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INTERNATIONAL CAPITAL FLOW PRESSURES

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ABSTRACT

Pressures on currencies manifest in exchange rate adjustments and international capital flows, and can also be offset by policy responses. This paper presents a theory-based measure of capital flow pressures, a new Exchange Market Pressure index, which combines pressures observed in exchange rate adjustments, official foreign exchange intervention and monetary policy changes. We use the index to identify so called safe-haven and risk-on status currencies and investigate the drivers of this status, showing the importance of country net foreign asset positions, size, and capital account openness. We also re-assess the contribution of the global financial factor in international capital flow pressures. The global factor explains a larger share of pressures on currencies measured using the EMP compared with using capital flow quantities. However, this global factor share is strongly dominated by idiosyncratic variation and only episodically large.

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1 Introduction

International capital flows are consistently found to be important for economic outcomes and, to a large extent, driven by global factors (Milesi-Ferretti and Tille, 2011; Forbes and Warnock, 2012; Fratzscher, 2012; Rey, 2015; Cerutti et al., 2019).[1] These issues are the subject of different strands of literature on the policy spillovers and spillbacks from international capital flows, and the associated policy prescriptions. A key finding is that international capital flows tend to enter emerging markets when global risk perceptions are low and global liquidity ample, and retreat when global financial conditions tighten. Exchange rates also respond to global financial conditions, with relative appreciations under elevated global risk aversion a feature of so called safe haven currencies (Ranaldo and Soederlind, 2010; Botman, Filho and Lam, 2013; Habib and Stracca, 2012; de Carvalho Filho, 2015; Bundesbank, 2014). The broader literature also considers the currencies that exhibit outflow pressures with elevated risk, and addresses other manifestations of the sensitivity of capital flow pressures to global financial factors such as the failure of uncovered interest rate parity (Du and Schreger, 2016; Maggiori et al., 2019). This sensitivity is key to understanding the degree to which local economies retain some domestic policy autonomy and the relative importance of local and idiosyncratic factors (Miranda-Agrippino and Rey, 2015; Obstfeld, Ostry and Qureshi, 2019; Cerutti, Claessens and Rose, 2019).

Features of the international monetary system may need to be more extensively accounted for within this broader literature. In countries with flexible exchange rate regimes, exchange rates move quickly in response to incipient changes in capital flows, supplementing or even obviating the adjustment in capital flow volumes (Chari, Stedman and Lundblad, 2017). Without a fully flexible exchange rate regime, policy interventions such as domestic policy rate changes or official foreign exchange interventions imply that international capital flow pressures are neither fully reflected in exchange rates or interest rates, nor in capital flows for many countries. Indeed, the use of policy tools in response to exchange market pressures is pervasive, especially in emerging markets, but also in some advanced economies (Ghosh, Ostry and Qureshi, 2018). Despite earlier literature with more mixed conclusions, recent evidence points to foreign exchange intervention with a high success rate under some criteria (Fratzscher, Gloede, Menkhoff, Sarno and Stohr, 2019). Accordingly, empirical studies that use cross-country data on realized capital flows or exchange rate changes to inform the range of key questions in international finance cannot just absorb these considerations in controls like country fixed effects. The use of these instruments varies over time, as exchange rate and monetary regimes evolve (Klein and Shambaugh, 2008; Ilzetzki, Reinhart and Rogoff, 2017).

[1] See also Ahmed, Coulibaly and Zlate (2017), Ghosh, Qureshi, Kim and Zalduendo (2014), Aizenman, Binici and Hutchison (2014), Eichengreen and Gupta (2015), Mishra, Moriyama, N'Diaye and Nguyen (2014) and Avdjiev, Gambacorta, Goldberg and Schiaffi (2017b).

In this paper we present a new measure to capture international capital flow pressures in the form of a fully revamped and theory-based Exchange Market Pressure (EMP) index. This index is conceptually grounded in a simple model combining balance of payments equilibrium and international portfolio demand conditions with adjustments for portfolio-related wealth effects. The international financial flow perspective and international portfolio balance approach follow a long tradition (Girton and Henderson, 1976; Henderson and Rogoff, 1982; Branson and Henderson, 1985; Kouri, 1981; Blanchard, Giavazzi and Sa, 2005; Coeurdacier and Rey, 2013; Caballero, Farhi and Gourinchas, 2016; Gabaix and Maggiori, 2015).

This EMP presents capital flow pressures in units of exchange rate depreciation equivalents and can be viewed as a tool for measuring international capital flow pressures consistently across countries and over time. It has the interpretation of a super-exchange rate index, directly accounting for observed currency movements, as well as monetary policy changes and central bank interventions in the foreign exchange market by converting these into exchange rate depreciation equivalent units. The equivalency formulas basically take incipient pressures for example on quantities of flows offset by foreign exchange intervention and solve for the exchange rate changes that otherwise could have closed that balance of payments gap. The simple theoretical construct also has the benefit of directly generating the range of domestic and foreign drivers around risk sentiment, policy, and economic size that routinely appear in empirical analyses of the global financial cycle and drivers of international capital flows (Calvo, Leiderman and Reinhart, 1993; Miranda-Agrippino and Rey, 2015; Barrot and Serven, 2018; Avdjiev, Gambacorta, Goldberg and Schiaffi, 2017b; Cerutti, Claessens and Rose, 2019).

As both proof of concept and a source of concrete results, we generate monthly EMP series spanning 2000 through 2018, carefully computing these series for 41 countries. The performance and features of our new EMP are then illustrated using country examples, focusing on four countries with diverse exchange rate regimes and currency characteristics: Australia, Brazil, Korea, and Switzerland. The rich empirical relevance of the full country panel data is demonstrated in two important topical applications. The first application revisits the asset pricing literature approach to the identification of safe haven currencies, wherein currencies are characterized as having "safe haven" feature if valuations rise when global risk conditions worsen, as in Brunnermeier, Nagel and Pederson (2008), Ranaldo and Soederlind (2010), Habib and Stracca (2012), Fatum and Yamamoto (2016) and Bundesbank (2014).[2] Empirical analyses implemented using observed exchange rate movements may generate distorted results if including the many countries

[2]More recent papers by Avdjiev, Bruno, Koch and Shin (2019) and Avdjiev, Du, Koch and Shin (2017a) argue that the correlation between risk sentiment and the dollar can proxy the shadow price of bank leverage and explain cross-border bank lending. Wong and Fong (2013) is an exception in that they rely on options prices, and so-called risk reversals, to gauge the degree to which financial market participants expect currencies to behave as safe havens.

that respond to currency pressures by intervening in the foreign exchange market or by changing the policy rate. The estimated correlations used for assessing safe haven or risk-on status are thus subject to attenuation bias. We revisit this application, instead using the EMP to construct a counterfactual excess currency return and its correlation with risk which we label the Global Risk Response index (GRR). Our analysis shows that a couple of advanced country currencies have safe haven status only sometimes (e.g. United Kingdom pound and Danish krone) and others have this status more persistently (Swiss franc, Japanese yen, US dollar), with varying strength of this feature over time. It also shows the comparative responses across countries of international capital flow pressures to higher risk, with commodity currencies tending to fare worse than the currencies of other advanced economies or emerging markets.

We also use these types of insights to revisit the analysis of Habib and Stracca (2012), which carefully explores which country characteristics are associated with safe haven currency status using an exchange rate based measure and time series panel regressions.[3] Using the EMP and GRR we show that the safe-havenness of currencies is exclusively an advanced country phenomenon. Safe-havenness exhibits historical persistence as it is significantly related to its own lag in advanced economies, but underlying factors that vary over time in advanced economies, such as large net foreign assets positions, economic size, and financial openness, matter for overall positive or negative risk consequences, while these factors are less relevant for the pressures experiences by emerging markets.

As a second application, we use the EMP to revisit the Cerutti, Claessens and Rose (2019) critique of the importance of the global financial cycle in international capital flows. Based on panel regressions of net capital flows on global factors, those authors argued that the global financial cycle is not as prominent a driver of international capital flows as argued in the influential work of Miranda-Agrippino and Rey (2015) and Bruno and Shin (2015). Using our EMP as an alternative measure of international capital flow pressures, we find that the proportion explained by global factors is two to three times larger than would be measured using quarterly capital flow data. Nonetheless, the strength of the global factor in explaining capital flow variation is still under 25 percent and is highly episodic. These findings complement other research on international bank claims and market-based flows showing that the importance of the common global factor changes significantly over time with the balance sheet health of market participants and the alignment of key country monetary policy paths (Avdjiev, Gambacorta, Goldberg and Schiaffi, 2017b), and differs for extreme events or stress episodes characterized by capital stops, flights, surges, or retrenchments (Forbes and Warnock, 2012). Local or unexplained factors still

[3] Habib and Stracca (2012) acknowledge the potential attenuation issue that arises in their empirical analysis, as currencies might appear as safe havens only because policy interventions keep these currencies pegged to the dollar to various degrees. Their method of addressing such attenuation biases is to introduce foreign reserve changes and interest rate changes as control variables in empirical specifications.

dominate global factors in general.

Finally, our research emphasizes that implementing the EMP empirically requires careful data work. Important data decisions include choosing the reference currency for countries' exchange rate regimes and selecting monetary policy rates. Another key data consideration includes appropriately measuring foreign exchange interventions, including possibly accounting for use of derivatives, and correcting official foreign exchange reserve changes for those arising from valuation effects. Important parameter decisions pertain to choices on capital flow elasticities, as these are not well pinned down in the literature. Also consequential are treatments of the role of currency denomination in portfolios of foreign assets and liabilities (Benetrix, Lane and Shambaugh, 2015; Maggiori, Neiman and Schreger, 2019). While countries' foreign assets are usually quoted in equivalents of either domestic currency or US dollars, the currency denomination of countries' liabilities is much more diverse.

The paper is structured as follows. Section 2 provides the rationale for the exchange market pressure index and discusses our approach in relation to early index variants. The model and derivation for our EMP and related intuitions are provided. Section 3 focuses on empirical implementation, presenting important data and parameter choices, and illustrating results. Section 4 provides the application to safe haven currency status, the global risk response, and advanced economies versus emerging markets differences. Section 5 presents the results contrasting the use of the EMP and capital flows to quantify the global factor in international capital flow pressures. The final section discusses the implications of our findings and concludes.

2 Exchange Market Pressure

2.1 Early Variants

Primarily used in studies of currency crises and spillovers of policies across borders, prior variants of an exchange market pressure index take the form of a weighted index of changes in the exchange rate, changes in official foreign exchange reserves and (sometimes) changes in policy interest rates:

$$EMP_t = w_e \left(\frac{\Delta e_t}{e_{t-1}} \right) - w_R \left(\frac{\Delta R_t}{S_t} \right) + w_i(\Delta i_t) \tag{1}$$

where the index pertains to a particular country, $\left(\frac{\Delta e_t}{e_{t-1}} \right)$ is the percentage change in the exchange rate e_t, defined as domestic currency per unit of foreign currency at time t over a Δt interval. ΔR_t is the change in the central bank's foreign exchange reserves as a proxy for foreign exchange interventions. S_t scales these reserve changes, and Δi_t represents the change in the policy interest rate. w_k are the weights at which components $k = (e, R, i)$ enter the index. The weighting choices w_k utilized in the literature are presented in Appendix Table A1. These weights are largely intended to filter out noisy signals generated by movements in exchange rates and official reserves. The scaling choice S_t are intended to indicate the relative magnitude or importance of official foreign exchange purchases or sales relative to the relevant country features. The weights and scaling factors reflect the desire to have a practical basic measure to apply across countries and time.

Despite delivering ease of implementation, these prior choices are not neutral for the realization of the index. The scaling of reserves affects the contribution of the amplitude of the reserves changes to the EMP. Girton and Roper (1977) and Weymark (1995) scale the changes in reserves by the monetary base. The logic stems from questionable assumptions about the role of domestic money in international financial markets, including perfect capital mobility and perfect substitutability across assets issued by different countries and in different currencies.[4] Kaminsky and Reinhart (1999) instead scale by the level of reserves and Eichengreen et al. (1994) use a narrow monetary aggregate. Scaling by the initial level of reserves results in a higher amplitude of scaled reserve changes when the initial level of reserves is low, relative to when it is high. Scaling by a monetary aggregate makes the scaling sensitive to the variation of money multipliers over time and across countries. None of these approaches provide a meaningful concept of equivalence between the contributing components of currency depreciation and reserve losses within the EMP.

Prior approaches to weighting the different components of the index likewise vary in both economic relevance and conceptual underpinnings. Such conceptual underpinnings are extremely important as the EMP, taken literally, fundamentally adds together price dynamics (changes in exchange rates and policy rates) and flow quantity dynamics (official foreign exchange intervention). Weymark (1995) suggests that the change in reserves should be weighted by the elasticities of money demand to interest rates and prices to the exchange rate, as these are the main channels of balance of payments adjustment in monetary models. Tanner (2002) and Brooks and Cahill (2016) apply equal weights to exchange rate and official reserves, giving movements in official reserves prominant weight even for countries with fully floating exchange rates.[5] Patnaik et al. (2017) propose an EMP index that includes observed exchange rates and foreign exchange intervention, with a scaling factor proportional to the size and liquidity of the foreign exchange market. Weights are based on an estimated sensitivity of the exchange rate to changes in official

[4] Models based on money market equilibrium conditions are problematic, even if updated, since central banks have engaged in quantitative easing or other policies that change the monetary base without relating to broader money or the foreign exchange market.

[5] In this latter case, observed official reserve movements are unlikely to reflect actual interventions and instead are more likely due to portfolio valuation effects.

reserves.[6] Most other studies remain "agnostic" as to whether such elasticities can be appropriately estimated or make sense, and instead employ precision weights. Precision weights essentially weight the components of the index by the inverse of their sample variance, which ensures that the variation in all the elements of the EMP contribute equally, and hence, that none of the components individually dominate the index.[7] However, exchange rate policy regimes should substantively influence the relative role of the components, as noted by Li, Rajan and Willett (2006). Precision weights give more weight to the component with less variation. In pegged exchange rate systems, this tends to be the exchange rate, yet the changes in reserves clearly contain more information on exchange market pressures when the exchange rate is pegged.

2.2 Modelling Exchange Market Pressures

Our approach to index construction rests on deriving a logical equivalence between the amount of exchange rate depreciation, official reserve sales, or monetary policy changes that offset exogenous quantities of private capital flow pressures. The balance of payments equilibrium condition, along with appropriately defined foreign asset and foreign liability portfolio equations, underpin a derived equivalence. The balance of payments identity is foundational as it carefully tracks interest payments on foreign assets and liabilities, foreign currency flows through trade, net and gross flows of foreign currency assets and liabilities, and official foreign exchange interventions. The simple logic of our approach is that any given excess supply or demand for a currency - an international capital flow pressure - can be offset by an equivalent amount of foreign exchange intervention quantity, by an endogenous exchange rate movement, or by a change in the domestic monetary policy rate sufficient to generate a private balance of payments flow. The equivalence factors across these components derive directly from the different ways that exchange rates and interest rates enter the balance of payments identity and via appropriate specifications of international asset demand functions with imperfect asset substitutability. The equivalencies thus depend on elasticities of response of foreign assets and foreign liabilities to exchange rate and interest rate changes, the currency of invoicing or denomination on international trade and debt positions, and the stocks of outstanding foreign asset and liability positions.

[6] A separate strain of literature assesses the correspondence between central bank foreign exchange interventions in a pegged system and exchange rate changes in a floating rate system, or the effectiveness of foreign exchange interventions in affecting the exchange rate, e.g. Menkhoff (2013) and Blanchard, Adler and de Carvalho Filho (2015). These studies find a positive correspondence between increases in central bank foreign asset holdings in pegged regimes and exchange rate appreciation in a floating regime. The estimated correspondences carry information about net capital flow responsiveness to the exchange rate, but are translated into quantitative proxies for elasticities of gross private foreign investment positions. Patnaik et al. (2017) show how the correspondence varies across countries, and explain this variation with cross country differences in trade, GDP and net FDI stocks as proxies for local currency market turnover.

[7] Eichengreen, Rose and Wyplosz (1994) offer a thorough discussion of the advantages and drawbacks of using this weighting scheme.

The balance of payments (BoP), expressed in foreign currency equivalents, reflects all sources of demand and supply of foreign currency in terms of domestic currency arising from cross-border payments needs during a specified period. The BoP for the period between time $t-1$ and time t (period t), is given by

$$FXI_t = NX_t + \left(i^*_{t-1} NFA^{fx}_{t-1} - \frac{i_{t-1}}{e_{t-1}} NFL^d_{t-1} + i^*_{t-1} R_{t-1} \right) + \left(\frac{1}{e_{t-1}} \Delta NFL^d_t - \Delta NFA^{fx}_t \right) \quad (2)$$

where FXI_t reflects foreign exchange interventions in period t. The first term on the right hand side is the net trade balance accumulated in period t, NX_t. The second term in parentheses reflects the net foreign investment income balance for period t, which includes interest receipts accrued at the beginning of period t on private positions and on the foreign official reserve balance R_{t-1}. The exchange rate e_t is defined in units of domestic currency per unit of foreign currency. Private foreign assets and liabilities can be issued in domestic currency (superscript d) and foreign currency (superscript fx). This distinction is important conceptually as it is relevant for how exchange rates directly and indirectly influence foreign currency flows. The stock of net foreign currency denominated assets at time t is defined as $NFA^{fx}_t = FA^{fx}_t - FL^{fx}_t$ and net domestic currency denominated foreign liabilities are defined as $NFL^d_t = FL^d_t - FA^d_t$. Countries that borrow internationally exclusively in domestic currency and exclusively hold foreign currency denominated foreign assets have $NFA^{fx}_t = FA^{fx}_t$ and $NFL^d_t = FL^d_t$, and gross and net foreign positions are the same.[8] The interest rates used to calculate interest income and payments accrued to foreign assets and liabilities depend on the currency of denomination. Interest income denominated in domestic currency is assumed to accrue on the beginning of period stock of foreign positions, and is converted into foreign currency equivalents using the beginning of period exchange rate e_{t-1}. The last term in parentheses captures financial account transactions taking place during period t. These are expressed in foreign currency equivalents, converted using the beginning of period exchange rate. Financial account transactions do not include changes in aggregate net foreign asset positions due to valuation effects from exchange rate changes, as valuation changes do not give rise to transactions or payments needs *per se*.[9]

The international financial flow perspective and international portfolio balance approach follow the long tradition of Girton and Henderson (1976), Henderson and Rogoff (1982), Branson and Henderson (1985), Kouri (1981), Blanchard et al. (2005), Coeurdacier and Rey (2013), Caballero, Farhi and Gourinchas (2016), and Gabaix and Maggiori (2015). We assume imperfect

[8]This was implicitly assumed to hold for all countries in an earlier version of this model, presented in Goldberg and Krogstrup (2018).

[9]Exchange rate valuation changes in foreign wealth, which are first order, can trigger rebalancing of portfolios that affect financial account transactions. Second order valuation changes in the foreign currency value of domestic currency denominated flows could occur, but we leave this out through the simplifying assumption that flows are converted at the beginning of period exchange rate.

substitutability between domestic and foreign currency denominated assets, modeled as home bias for domestic currency denominated assets, following Blanchard et al. (2005) and consistent with the empirical evidence on home currency bias in international portfolios by Maggiori, Neiman and Schreger (2019).[10] Demand for net private foreign assets denominated in foreign currency, and net liabilities denominated in domestic currency (and hence foreign currency from the perspective of the foreign creditor) are functions of relative expected returns, expressed as deviations from uncovered interest rate parity (uip_t), risk sentiment pertinent to each country's investment decisions, s_t and s_t^*, and domestic and foreign financial wealth, W_t and W_t^* respectively, both expressed in terms of their local currencies. The portfolio demand equations are given by:

$$NFA_t^{fx} = \kappa \frac{W_t}{e_t} \cdot [1 - \alpha(uip_t, s_t)] \tag{3}$$

$$NFL_t^{d} = \kappa^* e_t \cdot W_t^* \cdot [1 - \alpha^*(-uip_t, s_t^*)] \tag{4}$$

where uip, the deviation from uncovered interest rate parity from the point of view of the investor located in Home, is defined as

$$uip_t = i_t - i_t^* - \frac{E_t(e_{t+1}) - e_t}{e_t}. \tag{5}$$

α and α^* capture the portfolio shares of residents' investment wealth that are in domestic currency assets, with α, α^*, α'_{uip} and $\alpha^{*'}_{uip^*}$ positive. Risk sentiment is assumed to be independent of relative expected returns. An increase in risk sentiment s_t and s_t^* signal greater risk aversion and investment portfolio concerns. These induce a retrenchment toward local currency investments, such that α'_s and $\alpha^{*'}_{s^*}$ are positive.[11] κ and κ^* are indices of home and foreign capital account openness respectively. Capital openness indices moderate the share of investable wealth held in foreign currency denominated assets, scaling the realized net foreign currency investment shares. This specification simplifies the derivations substantially, as it generates direct proportionality between quantities (net foreign currency assets and liabilities) and the degree of capital account

[10] Maggiori, Neiman and Schreger (2019) show that currency denomination of assets is the main factor driving demand and home bias. When currency of denomination is accounted for, remaining credit risk differentials among assets largely do not explain asset demand patterns. Camanho, Hau and Rey (2018) provide a recent examination of home bias in portfolio models using equity fund data.The role of the sign and size of the foreign currency mismatch in cross border portfolio adjustments is well known. Krogstrup and Tille (2018) discuss this role and provide evidence in the case of banks.

[11] The difference in level between α and α^* is conditional on the arguments reflecting the differences in size of domestic and foreign financial asset markets.

openness, or conversely, the strength of capital controls.[12] Plots of capital controls against gross foreign assets and liabilities in percent of GDP confirm a negative relationship particularly on the foreign liabilities side (Fernandez, Klein, Rebucci, Schindler and Uribe, 2016), lending some support to our modeling approach.[13]

Wealth, expressed in domestic currency equivalents, consists of domestic assets DA (or DA^* for foreign investors) and net foreign assets, including domestic currency d and foreign currency fx denominated assets and liabilities:

$$\begin{aligned} W_t &= DA_t + e_t NFA_t^{fx} - NFL_t^d \\ W_t^* &= DA_t^* + \frac{1}{e_t} NFL_t^d - NFA_t^{fx} \end{aligned} \tag{6}$$

The evolution in domestic wealth is captured by $\mathrm{d}w_t$, which can be interpreted as domestic real GDP growth and real asset valuation changes, as well as wealth changes due to changes in the exchange rate which alter the domestic currency value of foreign denominated net assets due to currency mismatch:

$$\begin{aligned} dW_t &= dw_t + e_t NFA_t^{fx} \frac{de_t}{e_t} \\ dW_t^* &= dw_t^* - \frac{1}{e_t} NFL_t^d \frac{de_t}{e_t} \end{aligned} \tag{7}$$

An appreciation of the foreign currency increases the domestic currency value of net foreign currency denominated assets, and hence wealth, if the home country is net long in foreign currency denominated assets, i.e. has more foreign currency denominated assets than liabilities.[14]

To arrive at an expression for the change in demand for foreign currency denominated assets as a function of its various drivers, we totally differentiate (3) and (5), substitute in (7) and rearrange terms:

$$dNFA_t^{fx} = NFA_t^{fx} \left(\frac{dw_t}{W_t} + \epsilon_e^{NFA} \frac{de_t}{e_t} + \epsilon_i^{NFA} (di_t - di_t^*) + \epsilon_s^{NFA} ds_t \right) \tag{8}$$

[12] By implication, as the level of net foreign currency assets and liabilities already reflects the *ex ante* strength of capital controls, independent data on *ex ante* capital controls is not needed for the empirical implementation. Alternatively, if the κ terms were multiplied with the α functions, e.g. $NFA_t^{fx} = \frac{W_t}{e_t} \cdot [1 - \kappa\alpha(uip_t, s_t)]$, the proportionality is lost and the κ terms will show up in the derivations independently of the levels of positions. Or, the κ terms could be multiplied with the arguments inside the α functions, which would result in a specification that reduces the sensitivity of capital flows to deviations in *uip* or to risk shocks, without affecting the levels of net currency positions. In some countries, changing the incidence of capital controls can be used as a capital flow management instrument, as can prudential policy instruments.

[13] We confirm this relationship for net foreign assets by currency (not shown).

[14] If interest rates change the deviations from interest parity or if risk sentiment changes, the desired allocation of wealth between domestic and foreign currency denominated assets may change but total current wealth is not affected.

where ϵ_e^{NFA} is the elasticity of foreign currency denominated net assets with regard to the exchange rate, defined as

$$\epsilon_e^{NFA} \equiv \frac{dNFA_t^{fx}}{de_t}\frac{e_t}{NFA_t^{fx}} = -\left(\frac{\alpha'_{uip}\frac{E_t(e_{t+1})}{e_t}}{1-\alpha} + 1 - \frac{e_t NFA_t^{fx}}{W_t}\right). \tag{9}$$

The first term captures the reduction in the demand for foreign currency assets when holding constant the total wealth in domestic currency equivalents and the share of this wealth that is allocated toward foreign assets. The second term captures the portfolio reallocation away from foreign currency assets triggered by the expected future depreciation from a current appreciation through a widening of the deviation from *uip*. The third term captures the effect of an increase in total wealth due to the higher value of the net share of wealth invested in foreign currency assets (a wealth valuation effect due to a foreign currency mismatch). If the wealth valuation effect does not outweigh the first two portfolio rebalancing terms, the elasticity is negative, i.e. a domestic currency depreciation leads to a reduction in home's demand for foreign currency assets. If the wealth valuation effect instead dominates, the sign of the elasticity could shift.

ϵ_i^{NFA} is a semi-elasticity of net foreign currency assets with respect to the interest rate:

$$\epsilon_i^{NFA} \equiv \frac{dNFA_t^{fx}}{di_t}\frac{1}{NFA_t^{fx}} = -\frac{\alpha'_{uip}}{1-\alpha}. \tag{10}$$

(10) captures the portfolio reallocation effect on foreign asset demand due to a change in the deviation from *uip* triggered by an interest rate change.[15]

Finally, the definition of the elasticity of foreign asset demand with respect to risk sentiment s is:

$$\epsilon_s^{NFA} \equiv \frac{dNFA_t^{fx}}{ds_t}\frac{1}{NFA_t^{fx}} = -\frac{\alpha'_s}{1-\alpha}. \tag{11}$$

[15] Conditions for $\epsilon_e^{NFA} = e_i^{NFA}$ are $\frac{E(e_{t-1})}{e_t} \approx 1$ and $w_t = e_t NFA^{fx}$, with net foreign assets fully dominating home wealth for portfolio purposes. This condition will not hold in general.

Taking similar steps, the change in net foreign liabilities issued in domestic currency is:

$$dNFL_t^d = NFL_t^d \left(\frac{dw_t^*}{W_t^*} + \epsilon_e^{NFL} \frac{de_t}{e_t} + \epsilon_i^{NFL}(di_t - di_t^*) + \epsilon_s^{NFL} ds_t^* \right) \tag{12}$$

where:

$$\epsilon_e^{NFL} \equiv \frac{dNFL_t^{fx}}{de_t} \frac{e_t}{NFL_t^{fx}} = \left(\frac{\alpha_{uip}^{*'} \frac{E_t(e_{t+1})}{e_t}}{1-\alpha^*} + 1 - \frac{NFL_t^d}{e_t W_t^*} \right) \tag{13}$$

$$\epsilon_i^{NFL} \equiv \frac{dNFL_t^d}{di_t} \frac{1}{NFL_t^d} = \frac{\alpha_{uip}^{*'}}{1-\alpha^*} \tag{14}$$

$$\epsilon_s^{NFL} \equiv \frac{dNFL_t^d}{ds_t^*} \frac{1}{NFL_t^d} = -\frac{\alpha_s^{*'}}{1-\alpha^*} \tag{15}$$

When expressing the change in foreign currency asset demand in terms of elasticities, the capital control indices cancel out. The role of capital controls appears implicitly in the quantities to which the derived elasticities apply, i.e. the net foreign assets in foreign currency and net foreign liabilities in domestic currency.

Differentiating the BoP expression (2) with respect to all arguments that can shift, inserting equations (8) and (12), and rearranging yields the final form for the derived **Exchange Market Pressure** index and its drivers:

$$\begin{aligned} EMP_t &\equiv \frac{de_t}{e_t} + \frac{\pi_{i,t}}{\pi_{e,t}} di_t - \frac{1}{\pi_{e,t}} FXI_t \\ &= \frac{\pi_{i,t}}{\pi_{e,t}} di_t^* + \frac{NFA_t^{fx}}{\pi_{e,t}} \left(\frac{dw_t}{W_t} + \epsilon_s^{NFA} ds_t \right) - \frac{NFL_t^d}{e_t \pi_{e,t}} \left(\frac{dw_t^*}{W_t^*} + \epsilon_s^{NFL} ds_t^* \right) \end{aligned} \tag{16}$$

where

$$\pi_{e,t} = e_t NX' + \frac{NFL_t^d}{e_{t-1}} \epsilon_e^{NFL} - NFA_t^{fx} \epsilon_e^{NFA}, \tag{17}$$

$$\pi_{i,t} = \frac{NFL_t^d}{e_{t-1}} \epsilon_i^{NFL} - NFA_t^{fx} \epsilon_i^{NFA}. \tag{18}$$

The EMP_t, given by the top line of equation (16), is expressed in units of depreciation against the foreign reference currency. $\pi_{e,t}$ and $\pi_{i,t}$ are conversion factors. The second line of equation (16) reflects the drivers of exchange market pressure, directly mapping to terms that appear in the broader literature on capital flows and global financial cycles. Foreign policy rates and risk sentiment appear prominently, as do exogenous forces which increase domestic and foreign investable wealth.

This measure of exchange market pressures, including its derived conversion of quantities of FXI and monetary policy into currency depreciation units, is highly intuitive. $\pi_{e,t}$ converts a specific quantity of foreign exchange intervention into the equivalent domestic currency depreciation units. The larger the $\pi_{e,t}$, the smaller the equivalent currency depreciation that would have been needed to offset the capital flow gap reflected in sales of foreign currency reserves or increases in domestic policy rates. The size of $\pi_{e,t}$ is determined by the strength of the near term mechanisms through which exchange rate depreciation could generate a private balance of payments volume response equivalent to the volume gap which would otherwise be bridged by official FXI. $\pi_{e,t}$ is increasing in the net export sensitivity to the exchange rate and generally increasing in the country's net foreign currency asset and net domestic currency liability positions. A domestic currency depreciation expands the *uip* deviation and generates portfolio reallocations, reducing net foreign demand for home currency liabilities and net domestic demand for foreign currency denominated assets. Countries with larger initial net positions have larger net changes.

Valuation effects on the net position also play a role (equation 9). The larger is the net long position in foreign currency investments of home investors, the greater is the wealth effect when the domestic currency depreciates, spilling over into expanded foreign asset demand through this channel. Similarly, the longer are foreign investors in Home currency, the more it will reduce their wealth when the home currency depreciates, which will lead to a reduction in foreign investment in Home (a capital outflow). These wealth effects have the potential to reduce $\pi_{e,t}$ if home investors are sufficiently long in foreign currency, or if foreign investors are sufficiently long in home currency investments. Being short in foreign currency investment (e.g. when domestic banks fund in foreign currency) can conversely increase $\pi_{e,t}$.

$\pi_{i,t}$ determines the contribution of interest rate changes to the EMP. Comparing the mathematical expressions for $\pi_{i,t}$ and $\pi_{e,t}$ shows that under the assumption of moderate valuation wealth effects in the exchange rate elasticities, $\pi_{i,t}$ is likely to be larger than $\pi_{e,t}$, suggesting that interest rate basis point changes contribute relatively more than one-for-one to exchange rate depreciation equivalents in the EMP.

3 Empirical Implementation

Constructing the EMP requires careful implementation choices. This section discusses the data and parameterization decisions. The baseline EMP is constructed using monthly data for 41 countries listed in Appendix Table A2, spanning both advanced economies and emerging markets starting in 2000 and extending through the end of 2018.

3.1 Key Data Choices

Implementation of the EMP relies on appropriate data series. First, it is important to capture official foreign exchange interventions accurately. When authorities do not publish FXI data, choosing accurate approximation and justments are key. An additional choice is the reference currency used for assessing the pressures on a currency. Third, rates used for monetary policy need to be selected. Finally, the measure of portfolio elasticities of the response to *uip* and risk is important. Trade volumes respond slowly to changes in interest and exchange rates, and for the purposes of implementation in monthly data, we assume that short run trade balance elasticity $NX' = 0$, and $\frac{E(e_{t+1})}{e_t} \approx 1$.

The core data are drawn from national central banks, the IMF's International Financial Statistics (IFS), and International Investment Positions and International Exposure data (Benetrix, Lane and Shambaugh, 2015). Extended coverage of the EMP back in time is achieved by supplementing some quarterly data with earlier annual values of gross foreign assets and liabilities. All data sources and definitions are provided in Appendix Table A3.

3.1.1 Country Sample and Time Period

The countries included in our sample are chosen based on data availability. We include countries for which the construction of the EMP start in 2002 at the latest, beginning in 2000 for most countries.[16] Because the EMP relies on exchange rate variation, we exclude countries that do not have their own currency, or have multiple official exchange rates. The euro area as a whole is included, but individual euro area countries are excluded.[17] Appendix Table A2 presents the country sample while Table A3 describes the data sources and definitions. Data sample and descriptive statistics are provided in Table A4 for the period from January 2000 to December 2018. EMP values for Advanced and Emerging Markets, with subperiods of pre-crisis (2000m1-2007m6), crisis (2007m7-2009m6), and post-crisis (2009m7-2018m12), are described in Table A5. IMF country classifications sort countries into Advanced Economies versus Emerging and Developing economies.

3.1.2 Capturing Foreign Exchange Intervention

Studies of foreign exchange intervention (FXI) often rely on changes in published IMF official foreign reserves data by country-date. This approach can, however, generate biased values for actual FXI because exchange rate changes induce valuation effects. These valuation effects arise because central bank reserve portfolios are typically comprised of assets spanning a basket of currencies, instead of exclusively being invested in a single base currency. US dollar denominated

[16] Even when data is available, we have also excluded very small countries, defined as having population size below half a million or annual per capita income average since 2002 below US dollars 1000.

[17] We include Estonia and Latvia up until their dates of entry into the euro area in January of 2011 and 2014 respectively, but do not include countries that joined the euro earlier. We do not include Slovenia and Slovakia, which joined in 2007 and 2009 respectively. Venezuela is excluded based on lack of clarity about the relevant official exchange rate for capital account transactions.

assets, on average, represent 60 to 65 percent of total foreign reserve portfolios, with euros dominating the remainder (Goldberg, Hull and Stein, 2013; Eichengreen, Chitu and Mehl, 2016).[18] Accordingly, the value of official reserves reported in US dollar equivalents fluctuates with the exchange rate vis-à-vis the other currencies in which the reserve assets are held. Indeed, appropriately accounting for valuation changes and active accumulation or depletion of reserves is a central contribution of the comprehensive discussion by Dominguez et al. (2012).

We address the valuation distortions by measuring FXI spot interventions using a combination of three complementary approaches, depending on data availability. Published data on official interventions are used when available, which is the case for 10 countries. In the absence of published data, we estimate FXI based on official reserve flows from national balance of payments statistics, when these are available in monthly frequency, which is the case for an additional 15 countries. Balance of payments data is based on transactions and is hence net of valuation changes, although it does contain interest receipts on foreign assets requiring an additional correction. For the remaining countries and time periods, we adjust changes in official foreign reserve positions for valuation and interest receipts. The procedure we follow is described in our online appendix on Measuring Foreign Exchange Interventions.

Some central banks also intervene in foreign exchange markets using methods that go beyond the more traditional spot sales and purchases of currency. The additional methods include off balance sheet derivatives instruments such as foreign currency forwards and futures, swaps and options intended to better target interventions (e.g. Domanski, Kohlscheen and Moreno, 2016; Kohlscheen and Andrade, 2014). Different reasons for such interventions include the need to target specific markets or meet foreign currency liquidity needs. It is not clear how various derivatives instruments map to a spot-intervention equivalent measure and the availability of derivatives data is limited. Accordingly, we exclude this adjustment from our measure of FXI. Our online appendix includes a list of the countries for which available data suggest accounting for derivatives may be important.

3.1.3 Reference Currency for the *EMP*

The EMP can be constructed vis-à-vis the main monetary reference currency of the country or vis-à-vis a common international currency like the US dollar. We use the Klein and Shambaugh (2008) classification system for selecting the main reference currency by country and date.[19] In practice, most countries have the US dollar as reference currency, with the exceptions of a number of European non-euro countries which have the euro as main reference currency (and had the

[18] Data on the full currency breakdown of central bank foreign currency reserves is not readily available in cross country comparable data sources. The IMF's COFER database keeps data for individual countries strictly confidential, providing a breakdown across advanced economies and emerging and developing countries.

[19] We extrapolate this information, available quarterly until the first quarter of 2014 through 2018.

Deutsche mark before the euro), Singapore, which has the Malaysian baht as reference currency, and New Zealand which has the Australian dollar as reference currency. The US and the euro area are each other's country of reference currency respectively. In exercises that compare patterns in the global financial cycle and the safe haven characteristics of currencies across countries, the US dollar is used as a common comparison currency for all other countries.

3.1.4 Measuring Monetary Policy and Risk Changes

Home monetary policy rates directly enter the EMP as interest rate changes. Foreign interest rates are drivers of pressures. We use policy interest rates from national central banks or from the IFS when available, and complement these with other types of short-term interest rates when needed (Table A3). As short term policy rates do not fully reflect monetary policy measures when countries are near or at the zero lower bound (ZLB), we also use a shadow policy rate generated by Krippner (2016) for the US, UK, Japan, and euro area in the ZLB periods.

As measures of global risk, we follow the literature and focus on changes in the VIX index of the Chicago Board Options Exchange (CBOE). We also compare with a constructed global risk aversion shock from Habib and Stracca (2012) for robustness. These risk aversion shocks, updated by Habib and Stracca, correspond to conditions of i) an increase in the VIX plus ii) a fall in the return of a global unhedged (in local currency) stock portfolio, with the series normalized to mean zero.

3.1.5 Currency Denominations of Foreign Assets and Liabilities

Distinguishing foreign currency and domestic currency positions is relevant for understanding wealth and interest rate effects (Maggiori, Neiman and Schreger, 2019). On the foreign liability side, the range of experiences across countries is broad, with shares spanning about 20 percent to nearly 90 percent. While the pre-crisis period (2000-2008) had higher foreign currency shares in liabilities compared with the early post-crisis period (2009-2012), the order of magnitude remained high for many countries (Benetrix, Lane and Shambaugh, 2015). Foreign assets are much more likely to be denominated in foreign currencies, generally exceeding 90 percent (Appendix Figure A1).

3.2 Portfolio Elasticities

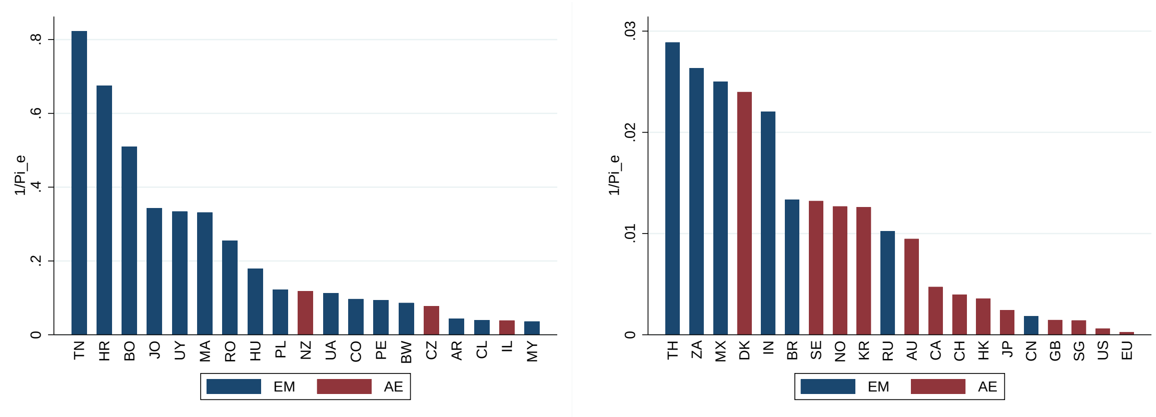
Available evidence supports our central portfolio mechanisms, as foreign shares in investors' portfolios respond significantly positively to a currency depreciation shock (Hau and Rey, 2004; Hau and Rey, 2006; Curcuru, Thomas, Warnock and Wongswan, 2014). The net foreign asset and liability elasticities with respect to exchange and interest rates used in the EMP are fundamental concepts, yet consensus elasticity estimates are not available. Part of the explanation for this gap is that identifying causality from exchange and interest rate movements to international capital flows is difficult. Recent insights are drawn from analyses of specific types of flow data, typically portfolio equity flows at the level of investment funds, which allow for more granularity, higher frequency, and an assessment of the relative timing of exchange rate and capital flow changes. Mutual funds in the US, UK, Eurozone, and Canada exhibit economically relevant portfolio rebalancing that is symmetric for both positive and negative changes in excess returns (Camanho, Hau and Rey, 2018). Moreover, the sign and size of the foreign currency mismatch in bank balance sheets affects the response of bank cross border funding flows to exchange rate changes (Krogstrup and Tille, 2018). Securities-level investment positions support distinguishing mutual fund portfolio sensitivities into domestic versus foreign currencies (Maggiori et al., 2019).[20]

Country aggregate data on components of global liquidity shows that elasticities of flows to domestic policy rates, US policy rates, and risk sentiment vary across market-based finance versus banking flows (Avdjiev, Gambacorta, Goldberg and Schiaffi, 2017b). Implied elasticities, relevant for ϵ_k^{FA}, ϵ_k^{FL} where $k = e, i, s$ in the EMP suggest that a 100 basis point increase in local policy rates tends to raise external debt growth rates by between 0.5 and 1 percent in a quarter, while sensitivities to a 100 basis point increase in the Federal Funds Rate (or shadow rate equivalent) are higher, reducing growth rates by between 5 and 8 percent in a quarter. Panel regression results directly based on the net foreign currency asset and net domestic currency liability data for our sample of countries and time frame yields similar order of magnitude effects.[21] The exchange rate elasticity estimates suggest that a 1 percent exchange rate depreciation against the US dollar should lead to a 0.05 percent reduction in foreign asset holdings in the following quarter (i.e. a capital inflow due to domestic resident retrenchment). Moreover, a 1 percentage-point increase in the domestic interest rate is estimated to induce a 0.14 percent retrenchment in domestic residents' foreign assets (i.e. a gross resident inflow). Due to the potential for attenuation bias as discussed above, these estimates are likely to be lower limits for the elasticities. Results suggest stronger responses in emerging markets than in developing countries. The exchange rate elasticity in the foreign liabilities regression is of similar absolute size to that found in the foreign asset regression.

The baseline EMP used for our applications is constructed using a range of sensitivities of home and foreign portfolio demands to interest and exchange rates. We choose ϵ_e^{FA} and $\epsilon_e^{FL} = 0.10$ and consider the alternatives of $[0.05, 0.15]$. We use ϵ_i^{FA} and ϵ_i^{FL} values that are three times as large as the associated exchange rate elasticities values for robustness.

[20] The role of the US dollar in international portfolios has been unique in recent history. When foreigners buy US securities, they predominantly buy dollar-denominated securities, behaving like US investors.

[21] Our online appendix on Exchange Rate and Interest Rate Elasticities from panel regressions discusses estimation details and limitations.



(a) $1/\pi_e > 0.03$

(b) $1/\pi_e < 0.03$

Figure 1: **Average $1/\pi_e$ by Country (2009m7-2018m12)**
$\frac{1}{\pi_e}$ is the post-GFC average equivalent currency depreciation that would be needed to offset the capital flow gap reflected in sales of foreign currency reserves of 1 billion US dollars. The bars are color-coded by AE (red) and EM (blue) countries. Armenia and Senegal are excluded due to very large numbers, as net cross currency border positions are small.

3.3 The Baseline *EMP*

The empirical conversion factors that map FXI_t and di_t into currency depreciation units within the EMP are constructed based on equations (16), (17), and (18). $\frac{1}{\Pi_{e,t}}$ reflects how much one unit of FXI offsets currency depreciation. Constructed as post-crisis period monthly average values, Figure 1 shows the range of FXI conversion factors for advanced economies (red bars) and emerging market (blue bars) when FXI is valued in billions of US dollars. For the countries with the lowest conversion factors, a one billion US dollar foreign currency intervention (sale) offsets up to 3 percentage points of currency depreciation. The potential conversion rate is much higher for larger emerging markets like Thailand, Mexico, India, Brazil, Russia, India and China. Most advanced economies have implied conversion rates that are an order of magnitude smaller than those for emerging markets. For example, the $\frac{1}{\Pi_{e,t}}$ conversion factor suggests that a one billion US dollar intervention would instead deliver a currency depreciation offset of less than 0.5 percentage points for Canada, Switzerland, Hong Kong and Japan. The US and euro area direct implied intervention effects would be even smaller, consistent with a long literature that emphasizes the role of oral interventions and scale, which is measured relative to GDP for Fratzscher, Gloede, Menkhoff, Sarno and Stohr (2019) and relative to foreign exchange transaction volumes for Patnaik, Felman and Shah (2017). This type of magnitude consideration is consistent with skepticism around the opportunity cost of holding very large stocks of reserves for the largest economies (Goldberg, Hull and Stein, 2013).

3.3.1 Country-specific Examples

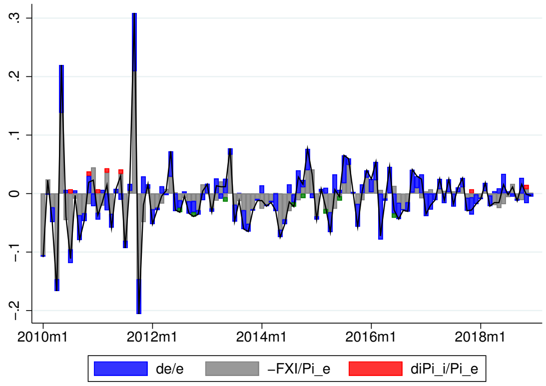
We next provide the EMP and its sensitivity to parameter choices. Four specific countries are used: Australia is selected as a commodity currency economy with a floating exchange rate, Brazil as an emerging market, Korea as a small open economy that has both experienced substantial pressures and used multiple instruments, and Switzerland as an advanced country that has actively used all three respective components of the EMP.

Figure 2 compares the EMP and the contributions of its component parts. A positive EMP denotes an international capital outflow pressure (local currency depreciation pressure), and a negative EMP denotes a capital inflow pressure (local currency appreciation pressure). The EMP for Australia, with its floating exchange rate, is primarily driven by exchange rate fluctuations, as would be expected. The three other countries occasionally or periodically intervene in foreign exchange markets and their EMPs are to a large degree driven by both exchange rate fluctuations and FXI. The contribution of the domestic policy rate changes are smaller.

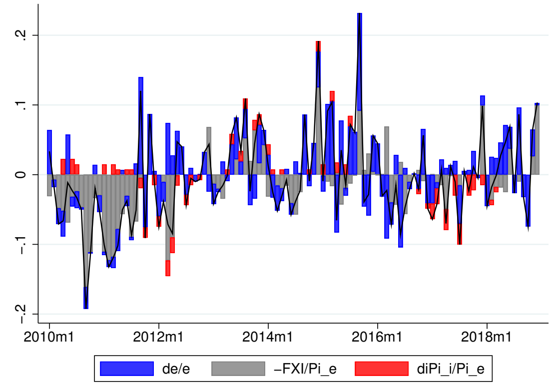
The difference between results when the EMP is based on the US dollar and the EMP is based on the euro, shown for Switzerland, illustrates the importance of the choice of reference currency used in the EMP. Switzerland's reference currency is the euro, per the Klein and Shambaugh (2008) classification. The EMP construction based on bilateral exchange rates vis-á-vis the euro, with euro denominated changes in official foreign reserves, suggests a smaller role for exchange rate fluctuations and a larger role for FXI to stabilize this relationship, in capturing capital flow pressures than suggested by the EMP based on the US dollar. In general, the choice of reference currency is particularly important during episodes when exchange rate changes dominate the index, but less so when reserves changes clearly dominate, as in the latter period for Switzerland.

The advantages of the EMP as a measure of balance of payments pressures include its comprehensiveness (i.e. covers all net non-reserve flows) and monthly frequency, as well as its comparability across different countries, currency regimes, and over time. Hence, it allows for an assessment of the link between capital flow pressures and global factors at a higher frequency and greater consistency across countries than accomplished using realized capital flow data based on Balance of Payments Statistics and global liquidity series. Figure 3 compares the baseline EMP with quarterly net private capital outflows in percent of GDP for Australia, Brazil, Korea, and Switzerland representing different degrees of exchange rate management across both time and countries. The sign and the direction of change in the EMP and realized net private capital flows are constructed to be directly comparable under the assumptions of the model.[22] As the level and amplitude of these two series are not comparable, for this illustration net capital flows

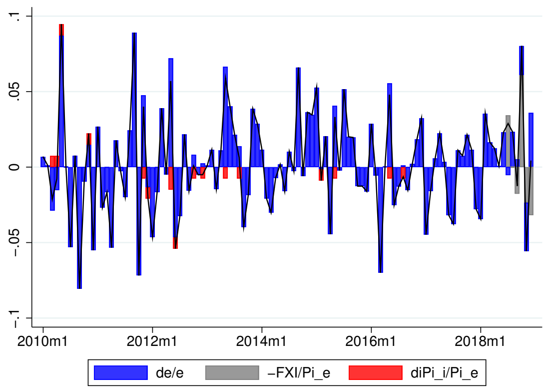
[22] If the current account persistently deviates from zero, this would lead to an average net capital flow reflecting the current account which would not constitute a capital flow pressure.



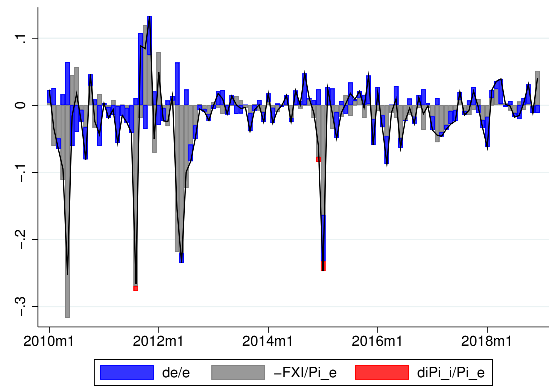
(a) Korea vis-à-vis US dollars



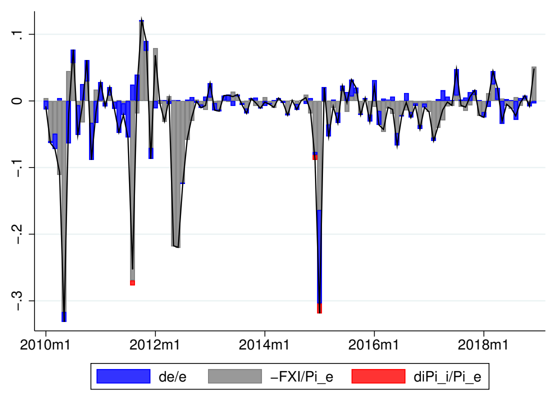
(b) Brazil vis-à-vis US dollars



(c) Australia vis-à-vis US dollars



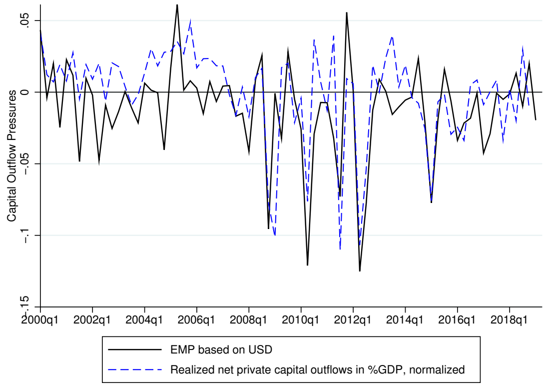
(d) Switzerland vis-à-vis US dollars



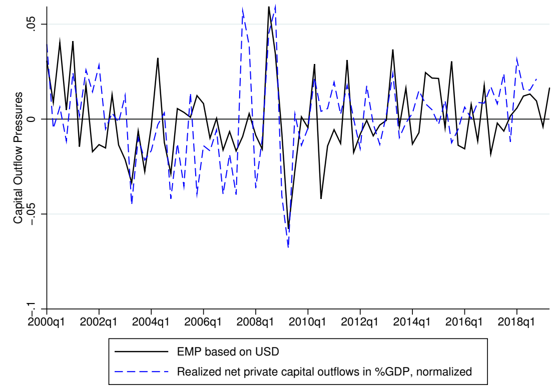
(e) Switzerland vis-à-vis Euro

Figure 2: **Individual Components of the EMP (2010m12-2018m12)**
Presented are the three components of the baseline EMP, including percentage changes in the exchange rate, changes in FXI scaled by $\frac{1}{\Pi_e}$ and changes in policy rates scaled by $\frac{\Pi_i}{\Pi_e}$. The first four charts are based on EMP against US dollars. The bottom chart for Switzerland reflects the EMP against its reference currency (EUR).

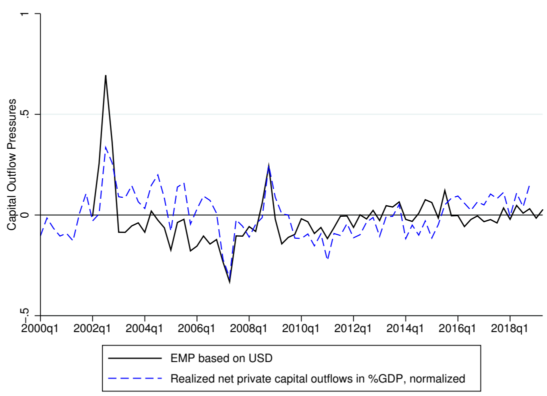
series are normalized to the mean and standard deviation of the EMP series.



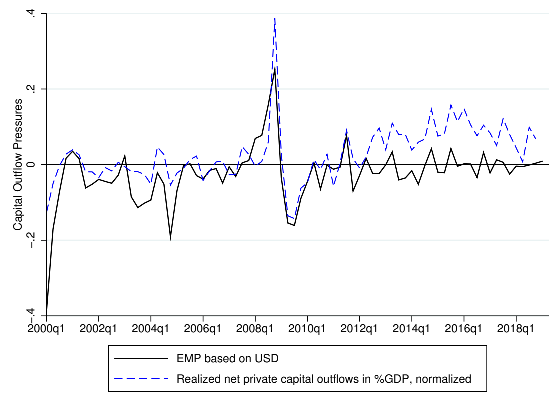
(a) Switzerland



(b) Australia



(c) Brazil



(d) Korea

Figure 3: EMP **and Net Private Capital Outflows, Quarterly Averages.**
Quarterly averages of monthly values of the EMP against the US dollar and normalized net capital outflows in percent of GDP. Net capital outflows are normalized to have the mean and standard deviation of the EMP series, for comparability. Positive values reflect net capital outflows and depreciation pressures against the reference currency. Negative values reflect net inflows and appreciation pressures.

As expected, the degree to which the EMP correlates with actual international capital flows depends on the currency regime in place. In countries where the exchange rate is freely floating, capital flow pressures result in more exchange rate adjustment, which in turn moderates realized private capital flows. Switzerland before 2008, when the exchange rate was freely floating, is a good example as in in Figure 3. In contrast, when the exchange rate is highly managed, capital flow pressures materialize in a private net capital flow which may be fully accommodated by changes in central bank foreign reserves or policy rate changes that stunt the exchange rate response. This has been the case in the post-crisis period for Switzerland, when the lower bound on interest rates resulted in a shift in monetary policy toward more active exchange rate management.[23] More generally, the correlation of the EMP with realized capital flows is dependent on currency regime. Capital flow pressures as captured by the EMP, and actual capital flows, are more correlated for countries with a higher degree of exchange rate management, and less so in countries with floating rates. This observation underscores the advantage of the EMP as a measure of capital flow pressures that is comparable across exchange rate regimes. It highlights the risk that research studies that are reliant purely on exchange rates or purely on capital flow data may miss important aspects of capital flow pressures, with results subject to attenuation biases.

3.3.2 Robustness: Country-specific Illustration

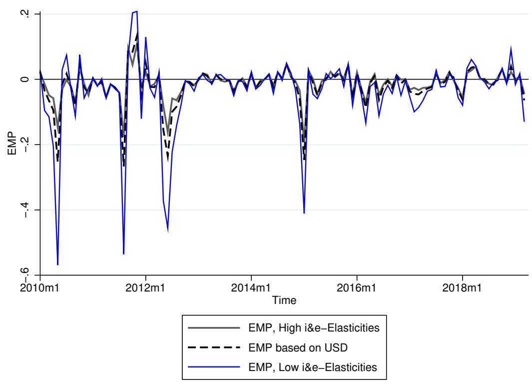
A central robustness consideration in the construction of the EMP pertains to the assumed elasticities of international portfolio adjustment to components of the *uip*. Our baseline approach constructs the EMP using an exchange rate elasticity of 0.10 and an interest elasticity of 0.30. As we have already discussed, the literature has not adequately converged on the stylized facts for such elasticities by country or over time. If the true empirical elasticities are substantially different, the baseline EMP will be inexact particularly for countries that manage their exchange rate using either FXI or di_t. Under a fully floating exchange rate regime, reserves and interest rate changes are less important, in which case the scaling of FXI and di will matter less (and the EMP overall is less of a contribution) as the exchange rate component of the index dominates.

We have performed extensive robustness analyses to alternative parameterizations. The role of altering the exchange rate elasticity assumption is illustrated in Figure 4, which displays the baseline EMP and two alternative versions constructed using the exchange rate elasticities of 0.05 and 0.15, and the interest elasticities of 0.15 and 0.45 respectively, for our four sample countries. Australia is the country with least exchange rate management, and also the country for which the exchange rate elasticity assumption matters the least. For all countries, the applications using the three alternative elasticity EMPs generate pressures in the same direction, but with the scale of contributions by FXI and di_t shifting accordingly.

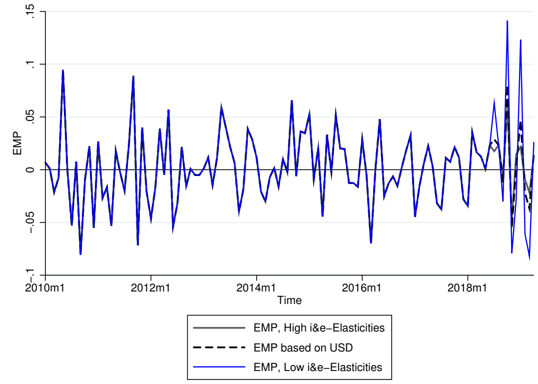
4 Understanding Safe Haven Currency Status

As a first broader empirical application, this section uses the EMP to identify so-called safe-haven status currencies and show the risk-on status of other currencies. We consider EMP and associated *uip* correlations with measures of global risk sentiment to construct a global risk response (GRR) index. We then revisit the question of which country features are correlated with

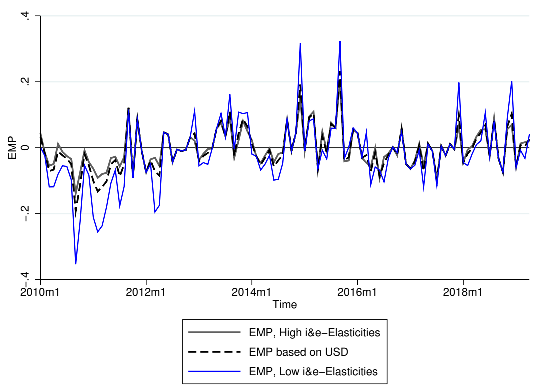
[23]The large realized capital inflow in late 2008 and early 2009 in Switzerland is related to the large scale foreign exchange swap operations carried out by the Swiss National Bank during this period.



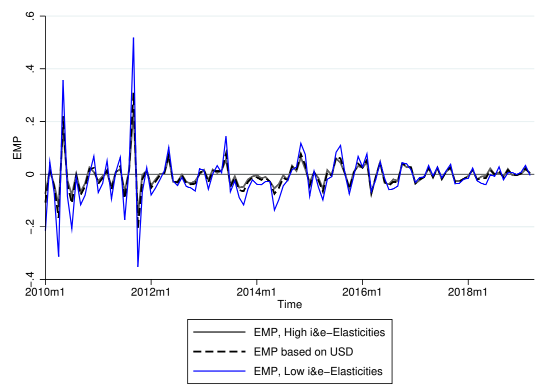
(a) Switzerland



(b) Australia



(c) Brazil



(d) Korea

Figure 4: EMP**: Alternative Exchange and Interest Rate Elasticity Assumptions**
EMP series constructed based on different values of the interest and exchange rate elasticity of gross foreign positions to changes in the domestic policy interest rate for constructing $\Pi_{i,t}$ and $\Pi_{e,t}$ constant. Baseline exchange and interest rate elasticities are 0.10 and 0.30 respectively, the low alternative elasticities are 0.05 and 0.15 respectively, and the high alternative elasticities are 0.15 and 0.45 respectively.

more pronounced positive or negative global risk responses of international capital flow pressures, as addressed in Habib and Stracca (2012). Section 5 builds on these insights by re-examining the importance of the global factor in international capital flows and the global financial cycle. We show that the EMP mitigates some attenuation bias on the size of this factor that arose in prior studies that exclusively rely on exchange rates (asset prices) or capital flows (asset quantities).

4.1 A Safe Haven Currency Index

In the asset pricing literature on safe-haven currencies, currencies are defined by exhibiting excess returns during risk-off episodes (Brunnermeier, Nagel and Pederson, 2008; Ranaldo and Soederlind, 2010; Habib and Stracca, 2012). Underlying this definition is a presumption that excess currency returns are driven by an increased demand for the currency during such risk-off episodes. However, in countries where authorities intervene to prevent the currency from responding to an increased demand, this safe-haven demand is also reflected in FXI or policy rate reductions; the excess return constructed based on observed exchange rate movements alone is subject to attenuation bias. The EMP can be thought of as a "super-exchange rate", or a counterfactual exchange rate movement that captures both observed and incipient pressures on a currency through the balance of payments. As the EMP allows us to capture such manifestations of safe haven demand for a currency consistently across exchange rate regimes, we revisit the features of countries that are associated with safe haven status. First, we compute a counterfactual excess return (cer^j) to holding currency j, defined as the monthly rate of counterfactual appreciation of the exchange rate of currency j against the US dollar, relative to a US dollar investment:

$$cer_t^j = -EMP_t^j + i_t^j - i_t^* \tag{19}$$

where EMP_t^j is expressed in terms of domestic currency units per US dollar. An increase means a counterfactual depreciation of the domestic currency, and it hence enters with a minus. i_t^j and i_t^* are short-term money market or policy rates applying to a one-month holding period.

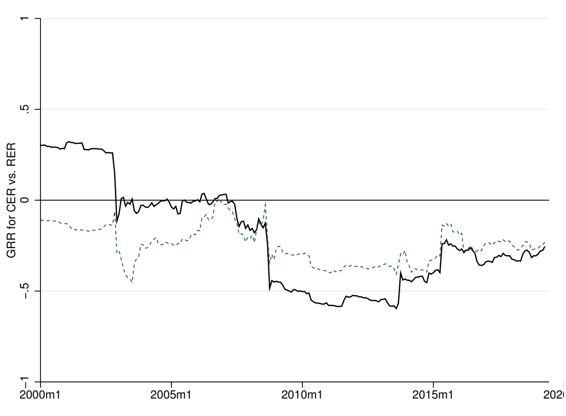
A currency j exhibits safe haven demand characteristics on average during the period from $t - x$ to t, if its uncovered excess returns rise when risk shocks are higher

$$GRR_t^j = corr_{t-x,t}(cer_t^j, v_t) > 0 \tag{20}$$

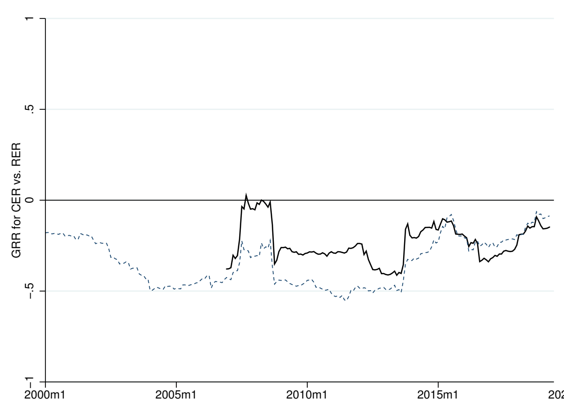
where v_t is a measure of a global risk shock, for example as captured by variation in the VIX or an alternative constructed measure such as the Habib and Stracca (2012) global risk aversion series. We call this correlation the Global Risk Response index, the GRR, with positive values reflecting currency appreciation and inflow pressures relative to those weighing on the US dollar (or other reference currency) when risk increases. We refer to currencies with persistently negative GRR as risk-on currencies. Persistently positive values are consistent with a currency having a safe haven interpretation.

Constructed here as a rolling five year correlation with the VIX, the resulting GRR exhibits substantial variation over time and across countries.[24] This dynamic is illustrated by the four sample countries shown in Figure 5. The Swiss franc consistently exhibits safe haven status with $GRR > 0$, particularly when measured against the euro. This status episodically would appear much weaker if the GRR were constructed using the observed exchange rate instead of with the EMP. Against the US dollar, the sign of the GRR based on the observed exchange rate

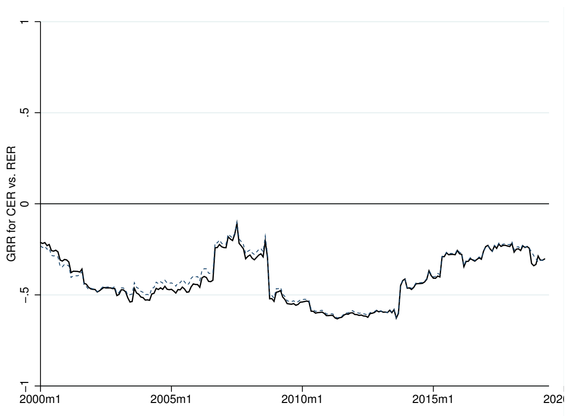
[24] Observations for the GRR are based on 5 years of prior monthly data. If pre-2000 EMP data are unavailable for some countries, some early GRR observations will be missing from the regression sample.



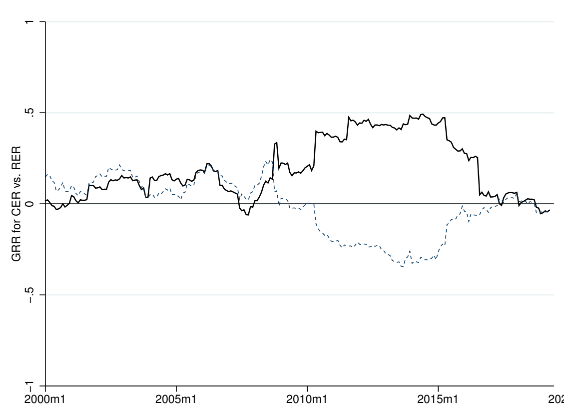
(a) Korea vis-à-vis US dollars



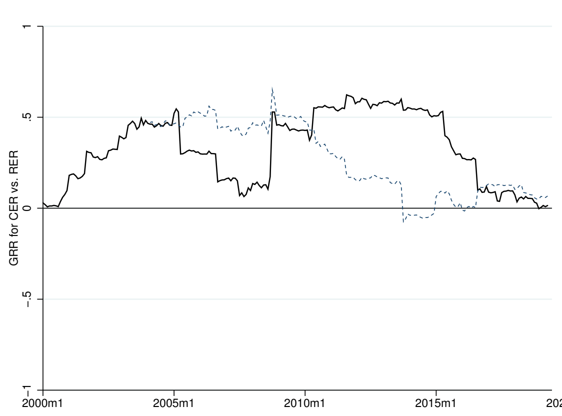
(b) Brazil vis-à-vis US dollars



(c) Australia vis-à-vis US dollars



(d) Switzerland vis-à-vis US dollars



(e) Switzerland vis-à-vis euro

Figure 5: **Global Risk Response (GRR) Comparison**
Solid lines depict GRR estimates for counterfactual excess returns based on the EMP against the US dollar. Dashed line indicates the GRR for the realized excess return to US dollars.

switches to negative during Switzerland's period of active exchange rate management between 2009 and 2014. By contrast, the Australian dollar behaves more like a commodity currency, consistently depreciating and with declining uncovered returns when risk rises. The Korean GRR is another interesting example, strongly demonstrating the type of attenuation bias on status when the pressures on a currency are measured using observed exchange rates instead of using the counterfactual EMP. In the pre-crisis period, the exchange rate based measure provides weaker or opposite indications of risk consequences for Korean capital flow pressures.

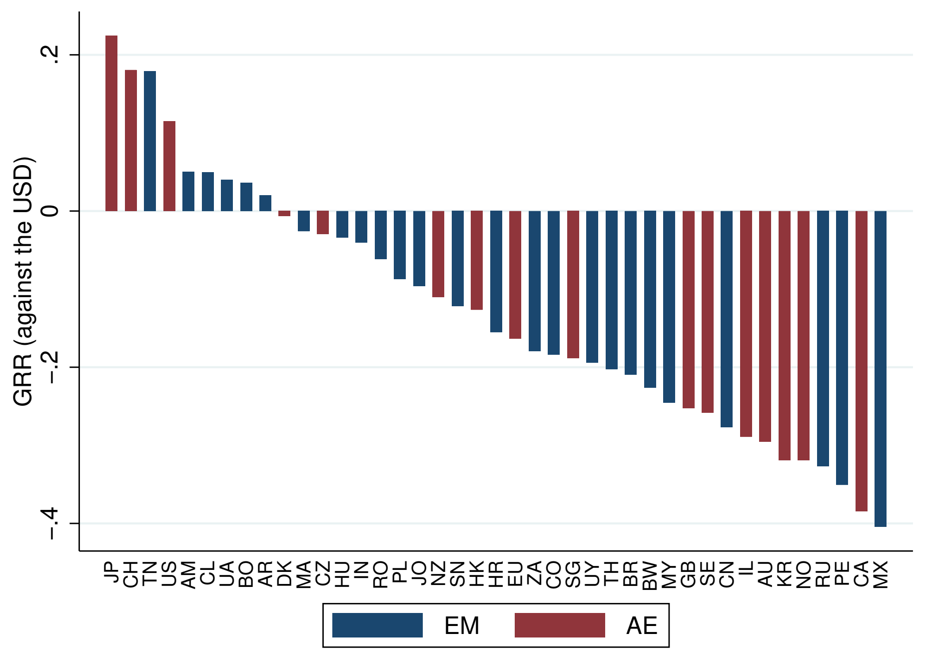


Figure 6: **Average GRR by Country (2014m7 - 2018m12)**
GRR based on the EMP against the USD and averaged across the time period 2014m7-2018m12 by country. The bars are color-coded by AE (red) and EM (blue) countries. The depicted EMP for the US is measured against the euro.

Across the full sample of 41 countries in the post-GFC period, a small group of countries exhibit consistent safe-haven status, with $GRR > 0$, based on correlations between the baseline EMP and the VIX (bottom panel of Figure 6). The Japanese yen, the US dollar (measured against the euro), and the Swiss franc have this status through 2018. The Swiss franc status is most pronounced when measured relative to the euro (Figure 5). In the remaining countries with positive average GRRs, these are occasionally significantly different from zero for Denmark. The rolling GRR chart for the UK pound (Appendix Figure A2) shows positive correlations through 2008 against the dollar, while correlations post-GFC fall below zero and are not significant. The safe haven status of the UK pound extended to 2014 when measured against the euro (not shown).

A larger group of currencies consistently exhibit what we refer to as risk-on currency status, with negative values of the GRR. These include so-called commodity currencies like the Australian dollar, the Canadian dollar, the Norwegian Krone, the South African rand, the Brazilian real, and the Russian ruble. Many other emerging markets and small advanced economies show less pronounced risk-on currency status with smaller but negative GRR values. As illustrated by Figure 6, within the sample of advanced economies color coded in red the measured variation in the risk response is large, both qualitatively and quantitatively. For some countries the indicated strength of these effects is starkly different when measured purely using exchange rates instead of the EMP as these tend to be countries that intervene in currency markets. Appendix Figure A2 provides time series patterns across each country. Results are broadly similar when constructed using the global risk shock measure of Habib and Stracca (2012) instead of the VIX (not shown).

Overall, this safe haven analysis based on the EMP confirms that three currencies, the Swiss franc, the Japanese yen and the US dollar, most consistently behave as so-called safe havens. Beyond earlier findings, our index takes into account that some safe haven currency pressures are manifested in policy interventions, such as for the Swiss franc in the post-crisis period. The safe havenness of the Swiss franc remained intact during this period when measured appropriately. Countries may have stronger risk-on behavior of currencies than suggested by analyses constructed just with the exchange rate, especially if policy interventions are used systematically to attenuate exchange rate responses, as exemplified by subperiods in Korea.

4.2 Drivers of Safe Haven Status

With excess returns in *uip* terms as the dependent variable, Habib and Stracca (2012) explore which country characteristics are associated with currencies having safe haven status. The underlying hypotheses, beyond inertia explanations, are that a currency may be "safe" if: i) the issuing country is itself safe and low risk; ii) its financial markets are large and liquid; and iii) it is financially open and global. The variables used for testing the contributions of these categories respectively include i) net foreign assets in percent of GDP, public debt to GDP, inflation levels, and country risk as measured by average interest differential; ii) country size in world economy, stock market capitalization to world GDP, and private domestic credit to GDP; and iii) capital account openness (Chinn Ito) and gross foreign assets and liabilities to GDP. Using monthly data from 1986 to 2009 for 51 currencies, and in specifications inclusive of lagged dependent variables, Habib and Stracca (2012) find the most consistent indicator of safe haven status to be country net financial assets, along with country size and stock market capitalization relative to world GDP. The role of net foreign assets is consistent with our modeling approach and home currency bias. In countries where residents hold larger foreign currency assets than issued domestic currency liablities, the home bias response to risk would tend to be dominated by residents repatriating foreign investments.

We revisit this regression approach to identifying drivers, instead using the cer_t^j as dependent variable, constructed relative to the US dollar, and utilizing data spanning 2000m1 to 2018m12. The specifications use a sample of 40 countries, excluding the US as the US dollar is the reference currency and US monetary policy is a control variable. The estimation equation is:

$$cer_t^j = \alpha_s ds_t^* + \beta\Omega_t^j * ds_t^* + \gamma\Omega_t^j + +\delta di_t^* + \zeta^j + \varepsilon_t^j \tag{21}$$

where cer_t^j is the counterfactual excess return using the super-exchange rate EMP and the short-term interest differential for country j at time t; ds_t^* is the global risk shock introduced as the VIX; and di_t^* is US monetary policy. Global risk enters estimation specifications directly and interacted with country-time specific variables, with each country variable also entering specifications in non-interacted form. The Ω_t^j are country-characteristics bundled according to the three hypotheses and presented together in groups in the columns of the results tables. The regressions are run for the entire time sample, separately for the pre- and post- crisis periods, and for emerging markets versus advanced economies. In order to keep the regression results tables concise, tables show estimated β and omit presentation of estimated α_s, γ, and δ. A parallel set of regressions also have been run using the global risk shock constructed in Habib and Stracca (2012), with very similar results that are not shown.

Table 1, columns I and VI provide results based on a specification excluding Ω_t^j for the advanced economies and emerging markets countries respectively. On average, higher risk is associated with lower excess returns across currencies, over time, and in both advanced economies and EMs. Columns II and VII show that the counterfactual excess returns based on the EMP are related to prior safe haven or risk status computed by interacting the VIX with the lagged GRR_t^j. Results shown in column II for advanced economies (column VII for emerging markets) indicate that the past safe havenness is a significant predictor of how the excess return responds to global factors in the sample of advanced economies, while the typical risk-on status in the sample of emerging markets is not significantly persistent.

We subsequently investigate whether this correlation can be explained by sets of fundamental variables, following the spirit of the analysis in Habib and Stracca (2012). Columns III and VIII contain regression results including the set of variables typically associated with country risk. Net foreign assets are associated with safe havenness in both country samples. However, the direction of this effect differs for advanced economies and emerging markets. Large positions for emerging markets are associated with depressed excess returns under elevated risk, while the opposite is observed for advanced economies. The interest differential and the level of public debt matter in the advanced economy subsample. Public debt is significant with the wrong sign, however,

	Advanced Economies					Emerging Markets				
	I	II	III	IV	V	VI	VII	VIII	IX	X
$dl(VIX)$	-0.052**	-0.038*	-0.063**	-0.087	-0.273***	-0.082***	-0.074**	-0.058	-0.099**	-0.067
	(0.014)	(0.014)	(0.017)	(0.049)	(0.042)	(0.018)	(0.025)	(0.037)	(0.035)	(0.034)
$dlVIX * GRR_{t-1}$		0.149*					0.088			
		(0.054)					(0.096)			
$dlVIX * InterestDiff_{t-1}$			-0.935**					-0.183		
			(0.264)					(0.270)		
$dlVIX * NFA/GDP_{t-1}$			0.015*					-0.179*		
			(0.007)					(0.079)		
$dlVIX * Infl_{t-1}$			-0.212					0.060		
			(0.166)					(0.199)		
$dlVIX * PubDebt/GDP_{t-1}$			0.000*					-0.000		
			(0.000)					(0.001)		
$dlVIX * ShareofWorldGDP_{t-1}$				1.293*					-0.598	
				(0.580)					(0.400)	
$dlVIX * StockmarketCap/GDP_{t-1}$				0.000					-0.001	
				(0.000)					(0.000)	
$dlVIX * Dom.Credit/GDP_{t-1}$				-0.000					0.001	
				(0.000)					(0.001)	
$dlVIX * (GFA + GFL)/GDP_{t-1}$					0.004					0.035
					(0.002)					(0.031)
$dlVIX * ChinnIto_{t-1}$					0.212***					-0.093
					(0.046)					(0.055)
R2	0.015	0.026	0.026	0.022	0.022	0.007	0.011	0.017	0.043	0.008
No.Obs	3376	3124	3127	2983	3146	5276	4552	4851	5082	5088

Table 1: **Safe Haven Panel Regressions**

Results from monthly panel regressions of equation 21, for cer (the counterfactual excess return based on the EMP against the US dollar) as dependent variable, from 2000m1 - 2018m12. No.Obs gives the number of regression observations. The regressions also include di^*_{ssr}, GRR_{t-1}, $InterestDiff_{t-1}$, NFA/GDP_{t-1}, $Infl_{t-1}$, $PubDebt_{t-1}$, $StockmarketCap_{t-1}$, $ShareofWorldGDP_{t-1}$, $DomCredit/GDP_{t-1}$, $(GFA+GFL)/GDP_{t-1}$, $ChinnIto_{t-1}$, and country fixed effects (not shown). The data source for stock market capitalization and public debt, the World Bank Financial Structure Database, has these series updated through 2016m12. As such series are typically slow moving, we assign the last available value for the associated series to all regression observations in the later dates of the regression sample. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels.

possibly reflecting reverse causality if demand for public debt is higher in countries considered more safe.

Columns IV and IX introduce the set of macro fundamental variables reflecting size of economy and financial market development. Economic size matters in advanced economies, with larger advanced economies less risk responsive or with more tendency toward safe havenness.

Columns V and X introduce variables that capture financial openness: an index of capital controls (the Chinn Ito index) and a de facto measure in the form of gross foreign assets to GDP. The Chinn Ito index is significant only for advanced economies, suggesting that advanced countries with more open capital accounts are more likely to be safe havens.

To conclude, using the counterfactual excess return based on the EMP instead of excess returns based on observed exchange rate changes allows us to capture safe haven patterns in currencies across exchange rate regimes. Our analysis of the drivers of such patterns confirms some of the determinants found in the literature, but shows a sharp distinction between advanced economies and emerging markets. We confirm that net foreign assets are a key determinant but directionally distinct across groups. We do not find financial market development to be important in differentiating risk behavior of currencies across emerging markets, however.

5 The Global Factor in Capital Flow Pressures

While highly statistically significant in many empirical studies, the importance of the global factor and global financial cycle in international capital flows is disputed by Cerutti et al. (2019). Their analysis focuses on the contribution to capital flow variation and uses net capital flow measures, some of which are subject to the attenuation bias addressed by the EMP as discussed in Section 3.3.1. Below we revisit the global factor analysis of capital flow pressures, instead applying the EMP in comparable empirical specifications.

5.1 The *EMP* and Global Liquidity Drivers

As shown explicitly shown by equation 16, global factors comprise changes in the foreign interest rate (di_t^*), changes in global financial risk sentiment as captured by ds_t^*, and changes in global financial wealth. Regressions for advanced economies and emerging market economies thus are conducted using the panel estimating equation over monthly or quarterly data:[25]

$$EMP_t^j = \beta_s ds_t^* + \beta_{i*} di_t^* + \beta_{sd} ds_t^* D_t^j + D_t^j + \zeta_t^j + \varepsilon_t^j \tag{22}$$

[25] To arrive at specification (22) from equation (16), the simplifying assumptions are made that the terms $\frac{FA'_s}{\Pi_{e,t}} ds_t - \frac{\frac{1}{e_t} FL'_W}{\Pi_{e,t}} dW^* + \frac{FA'_W}{\Pi_{e,t}} dW$ are uncorrelated with the regressors and picked up in country fixed effects and the error term.

where j-superscripts denote the country, ζ^j is a country-specific fixed effect, and the global financial risk sentiment and global interest rates are global factors. D_t^j is a dummy taking the value one in country months where the lagged GRR_t^j is positive and significantly different from zero at the 10% level. We expect a positive sign for β_{i^*}, i.e. a higher foreign interest rate should induce capital outflows and thus increase the EMP, all else equal. The sign for β_s depends on sensitivities to increases in risk perception. As discussed, the literature traditionally has found it to be positive for emerging markets, in that risk-off sentiment has been related to outflows, and negative for so-called safe haven countries (Habib and Stracca, 2012; Ranaldo and Soederlind, 2010). We hence expect β_s to be positive and β_{sd}, accounting for safe haven countries, to be negative. For each country sub-sample, we run the regressions for the entire period from 2000m1 to 2018m12, and for three sub-periods including the pre-financial crisis, the GFC period and the post crisis period. There are no instances of persistently significant safe haven currencies in the emerging market sample, where the interaction with a dummy variable is excluded.

In the baseline specification, global financial risk sentiment is measured by fluctuations in the VIX, following both the safe haven regressions and prior global factor studies (e.g. Forbes and Warnock, 2012; Rey, 2015). Recent research on global financial factors and capital flows brings into question the ability of the VIX or other indices to consistently capture global financial risk sentiment over time (Cerutti, Claessens and Rose, 2019; Avdjiev, Gambacorta, Goldberg and Schiaffi, 2017b; Krogstrup and Tille, 2018; Shin, 2016). We hence follow the more robust approach of Cerutti, Claessens and Rose (2019) and capture global common factors in alternative specifications by including time fixed effects in lieu of changes in the foreign interest rate and the VIX. Time fixed effects indiscriminately capture all global factors that affect capital flow pressures in the same way across the panel countries, including part of the impact of the VIX, the foreign interest rate, foreign financial wealth changes and other possible global factors that similarly impact the sample countries. The time fixed effect allows us to assess how much of the variation in capital flow pressure can be accounted for by common responses to global factors, but does not allow us to assign the global factor to individual types of drivers. Moreover, country specific variation not captured by time fixed effects can still be a response to global factors, if this response differs from the response of the average country of the sample.

The baseline panel regression results are displayed in columns I-V of Table 2 for the two subsamples and the different time periods. Changes in the VIX are significantly positive, as expected, in largely all specifications. The safe haven dummy interaction term is significantly negative in the crisis and post-crisis samples, capturing the qualitatively different global risk response of these countries. The overall share of variation explained by global factors reflected by the VIX is low, at under 1 percent, but slightly higher in the crisis period.

Column VI presents the results in the full sample including period fixed effects and excluding

(a) Advanced Economies

	I	II	III	IV	V	VI	VII	VIII (NCAP)
$dl(VIX)$	0.052**	0.087***	0.087***	0.322**	0.060**			
	(0.014)	(0.020)	(0.017)	(0.092)	(0.014)			
di^*	1.390**	1.303*	2.695*	4.344***	1.106*			
	(0.425)	(0.456)	(1.253)	(0.928)	(0.374)			
$dl(VIX)D$		-0.054	-0.096***	-0.196	-0.034	-0.064	-0.037	-14.706
		(0.030)	(0.020)	(0.100)	(0.031)	(0.035)	(0.048)	(10.219)
D		-0.009	-0.011	0.008	-0.017	-0.012	-0.005	-2.554
		(0.005)	(0.009)	(0.016)	(0.015)	(0.007)	(0.004)	(1.767)
R2	0.012	0.017	0.013	0.101	0.013	0.177	0.161	0.053
No.Obs	3380	3380	1310	360	1710	3380	1158	1131
No.C	15	15	15	15	15	15	15	15
Sample	full	full	pre	fc	post	full	full	full
PE	No	No	No	No	No	Yes	Yes	Yes
Frequency	M	M	M	M	M	M	Q	Q

(b) Emerging Markets

	I	II	III	IV	V	VI	VII	VIII (NCAP)
$dl(VIX)$	0.118***	0.118***	0.142	0.229***	0.070*			
	(0.025)	(0.025)	(0.078)	(0.049)	(0.026)			
di^*	1.985*	1.985*	-2.005	4.385	3.186**			
	(0.811)	(0.811)	(2.947)	(3.263)	(0.958)			
R2	0.006	0.006	0.004	0.032	0.007	0.078	0.122	0.078
No.Obs	5452	5452	2037	600	2815	5452	1859	1626
No.C	25	25	25	25	25	25	25	22
Sample	full	full	pre	fc	post	full	full	full
PE	No	No	No	No	No	Yes	Yes	Yes
Frequency	M	M	M	M	M	M	Q	Q

Table 2: **Global Factor Panel Regressions**

Results from monthly panel regressions of equation (22). i^* is the US policy interest rate. Shadow policy rates from Krippner (2016) are used for ZLB periods when avalable. No.Obs gives the number of regression observations. Column header indicates dependent variable. Sample indicates the time sample used ("full" is from 2000m1 to 2018m12, "pre" indicates the pre-crisis sample which stops in 2007m6, "fc" indices the GFC from 2007m7 to 2009m6, and "post" indices the post crisis sample from 2009m7 to 2018m12). PE indicates whether period fixed effects are included. All regressions include country fixed effects. Frequency indicates whether monthly end-of-month "M" or quarterly averages "Q" are used. Clustered standard errors are shown in parentheses. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels.

the VIX and i^*. Time fixed effects substantially increase the share of explained variation in the EMP. The share is highest, over 17 percent, in the advanced economy sample. Column VII presents results for the full sample using data on the EMP in quarterly frequency and compares the estimates with those using data on net capital flows in percent of GDP as in the literature on global factors in capital flows. Both regressions include period fixed effects as measure of global factors, and additionally account for safe haven characteristics in the advanced economy sample.

The share of variation explained in the EMP regression is three times larger than the net capital flows regression for advanced economies, and somewhat larger in the emerging market sample.

The EMP as a gauge of capital flow pressures thus points to a stronger role for a global financial cycle than observed when realized aggregates for international capital flows are analyzed. [26] This could derive from the fact that the EMP accounts for different types of manifestations of pressures (in flows or prices) instead of exclusively in outright international flows, especially for countries with more de facto flexibility in exchange rates. The share of variation that is explained in global factor regressions based on the EMP remains relatively modest, however. The results (columns I to V) are largely robust to using the observed US policy rate instead of a shadow rate, to using the global risk shock instead of the VIX, and to using the EMP against the reference currency instead of exclusively the US dollar (not shown).

6 Conclusions

This paper has introduced a new measure of capital flow pressures in the form of an exchange market pressure index. While exchange market pressure indices have a long tradition, our approach has a solid grounding in international financial portfolio theory, balance of payments accounting, and recent advances in understanding investment flows across borders. The EMP measure takes into account the form of exchange rate regime in place at each point in time, the returns on gross foreign assets and liabilities in different currencies, and the drivers of gross foreign asset and liability positions at the country level. This index can be computed for a broad panel of countries and over time, offers monthly variation in international capital flow pressures with at most a few months of lag, and takes into account actual observed variation as well as incipient capital flow pressures. The EMP has a super exchange rate interpretation, as both foreign exchange intervention and monetary policy are mapped into currency depreciation equivalents. Disadvantages are that the index is constructed rather than observed as data, and construction relies on assumed baseline portfolio response parameters with associated scope for mismeasurement.

The EMP is a useful tool for avoiding the type of attenuation bias that arises when exchange rates or capital flows are independently used in cross-country and time-series empirical analyses. This usefulness has been demonstrated with country examples and in two applications addressing current issues in international finance. First, we show that excess return or EMP correlations with risk sentiment measures provide informative insights into safe haven currency flows as well as risk-on status of other currencies. The country characteristics that drive these results differ across advanced and emerging markets, but underscore the importance of country size, net foreign

[26] Cerutti, Claessens and Rose, 2019 explore a very comprehensive span of types of international capital flow data, instead of this limited example we provide.

asset positions, and financial openness. Second, we show that the EMP is a useful alternative to the exchange rate and international capital flow series in quantifying the importance of the global factor across advanced economies and emerging markets. Our analysis confirms that the global factor is sizable, but also highly episodic. The EMP-based analysis explains significantly more cross-sectional and time variation than found exclusively based on capital flows, but still provides results supporting the dominant role of idiosyncratic factors in international pressures. We expect that ongoing research on time-variation in portfolio flows will aid continued refinement of the baseline EMP. Overall, our measure recognizes the richness of important differences in exchange rate and monetary regimes across countries and time, and advances our understanding of international capital flow pressures.

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Appendix

A Data Sources, Definitions and Descriptive Statistics

Study	EMP Definition[a]	Weighting Scheme[b]	Exchange Rate Definition
Girton and Roper (1977)	$\frac{de}{e} + \frac{dR}{M0}$	Equal	Nominal bilateral against US dollars
Eichengreen et al. (1994)[c]	$w_e \frac{de}{e} + w_i d(i - i^*) - w_R \frac{(dR - dR^*)}{M1}$	Precision	Nominal bilateral against DM / US dollars
Weymark (1995)	$\frac{de}{e} + w_R \frac{dR}{M}$	Model based price and interest elasticities	Nominal bilateral against US dollars
Sachs et al. (1996)	$w_e \frac{de}{e} - w_R \frac{(dR - dR^*)}{R}$	Precision	Nominal bilateral against US dollars
Kaminsky and Reinhart (1999)	$w_e \frac{de}{e} + w_R \frac{dR}{R}$	Precision	Real effective
Aizenman et al. (2012)[d]	$w_e \frac{de}{e} + w_i d(i - i^*) - w_R \frac{(dR - dR^*)}{R}$	Equal and Precision	Nominal bilateral against US dollars
Aizenman et al. (2016)	$w_e \frac{de}{e} + w_i d(i - i^*) - w_R \frac{(dR - dR^*)}{R}$	Precision	Nominal bilateral against reference currency
Patnaik et al. (2017)	$\frac{de}{e} - w_R dR$	Exchange rate elasticity to US dollars $1bn of interventions	Nominal bilateral against US dollars
Goldberg and Krogstrup[e]	$\frac{de}{e} - \frac{1}{\Pi_{e,t}} dR_t + \frac{\Pi_{i,t}}{\Pi_{e,t}} di$	Model based weight	Nominal bilateral against reference currency

[a] e is the exchange rate, R is central bank foreign currency reserves measured in US dollars, i is the interest rates, $M0$ is the monetary base, $M1$ is narrow money. Asterisks denote foreign or global variables.

[b] Precision weights as defined in text. w_e, w_R, and w_i are weights on exchange rate, reserves, and interest rate, respectively.

[c] Bilateral rates against Deutsche Mark used. (Eichengreen et al. (1996) instead apply bilateral rate against US dollars).

[d] Both Reserves and $M0$ used for scaling reserves.

[e] $\Pi_{e,t}$ and $\Pi_{i,t}$ are based on exchange rate sensitivities of gross external asset and liability positions and income balances. Reference currency as in Klein and Shambaugh (2008).

Table A1: **Exchange Market Pressure Indices in the Literature**

16 Advanced economies	25 Emerging Markets
United States, Japan, Switzerland, United Kingdom, Denmark, Norway, Sweden, Canada, Euro area, Czech Republic, Israel, South Korea, Singapore, Hong Kong, Australia, New Zealand	South Africa, Argentina, Bolivia, Botswana, Brazil, Chile, Colombia, Mexico, Peru, Uruguay, Jordan, India, Malaysia, Thailand, Morocco, Tunisia, Armenia, Senegal, Russia, China, Ukraine, Hungary, Croatia, Poland, Romania

Table A2: **Country Sample Table**

We have used the largest possible set of countries and excluded countries based on the following set of criteria: (1) data availability does not allow for construction of the EMP starting in 2002m12 at the latest, or until 2017m1 at the earliest, (2) very small countries, defined as countries with population size of less than 0.5 million and with GDP per capita of less than 1000 US dollars and (3) a number of individual countries for idiosyncratic reasons: Venezula (lack of clarity on the relevant exchange rate measure reflecting market pressures), Turkey, Paraguay, Belarus, Dominican Republic, Indonesia, Moldova, Philippines, and observations prior to 2002m1 for Armenia, Brazil and Ukraine, and prior to 2001m1 for Hong Kong and India (inadequate or inconsistent data on foreign currency exposures in foreign investment positions).

Variable	Definition	Source and Description
e	Baseline bilateral exchange rate.	End-of-month mid-point between bid and ask, domestic per unit of foreign. National central banks, the Federal Reserve and IMF International Financial Statistics.
R	Official foreign exchange reserves (total reserves minus gold)	In billions of reference currency units, end of period, monthly. Dollar value from IMF International Financial Statistics. Observations from 2004m5 to 2004m8 for Sri Lanka are excluded due to huge outlier values.
FXI	Estimate or data on official foreign exchange interventions, constructed as described in Appendix 1.	In billions of reference currency units, monthly flow. Data from national central banks, IMF International Financial Statistics, Balance of Payments, International Investment Position and the Exchange Reserves and Foreign Currency Liquidity Template.
i, i^*	Monetary policy or short-term rate	In percentage points, end of period, monthly. IMF International Financial Statistics or national Central Banks. Constructed as IFS policy rate line 60 if available, else policy rate from national central bank if available, else 3-month money market interest rate from IFS (line 60b) if available, else short-term treasury bond rate (IFS line 60c) if available, else deposit rates from IFS (only needed for parts of the sample period for Nicaragua, Panama, China and Argentina). For countries that have introduced negative policy interest rates, the relevant policy rate prior to the introduction of a negative rate is merged with the relevant rate post introduction for Denmark, Japan and EU.
i_{SSR}, i^*_{SSR}	Shadow policy rate in the US, euro area, Japan and UK	In percentage points, end of period, monthly. Krippner (2016).
GDP	Gross domestic product	In US dollars, quarterly. IMF International Financial Statistics.
VIX	CBOE Volatility Index	End of period, monthly. Extended backwards in time by the VXO from 1986m1 to 1989m12. Chicago Board Options Exchange.
FA	Total Foreign Assets less FDI	In billions of reference currency units. End of period, yearly, interpolated to monthly frequency. Own calculations based on IMF International Investment Positions.
FL	Total Foreign Liabilities less FDI	In billions of reference currency units. End of period, yearly, interpolated to monthly frequency. Own calculations based on IMF International Investment Positions.
$NCAP$	Net private capital outflows in percent of GDP	In percent, quarterly. IMF Financial Flows Analytics (FFA) database. Bangladesh and Panama do not have capital flows data.
$wAFC, wLFC$	Foreign currency weight of foreign assets and foreign liabilities (both derivatives are excluded)	Annual data from 1990 to 2012. Benetrix, Lane and Shambaugh (2015) Database.
Ref. Currency	Country's main reference currency	Annual data from 1960 to 2014, interpolated to monthly frequency and extrapolated to 2018. Klein and Shambaugh (2008) Database.

Table A3: **Data Sources and Definitions**

(a) Global Factors

	Mean	Max	Min	Std. Dev	Obs
di^*	-0.000	0.005	-0.013	0.002	228
di^*_{ssr}	-0.000	0.016	-0.013	0.003	228
$dlog(VIX)$	0.001	0.708	-0.373	0.165	228
vshock	0.002	5.987	-3.716	0.996	228

(b) Advanced Economies

	Mean	Max	Min	Std. Dev	Obs
$\frac{de_{base}}{e_{base}}$	-0.000	0.180	-0.154	0.023	3648
$\frac{de_{USD}}{e_{USD}}$	-0.000	0.180	-0.154	0.028	3648
FXI	0.569	103.225	-36.804	4.596	3636
FXI_{USD}	0.532	103.225	-36.000	4.685	3636
di	-0.000	0.026	-0.020	0.002	3648
di_{ssr}	-0.000	0.029	-0.020	0.002	3648
NFA_{base}	1914.367	19240.301	-117.880	3458.418	3620
NFA_{USD}	1877.696	19240.301	-117.880	3468.018	3620
NFL_{base}	2062.090	22532.004	-217.600	4340.497	3620
NFL_{USD}	2173.270	22532.004	-217.600	4574.387	3620
GRR	-0.096	0.529	-0.631	0.259	3357
$InterestDiff$	0.012	0.157	-0.109	0.029	3647
NFA/GDP_{t-1}	0.383	4.445	-0.583	1.039	3391
Infl_{t-1}	0.002	0.075	-0.709	0.079	3389
PubDebt/GDP_{t-1}	60.362	237.505	0.009	46.185	3623
$ShareofWorldGDP_{t-1}$	0.032	0.311	0.000	0.062	3419
$StockmarketCap/GDP_{t-1}$	113.070	464.721	0.345	87.903	3324
$(GFA+GFL)/GDP_{t-1}$	4.033	15.267	-3.319	3.807	3391
$Dom.Credit/GDP_{t-1}$	128.518	218.943	26.803	41.753	3349
ChinnIto	0.962	1.802	0.000	0.135	3647

(c) Emerging Markets

	Mean	Max	Min	Std. Dev	Obs
$\frac{de_{base}}{e_{base}}$	0.002	0.541	-0.169	0.029	5685
$\frac{de_{USD}}{e_{USD}}$	0.002	0.541	-0.169	0.033	5700
FXI	0.546	83.865	-129.204	6.316	5602
FXI_{USD}	0.560	83.865	-129.204	6.309	5602
di	-0.000	0.538	-0.388	0.020	5654
di_{ssr}	-0.000	0.538	-0.388	0.020	5654
NFA_{base}	170.142	5033.086	-98.276	645.634	5585
NFA_{USD}	166.930	5033.086	-98.276	646.183	5585
NFL_{base}	103.578	1803.301	0.346	205.642	5585
NFL_{USD}	105.055	1803.301	0.311	205.399	5585
GRR	-0.128	0.266	-0.594	0.159	4669
$InterestDiff$	0.066	1.183	-0.055	0.075	5656
NFA/GDP_{t-1}	-0.020	3.891	-0.914	0.293	5348
Infl_{t-1}	0.020	0.589	-0.778	0.131	5457
PubDebt/GDP_{t-1}	46.962	152.248	0.004	22.343	5688
$ShareofWorldGDP_{t-1}$	0.009	0.163	0.000	0.020	5452
$StockmarketCap/GDP_{t-1}$	49.887	464.721	0.101	53.220	5449
$(GFA+GFL)/GDP_{t-1}$	0.986	14.604	0.316	0.485	5348
$Dom.Credit/GDP_{t-1}$	54.618	201.595	5.590	35.667	5700
ChinnIto	0.524	1.826	0.000	0.342	5700

Table A4: **Data Sample and Descriptive Statistics**

The data are in monthly frequency and span 2000m1 to 2018m12. Gross foreign positions are interpolated from quarterly and yearly frequency. GDP is interpolated from quarterly frequency.

(a) Advanced Economies

	Mean	Max	Min	Std. Dev	Obs
Total	-0.008	0.984	-0.827	0.075	3608
Pre-crisis	-0.010	0.408	-0.823	0.073	1400
Crisis Period	-0.005	0.984	-0.548	0.103	384
Post-crisis	-0.006	0.533	-0.827	0.069	1824

(b) Emerging Markets

	Mean	Max	Min	Std. Dev	Obs
Total	-0.021	2.906	-2.903	0.248	5452
Pre-crisis	-0.050	2.906	-2.670	0.320	2037
Crisis Period	-0.024	0.951	-2.903	0.248	600
Post-crisis	0.000	1.445	-1.913	0.176	2815

Table A5: **Descriptive Statistics for the *EMP* against the US dollar**
The full sample runs from 2000m1 to 2018m12, the pre-crisis sample stops in 2007m6, the crisis sample runs from 2007m7 to 2009m6 and the post crisis sample runs from 2009m7 to 2018m12. Units are percentage point changes.

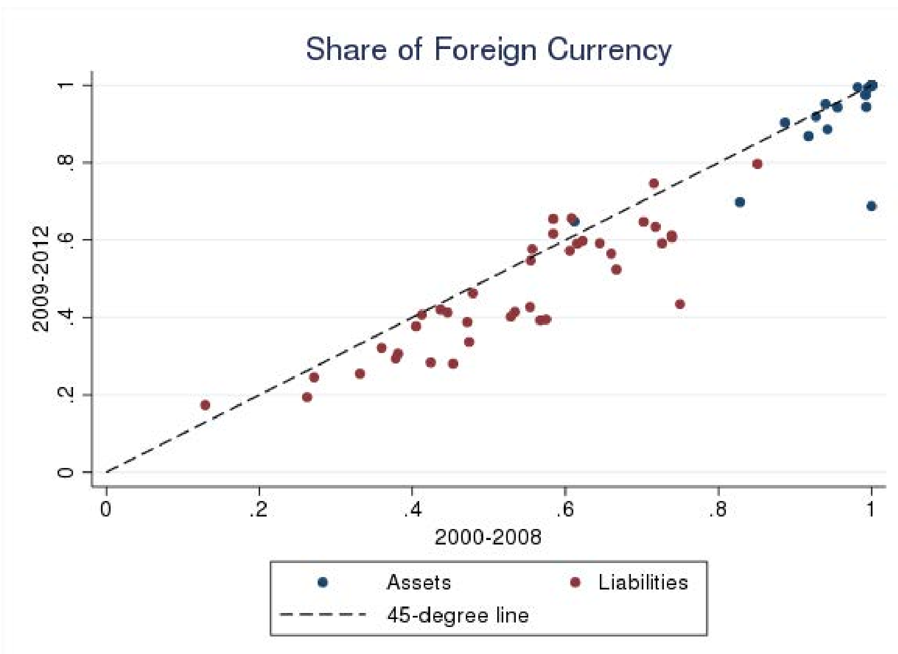
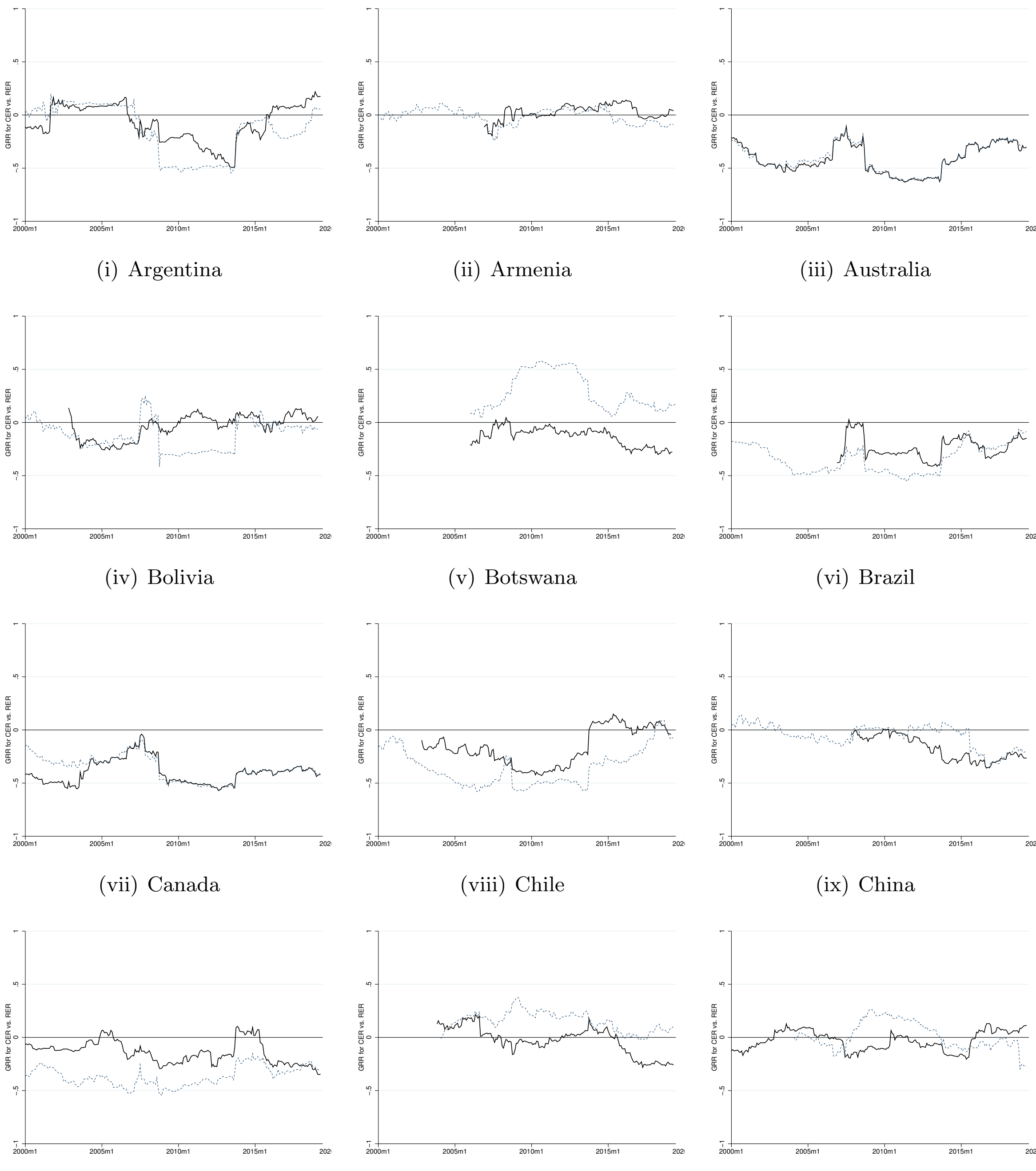


Figure A1: **Share of Foreign Currency: Assets and Liabilities, Pre- and Post-GFC**
Shares represent simple mean of foreign currency weights (1 - Domestic Currency) by country during pre- (2000-2008) and post-crsis (2009-2012). This data is available from Benetrix et al. (2015).



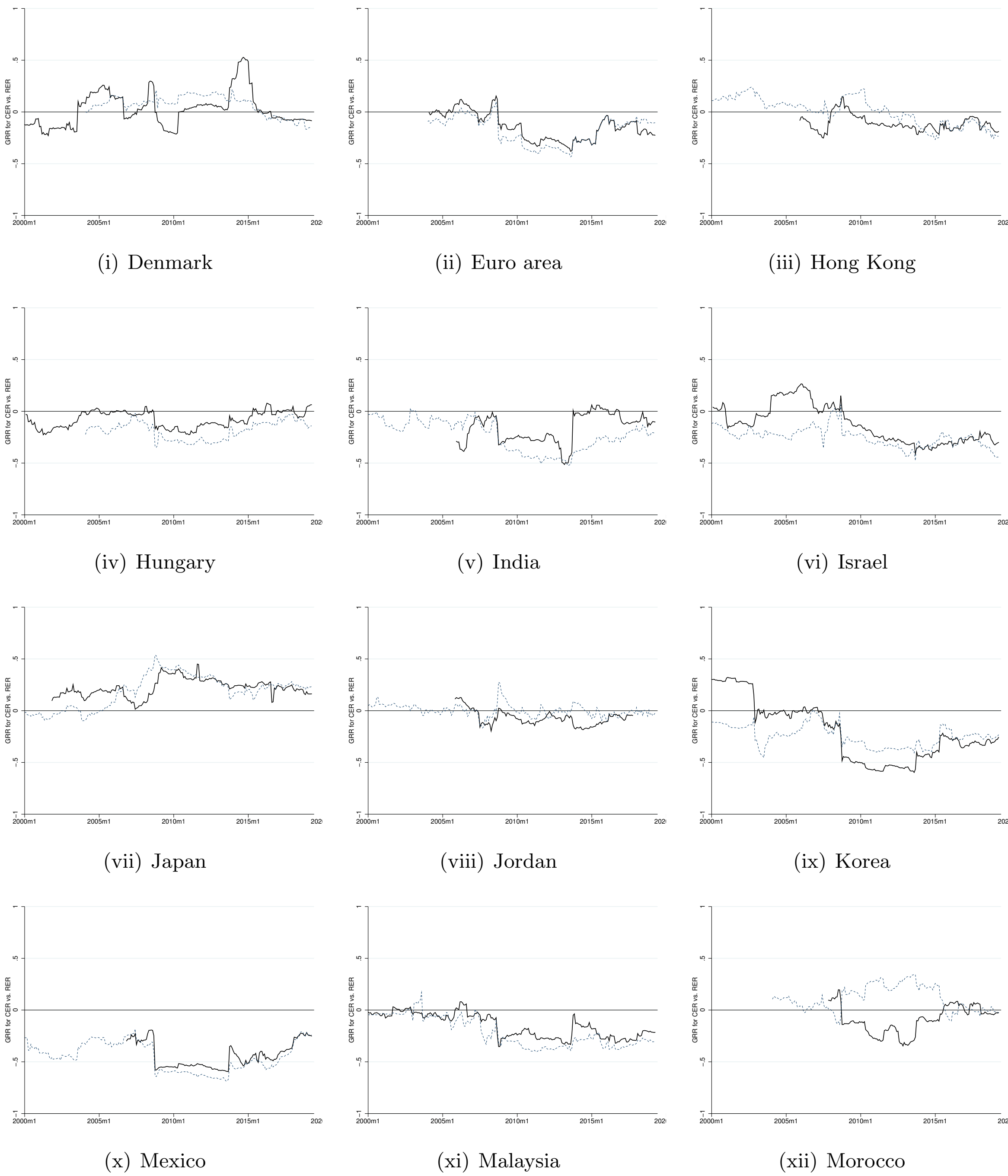
(i) Argentina (ii) Armenia (iii) Australia

(iv) Bolivia (v) Botswana (vi) Brazil

(vii) Canada (viii) Chile (ix) China

(x) Colombia (xi) Croatia (xii) Czech Republic

Figure A2: **Global Risk Response (GRR)**
Solid lines depict GRR estimates for counterfactual excess returns constructed using the EMP against the US dollar. Dashed line indicates the GRR for the realized excess return to US dollars.



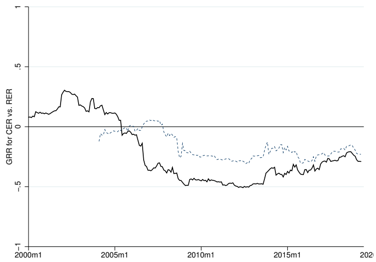
(i) Denmark (ii) Euro area (iii) Hong Kong

(iv) Hungary (v) India (vi) Israel

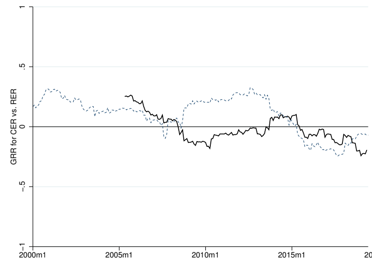
(vii) Japan (viii) Jordan (ix) Korea

(x) Mexico (xi) Malaysia (xii) Morocco

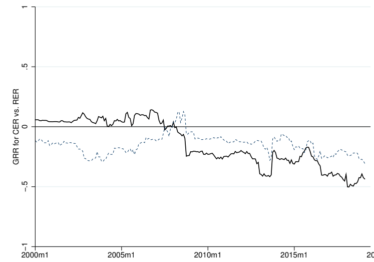
Figure A2: **Global Risk Response (*GRR*)** (continued)
Solid lines depict GRR estimates for counterfactual excess returns constructed using the EMP against the US dollar. Dashed line indicates the GRR for the realized excess return to US dollars.



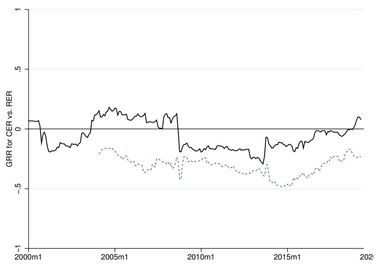
(xiii) Norway



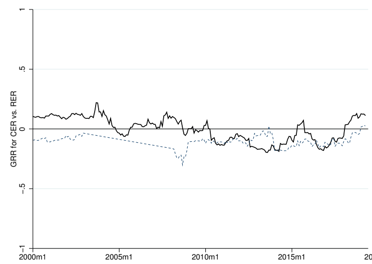
(xiv) New Zealand



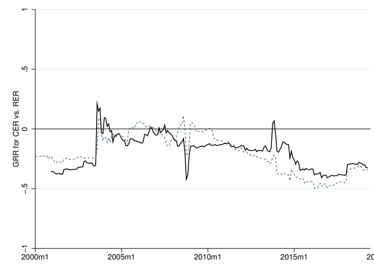
(xv) Peru



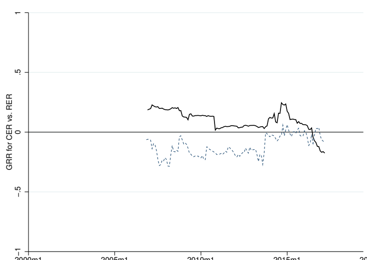
(xvi) Poland



(xvii) Romania



(xviii) Russia



(xix) Senegal

(xx) Singapore

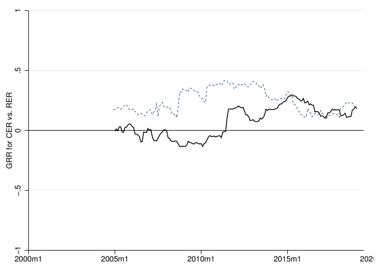
(xxi) South Africa

(xxii) Sweden

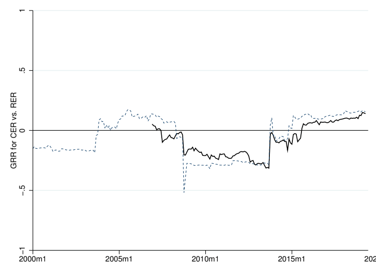
(xxiii) Switzerland

(xxiv) Thailand

Figure A2: **Global Risk Response (*GRR*)** (continued)
Solid lines depict *GRR* estimates for counterfactual excess returns constructed using the *EMP* against the US dollar. Dashed line indicates the *GRR* for the realized excess return to US dollars.

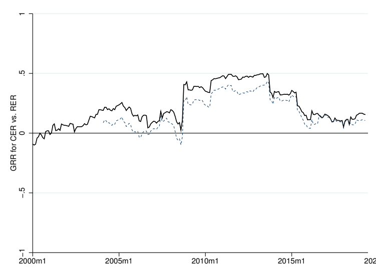


(xxv) Tunisia

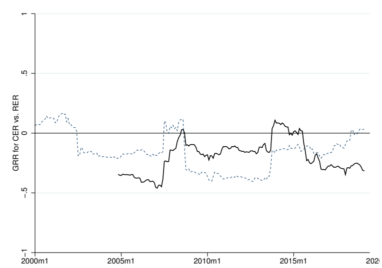


(xxvi) Ukraine

(xxvii) United Kingdom



(xxviii) United States



(xxix) Uruguay

Figure A2: **Global Risk Response (*GRR*)** (continued)
Solid lines depict GRR estimates for counterfactual excess returns based on the EMP against the US dollar. Dashed line indicates the GRR for the realized excess return to US dollars.

International Capital Flow Pressures

Online Appendix

Linda Goldberg   Signe Krogstrup

1 Measuring Foreign Exchange Interventions

This appendix describes the construction of the measure of FXI used in the EMP, as discussed in Section 3.1.2. The empirical measure of FXI that we use is based on estimates for official spot interventions:

$$FXI_t^j = FXI_t^{j,spot} \tag{1}$$

FXI^{spot} can be based on published interventions data, on interest-adjusted official reserves flows or on interest and exchange rate valuation adjusted changes in official reserve assets, depending on data availability. Interest and valuation exchange rate adjustments rely on a proxy for the currency composition of official reserves. The details of how we measure or proxy each of these are described in the subsections below.

Alternatively, FXI can also include derivatives, such that FXI has two components:

$$FXI_t^{j,alternative} = FXI_t^{j,spot} + FXI_t^{j,deriv} \tag{2}$$

There are some countries for which accounting for derivatives $FXI_t^{j,deriv}$ may be important based on available data.

Korea is a case in point, as illustrated in Figure 1. The blue bars reflect Korean official inventions in currency forward and futures markets while the gray bars reflect our measure of Korean spot interventions. Spot and derivatives interventions are somewhat correlated, such that spot interventions will tend to reflect, but underestimate, the total size of official FX interventions in Korea.[1]

The best source of spot foreign exchange interventions data are data published by the national authorities, and we use these whenever available. Ten countries publish interventions data in monthly or higher frequency, including India (since 2002), Argentina (since 2003), Canada (since 2008), Japan (since 1991), Euro area (since 2008), Australia (since 1989)[2], Brazil (since 2000), Mexico (since 1996), Israel (since 2002) and Russia (since 2008). A drawback with using national sources of published interventions data is that the definitions and coverage are not always clear and not necessarily consistent across countries. For example, Australia divides published interventions data into spot, swaps and other derivatives, but most of the other countries do not clearly disclose whether the published data contain derivatives interventions. We assume that when no further information is given, the published data reflect spot interventions.

A difference between published official interventions data and estimates based on adjusted

[1]In other countries, such as New Zealand, the correlation between estimated spot and derivatives interventions can be low to negative.

[2]Series ID is ARBANFXM.

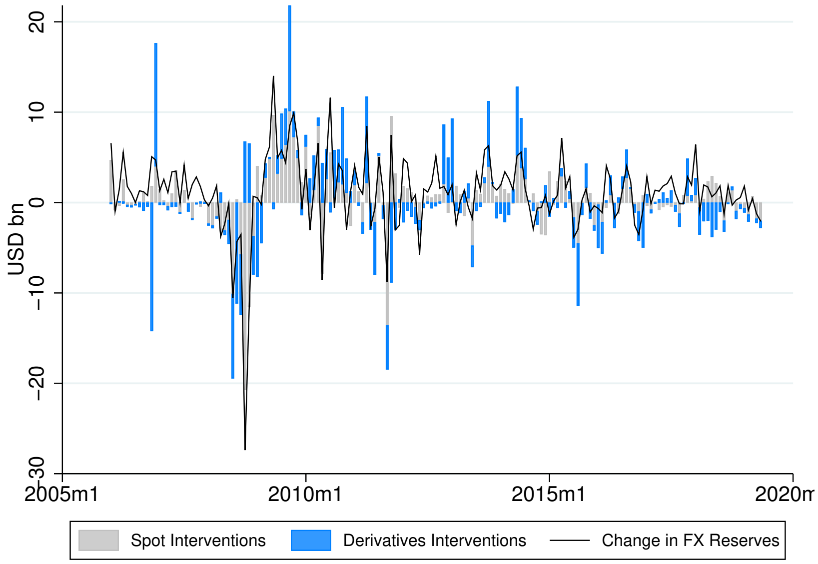


Figure 1: **Korea: Spot and Derivatives FXI and Changes in Official Reserves**
In billions US dollars, spot and derivatives interventions are stacked. Spot interventions are computed as monthly reserves flows from the balance of payments adjusted for interest receipts using COFER EM currency weights as described in Appendix 1 (source: Bank of Korea and IMF). Derivatives interventions are computed as predetermined short-term net drains on official reserves from long and short official forward and futures positions (source: IRFCL template, IMF). Changes in reserves are based on data from the international investment position (source: IMF).

changes in reserve positions or flows, as discussed below, is that official interventions data will often exclude operations due to non-exchange rate management aims, such as issuance of foreign currency debt by the government. Whether or not the latter reason for fluctuations in foreign reserves should be included in the measure of interventions depends on the government's reasons for issuing such debt. For practical reasons, we use published official foreign exchange interventions when available and do not attempt to include general government foreign exchange operations.[3] See also Bayoumi et al. (2015) for a discussion of this issue.

1.1 Currency Weights in International Reserves

In the absence of published data on foreign exchange interventions, we use either balance of payments flows or changes in the positions of official foreign reserves, adjusted for changes due to interest receipts and exchange rate changes, as described below. For this, we need data on the currency composition of official reserves. Some central banks disclose their currency composition

[3]This issue is relevant for Canada, for which published interventions data are far smaller in amplitude than other measures of spot FXI based on adjusted changes in reserve positions or flows, with the main difference being the role of the central bank's handling of the government's issuance of foreign currency denominated liabilities.

of reserves. Switzerland publishes currency weights from 1999. A set of countries report currency weights for more recent years through the Data Template on International Reserves and Foreign Currency Liquidity (IRFCL), used by authorities to report to the IMF (Dominguez et al., 2012; Adler et al., 2019).[4] We use the earliest available observations to fill in missing values for earlier years. For the remaining countries that do not disclose currency weights, we use average currency weights in official reserves as published in the IMF's COFER (Currency Composition of Official Foreign Exchange Reserves) database. These are divided into Advanced Economies and Emerging and Developing countries, and we separate the sample accordingly. COFER shares include US dollars, euros, Japanese yen, pounds sterling, Australian dollars, Canadian dollars and Swiss francs. Since COFER data end in 2015Q1, we use 2015Q1 currency composition data to fill the missing observations going forward. Hong Kong does not publish currency shares in their official foreign reserve, but since it has a currency board in US dollars, it is likely to hold a large part, if not the entire official reserve, in US dollar denominated assets. This is confirmed in McCauley and Chan (2014). Average EM COFER weights are hence likely to be misleading for Hong Kong, for which we instead assign a currency weight of 100 percent to US dollars.

For each country when data are available, we calculate the share of euros before 1999 as the sum of Deutsche marks, ECU, French francs and Netherlands currency.

1.2 Spot FXI Based on Balance of Payments Data

When countries and time periods for which published FXI data are not available, but balance of payments data are available in monthly frequency, we adjust official foreign exchange reserve flows for interest receipts according to the formula:[5]

$$FXI^{j,spot}_{t,BOP} = ORF^{j}_{t,BOP} - \sum_{g} i^{R}_{t-1,g} w_{t-1,g} R^{j}_{t-1,IIP} \tag{3}$$

where $ORF^{j}_{t,BOP}$ and $R^{j}_{t,IIP}$ are the official reserve inflows (defined as increases in reserves) or stock positions respectively, in US dollars equivalents, of country j in time period t from the balance of payments and international investment position statistics respectively. i^{R}_{g} is the interest received on foreign assets held in currency g and w_g is the weight of the official reserve held in currency g denominated assets.

Dominguez (2012) finds that most central banks place foreign assets in long-term safe bonds. Following Dominguez (2012) and Adler et al. (2019), we use data on long-term yields on the

[4] Croatia, Ukraine, Moldova, Bulgaria, Georgia, Morocco, Israel, Uruguay, Peru, Chile, Brazil, Australia, Canada, Sweden and Norway.

[5] Bulgaria(since 1996), Chile(since 2003), Czech Republic(since 2004), Denmark(since 1999), Euro Area(since 1999), Hungary (since 2014), Korea(since 1980), Philippines(since 1999), Poland(since 1997), Romania(since 1999), Thailand(since 1991), Turkey (since 1992) and Ukraine(since 2010).

government bonds of major reserve currencies as a proxy for i_g^R. We use the German yield as a proxy for the euro yield before 1999.

1.3 Spot *FXI* Based on IIP Positions Data

For countries and sub-periods for which neither published FXI data nor monthly balance of payments data are available, we adjust changes in official foreign exchange reserve positions from the international investment position for interest receipts and exchange rate valuation changes:

$$FXI_{t,IIP}^{j,spot} = \Delta R_{t,IIP}^j - \sum_g i_{t-1,g}^R w_{t-1,g} R_{t-1,IIP}^j + \sum_g \frac{de_t^g}{e_t^g} w_{t,g} R_{t-1,IIP}^j \tag{4}$$

where $\Delta R_{t,IIP}^j$ is the change in the foreign reserve position in US dollars, and $e_{USdollars}^g$ is the exchange rate of the US dollar against currency g, defined in units of g per US dollar. The proxies for interest receipts and currency weights are as described above.

The spot leg of currency swaps is included in the foreign exchange reserves in the general case, but not in certain cases, including the bilateral central bank swaps in Switzerland and the US (Goldberg, Kennedy and Miu, 2011; Rose and Spiegel, 2012; Andries, Fischer and Yesin, 2016; Bahaj and Reis, 2018). The recipients of the swaps lent the obtained international currencies on to domestic financial institutions in need of international funding (notably in US dollars and Swiss francs). In the absence of these swaps, the financial institutions needing foreign funding would arguably have sought to purchase this funding in the market, which would have led to pressures on conventional FX interventions or on the exchange rate.

In Switzerland, the spot leg of the central bank bilateral swaps issued in 2008 and 2009 were recorded separately from the foreign reserve in the balance sheet (this is not the case for spot legs of currency swaps with market participants). Since monthly data exist on these swaps, we add this separate balance sheet item to the foreign currency reserve for Switzerland before adjusting its changes for exchange rate valuation changes and interest receipts. In the US, the spot leg of the bilateral central bank swaps are also not included in the foreign reserve. Monthly data on the spot leg for the US are not available, however, and we therefore do not adjust in the case of the US.

1.4 Measuring Derivatives Interventions

An alternative definition of FX interventions includes derivatives interventions, as captured in expression 2. Accounting for the use of derivatives in interventions poses challenges. One is that the set of instruments used in FX interventions is evolving over time. Another challenge is that the correspondence between spot interventions and derivatives interventions will depend on the type of instrument used, and the reporting of derivatives and spot interventions is not always transparent and consistent. Finally, not all derivatives interventions are conducted to manage the exchange rate, but can also be targeted toward financial or market stability.

We again make use of the IRFCL data template. In this template, IMF member countries report official predetermined short-term net drains on foreign currency assets due to aggregate short and long positions in forwards and futures in foreign currencies vis-à-vis the domestic currency (including the forward leg of currency swaps, but not the spot leg). Since they are reported in terms of the net drains on reserves arising when the derivatives contracts mature (and not in terms of the market value or mark-to-market of the positions), these data are comparable to changes in reserves due to spot transactions.

Since the spot leg of currency swaps enters the official foreign reserve for the duration of the swap in most cases, a swap is recorded as a spot intervention today, combined with the opposite predetermined net drain due to the forward leg, and these two legs cancel out in the measure of interventions when derivatives interventions are included. Without a correction for the forward leg through the predetermined net drains, however, currency swaps figure as spot interventions. It is not *apriori* clear which of the two representations is correct. This will depend on FX market functioning and term FX demand, issues that go beyond the scope of this paper.

Not all derivatives interventions are included in the short-term predetermined net drains, however. Some are instead reported in other lines in the IRFCL template. For example, foreign currency options may never lead to a drain on reserves, and are hence not included in the predetermined net drains category, while they may have had strong effects on hedging demand and hence currency markets. It is not clear how to translate the use of such derivatives into a measure comparable with spot interventions consistently across countries, instruments and time, and we leave that for future research.

Figure 2 depicts the average share of variation in total alternative FXI measure based on equation 2 that is accounted for by variation in the derivatives term by country, for the individual country with available derivatives data as given in Table 1. A high share reflects either strong use of derivatives by authorities (New Zealand and Korea are examples). In these cases, not accounting for the use of derivatives may weaken the signal of capital flow pressures in the estimated FXI. In other cases, a high share reflects some use of derivatives while spot interventions are extremely low, which is typically the case in countries with freely floating exchange rates (e.g. Australia, Japan, EU, the UK and Canada). In these cases, it is less clear that derivatives interventions are important to account for.

Due to the lack of a clear and consistent accounting for derivatives interventions across countries, the unclear link between derivatives and spot interventions, and the limited availability of derivatives interventions data in many countries, we do not include derivatives inventions in our baseline measure of FXI.

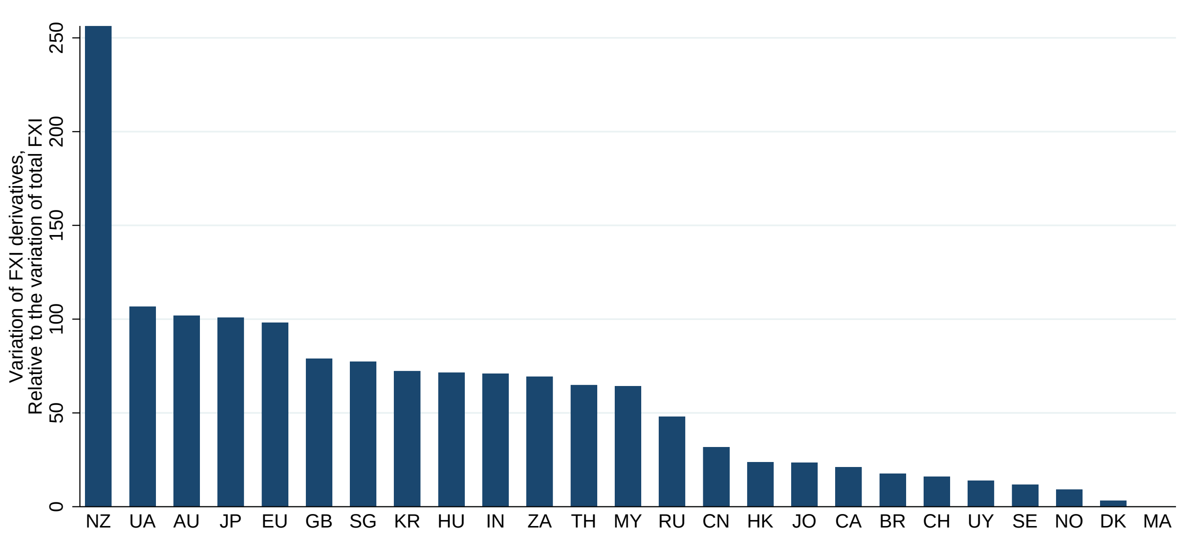


Figure 2: **Share of variation in $FXI^{alternative}$ due to derivatives**
calculated as the variation in estimated derivatives interventions as a share of estimated spot plus derivatives interventions for individual country samples for which data on derivatives interventions are available.

Country name	$FXI_t^{c,spot}$ data range	$FXI_t^{c,deriv}$ data range	Published FXI data range	$FXI_{t,BOP}^{c,spot}$ data range	$FXI_{t,IIP}^{c,spot}$ data range
United States	[1980m2,2019m4]	[2000m11,2019m4]			[1980m2,2019m4]
United Kingdom	[1980m2,2019m4]	[2000m5,2019m4]			[1980m2,2019m4]
Denmark	[1980m2,2019m3]	[2000m1,2019m3]		[1999m1,2019m3]	[1980m2,1998m12]
Norway	[1980m2,2019m4]	[2000m5,2019m4]			[1980m2,2019m4]
Sweden	[1980m2,2019m4]	[2000m9,2019m3]			[1980m2,2019m4]
Switzerland	[1980m2,2019m3]	[2000m10,2019m3]			[1980m2,2019m3]
Canada	[1980m2,2019m4]	[2000m5,2019m2]	[2008m1,2018m12]		[1980m2,2007m12] [2019m1,2019m4]
Japan	[1980m2,2019m4]	[2000m10,2019m4]	[1991m5,2018m12]	[1985m1,1991m4] [2019m1,2019m3]	[1980m2,1984m12] 2019m4
Euro area	[1999m2,2019m4]	[2000m1,2019m4]	[2008m1,2019m3]	[1999m2,2007m12]	[1999m2,1999m1] 2019m4
Australia	[1980m2,2019m4]	[2000m4,2019m3]	[1989m1,2018m6]		[1980m2,1988m12] [2018m7,2019m4]
New Zealand	[1980m2,2019m3]	[2000m4,2019m3]			[1980m2,2019m3]
South Africa	[1980m2,2019m3]	[2000m8,2019m3]			[1980m2,2019m3]
Argentina	[1980m2,2019m4]	[2001m3,2005m12]	[2003m1,2019m4]		[1980m2,2002m12]
Bolivia	[1980m2,2019m4]				[1980m2,2019m4]
Brazil	[2002m1,2019m4]	[2009m2,2019m4]	[2000m1,2019m2]	[1995m1,1999m12] [2019m3,2019m3]	[1980m2,1994m12] 2019m4
Chile	[1980m2,2019m2]	[2002m5,2019m3]		[2003m1,2019m2]	[1980m2,2002m12]
Colombia	[1980m2,2019m4]	[2000m6,2019m4]			[1980m2,2019m4]
Mexico	[1980m2,2019m4]		[1996m1,2019m4]		[1980m2,1995m12]
Peru	[1980m2,2019m2]	[2001m9,2004m6]			[1980m2,2019m2]
Uruguay	[1980m2,2019m3]	[2004m9,2019m3]			[1980m2,2019m3]
Israel	[1980m2,2019m4]	[2002m1,2018m3]	[2013m12,2019m3]		[1980m2,2013m11] 2019m4
Jordan	[1980m2,2017m10]	[2012m12,2015m12]			[1980m2,2017m10]
Hong Kong, PRC	[2001m1,2019m3]	[2000m5,2019m3]			[1991m1,2019m3]
India	[2001m1,2019m3]	[2007m11,2019m3]	[2002m1,2019m2]		[1980m2,2001m12] 2019m3
Korea	[1980m2,2019m3]	[2005m2,2019m3]		[1980m2,2019m3]	
Malaysia	[1980m2,2019m4]	[2000m5,2019m2]			[1980m2,2019m4]
Singapore	[1980m2,2019m3]	[2000m9,2019m3]			[1980m2,2019m3]
Thailand	[1980m2,2019m4]	[2000m5,2019m3]		[1991m1,2019m3]	[1980m2,1990m12] 2019m4
Botswana	[1980m2,2019m1]				[1980m2,2019m1]
Morocco	[1980m2,2019m3]	[2019m2,.]			[1980m2,2019m3]
Senegal	[1980m2,2019m2]				[1980m2,2019m2]
Tunisia	[1980m2,2019m1]				[1980m2,2019m1]
Armenia	[2002m1,2019m4]	[2009m9,.]			[1993m1,2019m4]
Russia Federation	[1994m1,2019m4]	[2007m10,2019m1]	[2008m8,2019m4]	[2007m1,2008m7]	[1994m1,2006m12] [2019m1,2019m4]
China, People's Republic	[1980m8,2019m3]	[2016m1,2017m8]			[1980m8,2019m3]
Ukraine	[2002m1,2019m4]	[2015m9,2016m3]		[2010m1,2019m3]	[1993m1,2009m12] 2019m4
Czech Republic	[1993m2,2019m4]	[2000m6,2001m2]		[2004m1,2019m3]	[1993m2,2003m12] 2019m4
Hungary	[1984m1,2019m4]	[2000m5,2019m4]		[2014m4,2019m3]	[1984m1,2014m3] 2019m4
Croatia	[1993m1,2019m3]				[1993m1,2019m3]
Poland	[1985m1,2019m3]	[2010m12,2017m3]		[1997m1,2019m3]	[1985m1,1996m12]
Romania	[1980m2,2019m3]	[2008m11,2014m1]		[1999m1,2019m3]	[1980m2,1998m12]

Table 1: **Data ranges and sources of data used to construct FXI, by country**
The construction of estimated FXI is based on a combination of published spot interventions data or estimates based on BOP flows or changes in IIP stocks of foreign official reserves, as described in the text. FXI derivatives can be added. The columns of this tables provides the available data ranges for each of these data sources by country, illustrating which data are used for FXI construction by time range. When two time ranges are provided, this indicates breaks in series for which data are not available. There are occasional missing values within the available derivatives data ranges, see IRFCL template for details.

2 Exchange and Interest Rate Elasticities from Panel Regressions

This appendix presents a panel regression of flows in foreign assets and liabilities on exchange and interest rates, with the aim of assessing the size of the elasticities of foreign investment positions to exchange and interest rate changes, as discussed in Section 2.2.

Estimating the response of capital flows to the exchange rate is complicated because of the endogeneity of capital flows and exchange rates to each other as well as to the exchange rate regime in place in the country in question. For example, we would expect an exchange rate appreciation to initially cause a capital outflow as international portfolios rebalance. However, we would expect a capital outflow shock to cause an exchange rate depreciation, or foreign exchange interventions (see also Klaassen, 2011). We only observe the equilibrium outcome for flows and the exchange rate, but not the partial responses that we are interested in assessing. There is hence clear potential for attenuation bias. We attempt to address these issues with a panel regression analysis of gross capital flows that produces empirical estimates of $\epsilon_e^{NFA,j}$ and $\epsilon_e^{NFL,j}$ based on equations (3) and (4). In this setup, endogeneity would tend to bias the estimates of the capital flow response to the exchange rate toward zero. Thus, if we find the right signs, we should be capturing the direction qualitatively and gain insight into the lower bound for the size of the response. To reduce the potential bias, we lag all explanatory variables by one quarter, keeping in mind that lagging may not fully address concerns in case of persistence in the regression variables. It also further increases the potential for attenuation bias as flows are likely to respond contemporaneously to exchange rates. Allowing an exchange rate shock to affect capital flows over the following three months is consistent with the timing of the effect estimated in Hau and Rey (2004), however.

With a broad panel of countries, the country specific variation in the exchange rate depends on the exchange rate regime. Countries with hard pegs, such as Hong Kong, will have minimal exchange rate variation, effectively preventing empirical measurement of the impact of exchange rate variation on private capital flows.[6] For this reason, we estimate the regression as a panel and impose the restriction that the elasticity of gross positions to the exchange rate is the same across groups of countries, as further discussed below. The panel approach allows us to produce predictions for exchange rate elasticities for countries that do not exhibit sufficient variation in the exchange rate to estimate the country specific elasticity. The panel approach also allows us to control for variation in gross positions due to common global shocks by including time fixed effects.

It is possible that the average elasticities of international investment positions depend on the composition of gross foreign asset and liabilities (e.g. Cerutti, Claessens and Puy, 2015), which may change over time. It is beyond the scope of this paper to estimate elasticities individually for all sub-items of international investment positions. As a short-cut, we exclude foreign direct investments (FDI) from the gross foreign investment positions. The share of FDI in gross positions

[6] Patnaik et al. (2017) face a similar problem and carry out estimations only for countries where variation allows for identification of the parameter they are focusing on. They then use the estimation equation to predict the parameter estimates for the countries that do not have sufficient variation to allow direct estimation, based on the characteristics that turn out to matter for the size of the parameter estimate.

has grown strongly in recent years (Milesi-Ferretti and Lane, 2017), but this type of investment is less likely to respond to exchange rate changes.[7] Portfolio and bank related international investment positions are more likely to be responsive to changes in prospective returns, absent capital controls.

We are interested in how investors respond actively to changes in exchange and interest rates and therefore consider transactions, i.e. flows, rather than changes in stock positions that contain valuation effects. This means that we cannot make an assessment for currency specific net foreign asset and liabilities positions, for which we only have stock data. Instead, we approximate net foreign assets in foreign currency by gross foreign assets, and net foreign liabilities in domestic currency by gross foreign liabilities. We then match capital flows in these categories to the stock positions to compute our dependent variable.

Global financial factors such as US monetary policy, risk aversion, global liquidity, and financial wealth accumulation are clearly of importance in driving global capital flows and should be controlled for, but these variables are very difficult to correctly measure empirically, in particular since the advent of the ZLB period.[8] Since these factors are not the focus of this exercise, we instead control for all common global factors by including time effects in the regressions. We control for country specific time invariant effects by including country fixed effects. Finally, growth in local wealth is approximated by local GDP growth. The estimating equations become:

$$\frac{dNFA_t^{fx,j}}{NFA_t^{fx,j}} = \epsilon_e^{NFA,j} dlog(e_{t-1}^j) + \epsilon_i^{NFA,j} d(i_{t-1}^j) + \epsilon_w^{NFA,j} dlog(GDP) + \varphi^j + \tau_t + \varepsilon_t^j \tag{5}$$

$$\frac{dNFL_t^{d,j}}{NFL_t^{d,j}} = \epsilon_e^{NFL,j} dlog(e_{t-1}^j) + \epsilon_i^{NFL,j} d(i_{t-1}^j) + \epsilon_w^{NFL,j} dlog(GDP) + \varphi^j + \tau_t + \varepsilon_t^j \tag{6}$$

where φ^j are country fixed effects that capture time invariant country specific factors influencing gross capital flows, and τ_t are time fixed effects that capture global factors including risk sentiment, global liquidity, and interest rates, financial conditions and growth in center countries (the VIX is hence not included explicitly). c is the country grouping for which the elasticity is estimated. In the baseline regression we restrict the elasticities to be the same for all countries, but we also allow for the elasticities to deviate between advanced economies and emerging and developing countries, by interacting all explanatory variables with a dummy taking the value one for emerging and developing countries. The expected signs according to the portfolio rebalancing hypothesis are $\epsilon_e^{NFA^{fx},j} < 0$ and $\epsilon_e^{NFL^{d},j} > 0$. The regression results are presented in Table (2), for the sample period from 1995Q1 to 2018Q4.

The parameter estimate signs and sizes are relatively robust to changes in the sample and estimation procedures (not shown), but significance varies a lot with the sample. Note that the fit of the regression (R^2) is relatively high. This primarily reflects a large portion of the variation explained by country and time fixed effects, in turn reflecting structural flows as well as global

[7] A further refinement of the approach would be to exclude long-term bank positions, if these could be consistently identified in the data.

[8] Avdjiev et al. (2017b) consider such factors as drivers of capital flows explicitly.

	I.NFA(fx)	II.NFL(d)	III.NFA(fx)	IV.NFL(d)
$dlog(e_{t-1}^j)$	-0.058*	0.048	-0.023	0.003
	(0.024)	(0.026)	(0.040)	(0.042)
$EM \times dlog(e_{t-1}^j)$			0.002	0.057
			(0.042)	(0.045)
$d(i_{t-1}^j)$	-0.208	-0.369*	1.557*	0.548
	(0.135)	(0.147)	(0.706)	(0.742)
$EM \times d(i_{t-1}^j)$			-1.844*	-0.956
			(0.719)	(0.756)
$dlog(GDP)$	0.336***	0.012	-0.086	0.016
	(0.098)	(0.103)	(0.164)	(0.175)
$EM \times dlog(GDP)$			0.790***	0.020
			(0.168)	(0.181)
R2	0.114	0.092	0.131	0.093
No.Obs	2089	2065	2089	2065

Table 2: **Regression Results: Portfolio Rebalancing of Gross Positions**
Results for estimating regression equations (5) and (6) based on gross capital flows as shares of stock positions. All specifications contain time and fixed effects (not shown). Regressions are based on quarterly data from 1995Q1 to 2018Q1. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels, respectively.

factors.

Columns I and II display the results from the baseline regressions where elasticities are restricted to be the same across advanced economies and emerging and developing economies. In the foreign asset regression, the exchange rate elasticity and interest rate semi-elasticity have the right signs and the former is marginally significant (column I). The exchange rate elasticity estimate suggests that a 1% exchange rate depreciation against the US dollar should lead to a 0.05% reduction in foreign asset holdings in the following quarter (i.e. a capital inflow due to domestic resident retrenchment). Moreover, a 1%-point increase in the domestic interest rate is estimated to induce a 0.14% retrenchment in domestic residents' foreign assets (i.e. a gross resident inflow). Due to the potential for attenuation bias as discussed above, these estimates are likely to be lower limits for the elasticities. GDP growth is also significant and with the right sign. When allowing the parameter estimates to differ across country samples (column III), significance is reduced and the results suggest stronger responses in emerging markets than in developing countries. When allowing for the elasticity to differ between advanced countries and emerging and developing countries (column II), significance drops, but the size and sign remain, suggesting that the elasticity is higher for emerging and developing countries.

In the foreign liabilities regressions (columns II and IV), the exchange rate elasticity has the right positive sign and is of similar absolute size to that found in the foreign asset regression, which is what we would expect. It is not significant, however, and the interest rate parameter estimate has the wrong sign.