Global uncertainty shocks and external monetary vulnerability. What determines cross-country heterogeneity?

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Abstract

The paper empirically investigates cross-country heterogeneity in vulnerability to global uncertainty shocks. Based on vector autoregressions, we create an index of external monetary vulnerability for 36 countries using estimated impulse responses of interest rate differentials, exchange rates, and foreign exchange reserves. Four main determinants of a country's score in the external vulnerability index are investigated: dominance in the international monetary and financial system, exposure to fickle capital flows, volatile macrofinancial histories, and macroeconomic fundamentals. Our results suggest that history and exposure matter most for a country's external vulnerability. In particular, frequent currency and sovereign default crises, and exposure to non-bank foreign investors and portfolio debt increase the sensitivity to a global uncertainty shock. By contrast, macroeconomic fundamentals such as public debt appear less relevant.

Keywords: international financial system, gross capital flows, exchange rates, foreign exchange intervention, global uncertainty shocks, emerging markets

JEL codes: E44, F31, F32, G15

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1 Introduction

The asymmetric nature of the international monetary and financial system and its consequences for macroeconomic dynamics is a long-standing theme in international finance. Especially the role of the US dollar as the dominant international currency and its associated 'exorbitant privilege' has been studied extensively (Eichengreen et al. 2018, Eichengreen 2012, Farhi & Maggiori 2017, Gopinath & Stein 2020, Gourinchas et al. 2019, Maggiori et al. 2019). Recent work suggests that international currencies offer investors a non-pecuniary 'liquidity yield' or 'safety premium' reflected in lower borrowing costs (Engel 2016, Engel & Wu 2018, Farhi & Maggiori 2017, Gopinath & Stein 2020). Episodes of increased global financial uncertainty lead to an increase in the liquidity yield on international currency assets, resulting in a flight-to-quality phenomenon that comes with an appreciation of those currencies. By contrast, non-dominant currencies must offer a higher expected rate of return on their assets, reflected in depreciations of the spot exchange rate and rising interest rate differentials – a monetary response that has been documented to be particularly severe in emerging market economies (Bhattarai et al. 2020, Choi 2018, Fink & Schüler 2015). Recent theoretical and empirical work suggests that the effects of such adverse shocks on exchange rates and interest rates may successfully be mitigated through sterilised foreign exchange intervention (Alla et al. 2019, Blanchard et al. 2015, Frankel 2019, Ghosh et al. 2016), but only at a loss in foreign exchange reserves.

An aspect that has been explored less is how those effects differ across countries. How heterogeneous are countries in their monetary response to uncertainty shocks? And what factors determine this heterogeneity? The present paper addresses these questions with a two-step empirical strategy.[1] First, we quantify the monetary effects of a global financial uncertainty shock proxied by the US stock market volatility index VIX on a set of 36 countries with independent currencies and floating exchange rates, comprising both advanced (AEs) and emerging market economies (EMEs). From country-wise vector autoregressions (VARs) with quarterly data with a maximum span from 1990Q1 to 2019Q4, we estimate the response of the US dollar exchange rate, the interest rate differential, and the change in foreign reserves, controlling for gross capital flows as key transmitters of the shock. Based on the cumulative impulse responses, we construct an *external monetary vulnerability index* that measures the severity in the depreciation of exchange rates, the rise in the interest rate differential, and the loss in foreign reserves, allowing for a cross-country

[1] A two-step approach to investigate cross-country heterogeneity has also been applied, e.g., in Cerutti et al. (2019) and Aizenman et al. (2016), but with different research questions.

comparison of degrees of vulnerability.

In a second step, we explore in multivariate regressions potential determinants of the observed cross-country heterogeneity. Drawing on various branches of literature, we identify three main types of structural factors that shape vulnerability to global uncertainty shocks: (i) the degree of dominance in the international monetary and financial system, which may give rise to safe-asset status that reduces monetary vulnerability to adverse shocks (Eichengreen et al. 2018, Farhi & Maggiori 2017, Gopinath & Stein 2020, Gourinchas et al. 2019, Maggiori et al. 2019); (ii) exposure to fickle capital flows and currency mismatches, as non-bank financial investors might be more sensitive to global factors (Cerutti et al. 2019, Puy 2016, Raddatz & Schmukler 2012) and as foreign-currency debt can increase volatility (Eichengreen et al. 2007); and (iii) volatile macrofinancial histories such as currency crises and sovereign default, which may influence historically entrenched risk perceptions of investors (Burger & Warnock 2006). We compare those structural factors with standard macroeconomic fundamentals such as GDP per capita, the stock of foreign reserves, public debt ratios, and the monetary policy regime. Besides various robustness tests, we also perform a cluster analysis to gain further insights into the empirical incidence of those structural determinant across different groups of countries and how this maps into differences in external monetary vulnerability.

Our analysis contributes to a growing literature on the domestic effects of global financial shocks in four ways (Aizenman et al. 2016, Akıncı 2013, Bhattarai et al. 2020, Bonciani & Ricci 2020, Carrière-Swallow & Céspedes 2013, Choi 2018, Fink & Schüler 2015, Kalemli-Özcan 2019, Miranda-Agrippino & Rey 2020, Li et al. 2019, Obstfeld et al. 2019). First, while many studies focus on the response of indicators related to domestic real and financial activity (Choi 2018, Bonciani & Ricci 2020, Fink & Schüler 2015, Obstfeld et al. 2019), we are specifically concerned with the monetary response represented by the US dollar exchange rate and the interest rate differential, in line with the aforementioned theoretical literature. Second, existing research has not accounted for sterilised foreign exchange intervention that may mitigate the effect on exchange rates and short-term interest rates as discussed in recent theoretical work (Alla et al. 2019, Benes et al. 2015, Cavallino 2019, Gabaix & Maggiori 2015, Ghosh et al. 2016). Third, while a few studies have shown that cross-country heterogeneity in the macroeconomic response to uncertainty shocks is related to institutional quality (Choi 2018, Bonciani & Ricci 2020), the exchange rate regime (Obstfeld et al. 2019), different monetary policy strategies (Bhattarai et al. 2020), and trade and financial openness (Bonciani & Ricci 2020), we account for structural factors related to countries' relevance in the international monetary and financial system, exposure to capital flows, and macrofinancial histories that have hitherto received less attention. Fourth, many studies specifically focus on EMEs (Bhattarai et al. 2020, Choi 2018, Fink & Schüler 2015, Obstfeld et al. 2019), whereas we considers both EMEs and AEs.

Our main findings are as follows. First, we document substantial cross-country heterogeneity in the response to global uncertainty shocks. EMEs like Brazil, Russia, and Argentina exhibit the strongest external monetary vulnerability. At the opposite end of the spectrum are AEs such as Switzerland, Japan, and Germany that gain foreign reserves, undergo currency appreciation, or display little sensitivity to the shock at all. Perhaps more surprisingly, some EMEs such as Thailand and the Philippines also exhibit relatively low degrees of external vulnerability, whereas for example New Zealand and Norway display above-average vulnerability. This suggests that the common finding that EMEs are more strongly affected by global uncertainty shocks (Bonciani & Ricci 2020, Carrière-Swallow & Céspedes 2013) only holds as a rough approximation for external monetary vulnerability. Second, we find that whereas macrofinancial history, exposure to capital flows, and dominance in the international monetary and financial system all matter for the degree of external vulnerability, history and exposure exhibit the greatest explanatory power and are robust throughout various specifications. Monetary dominance is also relevant, but has lower explanatory power and is slightly less robust. By contrast, macroeconomic fundamentals appear less relevant for a country's vulnerability in flight-to-quality episodes. Third, we identify four country groups: two extremes that perform well (poorly) across all three structural determinants, which maps into low (high) external vulnerability, and two intermediate groups of countries that exhibit a medium sensitivity to external shocks despite rather different structural characteristics. One group of mostly AEs is relatively dominant but exposed, whereas another group of EMEs is not strongly exposed but also not dominant. This suggests that monetary dominance and exposure offset each other to some degree in their effect on external monetary vulnerability.

The remainder of the paper is structured as follows. The next section reviews the related literature that informs our choice of structural determinants of monetary vulnerability. Section 3 discusses the empirical strategy and data. Section 4 presents the empirical results: estimated degrees of external vulnerability, their determinants, and the clustering of determinants across country groups. The last section concludes and discusses implications of our findings.

2 Global uncertainty shocks and monetary vulnerability: theory and existing evidence

The strand of theoretical literature that is most closely related to our empirical analysis studies domestic effects of adverse global financial shocks in an environment of imperfect financial markets (Alla et al. 2019, Cavallino 2019, Farhi & Werning 2014, Gabaix & Maggiori 2015). In these models, uncovered interest rate parity (UIP) does not hold as there is imperfect substitutability across internationally traded financial assets, which is reflected in risk premia. A representative (log-linearised) version of such a risk-adjusted UIP condition can be written as

$$(\mathbb{E}[s_{t+1}] - s_t) - (i_t - i_t^*) + \phi_t + \beta\theta_t = 0, \tag{1}$$

where $s_t, i_t, i_t^*, \phi_t, \theta_t, \beta$ are the spot exchange rate (domestic currency units per foreign currency unit), the domestic and foreign interest rate, an endogenous and exogenous component of the risk premium, and the sensitivity to the exogenous shock. An increase in the exogenous risk premium θ_t, e.g. due to a global uncertainty shock, lowers foreigners' appetite for home assets, which must be offset by a depreciation of the spot exchange rate (an increase in s_t), a rise in the interest rate differential, a reduction in the endogenous component of the risk premium ϕ_t, or a combination of those responses. A closely related strand of literature has argued that this deviation from UIP may be related to a non-monetary 'liquidity yield' or 'safety premium' on international safe assets (Engel 2016, Engel & Wu 2018, Farhi & Maggiori 2017, Gopinath & Stein 2020). A global uncertainty shock may then increases the safety premium on internationally dominant currencies.

The risk-adjusted UIP condition is often integrated into small-open economy models to study the effectiveness of capital controls or sterilised foreign exchange intervention (FXI) in reducing macroeconomic volatility. In these models, FXI operates through a portfolio balance channel as it changes the asset composition of the private sector, which in turn manipulates the endogenous component of the risk premium on domestic assets. The central bank can thus mitigate some of the effects of the global uncertainty shock, leading to a smaller depreciation of the domestic currency and a lower increase in the domestic interest rate at the expense of a loss in foreign reserves. A theoretical implication of this approach that has been less explored is that the intensity of the response to external shocks, represented by the parameter β, may differ across countries based on certain country-characteristics.[2]

A more empirically-oriented literature studies domestic macroeconomic effects of global uncertainty shocks and financial distress (Bhattarai et al. 2020, Carrière-Swallow & Céspedes 2013, Choi 2018, Fink & Schüler 2015, Li et al. 2019, Obstfeld et al. 2019). This research has shown that shocks to the US stock market volatility index VIX or US systemic financial stress indicators have considerable contractionary real effects abroad, especially in EMEs. With respect to financial effects, Bhattarai et al. (2020) document for a sample of 15 EMEs capital flow reversals, currency depreciation, and higher borrowing cost, consistent with the above theoretical framework. They find a more procyclical monetary policy response for a group of Asian EMEs (plus Russia and Turkey) compared to a group of Latin American EMEs, which they relate to greater monetary policy concerns over capital flow volatility. Choi (2018) finds that the rise in interest rate differentials is attenuated by institutional quality such as the strength of legal rights and efficiency of debt enforcement. Obstfeld et al. (2019) document that countries with fixed exchange rate regimes undergo a stronger contraction in domestic credit growth. Recently, Bonciani & Ricci (2020) used interaction terms in a local projection framework to study the effects of shocks to a global factor in the realised volatility in risky asset prices. They document cross-country heterogeneity that is related to external debt and financial risk ratings. Unlike these studies, we specifically focus on the response of exchange rates and interest rates while allowing for FXI, and consider both AEs and EMEs with floating exchange rates. Furthermore, we consider structural determinants of heterogeneity related to the international monetary system, exposure to capital flows, and macrofinancial history that have not been investigated before.

The theoretical foundations for the structural determinants we consider stem from a strand of literature that discusses countries' positions in the international monetary and financial system. One branch of this literature focuses on international currencies that are used as foreign exchange reserves, units of account in international debt contracts, and international means of exchange (e.g. to invoice trade) (Chinn & Frankel 2008, Eichengreen et al. 2018, Eichengreen 2012, Farhi & Maggiori 2017, Gopinath & Stein 2020, Gourinchas et al. 2019, Maggiori et al. 2019). International currency status is associated with the 'exorbitant privilege' of a weaker external constraint, reflected in low external borrowing cost and excess returns on external assets. In periods of international financial stress, the demand for

[2] In Alla et al. (2019), β is equal to unity, whereas in Cavallino (2019) and Gabaix & Maggiori (2015), it depends on exchange rate volatility and foreign investors' sensitivity to it. Farhi & Werning (2014) more generally discuss investors' preferences for a particular country's assets.

internationally liquid safe assets increases, resulting in currency appreciation and reduced yields (Engel 2016, Engel & Wu 2018). While the focus has long been on the US dollar as the dominant international currency, the rise of the euro and the Chinese yuan demonstrate that international currency status need not be confined to a single currency (Chinn & Frankel 2008, Eichengreen et al. 2018, Eichengreen & Lombardi 2017). Preconditions for international currency (or safe asset) status are financial openness and size (Chinn & Frankel 2008): to be internationally liquid, a currency issuer must be able to absorb foreign assets in exchange for domestic assets. Other factors are attractiveness for investors through stability in value and the ability to service their debt, as reflected in macroeconomic fundamentals such as fiscal surpluses and low public debt ratios (He et al. 2019).

A further branch of literature examines currencies that do not have international or safe asset status. For these currency issuers, flight-to-quality episodes typically come with currency depreciation and rising borrowing cost. Cerutti et al. (2019) document that the sensitivity of individual countries to a common global factor in bond and equity portfolio flows is largely determined by exposure to global mutual funds. Several studies show that mutual funds are more sensitive in their international portfolio allocation to global financial shocks than other financial investors (Puy 2016, Raddatz & Schmukler 2012). An earlier literature explores the causes and consequences of not being able to borrow abroad in home currency, the so-called 'original sin' (Eichengreen et al. 2007). Original sin is associated with increased macroeconomic vulnerability to external shocks and especially prevalent in EMEs, but has become somewhat less acute for many public borrowers over the last two decades. Burger & Warnock (2006) argue that countries with better historical inflation performance and stronger legal institutions exhibit more developed local bond markets. This suggests that solid fundamentals and stable macrofinancial histories may influence the sensitivity of countries to global financial shocks.

In sum, on the one hand, the literature on global uncertainty shocks documents a flight-to-quality phenomenon in response to global financial distress that is consistent with recent theoretical work on UIP deviations due to financial market imperfections. On the other hand, the literature on the international monetary and financial system and exposure of countries to capital flows implies that uncertainty shocks can be expected to have uneven impacts across countries. The more dominant a currency's role in the international monetary system, the less likely it is to undergo currency depreciation, interest rate increases, and losses in FX reserves. By the same token, currencies with more volatile macrofinancial histories that do not enjoy international currency status, are exposed to risk-sensitive foreign investors, and suffer from original sin are expected to exhibit a more adverse response to financial stress. Our analysis ties these two strands together by providing a systematic analysis of cross-country heterogeneity in response to uncertainty shocks and its structural sources.

3 Empirical strategy and dataset

3.1 Estimation approach

In the first step of our two-step empirical strategy, we run country-wise vector autoregressions (VARs) that estimate the response of domestic macro-financial variables to a global financial shock. The structural VAR(p) takes the form:

$$A_0 y_t = \nu + \sum_{j=1}^{p} A_j y_{t-j} + \epsilon_t, \tag{2}$$

where y_t is a vector of m variables, ν is a vector of intercepts, p is the lag order, A_0 and A_j are $m \times m$ parameter matrices, and ϵ_t is a vector of error terms. In the following, the vector y_t will firstly include a proxy for the global financial shock x_t, and then a set of endogenous domestic financial variables $y_{1t}, y_{2t}, ..., y_{m-1t}$. In line with the theoretical literature discussed above, the response variables, which will be discussed in more detail below, are the exchange rate (*XR*), the interest rate (*INTR*), and the change in foreign exchange reserves (*FXI*). In addition, we control for gross capital inflows (*GKI*) and outflows (*GKO*) as key transmitters of the shock. With this set of variables, the vector y_t is given by $y_t = [x_t, XR_t, INTR_t, FXI_t, GKI_t, GKO_t]'$.

The estimated reduced-form version of the VAR(p) in (2), written in VAR(1) form, is given by $y_t = \mu + B y_{t-1} + u_t$, where B is the $pm \times pm$ companion matrix. To obtain structural impulse response functions (*IRFs*), we rely on the common identification assumption that the global financial shock does not contemporaneously respond to any of the domestic variables in the VAR and thus order x_t first.[3] As in Schmitt-Grohé & Uribe (2018), we additionally require the specification of the first equation for the global financial shock x_t to be identical across countries to enable a cross-country comparison. To achieve this, we first estimate a univariate autoregressive model for x_t and use the Akaike information

[3]This implies that A_0^{-1} has a lower-triangular structure. A_0^{-1} can than be retrieved through the Cholesky decomposition P of the variance-covariance matrix Σ_u of the reduced-form VAR, $\Sigma_u = PP'$, such that $P = A_0^{-1}$ (Lütkepohl 2005, chap.2). Note that the ordering of the remaining variables is irrelevant for the identification of the structural shock of the first variable (x_t).

criterion (AIC) to determine the optimal lag length q. Prior to estimation, we then impose restrictions on the reduced-form coefficient matrix B, such that $b_{1,q+1}, ..., b_{1,pm} = 0$, where $b_{1,s}$ are the coefficients of the first row of B. This ensures that the first equation in the VAR is a univariate autoregressive process of order q for all countries. We will examine the robustness of our results to this additional restriction. Finally, note that in line with common practice (e.g. Bhattarai et al. 2020, Cesa-Bianchi et al. 2018), all variables are included in (log-)levels without prior filtering since the slope coefficients on unit root variables can be re-written as coefficients on differenced (and thus stationary) variables (Sims et al. 1990). We use the AIC to determine the lag length p of each country-specific VAR (allowing for a maximum lag length of four). Based on our identification strategy, we obtain impulse responses of all domestic variables in the VAR to a global financial shock.

To construct an empirical estimate of the degree of external monetary vulnerability, we use the cumulative impulse responses in the fourth quarter of *INTR*, *XR*, and the negative of *FXI*, defined as $CIRF_4^k = \sum_{i=0}^{4} IRF_i^k$, where $k = INTR, XR, -FXI$. The negative of *FXI* measures losses in foreign reserves; thereby all three measures can be interpreted as indicators of vulnerability to a global financial shock. To combine them into a single measure, we construct what we call the *external monetary vulnerability index* (*VULNEX*): the weighted mean over the three cumulative responses in the fourth quarter, where the weights are given by the inverse of the average over country-wise standard deviations (*SD*) of *INTR*, *XR*, and *FXI*:

$$VULNEX = \frac{1}{\sum w_k} \left(\sum_k w_k CIRF_4^k \right), \tag{3}$$

and $w_k = 1/\overline{SD_k}$. This measure assigns larger weights to the responses of those variables with smaller variation. We assess the robustness of our main results to two alternative versions of the *VULNEX*: to account for estimation uncertainty, we construct an index where the weights are given by the inverse of the standard error of the cumulative IRF in the fourth quarter, and we also consider a simple version based on an unweighted average.[4]

In a second step, we explore the correlates of this measure through multivariate cross-country regressions. Based on our discussion in section 2, we consider four groups of possible determinants of external vulnerability: three structural determinants related to monetary dominance, exposure, and macrofinancial history, as well as macroeconomic

[4]We further experimented with weights based on principal component analysis and on interquartile ranges instead of standard deviations, and the results were very similar.

fundamentals. We will both use principal component analysis to parsimoniously combine information embodied in different proxies (discussed in more detail below) and also explore the performance of individual proxies.

3.2 Empirical indicators and dataset

To proxy the global financial shock, we follow a large literature and use the log of the Chicago Board Options Exchange Market Volatility index (*VIX*) (Alla et al. 2019, Bruno & Shin 2015, Bhattarai et al. 2020, Carrière-Swallow & Céspedes 2013, Choi 2018, Obstfeld et al. 2019, Rey 2015). Alternative financial shock indicators will be explored in robustness tests. Our measure for the exchange rate is the (logged) bilateral nominal exchange rate with the US dollar (*XR*).[5] We consider both short- and long-term nominal interest rates. The policy or short-term interest rate (*INTR_ST*) is used in the baseline estimation, but we also check whether results differ with the long-term interest rate on (typically 10-year) government bonds (*INTR_LT*). Both variables are constructed as the differential with respect to the corresponding US interest rate. The change in foreign exchange reserves captures foreign exchange intervention by central banks (*FXI*). Following Blanchard et al. (2015), we construct it as the change in reserve assets plus changes in the central bank off-balance sheet foreign-exchange position, which measures intervention through derivative operations. The measure is normalised by lagged (and seasonally adjusted) nominal GDP. As short-term capital flows are expected to transmit the effect of global financial shocks on domestic financial variables, we additionally include the sum of portfolio and other investment gross in- and outflows (*GKI* and *GKO*), also normalised by lagged GDP.

To construct the dataset for the VAR estimations, data from multiple sources were pooled to maximise the time span for each country. In some cases, overlapping interest rates series of different length were spliced by extrapolating newer series backwards with the growth rate of older series to obtain the maximum possible number of observations.[6] The maximum span ranges from 1990Q1 to 2019Q4. The dataset covers 37 economies, out of which 24 are commonly regarded as EMEs and 13 as AEs.[7] Excluded were the USA as the issuer of

[5] An increase in *XR* thus represents a depreciation of the domestic currency vis-á-vis the US dollar. Effective exchange rates, which are trade-weighted exchange rates with respect to a basket of currencies, would be an alternative, but these series typically have a shorter time span. Given the dominant role of the US dollar in trade invoicing, international credit contracts, and foreign exchange reserves (Gopinath & Stein 2020, Maggiori et al. 2019), the US dollar exchange rate is the most important exchange rate for the countries in our sample.

[6] See Appendix A for details.

[7] EMEs: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Georgia, Guatemala, Hungary,

the dominant international currency and the source of the global financial shock, countries without an independent currency, and countries with pegged exchange rates as documented in the comprehensive regime classification in Ilzetzki et al. (2019). We include the Euro Area as a whole, as well as its three largest economies: France, Germany, and Italy.[8] Given these restrictions, country choice was mostly governed by data availability. As in Blanchard et al. (2015), we restrict the sample start in a few cases to exclude major crises events that led to changes in the exchange rate regime (see Appendix A). We further drop countries for which there are less than 30 degrees of freedom in the VAR.[9] On average, the country-wise VARs have 73 degrees of freedom.

For the second step of our analysis, we compile a cross-country dataset of structural determinants of external vulnerability. For the majority of indicators, we use the median value of annual data over the period 2006-2019 (unless stated otherwise).[10] For the degree of dominance in the international monetary and financial system (Eichengreen 2012, Farhi & Maggiori 2017, Gourinchas et al. 2019, Maggiori et al. 2019), we consider (i) the share of the domestic currency in global foreign exchange market turnover ($FXTURN$), (ii) the gross foreign asset position (excluding foreign exchange reserves) as a ratio to GDP ($FORASSET$) as a proxy for size (Chinn & Frankel 2008), from the database compiled by Lane & Milesi-Ferretti (2018),[11] and (iii) financial openness as pre-condition for monetary dominance (Chinn & Frankel 2008), utilising the financial account openness index ($FINOPEN$) constructed by Chinn & Ito (2006).[12]

Second, several measures are used to assess the exposure to fickle capital flows and currency mismatches. To account for different types of external creditors that may differ in their sensitivity to global financial shocks (Cerutti et al. 2019, Puy 2016, Raddatz & Schmukler

India, Indonesia, Israel, Korea, Mexico, Paraguay, Peru, Philippines, Poland, Romania, Russia, Singapore, South Africa, Thailand, Turkey.
AEs: Australia, Canada, Euro Area, France, Germany, Iceland, Italy, Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom.

[8]We refrain from including further Euro Area countries as their policy rate and exchange rate are identical, so that the results can be expected to be similar.

[9]In the baseline VAR with $INTR\_ST$, Georgia was therefore excluded as it had less than 30 degrees of freedom, leaving 36 countries.

[10]The starting date for the median values is set in correspondence with the latest country-specific sample start of the VARs (2006 for China). While the estimation sample for most countries reaches back well beyond 2006, a common cut-off was implemented to ensure the determinants are comparable across countries. See Appendix A for data definitions and sources.

[11]We will compare this to the *net* foreign asset position (NFA), which is less informative about size.

[12]We also tried the index constructed by Fernández et al. (2016), which is highly correlated with the one by Chinn & Ito (2006) and made little difference to our results.

2012), we consider the share of government debt held by foreign private investors, drawing on the updated database compiled by Arslanalp & Tsuda (2014*a*,*b*). We use a breakdown into bank (*BANKINV*) and non-bank foreign investors (*NONBANKINV*), but our main focus is on non-bank foreign investors as these have been found to be more sensitive to global financial shocks (Cerutti et al. 2019, Puy 2016, Raddatz & Schmukler 2012). In addition, the ratio of net portfolio external debt relative to foreign exchange turnover was used to proxy exposure to short-term external liabilities that are expected to be more responsive to shocks (*PORTFDEBT*). Finally, to account for exposure to currency mismatches as a source of volatility (Eichengreen et al. 2007), we use the share of external liabilities that are denominated in foreign currency (*FCLIAB*) from Bénétrix et al. (2019).

Third, we use a set of measures for volatile macrofinancial histories that may impact the liquidity and risk perceptions of international investors (Burger & Warnock 2006). Drawing on the historical work on financial crises by Reinhart & Rogoff (2011), we consider currency crises (*CURCRIS*) and sovereign defaults (*SOVDEF*) (external and domestic), and will also explore inflation crises (*INFLCRIS*) for comparison.[13] We use the annual frequency of these events between 1800 and 1989, i.e. before the sample start of our VAR estimations.[14] This rules out trivial contemporaneous correlation between these measures and the *VULNEX*. As an alternative measure for exchange rate risk, we also consider the volatility of the nominal US dollar exchange rate between the end of the Bretton Woods system and the sample start of the VAR (1974Q1-1989Q4), which we construct as the coefficient of variation over this period (*XRVOL*).

Finally, we consider a number of macroeconomic fundamentals. The gross national income per capita in US dollars (*GNI_PC*) captures economic development, which is correlated with economic and political stability, as well as institutional quality. In addition, we also examine the foreign exchange reserves-to-GDP ratio (*FXRES*) to capture the ability to intervene in FX markets, the number of years a country pursued an inflation-targeting regime between 1990 and 2019 (*IT*) as an indicator of the monetary policy commitment to price stability, and the government debt-to-GDP ratio (*GOVDEBT*) as an indicator for a country's ability to service their debts (He et al. 2019).

[13] Currency crises are defined as an annual depreciation of 15% or more. External sovereign defaults are defined as the failure to meet a principal or interest payment on foreign debt obligations on the due date under the conditions specified in the original contract. Domestic sovereign default is defined analogously but does not involve external creditors. Inflation crises are annual inflation rates of 20% or higher.

[14] Our main results are robust to counting the annual crisis frequency from 1900 instead of 1800.

Table 1: **Determinants of cross-country heterogeneity**

Type	Label	Definition	Used in principal component
Monetary dominance	*FXTURN*	Share of currency in global foreign exchange market turnover	*PC_DOMINANCE*
	FORASSET	Gross foreign assets (excluding FX reserves) to GDP	*PC_DOMINANCE*
	KAOPEN	Chinn-Ito capital account openness index	*PC_DOMINANCE*
Exposure	*NONBANKINV*	Share of government debt held by non-bank foreign investors	*PC_EXPOSURE*
	PORTFDEBT	Net portfolio external debt to foreign exchange turnover ratio	*PC_EXPOSURE*
	FCLIAB	Share of foreign currency liabilities	*PC_EXPOSURE*
Macrofinancial history	*CURCRIS*	Annual historical frequency of currency crises	*PC_HISTORY*
	SOVDEFAULT_DOM	Annual historical frequency of domestic sovereign default	*PC_HISTORY*
	SOVDEFAULT_EXT	Annual historical frequency of external sovereign default	*PC_HISTORY*
Fundamentals	*GNI_PC*	Gross national income per capita in US dollars	
	FXRES	Foreign exchange reserves (excluding gold) to GD	
	IT	Number of years of inflation targeting (1990-2019)	
	GOVDEBT	Government debt to GDP ratio	

Based on this grouping of explanatory factors, we use first principal components (PCs) to create indices (see Table 1). The eigenvectors of the PCA are reported in Appendix C. It can be seen that individual indicators load positively on the first PC, i.e. a higher share in global FX turnover increases the score of *PC_DOMINANCE*, a higher ratio of net portfolio debt increase *PC_EXPOSURE* and so forth. We considered the creation of a PC for solid macroeconomic fundamentals, but the factor loadings did not have signs consistent with such an interpretation (*GNI_PC* and *FXRES* positive, but *IT* and *GOVDEBT* negative and positive, respectively). We therefore insert the individual proxies separately in the regressions.

4 Results

4.1 Impulse responses and external monetary vulnerability index

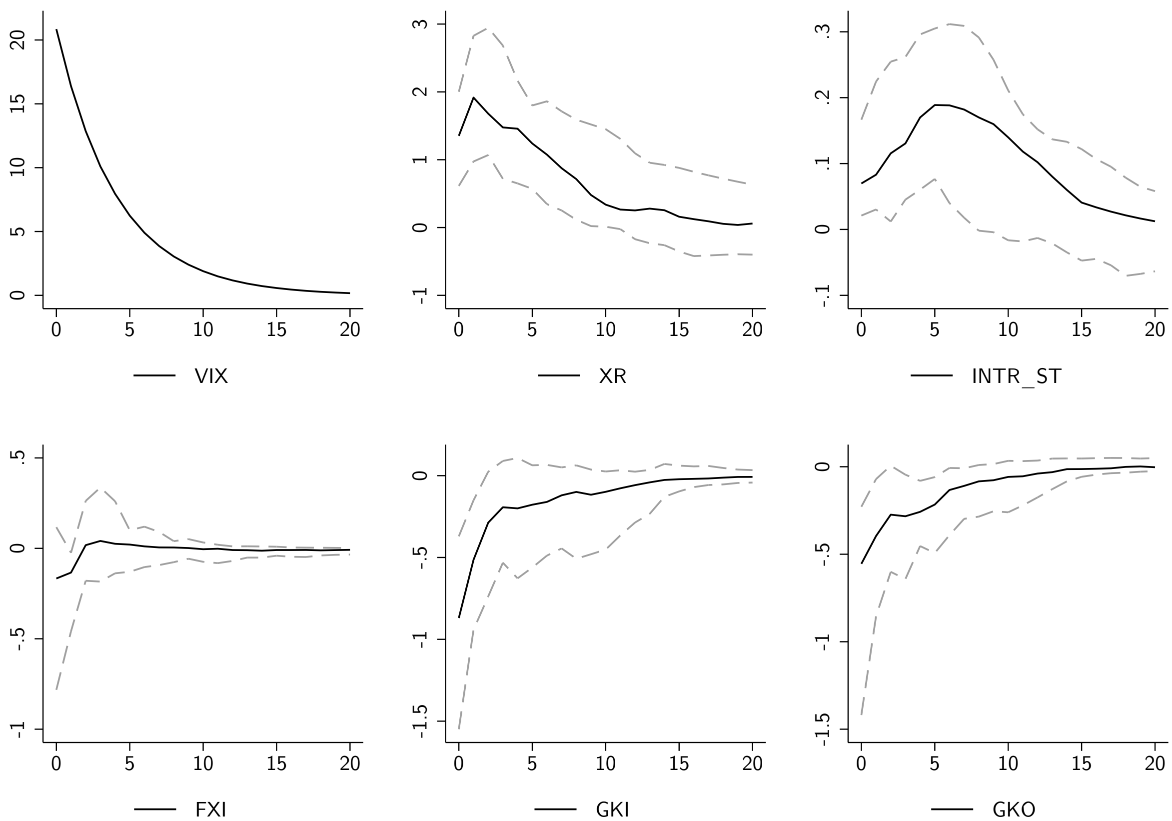
Figure 1 depicts the median over the country-wise impulse responses to a one standard-deviation shock to the *VIX*, together with the interquartile range.[15] A one standard-deviation shock to the *VIX* corresponds to an increase by around 21%. To put this into perspective, during the Global Financial Crisis, the *VIX* rose by about 85% in the fourth quarter of 2008. It can be seen that after about 10 quarters, the shock has largely dissipated.[16] For the median country, the global financial shock comes with a depreciation of the domestic currency against the US dollar by almost 2% in the first quarter. The differential of the domestic short-term interest rate with respect to the US federal funds rate increases by

[15]Figure A1 in Appendix B alternatively displays a weighted average of the country-specific point estimates, along with weighted averages of the country-specific confidence bands. The results are very similar.

[16]The estimated lag length q of the univariate process for the VIX is $q = 1$.

almost 0.2%-pts, peaking in the fifth quarter. The interquartile range indicates that some countries undergo a substantially stronger increase in the interest rate than others. The median country also loses foreign exchange reserves through FX sales of around 0.17% of GDP on impact. The interquartile range again points to heterogeneity, with some countries intervening quite heavily whereas others' foreign reserves barely change. Short-term gross capital in- and outflows contract severely on impact (by about 3.4% and 0.55% of GDP) and take several quarters to return to their steady states. Overall, these results are in line with the theoretical discussion in section 2: an increase in financial uncertainty enforces a higher expected rate of return for the median country, but there is also evidence of that the intensity of this response differs considerably across countries.

Figure 1: Impulse responses to VIX shock



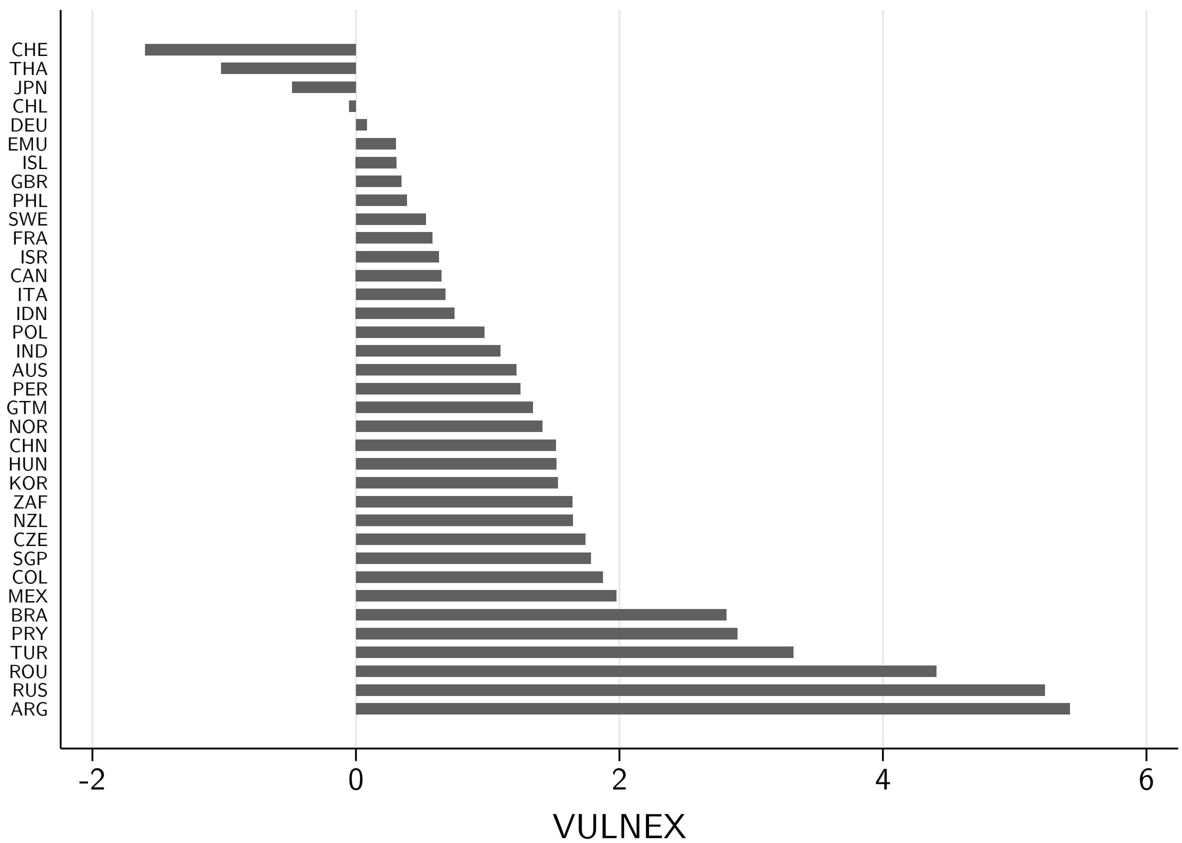
Notes: Median (solid line) and interquartile range (dashed lines) over countries' impulse responses. VIX: logged implied volatility index in S&P500 stock options (unit: percent), XR: logged nominal exchange rate with US dollar (unit: percent); INTR_ST: short-term nominal interest rate differential with US (unit: percentage points); FXI: foreign exchange intervention(%GDP) (unit: percentage points); GKI: short-term gross capital inflow (%GDP) (unit: percentage points); GKO: short-term gross capital outflows (%GDP) (unit: percentage points).

Based on the estimated cumulative impulse responses from the VAR, Figure 2 displays the *VULNEX*: our proxy for the degree of external monetary vulnerability as defined in equation (3), ranked from lowest to highest.[17] We note that the top eight of the ranking is populated by Switzerland with a score of -1.6, followed by Thailand, Japan, Chile, Germany, the Euro Area, Iceland, and the United Kingdom (with a score of 0.35). Many of those countries are AEs that are known to be financial centres, and some may enjoy regional safe asset status. However, with Thailand and Chile, there are also two EMEs among the top

[17] Cumulative IRFs in the fourth quarter of all variables in the VAR along with confidence bands are reported in Appendix B.

eight of the ranking. This illustrates that the commonly applied binary distinction between AEs and EMEs constitutes at best a rough predictor for external monetary vulnerability. The bottom eight of the ranking is made up of EMEs starting with Colombia with a score of 1.9, then Mexico, Brazil, Brazil, Paraguay, Turkey, Romania, Russia, and finally Argentina with a score of 5.4. Indeed, many of these countries have repeatedly been plagued by financial instability in the past and have a reputation of being hot spots of speculative and volatile capital flows. However, the *VULNEX* also shows that some EMEs are substantially worse off than others. Overall, this calls for a more detailed examination of structural determinants of external vulnerability across countries.

Figure 2: External monetary vulnerability index (*VULNEX*)



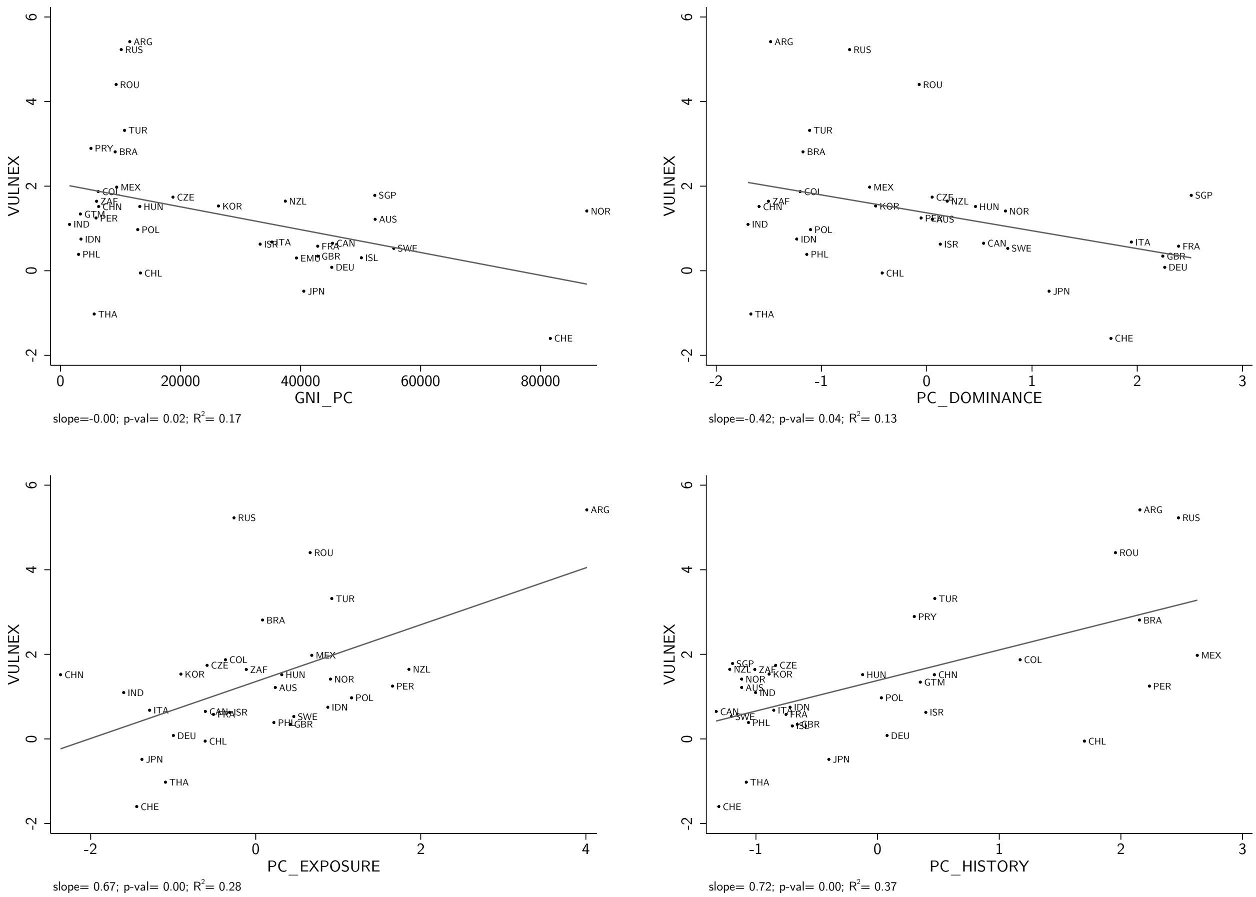
Notes: *VULNEX* is the weighted mean over the cumulative impulse response of *INTR*, *XR*, and the negative of *FXI* in the fourth quarter. Weights are given by the inverse of the average country-wise standard deviations over those variables.

4.2 Determinants of external monetary vulnerability

4.2.1 Regression analysis with principal components

Figure 3 gives a first impression of the relationship between the *VULNEX* and the main determinants of interest. GNI per capita is negatively correlated with the *VULNEX*, as richer countries tend to exhibit lower external vulnerability. However, it is also evident that income alone does a poor job in explaining different degrees of vulnerability across countries with a similar level of income, specifically at lower levels. As expected, *PC_DOMINANCE* is negatively correlated with the *VULNEX*; but it fails to explain substantial variation in the *VULNEX* between countries like Thailand and Argentina. *PC_EXPOSURE* and *PC_HISTORY* exhibit the expected positively correlation and comparatively high R^2s of 0.28 and 0.37, respectively. Overall, the scatter plots indicate a potential role for all of the four types of determinants, but suggest that in isolation, the indices only have limited explanatory power.

Figure 3: Scatter plots of external monetary vulnerability index (*VULNEX*) and structural determinants



Notes: Heteroskedasticity-robust standard errors were applied. p-val is the p-value of the slope coefficient. PC_DOMINANCE: first principal component of FXTURN, KAOPEN, and FORASSET; PC_EXPOSURE: first principal component of NONBANKINV, FCLIAB, and PORTFDEBT; PC_HISTORY: first principal component of CURCRIS, SOVDEF-DOM, and SOVDEF-EXT.

Table 2 reports results from multivariate regressions of the *VULNEX* on the principal components.[18] Specification (1) is the baseline, containing all three indices: *PC_DOMINANCE*, *PC_EXPOSURE* and *PC_HISTORY*. Each index is statistically significant at conventional levels and exhibits the expected sign: monetary dominance as proxied by *PC_DOMINANCE* reduces the vulnerability score, whereas exposure to fickle capital flows and currency mismatches captured by *PC_EXPOSURE*, and a history of crises (*PC_HISTORY*) increase it. Compared to the binary regressions reported in Figure 3 with R^2s of up to 0.37, the explanatory power of this model increases to an adjusted R^2 of 0.49. We also report a

[18] Due to data availability constraints, the Euro Area, Guatemala, Iceland, Paraguay, and Singapore drop out, yielding $N = 31$ observations in the baseline regression.

Shapley decomposition of the adjusted R^2 into the relative percentage shares contributed by each of the three variables. History appears to have the largest explanatory power (52%), followed by exposure (34%) and dominance (14%).

Table 2: Multivariate regressions of external monetary vulnerability index (*VULNEX*) on structural determinants: principal components

	(1)	(2)	(3)	(4)	(5)	(6)
PC_DOMINANCE	-0.255*	-0.273	-0.335**	-0.295**	-0.266	-0.465*
	(0.137)	(0.184)	(0.130)	(0.130)	(0.162)	(0.237)
PC_EXPOSURE	0.438***	0.435**	0.351*	0.530***	0.443**	0.412**
	(0.158)	(0.170)	(0.179)	(0.146)	(0.177)	(0.184)
PC_HISTORY	0.531**	0.539**	0.554**	0.462*	0.532**	0.500*
	(0.228)	(0.248)	(0.234)	(0.234)	(0.229)	(0.245)
GNI_PC		0.000				0.000
		(0.000)				(0.000)
FXRES			-0.024			-0.035*
			(0.017)			(0.019)
IT				-0.028*		-0.039**
				(0.016)		(0.018)
GOVDEBT					0.001	-0.002
					(0.007)	(0.006)
Constant	1.314***	1.277***	1.711***	1.718***	1.270**	2.420***
	(0.196)	(0.367)	(0.298)	(0.263)	(0.475)	(0.677)
Obs	31	31	31	31	31	31
Adj. R-squared	0.493	0.473	0.500	0.506	0.473	0.499
AIC	98.873	100.862	99.267	98.879	100.855	101.532
Shapley var1	0.142	0.096	0.171	0.151	0.125	0.114
Shapley var2	0.338	0.349	0.293	0.374	0.338	0.310
Shapley var3	0.520	0.482	0.531	0.474	0.533	0.433
Shapley var4		0.073	0.005	0.000	0.004	0.068
Shapley var5						0.038
Shapley var6						0.025
Shapley var7						0.013

Notes: Heteroskedasticity-robust standard errors were applied; standard errors in parentheses; *: $p < 0.10$, **: $p < 0.05$, ***: $p < 0.01$. AIC: Akaike information criterion. Shapley var 1-7: percent contribution of variable 1-7 (in order of appearance) to the adjusted R^2. *PC_DOMINANCE*: first principal component of *FXTURN*, *KAOPEN*, and *FORASSET*; *PC_EXPOSURE*: first principal component of *NONBANKINV*, *FCLIAB*, and *PORTFDEBT*; *PC_HISTORY*: first principal component of *CURCRIS*, *SOVDEF-DOM*, and *SOVDEF-EXT*.

Specifications (2)-(6) investigate the relevance of macroeconomic fundamentals. In (2), *GNI_PC* is added but turns out to be statistically insignificant and actually reduces the explanatory power compared to the baseline. Similarly, *FXRES* is statistically insignificant. While *IT* is statistically significant (at the 10% level) with the expected negative sign, its explanatory power is virtually zero as can be seen from the Shapley decomposition. *GOVDEBT* is statistically insignificant and reduces explanatory power compared to the baseline. Finally, specification (6) combines the three PCs with all fundamentals. Here, *FXRES* and *IT* are statistically significant and have the expected signs, whereas *GNI_PC* and *GOVDEBT* remain insignificant. However, the Shapley decomposition indicates that each of the fundamentals has comparatively low explanatory power (less than 7%) compared to the three PCs.

Overall, monetary dominance, exposure to capital flows, and volatile macrofinancial history all predict a country's monetary sensitivity to global financial shocks as measured by the *VULNEX*. Comparing the three groups of variables, macrofinancial history has the largest explanatory power, followed by exposure and monetary dominance. By contrast, GNI per capita and other macroeconomic fundamentals like the government debt ratio are less relevant. The only macroeconomic fundamentals that display some significance are the stock of foreign exchange reserves and inflation targeting, but these do not add notable explanatory power vis-á-vis history, exposure, and dominance.

4.2.2 Cluster analysis

History, exposure, and dominance are all correlated with external monetary vulnerability, but how are they distributed across countries in our sample? To gain insights into the incidence of structural factors and how they map into vulnerability, we conduct a partition cluster analysis that splits countries into groups based on the three PCs. We use the k-medians clustering method,[19] specifying a predetermined number of $k = 4$ clusters for convenience.[20]

The first cluster contains only AEs: the Eurozone countries France, Germany, Italy, as well as Japan, the United Kingdom, and Switzerland (see Table 3). This cluster has the largest average score of *PC_DOMINANCE* and the lowest score of *PC_EXPOSURE*, and

[19]In the k-medians clustering method, this is accomplished via an iterative algorithm that starts by randomly using k individuals as group centres and then forming an initial clustering by assigning the remaining individuals to the group with the closest centre. Then the median over those initial clusters is calculated, and individuals are shifted again to the cluster whose median is closest. This process is repeated until no more reshuffling occurs.

[20]This is supported by the fact that any further reduction of the within sum of squares is negligible after $k \geq 4$.

also exhibits the lowest average degree of external vulnerability (-0.07). The second clusters contains mostly AEs (Australia, Canada, Norway, New Zealand, and Sweden, as well as Czech Republic, Hungary, and Israel), while the third cluster consists of a group of only EMEs (China, India, Indonesia, Korea, Philippines, Poland, Thailand, Turkey, and South Africa). The second and third cluster have similar average *VULNEX* scores (1.17 and 1.13, respectively), but very different structural determinants: the second clusters performs relatively well with respect to monetary dominance and macrofinancial history, but is also quite strongly exposed to fickle capital flows and currency mismatches. The third cluster ranks lowest in terms of monetary dominance but is less exposed than the second cluster. Finally, the fourth cluster is composed of another group of EMEs: Argentina, Brazil, Chile, Colombia, Mexico, Peru, Romania, and Russia. This group has the strongest exposure and most volatile history, and a comparatively low monetary dominance score. It is also the cluster with the highest *VULNEX* score of 2.86, thereby forming the bottom.

Table 3: Average *VULNEX* and PCs over four country clusters

	PC_DOMINANCE	*PC_EXPOSURE*	*PC_HISTORY*	*VULNEX*
1	1.96	-0.87	-0.65	-0.07
2	0.37	0.28	-0.82	1.17
3	-1.28	-0.32	-0.53	1.13
4	-0.71	0.73	2.06	2.86

Notes: Cluster 1: CHE, DEU, FRA, GBR, ITA, JPN; cluster 2: AUS, CAN, CZE, HUN, ISR, NOR, NZL, SWE; cluster 3: CHN, IDN, IND, KOR, PHL, POL, THA, TUR, ZAF; cluster 4: ARG, BRA, CHL, COL, MEX, PER, ROU, RUS. *PC_DOMINANCE*: first principal component of *FXTURN*, *KAOPEN*, and *FORASSET*; *PC_EXPOSURE*: first principal component of *NONBANKINV*, *FCLIAB*, and *PORTFDEBT*; *PC_HISTORY*: first principal component of *CURCRIS*, *SOVDEF-DOM*, and *SOVDEF-EXT*.

The clustering confirms our previous finding that the AE/EME divide only serves as a crude predictor of external monetary vulnerability. While financially dominant AEs with internationally relevant currencies clearly perform the best, and exposed EMEs with turbulent macrofinancial histories populate the bottom, there is no clear grouping into AEs and EMEs in the middle. Instead, we observe an offsetting relationship between monetary dominance and financial exposure. Despite low monetary dominance, the group of mostly Asian EMEs performs similarly as the group with AEs like Australia, New Zealand, and several Eastern European countries that exhibit more dominance and a better historical performance, but are also more externally exposed. These results thus suggest that there are multiple factors that determine a country's response to global financial shocks. Performing relatively well in one dimension only, like monetary dominance, may be insufficient to reduce external vulnerability.

4.2.3 Regression analysis with individual indicators

In this section, we examine the performance of individual indicators as opposed to indices (see Table 4). We start with a baseline specification with the proxies we consider most relevant from the theoretical perspectives discussed above, and then explore the performance of alternative proxies. The baseline (1) consists of *FXTURN* as the main indicator for monetary dominance in global foreign exchange markets, *NONBANKINV* for exposure to non-bank foreign investors, and the frequency of past currency crises (*CURCRIS*) as the main proxy for volatile macrofinancial histories. All three indicators are statistically significant and have the expected signs. The adjusted R^2 is 0.24, compared to 0.49 in the baseline specification with PCs (Table 2), suggesting that combining information from multiple proxies improves explanatory power. According to the Shapley decomposition, *CURCRIS* has the largest contribution to the adjusted R^2 (56%), followed by *FXTURN* (25%) and *NONBANKINV* (19%).

Table 4: Multivariate regressions of external monetary vulnerability index (*VULNEX*) on structural determinants: individual indicators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
FXTURN	-0.042***	-0.032**	-0.061***	-0.060***	-0.037*			-0.046***	-0.021	-0.028**	-0.047***
	(0.013)	(0.012)	(0.015)	(0.018)	(0.019)			(0.015)	(0.020)	(0.014)	(0.013)
NONBANKINV	0.042**	0.038**	0.030**	0.049***	0.040**	0.037**	0.028**			0.035**	0.044**
	(0.016)	(0.015)	(0.013)	(0.018)	(0.019)	(0.017)	(0.013)			(0.016)	(0.019)
CURCRIS	7.469*	6.451	7.405*	6.737*	7.435*	8.078*	6.263	8.262*	7.382*		
	(4.170)	(4.398)	(4.140)	(3.908)	(4.240)	(4.252)	(4.193)	(4.235)	(4.099)		
GNI_PC		-0.000									
		(0.000)									
FXRES			-0.036*								
			(0.021)								
IT				-0.039							
				(0.025)							
GOVDEBT					-0.002						
					(0.007)						
NFA						0.001					
						(0.003)					
FORASSETS							-0.004**				
							(0.001)				
BANKINV								0.084			
								(0.094)			
FCLIAB									2.930		
									(1.763)		
XRVOL										0.006***	
										(0.002)	
INFLCRIS											4.578
											(3.938)
Constant	0.156	0.584	1.075*	0.749	0.269	-0.083	0.668	0.522	-0.366	0.314	0.407
	(0.561)	(0.712)	(0.547)	(0.759)	(0.816)	(0.584)	(0.612)	(0.440)	(0.874)	(0.496)	(0.649)
Obs	31	31	31	31	31	32	32	31	32	28	31
Adj. R-squared	0.237	0.239	0.264	0.268	0.210	0.135	0.257	0.174	0.223	0.352	0.132
AIC	111.508	112.257	111.233	111.075	113.444	118.411	113.545	113.975	114.625	92.789	115.536
Shapley var1	0.254	0.150	0.346	0.321	0.160	0.165	0.059	0.348	0.125	0.114	0.514
Shapley var2	0.186	0.154	0.105	0.211	0.182	1.052	0.409	0.784	0.568	0.142	0.355
Shapley var3	0.560	0.438	0.513	0.464	0.622	-0.217	0.531	-0.132	0.307	0.744	0.131
Shapley var4		0.257			0.037						

Notes: Heteroskedasticity-robust standard errors were applied; standard errors in parentheses; *: $p < 0.10$, **: $p < 0.05$, ***: $p < 0.01$. AIC: Akaike information criterion. Shapley var 1-4: percent contribution of variable 1-4 to the adjusted R^2 (in order of appearance).

Specifications (2)-(5) add macroeconomic fundamentals to the baseline (1). Similar to the regressions with PCs, *GNI_PC* is statistically insignificant and does not improve the explanatory power of the baseline (as reflected in a virtually identical adjusted R^2 and a higher AIC). The stock of foreign exchange reserves (*FXRES*) has the expected negative sign and is borderline statistically insignificant. It only marginally improves the explanatory power. The indicator for inflation targeting (*IT*) has the expected negative sign but is statistically insignificant. Similarly, the government debt to GDP ratio (*GOVDEBT*) is statistically insignificant and reduces the explanatory power of the model.

Specifications (6)-(11) test alternative proxies for our three structural determinants dominance, exposure, and history. In (6)-(7), we replace *FXTURN* with the net and gross foreign asset position, *NFA* and *FORASSETS*. Only *FORASSETS* is statistically significant and has the expected negative sign, confirming that *NFA* is not a good proxy for financial scope and that gross positions are more important for the monetary response to financial shocks. Specifications (8)-(9) experiment with alternative measures of foreign exposure. In (8), *NONBANKINV* is replaced with the share of government debt held by foreign banks (*BANKINV*). Interestingly, this variable is statistically insignificant, indicating that non-bank foreign investors react more strongly than banks when international liquidity preference changes. In (9), we use instead the share of foreign currency debt (*FCLIAB*), which has the expected positive sign but is borderline statistically insignificant, suggesting that exposure to fickle capital flows is more important for the *VULNEX* than currency mismatches. Specifications (10)-(11) further explore the relevance of volatile macrofinancial histories for the *VULNEX*. The volatility of exchange rates between 1974Q1 and 1989Q4 (*XRVOL*) as an alternative indicator for exchange rate risk is also positive and statistically significant (but less preferable than *CURCRIS* in terms of the number of observations). By contrast, the history of inflation crises (*INFLCRIS*) is not a statistically significant predictor of the *VULNEX*. This suggests that exchange rate instability may be more important for external monetary vulnerability than price instability.

Overall, this exercise confirms and expands the results with the PCs. Individual indicators for monetary dominance, exposure, and history are statistically significant and exhibit the expected signs. Besides relevance in global foreign exchange markets, the gross rather than net foreign asset position is negatively correlated with vulnerability. For exposure, non-bank foreign investors matter more than banks and currency mismatches. With respect to macrofinancial history, it is unstable exchange rate rather than inflation histories that correlate with current monetary vulnerabilities.

4.3 Extensions and robustness tests

4.3.1 Results with long-term interest rates

Next, we assess whether our main results differ when estimating the VAR with long-term interest rates (*INTR_LT*) instead of short-term rates.[21] Long-term rates are determined in (government) bond markets and thus not directly controlled by monetary authorities. Some of the literature on safe assets, liquidity yields and the UIP deviation specifically focuses on government bonds (Engel 2016, Engel & Wu 2018, He et al. 2019).

Overall, the results in Table 5 are similar compared to the *VULNEX* with short-term interest rates. In specifications (1)-(3), all PCs individually are statistically significant and have the expected signs, but in the multivariate specification (4), *PC_DOMINANCE* is no longer statistically significant. Similarly, all three individual indicators, *FXTURN*, *NONBANKINV*, *CURCRIS*, are statistically significant and have the expected sign, but *FXTURN* has lower explanatory power compared to the results with short-term interest rates (Shapley value of only 10% compared to 25%).[22] By contrast, *NONBANKINV* has slightly larger explanatory power. This suggests that monetary dominance may be less effective in reducing the sensitivity of long-term interest rates to global financial shocks than it is for policy rates. By contrast, exposure to capital flows appear to be more relevant for long-term interest rates. This can be expected, given that non-bank foreign investors are highly active in government bond markets and may thereby exercise strong effects on long-term rates.

[21]See Appendix B for estimated impulse responses and the resulting alternative external vulnerability index. The correlation between the baseline *VULNEX* and the *VULNEX* with long-term interest rates is 0.93, suggesting that there are only moderate differences. Note that Georgia was retained in the VAR estimations but instead China, Guatemala, and Paraguay had to be dropped to insufficient observations, resulting in 34 countries.

[22]Further estimations with individual indicators are reported in Appendix B.

Table 5: Multivariate regressions of external monetary vulnerability index with long-term interest rates on structural determinants

	(1)	(2)	(3)	(4)	(5)
PC_DOMINANCE	-0.343**			-0.159	
	(0.165)			(0.103)	
PC_EXPOSURE		0.560***		0.300*	
		(0.110)		(0.173)	
PC_HISTORY			0.630***	0.508**	
			(0.195)	(0.237)	
FXTURN					-0.028**
					(0.010)
NONBANKINV					0.039***
					(0.014)
CURCRIS					7.290*
					(3.934)
Constant	1.241***	1.235***	1.248***	1.202***	0.015
	(0.230)	(0.220)	(0.187)	(0.179)	(0.416)
Obs	31	30	32	30	30
Adj. R-squared	0.084	0.216	0.373	0.445	0.264
AIC	105.330	98.314	95.530	89.715	98.193
Shapley var1				0.097	0.106
Shapley var2				0.267	0.210
Shapley var3				0.636	0.684

Notes: Heteroskedasticity-robust standard errors were applied; standard errors in parentheses; *: $p < 0.10$, **: $p < 0.05$, ***: $p < 0.01$. AIC: Akaike information criterion. Shapley var 1-3: percent contribution of variable 1-3 (in order of appearance) to the adjusted R^2. *PC_POWER*: first principal component of *FXTURN*, *KAOPEN*, and *FORASSET*; *PC_EXPOSURE*: first principal component of *NONBANKINV*, *FCLIAB*, and *PORTFDEBT*; *PC_HISTORY*: first principal component of *CURCRIS*, *SOVDEF-DOM*, and *SOVDEF-EXT*.

4.3.2 Further robustness tests

In this section, we present a number of additional robustness tests to the baseline specification in Table 2 with the three PCs. In the first column of Table 6, we apply a jackknife estimator that drops one observation each from the sample and takes the average over the N replications. In our small-sample environment, this serves as a check how sensitive the results are to individual countries. As expected, p-values are slightly higher but all coefficients remain statistically significant and the estimated coefficients are even slightly larger. In the second and third columns, we use alternative versions of the *VULNEX* to assess whether the main results depend on our weighting scheme: in *VULNEX-SE*, the weights are given by the inverse of the standard error of the cumulative impulse response in the fourth quarter, and in *VULNEX-AVR* we use an unweighted average. In both cases, the estimated coefficients remain statistically significant. In the fourth specification, we select the lag length of the VARs with the Bayesian information criterion (BIC) instead of AIC. The BIC typically selects a shorter lag length. It can be seen that the main results hold up. In column five, we present an alternative *VULNEX* based on VAR estimations in which the coefficients on the domestic variables in the VIX-equation were not constrained to be zero. The coefficients on *PC_EXPOSURE* and *PC_HISTORY* remain statistically significant, but *PC_DOMINANCE* now becomes borderline statistically insignificant. As there are no economic grounds to expect differences given the assumed exogeneity of the *VIX*, this points to a genuine lack of robustness of *PC_DOMINANCE* compared to the other PCs. Finally, specifications (6) and (7) report results with two different financial stress indices compiled by the Office of Financial Research as alternative external shock variables. The *FSI* is a daily market-based indicator of stress in global financial markets that is based on 33 financial market variables. It is thus much broader than the *VIX* that is based on the US S&P 500. We consider both the general *FSI* and the *FSI* volatility (*FSI VOL*), which contains measures of implied and realised volatility from equity, credit, currency, and commodity markets. It can be seen that the main results hold up: all coefficients retain their sign and remain statistically significant. Overall, we conclude that our main results with *PC_EXPOSURE* and *PC_HISTORY* are highly robust, and that the results with *PC_DOMINANCE* are mostly robust.[23]

[23] Table A9 in Appendix B further reports Pearson correlation coefficients between the baseline *VULNEX* and the alternative *VULNEXES* used in specifications (2)-(7). Correlations are statistically significant and range from 0.87 to 0.97, suggesting that our baseline estimate of external vulnerability is highly robust.

Table 6: Robustness tests

	(1) JACKKNIFE	(2) VULNEX-SE	(3) VULNEX-AVR	(4) BIC	(5) UNCONSTR	(6) FSI	(7) FSI VOL
PC_DOMINANCE	-0.255*	-0.238***	-0.461*	-0.180*	-0.160	-0.376**	-0.303*
	(0.094)	(0.007)	(0.098)	(0.080)	(0.147)	(0.041)	(0.097)
PC_EXPOSURE	0.438**	0.352**	0.698**	0.266*	0.285**	0.431*	0.449*
	(0.026)	(0.014)	(0.013)	(0.063)	(0.016)	(0.052)	(0.076)
PC_HISTORY	0.531**	0.443**	0.840**	0.522**	0.375**	0.631**	0.593*
	(0.039)	(0.017)	(0.020)	(0.026)	(0.049)	(0.042)	(0.082)
Constant	1.314***	1.238***	3.215***	1.331***	0.970***	2.098***	1.601***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Obs	31	31	31	31	31	30	30
Adj. R-squared	0.493	0.571	0.442	0.415	0.415	0.473	0.407
AIC	98.873	79.059	134.439	95.476	83.273	108.134	111.437
Shapley var1	0.142	0.172	0.164	0.110	0.120	0.207	0.161
Shapley var2	0.338	0.316	0.328	0.214	0.320	0.264	0.302
Shapley var3	0.520	0.513	0.508	0.676	0.560	0.529	0.538

Notes: *PC_DOMINANCE*: first principal component of *FXTURN*, *KAOPEN*, and *FORASSET*; *PC_DOMINANCE*: first principal component of *NONBANKINV*, *FCLIAB*, and *PORTFDEBT*; *PC_HISTORY*: first principal component of *CURCRIS*, *SOVDEF-DOM*, and *SOVDEF-EXT*.

5 Conclusion

This paper has investigated the presence and sources of cross-country heterogeneity in external monetary vulnerability to global uncertainty shocks. It proposed a novel measure of such vulnerability based on estimated impulse responses of nominal exchange rates, interest rate differentials, and foreign reserves. It shows that the majority of countries undergo currency depreciation, rising interest rates, and/or lose foreign exchange reserves in response to those shocks. This is consistent with an interpretation of global uncertainty shocks as an increase in the liquidity yield on international currencies or safe assets that enforces an increase in the expected return on currencies that do not enjoy this status (Engel 2016, Engel & Wu 2018, Farhi & Maggiori 2017, Gopinath & Stein 2020). The contractionary monetary effects that we document for most countries are also in line with recent small open economy models that allow for non-monetary premia on financial assets (Alla et al. 2019, Cavallino 2019, Farhi & Werning 2014, Gabaix & Maggiori 2015). Our results contribute to this literature by demonstrating substantial cross-country differences in the magnitude of these effects, which are related to structural features such as exposure to fickle capital flows, volatile macrofinancial histories, and dominance in the international monetary system.

Our results support the finding that sensitivity of capital flows to global financial factors depends on external creditor type (Cerutti et al. 2019, Puy 2016, Raddatz & Schmukler 2012). We show that this sensitivity is not only reflected in quantity adjustment, but also price adjustment in exchange rates and interest rates. Our findings further support the argument that macrofinancial history influences investors' structural risk perceptions of different internationally traded financial assets (Burger & Warnock 2006). By contrast, macroeconomic fundamentals such as GDP per capita and public debt ratios appear to be less relevant.

With respect to research on the international monetary and financial system (Eichengreen et al. 2018, Eichengreen 2012, Farhi & Maggiori 2017, Gopinath & Stein 2020, Gourinchas et al. 2019, Maggiori et al. 2019), our findings demonstrate its asymmetric nature, which not only has profound macrofinancial implications for the dominant international currency issuer, but also for currencies that enjoy only limited international currency status – or none at all. Our results suggest that currencies that are not the most dominant ones but do play a significant role in the system (e.g. the Swiss franc and Japanese yen) also enjoy elements of an exorbitant privilege in the form of lower degrees of external monetary vulnerability. That does not mean they are not affected by global financial shocks: appreciation pressures due to flight-to-quality may well interfere with domestic economic policy objectives. However, their response to the shock is very different from those of currency issuers with low international relevance and strong exposure to capital flows.

We further contribute to this literature by presenting evidence that similar degrees of external vulnerability can be related to different structural factors: comparatively high exposure combined with more dominance, exhibited by a group of advanced countries such as Australia, Hungary, and Norway, or comparatively low exposure but less dominance, which can be found, for example, for India, Korea, and South Africa. Overall, this suggests that exposure, history, and dominance all influence external monetary vulnerability, and that exposure and dominance may partly offset each other.

With respect to policy, our analysis suggests that on the one hand, histories of macrofinancial instability may cast a long shadow that cannot easily be overcome. In conjunction with the structural position in the international monetary and financial system, this might evoke pessimism regarding the ability of currency issuers to mitigate external vulnerability. However, the finding that exposure to fickle capital flows is positively related to vulnerability suggests that policies that reduce such exposure can be beneficial. This could be accomplished by strengthening local as opposed to foreign borrowing, for example through the development of domestic financial institutions that provide a stable long-term demand for domestic bonds.

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Appendix

A Data description

Table A1: Data definitions and sources: variables in VAR

Variable	Description & unit	Source(s)	Notes
FXI	Flow of reserve assets plus rate of change in central bank off-balance sheet foreign exchange position, percent of (lagged) GDP	IMF-IFS, IMF-IRFCL; OECD	Flow of reserve assets are Reserve Assets (with Fund Record) from the Supplementary Items of the Balance of Payments (*BFRAFR_BP6_USD*). Central bank off-balance sheet items are Aggregate Short & Long Positions in Forwards and Futures in Foreign Currencies vis--vis the Domestic Currency (including the Forward Leg of Currency Swaps), Long Positions (*RAMFFL_USD*) plus Short Positions (*RAMFFS_USD*). GDP is from IFS or OECD and is seasonally adjusted. Where adjusted series were not available, seasonal adjustment was performed manually using the X-13 ARIMA SEATS routine of the United States Census Bureau. The routine was accessed through the R-package *seasonal*.
GKI, GKO	Sum of gross portfolio and other investment in- and outflows, percent of (lagged) GDP	IMF-BOP; OECD	GDP is from IFS or OECD and is seasonally adjusted. Where adjusted series were not available, seasonal adjustment was performed manually using the X-13 ARIMA SEATS routine of the United States Census Bureau. The routine was accessed through the R-package *seasonal*.
VIX	CBOE S&P 500 Volatility Index (implied volatility of stock options), natural log	FRED	
INTR_ST	Short-term (policy) interest rate, percent, differential with respect to US effective federal funds rate	BIS, FRED, IMF-IFS, OECD	Policy rates from BIS and IFS were used as default. Sporadic gaps were interpolated with the money market rate from IFS. For CHL, COL, MEX, PAR, PER, ISR, IDO, THA, CHN, CZE, ROM, ISL, the policy rate was extrapolated backwards with the growth rate of the closest substitute (e.g. short-term rate from OECD, money market or deposit rate from IFS).
INTR_LT	Long-term interest rate, percent, differential with respect to US 10-yr treasury rate	Datastream, FRED, IMF-IFS, OECD	Long-term interest rates (yield on 10-yr government bonds) from OECD, Datastream or IFS were used as default. For a few countries, treasury bill rates from IFS were used as substitute. Small gaps were linearly interpolated. For ARG and PER, the EMBIG was used. For CZE, HUN, POL, ROM, ISL, TUR, the long-term rate was extrapolated backwards with the growth rate of the closest substitute (e.g. treasury bill rate from IFS).
XR	Nominal US dollar exchange rate (average of period), natural log	IMF-IFS	

Table A2: Country-specific sample range: VAR estimations

Country	Sample start restricted to	Estimation period (baseline VAR)
Argentina	2005Q1	2005Q2–2019Q4
Australia		1990Q2–2019Q4
Brazil	2000Q1	1999Q4–2019Q4
Canada	1992Q1	1990Q2–2019Q4
Chile	1992Q1	1995Q3–2019Q3
China	2005Q3	2005Q4–2019Q4
Colombia		1996Q1–2019Q4
Czech Republic	1990Q4	1995Q2–2019Q4
Euro Area	1999Q1	1999Q2–2019Q4
France	1999Q1	1999Q2–2019Q4
Georgia	1999Q1	2008Q1–2019Q4*
Germany	1999Q1	1999Q2–2019Q4
Guatemala	1991Q3	2005Q1–2018Q4
Hungary		1995Q2–2019Q4
Iceland		1991Q1–2019Q4
India	1995Q3	1996Q3–2019Q4
Indonesia	2000Q1	2004Q1–2019Q4
Israel		1992Q1–2019Q4
Italy	1999Q1	1999Q2–2019Q4
Japan		1996Q1–2019Q4
Korea	2000Q1	2000Q2–2019Q4
Mexico	1996Q2	2001Q1–2019Q4
New Zealand		2002Q2–2019Q4
Norway		1994Q1–2019Q4
Paraguay	1991Q1	2000Q1–2019Q4
Peru	1994Q1	1994Q2–2017Q2
Philippines	2000Q1	2000Q2–2019Q1
Poland	1995Q3	2000Q1–2019Q4
Romania		2001Q3–2019Q4
Russia	2000Q1	2000Q2–2019Q4
Singapore		1995Q1–2019Q4
South Africa		1990Q2–2019Q4
Sweden	1993Q1	1993Q2–2019Q4
Switzerland		1999Q1–2019Q4
Thailand	2000Q1	2000Q2–2019Q4
Turkey	1998Q1	1998Q2–2019Q4
United Kingdom	1993Q1	1993Q2–2019Q4

Notes: Sample restrictions are based on the exchange regime classification in Ilzetzki et al. (2019) so as to exclude crises episodes that led to a change in the exchange rate regime. In the case of Argentina, the sample start was set to 2005Q1 because of sustained extreme macroeconomic adjustments after the 2001 crisis. The sample start for the Euro Area countries was set to the introduction of the euro. No value means no restriction was imposed on the default sample start (1990Q1). The second column displays the sample period in the baseline VAR resulting from the imposed restrictions in conjunction with data availability. *: Dropped due to less than 30 degrees of freedom.

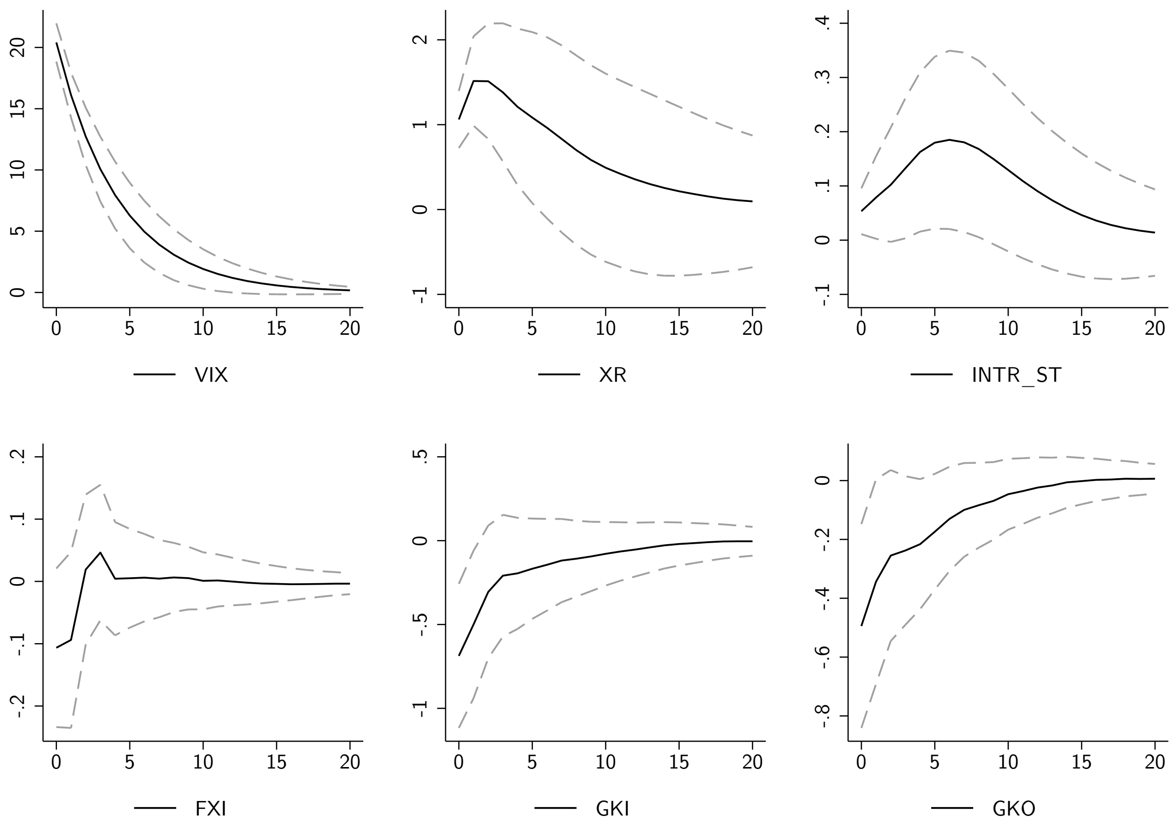
Table A3: Data definitions and sources: determinants of *VULNEX*

Variable	Variable group	Description & unit	Source(s)	Notes
FXTURN	Dominance	Share of currency in global foreign exchange market turnover, median between 2006-2019	BIS	
FORASSET	Dominance	Gross foreign assets (excluding FX reserves) to GDP, median between 2006-2019	Lane & Milesi-Ferretti (2018)	
KAOPEN	Dominance	Chinn-Ito capital account openness index, median between 2006-2019	Chinn & Ito (2006)	
NFA	Dominance	Net foreign assets to GDP, median between 2006-2019	Lane & Milesi-Ferretti (2018)	
NONBANKINV	Exposure	Share of government debt held by non-bank foreign investors, median between 2006-2019	Arslanalp & Tsuda (2014*a*,*b*)	
BANKINV	Exposure	Share of government debt held by foreign banks, median between 2006-2019	Arslanalp & Tsuda (2014*a*,*b*)	
PORTFDEBT	Exposure	Net portfolio external debt to foreign exchange turnover, median between 2006-2019	BIS, Lane & Milesi-Ferretti (2018)	
FCLIAB	Exposure	Share of foreign currency liabilities, median between 2006-2019	Bénétrix et al. (2019)	
CURCRIS	History	Annual frequency of currency crises, 1800-1989	Reinhart & Rogoff (2011)	For CZE and ISR, data only from 1940 and 1948, respectively, based on Ilzetzki et al. (2019)
SOVDEF	History	Annual frequency of sovereign default (external or domestic), 1800-1989	Reinhart & Rogoff (2011)	For CZE and ISR, data only from 1918 and 1948, respectively, based on Tomz & Wright (2007)
INFLCRIS	History	Annual frequency of inflation crises, 1800-1989	Reinhart & Rogoff (2011)	For CZE and ISR, data only from 1940 and 1948, respectively, based on Ilzetzki et al. (2019)
XRVOL_HIST	History	Coefficient of variation (standard deviation divided by average) of quarterly nominal US dollar exchange rate, 1974-1989	IMF (IFS), OECD	
GNI_PC	Fundamentals	Gross national income per capita in US dollars (Atlas method), median between 2006-2019	World Bank (WDI)	
GOVDEBT	Fundamentals	Total government debt to GDP, median between 2006-2019	Arslanalp & Tsuda (2014*a*,*b*)	
FXRES	Fundamentals	Foreign exchange reserves (excluding gold) to GDP, median between 2006-2019	Lane & Milesi-Ferretti (2018)	
IT	Fundamentals	Number of years in which a country pursued an inflation targeting regime, 1990-2019	IMF Finance & Development and national sources	

B Supplementary results: VAR estimation

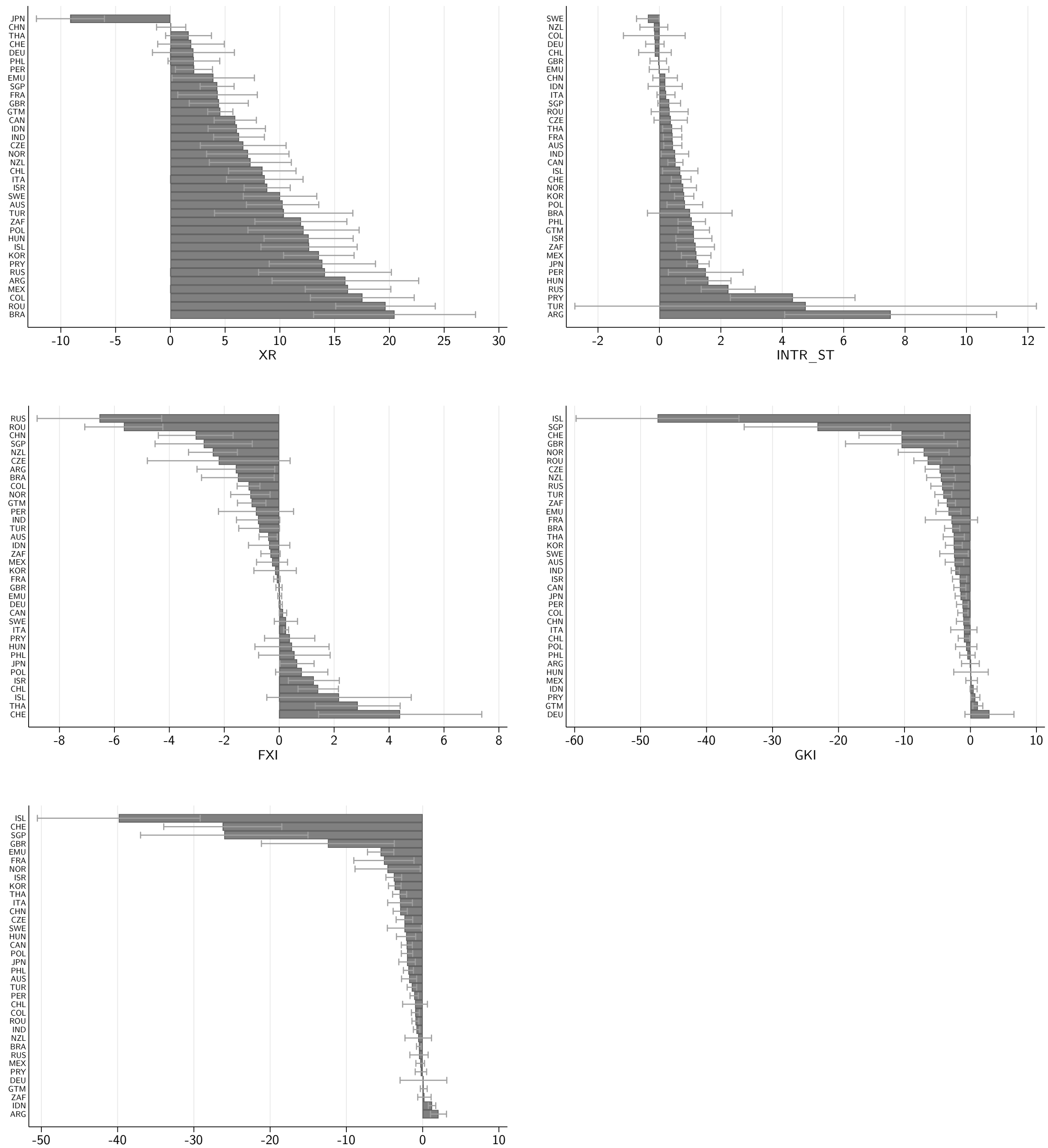
B.1 Impulse responses of baseline VAR

Figure A1: Impulse responses to VIX shock. Weighted mean with 68% confidence bands



Notes: Weights are the inverse of the standard error of the country-specific impulse response. VIX: logged implied volatility index in S&P500 stock options, XR: logged nominal exchange rate with US dollar; INTR_ST: short-term nominal interest rate differential with US; FXI: foreign exchange intervention(%GDP); GKI: short-term gross capital inflow (%GDP); GKO: short-term gross capital outflows (%GDP).

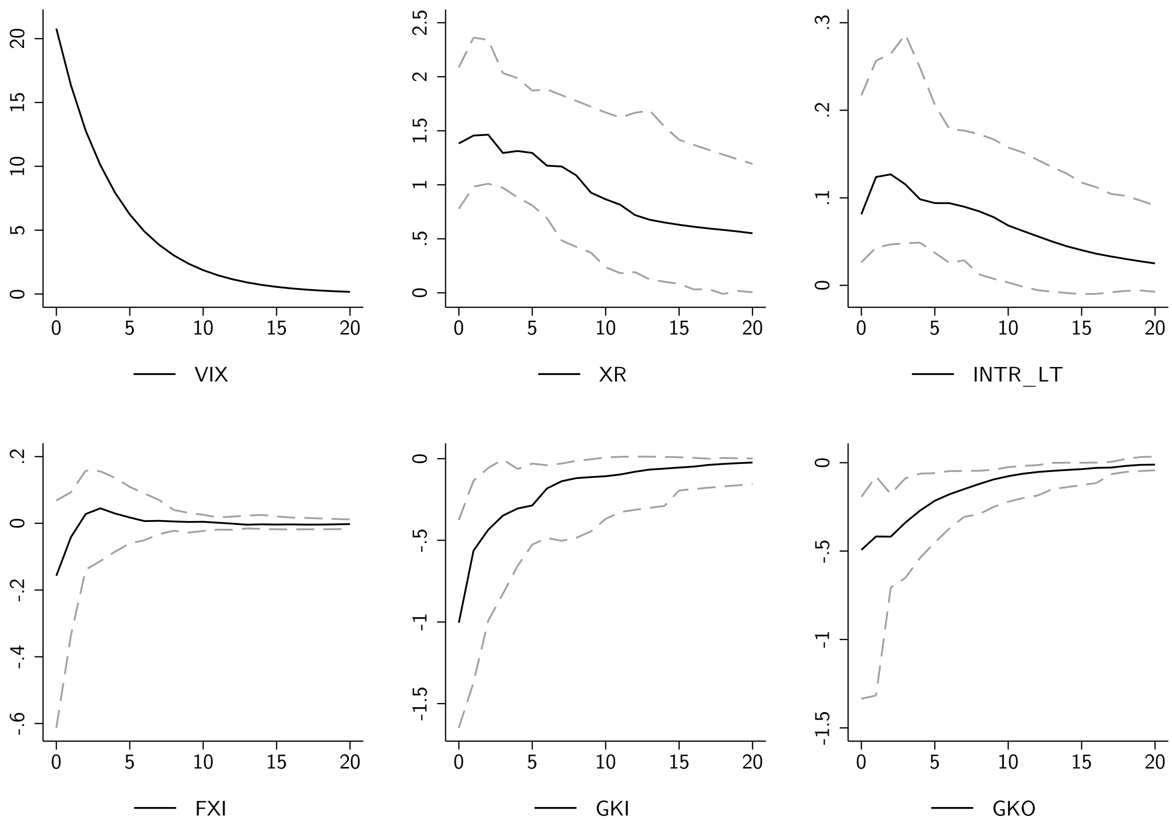
Figure A2: Cumulative impulse responses to VIX shock in fourth quarter with 68% confidence bands



Notes: VIX: logged implied volatility index in S&P500 stock options, XR: logged nominal exchange rate with US dollar; INTR_ST: short-term nominal interest rate differential with US; FXI: foreign exchange intervention(%GDP); GKI: short-term gross capital inflow (%GDP); GKO: short-term gross capital outflows (%GDP).

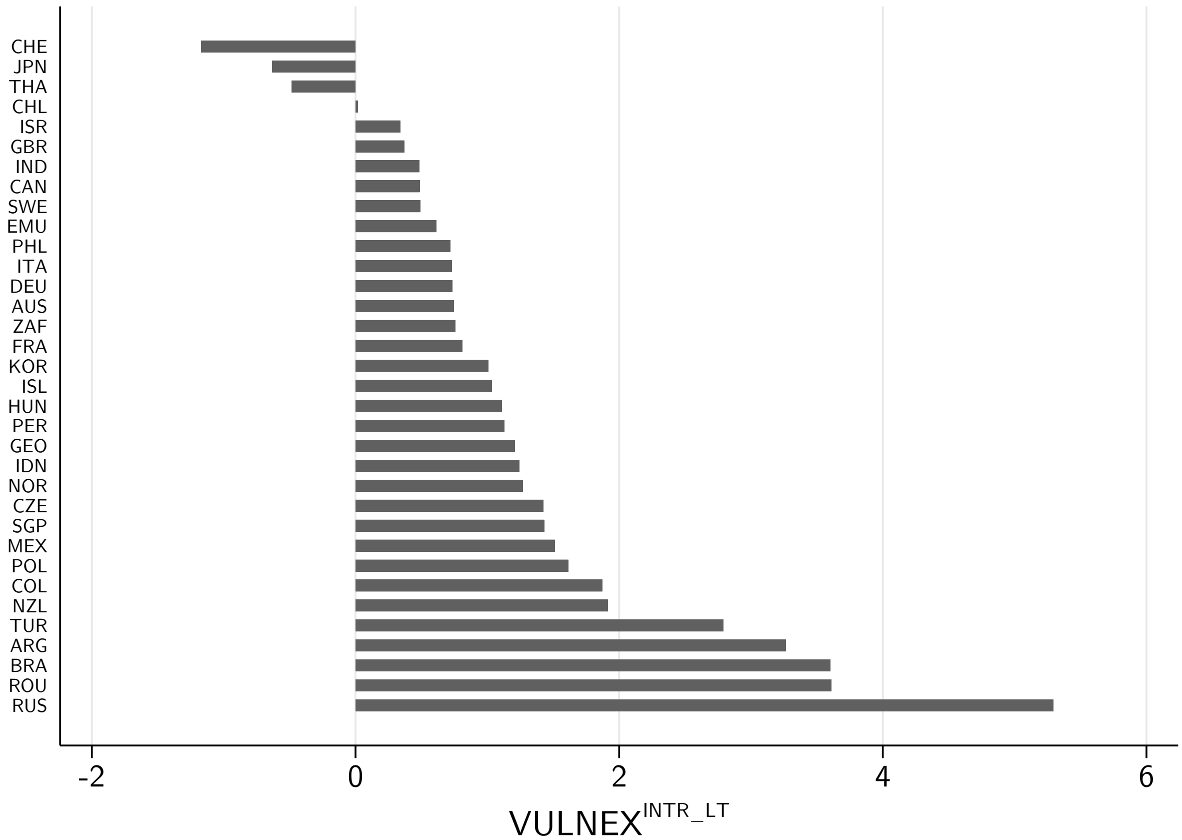
B.2 Impulse reponses and *VULNEX* with long-term interest rates

Figure A3: Impulse responses to VIX shock, VAR with long-term interest rates



Notes: Median (solid line) and interquartile range (dashed lines) over countries' impulse responses. VIX: logged implied volatility index in S&P500 stock options, XR: logged nominal exchange rate with US dollar; INTR_LT: long-term nominal interest rate differential with US; FXI: foreign exchange intervention(%GDP); GKI: short-term gross capital inflow (%GDP); GKO: short-term gross capital outflows (%GDP).

Figure A4: External vulnerability index with long-term interest rates



Notes: *VULNEX* is the weighted mean over the cumulative impulse response of *INTR*, *XR*, and the negative of *FXI* in the fourth quarter. Weights are given by the inverse of the average country-wise standard deviations over those variables.

C Supplementary results: structural determinants

C.1 Principal component analysis

Table A4: Eigenvectors of *PC_DOMINANCE*

Eigenvector of	PC1	PC2	PC3
FXURN	.512	.796	.323
FORASSET	.573	-.596	.562
KAOPEN	.641	-.102	-.761
Explained variance	58%	26%	16%

Notes: Eigenvectors of PC1 correspond to the factor loadings used for *PC_DOMINANCE*.

Table A5: Eigenvectors of *PC_EXPOSURE*

Eigenvector of	PC1	PC2	PC3
NONBANKINV	.517	.806	.289
PORTFDEBT	.632	-.132	-.763
FCLIAB	.577	-.577	.577
Explained variance	51%	28%	21%

Notes: Eigenvectors of PC1 correspond to the factor loadings used for *PC_EXPOSURE*.

Table A6: Eigenvectors of *PC_HISTORY*

Eigenvector of	PC1	PC2	PC3
CURCRIS	.552	-.629	.547
SOVDEF_DOM	.456	.777	.434
SOVDEF_EXT	.698	-.011	-.716
Explained variance	54%	32%	14%

Notes: Eigenvectors of PC1 correspond to the factor loadings used for *PC_HISTORY*.

Table A7: Eigenvectors of PCA with macroeconomic fundamentals

Eigenvector of	PC1	PC2	PC3
GNI_PC	.332	.675	.534
FXRES	.474	-.485	.613
IT	-.597	.374	.346
GOVDEBT	.556	.412	-.468
Explained variance	38%	29%	20%

C.2 Results with long-term interest rates and robustness tests

Table A8: Multivariate regressions of external vulnerability index with long-term interest rates on structural determinants

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FXTURN	-0.019*	-0.043***	-0.037**	-0.014			-0.033***	-0.011	-0.015	-0.032**
	(0.010)	(0.011)	(0.015)	(0.015)			(0.011)	(0.017)	(0.012)	(0.012)
NONBANKINV	0.035**	0.032***	0.041**	0.034*	0.033**	0.029**			0.037**	0.043***
	(0.014)	(0.011)	(0.016)	(0.017)	(0.014)	(0.013)			(0.014)	(0.015)
CURCRIS	6.466	7.101*	6.979*	7.224*	7.690*	6.430	8.534**	7.284*		
	(4.084)	(3.940)	(3.979)	(3.968)	(3.957)	(3.875)	(3.864)	(3.852)		
GNI_PC	-0.000									
	(0.000)									
FXRES		-0.031*								
		(0.018)								
IT			-0.020							
			(0.021)							
GOVDEBT				-0.006						
				(0.007)						
NFA					-0.001					
					(0.002)					
FORASSETS						-0.003**				
						(0.001)				
BANKINV							0.119			
							(0.075)			
FCLIAB								2.299*		
								(1.252)		
XRVOL_HIST									0.005***	
									(0.001)	
INFLCRIS										4.348
										(3.062)
Constant	0.405	0.735	0.341	0.339	-0.121	0.429	0.193	-0.288	0.112	0.226
	(0.567)	(0.497)	(0.646)	(0.671)	(0.416)	(0.482)	(0.392)	(0.556)	(0.385)	(0.502)
Obs	30.000	30.000	30.000	30.000	31.000	31.000	30.000	31.000	27.000	30.000
Adj. R-squared	0.266	0.284	0.254	0.251	0.210	0.301	0.226	0.229	0.412	0.122
AIC	98.951	98.178	99.411	99.534	102.530	98.709	99.689	101.751	75.238	103.480
Shapley var1	0.037	0.191	0.151	0.014	0.173	0.112	0.147	0.025	0.032	0.272
Shapley var2	0.167	0.153	0.237	0.173	0.918	0.513	0.892	0.770	0.233	0.513
Shapley var3	0.564	0.634	0.695	0.708	-0.091	0.375	-0.039	0.205	0.735	0.215
Shapley var4	0.233			0.105						

Notes: Heteroskedasticity-robust standard errors were applied; p-values in parentheses. AIC: Akaike information criterion. Shapley var 1-4: percent contribution of variable 1-4 to the adjusted R^2 (in order of appearance).

Table A9: Pearson correlation between baseline *VULNEX* and alternative *VULNEXES* used in robustness tests (Table 6)

	VULNEX
VULNEX-SE	0.917***
VULNEX-AVR	0.868***
BIC	0.929***
UNCONSTR	0.972***
FSI	0.911***
FSI VOL	0.883***

Notes: *, **, and *** denote statistical significance at the 10%, 5%, and 1%-level, respectively. VULNEX-SE is a weighted average with the inverse of the standard error of the cumulative impulse response in the fourth quarter as weights. VULNEX-AVR is based on an unweighted average of the cumulative response of INTR_ST, XR, and -FXI in the fourth quarter. BIC is based on lag-selection with the Bayesian Information Criterion. UNCONSTR is based on a VAR without zero-restrictions on the domestic variables in the VIX-equation. FSI is based on the general OFR financial stress index as the global financial shock. FSI VOL is based on the volatility-based OFR financial stress index as the global financial shock.