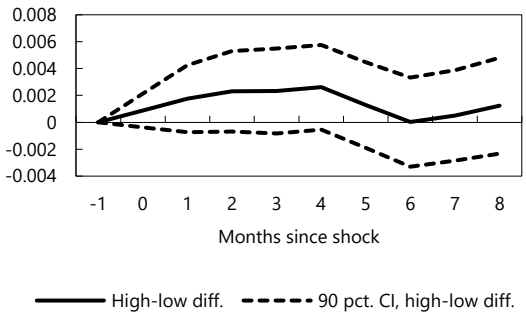
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

Figure 7. Impact of US Mon Pol shocks on REER—the role of FXI

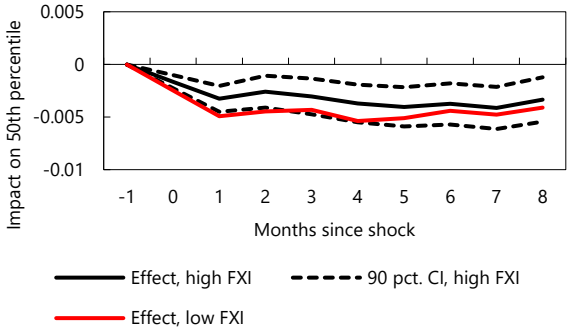
Panel A. 10th Percentile



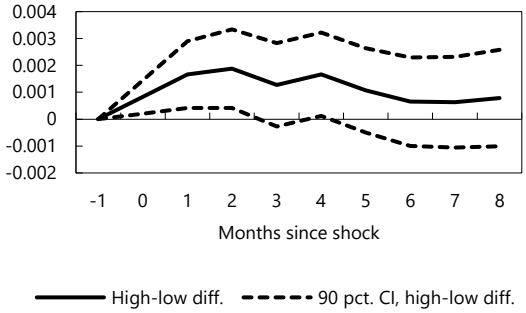
Panel B. 10th Percentile, Strong vs. Weak FXI response



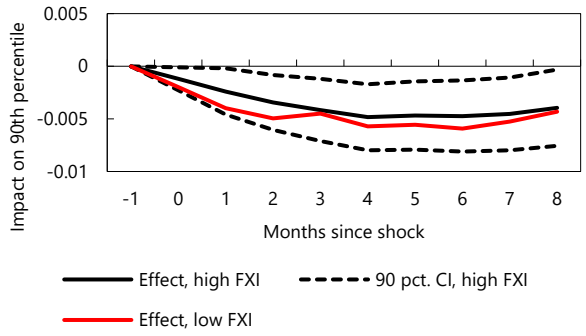
Panel C. 50th Percentile



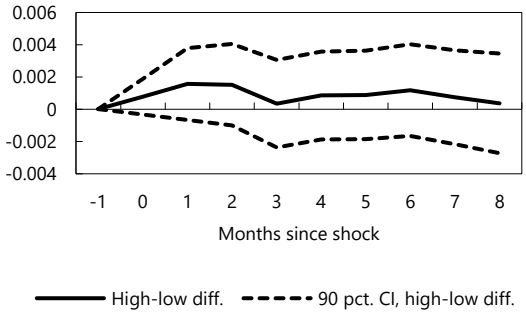
Panel D. 50th Percentile, Strong vs. Weak FXI response



Panel E. 90th Percentile

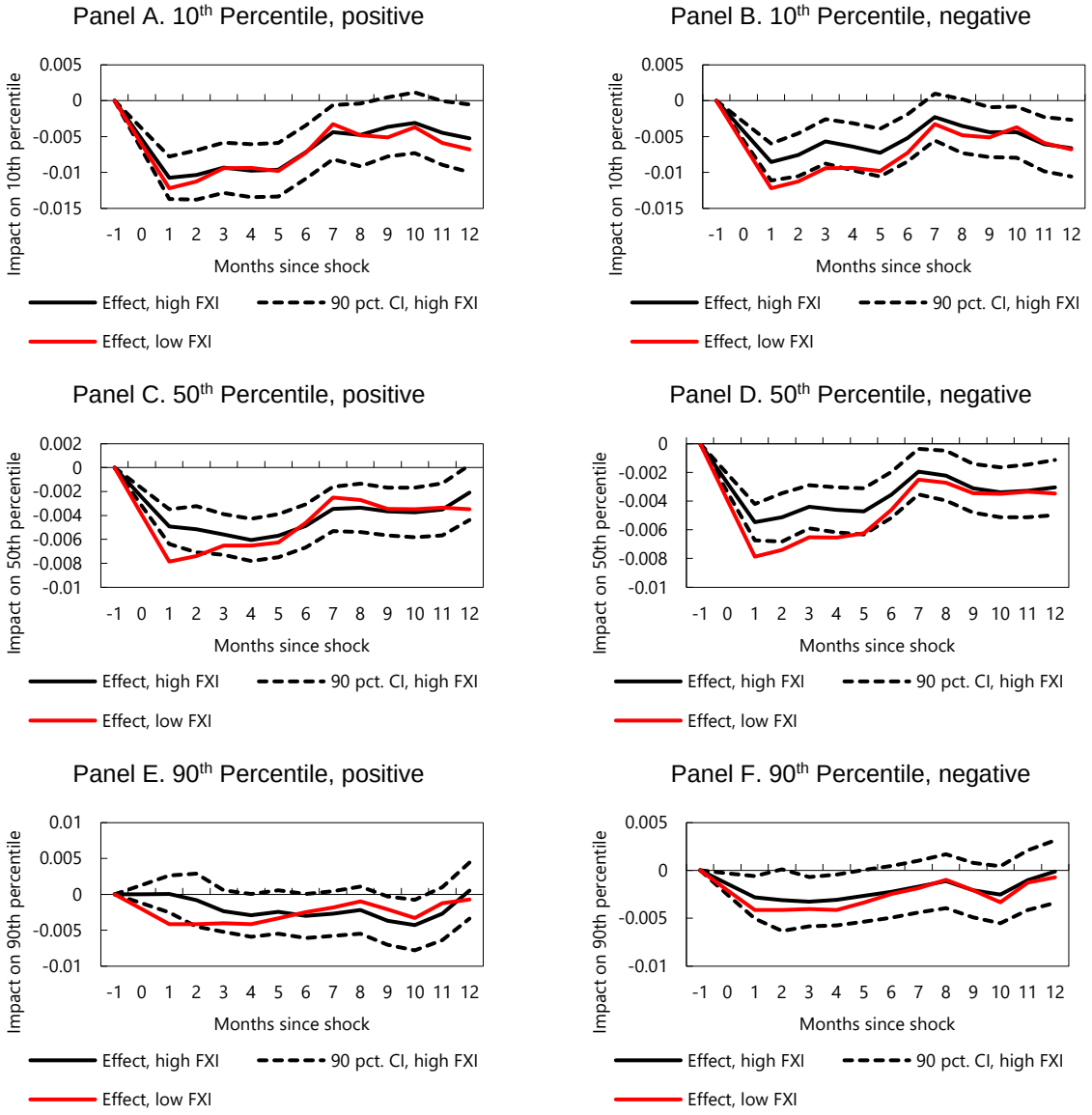


Panel F. 90th Percentile, Strong vs. Weak FXI response



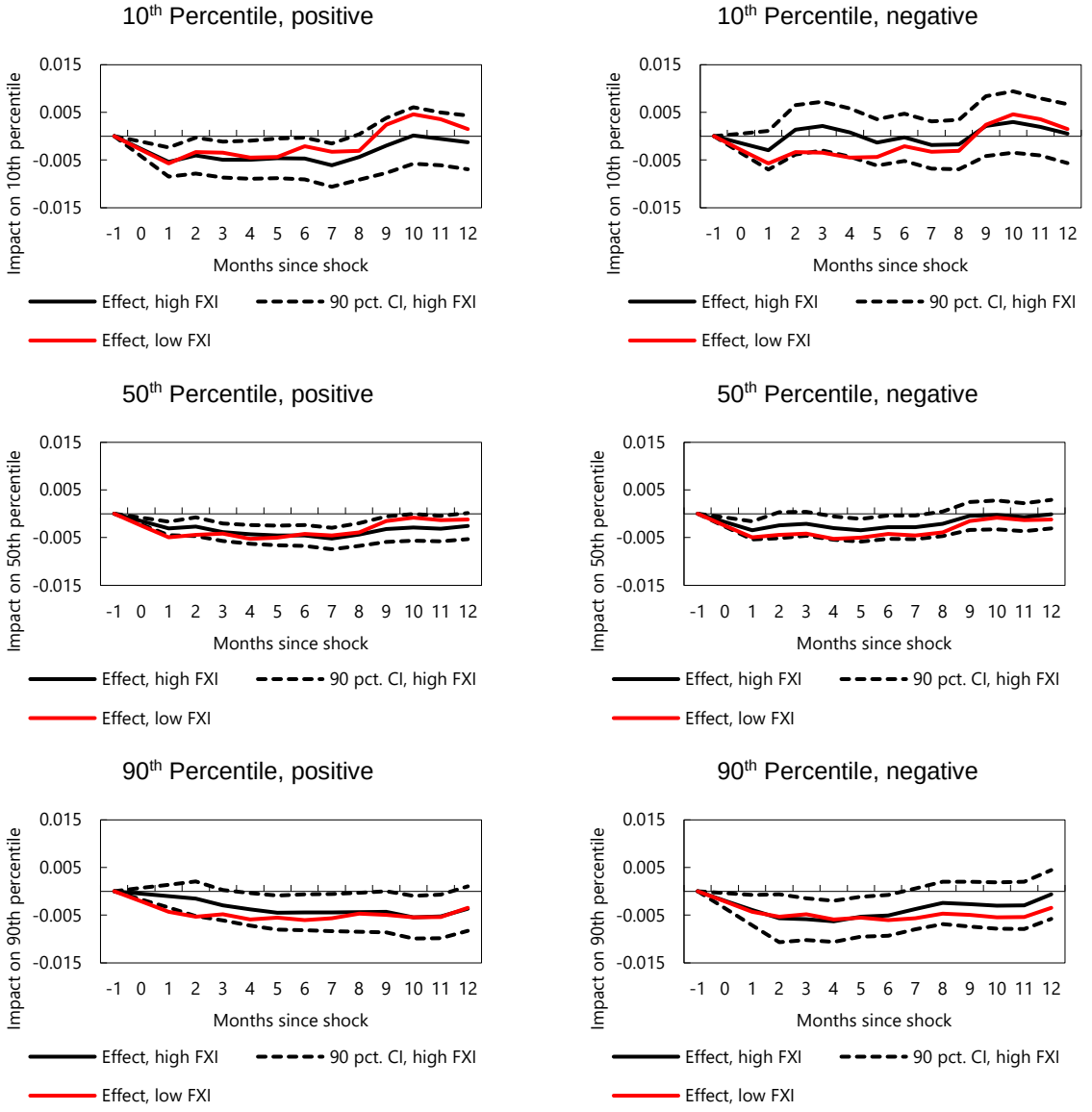
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in US monetary policy shocks, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

Figure 8. Impact of VIX shocks on REER—the role of FXI, by direction of intervention



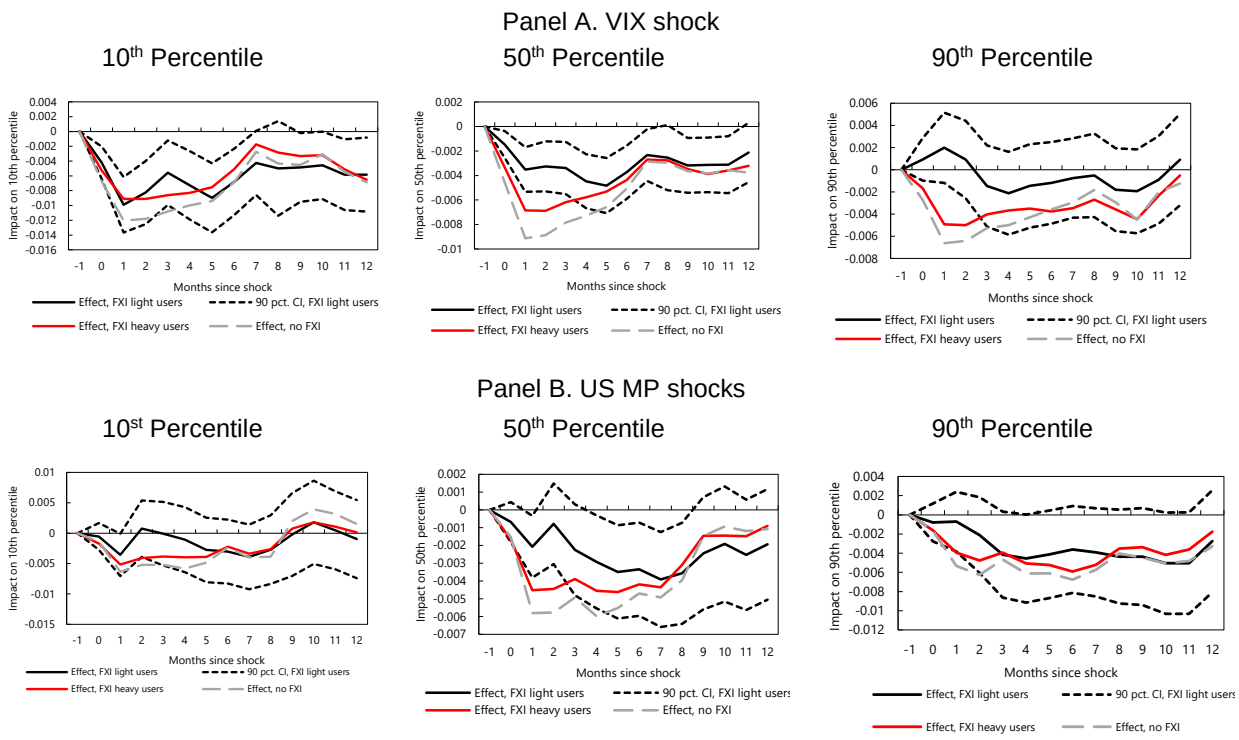
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the level of FXI and the direction of the intervention. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

Figure 9. Impact of US MON Pol shocks on REER—the role of FXI, by direction of intervention



Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the US monetary policy shock, conditional on the level of FXI and the direction of the intervention. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

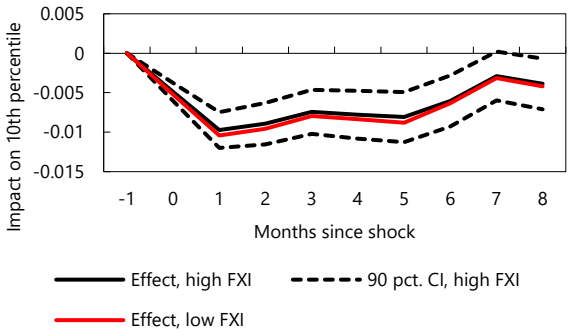
Figure 10. Impact on REER, by use of FXI



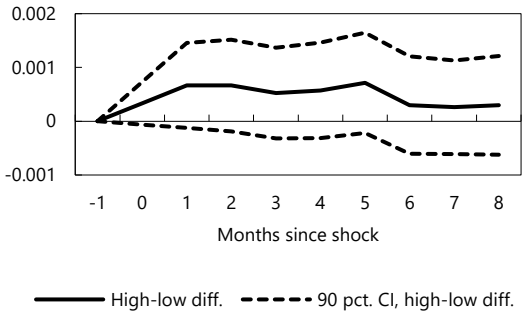
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in each shock, conditional on the level of FXI and the frequency of intervention. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

Figure 11. Impact of VIX shocks on REER—the role of CFM

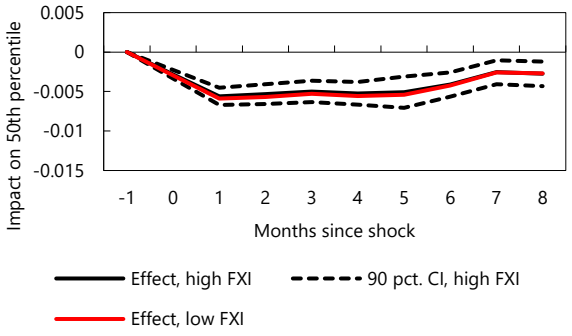
Panel A. 10th Percentile



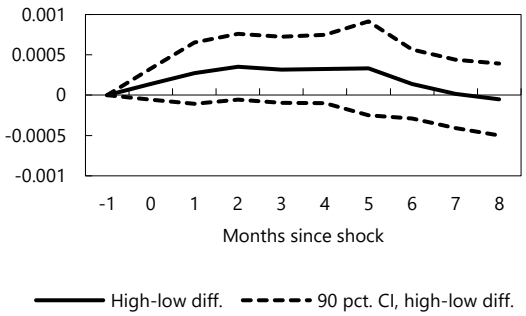
Panel B. 10th Percentile, Strong vs. Weak CFM response



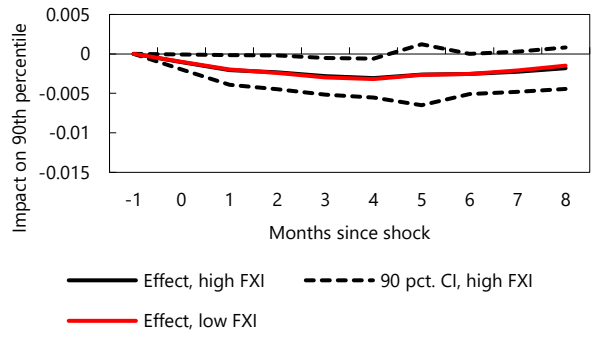
Panel C. 50th Percentile



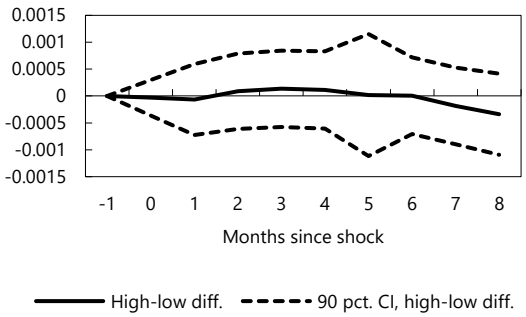
Panel D. 50th Percentile, Strong vs. Weak CFM response



Panel E. 90th Percentile

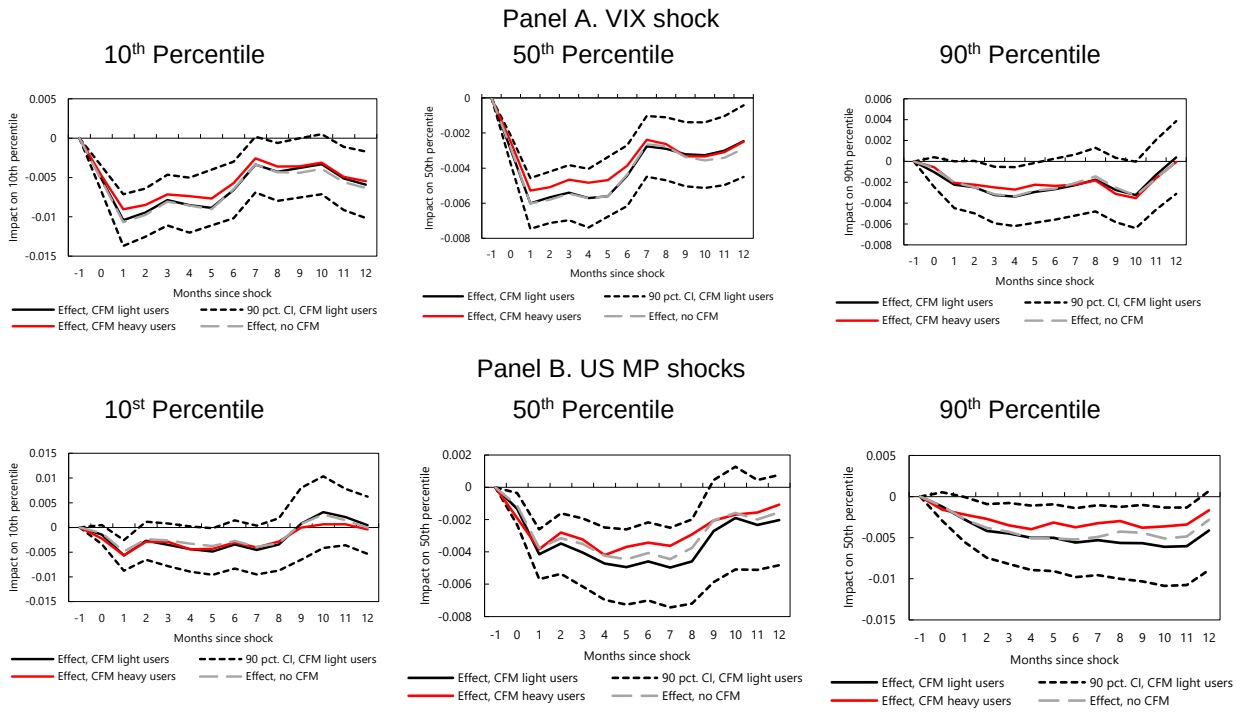


Panel F. 90th Percentile, Strong vs. Weak CFM response



Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the use of CFM. In the case of low CFM, the estimated coefficient is evaluated at zero, while in the case of high CFM it is evaluated at 1.

Figure 12. Impact on REER, by use of CFM

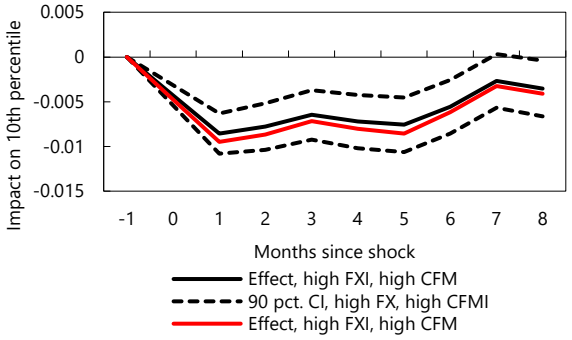


Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the use of CFM and the frequency of intervention. In the case of low CFM, the estimated coefficient is evaluated at zero, while in the case of high CFM it is evaluated at 1. Heavy CFM users are countries that, on average, have at least one CFM measure throughout the sample.

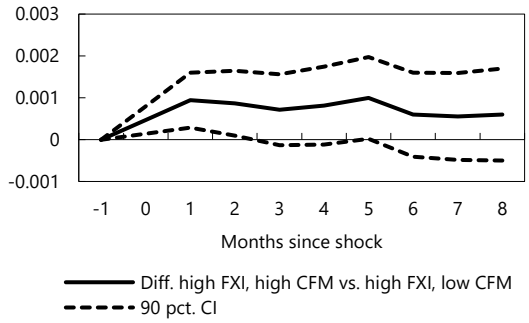
Figure 13. Impact on REER, FXI-CFM interactions

Panel A. VIX shocks, 10th Percentile

REER Dynamic Response

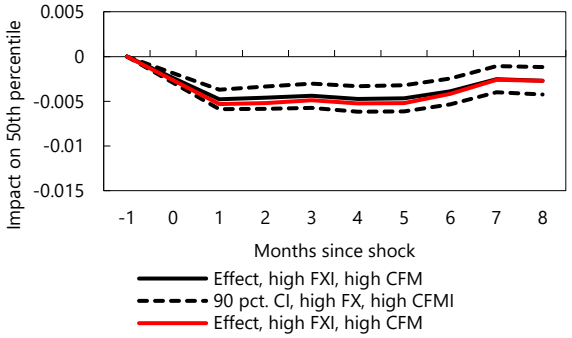


Difference between high FXI, high CFM and high FXI, low CFM

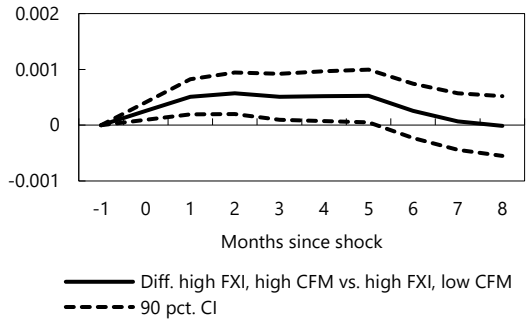


Panel B. VIX shocks, 50th Percentile

REER Dynamic Response



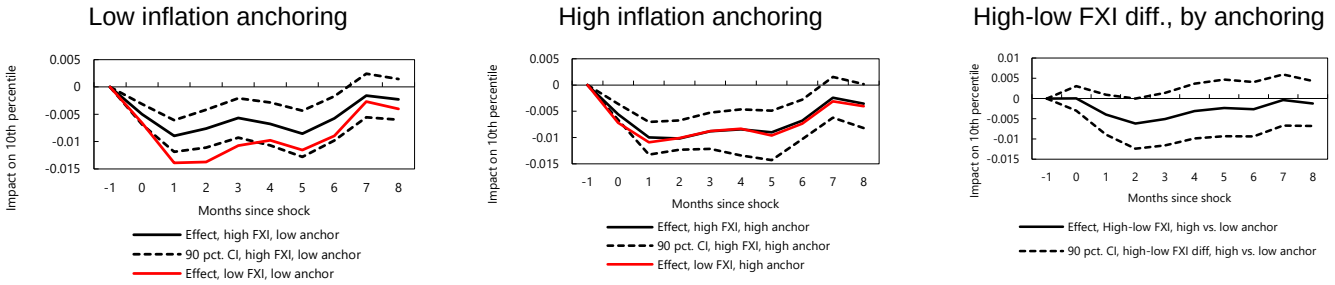
Difference between high FXI, high CFM and high FXI, low CFM



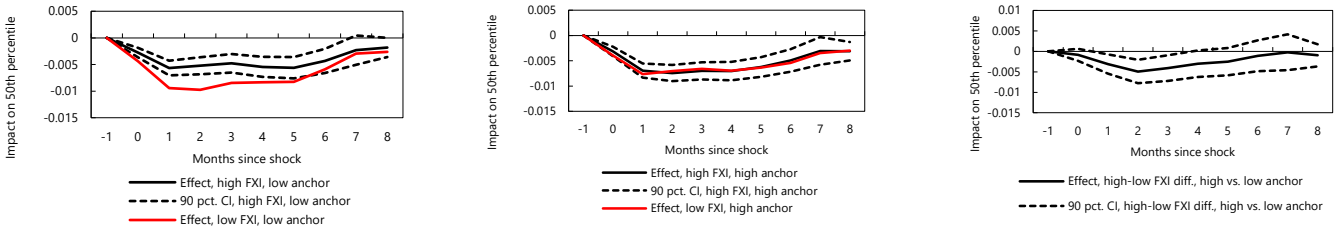
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the level of FXI, CFMs, and its product. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution. In the case of low CFM, the coefficient is evaluated at 0, while for high CFM it is evaluated at 1.

Figure 14. Impact on REER, effectiveness of FXI, by inflation anchoring

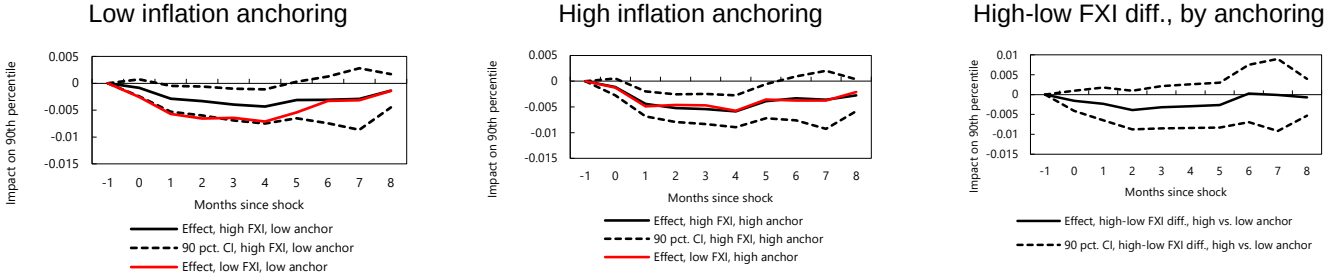
Panel A. VIX shocks, 10th percentile



Panel B. VIX shocks, 50th percentile

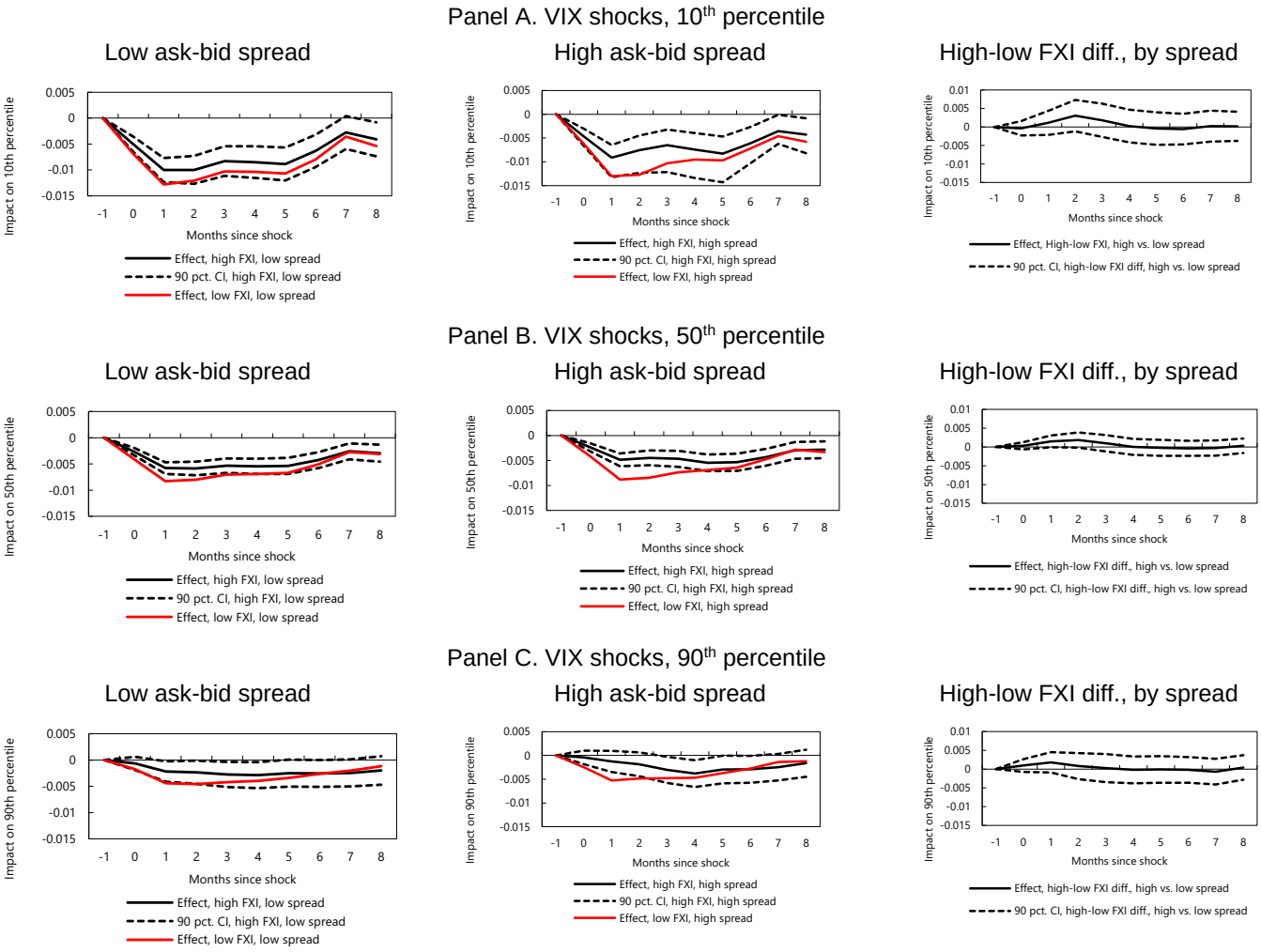


Panel C. VIX shocks, 90th percentile



Note: The left and middle panels show the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute). The right panel measures the difference in the difference between high and low FXI, for countries with high and low inflation anchoring.

Figure 15. Impact on REER, effectiveness of FXI, by ask-bid spread

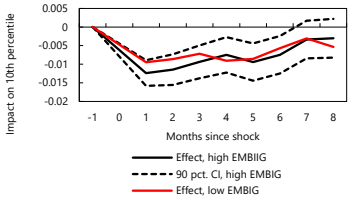


Note: The left and middle panels show the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute). The right panel measures the difference in the difference between high and low FXI, for countries with high and low ask-bid spreads.

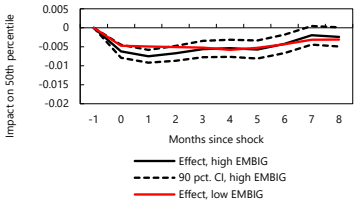
Figure 16. Impact of VIX changes on REER, by EMBIG spread

REER change

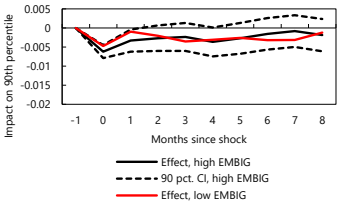
Panel A. 10th Percentile



Panel B. 50th Percentile

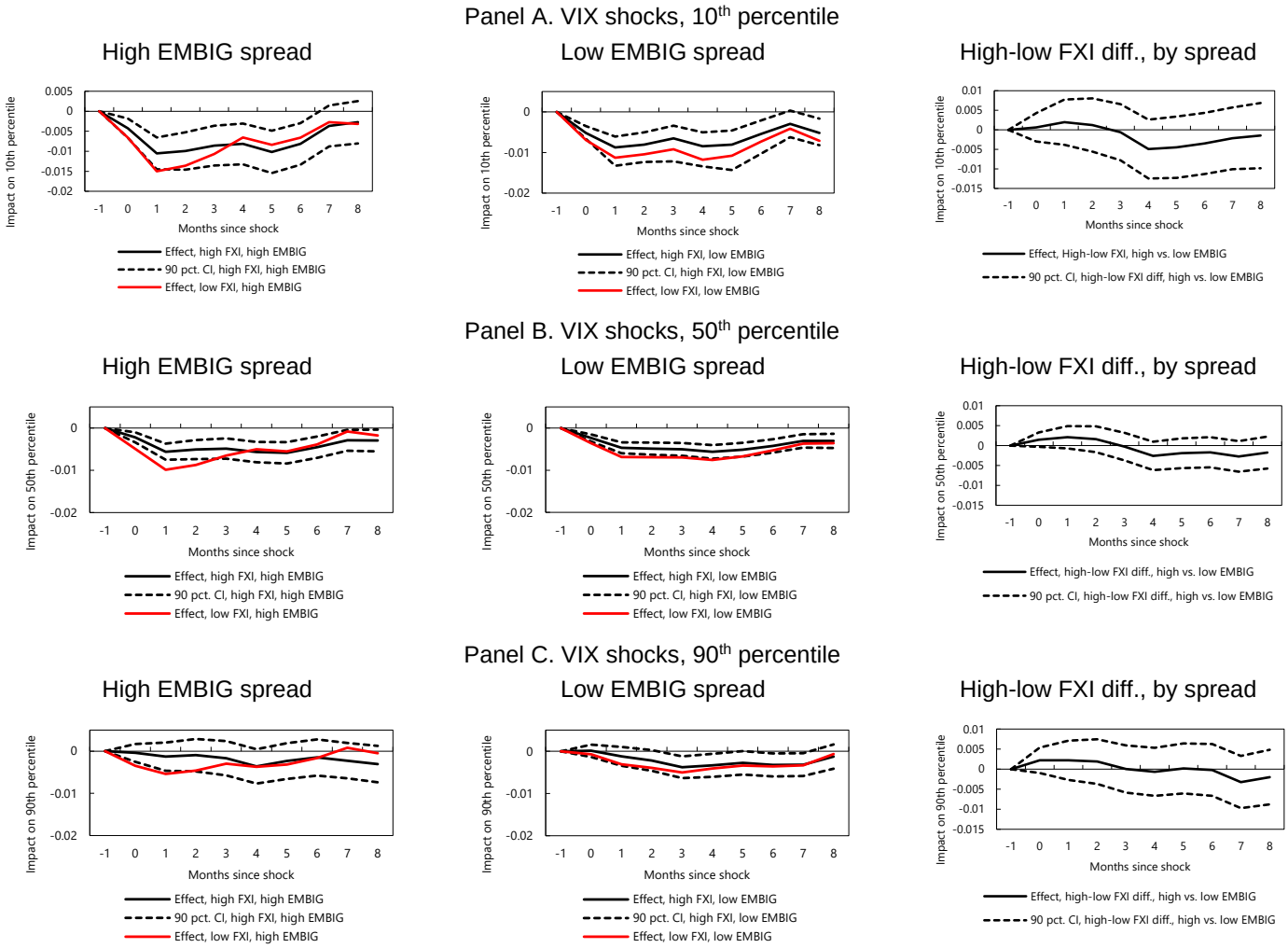


Panel C. 90th Percentile



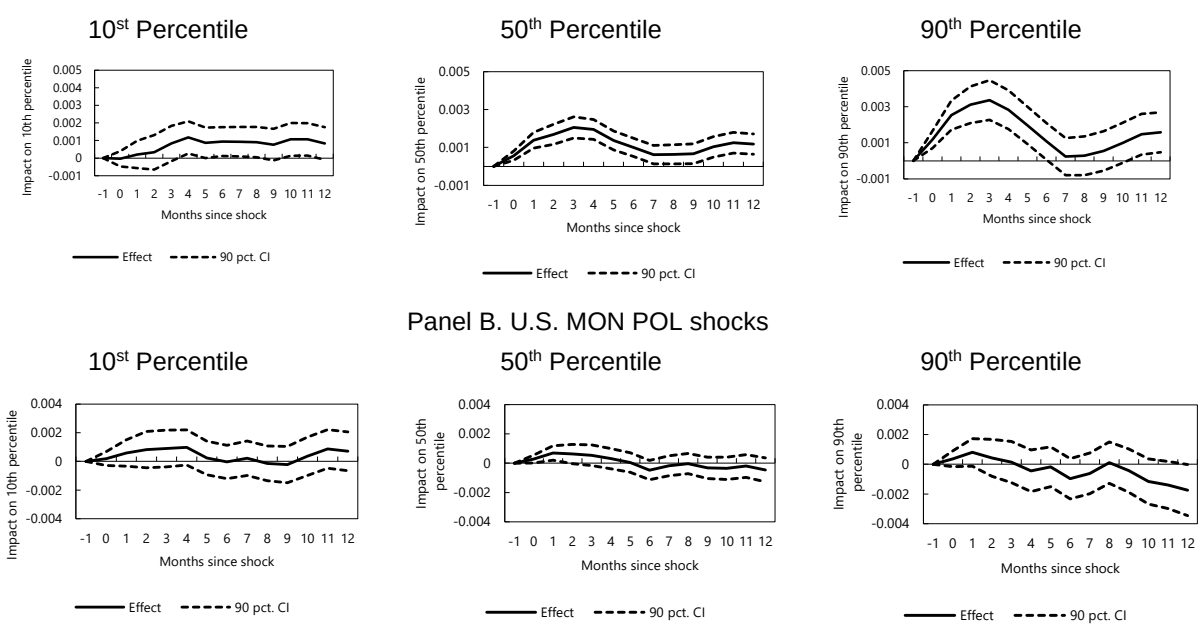
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, by EMBIG. High EMBIG is defined as country-month combinations when the EMBIG exceeds the mean for our sample. Countries with no EMBIG are classified as low EMBIG.

Figure 17. Impact on REER, effectiveness of FXI, by EBIG spread



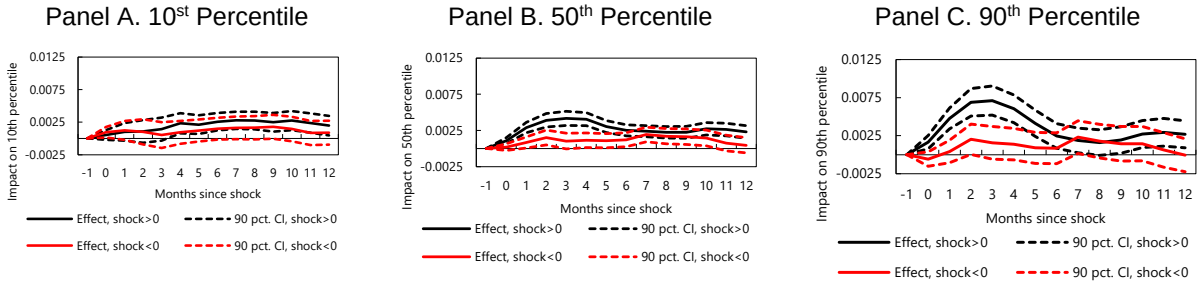
Note: The left and middle panels show the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute). The right panel measures the difference in the difference between high and low FXI, for countries with high and low EMBIG spreads.

Figure 18. Impact of REER volatility



Note: Each panel shows the response of a specific decile of the REER volatility distribution with respect to a one standard deviation change in each shock. REER volatility is the 6-month rolling standard deviation of the (log) REER.

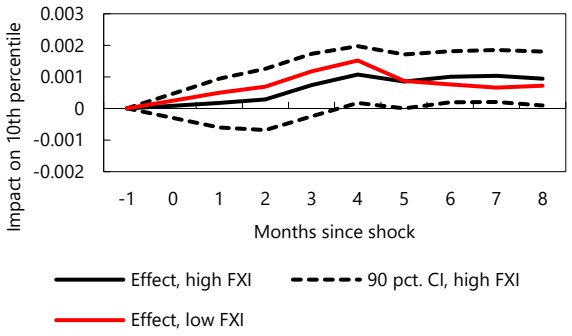
Figure 19. Impact of VIX shocks on REER volatility, by direction of shock



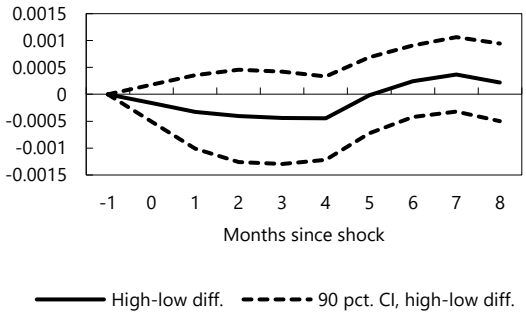
Note: Each panel shows the response of a specific decile of the REER volatility distribution with respect to a one standard deviation change in the VIX, conditional on the direction of the VIX change. REER volatility is the 6-month rolling standard deviation of the (log) REER.

Figure 20. Impact of VIX shocks on REER level vol.—the role of FXI

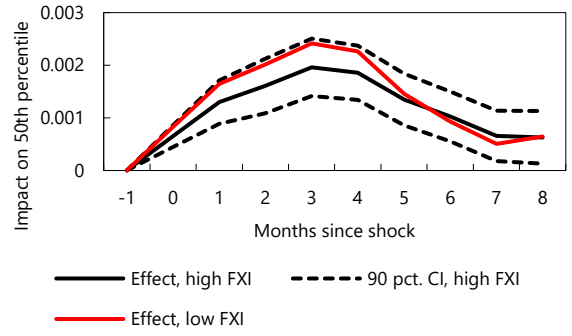
Panel A. 10th Percentile



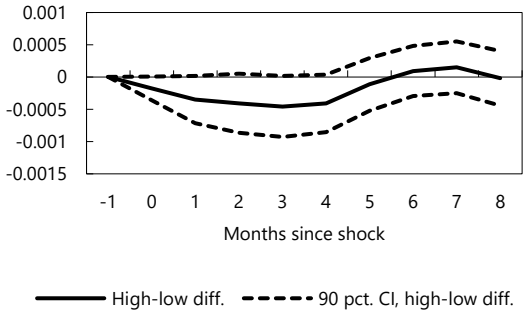
Panel B. 10th Percentile, Strong vs. Weak FXI response



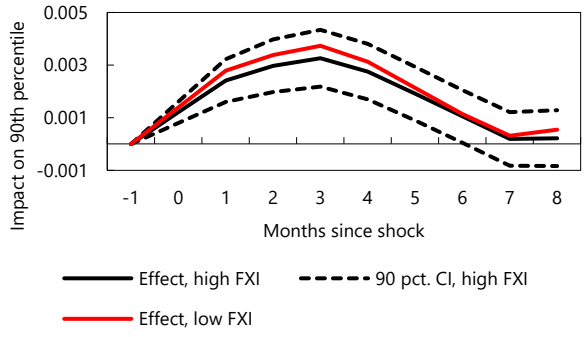
Panel C. 50th Percentile



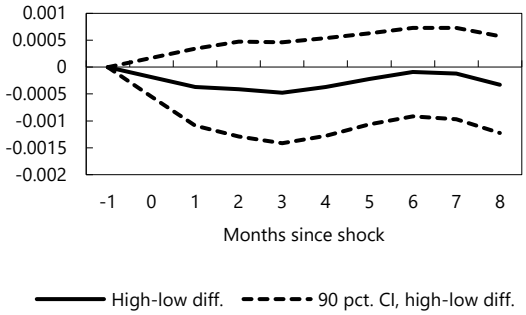
Panel D. 50th Percentile, Strong vs. Weak FXI response



Panel E. 90th Percentile



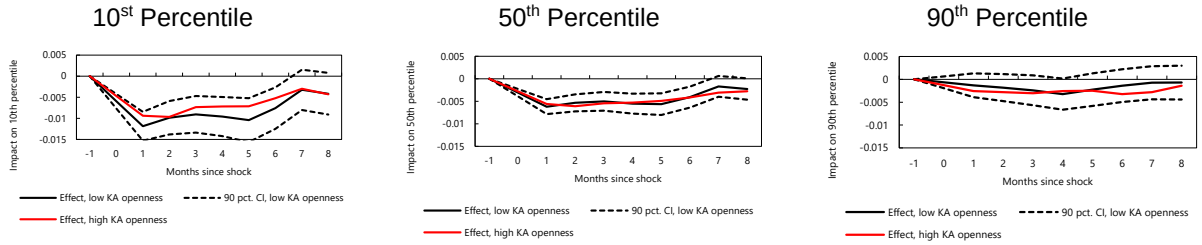
Panel F. 90th Percentile, Strong vs. Weak FXI response



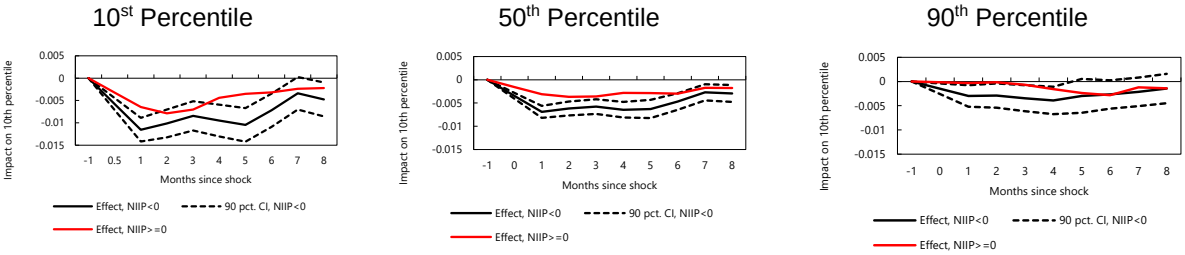
Note: Each panel shows the response of a specific decile of the REER volatility distribution with respect to a one standard deviation change in the VIX, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution. REER volatility is the 6-month rolling standard deviation of the (log) REER.

Figure 21. Impact of VIX shocks on REER, by states

Panel A. Capital Account Openness (Chinn-Ito)



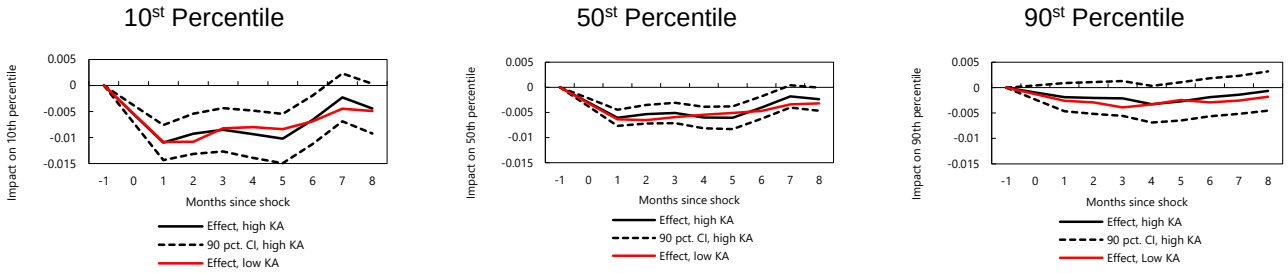
Panel B. Net Investment Position



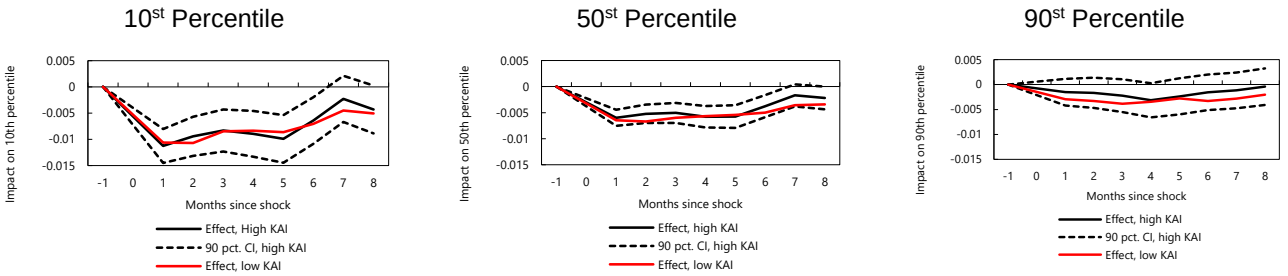
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on a state variable. For capital account openness (Chinn and Ito 2006) we split the sample using median values. For net foreign asset positions, we split the sample based on whether the country is a net lender or creditor.

Figure 22. Impact of VIX shocks on REER, by capital account openness (Fernandez and others, 2016)

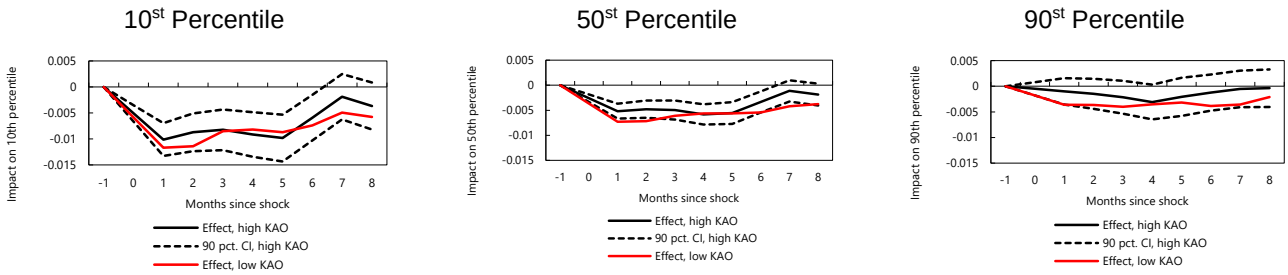
Panel A. Overall capital account openness index (KA)



Panel B. Capital account openness index, Inflows (KAI)



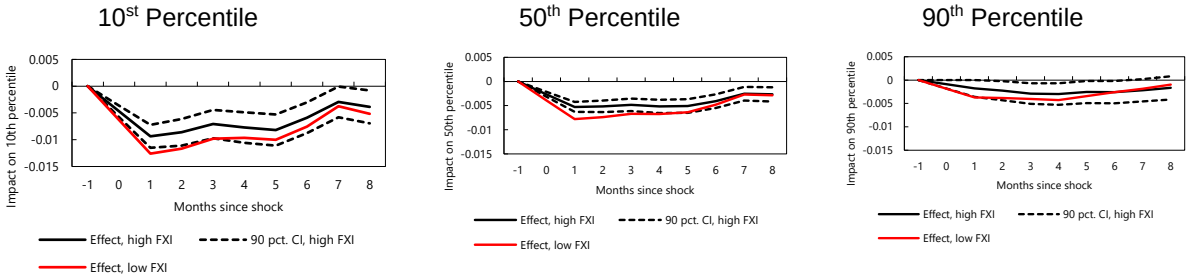
Panel C. Capital account openness index, Outflows (KAO)



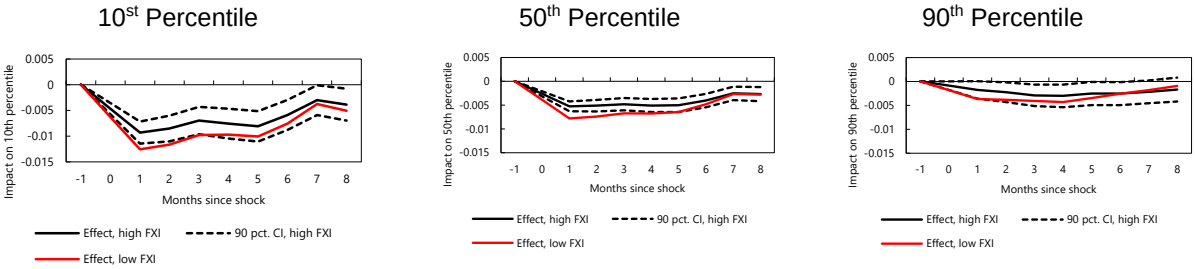
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on a state variable. For the capital account openness constructed in Fernandez and others 2016, we split the sample using median values. Panel A shows results for the overall index, Panel B for the index capturing inflow measures and panel C those that target outflows. A higher KA, KAO, KAI value indicates more restrictions (less openness).

Figure 23. VIX shocks, REER, and FXI—the role of future interventions

Panel A. VIX shocks, controlling only for contemporaneous interventions

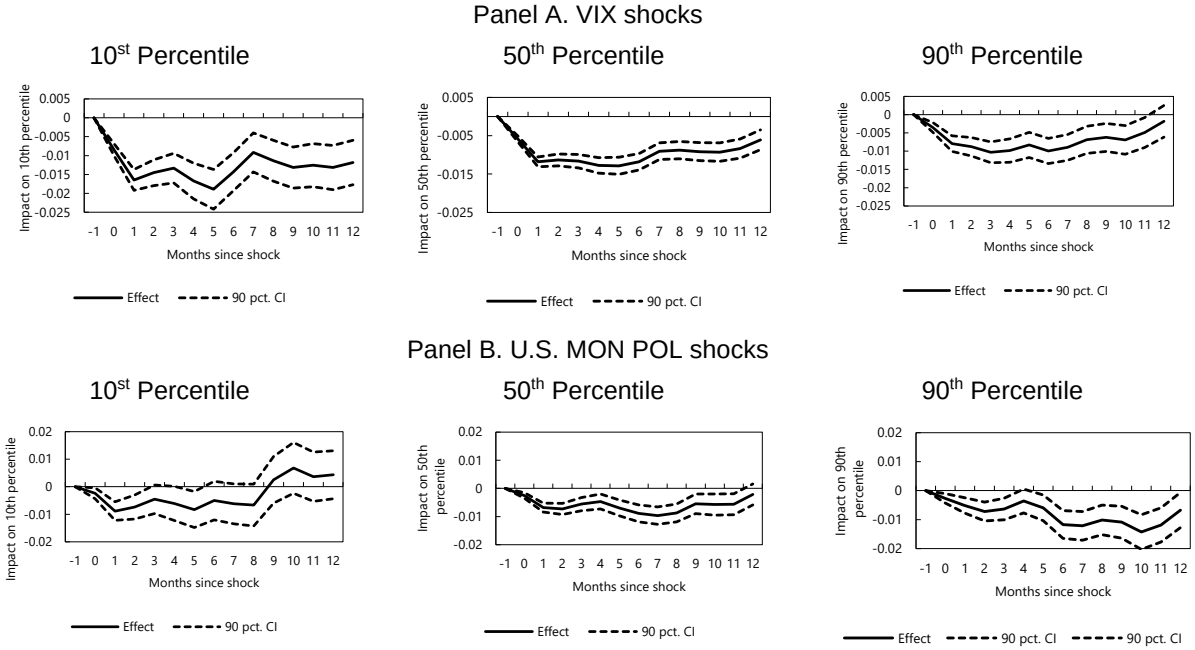


Panel B. VIX shocks, controlling for future interventions



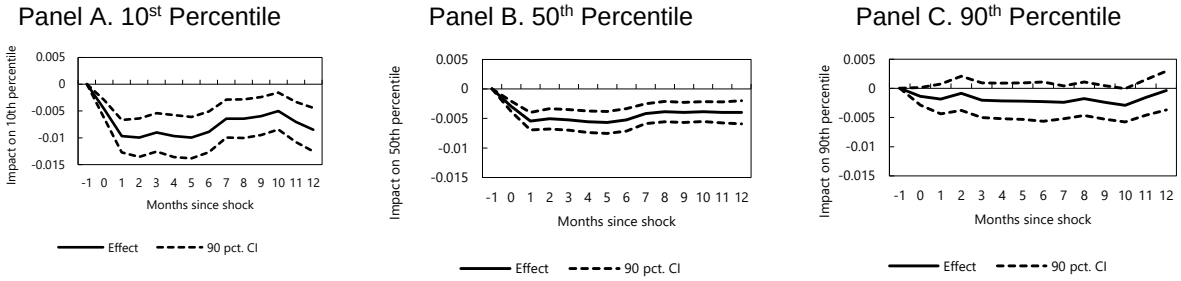
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the VIX, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

Figure 24. Impact of bilateral real exchange rate



Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) LCUS with respect to a one standard deviation change in each shock.

Figure 25. Impact of Shocks to the US Financial Conditions Index on REER



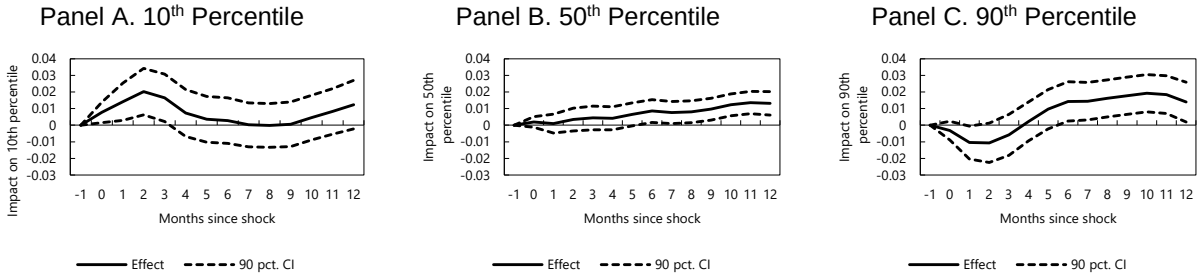
Note: Each panel shows the response of a specific decile of the distribution of the change in the (log) REER with respect to a one standard deviation change in the US financial condition index (IMF 2017).

Annex 2. Terms of Trade

This section complements the analysis in the main text by studying the response of the REER and its volatility to terms-of-trade shocks. As discussed in the main text, the evidence presented below shows that ToT shocks have only a limited effect on the REER. This is consistent with Fernandez, Schmitt-Grohé and Uribe (2017).

Figure A1. Impact of ToT shocks

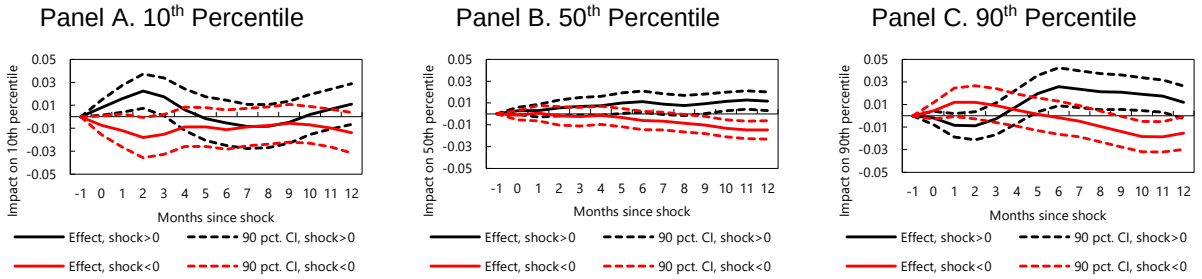
REER change



Note: Each panel shows the response of a specific decile of the (log) REER distribution with respect to a one standard deviation change in the gap between (log) ToT levels and its medium-term (HP) trend.

Figure A2. Impact of ToT shocks, by direction of shock

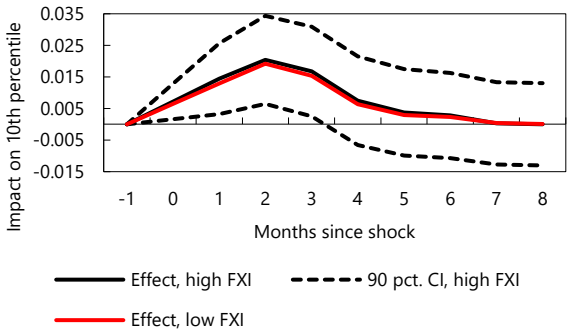
REER change



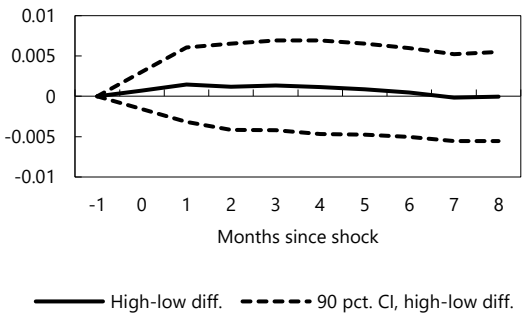
Note: Each panel shows the response of a specific decile of the (log) REER distribution with respect to a one standard deviation change in the gap between (log) ToT levels and its medium-term (HP) trend, conditional on the direction of the shock.

Figure A3. Impact of ToT shocks on REER—the role of FXI

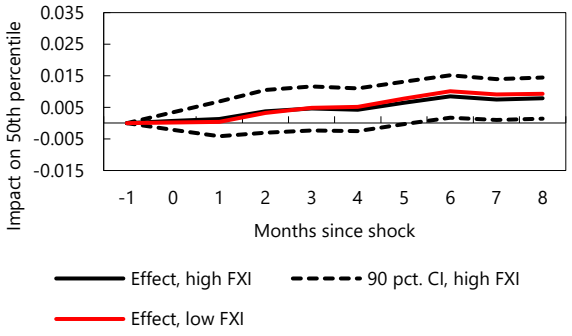
Panel A. 10th Percentile



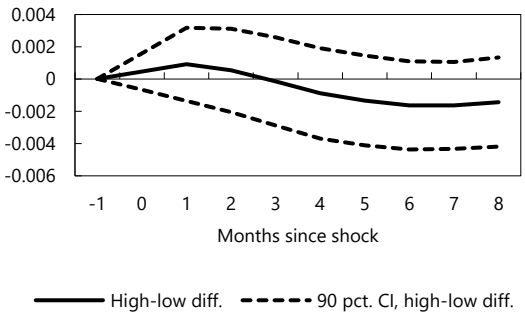
Panel B. 10th Percentile, Strong vs. Weak FXI response



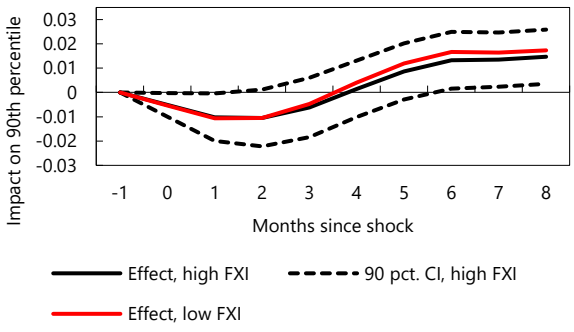
Panel C. 50th Percentile



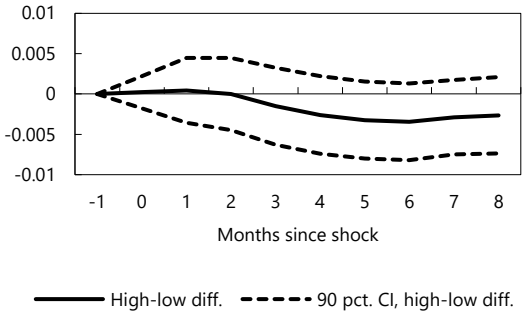
Panel D. 50th Percentile, Strong vs. Weak FXI response



Panel E. 90th Percentile

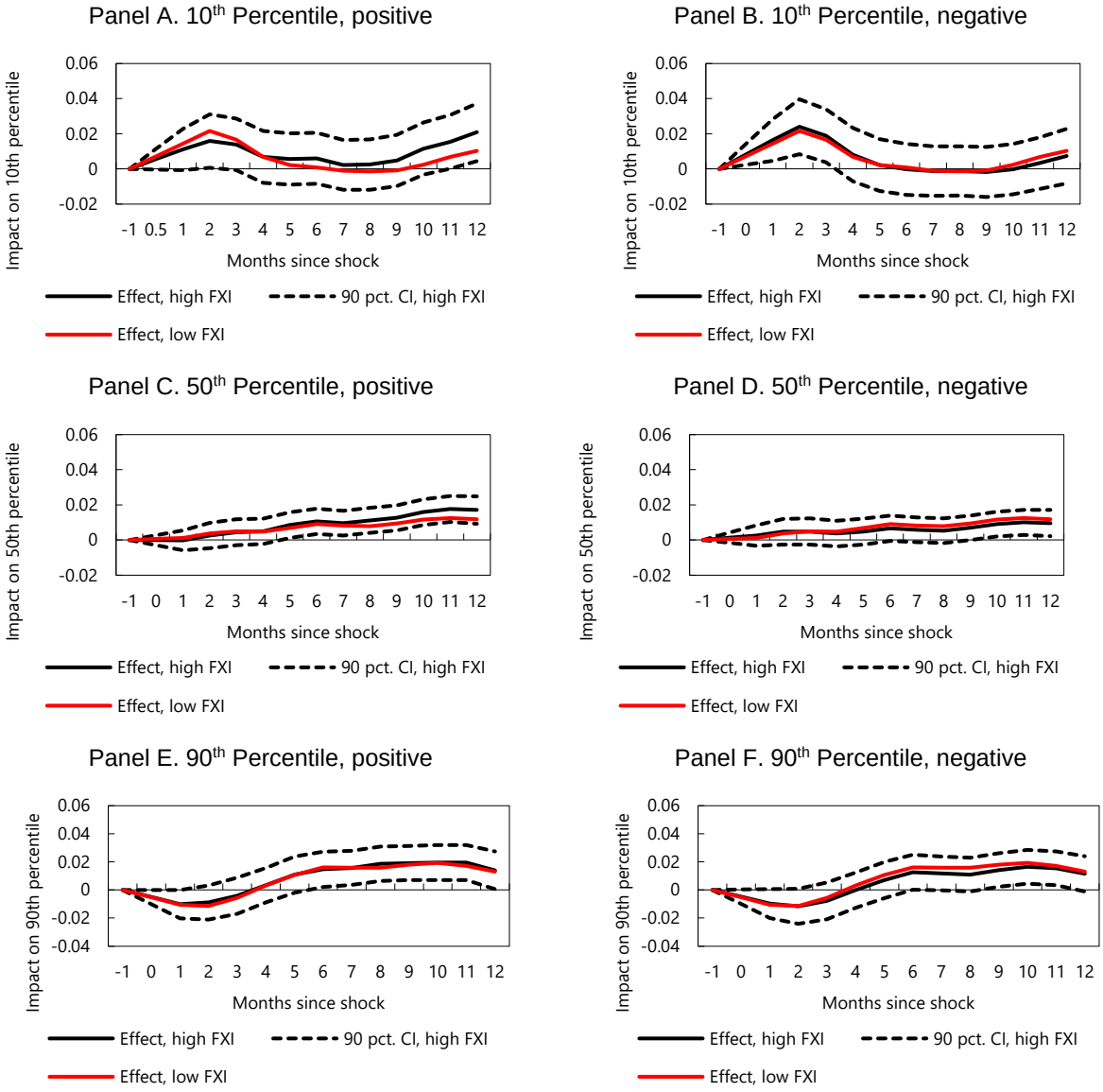


Panel F. 90th Percentile, Strong vs. Weak FXI response



Note: Each panel shows the response of a specific decile of the (log) REER distribution with respect to a one standard deviation change in the gap between (log) ToT levels and its medium-term (HP) trend, conditional on the level of FXI. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

Figure A4. Impact of ToT shocks on REER—the role of FXI, by direction of intervention



Note: Each panel shows the response of a specific decile of the (log) REER distribution with respect to a one standard deviation change in the gap between (log) ToT levels and its medium-term (HP) trend, conditional on the level of FXI and the direction of the intervention. In the case of low FXI, the estimated coefficient is evaluated at zero, while in the case of high FXI it is evaluated at the 75th percentile of the (absolute) FXI distribution.

PUBLICATIONS

External Shocks, Policies, and the Distribution of Real Exchange Rate Movements

Working Paper No. WP/23/129