STAFF REPORTS

NO. 1051
FEBRUARY 2023

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FEDERAL RESERVE BANK *of* NEW YORK

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Federal Reserve Bank of New York Staff Reports, no. 1051
February 2023
JEL classification: F32, G11, G20

Abstract

The risk sensitivity of international capital flow pressures is explored using a new Exchange Market Pressure index that combines pressures observed in exchange rate adjustments with model-based estimates of incipient pressures that are masked by foreign exchange interventions and policy rate adjustments. The sensitivity of capital flow pressures to risk sentiment, including for so-called safe-haven currencies, evolves over time, varies significantly across countries, and differs between normal times and extreme stress events. Across countries, risk sensitivities and safe-haven status are associated with self-fulfilling exchange rate expectations and carry trade funding currencies. In contrast, association with more traditional macroeconomic country characteristics is weak.

Key words: exchange market pressure, risk aversion, safe haven, capital flows, exchange rates, foreign exchange intervention, global financial cycle

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1 Introduction

International financial flows and currency values are important for economic outcomes and their drivers are subject to intense study. Research finds that both capital flows and exchange rates are driven by local and global factors, with the latter inclusive of risk sentiment and the monetary policy stance of reserve currency countries (Milesi-Ferretti and Tille 2011; Forbes and Warnock 2012; Fratzscher 2012; Rey 2015, Bruno and Shin 2015, Kalemli-Özcan 2019). The sensitivity to global factors is key to understanding the degree to which local economies retain some domestic policy autonomy and the appropriate macro-financial policy toolkits to apply (Rey 2015; Obstfeld et al. 2019).

International capital flows tend to enter some advanced economies and emerging markets when global risk perceptions are low and global liquidity ample, and retreat when global financial conditions tighten. Risk-on currencies tend to depreciate with elevated global risk conditions, and so called safe haven currencies tend to appreciate (Ranaldo and Soederlind 2010; Botman et al. 2013; Habib and Stracca 2012; de Carvalho Filho 2015). The strength of global factors in driving flows and currencies vary substantially across countries and over time (Avdjiev, Gambacorta, Goldberg and Schiaffi 2020), and are particularly strong when risk conditions are more pronounced (Chari et al. 2022, Forbes and Warnock 2021, Obstfeld, Ostry and Qureshi 2019). Evidence for the strength of the global factor is stronger in asset prices than in capital flow volumes (Miranda-Agrippino and Rey 2015; Cerutti et al. 2019).

In this paper, we revisit these issues by recognizing that the observed responses of quantities of capital flows, exchange rates, and domestic monetary policy to global factors are interdependent and in many countries cannot be studied in isolation. In countries with fully flexible exchange rate regimes, exchange rates move quickly in response to incipient changes in capital flows, supplementing or even obviating the adjustment observable in capital flow volumes (Chari, Stedman and Lundblad, 2021). In contrast, in fixed exchange rate regimes, managed floats, or even in some de jure flexible exchange rate regimes, central banks use policy interventions such as domestic interest rate changes and official foreign exchange interventions to reduce the realized exchange rate response to global factors (Ghosh, Ostry and Qureshi, 2018).[1] In such cases, capital flow pressures may show up in foreign exchange interventions or in policy rate changes rather than in exchange rates. Accordingly, viewing capital flow responses to global factors separately from the exchange rate or policy response will provide an incomplete picture of the actual capital flow pressures at play.

[1] Gagnon (2016) nicely summarizes the skeptical historical perspective on effectiveness, starting with the time of the Plaza Accord in the 1980s, before presenting recent evidence that foreign exchange intervention can be a useful tool to counter market-driven imbalances. Other recent evidence points to foreign exchange intervention having a higher success rate than previously argued on the basis of a range of criteria (Adler, Lisack and Mano 2019, Fratzscher, Gloede, Menkhoff, Sarno and Stöher 2019).

To account for the interdependencies between capital flows on the one hand, and exchange rate changes, foreign exchange interventions and policy rate changes on the other, we first present a new measure of international capital flow pressures, which is a revamped version of an Exchange Market Pressure (EMP) index. EMP indices are weighted and scaled sums of exchange rate depreciation, official foreign exchange intervention, and policy rate changes. Earlier versions of exchange market pressure indices have been used in a broad range of applications in the literature, from studying balance of payments crises (Eichengreen, Rose and Wyplosz 1994) to monetary policy spillovers (Aizenman, Chinn and Ito 2016b) and classifying exchange rate regimes (Frankel 2019). However, the weighting and scaling of the inputs have problematic features, leading those indices to mischaracterize the patterns of pressures across countries and over time, as discussed more extensively in the Appendix.

Our construction instead derives the relevant weighting and scaling terms within the index through an approach that utilizes key relationships in balance of payments equilibrium, international portfolio demands for foreign assets, and valuation changes on portfolio-related wealth.[2] Drawing lessons from the international portfolio balance approach follows a long tradition, from Girton and Henderson (1976), Henderson and Rogoff (1982), Branson and Henderson (1985), and Kouri (1981), to the more recent empirical and modelling innovations of Blanchard, Giavazzi and Sa (2005), Coeurdacier and Rey (2012), Caballero, Farhi and Gourinchas (2016), and Gabaix and Maggiori (2015). The EMP framework thus ties into important research on the role of wealth and valuation effects in driving short-run international portfolio adjustments (for example, Gourinchas and Rey 2014; Benetrix, Lane and Shambaugh 2015; Lane and Milesi-Ferretti 2018;Camanho, Hau and Rey 2015); the roles of currency denomination in portfolios of foreign assets and liabilities (Benetrix, Lane and Shambaugh 2015; Maggiori, Neiman and Schreger 2020); the role of home bias in allocation of investment portfolios (Coeurdacier and Rey 2012; Coeurdacier and Gourinchas 2016; Maggiori, Neiman and Schreger 2020; Faia et al. 2022); and the role of the sensitivity of portfolio allocations to changes in risk and return conditions (Bacchetta, Davenport and van Wincoop 2022; Koijen and Yogo 2020; Jiang, Richmond and Zhang 2021 and Camanho, Hau and Rey 2015).

The logic of our EMP index is that international capital flow pressures show up in a specific combination of exchange rate movements, foreign exchange intervention, and policy rate response that can be jointly expressed in equivalent exchange rate depreciation units. The result is like a super-exchange rate index. Within the context of a fixed exchange rate regime, the theory-based equivalency formulas take pressures in the form of capital flows, absorbed by foreign exchange

[2]Goldberg and Krogstrup (2019) is the earlier working paper version of this paper that developed a new EMP measure and conducted initial empirical explorations. The current version has a significantly revised EMP derivation, updated empirical application, and more comprehensive placement in recent literature on capital flows, home bias, portfolio allocations, risk sensitivities, and safe haven assets.

interventions conducted to prevent an exchange rate response, and provides the counterfactual exchange rate change that otherwise would have been needed to close the balance of payments gap and prevent the observed intervention flow. This constructed exchange rate change equivalent from foreign exchange intervention is then directly comparable to the capital flow pressure recorded for an otherwise identical country that instead allowed the exchange rate to adjust to reflect the pressure. The constructed conversion factors, instead of the scaling and weighting terms in the earlier indices, directly tie between exchange rate changes, foreign exchange interventions and policy rate changes to well known portfolio rebalancing and wealth channels through the balance of payments.

An important feature of the EMP is that it is measured in terms of exchange rate equivalents and hence is measured relative to the pressures of a foreign currency. This contrasts with data on realized capital flows, for which absolute levels are meaningful. Our baseline constructs the EMP as relative to each currency's own monetary reference currency, which in our sample are the USD and the euro respectively. For robustness, we also implement and consider robustness to measuring the EMP against only USD and against an effective exchange rate basket of currencies using weights in financial portfolios.

We construct monthly series of the EMP for 41 countries for 2000 through 2021. A set of applications illustrate the importance of taking into account all the input components of the EMP for comparing and analyzing capital flow pressures across countries and currencies. While accounting for the different components reflecting capital flow pressures is relevant for the broader empirical literature, the focus in this paper is specifically on the link between capital flow pressures, risk sentiment and global factors.[3]

First, the empirical measure shows the variation in the different components of capital flow pressures across countries and over time. Currency depreciation alone characterizes less than half of the country-month observations across the advanced and developing countries in the sample. The contributions of the different components to the EMP vary across periods with high stress in global financial markets and more normal times. Interestingly, on average, countries tend to allow - or to succumb to - even more exchange rate variability during periods of the most extreme risk sentiment, with significant variation across countries. This variation reinforces the importance of our approach towards accounting for the different components of the EMP in any cross country time series analysis, including around understanding the importance of the global factor and viability of toolkits. The evidence also warns against general assumptions that the majority of countries either maintain fully flexible exchange rates or pegs, with our results consistent with

[3]Goldberg and Krogstrup 2019 for example revisits the literature on the relative importance of local vs. global factors in driving capital flows across countries, showing the importance of a more comprehensive measure of capital flow pressures across countries.

evidence in Frankel (2019)

Second, we revisit the literature on currency risk sensitivities and safe haven currency status. Generally, currencies are characterized as having "safe haven" features if their valuations rise when global risk conditions worsen (Brunnermeier, Nagel and Pederson 2008, Ranaldo and Soederlind 2010, Habib and Stracca 2012, and Fatum and Yamamoto 2016).[4] Our evidence about the prevalence of other components in reflecting international capital flow pressures suggests that some empirical analyses based exclusively on observed exchange rate movements may generate results that are both imprecise and subject to attenuation bias, as these miss the fact that many countries respond to currency pressures by intervening in the foreign exchange market or changing the policy rate, in addition to allowing some exchange rate adjustment.[5] Indeed an interesting observation is that on average, exchange rate adjustments capture more - not less - of the international capital flow pressure during the most extreme stress periods.

To account for attenuation bias in assessing safe haven currencies, we instead use the EMP and assess its rolling correlation across time with global risk sentiment, labelling the result as the Global Risk Response index (GRR). The data confirm the designation of the Swiss franc, the Japanese yen and US dollar as key safe haven currencies, and add the Danish krone measured relative to the euro and Hong Kong Dollar to the set of safe haven currencies. The latter currencies are characterized by managed exchange rate regimes, so accounting for foreign exchange interventions and policy rate adjustments in the response to risk are key to reflecting their tendencies to attract net capital inflows.

Finally, we use the EMP to revisit questions of which underlying factors are associated with currencies exhibiting safe haven features, using the regression approaches of the literature. The analysis suggests that safe haven features of currencies tend to be persistent. Empirically, these features are associated with self-fulling expectations of currency movements based on previous associations between capital flow pressures and risk, as well as interest rate levels, suggesting that carry trade funding currencies tend toward appearing as safe-haven currencies. In contrast, the more traditional macroeconomic determinants typically investigated in the literature are less consistently significant in capturing safe-haven features.

The paper is structured as follows. Section 2 presents the exchange market pressure index and discusses the intuition behind the index. Section 3 focuses on empirical implementation, presenting important data and parameter choices. Section 4 illustrates the variation in the different components of the index across countries and across high stress and normal periods,

[4] Wong and Fong (2018) 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.

[5] 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 2019).

and provides the application to safe haven currency status and its drivers. The final section discusses the implications of our findings and concludes.

2 Exchange Market Pressure

Prior variants of exchange market pressure indices have been used in studies of currency crises and spillovers of policies across borders, and characterizations of exchange rate regimes. EMP used have typically taken 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 (FXI). 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 like scaling by reserves or the monetary base are not neutral for the realization of the index. 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. In addition, as we turn to the derivation and the empirical model, we caution against using the change in foreign exchange rates instead of using other proxies for FXI where feasible.

Our approach focuses instead on informing the weights of the index through the underlying drivers with a model of supply and demand for currency based on the balance of payments, international portfolio decisions, and wealth accumulation equations at home and abroad. Our approach leads to significantly different patterns of measured pressures across countries and over time, and has clear economic underpinnings. As detailed in the next sections, the balance of payments (BOP) identity is foundational, tracking interest payments on outstanding foreign assets and liabilities, foreign currency flows through trade, gross flows of foreign currency assets and liabilities, and official foreign exchange interventions. Also fundamental are international portfolio allocation decisions, in part driven by the wealth dynamics of domestic and foreign investors.

The basic logic of our index derivation 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 (FXI), or by an endogenous exchange rate movement or change in the domestic monetary policy rate sufficient to generate an off-setting private balance of payments flow. Instead of scaling and weighting as in the extant literature, we derive equivalence factors across these components directly from the different ways that exchange rates and interest rates enter the balance of payments, along with specifications of international asset demand functions with imperfect asset substitutability and valuation effects on outstanding positions. The equivalencies, for example between quantities of FXI and units of currency depreciation, thus depend on the elasticities of the responses of foreign assets and foreign liabilities to exchange rate and interest rate changes, the currency of invoicing or denomination of international trade and debt positions, and the stocks of foreign asset and liability positions.

2.1 The Balance of Payments

The BOP is expressed in nominal foreign currency equivalents, and reflects all sources of demand and supply of foreign currency arising from cross-border payments and receipts during a specified period. The BOP flows in the period between time $t-1$ and time t are given by

$$FXI_t = NX_t + \left(i^*_{t-1} A_{t-1} - i_{t-1} \frac{L_{t-1}}{e_{t-1}} + i^*_{t-1} R_{t-1} \right) + \left(\frac{1}{e_t} IL_t - IA_t \right) \tag{2}$$

where FXI_t reflects official foreign currency financial transactions, or foreign exchange interventions, during period t, and the exchange rate e_t is defined in units of Home currency per one unit of Foreign currency.

The first term on the right hand side is the net trade balance accumulated in period t, NX_t, which we assume to be invoiced in foreign currency. The second term (in parentheses) reflects the net foreign investment income balance for period t, inclusive of interest and dividend receipts on foreign official reserves accrued at the beginning of period t, R_{t-1}. The stock of foreign currency denominated assets coming into period t is denoted A_{t-1} and domestic currency denominated foreign liabilities are denoted L_{t-1}. Our baseline derivation assumes that countries borrow internationally exclusively in their domestic currency and exclusively hold foreign currency denominated foreign assets.[6] The interest and dividend payments accruing to foreign assets and liabilities are at rates i^* and i respectively, depend on the country of issuance.[7] Interest and dividend income and payments are assumed to accrue on the beginning of period stocks of external positions using the beginning of period interest rate and dividend yields. Payments are converted into foreign currency equivalents when appropriate.

The last term in parentheses captures financial account transactions (capital flows) that take place between end of time $t-1$ and through time t, expressed in foreign currency equivalents. These transaction based flows, indicated by notation I, do not include changes in the stocks of foreign assets and liabilities that are due to valuation effects. Instead, portfolio adjustments triggered by changes in asset prices and exchange rates result in transactions-based flows and modelled in the next section. After specifying all of these positions and flows, and taking total differentials, the formula for the EMP inclusive of scaling and weighting factors, and the drivers of this measure of capital flow pressures are clearly delineated.

2.2 Gross Asset and Gross Liability Flows

Capital flows are driven by the Home demand for Foreign liabilities and the Foreign demand for Home liabilities. We assume imperfect substitutability between domestic and foreign currency denominated assets, consistent with home bias for domestic currency denominated assets, following Blanchard, Giavazzi and Sa (2005), and consistent with the extensive empirical evidence on home bias discussed in Coeurdacier and Rey (2012), Maggiori, Neiman and Schreger (2020), and Faia, Salomao and Veghazy (2022).[8] Below, Home demand for Foreign liabilities is expressed as a share of Home's financial wealth, W_t, while Foreign demand for Home liabilities is expressed as a share of Foreign's total wealth, W_t^*, both expressed in terms of their respective local currencies. The portfolio demand equations are given respectively by:

$$\tilde{A}_t e_t = W_t \cdot [1 - \alpha(uip_t, l_t^*, s_t)] \tag{3}$$

$$\frac{\tilde{L}_t}{e_t} = W_t^* \cdot [1 - \alpha^*(-uip_t, l_t, s_t)] \tag{4}$$

[6] The assumption of domestic currency debt issuance does not holds empirically for some countries. An earlier version of the model includes the case where countries borrow and lend in both domestic and foreign currency in Goldberg and Krogstrup (2019). Moreover, a version of the model with foreign liabilities issues only in foreign currency is available upon request.

[7] Country and asset specific risk premia are not modelled, but can be viewed as captured partly by the interest rate level as well as a local risk factor added in the asset demand functions below.

[8] Maggiori, Neiman and Schreger (2020) show currency denomination of assets as the main factor driving demand and home bias, while Faia, Salomao and Veghazy (2022) find this result is a feature of investment funds, but not insurance and pension bond funds for European investors.

where

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

uip_t is the deviation from uncovered interest rate parity from the point of view of the investor located in Home. The shares α and α^* capture the shares of residents' portfolios that they desire to be denominated in their domestic currency. These shares depend on the expected relative risk-adjusted return on Foreign versus Home assets as captured by uip_t, with $\alpha'_{uip} > 0$ and $\alpha^{*'}_{uip} > 0$, and on risk factors.[9] Local risk factors, l_t and l_t^*, capture country-specific risk. While the global risk factor, s_t, is a common factor across countries, the response of asset demand to the global factor can differ across countries. Risk factors are assumed to be independent of relative expected returns. An increase in risk aversion of investors implies that α'_l, $\alpha^{*'}_{l^*}$, α'_s and $\alpha^{*'}_s > 0$.[10] For both Home and Foreign, the share of financial wealth invested in domestic assets is assumed higher than the domestic role in the global economy, consistent with the empirically relevant feature often described as home bias.

Home and foreign wealth, expressed in domestic currency equivalents, consists of domestic assets D (or D^* in the case of Foreign) and holdings of foreign assets net of issued foreign liabilities:

$$\begin{aligned} W_t &= D_t + e_t A_t - L_t \\ W_t^* &= D_t^* + \frac{1}{e_t} L_t - A_t \end{aligned} \tag{6}$$

For later use, Foreign's stock of wealth in period t is driven by the components of the previous period stock of wealth updated by real growth[11] captured by $\dot{g_t^*}$, valuation effects from asset prices in both Home and Foreign markets, $\dot{p_t}$ and $\dot{p_t}^*$, exchange rate valuation effects,, $\dot{(e_t)}$ as well as international interest and dividend payments taking place in the beginning of period t:[12]

$$W_t^* = \left(1 + \dot{p_t}^* + \dot{g_t^*}\right) D_{t-1}^* + \frac{L_{t-1}}{e_{t-1}} \left(1 + \dot{p_t} - \dot{e_t} + i_{t-1}\right) - A_{t-1} \left(1 + \dot{p_t}^* + i_{t-1}^*\right) \tag{7}$$

where dots denote relative changes between period $t-1$ and t, as in $\dot{e} = \frac{e_t - e_{t-1}}{e_{t-1}}$.

[9] While the derivation in the text does not account for the possible presence of capital flow restrictions, Goldberg and Krogstrup (2019) show how capital flow restrictions can easily be added to the model.

[10] A complementary approach to portfolio reallocations could be through explicit modelling of global bank decisions, for example building on the insights in Shin (2016) and Avdjiev, Bruno, Koch and Shin (2019a).

[11] We do not have a real sector in our model, and real growth is instead specified as a real growth rate of domestic assets. The term can be interpreted as net accumulation of real capital stock. Alternatively, in the empirical application, we interpret the real growth term as a proxy for, or related to, real income growth of the domestic economy.

[12] Interest and dividend payments on Home asset holdings, D_t, are not included in aggregate wealth by country, as these both yield from and accrue to residents of the same country.

Gross liability flows issued in domestic currency in period t, IL, are modelled as the difference between desired ($\tilde{L}$) and actual ($\bar{L}$) values of gross foreign liabilities updated by valuation effects due to exchange rate and asset price changes:

$$IL_t = \tilde{L}_t - \bar{L}_t \tag{8}$$

where $\frac{\tilde{L}_t}{e_t}$ is Foreign's desired holdings of Home liabilities described in expression (4) and where Foreign's holdings of Home's liabilities coming out of period $t-1$, $\frac{\bar{L}_t}{e_t}$, are updated with valuation changes taking place in period t due to changes in Home asset prices, p_t, and the exchange rate:

$$\frac{\bar{L}_t}{e_t} = \frac{L_{t-1}}{e_{t-1}} \left(1 + \dot{p}_t - \dot{e}_t\right), \tag{9}$$

Gross liability flows expressed in foreign currency equivalents in period t reflect Foreign investors' wish to reallocate Foreign's total wealth in period t, expression (7), between domestic and foreign investments as a response to changes in expected returns and risks, and taking into account changes in the Foreign currency equivalent value of wealth. Inserting expressions (4), (7) and (9) into equation (8), and linearizing around a balance of payments equilibrium characterized by $L_t = \tilde{L}_t = \bar{L}_t$, such that $\frac{W_t^* e_t}{L_t} = \frac{1}{1-\alpha^*}$, yields[13]

$$\begin{aligned} \frac{dIL_t}{L_t} =& \frac{de_t}{e_{t-1}} \epsilon_e^L + \left[di_t - di_t^*\right] \epsilon_i^L - \left[\frac{dp_t}{p_{t-1}} - \frac{dp_t^*}{p_{t-1}^*}\right] \left[\alpha^* \frac{L_{t-1}}{L_t} \frac{e_t}{e_{t-1}}\right] \\ &+ \frac{dg_t^*}{g_{t-1}^*} \left[(1-\alpha^*) \frac{D_{t-1}^* e_t}{L_t}\right] - dl_t \left[\frac{\alpha_l^{*'}}{1-\alpha^*}\right] - ds_t \left[\frac{\alpha_s^{*'}}{1-\alpha^*}\right] \end{aligned} \tag{10}$$

where the elasticity of gross foreign liability flows with respect to Home's interest rate and with respect to the exchange rate, are defined respectively, as[14]

$$\epsilon_i^L = \frac{dIL_t}{L_t} \frac{1}{de_t} = \frac{\alpha_{uip}^{*'}}{1-\alpha^*} > 0 \tag{11}$$

$$\epsilon_e^L = \frac{dIL_t}{L_t} \frac{e_{t-1}}{de_t} = \left[\frac{\alpha_{uip}^{*'}}{1-\alpha^*} \frac{e_{t-1}}{e_t} \frac{E(e_{t+1})}{e_t} + \alpha^* \frac{L_{t-1}}{L_t} \frac{e_t}{e_{t-1}}\right] > 0 \tag{12}$$

[13]The linearization around a balance of payments equilibrium in which there are no private capital flows also implies a level of foreign exchange interventions, exchange rate and policy rate at trend levels. For FXI, this is defined as equal to the net export proceeds and the income balance. This may seem restrictive as a starting point, but the same results could be obtained by linearizing around an equilibrium in which there is a structural level of private capital flows that adds to an associated trend level of FXI. The empirical implications of this linearization assumption is that the first difference in FXI in the linearized expression should me measuring the different of FXI from its trend level. We implement the latter approach in our empirical application.

[14]The elasticity with respect to the interest rate is a semi-elasticity in the way that it is defined here.

Useful for empirical implementation and constructing the EMP is the approximation that the value of total foreign liabilities in domestic currency is a slow-moving process and hence $\frac{L_{t-1}}{L_t}\frac{e_t}{e_{t-1}} \approx 1$ and that the future exchange rate is expected to move the same way as the current exchange rate, i.e. $\frac{e_{t-1}}{e_t}\frac{E(e_{t+1})}{e_t} \approx 1$. [15] The expression for the exchange rate elasticity of foreign liabilities flows becomes:

$$\epsilon_e^L \approx \left[\frac{\alpha_{uip}^{*\prime}}{1-\alpha^*} + \alpha^*\right] > 0 \tag{13}$$

The elasticity of gross liability flows to Home's interest rate is unambiguously positive, as a higher interest rate leads to a higher expected return on Home's foreign liabilities, which raises the desired portfolio share of Home's liabilities in Foreign's portfolio through equation (4).

The elasticity of gross liability flows to the exchange rate is also positive, and intuitive. A depreciation today of Home currency in terms of foreign currency (i.e. an increase in e_t) initially reduces the expected future rate of depreciation of Home currency, leading to an increased expected yield and hence a higher desired share of holdings of Home's liabilities through equation (4). This is the first term in (12). The depreciation also reduces the value of Foreign's holdings of Home liabilities and Foreign's overall wealth through exchange rate valuation effects. Lower overall wealth reduces desired holdings of Home's liabilities, but only by the share $1-\alpha^*$ of the valuation loss from the currency depreciation, whereas the value of Foreign's liabilities have fallen by the full amount. Foreign will hence adjust its portfolio by new purchases of Home's liabilities to make up for the lost portfolio share, all else equal, through the second term in expression (12). The greater the home bias, α^*, the more of the valuation loss of a depreciation will be spread out over Foreign's own domestic assets and the greater the active adjustment of the holding of Home's liabilities. The elasticity of gross liability flows to Home's and Foreign's asset prices, p_t and p_t^* respectively, are positive for the same reasons as the valuation effect of an exchange rate change. By symmetry, gross Home demand for Foreign liabilities and flows expressed in foreign currency equivalents are described by:

$$IA_t = \tilde{A}_t - \bar{A}_t, \tag{14}$$

$$\bar{A}_t e_t = (1 + \dot{p_t}^* + \dot{e}_t)\, A_{t-1} e_{t-1} \tag{15}$$

and

$$W_t = (1 + \dot{p}_t + \dot{g}_t)\, D_{t-1} + e_{t-1}A_{t-1}\left(1 + \dot{p_t}^* + \dot{e}_t + i_{t-1}^*\right) - L_{t-1}\left(1 + \dot{p}_t + i_{t-1}\right) \tag{16}$$

[15] For example, see Engel and Wu 2021 for discussion of the performance of alternative assumptions.

Taking the same steps as for gross liabilities above generates

$$\begin{aligned}\frac{d\left(IA_t\right)}{A_t} &= \frac{de_t}{e_{t-1}}\epsilon_e^A + \left[di_t - di_t^*\right]\epsilon_i^A + \left[\frac{dp_t}{p_{t-1}} - \frac{dp_t^*}{p_{t-1}^*}\right]\left[\alpha\frac{A_{t-1}}{A_t}\frac{e_{t-1}}{e_t}\right] \\ &+ \frac{dg_t}{g_{t-1}}\left[(1-\alpha)\frac{D_{t-1}}{A_t e_t}\right] - dl\left[\frac{\alpha_l'}{1-\alpha}\right] - ds\left[\frac{\alpha_s'}{1-\alpha}\right]\end{aligned} \tag{17}$$

where the elasticity of gross foreign asset flows with respect to the interest rate and the exchange rate are respectively [16]

$$\epsilon_i^A = \frac{dIA_t}{A_t}\frac{e_{t-1}}{de_t} = -\frac{\alpha_{uip}'}{1-\alpha} < 0 \tag{18}$$

$$\epsilon_e^A = \frac{dIA_t}{A_t}\frac{e_{t-1}}{de_t} = -\left[\frac{\alpha_{uip}'}{1-\alpha}\frac{e_{t-1}}{e_t}\frac{E(e_{t+1})}{e_t} + \alpha\frac{A_{t-1}}{A_t}\frac{e_{t-1}}{e_t}\right] < 0 \tag{19}$$

Under similar approximations as considered for the elasticities of foreign liabilities flows, that $\frac{A_{t-1}}{A_t}\frac{e_{t-1}}{e_t} \approx 1$ and $\frac{e_{t-1}}{e_t}\frac{E(e_{t+1})}{e_t} \approx 1$, the expression for the exchange rate elasticity of foreign asset flows becomes:

$$\epsilon_e^A \approx -\left[\frac{\alpha_{uip}'}{1-\alpha} + \alpha\right] < 0 \tag{20}$$

The elasticity of gross foreign assets to an increase in the exchange rate (an appreciation of the foreign currency) is unambiguously negative, for the symmetrical reasons that the exchange rate elasticity of liabilities is positive. A higher value of the foreign currency increases the expected future depreciation, which reduces the desired share of wealth held in foreign assets. At the same time, an appreciation has increased the value of foreign assets more than the value of wealth, and given the desired foreign asset share, some foreign assets should be sold off.

2.3 The Exchange Market Pressure Index

The content of the preceeding sections provide the elements for the theory-based EMP and appropriate multipliers on foreign exchange intervention and interest rate changes. Linearizing the BOP, equation (2) with respect to the various drivers of components, yields

$$dFXI_t = dNX_{e,t} + \left(\frac{L_t}{e_t}\frac{dIL_t}{L_t} - A_t\frac{dIA_t}{A_t}\right) \tag{21}$$

Then, inserting equations (10) and (17), and combining terms so as to keep those reflecting realized international capital flow pressure on the left hand side, and the so-called drivers of these

[16] The elasticity with respect to the interest rate is a semi-elasticity in the way that it is defined here.

pressures on the right-hand side, the EMP is defined as:

$$\begin{aligned}
EMP_t \equiv & \frac{de_t}{e_{t-1}} + di_t \frac{\pi_i}{\pi_e} - \frac{dFXI_t}{\pi_e} \\
= & ds \frac{1}{\pi_e} \left[\frac{L_t}{e_t} \frac{\alpha_s^{*'}}{1-\alpha^*} - A_t \frac{\alpha_s^{'}}{1-\alpha} \right] + di_t^* \frac{\pi_i}{\pi_e} \\
& \left(\frac{dp_t}{p_{t-1}} - \frac{dp_t^*}{p_{t-1}^*} \right) \frac{1}{\pi_e} \left[\frac{L_{t-1}}{e_{t-1}} \alpha^* + \frac{e_{t-1}}{e_t} A_{t-1} \alpha \right] \\
& + \frac{dg_t}{g_{t-1}} \frac{1}{\pi_e} \left[(1-\alpha) \frac{D_{t-1}}{e_t} \right] - \frac{dg_t^*}{g_{t-1}^*} \frac{1}{\pi_e} \left[(1-\alpha^*) D_{t-1}^* \right] \\
& + dl \frac{1}{\pi_e} \left[\frac{L_t}{e_t} \frac{\alpha_l^{*'}}{1-\alpha^*} \right] - dl^* \frac{1}{\pi_e} \left[A_t \frac{\alpha_l^{'}}{1-\alpha} \right]
\end{aligned} \tag{22}$$

where π_i and π_e are country and time varying and represented by:

$$\pi_e = \left[dNX_{e,t} + \frac{L_t}{e_t} \epsilon_e^L - A_t \epsilon_e^A \right] > 0 \tag{23}$$

$$\pi_i = \left[\frac{L_t}{e_t} \epsilon_i^L - A_t \epsilon_i^A \right] > 0 \tag{24}$$

and $dFXI_t$ and de_t are deviations from their trend levels (see footnote 13).

The $\frac{1}{\pi_{e,t}}$ is the equivalency factor between dollar quantities of central bank foreign exchange intervention and the equivalent units of currency depreciation avoided. The translation of quantities to prices (exchange rates) depends on the previously described sensitivity of unit flows to exchange rate movements through net exports and through portfolio and wealth channels. The conversion factors are both country and time varying.

Within the conversion factors are intuitive components from the BOP dynamics. First, a trade balance channel would allow currency depreciation to improve currency inflows through next export revenues, requiring less depreciation to close the BOP in response to a shock. However, in practice the trade effects $dNX_{e,t}$ are essentially zero in the near term dynamics around global liquidity pressures. More important are the capital account related flows. The next term corresponds to adjustments in portfolio demands of Foreign and Home investors due to depreciation strengthening the expected returns on Home investments relative to Foreign investments within the uip_t. This effect is greater when portfolio demands are more sensitive, i.e. when $\frac{\alpha'_{uip}}{1-\alpha}$ and $\frac{\alpha^{*'}_{uip}}{1-\alpha^*}$ are larger. Next, depreciation reduces the value of prior holdings of Home liabilities within the Foreign investor portfolio. The larger this effect, the more demand for such Home liabilities will increase to achieve targeted Home portfolio weights in the Foreign investors' portfolios. Likewise, currency depreciation has a direct translation effect of over-weighting Foreign assets in the Home investor portfolio.

The equivalences between interest rate changes and rates of Home currency depreciation work through the multiplier $\frac{\pi_{i,t}}{\pi_{e,t}}$. The numerator is positive, but the incipient pressure on a currency relieved by raising Home policy rates depends on portfolio sensitivities to *uip*. If these are very weak, so that α'_{uip} is small, the interest rate rise does not affect net capital inflows much, and little of the incipient pressure on a currency is met by this Home policy change. By contrast, if portfolio sensitivities to *uip* are large, this term contributes significantly to the capital account adjustment and the equivalence factor is larger, implying that substantially more currency depreciation would have been needed to close imbalances.

The key caveat about the EMP is that it is based in a linearized version of the model around equilibrium conditions in the balance of payments and systems of foreign asset and liabilities demand. This allows us to solve the model analytically, resulting in a simple and intuitive expression for the EMP and its drivers. However, the derivation accordingly ignores potentially complex interactions that occur outside equilibrium conditions, and also would be difficult to model and parameterize. While a more general derivation of the expression for the EMP that would allow us to characterize possible interactions precisely could be desirable, it is outside of the scope of this paper.

3 Implementing the EMP

We have implemented the EMP for a sample of countries chosen based on data availability with the series mostly from the beginning of 2000 or starting, at the latest, in 2002.[17] 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. Appendix Table A2 presents the country sample, Appendix Table A3 describes the data sources and definitions, and Table A5 presents descriptive statistics.

EMP implementation for any country first requires determining the currency against which the value of Home is analyzed. The main empirics define all country exchange rates vis-à-vis USD or vis-à-vis the euro as main monetary reference currencies of the country. In practice, most countries have the US dollar as reference currency, with the exceptions of a number of European non-euro area countries for example inclusive of the UK, Switzerland, Denmark, Sweden and the US itself, which have the euro as main reference currency; Singapore, which has the Malaysian baht as reference currency, and New Zealand which has the Australian dollar as reference currency (Klein and Shambaugh 2008). For both of the latter, our analytics set reference currencies as

[17]Even when data is available, we exclude small countries with a population size below half a million or an annual per capita income average since 2002 below USD 1000.

the USD. Because the USD is the main reference currency, we exclude the US from the sample used for certain analytics. This leads to a sample of 41 countries including the US, and 40 when the US is excluded. An alternative approach is to define currency movements against a financial exchange rate. We follow this approach and present high level observations in the robustness section, also noting related conceptual difficulties with this approach.

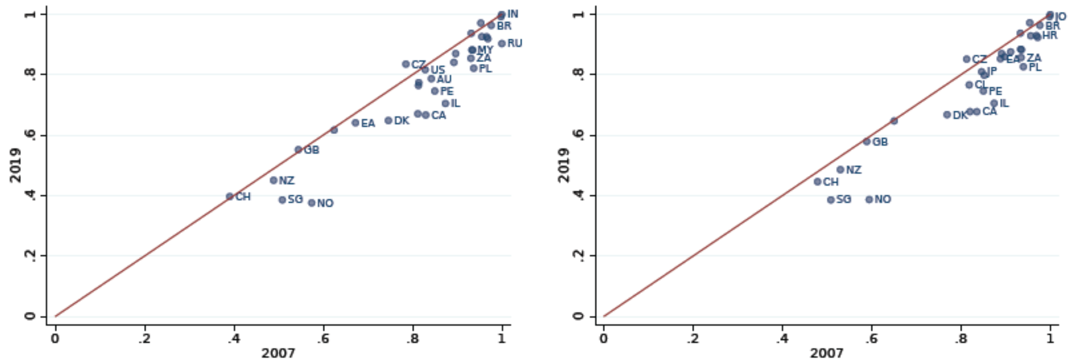
The assumptions that researchers must make in implementing the EMP formula vary by the frequency of the data used in the application. As our main application is at monthly frequency we assume that $dNX_{e,t} = 0$. Interest rates, mostly drawn from IMF International Financial Statistics, are adjusted to one period returns, so that a monthly construction of the EMP uses one year interest rates divided by 12. For periods defined by quantitative easing, forward guidance, and the zero lower bound, we use Krippner Shadow short rates (www.ljkmfa.com) for the United States, euro area, Japan, United Kingdom, Switzerland, Canada, Australia and New Zealand.

3.1 International Portfolios

Our approach to α_t and α_t^* follows closely the broader literature on home bias and country portfolio shares, for example Coeurdacier and Gourinchas (2016); Coeurdacier and Rey (2012); Lane and Milesi-Ferretti (2018); Camanho, Hau and Rey (2015); and Maggiori, Neiman and Schreger (2020). The External Wealth of Nations (EWN), updated through 2020 by Milesi-Ferretti, provides annual series for Foreign holdings of Home's Liabilities $\frac{L_t}{e_t}$ and Home holdings of Foreign liabilities A_t, with reported series for portfolio equity, debt, and financial derivatives. We update the Coeurdacier and Rey (2012) measures of home-bias or home portfolio shares α_t using domestic and foreign holdings of stocks, bonds and bank loans. The earlier work used data through 2008 and found that the α_t values for countries tended to decline in the period preceding the global financial crisis (GFC), but generally ranged between 0.60 and 0.90 across countries.

Our updated series through 2020 covers countries in our sample, examining equity, bond market, and bank loans while also constructing aggregated measures by country and over time (annual).[18] Figure 1 highlights that the trends toward reduced home bias (declines in our α_t) identified through 2008 by Coeurdacier and Rey (2012) continued for equity portfolio data through 2019. All countries show further declines in equity home bias, including for those that had less home bias in the period prior to the GFC. By contrast, home share of debt holdings ended up broadly similar in 2019 compared to 2007, despite some country values either rising or falling modestly. Bank loan share coverage is weaker for our country sample, but exhibits more similarity than difference compared with 2007 values. Comparisons of 2007 and 2019 α_t for equities, bank

[18] We follow Coeurdacier and Rey (2012), computing the annual share of each country's equity investments in domestic equity market, with our update covering 36 of our 41 sample countries. For banking share this update covers 16 of our 41 sample countries. The bond share update covers 24 of the 41 countries. Details are provided in the Appendix.



(a) Home Asset Share, 2007 v. 2019 (b) Home Currency Asset Share, 2007 v. 2019

Figure 1: α_t **by Country in 2007 and 2019**
α_t represents the share of a country's portfolio investments held in domestic assets or domestic-currency-denominated assets. Data points below (above) the 45-degree line indicate that the home asset share decreased (increased) between 2007 and 2019. Some country labels are removed for readability.

loans, and bond data, and then of summed totals have ranges generally from around 0.40 to close to 95 percent. As availability of inputs to total α_t vary, we assign maximum available content at each point in time to country values used in our applications.

α_t^* is the rest of the world (Foreign) financial assets that are not invested in Home liabilities. This computation uses the sum over the total of domestic and foreign positions by countries at each date. $(1-\alpha_t^*)$ is computed by countries using the information previously applied for α^t but excluding the Home Country from the denominator and including the associated Home Country Liabilities in the numerator. This share strongly reflects country size and financial market depth in the world financial economy. Many countries face an α_t^* above 0.99, as they are relatively small in the universe of domestic and foreign investment opportunities relative to the rest of the world. Exceptions are countries like the United Kingdom, Switzerland, the euro area aggregate, Japan, Norway, and the United States where recent values are closer to 0.80.

Consistent with the EMP derivation, our a focus is on domestic currency denominated Home liabilities and foreign currency denominated Foreign liabilities. Accordingly, we use currency weights from the database of Benetrix, Gautam, Juvenal and Schmitz (2020), which extend through 2017. We maintain the 2017 values through the end of sample, pending further source data updates, and interpolate all annual observations to monthly series.

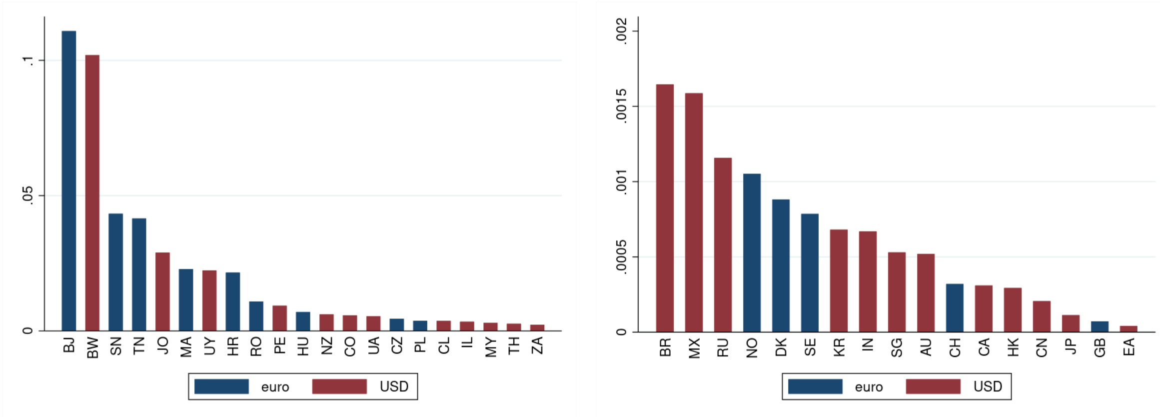
Portfolio share sensitivities to uip enter elasticities through $\frac{\alpha'_{uip}}{1-\alpha}$. These sensitivities are more difficult to quantify. Empirical specification using country aggregate data on components of global liquidity shows that elasticities of flows to domestic policy rates, US policy rates, and risk sentiment vary across market-based finance versus banking flows, in addition to varying over time (Avdjiev, Gambacorta, Goldberg and Schiaffi 2020). Studies using data on foreign shares in investors' portfolios find these shares respond significantly positively to currency depreciation shocks (Hau and Rey 2004; Hau and Rey 2006; Curcuru, Thomas, Warnock and Wongswan 2014). However, recent literature on portfolio sensitivities largely concludes these elasticities are surprising small. Bacchetta, Davenport and van Wincoop (2022) argue that weak responses might arise as some investor types, for example employer sponsored retirement accounts or mutual funds, infrequently adjust portfolios. Koijen, Richmond and Yogo (2020) find substantial heterogeneity in demand curves of mutual investors for equities, with hedge funds and small active investors more responsive. Koijen and Yogo (2020) and Jiang, Richmond and Zhang (2021) find demand elasticities that differ substantially across asset classes in the international investment space: after controlling for ex ante home bias, elasticities with respect to excess returns are ten times higher for short term debt compared with long term debt and five times higher than for equity. Faia, Salomao and Veghazy (2022) find some rebalancing in response to shocks, with granularity across types of bonds, maturities and investors. Still, this literature finds international asset demand to be fairly inelastic with respect to returns.

We assume specific empirical values of α'_{uip} at 0.01, and ${\alpha^*_{uip}}'$ at 0.0005. Under these assumptions, consider the effect of a 1 percent change in uip (a change of 0.01), which could arise from domestic interest rates or the expected exchange rate path, on ϵ_e^A. If Home has a domestic portfolio allocation of 0.60 (60 percent) and the foreign allocation share at 0.40, a 100 basis point change in excess returns would raise the home share by 0.025 to 0.625 (62.5 percent). If Home is facing a world α^* of 0.98, the elasticity of response to a 100 basis point increase in uip is even higher given the wealth and substitution effects. Under these same assumptions, ϵ_i^A is -0.025 and ϵ_i^L is 0.05.

3.2 Implied Conversion Factor on FXI and Interest Rates

The portfolio share and elasticities, and the gross international positions within $\pi_{e,t}$, are used to generate the empirical conversion factors that map FXI_t (and di_t) into currency depreciation units within the EMP. Figure 2 presents country-specific $\frac{1}{\pi_{e,t}}$ based on data for 2019, illustrating how much currency depreciation is implied to be avoided for every 1 billion units of FXI, where red bars correspond to economies with the USD as the reference currency and blue bars correspond to economies with the *euro* as reference currency. Countries are indicated by two letter identifiers defined in Appendix Table A2. Emerging market economies concentrated in the left panel have a conversion factor on foreign exchange intervention generally an order of magnitude larger than for advanced economies.

Using 2019 data, the $\frac{1}{\pi_{e,t}}$ conversion factor suggests that a one billion unit intervention would instead deliver similar currency depreciation effects for Brazil and Mexico, at nearly 0.002 per-



(a) $1/\pi_e > 0.002$ (b) $1/\pi_e < 0.002$

Figure 2: **2019 Average $1/\pi_e$ by Country**
$\frac{1}{\pi_e}$ is the 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 or euros in 2019 on average, depending on reference currency. The bars are color-coded by USD (red) and euro (blue) reference currencies.

centage points of avoided currency depreciation, deliver less than half that value for Australia, Singapore and Switzerland, and which is a factor at least twice as high as that delivered for Japan. The US and euro area intervention equivalent currency effects are even smaller. These relatively small quantitative depreciation equivalents from FXI are consistent with the evidence that oral interventions and the larger scale of interventions are needed for such countries to avoid currency depreciation (Fratzscher, Gloede, Menkhoff, Sarno and Stöher 2019) and observations about the high opportunity cost of holding very large stocks of reserves (Goldberg, Hull and Stein 2013).

The overall patterns in $\frac{1}{\pi_{e,t}}$ are driven strongly by country gross external asset and liability positions in associated currencies, and by the home asset shares. Another interesting feature stems from the type of data on α shown in Figure 1. Higher α and α^* values tend to decrease $\frac{1}{\pi_{e,t}}$. Thus, the correspondence between a unit change in capital flows and an associated currency depreciation changes over time. As the home asset shares decline, foreign exchange intervention delivers more effective results as measured by units of currency depreciation avoided.[19]

Another noteworthy observation is that, given the assumed values for α'_{uip} and ${\alpha^*_{uip}}'$, the model generates relatively small contributions of interest rate changes to the EMP. This primarily occurs because of limited international portfolio reallocations occurring with respect to uip changes, and is also consistent with evidence that valuation effects can be stronger than other exchange rate effects in some capital account adjustments. Future research could consider

[19]Figure A2 shows some of the time variation in these measures for a sample of countries, also illustrating how these change if the reference currency is the dollar versus the euro.

in greater detail the specific types of investors involved at the country level and perhaps more regionally localized international investment sensitivities and home bias computations.

3.3 Monthly Foreign Exchange Intervention Series

The earlier applications of EMP series used changes in official reserves as proxies for FXI. Indeed, the most consistently available data across countries are published official reserve holdings. However, changes in official holdings are imperfect measures of FXI for two overall reasons, requiring choices and assumptions to be made that allow for estimation. First, some central banks also intervene in foreign exchange markets using off balance sheet derivatives instruments such as foreign currency forwards and futures, swaps and options (e.g. Domanski, Kohlscheen and Moreno 2016; Kohlscheen and Andrade 2014). Such instruments are by definition not recording on the central bank balance sheet. Derivatives interventions are in some cases used for targeting specific markets or meeting foreign currency liquidity needs. It is not clear how different types of derivatives instruments map to a spot-intervention equivalent measure. Moreover, the availability of derivatives data is limited. Accordingly, we exclude this adjustment from our measure of FXI. Second, changes in official reserve holdings are affected by distorting valuation effects, making them imperfect measures of spot FXI.[20]

Measuring foreign exchange intervention (FXI) activity consistently across countries hence requires making choices on what types of interventions to include and assumptions allowing for estimation. We measure spot interventions using a combination of three complementary approaches, depending on sample countries' individual data availability. Thus, published data on official spot interventions are used when available (10 countries in our sample). 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 (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.

FXI series can take positive values, as countries accumulate official foreign exchange reserves instead of realizing currency appreciation. Switzerland, for example, has accumulated tens of billions of US dollar reserves in multiple individual months, while selling reserves in other months. Thailand likewise has both positive FXI months and negative FXI months, with much smaller magnitudes of flows.

[20]Exchange rate changes across currencies within an official reserve portfolio can induce valuation effects due to the multiple currencies of assets in the portfolio, as discussed in Dominguez, Hashimoto and Ito (2012).

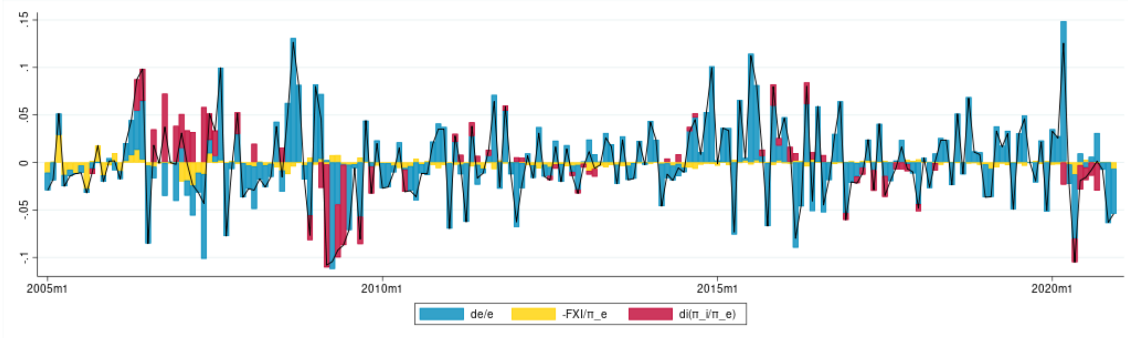
3.4 Monthly EMP Series with Components, Using Reference Currencies

The resulting EMP values vary across countries and time. Four specific country examples illustrate these points: Colombia using a variety of tools in response to international capital flow pressures; China, heavily utilizing FXI and later allowing greater contributions of exchange rate movements; Thailand as an emerging market applying FXI to avoid either appreciation or depreciation; and Switzerland as an advanced country that has actively used all three respective components of the EMP and with a currency value measured and in recent years stabilized relative to the euro.

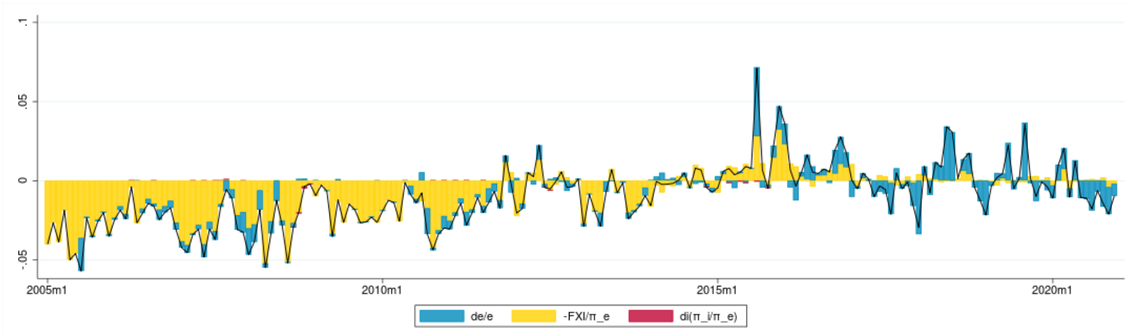
Figure 3 shows that Switzerland's interventions became more active in the years after the global financial crisis, when the policy rate became limited by the proximity of the lower bound. Interventions have resulted in significant growth in Swiss foreign exchange reserves, but the contributions to the EMP from interventions exhibited in Figure 3 are nevertheless relatively modest. This is because Swiss cross border holdings of financial assets are exceptionally large, in turn reducing the weight of the foreign exchange interventions in the Swiss EMP. In other words, Swiss deep and broad financial market and high international position increases the needed size of interventions per unit of prevented exchange rate change, relative to other countries, as also clear from Figure 2. China's interventions have aimed at limiting appreciation against the dollar, but the figure suggests more flexibility in the dollar value of the renminbi since 2015. A caveat on Chinese exchange market pressures is that they do not account for capital flow management measures (Goldberg and Krogstrup 2019). The examples in Figure 3 underscore that differences between observed currency movements and the international capital flow pressures captured by the EMP can be substantial for some countries. Attenuation bias when using exchange rate paths or observed capital flows individually as measures of exchange market pressures could hence be material, and may change over time.

4 The EMP, Risk Sentiment, and the Global Factor

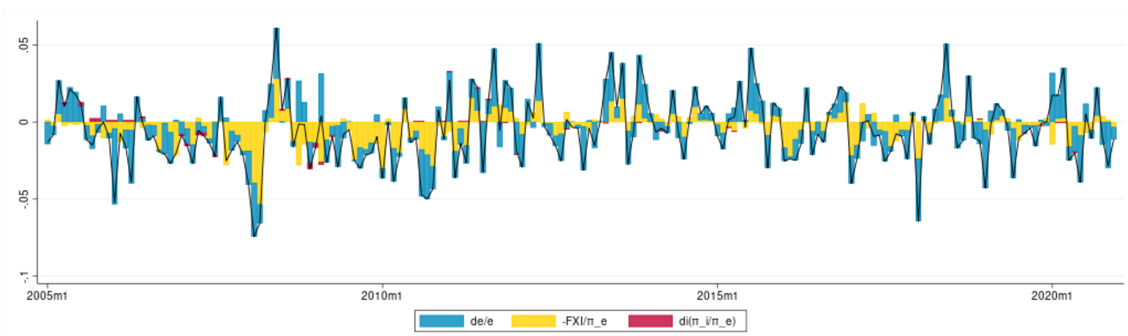
International capital flow pressures are driven by global factors or advanced economy push factors and by local pull factors. A long history of studies of capital flow drivers, and the influential work of Miranda-Agrippino and Rey (2015), point to a large and important global factor particularly associated with US monetary policy and risk sentiment. Some studies point to a close relationship between US monetary policy and risk sentiment (Kalemli-Özcan 2019). Other studies keep these drivers separate and find for a reduced role of risk sentiment via the VIX as reflecting the



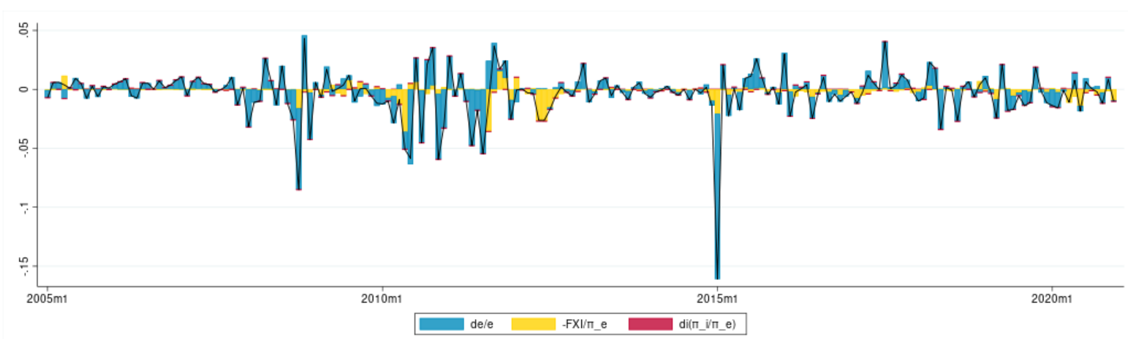
(a) Colombia



(b) China



(c) Thailand



(d) Switzerland

Figure 3: **Individual Components of the EMP (2005-2020)**
Presented are the EMP series with colors indicating the contributions of the three underlying associated respectively with percentage changes in the exchange rate, changes in FXI multiplied by $\frac{1}{\pi_e}$ and changes in policy rates multiplied by $\frac{\pi_i}{\pi_e}$. Panels (a)-(c) are constructed using the UD dollar as reference currency. Panel (d) is based on the EMP against the euro.

higher price of risk on bank balance sheets post GFC and after regulatory changes (Shin 2016).[21] Relatedly, drivers of global liquidity flows - whether bank-based funding or market-based funding - evolve over time as the composition and health of global banks evolves and regulation changes (Avdjiev, Gambacorta, Goldberg and Schiaffi 2020). Moreover, these relationships differ between normal periods and high stress periods, as emphasized by Forbes and Warnock (2021) and Chari, Dilts Stedman and Forbes (2022).

The next sections provide a series of tests of the relationship between the EMP and risk sentiment, and of the overall role of the global factor in international capital flow pressures. We begin with descriptive statistics on the contributions of exchange rates, official intervention, and interest rate changes to the EMP across types of countries, and across normal and high stress periods. We then turn to how the EMP series correlate with risk sentiment, constructing our GRR (Global Risk Response) measure by country and by month. Stress periods are defined using extreme values of risk sentiment. Our baselines use the VIX, while supplemental results from robustness checks utilize the distribution of realizations of the BEX RA measure of risk sentiment (Bekaert, Engstrom and Xu 2021), the euro $VSTOXX$ index, and the $RORO$ (Risk-On Risk-Off) series (Chari, Stedman and Lundblad 2020).

The results underline how international capital flow pressures as measured by our EMP series respond differently to high stress periods across countries and over time, also in comparison with normal times. The results are used to categorize countries as having so-called safe-haven status, defined as those exhibiting appreciation pressures against their reference currency when risk sentiment is more strained. Initial results contrast results exclusively based on exchange rates with those based on the EMP and demonstrate that relying only on exchange rate based analytics can grossly understate the international capital flow pressures experienced by some countries as risk conditions evolve. Further results explore the country and currency characteristics that are associated with the sensitivity of the EMP to risk, revisiting the empirical literature on the drivers of so-called safe haven currencies.

4.1 EMP Variance Decomposition and Contributions from Components

The contributions of the different components to the variance of the EMP differ across normal periods and high stress periods. This point is illustrated by isolating the monthly values of the VIX that are at or above the 90th percentile of the distribution in the period between 2000m1 and 2020m12. The resulting series of months denoted as high stress periods include dates around the September 11 2001 attacks, corporate scandals in mid 2002 to early 2003, the Global Financial

[21] Shin (2016) argues that the broad USD exchange rate became a better metric of risk appetite, reflected in cross-border dollar funding and investment flows (Avdjiev, Bruno, Koch and Shin 2019a, Avdjiev, Du, Koch and Shin 2019b).

Crisis (GFC), the euro area debt crisis, the US debt ceiling, and the early months of the COVID-19 pandemic.[22].

A first set of exercises show that the contributions to the EMP of exchange rate movements per se can be quite different in high stress months, even beyond a focus exclusively on the months associated with the GFC or the early COVID-19 pandemic. The broad characterization across all country-month observations is provided in Table 1.

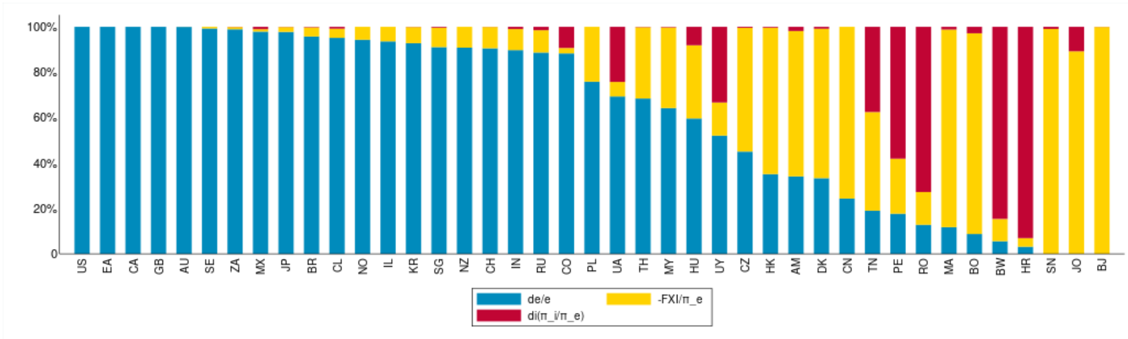
	Rank correlations by de/e share	Share of countries by de/e share of total EMP variance		
		<10 percent	$[10;90]$ percent	>90 percent
Normal periods	–	15	44	41
High stress periods	0.89	10	46	44
GFC	0.72	15	39	46
Pandemic	0.77	15	34	51

Table 1: **EMP Decomposition and Country Shares of Exchange Rate Component**
Spearman rank correlations of countries by de/e share of total EMP variance across normal periods and high stress periods, also the cases of the Global Financial Crisis (GFC) and the covid-19 pandemic. Further, the table contains information on the country distribution by de/e share of total EMP variance.

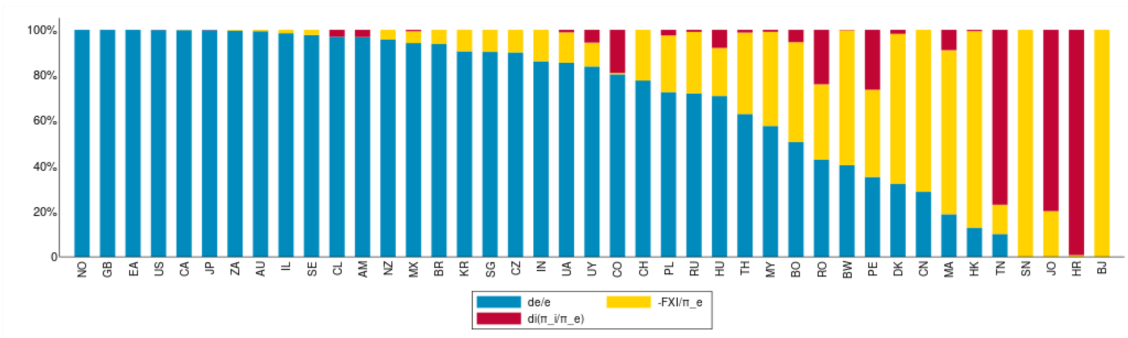
These compositional differences also appear through comparisons of the share of country months that have the pure currency component accounting for less than 10 percent of the EMP, between 10 and 90 percent, and over 90 percent of measured EMP. Rank correlation coefficients across countries consider whether the countries that rank highest to lowest in terms of the currency component (de/e) of the total EMP variance are similar across the normal versus high stress periods, also with the specific comparison of the GFC and pandemic. In addition, it shows the prevalence of mainly floaters (here considered as those currencies with exchange rate change contributions in excess of 90 percent of total EMP) versus countries that manage their exchange rate more actively (where the exchange rate contribution to the EMP is below 10 percent). The strong weight in the center category of diverse contributions to the EMP resonates with the arguments of Frankel (2019), who used foreign exchange reserve changes as a percentage of base money compared with observed currency appreciations against USD to classify many countries as systematic managed floaters.

During the highest stress episodes, countries on average allow more exchange rate variation to absorb capital flow pressures than during normal times and even during otherwise elevated risk sentiment. Some countries might recognize that intervention in the foreign exchange market may not be as effective during periods of extreme stress when currency pressures are large and

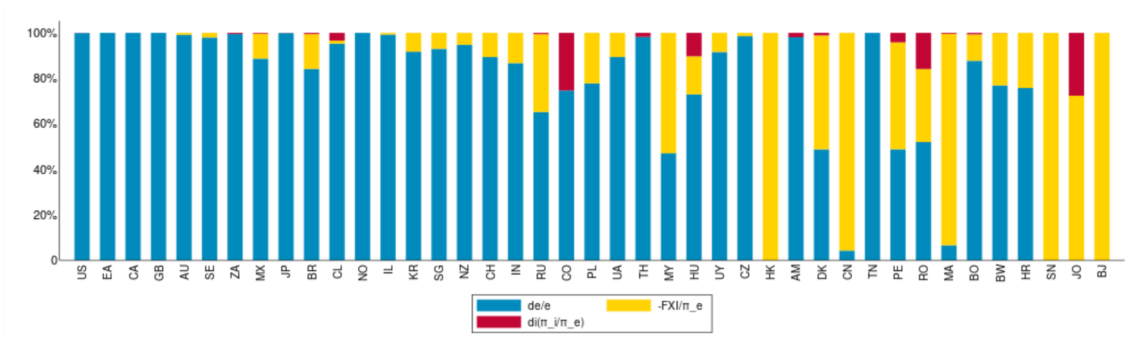
[22] The high stress dates overlap with, but are not identical to 90th percentile dates derived using the $RORO$, BEX risk aversion index, and the $VSTOXX$. The $RORO$ dates, with the index construction based on a broader series of data inputs, are particularly distinct as shown in the Appendix Table A6



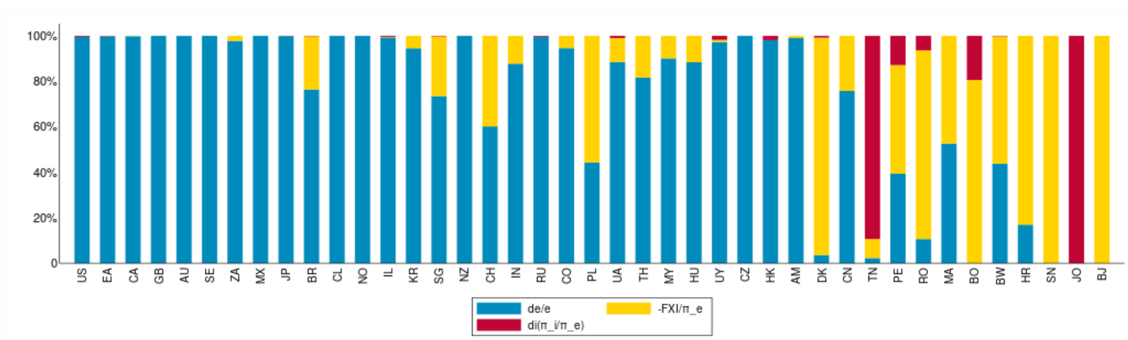
(a) Normal periods



(b) High stress periods



(c) Global Financial Crisis



(d) Covid-19 pandemic

Figure 4: **Individual Components of the EMP During Normal times and Stress Periods** Contributions from the individual components of the EMP across (a) all periods, (b) all high stress periods, (c) the Global Financial Crisis and (d) the Covid-19 pandemic.

might entail losing large quantities of official foreign currency reserves, so that they take at least a temporary currency depreciation.

Foreign exchange intervention accounts for the majority of the EMP that is not attributed to exchange rate movements. The interest rate component accounts for almost all variation for very few countries. The contribution of the interest rate component is most pronounced in countries with high inflation and policy rates that have not been constrained by the effective lower bound and zero lower bound. Central banks in these countries have been able to use the policy rate more actively in response to capital flow pressures. By contrast, in a country such as Denmark the interest rate component contributes little to the variance of the EMP even though this is the primary tool of the Danish Central Bank.

The decomposition by country is shown across the panels of Figure 4. Figure 4 shows the distribution across countries of contributions to the variance of the EMP from the individual components of the index across the less extreme VIX dates (normal periods) in comparison with the extreme dates (high stress periods). The lower panels show the distribution under the GFC and the COVID-19 pandemic. All panels use the country ordering of the panel based on less stressful months, labeled as normal periods. Countries are shown from left to right using the ordering of the contribution of direct currency movements within the EMP, keeping across all panels the ordering from the normal periods.

The table and Figure 4 demonstrate that, even in normal periods, more than half of the country-months in our sample have exchange market pressure that is not fully reflected by exchange rate movements (Figure 4, blue areas). The rest of the pressures are associated with a mixture of currency intervention activity (in yellow) and less so with interest rate adjustments (in red). Another interesting, and perhaps unexpected, observation is that on average exchange rate adjustments capture more - not less - of the international capital flow pressure during the most extreme stress periods during the GFC and pandemic crisis months. During these times, the share attributed to foreign exchange intervention is weaker for some countries while much stronger for others, with generally weaker contributions of interest rate changes. The panels of Figure 4 illustrate the large differences across countries. Some countries, including for example Switzerland, have used FXI to a greater extent during high stress episodes than during normal times.[23]

[23]The pattern of rank correlations across periods is similar, but the magnitudes a bit smaller, when financial exchange rates are used in place of reference exchange rates as in Appendix Table A7

4.2 Safe Haven Currencies, the EMP and Risk Sensitivity

Some currencies are typically considered safe haven currencies, including the US dollar, the Swiss franc and the Japanese yen. The asset pricing literature often defines safe-haven currencies as those exhibiting excess returns during risk-off episodes (Ranaldo and Soederlind, 2010, Habib and Stracca, 2012, Fatum and Yamamoto 2016).[24] There is no consensus on what drives currency safe haven status. One view is that "safe havenness" reflects self-fulfilling expectations. A common expectation among market participants that a currency appreciates during risk off times, because it has done so in the past, making the expectations self-fulfilling and driving demand for these currencies to increase as global risk conditions tighten. Some evidence supports self-fulfilling expectations playing a role, but this is viewed as far from the whole story (Habib and Stracca, 2012). Alternatively, excess returns during risk off episodes can be driven by unwinding of carry trades for low-interest funding currencies, which would also be associated with capital inflows in these currencies (Brunnermeier, Nagel and Pederson, 2008). Finally, safe haven currencies may be variants of global safe assets (Gourinchas and Jeanne (2012)) that ensure the owner against financial income loss during global risk off, driving demand up for the currency during such episodes.

While the self-fulfilling explanation of safe haven currencies depends on the materialization of excess returns *per se*, a currency can exhibit characteristics of a global safe asset or a carry trade funding currency in the sense of receiving inflows during risk off periods, even if it does not exhibit excess returns or currency appreciation during such episodes. In countries where authorities intervene to prevent the currency value from responding to an increase in demand, safe haven demand can also be reflected in FXI or policy rate reductions. Similarly, inflows into a safe haven currency that is fully flexible would result in an increase in excess returns sufficient to prevent the surge in demand from resulting in an actual international capital flow. Indeed, Yesin (2017) shows that episodes of Swiss franc appreciation during risk off are not associated with capital inflows. This means that a focus on either excess currency returns or capital flows, for identifying safe haven currencies alone, risks missing the bigger picture of safe haven currencies and how they evolve over time as currency regimes change.

A more general empirical assessment of safe haven currencies considers a safe haven currency as exhibiting capital inflow *pressures* during risk off episodes. In this context we make use of the EMP 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. Rolling correlations between the EMP and the VIX, labelled as the Global Risk Response (GRR) index,

[24] This topic is also related to and can inform more recent work on explaining convenience yields and the dominant roles of the the USD internationally, see Gourinchas et al. (2019), Caballero et al. (2016), Du et al. (2018), Goldberg and Tille (2016), Maggiori (2017).

are computed. The sign and persistence of these correlations are used to identify safe-haven status currencies versus those that tend to experience capital outflow pressures when the VIX rises.[25] Specifically, we define a currency j as exhibiting safe-haven characteristics during period $t-x$ to t, if it tends to appreciate or experience international capital inflow pressures when risk shocks are higher:

$$GRR_t^j = -corr_{t-x,t}(EMP_t^j, s_t) > 0 \tag{25}$$

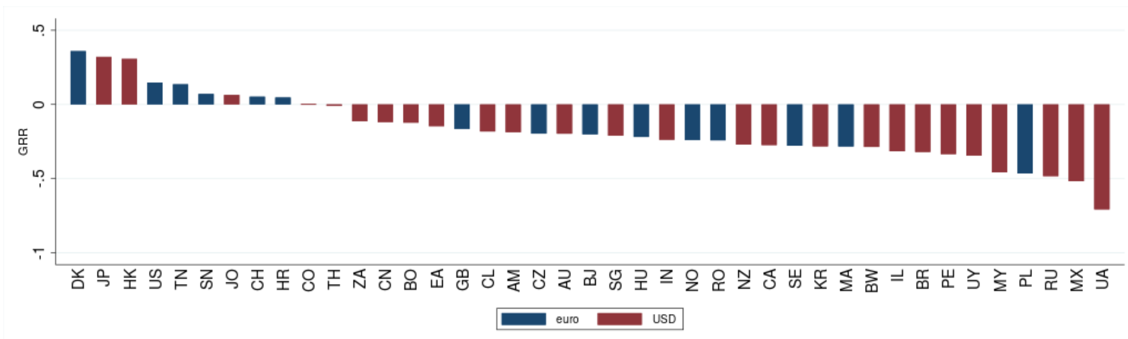
where s_t is captured by variation in the VIX for our baseline specifications, and alternative measures ($VSTOXX$, $BEXRA$, $RORO$) are considered for robustness (Section 4.5 and Online Appendix). The GRR is constructed as a rolling five year correlation with the VIX using 5 years of prior monthly data. Currencies with persistently negative GRR are interpreted as risk-on currencies while those with persistently positive GRR are described as safe havens. The EMP used in these analyses are defined relative to their own reference currencies, so that for example the GRR values for the Swiss franc or Danish kroner could be positive relative to the euro, indicating that relative performance, without specifying their status relative to the USD.[26]

Only a small group of countries exhibits consistent safe-haven status, with $GRR > 0$. Panel (a) of Figure 5 shows the ranking of countries using June 2013 GRR values based on the EMP, while panel (b) shows the scale and rankings of country GRRs exclusively on observed currency depreciation. The Japanese yen, the US dollar (measured against the euro), and the Swiss franc have this status on average over time, while currencies like the Danish krone and the Hong Kong dollar show significantly stronger positive correlations using the EMP, compared with exclusively using observed currency movements. The Swiss franc status is most pronounced when measured relative to the euro (Figure 6). 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. The ranking of countries changes when constructed exclusively using currency depreciation, and the magnitude of the risk response is somewhat smaller for countries that use other tools. While some emerging market economies have positive values, these tend to be noisy and not statistically significant.

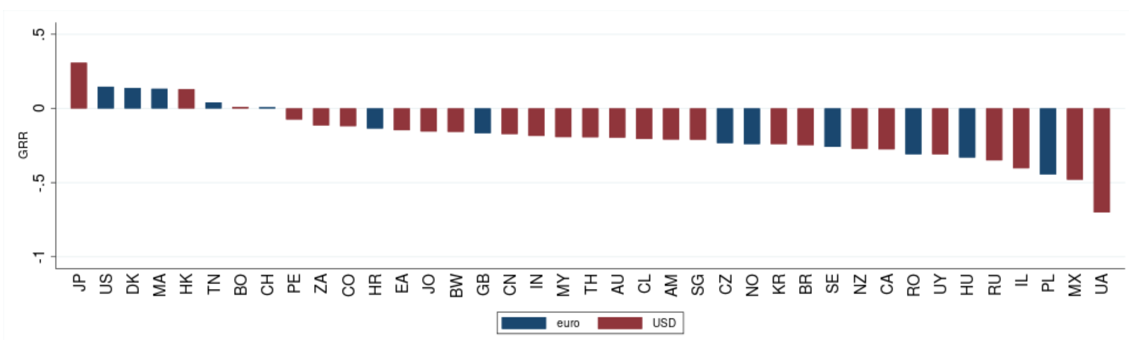
Most countries have EMP series that consistently exhibit negative values of the GRR. As illustrated by Figure 5, within the sample of advanced economies color coded in red the measured variation in the risk response is large, both qualitatively and quantitatively in both advanced and emerging market economies. Strong negative values are found in so-called commodity currencies in particular, like the Australian dollar, the Canadian dollar, the Norwegian krone, the South

[25] A caveat is that our approach does not allow for distinguishing the element of self-fulfilling expectations as driver of safe haven status that may play out differently in flexible rate regimes relative to managed currencies.

[26] Appendix Figure A4 shows that this status does not necessarily transcend shifting the reference currency choice.



(a) Construction based on EMP – reference currency



(b) Construction based on de/e – reference currency

Figure 5: **Ranking of GRR by Country: Near-Term Post-GFC**
Panel (a) shows the GRR based on changes in a country's EMP based on a reference currency using data from July 2009 through June 2013. Panel (b) displays the GRR based on changes in a country's bilateral exchange rate against its reference currency from July 2009 through June 2013. Spearman's rank correlation between panels (a) and (b) is 0.753.

African rand, the Brazilian real, and the Russian ruble. Many other emerging markets and small advanced economies show less pronounced pressures, with smaller negative GRR values.

We also consider time variation, which shows that the so-called safe haven feature is not time invariant. The GRR exhibits substantial variation over time and across countries,[27] as clearly indicated by Figure 6. Against the USD, the Japanese GRR is significantly and consistently positive, an attribute that lends the yen a characteristic of being one of the so-called safe haven currencies, even when computed vis-a-vis USD. The Swiss franc, by contrast, is not consistently measured as having safe haven status with $GRR > 0$. Two countries stand out, namely Denmark and Hong Kong, by not usually being considered as having safe haven currencies. Both countries have fixed exchange rate systems and only measure as safe havens when taking into account their interventions in the foreign exchange market. By contrast, the Brazilian EMP behaves like a commodity currency, consistently facing depreciation and capital outflow pressures with declining returns when risk rises. For example, the GRR is consistently negative but with weaker risk response in a period from around 2015 before increasing again closer to 2020.

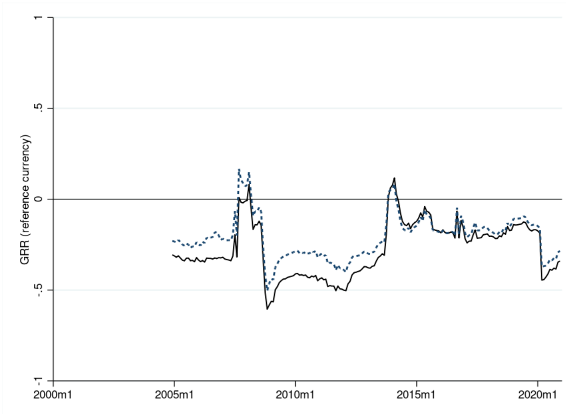
4.3 Regime differences in EMP Risk Sensitivity

Differences in sensitivities across periods, that have been identified as key stress events, are a feature of important contributions by Forbes and Warnock (2012), Forbes and Warnock (2021), Chari, Stedman and Lundblad (2021) and Chari, Dilts Stedman and Forbes (2022). This raises the question of whether the average EMP sensitivity to VIX is indicative of sensitivity in extreme risk periods, or if nonlinearities characterize responses.

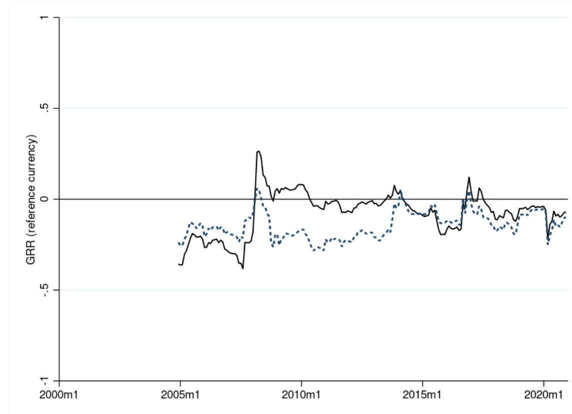
Tests explore the sign and scale of differences in risk sensitivity between the full set of country-month observations and those excluding the high risk periods, defined by the 90th percentile of the VIX distribution. Difference in means tests focus on all countries and those that have so-called safe-haven status. The results show that the sensitivities of this later group are consistent for all periods and when the extreme stress events are excluded from the computations. By contrast, the other countries have significantly lower risk sensitivities when the GRR excludes the extreme risk dates. Those sensitivities are closer to zero, and in many countries are noisy enough to not be statistically different from zero.

Additional tests examine whether average sensitivities have changed over time, for example reflecting lessons learned and reforms after the GFC. Shin (2016) argued that the VIX lost its strong power, while Avdjiev, Gambacorta, Goldberg and Schiaffi (2020) and Buch and Goldberg (2020) find that changes in the regulatory environment made bank-based international capital flows less sensitive to risk events. Table 2 results show that overall pressures on currencies across

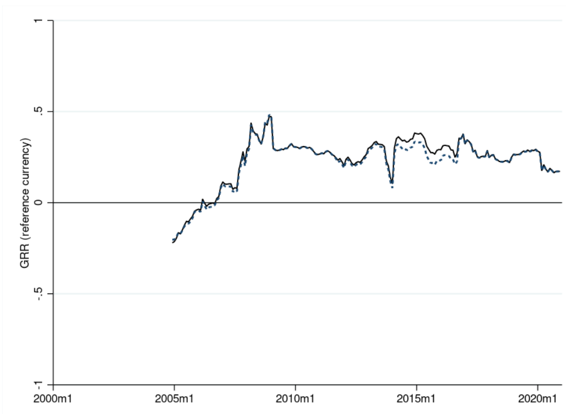
[27] Observations for the GRR are based on 5 years of prior monthly data. If pre-2000 EMP data are unavailable for some countries, some early GRR observations will be missing from the regression sample.



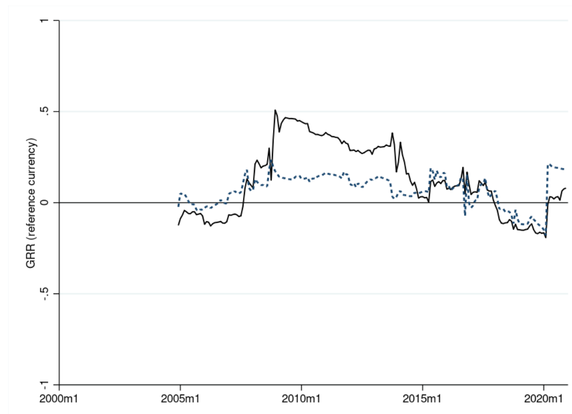
(a) Brazil



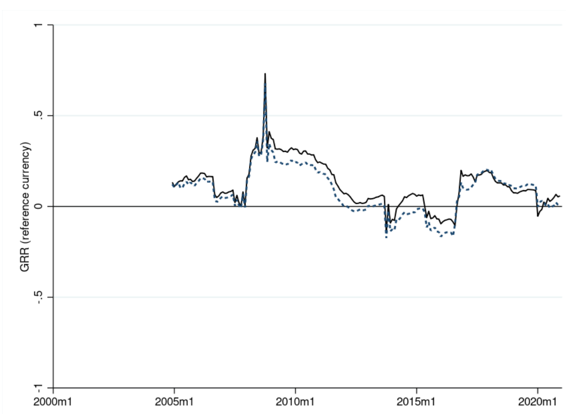
(b) Thailand



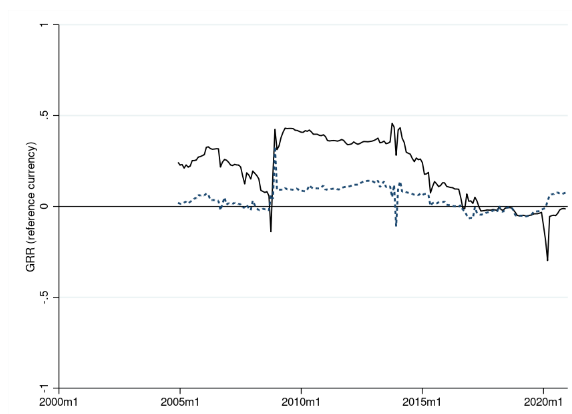
(c) Japan



(d) Hong Kong



(e) Switzerland



(f) Denmark

Figure 6: **Global Risk Response (GRR) Comparison, Using the VIX**
GRR using the VIX as the risk sentiment proxy and based on the EMP against the US dollar in panels (a) through (d) and against the euro in panels (e) through (f). The solid line displays GRR computed the EMP. The dashed line displays the GRR computed using realized depreciation rate.

a broad group of countries and based on the EMP continue to have strong sensitivity to risk conditions. Safe haven countries have stronger correlations post GFC compared with the GFC and earlier. Other countries have similar sensitivities on average.[28]

(a) Full Sample: January 2000 to December 2020

	All	Safe Haven	Excl. Safe Haven
GRR – All Periods	-0.11***	0.15***	-0.15***
GRR – Excluding P90	-0.02***	0.15***	-0.05***
Difference	-0.09***	-0.00	-0.10***

(b) Pre-GFC

	All	Safe Haven	Excl. Safe Haven
GRR – All Periods	-0.10***	0.11***	-0.13***
GRR – Excluding P90	-0.04***	0.10***	-0.06***
Difference	-0.06***	0.01	-0.07***

(c) Post-GFC

	All	Safe Haven	Excl. Safe Haven
GRR – All Periods	-0.08***	0.11***	-0.11***
GRR – Excluding P90	-0.03***	0.12***	-0.06***
Difference	-0.05***	-0.02*	-0.05***

Table 2: **Difference-in-Means Tests for GRR against each country's reference currency.** GRR is computed as -1 times the rolling correlation over 5 years between EMP against reference currency and the VIX. In the excluding P90 analysis, the rolling correlation is calculated excluding months at or above the 90th percentile value of the VIX from 01/2000 to 12/2020. Safe haven currencies are the DKK, HKD, JPY, CHF, and USD. Significance in the first two rows indicate whether the average is different from 0. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels.

[28]If there are weaker effects, this could arise because a period of time used in estimation has fewer observations of the high stress values that are associated with elevated correlations, or because there is attenuation bias in the studies that use only capital flows or exchange rate movements as dependent variable as these do not fully reflect the incidence of exchange market pressures.

4.4 Country and Currency Characteristics Associated with Safe Haven Status

Which macroeconomic and financial factors are associated with safe haven currencies and currencies with more extreme risk-on status? Highlighting correlated associated with some currencies habitually experiencing inflows or excess returns when global risk conditions worsen. As already noted, some attenuation bias in the extant literature results from only considering exchange rate responses to risk factors may mean inaccurate results for carry trade or safe haven drivers of safe haven currencies. We instead construct and employ a counterfactual excess return based on the EMP and test self-fulfilling drivers, carry trade funding currency drivers, and safe asset drivers. To our knowledge, the previous empirical literature has not explored these different drivers collectively.

A self-fulfilling explanation for a safe haven currency is present if the currency is floating and its EMP response to a risk shock is correlated with the past response to risk shocks, which we measure by the level of lagged GRR. The dummy "Floater" is equal to one when a currency is freely floating, which we define as those for which the share of de/e in the total EMP variance is above 90 percent.

A currency is more likely to be used as a carry trade funding currency, and hence to have a stronger response of the EMP to a risk shock, if past interest rate levels associated with the currency has been low. We define a low interest rate relevant for carry trade by a lagged interest rate level below the interest rate of its reference currency, and set the dummy CarryTrade to one for such country months, and zero otherwise. Carry trades are typically unwound when risk increases, allowing funding to flow back to the country of origin.

Finally, safe haven dynamics can be driven by safe asset motives if assets issued in the currency are considered safe and liquid. Habib and Stracca (2012) capture safe asset drivers in three conjectures, namely that a currency may be a "safe haven" (or a safe asset) if: i) the issuing country is itself regarded as a safe country and with low financial risk; ii) its financial markets are large and liquid; and iii) it is financially open and global. 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 index) 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.

We test the three categories of drivers of safe haven currencies using monthly data for 40 countries for 2000 through 2020, exploring the sensitivity of the counterfactual excess return to risk in specifications containing a range of controls. To recognize the EMP sensitivity to risk sentiment, results based on counterfactual excess return realizations are compared with results using realized excess returns based on exchange rates. Test consider whether results are driven by the variation contained in the set of safe haven currencies alone, defining safe-haven currency observations according to average $GRR > 0$ with statistical significance over the full sample period.[29] Finally, differences in sensitivities across normal risk periods versus extreme risk periods are examined.

Following Brunnermeier et al. (2008), $z_t^{j,e}$ denotes the excess return of currency j relative to its reference currency, and by $z_t^{j,EMP}$ the counterfactual excess return of currency j relative to its reference currency, taking into account policy responses to flows.[30]

$$z_t^{j,e} = i_{t-1}^j - i_{t-1}^* - \frac{e_t^j - e_{t-1}^j}{e_{t-1}^j} \tag{26}$$

$$z_t^{j,EMP} = i_{t-1}^j - i_{t-1}^* - EMP_t^j \tag{27}$$

The baseline estimation equation follows from the EMP model derivation and is given by:

$$z_t^{j,EMP} = \alpha_s ds_t + \beta\Omega_t^j * ds_t + \gamma\Omega_t^j + +\delta di_t^* + \zeta^j + \varepsilon_t^j \tag{28}$$

where ds_t is the global risk shock introduced as the VIX; and di_t^* is the US or euro area policy rate, depending on which reference currency is relevant for a country in the estimation sample. Global risk enters estimation specifications directly and is 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 for interactions across table columns, but included as a full set of controls in all specifications. The interaction terms with the VIX capture the dependence of risk sensitivity on country or economic characteristics, with controls for the average effect of these characteristics on realized excess returns. Tables below show estimated β and omit the presentation of the parameter estimates for γ, δ and the country fixed effect ζ^j. The column organization within tables follows the spirit of the analysis in Habib and Stracca (2012), in that variable grouping are associated with a specific hypothesis. Results are presented in Tables 3 and 4.[31]

[29] Note that future refinements will rely only on ex-ante periods for defining currency status. The full period statistical tests identify the United States, Denmark, Switzerland, Japan, and Hong Kong as satisfying the criteria.

[30] Min et al. (2016) establish different dynamic linkages between equity and currency returns across six OECD countries during the 2008 financial crisis, a global shock.

[31] Further robustness check tables are provided as online appendix materials, as Tables OA1 to OA7.

The first finding is that, regardless of whether constructed using $z_t^{j,e}$ or $z_t^{j,EMP}$, deteriorated risk sentiment as reflected by positive changes in the VIX on average lead to international capital outflow pressures and depreciation pressures. The implication is that the average effect of $dVIX$ is negative, as expected for realized excess returns.

Delving further, other columns of Table 3 present the results of panel regressions including explanatory variables that capture self-fulfilling expectations and carry trade funding currency drivers of safe haven flows. It also controls for differences in safe haven risk sensitivities depending on reference currency. Three results emerge from Table 3 on drivers of safe haven characteristics. First, Columns I and III show that safe haven characteristics of risk responses are relatively stronger when the reference currency is the euro compared to the USD, consistent with the USD being a safe haven currency. Second, Columns II and IV illustrate that risk sensitivity is highly persistent on average, similar to the correlations over the previous 5 years as reflected in interaction with GRR_{t-1}. This persistence is only significant when the currency is floating, consistent with the hypothesis that safe haven currencies are driven by self-fulfilling expectations of currency appreciation (rather than capital inflows) during risk-off. This pattern in capital flow pressures is not present for currencies that are not floating and hence do not allow for anticipated excess returns under tightening risk conditions. Third, countries with lower interest rates see a greater tendency for safe haven type capital inflow pressures when risk rises, consistent with low-interest rate currencies being used as carry trade funding currencies. The analysis cannot distinguish if the association with low interest rates instead reflects other factors, such as low country risk. Finally, while the results are qualitatively similar across specifications based on the EMP and based on exchange rate appreciation, differences across the specifications in terms of the size of parameter estimates and significance may be driven by the EMP reducing attenuation bias.

Table 4 contains regression results focusing on the set of variables typically associated with countries that issue safe assets. Columns II and VII contain variables capturing country risk (or country safety). Columns III and VIII introduce the set of macro fundamental variables reflecting size of economy and financial market development and depth.[32] Columns IV and IX 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. Finally, Columns V and X combine variables. While these are likely to be co-linear, we mainly view these specifications are tests for incremental explanatory power from combined inclusion. The Table shows that safe asset variables are generally not significantly related to the risk response of currencies. In some

[32]Financial market depth also captures liquidity, has long been identified as a feature of reserve currency status of currencies, for example by Krugman (1984) and later by Goldberg and Tille (2006), Goldberg and Tille (2008), and Goldberg and Tille (2009). Indeed, this liquidity focus also ties into our construction of the EMP, as it relates to the impact of flows through the portfolio demands sensitivities to changes in asset returns.

	$z^e * 1000$		$z^{EMP} * 1000$	
	I	II	III	IV
$dVIX$	-0.648**	-0.557**	-0.758***	-0.706***
	(0.203)	(0.178)	(0.212)	(0.161)
$dVIX * RefUSD$	-1.053***	-0.786**	-1.051***	-0.823***
	(0.303)	(0.254)	(0.310)	(0.247)
$dVIX * GRR_{t-1}$		0.495		0.394
		(0.712)		(0.758)
$dVIX * GRR_{t-1} * Floater$		3.171***		2.912**
		(0.873)		(0.947)
$dVIX * CarryTrade_{t-1}$		0.629**		0.789***
		(0.230)		(0.233)
Constant	28.818***	36.556***	29.292***	37.777***
	(6.030)	(4.112)	(5.662)	(4.015)
Adj. R2	0.032	0.155	0.035	0.137
No.Obs	9824	7564	9276	7495

Table 3: **Safe Haven Drivers: Panel Regressions**

Results from monthly panel regressions from 2000m1 - 2020m12 excluding the United States. z^e*1000 and z^{EMP}*1000 are dependent variables, winsorized at the 1st and 99th percentile. No.Obs gives the number of regression observations. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels.

regressions, but not all, a higher level of public debt is weakly related to a safe haven tendency, which is not consistent with the prediction. Similarly, higher domestic credit and greater gross foreign positions are weakly significant in some regressions and with the right sign, but results are not robust across specifications.

Results for safe asset regressions do not change much when dividing the sample into safe haven and non-safe haven countries, or when considering only high-stress dates, or low-stress dates (Tables 4, OA7, OA6). All in all, these groupings of explanatory variables contribute little to explaining differences in effects of $dVIX$ on realized excess returns. Safe asset drivers of safe havenness of currencies do not receive much support from our data. Similar qualitative results are found in specifications with alternative fixed effects inclusions.

To conclude, regression specifications using the counterfactual excess return based on the EMP allow us to capture safe haven as well as risk off patterns in currencies across exchange rate regimes. Our analysis of the drivers of such patterns confirms some of the determinants that can be associated with safe haven status of a currency, namely persistence and self-fulfilling expectations and carry trade funding currency status. In contrast, determinants associated with safe assets found little support in the data, with the size of the public debt and gross foreign positions occasionally and weakly showing significant associations. Financial market development and financial openness changes over time, with country fixed effects in specifications, do not

	$z^e * 1000$					$z^{EMP} * 1000$				
	I	II	III	IV	V	VI	VII	VIII	IX	X
$dVIX$	-1.353***	-1.579***	-1.983***	-1.638***	-1.870**	-1.482***	-1.695***	-2.307***	-1.890***	-2.299***
	(0.187)	(0.365)	(0.327)	(0.441)	(0.543)	(0.191)	(0.400)	(0.362)	(0.394)	(0.541)
$dVIX * NFA/GDP_{t-1}$		0.173			-0.268		0.191			-0.255
		(0.196)			(0.264)		(0.188)			(0.238)
$dVIX * Infl_{t-1}$		-6.838			-5.409		-7.749			-4.636
		(4.554)			(4.820)		(5.607)			(5.680)
$dVIX * PubDebt/GDP_{t-1}$		0.007*			0.007*		0.007			0.006
		(0.003)			(0.003)		(0.003)			(0.003)
$dVIX * ShareofWorldGDP_{t-1}$			2.730		1.354			1.995		1.002
			(5.446)		(6.423)			(5.283)		(5.809)
$dVIX * StockmarketCap/GDP_{t-1}$			0.000		0.001			0.000		0.001
			(0.001)		(0.001)			(0.000)		(0.001)
$dVIX * Dom.Credit/GDP_{t-1}$			0.006		0.000			0.008		0.003
			(0.004)		(0.005)			(0.004)		(0.005)
$dVIX * (GFA + GFL)/GDP_{t-1}$				0.106*	0.114				0.109*	0.101
				(0.044)	(0.069)				(0.047)	(0.067)
$dVIX * ChinnIto_{t-1}$				0.008	-0.031				0.138	0.114
				(0.562)	(0.555)				(0.532)	(0.538)
Constant	36.616***	18.664**	41.717***	81.453***	45.729**	36.994***	29.399***	48.678***	77.695***	63.307***
	(0.059)	(6.388)	(7.726)	(18.153)	(15.942)	(0.065)	(5.922)	(7.547)	(15.986)	(16.091)
Adj. R2	0.028	0.112	0.031	0.055	0.125	0.032	0.074	0.037	0.049	0.087
No.Obs	9824	8744	8859	8877	8588	9276	8342	8345	8446	8188

Table 4: **Safe Haven Drivers: Panel Regressions**

Results from monthly panel regressions of equations 26 and 27 from 2000m1 - 2020m12 excluding the United States. z^e*1000 and z^{EMP}*1000 are dependent variables, winsorized at the 1st and 99th percentile. No.Obs gives the number of regression observations. All specifications include country fixed effects and control for di^*. Specifications with interaction terms with $dVIX$ include the corresponding non-interaction controls which can include NFA/GDP_{t-1}, $Infl_{t-1}$, $PubDebt_{t-1}$, $StockmarketCap_{t-1}$, $ShareofWorldGDP_{t-1}$, $DomCredit/GDP_{t-1}$, $(GFA + GFL)/GDP_{t-1}$, $ChinnIto_{t-1}$ (not shown). Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels.

differentiate risk behavior of realized excess returns.

4.5 Robustness

We conduct a range of robustness checks on the construction of the EMP and on the sensitivity to risk sentiment, with details on the findings included in the Appendix.

First, our analytics on EMP construction rely on different combinations of α and $\alpha^{'}$, and of α^{*} and $\alpha^{*'}$. We have followed the literature in α construction, and drawn lessons from especially a recent literature in $\alpha^{'}$ construction. In our view, especially $\alpha^{'}$ might be too low, suggesting international portfolio demand response to expected excess returns might be too weak. In addition, our approach to considering foreign demand for domestic debt assets defines Foreign to be the entire rest of world. The share of world investor wealth allocated to any single country portfolio is small, and the response is bounded accordingly. To the extent that investor patterns may be more concentrated and elasticities to returns higher, this will change the contributions of interest rates and foreign exchange intervention to the overall EMP. Future work can explore alternative approaches to measuring foreign investor behavior and the potential to magnify the response of foreign portfolio flows, delivering stronger interest rate and FXI contributions.

Second, we explore the difference in EMP series and behaviors if the definition is as a financial exchange rate instead of a bilateral exchange rate with a reference currency defined relative to the USD or euro. As the EMP measures capital flow pressures relative to that experienced by the reference currency, this choice reinforces that care is appropriate when comparing EMP developments across countries with difference reference currencies. Indeed, valid arguments could be made for instead constructing a financial exchange rate instead to capture the broader set of currencies represented in the financial accounts of an economy.

We explore this alternative approach by broadly following the construction methods for financial exchange rates as most recently implemented by Benetrix, Gautam, Juvenal and Schmitz (2020) building on Lane and Shambaugh (2010) and Benetrix, Lane and Shambaugh (2015), where annual financial exchange rate series are constructed for countries through 2017. For each country, measures of total external assets and liabilities, using country-year level data on external equity, debt, and financial derivatives, are from Lane's and Milesi-Ferretti's External Wealth of Nations dataset (available through 2020).[33] As weights are available from 1990 through 2017, for years after 2017, the Benetrix, Gautam, Juvenal and Schmitz (2020) 2017 weight values are

[33]Our application requires creating weights for 10 currency areas not in the IMF/Benetrix et al. (2020) data. Euro Area (EA) aggregate weights are calculated as the (foreign asset and liabilities) weighted average of individual EA countries, with the countries included the same as those used by Coeurdacier and Rey (2012) and, therefore, in our alpha construction. Regional averages (ex: South America, North Africa, etc.) are similarly computed as a weighted average of individual countries in the region.

maintained through the end of 2020. [34]

Our analysis of resulting series shows that for most countries changes in their bilateral exchange rates against reference currencies and in their financial exchange rates have overall correlations above 0.90. This close co-movement reflects that well documented strong international roles of the dollar in particular, as well as the euro. However, important outliers with lower correlations include Switzerland, Denmark, United Kingdom, Hong Kong, Jordan, Norway, and Sweden. These differences arise because some countries with a euro reference currency still have a substantial share of financial transactions – from a third to over a half – denominated in USD. Moreover other countries like Hong Kong and Jordan that had reference currencies as USD have a substantial share of transactions in other currencies (CNY and euro respectively). Given the tight correlations for most bilateral reference currencies with the financial exchange rates, the key differences in EMP risk characterizations are for those exception countries indicated above. For these countries, the weight on the exchange rate movement tends to rise within the overall EMP, as multilateral exchange rates can change even when bilateral exchange rates using the reference currency are stabilized by FXI (Table A7 and Figure A3).

While the concept of a financial exchange rate is appealing for our application, these series have limitations. The exposure implied by the available data are unlikely to accurately capture financial exposures in foreign positions. These series do not incorporate exposures off balance sheet that can be large enough to make the on-balance sheet exposures misleading. Using the case of Denmark as a specific example, many institutional investors hold dollar assets but swap these into euro in the foreign currency swap and/or forward markets. They do this exactly because the euro is stable against the Danish Kroner due to their monetary policy, and hence stable relative to domestic purchasing power which these investors anchor against. Taking this hedging into account in exposure measurement would hence greatly increase the euro exposure, more in line with the reference currency approach. Using the imprecise on-balance sheet financial exposures exchange rate as a measure of capital flows may hence mis-characterize movements in the exchange rate as inflows when the movements are due to euro-USD exchange rate moves. This potential for mismeasurement is likely to be biased toward under-weighting exposures against the reference currency in particular in countries that manage their currency against the reference currency. We have for this reason maintained the reference currency approach as baseline.

[34] This construction differs from their financial exchange rates by excluding a country's domestic currency and non-major currencies, considering currency movements against only USD, EUR, GBP, JPY, and CNY denominated assets and liabilities (for countries other than the US, EA, UK, JP, and CN for which we also exclude the respective domestic currency), with currency weights are normalized to sum to 1 within each country-year and then country-year level values are interpolated (smoothed) at the country-month level. As the construction formula is a recursive series, we set the initial (January 2000) value to 100, in line with the approach of Benetrix, Gautam, Juvenal and Schmitz (2020). Special thanks to Luciana Juvenal for providing their underlying data and construction code.

Finally, we perform extensive analytics to understand how the risk sensitivity results perform when the baseline VIX series is replaced, respectively, with the $BEXRA$ risk sentiment, $VSTOXX$ index, and $RORO$ series of Chari, Stedman and Lundblad 2020). The most extensive new work needed to operationalize these robustness checks was in extending the $RORO$ series through 2022, relative to the April 2020 end date in Chari, Stedman and Lundblad 2020. The extension required updating input series and rerunning the author's code for principal component analysis over these series, and then using a monthly sum of the daily $RORO$ series to generate a risk measure more comparable to the VIX type metric. Figure A1 shows that the resulting series are different in their characteristics.

For each of these distinct risk measures, distinct GRR series are generated along with series specific dates that are considered the highest stress dates per the 90^{th} and 95^{th} percentiles of each respective distribution. This date construction either uses all available data, in which case the $RORO$ series has a later start date (2003), or uses a comparable abridged time frame for all series spanning 2003 through 2020 monthly observations so that stress date distributions across risk series are measured using a common time frame. These checks are important, as the $RORO$ series tends to exhibit greater differences, due to broader inputs and different construction methods, than the alternatives. The $RORO$ distribution of observations is more balanced in terms of extreme observations as lowest risk and highest risk, instead of weights that are flatter across normal times and then concentrated in the upside value extremes only for the the alternative risk series. Accordingly, the high stress episodes for the VIX end up picking up earlier dates in 2007 and 2008 than within the GFC period by other series, less weight on 2009 observations, and more weight on strains in 2015 and 2018, detailed in Appendix Table A6.

Analytics test for differentiation in risk sensitivity, replicating all of the regression tables with the alternative risk series. Appendix Table A8 shows difference in means tests for the associated GRR constructions. All series show positive GRR average values for the safe haven currencies, and negative GRR correlations for the sample that excludes the safe haven currencies. The $BEXRA$ risk sentiment and $VSTOXX$ exhibit similar patterns relative to the VIX construction. The sensitivities measured using the $RORO$ instead rise over time for the non-safe haven currencies, driven by the rise in normal periods' risk sensitivity, while the sensitivities for safe haven currencies appear to decline. Additional analytics reproduce the regression tables on the drivers of these sensitivities.[35]

[35]Further tables of results are available in the Online Appendix.

5 Conclusions

This paper has presented a new measure of capital flow pressures in the form of an exchange market pressure index that takes into account pressures that manifest in exchange rate movements, as well as pressures that are instead realized in official foreign exchange intervention or offset by monetary policy rate changes.The EMP construction is grounded in balance of payments relationships, and reflects analytical advances in understanding international financial flows. The EMP has a super exchange rate interpretation, as foreign exchange intervention and monetary policy changes are mapped into equivalent units of currency depreciation. The measure allows for comparison of international capital flow pressures across countries and across time, allowing for the different exchange rate and monetary policy regimes that are in place. The construction also demonstrates clearly how the drivers of international capital flow pressures, including those described as the global factor, arise from gross foreign asset and liability positions.

We have computed the EMP for 40 countries and over 20 years of data, providing an empirical measure of monthly variation in international capital flow pressures. The empirical applications demonstrate the EMP usefulness by avoiding the type of attenuation bias that arises when exchange rates or capital flows are separately explored in cross-country and time-series empirical analyses. Currency depreciation alone characterizes less than half of the country-month observations across the advanced and developing countries. The contributions of currency depreciation, foreign exchange intervention, and monetary policy effects vary across periods with high stress in global financial markets and more normal times.

International capital flow pressures are shown to be highly responsive to global risk conditions, with differences across types of countries and also in the highest risk months. Countries clearly sort into a few so-called safe haven currencies, and then other advanced and emerging market economies. The currency features associated with safe haven currency status include low interest rates consistent with funding currency use, and self-fulfilling expectations based on prior safe haven characteristics. Macroeconomic country features relating to safe assets, such as country risk measures, country size, foreign asset positions, financial openness and liquidity, are not found to be robustly and significantly associated with safe haven currency status.

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Appendix

A Early EMP 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:

$$EMP_t = w_e \left(\frac{\Delta e_t}{e_{t-1}}\right) - w_R \left(\frac{\Delta R_t}{S_t}\right) + w_i(\Delta i_t) \tag{29}$$

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.[1] Kaminsky and Reinhart (1999) instead scale by the level of reserves and Eichengreen, Rose and Wyplosz (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.

Prior approaches to weighting the different components of the index likewise vary in both economic relevance and conceptual underpinnings. Such conceptual underpinnings are extremely

[1]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.

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, Rose and Wyplosz (1994)[c] and Forbes (2002)	$w_e\frac{de}{e} + w_i d(i-i^*) - w_R\frac{(dR-dR^*)}{M1}$	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, Tornell and Velasco (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, Lee and Sushko (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, Chinn and Ito (2016b)	$w_e\frac{de}{e} + w_i d(i-i^*) - w_R\frac{(dR-dR^*)}{R}$	Precision	Nominal bilateral against reference currency
Patnaik, Felman and Shah (2017)	$\frac{de}{e} - w_R dR$	Exchange rate elasticity to US dollars $1bn of interventions	Nominal bilateral against US dollars
Frankel (2019)	$\Delta log(H_t) + (\Delta Res)/MB_t$	Equal	Nominal bilateral against US dollar/SDR

[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, Rose and Wyplosz (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: **Earlier Exchange Market Pressure Indices in the Literature**

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.[2]

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

Patnaik, Felman and Shah (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 reserves.[3] 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.[4] 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.

We have replicated four types of approaches to include the features of Girton and Roper (1977), Eichengreen, Rose and Wyplosz (1994), Kaminsky and Reinhart (1999), Aizenman, Binici and Hutchison (2016a). For the replication we utilize our measure of foreign exchange intervention to focus on the broader issue of the EMP construction, avoiding the additional issue in those studies of well known problems with using changes in foreign exchange reserves as the proxy for foreign exchange intervention. We find that each of these series generate vastly different results from each other, and from our measure. The changes are meaningful for the relative contributions of FXI to a measure of pressures. For example, expressed in our EMP format, Kaminsky and Reinhart (1999) and more generally the approach using precision weights tend to significantly downweight the contribution of foreign exchange intervention relative to currency movements across many countries. These differences show up in the levels of observed pressures, and show up significant differences across all of the measures in the GRR ranking of countries in how pressures respond to measures of risk sentiment.

[3]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, Felman and Shah (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.

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

B Data Sources, Definitions and Descriptive Statistics

16 Advanced economies	25 Emerging Markets
United States (US), Japan (JP), Switzerland (CH), United Kingdom (GB), Denmark (DK), Norway (NO), Sweden (SE), Canada (CA), Euro area (EA), Czech Republic (CZ), Israel (IL), South Korea (KR), Singapore (SG), Hong Kong (HK), Australia (AU), New Zealand (NZ)	South Africa (ZA), Benin (BJ), Bolivia (BO), Botswana (BW), Brazil (BR), Chile (CL), Colombia (CO), Mexico (MX), Peru (PE), Uruguay (UY), Jordan (JO), India (IN), Malaysia (MY), Thailand (TH), Morocco (MA), Tunisia (TN), Armenia (AM), Senegal (SN), Russia (RU), China (CN), Ukraine (UA), Hungary (HU), Croatia (HR), Poland (PL), Romania (RO)

Table A2: **Country Sample**

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, (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: Venezuela (lack of clarity on the relevant exchange rate measure reflecting market pressures), Turkey, Paraguay, Belarus, Dominican Republic, Indonesia, Moldova, Philippines, observations prior to 2002m1 for Morocco.

Variable	Definition	Source and Description	Missing Country-Years
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.	Jordan (2017m11- m12, 2018-2020)
FXI	Estimate or data on official foreign exchange interventions.		
	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 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.
Benin (2000-2001m11, 2017m4-2020), Senegal (2000-2001m11, 2017m4-2020)			
A_t	Gross external assets defined as the sum of portfolio equity assets, debt assets, and financial derivatives assets	In US dollars, end of period, annual from 1970 to 2020. External Wealth of Nations Database based on Lane and Milesi-Ferretti (2018).	Morocco (2000-2001)
$\frac{L_t}{e_t}$	Gross external liabilities defined as the sum of portfolio equity liabilities, debt liabilities, and financial derivatives liabilities	In US dollars, end of period, annual from 1970 to 2020. External Wealth of Nations Database based on Lane and Milesi-Ferretti (2018).	
i_{SSR}, i^*_{SSR}	Shadow policy rate in for the US, EA, JP, UK, CH, CA, AU and NZ	In percentage points, end of period, monthly. Krippner (2016).	

Table A3: **Data Sources and Definitions**

Variable	Definition	Source and Description	Missing Country-Years
α_t	Shares of residents' portfolios that residents desire to be denominated in domestic currency	Home Asset Share is calculated as the sum of domestic equities, bonds, and banking assets as a share of total equities, bonds, and banking assets. If asset class data is unavailable, the measure is calculated on the available asset data. Data sourced from the World Bank Development Indicators, IMF International Financial Statistics, and Bank for International Settlements. In US dollars, end of period, annual. Authors' calculations based on Coeurdacier and Rey (2012).	
α_t^*	Share of ROW's portfolios invested outside of a given country	α_t^* is calculated as the sum of a country's foreign equity, bond, and banking liabilities divided by the sum of all other country's equities, bonds, and banking assets. If asset class data is unavailable, the measure is calculated on the available asset data. Data sourced from the World Bank Development Indicators, IMF International Financial Statistics, and Bank for International Settlements. In US dollars, end of period, annual. Authors' calculations.	
GDP	Gross domestic product	In US dollars, quarterly. IMF International Financial Statistics.	Armenia (2000-2013), Colombia (2000m1-m2), Croatia (2000m1-m2), Senegal (2000-20008m2), Tunisia (2000m1-m2), Ukraine (2000-2001m2)
VIX	CBOE Volatility Index	End of period, monthly. Extended backwards in time by the VXO from 1986m1 to 1989m12. Chicago Board Options Exchange.	
$RORO$	Risk on risk off measure	Monthly average of daily data from 2003 to 2021. Construction code sourced from Chari, Stedman and Lundblad (2020) with own update through 2021.	
BEX RA	Risk appetite and uncertainty series, monthly, 1986 to 2021, sourced from Bekaert, Engstrom and Xu (2021).		
VSTOXX	Euro Stoxx Volatility Index	Daily data from 1999 to 2021, sourced from Qontigo.	

Table A4: **Data Sources and Definitions Continued**

(a) Safe Havens

	Mean	Max	Min	Std. Dev	Obs
EMP_{ref}	-0.000	0.089	-0.077	0.018	1199
de/e	-0.000	0.089	-0.140	0.019	1260
FXI_{USD}	1.377	103.225	-36.000	7.770	1248
di	-0.000	0.005	-0.020	0.002	1260
A, billions USD	4.437	22.048	0.157	5.293	1260
L/e, billions USD	5.324	34.852	0.204	7.917	1260
α	0.715	0.909	0.366	0.149	1260
α^*	0.961	0.999	0.777	0.057	1260
Interest Diff	-0.003	0.058	-0.069	0.025	1260
NFA/GDP_{t-1}	0.751	5.744	-0.584	1.264	1260
Infl_{t-1}	0.012	0.065	-0.050	0.016	1260
Public debt, in % of GDP_{t-1}	78.740	261.982	0.052	71.950	1198
Country $\text{GDP}_{t-1}/WorldGDP_{t-1}$	0.069	0.309	0.003	0.095	1260
Stock market capitalization, in % of GDP_{t-1}	274.976	1713.299	46.905	339.801	1260
$GFA + GFL/GDP_{t-1}$	5.209	17.715	-4.316	4.058	1260
Private domestic credit, in % of GDP_{t-1}	169.497	218.944	77.481	21.035	1260
ChinnIto	1.000	1.000	0.995	0.000	1260

(b) Non-Safe Havens

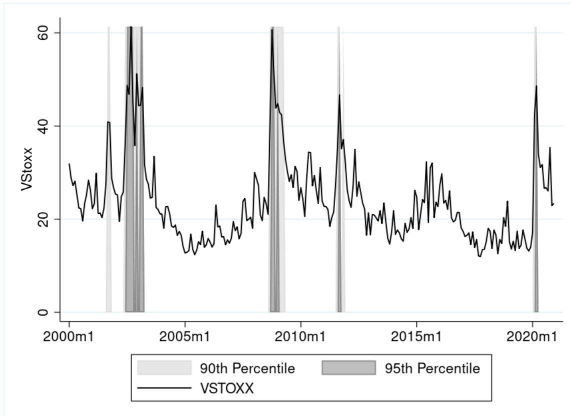
	Mean	Max	Min	Std. Dev	Obs
EMP_{ref}	-0.001	0.100	-0.079	0.026	8312
de/e	0.001	0.541	-0.169	0.027	9070
FXI_{USD}	0.437	83.865	-129.204	5.215	8950
di	-0.000	0.340	-0.388	0.013	8978
A, billions USD	0.912	22.716	0.000	2.963	9048
L/e, billions USD	1.097	26.585	0.001	3.487	9072
α	0.861	1.000	0.371	0.147	9072
α^*	0.994	1.000	0.878	0.017	9072
Interest Diff	0.043	1.184	-0.058	0.059	8979
NFA/GDP_{t-1}	0.059	4.849	-0.926	0.598	8058
Infl_{t-1}	0.038	0.589	-0.048	0.044	8820
Public debt, in % of GDP_{t-1}	48.277	158.548	3.902	23.511	8969
Country $\text{GDP}_{t-1}/WorldGDP_{t-1}$	0.010	0.168	0.000	0.020	8196
Stock market capitalization, in % of GDP_{t-1}	65.798	393.036	-0.067	59.675	8316
$GFA + GFL/GDP_{t-1}$	1.705	15.759	0.227	2.364	8058
Private domestic credit, in % of GDP_{t-1}	70.513	195.146	0.699	44.001	8773
ChinnIto	0.651	1.000	0.000	0.355	9072

Table A5: **Data Sample and Descriptive Statistics**

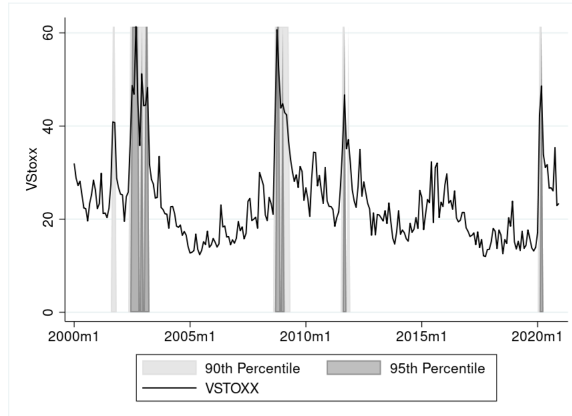
The data are in monthly frequency and span 2000m1 to 2020m12. Safe havens are assumed as United States, Japan, Switzerland, Hong Kong, and Denmark.

Home α Computations

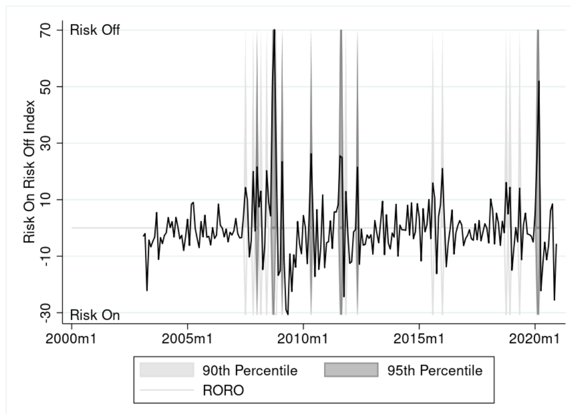
Home bias is calculated as each country's domestic assets a share of total (domestic+foreign) assets at time t. Following Coeurdacier and Rey (2012), we consider three asset categories: equity, debt, and bank loans. Domestic equity is calculated as the difference between domestic equity market capitalization and foreign equity liabilities; domestic debt is the difference between total outstanding bonds and foreign held domestic bonds; domestic banks owed by domestic counterparties sums the claims on the central banks, central governments, and other sectors.The denominator considers the total assets for each country at time t. Total debt is calculated as domestic equity market capitalization minus foreign equity liabilities plus foreign equity assets. Total debt is calculated as outstanding bonds minus foreign held domestic bonds plus domestic holdings of foreign bonds. Continually, banking assets considers the sum of domestic banking assets and foreign banking assets. Domestic equity market capitalization data is from the World Bank's World Development Indicators database and foreign equity assets and liabilities data are from the IMF's International Financial Statistics (IFS) database. All data is at the country-year level and reported in US Dollars.This update of Coeurdacier and Rey (2012) covers 36 of our 41 sample countries. Data on outstanding bonds was sourced from the BIS. Debt liabilities and debt assets were sourced from the International Monetary Fund's International Financial Statistics database. The datasets are reported at the country quarter level in millions of USD. Analysis uses aggregated country-year levels. This covers 24 of the 41 countries in the sample. For banking share, we obtain data on claims on the central bank, central government, and other sectors from the Other Depository Corporations Survey via the IMF's International Financial Statistics (IFS). We source data on foreign banking assets of domestic banks of each country from the BIS's Locational Banking Statistics (LBS) database. All data is at the country-year level. BIS data is reported in US Dollars, and IMF data is converted to US Dollars using end-of-period exchange rates. This update of Coeurdacier and Rey (2012) covers 16 of our 41 sample countries.



(a) VSTOXX



(b) BEX RA



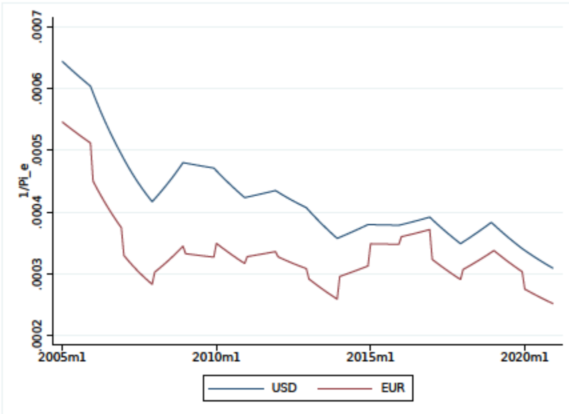
(c) RORO

Figure A1: **Alternative Risk Measures with High Stress Dates Indicated**
The Euro Stoxx 50 Volatility Index (VSTOXX) is in daily frequency and spans from 2000 to present day. End of period values were chosen to aggregate to the monthly level. BEX RA, a risk aversion index from Bekaert et al. (2021), is monthly frequency and spans 1986 to 2021. RORO, our extended version of data from Chari et al. (2020), is initially computed at daily frequency, summed within a month, and spans 2003 to 2021. Highlighted periods represent intervals where the risk measure is at or above the 90th percentile.

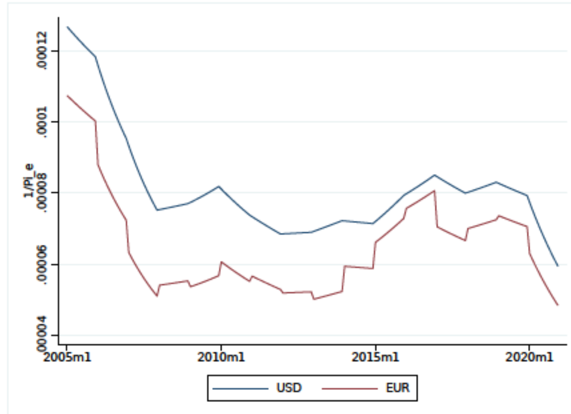
	$P_i^{90} > X_{it}$	$P_i^{90} \leq X_{it} < P_i^{95}$	$P_i^{95} \leq X_{it}$
2001m9		BEX RA, VIX, VSTOXX	
2001m10		BEX RA, VIX, VSTOXX	
2002m6	BEX RA, RORO, VIX	VSTOXX	
2002m7	BEX RA, RORO	VIX	VSTOXX
2002m8		BEX RA, VIX	VSTOXX
2002m9			BEX RA, VIX, VSTOXX
2002m10		BEX RA	VIX, VSTOXX
2002m11	BEX RA, RORO, VIX	VSTOXX	
2002m12	RORO, VIX	BEX RA	VSTOXX
2003m1	RORO, VIX	BEX RA, VSTOXX	
2003m2	RORO	BEX RA, VIX	VSTOXX
2003m3	BEX RA, RORO	VIX	VSTOXX
2007m7	BEX RA, VIX, VSTOXX	RORO	
2007m11	BEX RA, VIX, VSTOXX	RORO	
2008m1	BEX RA, VIX, VSTOXX		RORO
2008m3	BEX RA, VIX, VSTOXX	RORO	
2008m6	BEX RA, VIX, VSTOXX	RORO	
2008m9	VIX	VSTOXX	BEX RA, RORO
2008m10			BEX RA, RORO, VIX, VSTOXX
2008m11		RORO	BEX RA, VIX, VSTOXX
2008m12	RORO	VSTOXX	BEX RA, VIX
2009m1	RORO		BEX RA, VIX, VSTOXX
2009m2		VSTOXX	BEX RA, RORO, VIX
2009m3	RORO	VSTOXX	BEX RA, VIX
2009m4	RORO	VSTOXX	BEX RA, VIX
2009m5	RORO, VSTOXX	BEX RA, VIX	
2009m6	RORO, VIX, VSTOXX	BEX RA	
2009m10	RORO, VIX, VSTOXX	BEX RA	
2010m5	BEX RA, VSTOXX	VIX	RORO
2010m6	RORO, VIX, VSTOXX	BEX RA	
2011m8	BEX RA	VIX, VSTOXX	RORO
2011m9			BEX RA, RORO, VIX, VSTOXX
2011m10	BEX RA, RORO, VSTOXX	VIX	
2011m11	BEX RA	RORO, VIX, VSTOXX	
2012m5	BEX RA, VIX, VSTOXX		RORO
2015m8	BEX RA, VIX, VSTOXX	RORO	
2016m1	BEX RA, VIX, VSTOXX	RORO	
2018m10	BEX RA, VIX, VSTOXX	RORO	
2018m12	BEX RA, VIX, VSTOXX	RORO	
2019m5	BEX RA, VIX, VSTOXX	RORO	
2020m2	VIX	VSTOXX	BEX RA, RORO
2020m3			BEX RA, RORO, VIX, VSTOXX
2020m4	RORO, VSTOXX	BEX RA	VIX
2020m5	BEX RA, RORO, VSTOXX	VIX	
2020m6	BEX RA, RORO, VSTOXX	VIX	
2020m10	RORO, VIX, VSTOXX	BEX RA	

Table A6: **Comparison of High Stress Dates Using Alternative Risk Measures**
Event dates are determined as months within 01/2000 to 12/2020 that are at or above the 90^{th} percentile value for each of the alternative risk measures. X_{it} denotes a risk measure value, X, for a given risk measure i, in time t. P_i^{90} and P_i^{95} correspond to the 90^{th} and 95^{th} monthly risk values for a given risk measure i.

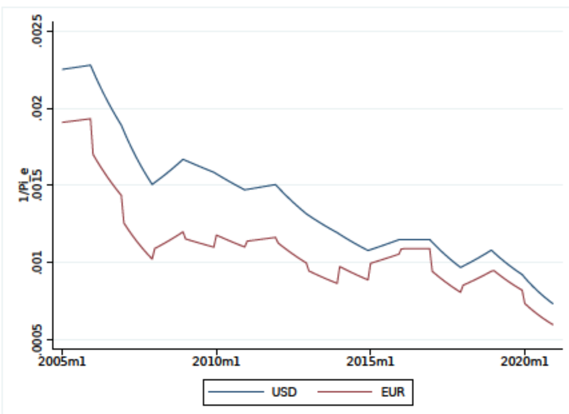
C Additional Results and Robustness



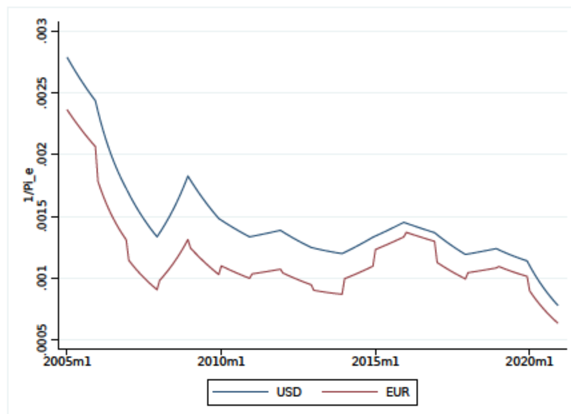
(a) Switzerland



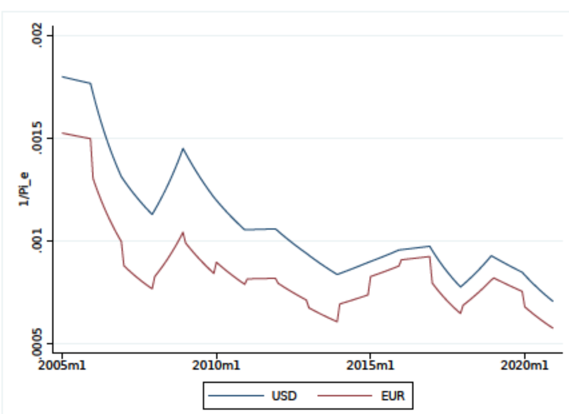
(b) United Kingdom



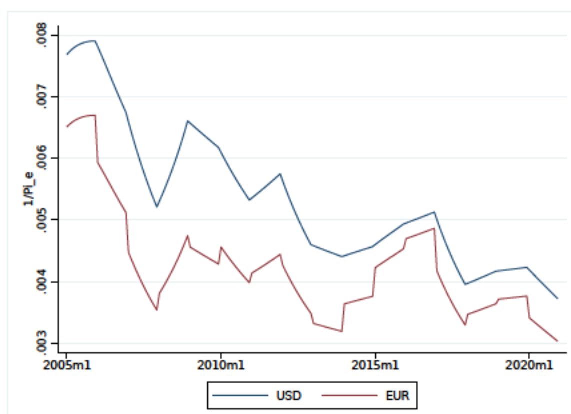
(c) Denmark



(d) Norway



(e) Sweden

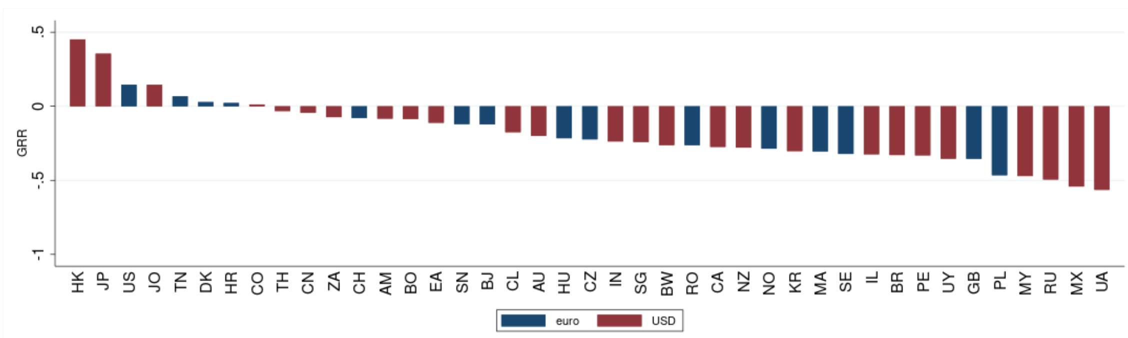


(f) Poland

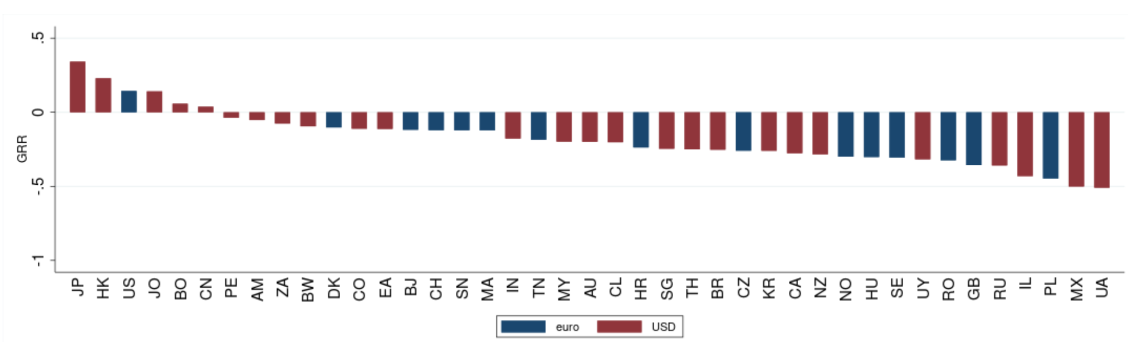
Figure A2: $\frac{1}{\pi_e}$ **Comparison using U.S. Dollar vs Euro Reference Currency**
Efficacy of foreign exchange intervention against the U.S. Dollar and Euro over time for select countries.

	Rank correlations by de/e share	Share of countries by de/e share of total EMP variance		
		<10 percent	$[10;90]$ percent	>90 percent
Normal periods	–	7	51	41
High stress periods	0.80	5	44	51
GFC	0.67	0	44	56
Pandemic	0.59	7	34	59

Table A7: **EMP Decomposition and Shares of Financial Exchange Rate Component**
Spearman rank correlations of countries by de/e share of total EMP variance across normal periods and high stress periods, also the cases of the Global Financial Crisis (GFC) and the covid-19 pandemic. Further, the table contains information on the country distribution by de/e share of total EMP variance.

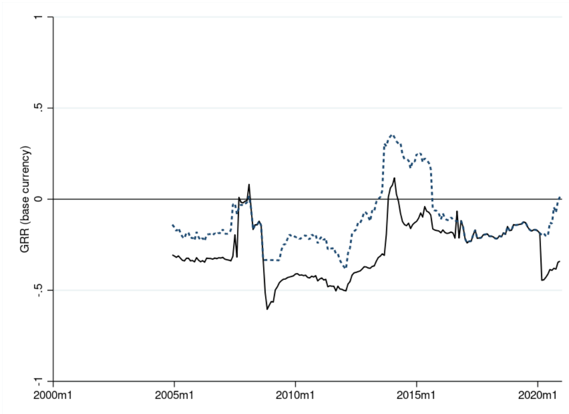


(a) Construction based on EMP – Financial Exchange Rate

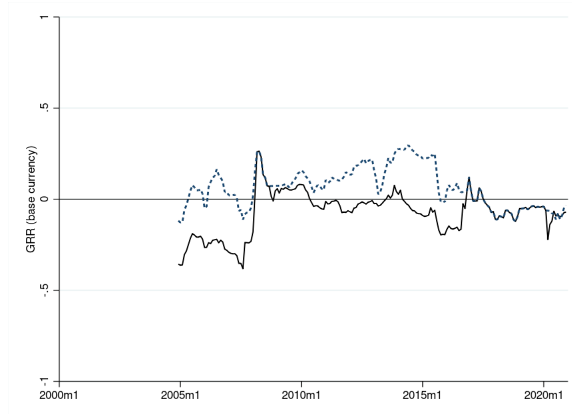


(b) Construction based on de/e – Financial Exchange Rate

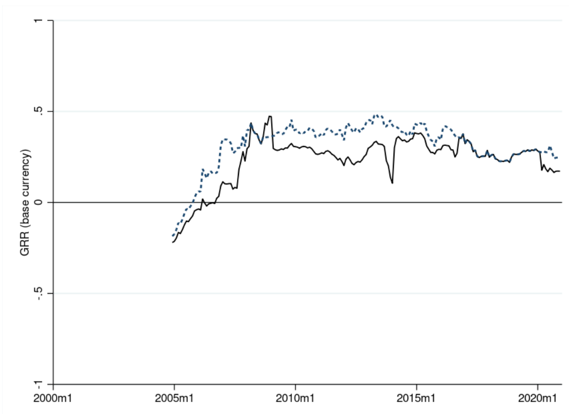
Figure A3: **Country Ranking by GRR with Financial Exchange Rate**
Panels (a) and (b) shows the GRR based on changes in a country's EMP based on a financial exchange rate using data from July 2009 through June 2013.



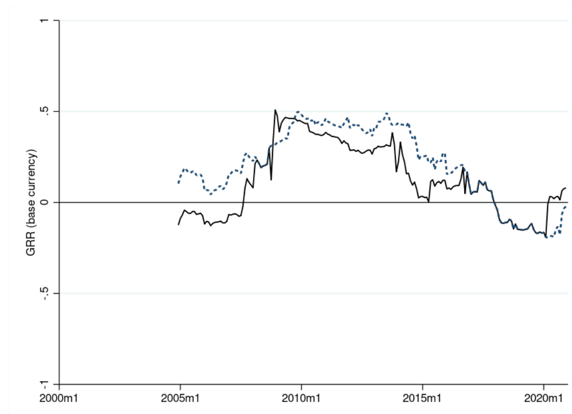
(a) Brazil



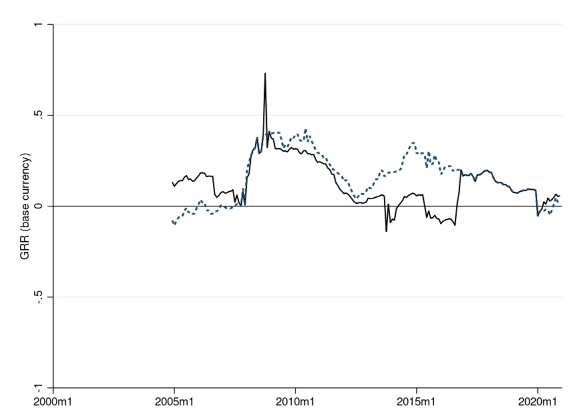
(b) Thailand



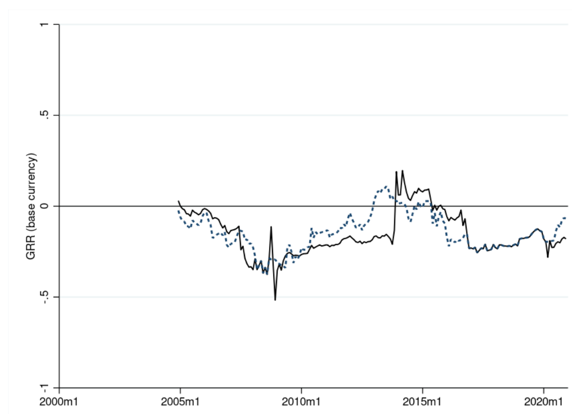
(c) Japan



(d) Hong Kong



(e) Switzerland



(f) United Kingdom

Figure A4: **Global Risk Response: All Months and Excluding High Stress Dates**
GRR based on the EMP against the US dollar in panels (a) through (d) and against the Euro in panels (e) through (f) over 5 years of monthly data. The solid line displays the GRR calculated using all observations from 2000 to 2020. The dashed line displays the GRR calculated excluding observations at or above the 90th percentile of the VIX over 01/2000 to 12/2020.

(a) VSTOXX

Full Sample	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.128***	0.160***	-0.167***
GRR- Excluding P90	-0.006***	0.170***	-0.031***
Difference	-0.121***	-0.011	-0.137***

Pre-GFC	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.090***	0.116***	-0.119***
GRR- Excluding P90	0.006	0.114***	-0.009**
Difference	-0.097***	0.002	-0.110***

Post-GFC	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.103***	0.098***	-0.131***
GRR- Excluding P90	-0.046***	0.113***	-0.068***
Difference	-0.057***	-0.015	-0.063***

(d) BEX

Full Sample	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.140***	0.114***	-0.176***
GRR- Excluding P90	-0.029***	0.134***	-0.051***
Difference	-0.112***	-0.020***	-0.124***

Pre-GFC	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.097***	0.103***	-0.125***
GRR- Excluding P90	-0.029***	0.086***	-0.045***
Difference	-0.068***	0.017	-0.080***

Post-GFC	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.125***	0.066***	-0.151***
GRR- Excluding P90	-0.062***	0.072***	-0.081***
Difference	-0.063***	-0.006	-0.070***

(g) RORO

Full Sample	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.232***	0.102***	-0.279***
GRR- Excluding P90	-0.162***	0.045***	-0.191***
Difference	-0.071***	0.057***	-0.088***

Pre-GFC	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.104***	0.164***	-0.141***
GRR- Excluding P90	-0.083***	0.106***	-0.109***
Difference	-0.021***	0.058***	-0.032***

Post-GFC	All	Safe Haven	Excl. Safe Haven
GRR- AllPeriods	-0.269***	0.023	-0.310***
GRR- Excluding P90	-0.218***	0.072***	-0.258***
Difference	-0.052***	-0.049**	-0.052***

Table A8: **GRR Difference in Means Tests for GRR with Alternative Risk Indices**

GRR is computed as -1 times the rolling correlation over 5 years between EMP against reference currency and the alternative risk measure. In the excluding P90 analysis, the rolling correlation is calculated excluding months, between 01/2000 to 12/2020, that are at or above the 90th percentile value of the alternative risk measure. Safe haven currencies are the DKK, HKD, JPY, CHF, and USD. Significance in the first two rows indicate whether the average is different from 0. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels.