Journal of Money, Credit and Banking
Peer-reviewed and accepted version

Exchange Rate Sensitivity and the Net Foreign Asset Composition

Malin Gardberg

Published version:
https://doi.org/10.1111/jmcb.12861

Research Institute of Industrial Economics
P.O. Box 55665
SE-102 15 Stockholm, Sweden
info@ifn.se
www.ifn.se

Exchange rate sensitivity and the net foreign asset composition

Malin Gardberg*†

February 2, 2021

Abstract

Many currencies, especially from countries with negative net foreign assets, depreciate during financial turbulence. Using a panel of 26 currencies for the period 4/2002 – 12/2019, I show that the net foreign asset composition is related to the exchange rate sensitivity to global financial market uncertainty changes. Net foreign debt is associated with a higher sensitivity, whereas net equity and FDI are not. Ownership matters too, as this association is stronger for private net liabilities. In emerging markets, this vulnerability arises from net other investments, while G10 currencies are more sensitive the more private net portfolio debt the countries have.

JEL Classifications: F31, F32, G15, G20, C23

Keywords: Exchange rates, private net foreign portfolio debt, financial market risk tolerance

*malin.gardberg@ifn.se, Research Institute of Industrial Economics (IFN), Box 55665, SE-102 15 Stockholm, Sweden.

†I thank Lorenzo Pozzi, Casper de Vries, Agnieszka Markiewicz, Massimo Giuliodori, Vadym Volosovych and two anonymous referees for valuable comments and suggestions. Seminar participants at Erasmus School of Economics, Tinbergen Institute, RGS, GEP/CEPR, Bank of Finland, Unicredit & SUERF, IFN and NorMac are also gratefully acknowledged for their constructive feedback. I am also grateful for funding from Jan Wallanders och Tom Hedelius stiftelse samt Tore Browaldhs stiftelse and the Marianne and Marcus Wallenberg Foundation. This paper has previously been circulated as "Linking net foreign portfolio debt and equity to exchange rate movements".

1 INTRODUCTION

There have been large swings in both the financial sector's risk appetite and exchange rates during the past 15 years, and many countries with large negative net foreign asset positions have seen their currencies depreciate sharply during times of global financial market turbulence. Several central banks, especially in emerging markets, responded to this by conducting substantial currency interventions to dampen the exchange rate movements. Different types of external capital are however heterogeneously influenced by global risk, and the country's underlying foreign debt and asset structure might affect how the exchange rate reacts to financial market turmoil. This paper therefore empirically disentangles how the composition of net foreign assets is related to the exchange rate sensitivity to global financial market uncertainty.

Gabaix & Maggiori (2015) (hereafter GM15), propose a theory of exchange rate determination based on global imbalances and resulting capital flows in imperfect financial markets. As financiers' risk-bearing capacity is limited, currencies of countries with large external debts must offer high expected returns to compensate for the resulting currency risk. Balance sheet changes of financial institutions impact the pricing (or level) of foreign currency lending, which in turn affects the exchange rate.[1] Della Corte *et al.* (2016) indirectly prove this by showing that countries' external imbalances explain cross-sectional variation in currency excess returns. They hypothesize that net debtor countries must offer a currency risk premium to compensate investors for taking on this risk, as debtor currencies tend to depreciate when risk taking is limited. Habib & Stracca (2012) also empirically confirm that currencies with large external imbalances are more vulnerable to global risk sentiment swings.[2]

International capital flows to both advanced and emerging market economies are procyclical and tend to amplify business cycle fluctuations.[3] However, not all types of capital flows are equally procyclical. Brunnermeier *et al.* (2012) and Avdjiev *et al.* (2018) note that aggregate FDI and net portfolio equity flows are generally fairly stable over the financial business cycle. This is partly due to a different investor base which is less leveraged and which has a more long term focus than debt investors. Another reason is that equity and FDI investments involve more risk and profit sharing, as foreign equity investors absorb the valuation losses in a financial crisis, which, combined with local currency depreciation, discourages portfolio equity outflows. Debt flows, on the other hand, portray strong procyclicalities. Banks intermediate a large share of the debt inflow, and bank lending responds not only to the creditworthiness of a project, but also to the bank's balance-sheet capacity. Moreover, debt is subject to maturity mismatch and roll-over risk.[4] Consequently, countries with large outstanding net debt liabilities should have currencies that are more vulnerable to changes in the banking sector risk-bearing capacity or the global risk sentiment than countries with the equivalent net portfolio equity and FDI liabilities.

In a panel study of 25 exchange rates against the USD over the period 4/2002 – 12/2019, I identify the types of net foreign assets that are associated with a higher exchange rate sensitivity to global risk intolerance changes. I disentangle how the relationship between changes in financial sector risk-bearing capacity (proxied by changes in the VIX index or the Libor-OIS spread) and different types of foreign capital, such as portfolio debt, equity, FDI, and other investments, are related to exchange rate movements. I differentiate between private and public net foreign assets and investments (and banks and corporates), as both public and private debtors (and banks and corporates), but also investors in private and public debt, generally have different risk profiles and investment horizons. I moreover show how the relationship between risk intolerance, net foreign asset composition, and exchange rates differs between G10 and emerging market (EM) currencies, and how this relationship has evolved over the sample period. Many previous studies have looked at the exchange rate impact of international capital flows[5], but so far only Habib & Stracca (2012) have looked at how net foreign liabilities affect the exchange rate impact of global risk sentiment changes. To the best of my knowledge, nobody has yet looked at how the *composition* of net foreign assets relate to the impact of financial market uncertainty on the exchange rate.

My main findings are that the composition of the net foreign asset position is related to the exchange rate sensitivity to changes in global financial market risk tolerance. Countries with large net external debt liabilities, particularly in net portfolio debt and other investment liabilities, have currencies that are more sensitive and tend to depreciate far more in response to financial market turbulence than countries with smaller net external debt liabilities. Moreover, currencies of countries with the equivalent negative net foreign equity or FDI position are much less affected by changes in the global risk sentiment. Due to these offsetting exchange rate effects of net external debt and equity positions, the impact of financial market imbalances is underestimated if we only look at the total net foreign assets. These results can moreover be seen as a confirmation of GM15's theory that changes in the risk-bearing capacity of financial intermediaries affect exchange rates, as it is the asset classes that are typically intermediated by banks and financial institutions (such as portfolio debt, bank loans, and trade credits) that are associated with a higher exchange rate sensitivity.

Secondly, I find that the ownership of the net foreign assets matters. The exchange rate sensitivity is higher in countries with high private net foreign liabilities like portfolio debt and other investment liabilities as opposed to public liabilities. Moreover, EM currencies are in general more sensitive to global risk sentiment changes than G10 currencies. Additionally, I find that the exchange rate vulnerability is associated with slightly different asset classes for the G10 and EM currencies. In the emerging markets, the exchange rate sensitivity is higher in countries where the banking sector net other debt liabilities (including bank loans, trade credits, and bank deposits) are large, as predicted by GM15. The G10 currencies are also more vulnerable to changes in the risk sentiment the more net external portfolio debt the countries have. Finally, I find that the relationship between banking sector risk intolerance, net positions and exchange rates has become stronger since the financial crisis.

These results are important for risk calculations and hedging decisions, but they also have policy implications. Many central banks[6] have engaged in currency interventions to smooth exchange rate volatility during times of financial turmoil in the past. My results reveal one source of this vulnerability and highlights a channel through which financial intermediaries can have destabilizing effects on the economy. These results are also crucial for the evaluation of financial market reforms. There are substantial differences in how debt and equity investments are taxed in most countries, and a change in the relative tax burden on either asset class could thus impact the exchange rate vulnerability as well. Many emerging market economies also have substantial restrictions on foreign ownership of debt, but especially equity products. When evaluating the costs and benefits of allowing foreign investors in the local financial markets, these findings provide important information on the heterogeneous exchange rate impact of foreign debt and equity ownership. Finally, these findings are also interesting from a corporate finance perspective. Modigliani & Miller (1958) state that if financial markets are complete, the liability structure should not affect the firm value. If this logic is transferred to the aggregate level, the value of a country's assets should not depend on its debt-to-equity ratio. As the price that investors are willing to pay for a country's currency depends on the economy's underlying capital structure, the Modigliani-Miller theorem does not hold in the aggregate.

The rest of the paper is structured as follows: Section 2 describes the method and models, Section 3 describes the data, Section 4 presents and discusses the results and Section 5 concludes.

2 EMPIRICAL FRAMEWORK

The empirical model used in this paper is inspired by GM15's exchange rate model with imperfect markets, where exchange rates are determined by capital flows, countries' net foreign asset positions, and the financial sector risk-bearing capacity.[7] International capital flows resulting from households' investment decisions are intermediated by financiers, who bear the resulting currency risk. The exchange rate is determined by the demand and supply of capital denominated in the different currencies, where s_t is defined as the quantity of US dollars bought by 1 unit of foreign currency (i.e., $\Delta s > 0$ implies a foreign currency appreciation) in period t. The financiers are subject to financial constraints, which limit their risk-bearing capacity. The ability to bear risk is denoted by RI, where a higher RI implies higher risk intolerance or lower financier risk-bearing capacity. Financiers need compensation for taking on currency risk from financing the imbalance, and to be willing to absorb this risk, they must expect the foreign (debtor) currency to appreciate. According to GM15's Proposition 2, the impact of a change in financial sector risk-bearing capacity RI on the exchange rate s_0 in a two-period two-country setting is:

$$\frac{\partial s_0}{\partial RI} = \frac{-nfa_0}{2 + RI} \tag{1}$$

where nfa_t is the net foreign asset position in time t. This implies that currencies of countries with negative net foreign assets will depreciate if there is a sudden worsening of the financier's risk-bearing capacity, whereas currencies of countries with positive net foreign assets appreciate. This also holds when different types of net foreign assets are considered. If we consider nfa fixed and treat s as a function of only RI, $f(RI)$, by using approximation by differentials we can use $ds_0 \approx \Delta s_0$, where

$$\Delta s_0 = f'(RI)\Delta RI = \frac{-nfa_0}{2+RI}\Delta RI \tag{2}$$

Thus, the change in the exchange rate depends on the country's net foreign asset position and the level and change in the financial sector's risk-bearing capacity.

The basic panel within-group (WG) regression that looks at the interaction of different net foreign assets to GDP (NFA_{it}) and the change in global financial sector risk intolerance (ΔRI_t) on exchange rate changes (Δs_{it}), is based on equation (2). Here s_{it} represents the log spot exchange rate of currency i in period t in units of USD per foreign currency. Thus, $\Delta s > 0$ implies an appreciation of the foreign currency against the USD, where $\Delta s_{it+1} = s_{it+1} - s_{it}$. Risk intolerance denotes the financial sector willingness and ability to bear risk, where ΔRI_t is proxied either by a change in the VIX index, which measures general financial sector risk intolerance, or by the Libor-OIS spread, which measures banking sector risk. The basic exchange rate model is:

$$\Delta s_{it} = \alpha\Delta RI_t + \beta'\Delta RI_t NFA_{it} + \zeta' NFA_{it} + \delta' X_{it-1} + \gamma_i + \varepsilon_{it} \tag{3}$$

where NFA_{it} and X_{it} are vectors of different net foreign assets and controls, the vectors β, ζ and δ contain the estimated coefficients, γ_i is the currency fixed effect and ε_{it} is the error term. α is the general exchange rate impact of ΔRI_t. During times of diminishing risk tolerance, most currencies, except the so called "safe haven currencies", tend to depreciate, so we expect $\alpha < 0$. If we only consider total net foreign assets to GDP in each country, i.e., $NFA_{it} = [nfa_{it}]$, the estimated coefficient on the interaction term is expected to be positive; countries with negative nfa react stronger to increases in risk intolerance and depreciate more (as $\Delta s < 0$ implies a depreciation against the USD). This is also what Proposition 2 of GM15 predict. When the financial sector's risk-bearing capacity is good (RI is low), the currency returns of the net debtor currencies are positive, while during times of financial distress, currencies with negative net foreign assets depreciate due to foreign capital outflows. It is however possible that it is not only the different net foreign asset positions that affect the exchange rate, but that the exchange rate also has an impact on the external debts and liabilities. To avoid this simultaneity problem, and because I am interested in the exchange rate impact conditional on the net positions, I use the beginning of period net values.[8] Due to intra-cluster correlation both across time and currencies, I adjust the standard errors for clustering by currency and time.[9]

Not all types of foreign capital flows are procyclical and equally influenced by the global risk sentiment; debt assets are more affected by the global risk sentiment than equity. In the main analysis we therefore look at two net components, net total debt ($nTotDebt$) and net total equity ($nTotEquity$)[10], i.e., $NFA = [nTotDebt\ nTotEquity]$, where the interaction of these with ΔRI are the variables of interest. Currencies with negative net foreign debt assets are expected to be most affected by the global financial business cycle, as foreign banks often repatriate capital during episodes of low risk tolerance. In contrast, equity investors are discouraged from selling their assets due to the depressed equity prices. The coefficient on the interaction term with net total foreign debt is therefore expected to be positive. Moreover, I expect this coefficient to be larger in magnitude than the one on net total foreign equity liabilities, as I expect net foreign equity liabilities to have a much smaller destabilizing exchange rate impact. As there are substantial differences between different types of debts and equity, the net positions in NFA are subsequently split into net portfolio debt ($nPDebt$), net other investment ($nOther$), net portfolio equity ($nPEquity$), and net FDI ($nFDI$). The variables $nPDebt$, $nOther$, $nPEquity$, and $nFDI$ interacted with ΔRI are in this case our variables of interest.

The public sector generally has broader access to finance than the private sector and is less dependent on financial intermediaries. The foreign creditors financing public and private debt are moreover likely to differ both w.r.t. risk tolerance and investment horizon, as private debt is generally perceived as riskier than government debt. The higher risk excludes many pension funds and low-risk investors (which are often less leveraged) from investing in private debt, and many insurance and pension funds are required to hold a substantial share of low-risk government bonds. Avdjiev *et al.* (2018) find that sovereign capital in- and outflows respond little to global risk sentiment changes, whereas both private debt in- and outflows are positively correlated with the VIX index. Moreover, Adams-Kane *et al.* (2017) show that foreign banks that experience an economic crisis in their home country cut down on their lending to developing countries substantially and often repatriate capital to boost their liquidity at home instead of diversifying their lending internationally. Consequently, debt intermediated by the banking sector is highly procyclical and more volatile than non-bank debt flows, and the exchange rate response could thereby also be affected by the net foreign asset ownership structure. The net debt assets in NFA are therefore also split into net holdings by the private sector ($priv$), general government ($govt$), deposit-taking financial institutions ($bank$), and non-bank sectors ($osect$), which is mostly the corporate sector.

Avdjiev *et al.* (2018) note that capital flows to and from advanced and emerging economies (EM) react differently to uncertainty shocks, which might lead to different exchange rate outcomes. EM investments are generally perceived as riskier than investments in most advanced economies, which might attract a different foreign investor base and exclude some low-risk investors. A change in the global risk sentiment might affect investors differently, leading to different reactions in the G10 and EM currencies, so the sample is also split between G10 and EM currencies. The relationship between imbalances, risk-bearing capacity, and exchange rates might also have changed over time, as financial innovation has led to a wider range of financial products, financial reforms and financial integration has altered foreign capital flow characteristics, and changes in banking regulations after the credit crisis have changed the amount and type of risk-taking allowed by financial institutions. I therefore also look at a post-crisis sample (1/2010 – 12/2019).

The control variables in X_{it} include yield differentials such as the difference in local stock market performance versus the US ($\Delta stock_{it} - \Delta SP500_t$), inflation differentials ($\pi_{it} - \pi_{USt}$) and 3 month interbank rate differentials ($i_{it} - i_{USt}$). To account for carry trade reversals, the interaction of the interest differential and the risk sentiment, $(i_{it} - i_{USt})VIX_t$, is included like in Habib & Stracca (2012). Crisis dummies for the months September-December 2008 and relative PPP (PPP_{it}) are also included, and the total net foreign assets to GDP (nfa_{it}) are used to control for the country's financing needs. Log changes in central bank currency reserves (ΔRes_{it}) capture central bank currency interventions and the real central bank policy rate (CBr_{it}) control for the domestic monetary policy. As the exchange rate might affect inflation, interest rates, and stock markets, lags of all the control variables are used to avoid possible simultaneity issues.

3 DATA

The analysis is conducted using monthly data for an unbalanced panel of 26 advanced (G10) and emerging market (EM) currencies from 4/2002 to 12/2019. Bilateral (end of period) exchange rates against the USD are downloaded from IMF's IFS (2020) database.[11]

Data on total external assets, liabilities, and subcomponents are collected from IMF's Balance of Payments and International Investment Position Statistics (BoP-IIP, 2019). As these data are only available at a quarterly frequency, the last known value is used until the data is updated next quarter. External assets are the USD value of the assets a country owns abroad, and external liabilities the USD value of domestic assets owned by foreigners. Total debt consists of portfolio debt, direct investment debt, and other investment debt (currency and deposits, loans, other accounts receivable, trade credits and advances). Total equity consists of portfolio equity and direct investment equity. Net foreign assets (nfa) is the difference between external assets and liabilities relative to GDP (with GDP data from the IFS (2020) database). Net total debt ($nTotDebt$), net total equity ($nTotEquity$), net portfolio debt ($nPDebt$), net portfolio equity ($nPEquity$), net direct investment assets ($nFDI$), and net other investments ($nOther$) are defined similarly as ratios to GDP. These are depicted in Figure 1 and described in the Online Appendix. The net debt positions are also split into net assets held by the private sector ($nTotDebt^{priv}$) and the general government ($nTotDebt^{govt}$).[12] The privately-held net assets are in turn split between deposit-taking corporations ($bank$) and other sectors ($osect$), which includes non-financial corporations, other financial corporations, households, and other sectors. This breakdown is also available for net portfolio debt and net other investment assets ($nPDebt$ and $nOther$). The private net foreign position is created by subtracting private foreign liabilities from private foreign assets, and the same applies to the other ownership positions. As the ownership breakdown is a novel feature of the BoP-IIP statistics, a note of caution is needed as the countries' reporting standards vary somewhat. In an extension, I also use the proportion of external debt liabilities denominated in local currency (LCD) provided by Bénétrix *et al.* (2019) for the years 2001–2017. The annual end-of-period data is converted to monthly observations by keeping the data constant until a new observation is available.[13]

This paper uses two different proxies for risk intolerance. The first one is the VIX index, which is the most commonly used risk aversion measure in financial markets and is the "risk-neutral" expected stock market variance based on the implied volatility of S&P500 index options. A surge in the VIX index ($\Delta VIX > 0$) implies higher financial market volatility and typically higher risk intolerance (Collin-Dufresne *et al.*, 2001). The second measure, the Libor-OIS spread, is the 3-month interbank interest rate (Libor) and Overnight Index Swap (OIS) difference. As the OIS contract is considered fairly risk free (as no principal is exchanged with a swap) while the Libor reflects the credit risk of borrowing to banks, the Libor-OIS spread is an indicator of banking sector risk. A widening of the Libor-OIS spread ($\Delta LibOIS > 0$), implies an increase in banking sector uncertainty. The Libor-OIS spread consists of the GDP-weighted Libor-OIS spreads of the US, UK, Eurozone (Germany), Switzerland, and Japan. To make the Libor-OIS spread exogenous to own-country changes, the contribution of the own-country Libor-OIS spread is excluded from the global average for these countries. For robustness, I also use a GDP-weighted average of sovereign CDS-spreads and a decomposition of the VIX into a variance premium and the conditional variance from Bekaert & Hoerova (2014). Data for the Libor-OIS and CDS spreads and the VIX index are downloaded from Bloomberg. To make the risk measures comparable, they are all normalized to have a mean of 0 and a standard deviation of 1.

Control variable data for inflation (CPI), PPP, and central bank reserves data are from IMF databases (IFS and WEO), the interbank interest rates and stock market indices are from OECD's Monthly Monetary and Financial Statistics (MEI) (and central banks of the non-OECD countries), and central bank policy rates are from BIS policy rate statistics. The interest rate differential is the immediate interbank rate difference between the foreign country and the US. The stock market differential captures the monthly difference in the main foreign country stock market index versus the US, and the inflation differential is the difference between foreign and US CPI. The change in foreign currency reserves is defined as the change in foreign reserve assets relative to GDP.

4 RESULTS

4.1 Net foreign assets

First, the within-group (WG) results of equation (3), which looks at the relationship between total net foreign assets (nfa) and the exchange rate, are presented in Table 1 in columns $i - iv$.[14] The coefficients on the change in global risk intolerance ΔRI, as proxied the change in financial market volatility, ΔVIX, or banking sector uncertainty, $\Delta LibOIS$, and the interaction terms are significant and of the expected sign. The negative estimated coefficient on ΔRI implies that a surge in RI leads to a general currency depreciation against the USD (as $\Delta s < 0$ is a foreign currency depreciation). The positive coefficients on the interaction terms imply that countries with negative net foreign assets ($nfa < 0$) depreciate further in case of a sudden worsening of the financial market sentiment (ΔVIX or $\Delta LibOIS > 0$), whereas countries with a positive net foreign asset position experience a much smaller currency depreciation (if any). The total estimated impact on Δs of ΔRI is $\hat{\alpha} + \hat{\beta}\overline{nfa}$ where $\overline{nfa}$ is the average nfa. The results in column ii thus suggest that if the VIX index increases by one standard deviation, currencies with no net foreign assets depreciate by 1.48 % against the USD, while countries with negative net foreign assets experience a much larger depreciation.[15]

4.2 Net total debt and net total equity

As not all types of capital are equally affected by the business cycle, the positions are split into net total debt (*nTotDebt*) and net total equity (*nTotEquity*). This allows us to see whether currencies with negative net foreign debt assets (portfolio debt, bank and corporate loans, bank deposits, trade credits, other and direct investment debt) are more sensitive to risk sentiment changes than countries with similar net foreign equity positions (portfolio equity, other and direct investment equity). As capital flows to and from emerging markets tend to behave somewhat differently than G10 country flows, and as this relationship might have changed over time, the sample is also split between G10 and EM currencies, and reduced to a post-crisis sample (1/2010–12/2019).

As can be seen from columns $v - xii$ in Table 1, the estimated coefficients on ΔVIX and $\Delta LibOIS$ are negative and significant in most cases except the G10 sample, implying that countries generally experience a currency depreciation against the USD when global risk intolerance increases. The coefficients on ΔVIX and $\Delta LibOIS$ are much larger for the EM currencies than for the full or G10 currency sample, which implies that swings in risk intolerance are generally associated with larger fluctuations in EM than G10 currencies, regardless of their net foreign debt or equity positions. The estimated interaction coefficients including *nTotDebt* and the VIX or Libor-OIS spread changes are all positive, and significant in all models except column x. These results imply that negative net debt assets are associated with a higher exchange rate sensitivity to surges in risk intolerance (i.e., the currency depreciates even further), whereas currencies of countries with positive net debt assets depreciate much less or not at all. Thus, countries that rely more on net foreign financing through assets that are to a larger extent intermediated by banks have exchange rates that are more sensitive to global risk appetite swings. The impact of net equity positions on the exchange rate sensitivity is small and insignificant in most cases. However, for the EM countries, the results indicate that currencies of countries with positive net equity tend to depreciate when the banking sector uncertainty increases. An explanation to this could be that debt and equity are to some extent substitutes, and that countries with a higher share of net foreign equity financing have less net foreign debt financing. It could however be that some countries are unable to attract foreign equity financing due to poor institutional quality and are therefore forced to finance themselves through debt. Due to these endogeneity concerns, I interpret these results (and especially the EM sample results) as correlations rather than causal effects. In the post-crisis sample, the interaction effect of banking sector uncertainty, $\Delta LibOIS$, is much larger (but less precise) than in the full sample. This suggests a stronger relationship and interactions between the banking sector and foreign exchange markets now than before the crisis, while the effect of ΔVIX has remained fairly constant. As the Chow test indicates structural instability between both the G10 and EM subsamples, and in the series over time, more weight should be given to the subsample results.[16]

The total exchange rate impact of a risk intolerance change, ΔRI, is $\hat{\alpha}+\hat{\beta}_1\overline{nTotDebt}+\hat{\beta}_2\overline{nTotEquity}$. Figure 2 illustrates how the different currencies in the sample tend to react during fluctuations in the VIX index or the Libor-OIS spread. According to the figure, reactions between the different currencies vary substantially. A one standard deviation increase in the VIX index is associated with only a slight depreciation of the CHF by 0.4% against the USD, whereas the ZAR, TRY, RON, and CLP with large negative net debt positions tend to depreciate the most, by over 2%. This is equivalent to a bit over half of a standard deviation for these currencies, which suggests that this effect is substantial for large imbalances.[17] The conditional correlation between $\Delta LibOIS$ and Δs is fairly similar to the ΔVIX and Δs correlation for the EM currencies, but is somewhat weaker for the G10 currencies.

As different sources and recipients of external financing are heterogeneously affected by fluctuations in global risk tolerance, the exchange rate response might also depend on the ownership structure of the net positions. Therefore, the exchange rate impact of private (*priv*) and general government (*govt*) net total debt is considered separately. As financial institutions might have different investment objectives than corporations and households, the private net debt is also split into net positions by deposit-taking financial institutions (*bank*), and non-bank sectors (*osect*), which is mostly the corporate sector. The results in the odd-numbered columns in Table 2 suggest that the exchange rate sensitivity is much higher in countries with substantial private net total debt than in countries with the same government net total debt in all subsamples. Moreover, the even-numbered columns reveal that the exchange rate vulnerability is high both in countries with substantial corporate and banking sector net debt liabilities in the full sample, as both interaction terms with $nTotDebt^{osect}$ and $nTotDebt^{bank}$ are significant. However, in the G10 and EM subsamples the results suggest that the vulnerability arises from the banking sector rather than the corporate sector. This finding that especially banking sector net debt liabilities are associated with higher exchange rate sensitivity further corroborates GM15's theory that changes in financial intermediaries' risk-bearing capacity cause banks to reprice their foreign lending, which affects both capital flows and the exchange rate and gives rise to this exchange rate sensitivity.

4.3 Net portfolio debt and equity, net FDI, and net Other investment

The net foreign assets are then split into the components net portfolio debt (*nPDebt*), net portfolio equity (*nPEquity*), net portfolio FDI (*nFDI*), and net other investment (*nOther*), where the other investments consist mostly of bank and corporate loans, bank deposits, and trade credits. The positive interaction coefficients on *nPDebt* and *nOther* in Table 3 suggest that negative net foreign portfolio debt and other investment assets are associated with a significantly deeper currency depreciation during financial turbulence in both the full and the post-crisis sample.[18] This is also illustrated in the two upper heat maps in Figure 3 that are based on column 2 in the upper panel of Table 3; VIX increases are associated with deeper exchange rate depreciation in countries with negative *nPDebt* and *nOther*. As a large share of the foreign debt inflow is intermediated by foreign banks whose risk-bearing capacity decreases during times of financial uncertainty, an increase in risk intolerance thus translates into a deeper currency depreciation in countries with large portfolio debt and other debt liabilities. However, currencies of countries with similar net external portfolio equity are not affected by the market sentiment swings to the same extent. There are some indications that net portfolio equity and FDI liabilities might even insulate the exchange rate from an increase in financial market risk aversion, as the coefficients on the interaction terms including *nPEquity* (and occasionally *nFDI*) are often negative and some times significant. A potential explanation for this is that debt and equity financing are substitutes, so countries that have more equity financing have less debt financing instead. These results also support GM15's exchange rate theory, as both portfolio debt and other investment debt are typically intermediated by financial institutions, whereas FDI and portfolio equity are not. This applies to both the general risk intolerance measure, the VIX, and the banking sector measure, the Libor-OIS spread. The post-crisis conditional impact of ΔVIX is somewhat bigger, whereas the conditional impact of $\Delta LibOIS$ has become much stronger since the crisis (while the general effect has gotten smaller and is insignificant). One potential explanation for this is that banks adjust their foreign lending much faster in response to risk tolerance changes, due to either regulatory changes or necessity, and that they pay more attention to the imbalances post-crisis. In the G10 sample, the vulnerability to VIX or Libor-OIS spread changes is significantly higher the larger the net portfolio debt liabilities, but also to some extent, the other investment liabilities are. In the EM sample, where net other investment debt liabilities are more prevalent than net portfolio debt, the VIX vulnerability is higher in countries with net other investment liabilities in the post-crisis period, thus suggesting that the exchange rate vulnerabilities originate from somewhat different sources in the subsamples.

Finally, I look at how the portfolio debt and other investment ownership structure relates to exchange rate sensitivity.[19] As can be seen from Table 4, it is mainly net foreign portfolio debt and other investments (mostly bank loans) in the private sector that are associated with a higher exchange rate vulnerability in the full and the post-crisis sample. The effect is larger for the net other private debt than for the net private portfolio debt, which is also illustrated in the heat maps in the lower panel of Figure 3. Noteworthy is also that the interaction effects are somewhat larger for the private net assets than for the total net assets in the upper panel of Figure 3. When I separate the impact between the banking sector and non-bank (mostly corporate) sector in the even numbered columns in Table 4, I find that the sensitivity is amplified by banking sector net liabilities in both portfolio and other investment debt in both the full and post-crisis samples. In the emerging markets, it is mainly the net other investment debt in the private sector (and especially the banking sector) that is associated with a higher exchange rate vulnerability. For the G10, the vulnerability is instead higher when the banking sectors' net portfolio liabilities are high. The interaction effects are once again larger in the post-crisis period, especially for the Libor-OIS spread, suggesting that the financial intermediaries' impact on exchange rates has become larger over time. As the exchange rate vulnerability arises from the banking sector in particular, this gives further support to GM15's theory that a reduction in risk tolerance leads to an exchange rate depreciation of the debtor country due to a scale back in foreign lending. The EM sample results can also be linked to Adams-Kane et al.'s (2017) findings that foreign banks reduce their foreign lending to developing countries during crises, which makes the exchange rate more vulnerable to swings in the global risk sentiment as well.

4.4 Different mechanisms

External debt denominated in foreign versus local currency

GM15 predict that the exchange rate vulnerability arises from the change in intermediary risk-bearing capacity, which affects the intermediaries ability or willingness to take on currency risk. If that is the case, currencies with a higher share of external debt in local currency should be more sensitive to financial turbulence. Foreign currency debt is however generally associated with higher risk than local currency debt both due to the "Original sin" related to foreign currency debt, and as debtors are less likely to default on local currency obligations[20], which could also increase the sensitivity and thus reduce the local currency effect. Table 5 presents the results from a triple interaction specification with $nTotDebt$ interacted with both the risk intolerance changes and the share of external debt liabilities denominated in local currency the previous year (LCD). The interaction terms are mostly insignificant.[21] However, the signs of the coefficients and the heat map in Figure 4 reveal that this sensitivity in the full, G10, and post-crisis sample is higher among currencies with a higher share of local currency debt and with negative $nTotDebt$, which again supports GM15's intermediation hypothesis. The EM currency results are more inconclusive, which may suggest that for them the "Original Sin"-effect is stronger than the intermediation effect.

Alternative RI measures

There is no clear consensus on the optimal proxy for financial sector risk intolerance, although the VIX index is the most commonly used. Bekaert *et al.* (2013) and Bekaert & Hoerova (2014) decompose the squared VIX index into an equity variance risk premium (the expected premium from selling stock market variance in a swap contract) and the conditional stock market variance. They argue that the variance premium can be used as a measure of risk aversion and other non-linear pricing effects, while the conditional variance is an estimate of uncertainty or the quantity of risk. As the separation of the quantity of risk from risk aversion might give us more information about the mechanisms at play, I look at the impact of risk aversion changes as proxied by variance premium changes ($\Delta VarPrem$) and uncertainty changes ($\Delta CondVar$). Table O.A.3 in the Online Appendix reveals that $\Delta CondVar$ has a larger general exchange rate impact than $\Delta VarPrem$. The interaction effects of $\Delta VarPrem$ and $\Delta CondVar$ are similar, where both changes in risk aversion and uncertainty have larger exchange rate effects in countries with net total foreign debt liabilities, and especially so in the private sector (although the effect of $\Delta CondVar$ is at times insignificant). This suggests that uncertainty changes have a larger general impact on all currencies than risk aversion changes, while the exchange rate effect of risk intolerance changes is slightly more related to the country's underlying net foreign asset position (which supports GM15's intermediation story). Moreover, Della Corte *et al.* (2018) show that global sovereign credit risk, as measured by credit default swap spreads, is also related to exchange rate movements. The results in Table O.A.3 show that global CDS spread changes have a large general effect, and that the higher credit risk is also associated with a stronger depreciation of the currencies with large net debt liabilities, and especially in the private sector.[22]

Gross foreign asset and liability positions

Forbes & Warnock (2012) show that gross foreign capital inflows can behave very differently from net inflows during sudden capital flow stops. Although looking at the gross positions and exchange rate relationship is a fundamentally different question, my conclusions based on net positions also apply to gross positions. Table O.A.4 in the Online Appendix shows the exchange rate impact of ΔRI, conditional on foreign debt and equity assets and liabilities to GDP ($AssetsTotDebt$, $AssetsTotEquity$, $LiabTotDebt$ and $LiabTotEquity$). The results imply that gross debt liabilities (especially private) are associated with weaker currencies against the USD during financial turbulence, and that gross debt assets are associated with a stronger exchange rate, both in the full sample and subsamples. The gross equity positions do not show a similar pattern, just like with the net positions. These results generally support the claim that the exchange rate is more sensitive to ΔVIX or $\Delta LibOIS$ the higher the foreign debt liabilities are, and that foreign debt asset holdings offset this effect.

4.5 Robustness

Finally, several robustness tests are carried out, and some are presented in the Online Appendix. The inclusion of time fixed effects is not possible due to linear dependence with the global VIX index and Libor-OIS spread. To confirm that some underlying time trend does not drive the results, I include time fixed effects and exclude ΔVIX or $\Delta LibOIS$ (Table O.A.5). My conclusions are also robust to the inclusion of currency-specific time trends as well as the use of net foreign asset position values instead of GDP shares. The results are not driven by outliers either, as the conclusions prevail with winsorized data.

As the VIX index originates from US stock options, there is a concern that USD movements influence the VIX. To exclude this channel, the analysis is done with SEK and KRW as base currencies while excluding the USD, as changes in these smaller currencies are unlikely to have substantial effects on the VIX or the Libor-OIS spread. As policymakers might be interested in currency movements against the country's important trading partners, the analysis is done with the change in the trade-weighted currency basket (the broad nominal effective exchange rate (NEER) index from BIS) as dependent variable. The results in Table O.A.6 reveal that my conclusions are valid for alternative base currencies and a trade-weighted currency basket, implying that the results are unlikely to be driven by the impact of USD on VIX. The original conclusions also prevail after excluding the "safe haven" currencies USD, JPY, and CHF from the sample. Regarding endogeneity concerns between the net foreign asset position and exchange rate changes, I reach the same conclusions even if I condition the exchange rate response on net foreign asset positions lagged by 12 months, or if I use an instrumental variable (IV) approach where the nfa positions are instrumented by 1, 3 or 12 month lags (see Tables O.A.7 and O.A.8). To ensure that the results are not driven by inflation, stock market, or interest rate expectations, further lags of these (and all other control variables) are used to confirm this. To rule out that the results are driven by omitted variable bias as I use lagged control variables, I confirm that my conclusions also hold when using contemporaneous values of the control variables.

5 CONCLUSION

GM15's exchange rate theory predicts that exchange rates of countries with net foreign liabilities are more sensitive to reductions in financial market risk-bearing capacity, as the indebtedness affects the financial intermediaries willingness and ability to finance the imbalances and take on currency risk. I find that this is indeed the case, but more importantly, that different types of net foreign assets have different effects on this exchange rate vulnerability. In this panel study of 25 G10 and EM currency pairs against the USD over the period 4/2002 – 12/2019, I present a link between the composition of net foreign assets and the way exchange rates react to financial market uncertainty. Net foreign debt liabilities, which are mostly intermediated by financial institutions, are associated with a higher exchange rate sensitivity to financial market uncertainty changes. Net foreign equity and direct investment liabilities, which involve more risk sharing and are to a lesser extent intermediated by banks, do not have this effect and might, if anything, even dampen the exchange rate impact somewhat. Thus, the exchange rates of countries with large net foreign debt liabilities depreciate much more in response to a drop in the global risk sentiment than countries with the equivalent net foreign equity position. This applies both to a general measure of financial sector risk intolerance, the VIX index, and a measure of banking sector risk intolerance, the Libor-OIS spread. Due to these offsetting exchange rate effects of the different types of net foreign assets, if one only considers the total net foreign asset position's impact, the negative impact of different external imbalances on exchange rate stability is underestimated.

Another important finding is that the distinction between private and public net foreign debt assets matters, as the exchange rate sensitivity is higher especially in countries with large private net foreign debt liabilities as opposed to public. This again supports GM15's intermediation story, as the public sector tends to have better access to finance and be less dependent on financial intermediaries, and is often associated with lower risk. The exchange rate impact of the Libor-OIS spread conditional on the different types of net foreign assets has moreover become larger and stronger since the financial crisis. Currencies of countries with negative net debt thus respond more strongly to changes in banking sector risk now than before the credit crisis. These findings are important for policymakers concerned about exchange rate vulnerability to the global financial business cycle and for the evaluation of financial market reforms. Policymakers should be more alert when private net foreign debt liabilities are large. As the impact of the banking sector uncertainty has become stronger since the crisis, this also warrants more attention than before.

I also find that EM currencies are overall more influenced by the global risk sentiment than G10 currencies. The vulnerability moreover originates from different asset classes for the G10 and EM currencies. In the G10 countries, where both the external portfolio debt and other investment markets are large, it is mainly net external portfolio debt that is associated with this sensitivity. In the emerging markets, where most external financing is through "other investment debt", currencies are more sensitive the more net external other investment debt there is in the banking sector. This gives further support to GM15's theory that changes in the risk-bearing capacity of international financiers can give rise to exchange rate movements in debtor country currencies. This is also supported by the indication that this vulnerability is higher in countries where the share of local currency debt is higher. GM15's model, which the empirical model is partly based on, does however not allow for different types of external debtors or creditor, nor for several different types of foreign assets. Extending the model to allow for both investor and asset heterogeneity thus remains an important task for the future.

References

Adams-Kane, Jonathon, Caballero, Julian A, & Lim, Jamus Jerome. 2017. Foreign bank behavior during financial crises. *Journal of money, credit and banking*, **49**(2-3), 351–392.

Aizenman, Joshua, & Binici, Mahir. 2016. Exchange market pressure in oecd and emerging economies: Domestic vs. external factors and capital flows in the old and new normal. *Journal of international money and finance, vol 66*.

Alquist, Ron, & Chinn, Menzie D. 2008. Conventional and unconventional approaches to exchange rate modelling and assessment. *International journal of finance and economics*, **13**(1), 2–13.

Amstad, Marlene, Packer, Frank, & Shek, Jimmy. 2018 (Mar.). *Does sovereign risk in local and foreign currency differ?* BIS Working Papers 709. Bank for International Settlements.

Ang, Andrew, Hodrick, Robert, Xing, Yuhang, & Zhang, Xiaoyan. 2006. The cross-section of volatility and expected returns. *Journal of finance*, **61**(1), 259–299.

Araujo, Juliana D., David, Antonio C., van Hombeeck, Carlos, & Papageorgiou, Chris. 2015. Joining the club? procyclicality of private capital inflows in low income developing countries. *Imf working paper no. 15/163*.

Avdjiev, Stefan, Hardy, Bryan, Kalemli-Ozcan, Sebnem, & Servén, Luis. 2018. *Gross capital flows by banks, corporates and sovereigns.* NBER Working Papers 23116. National Bureau of Economic Research.

Bai, Jushan, & Perron, Pierre. 2003. Computation and analysis of multiple structural change models. *Journal of applied econometrics*, **18**(1), 1–22.

Bekaert, Geert, & Hoerova, Marie. 2014. The VIX, the variance premium and stock market volatility. *Journal of econometrics*, **183**(2), 181–192.

Bekaert, Geert, Hoerova, Marie, & Lo Duca, Marco. 2013. Risk, uncertainty and monetary policy. *Journal of monetary economics*, **60**(7), 771–788.

Bluedorn, John, Duttagupta, Rupa, Guajardo, Jaime, & Topalova, Petia. 2013. Capital flows are fickle; anytime, anywhere. *Imf working papers 13/183*.

BoP-IIP. 2019. *Balance of payments and international investment position statistics.* Database. International Monetary Fund.

Broner, Fernando, Didier, Tatiana, Erce, Aitor, & Schmukler, Sergio. 2013. Gross capital flows: Dynamics and crises. *Journal of monetary economics*, **60**(1), 113–133.

Brunnermeier, Markus, Rodrik, Dani, Gregorio, José De, Eichengreen, Barry, El-Erian, Mohamed, Fraga, Arminio, Ito, Takatoshi, Pisani-Ferry, Philip R. Lane Jean, Prasad, Eswar, Rajan, Raghuram, Ramos, Maria, Rey, Hélène, Rogoff, Kenneth, Shin, Hyun Song, Velasco, Andrés, di Mauro, Beatrice Weder, & Yu, Yongding. 2012. *Banks and cross-border capital flows: Policy challenges and regulatory responses.* Tech. rept. Brookings Committee on International Economic Policy and Reform.

Brunnermeier, Markus K., Nagel, Stefan, & Pedersen, Lasse H. 2009. Carry Trades and Currency Crashes. *Pages 313–347 of: NBER Macroeconomics Annual 2008, Volume 23.* NBER Chapters. National Bureau of Economic Research, Inc.

Bénétrix, Agustin S., Lane, Philip R., & Shambaugh, Jay C. 2015. International currency exposures, valuation effects and the global financial crisis. *Journal of international economics*, **96**, 98–109.

Bénétrix, Agustin S., Gautam, Deepali, Juvenal, Luciana, & Schmitz, Martin. 2019. Cross-border currency exposures. *Imf working paper*, **WP 19/299**.

Calvo, Guillermo A., Leiderman, Leonardo, & Reinhart, Carmen M. 1993. Capital inflows and real exchange rate appreciation in latin america: The role of external factors. *Imf staff papers*, **40**, 108–151.

Collin-Dufresne, Pierre, Goldstein, Robert S., & Martin, J. Spence. 2001. The determinants of credit spread changes. *The journal of finance*, **56**.

Correia, Sergio. 2016. *Linear models with high-dimensional fixed effects: An efficient and feasible estimator.* Tech. rept. Working Paper.

Della Corte, P, Sarno, L, & Sestieri, G. 2012. The predictive information content of external imbalances for exchange rate returns: How much is it worth? *Review of economics and statistics*, **94**.

Della Corte, P, Riddiough, S, & Sarno, L. 2016. Currency premia and global imbalances. *Review of financial studies*, **29**.

Della Corte, Pasquale, Sarno, Lucio, Schmeling, Maik, & Wagner, Christian. 2018. Exchange rates and sovereign risk. *Working paper.*

Driscoll, John, & Kraay, Aart. 1998. Consistent covariance matrix estimation with spatially dependent panel data. *The review of economics and statistics*, **80**(4), 549–560.

Eichengreen, Barry, & Hausmann, Ricardo. 1999 (November). *Exchange rates and financial fragility.* Working Paper 7418. National Bureau of Economic Research.

Fernández-Arias, Eduardo. 1996. The new wave of private capital flows: Push or pull? *Journal of development economics*, **48**, 389–418.

Forbes, Kristin J., & Warnock, Francis E. 2012. Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of international economics*, **88**(2), 235–251.

Gabaix, Xavier, & Maggiori, Matteo. 2015. International liquidity and exchange rate dynamics. *Quarterly journal of economics*, **130**, 1369–1420.

Ghosh, Atish R.and Qureshi, Mahvash S., Kim, Jun Il, & Zalduendo, Juan. 2014. Surges. *Journal of international economics*, **92**, 266–285.

Gourinchas, Pierre-Olivier, & Rey, Hélène. 2007. International financial adjustment. *Journal of political economy*, **115**, 665–703.

Habib, Maurizio, & Stracca, Livio. 2012. Getting beyond carry trade: What makes a safe haven currency? *Journal of international economics*, **87**, 50–64.

IFS. 2020. *International financial statistics*. Database. International Monetary Fund.

Jorda, Oscar, & Taylor, Alan M. 2012. The carry trade and fundamentals: Nothing to fear but feer itself. *Journal of international economics*, **88**, 74–90.

Kaminsky, Graciela L., Reinhart, Carmen M., & Vegh, Carlos A. 2004. *When it rains, it pours: Procyclical capital flows and macroeconomic policies*. Nber working papers 10780. National Bureau of Economic Research.

Levchenko, Andrei, & Mauro, Paolo. 2007. Do some forms of financial flows help protect against "sudden stops"? *The world bank economic review*, **21**, 389–411.

Martin, Anna D, & Mauer, Laurence J. 2003. Exchange rate exposures of us banks: A cash flow-based methodology. *Journal of banking and finance*, **27**.

Modigliani, F., & Miller, M. 1958. The cost of capital, corporation finance and the theory of investment. *American economic review*, **48**, 261–297.

Ricci, L. A., Milesi-Ferretti, G. M., & Lee, J. 2013. Real exchange rates and fundamentals: A cross-country perspective. *Journal of money, credit and banking*, **45**, 845–865.

Tai, Chu-Sheng. 2005. Asymmetric currency exposure of us bank stock returns. *Journal of multinational financial management*, **15**.

Notes

[1]GM15 note that active exchange rate risk taking is concentrated among a few large financial firms. About 80 % of the exchange rate flows in 2014 were concentrated among the ten largest banks, with currency risks accounting for a large share of overall risk taking. According to Deutsche Bank's and Citigroup's 2003 regulatory filings, currency risk accounted for 17-35 % of total stressed value at risk. Moreover, e.g. Tai (2005) or Martin & Mauer (2003) find that financial institutions absorb part of the currency risk.

[2]The related sudden stop literature on the causes of sudden capital flow reversals has also established that external "push" factors are the main drivers of capital flows, whereas the magnitude of such flows are determined by domestic "pull" factors (see e.g. Calvo *et al.*, 1993; Fernández-Arias, 1996; Ghosh *et al.*, 2014).

[3]Kaminsky *et al.* (2004), Brunnermeier *et al.* (2012) Bluedorn *et al.* (2013), Broner *et al.* (2013), Araujo *et al.* (2015).

[4] Levchenko & Mauro (2007) also find that especially FDI, but also portfolio equity flows, are fairly stable during sudden capital flow stops, whereas portfolio debt and other investment flows experience substantial reversals.

[5]E.g. Gourinchas & Rey (2007), Alquist & Chinn (2008), Della Corte *et al.* (2012), Aizenman & Binici (2016) and Ricci *et al.* (2013) find that net foreign assets have an impact on nominal or real exchange rates.

[6]This includes among others the central banks of Brazil, India, Indonesia, Japan, Mexico, Poland and Switzerland.

[7]Details about the model are available in the Online Appendix.

[8] There are several reasons to be concerned about endogeneity regarding the relationship between exchange rates and net foreign asset positions, which is why I interpret the results as correlations rather than causal effects. In the robustness section I however show that the conclusions also hold when using further lags of the net positions (3 and 12 month lags) or an instrumental variable approach where the net positions are instrumented by 1, 3, and 12 month lags.

[9] The two-way clustering is done using the package by Correia (2016). As the number of clusters is small, finite-sample corrections are applied to deal with the possible downward bias. The conclusions are robust to adjustment for clustering by either currency or time only, and for the error adjustment for cross-sectional correlation with the Driscoll & Kraay (1998) procedure.

[10]Total debt assets include portfolio debt, FDI debt, and other debt such as bank loans and deposits, other loans, trade credits, and other accounts payable and receivable. Total equity assets include Portfolio equity and FDI equity.

[11]The included currencies are listed in the Online Appendix O.A.2, and are freely floating or at most subject to a managed float. Observations for currencies temporarily subject to exchange rate pegs or strict capital controls (CHF 2011-2014 and INR as of 8/2013) are excluded, as well as TRY from 12/2015 onward due to the Turkish currency and debt crisis.

[12]This data is missing for Canada, New Zealand and Peru.

[13]The local currency debt share for Romania is from Bénétrix *et al.* (2015) and ends in 2012.

[14]For the sake of space the constitutive terms and control variables are not presented in the tables included in the text. A table with constitutive terms and control variables for a selection of the models is found in the Online Appendix. A lagged dependent variable was initially included, but was excluded as it was mostly close to zero and rarely significant.

[15]E.g. Mexico, which has an average nfa among the net debtor countries (-0.4% of GDP), would depreciate by an additional 0.42 %-points against USD, so in total by 1.9 %. The exchange rate impact of the increase in VIX is thus over 20 % larger for MXN than for a country with zero net foreign assets.

[16] The Chow test for structural stability tests whether the true coefficients of linear regressions on different datasets are identical, with H_0: no structural subsample differences. Currency-specific Bai & Perron (2003) breakpoint tests for an unknown breakpoint also suggest a structural break at some point between 7/2007–10/2008 for most currencies.

[17]These effects are substantial but yet plausible; they are larger but generally comparable to the carry trade effect on excess currency returns (see Jorda & Taylor (2012), Brunnermeier *et al.* (2009)) or exchange rate changes (see Table O.A.2 with reported control variables). Moreover, the exchange rate movement dispersion is comparable to the disparity in average returns on equity portfolios that are sorted based on their VIX exposure (Ang *et al.*, 2006).

[18]Currencies could also be affected by the level of risk tolerance and not just the change. I find that a higher VIX index

and a wider Libor-OIS spread is in some cases associated with weaker currencies in countries with substantial private net foreign portfolio and other investment debt as well (not reported). However, once I include interaction terms with both the level and the change in RI in the specifications, only the interaction terms with the change in risk intolerance are significant, which suggests that the baseline specification is the most appropriate.

[19] As there is insufficient data on portfolio equity and FDI holdings by sector, the analysis is limited to net external portfolio debt and other investments. Net other investments by the government are either missing, zero or very small for most countries and are hence also excluded.

[20] This applies especially to sovereigns, which have the option to print more currency (Amstad *et al.*, 2018). The "Original sin", coined by Eichengreen & Hausmann (1999), refers to the situation where a country cannot borrow abroad in the domestic currency and has problems borrowing in local currency at long maturities and at fixed rates at home, which creates financial fragilities due to currency or maturity mismatches.

[21] This is likely partly due to multicollinearity, as the LCD share is highly persistent in most countries and varies only annually (as it is available only at annual frequency).

[22] I have also looked at the interaction between changes in the OIS-T-Bill spread (as a proxy for changes in liquidity risk) and net foreign positions, and I found no significant exchange rate impact. This suggests that the results are not driven by liquidity risk changes but rather by credit risk changes.

TABLES

	Full sample						G10		EM		Post-crisis	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)
ΔVIX	-1.80***	-1.48***			-1.22***		-0.76		-2.12***		-1.22***	
	(0.37)	(0.33)			(0.34)		(0.44)		(0.32)		(0.34)	
ΔLibOIS			-1.29**	-1.14*		-1.05*		-0.69		-1.73**		-1.44
			(0.47)	(0.56)		(0.56)		(0.60)		(0.74)		(1.23)
ΔVIX*nfa	1.12**	1.04**										
	(0.45)	(0.44)										
ΔLibOIS*nfa			0.92***	0.91***								
			(0.27)	(0.32)								
ΔVIX*nTotDebt					1.69***		1.43**		2.23**		2.01***	
					(0.50)		(0.56)		(0.80)		(0.51)	
ΔVIX*nTotEquity					-0.11		-0.51		-3.64***		-0.42	
					(0.46)		(0.51)		(0.77)		(0.30)	
ΔLibOIS*nTotDebt						1.17**		0.98*		2.26		4.46*
						(0.44)		(0.44)		(1.52)		(2.28)
ΔLibOIS*nTotEquity						0.05		-0.42		-2.79*		0.07
						(0.55)		(1.11)		(1.57)		(1.24)
R^2	0.13	0.18	0.04	0.13	0.19	0.13	0.18	0.14	0.21	0.14	0.16	0.07
Chow							5.1***	3.8***	5.1***	3.8***	7.3***	9.9***
N	25	25	25	25	25	25	9	9	16	16	25	25
Obs	5,054	5,054	5,054	5,054	4,888	4,888	1,704	1,704	3,184	3,184	2,781	2,781
Controls	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Columns $i - iv$: WG estimation of $\Delta s_{it} = \alpha\Delta RI_t + \beta\Delta RI_t nfa_{it} + \zeta nfa_{it} + \delta' X_{it-1} + \gamma_i + \varepsilon_{it}$ where RI is proxied by the VIX index (VIX) or Libor-OIS spread ($LibOIS$), nfa is net foreign assets to GDP, X_{it} is a vector of controls and γ_i currency FE. Cols $v - xii$: $\Delta s_{it} = \alpha\Delta RI_t + \beta_1\Delta RI_t nTotDebt_{it} + \beta_2\Delta RI_t nTotEquity_{it} + \zeta_1 nTotDebt_{it} + \zeta_2 nTotEquity_{it} + \delta' X_{it-1} + \gamma_i + \varepsilon_{it}$, where $nTotDebt$ and $nTotEquity$ denote net total external debt and equity to GDP. Robust SE clustered by currency and time in brackets. Symbols ***, ** and * denote significance at 1%, 5% and 10 % levels. Full sample 4/2002–12/2019 and post-crisis sample 1/2010–12/2019. Chow is the Chow test for subsample poolability, with H_0: no structural subsample difference.

Table 1: Net foreign assets, net total external debt and equity assets and exchange rate movements

	Full sample				**G10**				**EM**			
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)
ΔVIX	-1.36***	-1.32***			-0.83*	0.11			-1.52***	-1.68***		
	(0.34)	(0.38)			(0.40)	(0.42)			(0.40)	(0.38)		
ΔVIX*nTotDebt^{priv}	2.40***				1.80**				3.50**			
	(0.75)				(0.73)				(1.24)			
ΔVIX*nTotDebt^{govt}	0.59	0.98			-0.42	0.65			-0.13	-0.55		
	(0.56)	(0.75)			(0.79)	(0.86)			(1.17)	(1.05)		
ΔVIX*nTotDebt^{osect}		2.40**				0.35				-0.04		
		(0.94)				(0.69)				(1.70)		
ΔVIX*nTotDebt^{bank}		3.45*				5.23**				8.99**		
		(1.83)				(1.56)				(3.38)		
ΔLibOIS			-1.31**	-1.28**			-0.96	-0.04			-1.32**	-1.46**
			(0.55)	(0.52)			(0.58)	(0.46)			(0.53)	(0.61)
ΔLibOIS*nTotDebt^{priv}			1.77***				1.31**				3.71**	
			(0.61)				(0.50)				(1.58)	
ΔLibOIS*nTotDebt^{govt}			-1.57	-1.72			-4.25	-1.01			-1.55	-2.39*
			(1.56)	(1.32)			(3.43)	(1.67)			(1.43)	(1.36)
ΔLibOIS*nTotDebt^{osect}				1.56**				-0.06				2.21
				(0.66)				(0.56)				(2.52)
ΔLibOIS*nTotDebt^{bank}				3.07**				4.55**				5.72**
				(1.39)				(1.30)				(2.66)
R^2	0.20	0.20	0.15	0.15	0.19	0.20	0.16	0.16	0.22	0.22	0.15	0.15
Chow					3.0***	4.0***	2.7***	2.5***	3.0***	4.0***	2.7***	2.5***
N	22	22	22	22	7	7	7	7	15	15	15	15
Obs	3,853	3,853	3,853	3,853	978	978	978	978	2,875	2,875	2,875	2,875

Note: WG estimation of $\Delta s_{it} = \alpha \Delta RI_t + \sum^O (\beta_o \Delta RI_t nTotDebt^o_{it}) + \sum^O (\zeta_o nTotDebt^o_{it}) + \delta' X_{it-1} + \gamma_i + \varepsilon_{it}$ where RI is proxied by the VIX index (VIX) or Libor-OIS spread ($LibOIS$), $nTotDebt^o$ is net total external debt to GDP in different sectors, with $o = priv$ (private sector), $govt$ (government), $bank$ (banking sector) or $osect$ (non-bank sector), X_{it} contain controls and γ_i the currency FE. Sample: 4/2002–12/2019. Robust SE clustered by currency and time in brackets. Symbols ***, ** and * denote significance at 1%, 5% and 10 % levels. Chow is the Chow test for subsample poolability.

Table 2: Net external debt assets in different sectors and exchange rate movements

	Full sample				G10				EM			
	4/2002-12/2019		1/2010-12/2019		4/2002-12/2019		1/2010-12/2019		4/2002-12/2019		1/2010-12/2019	
ΔVIX	-1.18***	-1.16***	-1.06***	-1.08***	-1.07	-0.90*	-1.07	-1.02*	-2.03***	-1.37***	-1.66***	-1.10***
	(0.36)	(0.36)	(0.34)	(0.35)	(0.64)	(0.44)	(0.60)	(0.54)	(0.35)	(0.39)	(0.34)	(0.37)
ΔVIX*nPDebt	1.39**	1.76***	2.33***	2.20***	1.01	1.61**	2.21*	2.58**	3.24**	1.47	2.24*	1.38
	(0.59)	(0.48)	(0.48)	(0.48)	(1.02)	(0.60)	(1.09)	(0.86)	(1.33)	(1.71)	(1.24)	(1.42)
ΔVIX*nOther	2.08	2.60**	4.26***	3.81***	1.14	1.95	4.78	5.20*	2.44	2.39	4.73**	3.62**
	(1.51)	(1.21)	(1.31)	(0.98)	(2.48)	(1.76)	(2.69)	(2.45)	(2.46)	(1.99)	(1.72)	(1.65)
ΔVIX*nPEquity	-0.75***		-0.81***		-0.65		-0.73*		-4.31***		-2.86***	
	(0.23)		(0.19)		(0.45)		(0.32)		(1.29)		(0.80)	
ΔVIX*nFDI	0.70		-0.54		1.34		1.03		-2.77**		-2.83***	
	(0.84)		(0.66)		(1.90)		(1.52)		(1.17)		(0.62)	
R^2	0.19	0.19	0.17	0.16	0.18	0.18	0.17	0.16	0.21	0.20	0.17	0.17
Chow			6.2***	7.2***	3.7***	3.2***	4.1***	5.2***	3.7***	3.2***	4.6***	4.8***
N	25	25	25	25	9	9	9	9	16	16	16	16
Obs	5,054	5,054	2,805	2,805	1,870	1,870	1,028	1,028	3,184	3,184	1,777	1,777

	Full sample				G10				EM			
	4/2002-12/2019		1/2010-12/2019		4/2002-12/2019		1/2010-12/2019		4/2002-12/2019		1/2010-12/2019	
ΔLibOIS	-1.05**	-0.98*	-0.78	-0.82	-0.83	-0.73	0.43	-0.66	-1.70**	-1.13*	-0.67	-1.13
	(0.50)	(0.52)	(1.09)	(1.09)	(0.65)	(0.57)	(1.22)	(1.24)	(0.74)	(0.54)	(2.05)	(1.21)
ΔLibOIS*nPDebt	0.43	0.96***	4.57*	4.31**	0.63	0.95	6.98**	4.87*	1.91	-0.59	-4.29	-3.34
	(0.53)	(0.34)	(2.49)	(1.71)	(0.79)	(0.52)	(2.86)	(2.11)	(1.92)	(1.41)	(7.98)	(6.84)
ΔLibOIS*nOther	1.48	2.34*	12.9*	12.4**	1.74	2.26	16.0*	12.5*	1.37	2.69	15.1	15.1*
	(1.54)	(1.29)	(6.74)	(5.11)	(2.45)	(1.95)	(8.04)	(6.30)	(2.21)	(2.19)	(9.25)	(7.84)
ΔLibOIS*nPEquity	-1.03		-0.52		-0.48		-1.27		-3.87**		3.77	
	(0.63)		(0.87)		(1.18)		(0.78)		(1.78)		(6.93)	
ΔLibOIS*nFDI	0.90		-0.89		0.50		-5.89		-1.44		1.48	
	(0.89)		(3.54)		(1.94)		(5.58)		(1.84)		(8.58)	
R^2	0.13	0.13	0.08	0.08	0.14	0.14	0.05	0.05	0.14	0.14	0.10	0.10
Chow			8.3***	10.1***	3.0***	3.6***	2.6***	3.0***	3.0***	3.6***	6.9***	8.6***
N	25	25	25	25	9	9	9	9	16	16	16	16
Obs	5,054	5,054	2,805	2,805	1,870	1,870	1,028	1,028	3,184	3,184	1,777	1,777

Note: WG regression of $\Delta s_{it} = \alpha \Delta RI_t + \beta_1 \Delta RI_t nPDebt_{it} + \beta_2 \Delta RI_t nOther_{it} + \beta_3 \Delta RI_t nPEquity_{it} + \beta_4 \Delta RI_t nFDI_{it} + \zeta' NFA_{it} + \delta' X_{it-1} + \gamma_i + \varepsilon_{it}$ where RI is proxied by the VIX index or Libor-OIS spread ($LibOIS$) and $nPDebt$, $nOther$, $nPEquity$ and $nFDI$ denote net external portfolio debt, other investments, portfolio equity and direct investment to GDP. X_{it} contain controls, $NFA_{it} = [nPDebt\ nOther\ nPEquity\ nFDI]$ and γ_i is the currency FE. Robust SE clustered by currency and time in brackets. Symbols ***, ** and * denote significance at 1%, 5% and 10 % levels. Chow is the Chow test for subsample poolability.

Table 3: Different net external asset components and exchange rate movements

	All currencies				**G10**				**EM**				
	4/02-12/19		1/10-12/19		4/02-12/19		1/10-12/19		4/02-12/19		1/10-12/19		
ΔVIX	-1.23***	-1.27***	-0.97***	-0.97**	-0.79*	0.06	-0.54	0.04	-1.38***	-1.56***	-1.05**	-1.16***	-1.32***
	(0.34)	(0.36)	(0.34)	(0.37)	(0.40)	(0.41)	(0.54)	(0.43)	(0.40)	(0.34)	(0.39)	(0.36)	(0.41)
ΔVIX*nPDebt^{priv}	2.57***		3.62***		2.08**		4.99**		1.61		0.56		
	(0.74)		(0.75)		(0.78)		(1.84)		(2.76)		(2.09)		
ΔVIX*nOther^{priv}	5.12***		7.27***		3.48*		12.0*		4.98**		6.59**		
	(1.45)		(1.81)		(1.59)		(5.78)		(2.28)		(2.51)		
ΔVIX*nPDebt^{govt}	0.75	0.79	1.66***	1.89***	-0.36	0.52	2.72	3.03	1.58	0.24	1.78	1.23	
	(0.61)	(0.76)	(0.49)	(0.64)	(1.04)	(0.97)	(1.73)	(1.57)	(1.77)	(2.25)	(1.47)	(2.26)	
ΔVIX*nPDebt^{osect}		2.95**		3.79***		0.46		3.78		-2.14		-0.36	
		(1.18)		(1.34)		(1.23)		(2.82)		(3.55)		(1.13)	
ΔVIX*nPDebt^{bank}		2.67**		4.11***		5.32**		5.89***		12.1		6.20	6.12
		(1.27)		(1.32)		(1.63)		(1.15)		(7.19)		(6.67)	(5.82)
ΔVIX*nOther^{osect}		3.33		5.19		-2.66		25.2		1.64		2.22	
		(2.27)		(3.89)		(7.96)		(16.8)		(2.51)		(3.46)	
ΔVIX*nOther^{bank}		6.25**		8.34***		5.03**		12.2*		6.89		9.58	11.4**
		(2.64)		(2.88)		(2.04)		(5.17)		(5.44)		(6.33)	(4.53)
R^2	0.20	0.20	0.17	0.17	0.19	0.20	0.16	0.17	0.22	0.22	0.18	0.18	0.18
Chow			5.5***	4.5***	2.4**	2.9***	4.6***	3.8***	2.4**	2.9***	4.1***	3.6***	2.1**
N	22	22	22	22	7	7	7	7	15	15	15	15	15
Obs	3,874	3,874	2,182	2,182	978	978	569	569	2,896	2,896	1,613	1,613	1,613

	All currencies				**G10**				**EM**				
	4/02-12/19		1/10-12/19		4/02-12/19		1/10-12/19		4/02-12/19		1/10-12/19		
ΔLibOIS	-1.21**	-1.20**	-0.41	-0.32	-1.13	-0.14	0.24	3.20*	-1.33**	-1.44**	-0.82	-1.85	-1.00
	(0.48)	(0.49)	(1.18)	(1.40)	(0.66)	(0.57)	(1.37)	(1.51)	(0.50)	(0.58)	(1.31)	(1.20)	(1.46)
ΔLibOIS*nPDebt^{priv}	1.57***		8.87**		1.43**		10.8*		4.42		5.02		
	(0.49)		(3.46)		(0.55)		(5.41)		(7.11)		(14.7)		
ΔLibOIS*nOther^{priv}	4.47**		25.9**		1.33		31.2		3.91		28.3**		
	(1.95)		(9.20)		(3.44)		(16.6)		(2.85)		(12.2)		
ΔLibOIS*nPDebt^{govt}	-2.83**	-3.09*	3.09	3.98	-5.05	-2.02	7.38	9.45	-2.27	-3.85*	-4.40	-9.86	
	(1.30)	(1.55)	(4.41)	(4.44)	(4.37)	(2.27)	(6.46)	(7.02)	(1.34)	(2.10)	(5.80)	(6.01)	
ΔLibOIS*nPDebt^{osect}		1.37**		8.71*		-0.21		2.56		-1.56		10.2	
		(0.55)		(4.30)		(0.57)		(6.96)		(9.26)		(13.2)	
ΔLibOIS*nPDebt^{bank}		2.46**		11.5**		6.16***		18.5***		13.6		-0.56	7.74
		(1.06)		(4.47)		(1.29)		(4.54)		(8.58)		(35.0)	(30.9)
ΔLibOIS*nOther^{osect}		3.53		19.1		-11.3*		50.2		3.29		-7.09	
		(2.78)		(16.4)		(5.48)		(55.3)		(4.42)		(13.3)	
ΔLibOIS*nOther^{bank}		5.21		29.7***		-0.48		30.0		3.15		58.2**	49.2**
		(3.14)		(10.4)		(4.41)		(21.0)		(4.85)		(21.2)	(18.0)
R^2	0.15	0.15	0.09	0.09	0.16	0.17	0.06	0.08	0.15	0.15	0.11	0.11	0.11
Chow			8.8***	7.1***	2.0**	2.1**	2.8***	2.5***	2.0**	2.1**	8.0***	7.0***	4.2***
N	22	22	22	22	7	7	7	7	15	15	15	15	15
Obs	3,874	3,874	2,182	2,182	978	978	569	569	2,896	2,896	1,613	1,613	1,613

Note: WG regression: $\Delta s_{it} = \alpha \Delta RI_t + \sum^O (\beta_{1o} \Delta RI_t nPDebt^o_{it}) + \sum^O (\beta_{2o} \Delta RI_t nOther^o_{it}) + \sum^O (\zeta_{1o} nPDebt^o_{it}) + \sum^O (\zeta_{2o} nOther^o_{it}) + \delta' X_{it-1} + \gamma_i + \varepsilon_{it}$ with RI proxied by the VIX index (VIX) or Libor-OIS spread ($LibOIS$), $nPDebt^o$ and $nOther^o$ are net external portfolio debt and other investments to GDP, with $o = priv$ (private sector), $govt$ (government), $bank$ (banking sector) or $osect$ (non-bank sector), X_{it} is a vector of controls and γ_i the currency FE. Robust SE clustered by currency and time in brackets and ***, ** and * denote significance at 1%, 5% and 10 % levels. Chow is the Chow test for subsample poolability.

Table 4: Net portfolio debt and other investments in different sectors and exchange rate movements

	Full sample		Post-crisis		G10		EM	
ΔVIX	-1.80***		-1.41***		-1.81***		-1.19***	
	(0.34)		(0.44)		(0.48)		(0.32)	
ΔVIX*nTotDebt	-0.11		1.33		-1.45**		2.55*	
	(0.97)		(1.21)		(0.52)		(1.37)	
ΔVIX*LCD	2.18***		0.99		2.46**		-0.73	
	(0.69)		(1.03)		(0.75)		(2.27)	
ΔVIX*nTotDebt*LCD	7.51*		2.91		11.42***		-3.57	
	(4.02)		(4.87)		(2.11)		(6.88)	
nTotDebt*LCD	4.47**	4.26**	4.59	4.82	7.50**	7.43*	4.19	3.87
	(1.74)	(1.91)	(3.00)	(3.65)	(3.08)	(3.38)	(3.80)	(3.96)
ΔLibOIS		-1.47**		-2.64		-1.50*		-1.02
		(0.60)		(1.56)		(0.71)		(0.65)
ΔLibOIS*nTotDebt		-0.11		2.38		-0.53		1.62
		(0.63)		(3.24)		(0.39)		(1.92)
ΔLibOIS*LCD		1.58**		4.66**		1.88**		-0.39
		(0.64)		(1.73)		(0.70)		(2.25)
ΔLibOIS*nTotDebt*LCD		5.07**		7.31		5.97***		-0.55
		(2.07)		(9.70)		(1.61)		(7.76)
Obs	4,576	4,576	2,471	2,471	1,604	1,604	2,972	2,972
R^2	0.19	0.14	0.16	0.08	0.19	0.15	0.21	0.15
N	25	25	25	25	9	9	16	16

Note: Regression of $\Delta s_{it} = \alpha \Delta RI_t + \beta_1 \Delta RI_t nTotDebt_{it} + \beta_2 \Delta RI_t LCD_{it} + \beta_3 \Delta RI_t nTotDebt_{it} LCD_{it} + \beta_4 nTotDebt_{it} LCD_{it} + \beta_5 LCD_{it} + \beta_6 nTotDebt_{it} + \delta' X_{it-1} + \gamma_i + \varepsilon_{it}$, where RI is proxied by the VIX index (VIX) or Libor-OIS spread ($LibOIS$), LCD refers to the proportion of the external debt liabilities denominated in local currency the previous year, X_{it} a vector of controls and γ_i currency FE. Robust SE clustered by currency and time in brackets and symbols ***, ** and * denote significance at 1%, 5% and 10 % levels. Sample period is 4/2002–12/2018 in the full sample and 1/2010–12/2018 in the post-crisis sample.

Table 5: Triple interaction specification - the proportion of local currency debt

FIGURES

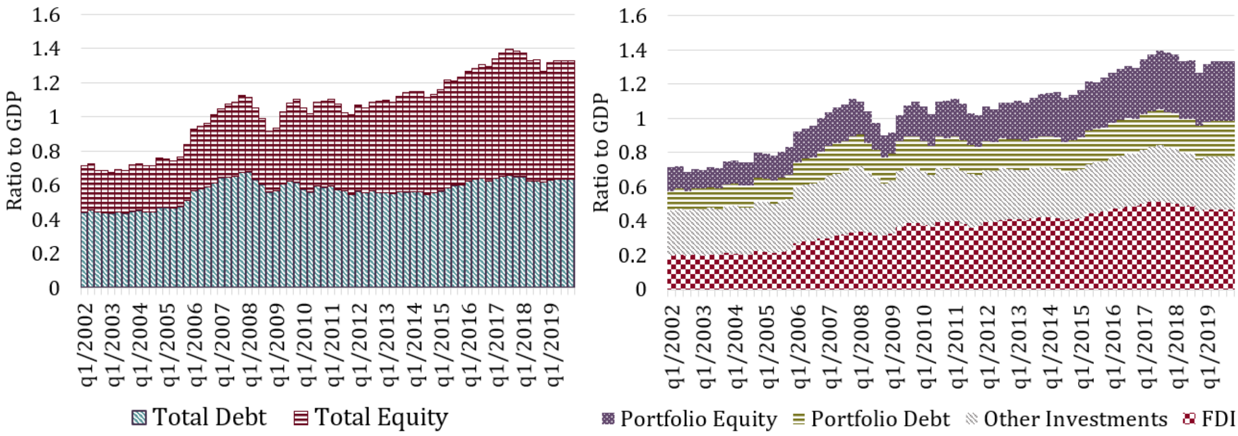
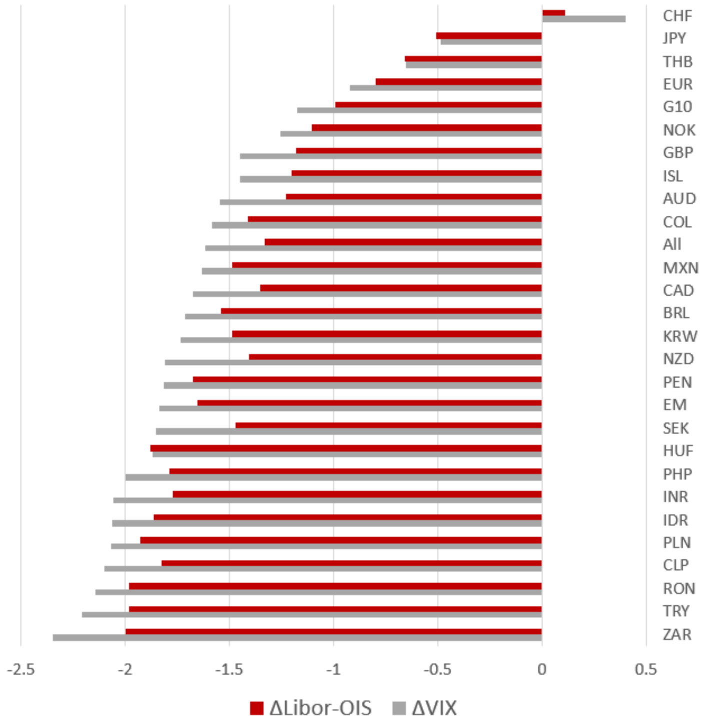


Figure 1: Different types of foreign assets in the sample



Note: Estimated exchange rate impact of a Libor-OIS spread or VIX index change, $\hat{\alpha} + \hat{\beta}_1 \overline{nTotDebt} + \hat{\beta}_2 \overline{nTotEquity}$, where bars denote country averages. Calculations are based columns $vii - x$ in Table 1.

Figure 2: Total effect of ΔRI taking the impact of nTotDebt and nTotEquity into account

ΔVIX \ $nPDebt$	-1	-0.5	0	0.5	1
1.5	-6.4	-4.1	-1.7	0.6	2.9
1	-4.9	-3.0	-1.2	0.7	2.6
0.5	-3.5	-2.0	-0.6	0.9	2.3
0	-2.0	-1.0	0.0	1.0	2.0
-0.5	-0.5	0.0	0.6	1.1	1.7
-1	0.9	1.0	1.2	1.3	1.4
-1.5	2.4	2.1	1.7	1.4	1.1

ΔVIX \ $nOther$	-1	-0.5	0	0.5	1
1.5	-6.3	-4.0	-1.7	0.6	2.8
1	-4.4	-2.8	-1.2	0.5	2.1
0.5	-2.6	-1.6	-0.6	0.4	1.4
0	-0.7	-0.3	0.0	0.3	0.7
-0.5	1.2	0.9	0.6	0.3	0.0
-1	3.1	2.1	1.2	0.2	-0.8
-1.5	5.0	3.4	1.7	0.1	-1.5

ΔVIX \ $nPDebt^{priv}$	-1	-0.5	0	0.5	1
1.5	-7.2	-4.5	-1.8	0.8	3.5
1	-5.3	-3.3	-1.2	0.8	2.8
0.5	-3.4	-2.0	-0.6	0.8	2.2
0	-1.5	-0.8	0.0	0.8	1.5
-0.5	0.4	0.5	0.6	0.7	0.8
-1	2.3	1.8	1.2	0.7	0.2
-1.5	4.2	3.0	1.8	0.7	-0.5

ΔVIX \ $nOther^{priv}$	-1	-0.5	0	0.5	1
1.5	-9.7	-5.8	-1.8	2.1	6.0
1	-6.5	-3.9	-1.2	1.4	4.1
0.5	-3.4	-2.0	-0.6	0.8	2.1
0	-0.2	-0.1	0.0	0.1	0.2
-0.5	3.0	1.8	0.6	-0.6	-1.8
-1	6.2	3.7	1.2	-1.2	-3.7
-1.5	9.3	5.6	1.8	-1.9	-5.7

Note: The heat maps describe how the exchange rate reaction depends on the VIX change (ΔVIX) and the net external portfolio debt ($nPDebt$), private net external portfolio debt ($nPDebt^{priv}$), net other debt liabilities ($nOther$), or private net other debt liabilities ($nOther^{priv}$) while keeping the other variables constant. Heat maps in the upper panel are based on results from column 2 in the upper panel of Table 3, and the lower panel is based on results from column 1 in the upper panel of Table 4.

Figure 3: Heat map of the exchange rate impact of ΔVIX and different net positions

LCD \ nTotDebt	-1.5	-1	-0.5	0	0.5	1	1.5
0	-1.6	-1.7	-1.7	-1.8	-1.9	-1.9	-2.0
0.2	-3.5	-2.8	-2.1	-1.4	-0.7	0.0	0.7
0.4	-5.3	-3.8	-2.4	-0.9	0.5	2.0	3.4
0.6	-7.1	-4.9	-2.7	-0.5	1.7	3.9	6.1
0.8	-8.9	-6.0	-3.0	-0.1	2.9	5.8	8.8
1	-10.7	-7.0	-3.3	0.4	4.1	7.8	11.5

Note: Heat map based on results in column 1 in Table 5 that describes how the exchange rate reaction to a change in the VIX index varies with both the LCD share and nTotDebt. LCD denotes the proportion of external debt liabilities denominated in local currency, and nTotDebt is the net external total debt to GDP.

Figure 4: Heat map of how the total ΔVIX impact varies with LCD and nTotDebt

APPENDIX TABLES

	Full sample					G10					EM				
	count	mean	sd	min	max	count	mean	sd	min	max	count	mean	sd	min	max
Δs	5054	-0.018	3.23	-23.7	15.4	1870	0.102	3.06	-18.0	12.9	3184	-0.088	3.32	-23.7	15.4
VIX Index	5054	19.0	8.12	9.51	59.9	1870	19.0	8.11	9.51	59.9	3184	19.0	8.14	9.51	59.9
Libor-OIS spread	5054	0.224	0.27	0.04	2.19	1870	0.222	0.27	0.04	2.19	3184	0.224	0.27	0.04	2.00
Var. Premium	4227	15.7	16.3	-2.88	88.6	1545	15.8	16.3	-2.88	88.6	2682	15.6	16.3	-2.88	88.6
Conditional Var.	4227	23.3	30.3	6.80	285	1545	23.4	30.1	6.80	285	2682	23.2	30.3	6.80	285
CDS spreads	5054	2.383	1.76	0.39	14.7	1870	2.393	1.78	0.46	12.7	3184	2.378	1.74	0.39	14.7
ΔVIX	5054	-0.003	0.57	-1.97	2.64	1870	-0.002	0.57	-1.97	2.64	3184	-0.003	0.57	-1.97	2.64
ΔLibOIS	5054	0.001	0.43	-2.06	4.58	1870	0.002	0.43	-2.06	4.58	3184	0.001	0.43	-1.77	3.81
ΔVarPrem	4227	-0.002	0.75	-3.20	3.38	1545	-0.002	0.75	-3.20	3.38	2682	-0.002	0.76	-3.20	3.38
ΔCondVar	4227	-0.001	0.88	-5.00	6.52	1545	0.000	0.88	-5.00	6.52	2682	-0.002	0.88	-5.00	6.52
ΔCDS	5052	-0.010	0.25	-0.85	1.12	1868	-0.010	0.25	-0.75	1.08	3184	-0.009	0.25	-0.85	1.12
nfa	5054	-0.147	0.48	-1.19	2.25	1870	0.107	0.65	-0.94	2.25	3184	-0.296	0.25	-1.19	0.39
nTotDebt	4890	-0.239	0.32	-1.18	1.15	1706	-0.221	0.47	-1.04	1.15	3184	-0.249	0.20	-1.18	0.19
nTotEquity	4890	-0.084	0.33	-0.97	1.91	1706	0.205	0.39	-0.55	1.91	3184	-0.239	0.14	-0.97	0.37
nTotDebt^{priv}	3900	-0.089	0.29	-0.74	1.21	980	-0.007	0.53	-0.74	1.21	2920	-0.117	0.13	-0.67	0.30
nTotDebt^{osect}	4162	0.008	0.20	-0.28	1.09	1170	0.156	0.31	-0.18	1.09	2992	-0.050	0.08	-0.28	0.22
nTotDebt^{bank}	3921	-0.070	0.14	-0.52	0.14	1001	-0.184	0.21	-0.52	0.14	2920	-0.030	0.06	-0.28	0.08
nTotDebt^{govt}	4262	-0.110	0.15	-0.53	0.81	1121	-0.054	0.22	-0.30	0.81	3141	-0.129	0.10	-0.53	0.12
nPDebt	5054	-0.094	0.27	-0.74	1.19	1870	-0.094	0.43	-0.74	1.19	3184	-0.094	0.09	-0.41	0.09
nPEquity	5054	-0.003	0.25	-0.71	1.78	1870	0.085	0.36	-0.71	1.78	3184	-0.055	0.11	-0.28	0.40
nFDI	5054	-0.109	0.22	-0.56	0.84	1870	0.071	0.20	-0.34	0.84	3184	-0.215	0.16	-0.56	0.33
nOther	5054	-0.111	0.12	-0.58	0.24	1870	-0.083	0.13	-0.54	0.24	3184	-0.127	0.11	-0.58	0.09
nPDebt^{priv}	4011	0.010	0.26	-0.62	1.20	1091	0.061	0.49	-0.62	1.20	2920	-0.009	0.04	-0.13	0.14
nPDebt^{osect}	4273	0.041	0.17	-0.18	1.01	1281	0.141	0.28	-0.18	1.01	2992	-0.002	0.04	-0.14	0.12
nPDebt^{bank}	4032	-0.038	0.14	-0.64	0.23	1112	-0.125	0.24	-0.64	0.23	2920	-0.004	0.02	-0.09	0.05
nPDebt^{govt}	4464	-0.081	0.13	-0.37	0.82	1303	-0.075	0.21	-0.30	0.82	3161	-0.084	0.08	-0.37	0.10
nOther^{priv}	4398	-0.071	0.09	-0.43	0.18	1214	-0.060	0.11	-0.43	0.18	3184	-0.075	0.08	-0.34	0.15
nOther^{osect}	4398	-0.034	0.05	-0.23	0.15	1214	0.005	0.04	-0.08	0.15	3184	-0.048	0.05	-0.23	0.13
nOther^{bank}	4398	-0.037	0.07	-0.50	0.20	1214	-0.065	0.11	-0.50	0.20	3184	-0.026	0.05	-0.22	0.07
Δshare-ΔSP500	5054	0.003	0.04	-0.25	0.39	1870	-0.000	0.02	-0.09	0.13	3184	0.005	0.04	-0.25	0.39
$\pi - \pi^{US}$	5054	1.202	3.43	-5.30	63.6	1870	-0.484	1.33	-5.16	4.86	3184	2.192	3.87	-5.30	63.6
$i - i^{US}$	5054	2.825	4.44	-5.08	53.0	1870	0.473	2.00	-5.08	6.21	3184	4.21	4.87	-2.42	53.0
ΔRes	5054	0.007	0.04	-0.42	0.41	1870	0.006	0.06	-0.42	0.41	3184	0.008	0.03	-0.18	0.41
PPP	5054	2.263	2.45	-0.68	8.37	1870	1.092	1.57	-0.38	4.97	3184	2.950	2.61	-0.68	8.37
CBr	5054	1.125	2.54	-11.47	17.9	1870	0.350	1.69	-4.04	6.46	3184	1.579	2.84	-11.47	17.9

Note: Δs is the monthly change in the foreign exchange rate against USD. The statistics for the risk measures (VIX index, Libor-OIS spread, Bekaert & Hoerova (2014)'s Variance Premium and Conditional Variance measures and the GDP-weighted global CDS spread) are in non-normalized form here in the table, and the changes in these measures are based on the normalized series. All net foreign positions are ratios to GDP. ΔshareΔSP500 is the difference in stock market return in the foreign country and the SP500, $\pi - \pi^{US}$ and $i - i^{US}$ are the respective differences in CPI and immediate interest rates between the foreign country and the US, ΔRes is the change in central bank reserves relative to GDP, PPP denotes relative PPP and CBr is the real central bank policy rate. Time period: 4/2002–12/2019.

Table A1: Descriptive statistics for the full sample

Variable	Δs	Δs (s.d.)	nfa	nTotDebt	nTotEquity	nPDebt	nOther	nPEquity	nFDI	nTotDebt				nPDebt				nOther		
										Priv	Govt	Bank	Osect	Priv	Govt	Bank	Osect	Priv	Bank	Osect
Australia	0.11	3.43	-0.55	-0.56	-0.03	-0.44	-0.04	-0.02	-0.08	-0.49	-0.08	-0.32	-0.11	-0.35	-0.09	-0.27	-0.08	-0.05	-0.04	-0.02
Brazil	-0.18	4.46	-0.33	-0.22	-0.25	-0.11	-0.06	-0.14	-0.16	-0.12	-0.09	-0.05	-0.03	-0.03	-0.07	-0.01	-0.02	-0.04	-0.03	-0.01
Canada	0.08	2.71	-0.04	-0.46	0.49	-0.34	-0.02	0.2	0.09	-0.29	-0.22	-0.21	-0.08	-0.22	-0.24	-0.13	-0.12	-0.03	-0.08	0.04
Chile	-0.08	3.33	-0.17	-0.19	-0.13	-0.03	-0.12	0.28	-0.44	-0.22	0.04	-0.05	-0.14	-0.06	0.03	-0.02	-0.04	-0.13	-0.03	-0.1
Colombia	-0.2	3.8	-0.31	-0.17	-0.26	-0.04	-0.12	-0.01	-0.25	-0.03	-0.15	-0.02	0	0.06	-0.1	-0.01	0.06	-0.07	-0.01	-0.06
Euro area	0.12	2.83	-0.12	-0.13	-0.04	-0.08	-0.05	-0.15	0.11	0.11	-0.19	-0.06	0.16	0.1	-0.19	-0.04	0.13	-0.01	-0.03	0.02
Hungary	-0.04	4.15	-0.83	-0.62	-0.44	-0.31	-0.25	-0.07	-0.44	-0.24	-0.37	-0.12	-0.06	-0.03	-0.27	-0.03	0	-0.15	-0.09	-0.06
India	-0.17	2.37	-0.1	-0.16	-0.12	-0.02	-0.15	-0.06	-0.05	-0.11	-0.05	-0.03	-0.08	-0.02	0	0	-0.01	-0.09	-0.03	-0.06
Indonesia	-0.18	2.7	-0.42	-0.32	-0.22	-0.08	-0.23	-0.08	-0.16	-0.11	-0.19	0	-0.09	-0.02	-0.06	0	-0.02	-0.06	0	-0.07
Israel	0.14	2.24	0.11	0.03	-0.17	0.01	0	-0.12	-0.03	0.17	-0.14	0	0.14	0.1	-0.09	0.03	0.08	0.04	-0.02	0.06
Japan	0.09	2.58	0.51	0.22	0.07	0.25	-0.03	-0.06	0.14	0.34	-0.11	0.08	0.25	0.39	-0.15	0.13	0.27	-0.06	-0.04	-0.02
Korea	0.06	3.16	-0.02	-0.09	-0.16	-0.07	-0.02	-0.17	0.01	-0.05	-0.02	-0.04	-0.02	-0.04	-0.02	-0.03	-0.01	-0.02	-0.01	-0.01
Mexico	-0.36	3.08	-0.42	-0.24	-0.28	-0.16	-0.02	-0.1	-0.24	-0.14	-0.1	0	-0.08	-0.06	-0.1	0	-0.06	-0.02	0	-0.02
New Zealand	0.18	3.66	-0.68	-0.74	-0.03	-0.41	-0.22	0.14	-0.3											
Norway	-0.02	3.35	1.04	0.03	1.05	0.25	-0.17	0.76	0.06	-0.52	0.62	-0.44	0.01	-0.29	0.62	-0.33	0.04	-0.14	-0.11	-0.03
Peru	0.01	1.47	-0.34	-0.32	-0.28	-0.11	-0.2	0	-0.3											
Philippines	0	1.59	-0.24	-0.28	-0.21	-0.09	-0.18	-0.12	-0.1	-0.08	-0.2	0.02	-0.09	0	-0.09	0.03	-0.03	-0.07	-0.01	-0.06
Poland	0.04	3.98	-0.54	-0.44	-0.28	-0.17	-0.18	-0.04	-0.32	-0.21	-0.22	-0.05	-0.07	0	-0.18	0	0	-0.13	-0.05	-0.08
Romania	-0.13	3.19	-0.47	-0.43	-0.26	-0.06	-0.27	-0.01	-0.35	-0.28	-0.13	-0.09	-0.1	0	-0.07	0	0	-0.19	-0.09	-0.1
South Africa	-0.12	4.88	-0.09	-0.16	-0.04	-0.11	-0.02	-0.01	-0.07	-0.05	-0.11	0.03	-0.04	-0.01	-0.1	0	-0.01	-0.01	0.03	-0.03
Sweden	0.04	3.33	-0.08	-0.61	0.43	-0.51	0.01	0.22	0.09	-0.5	-0.11	-0.41	0.01	-0.4	-0.11	-0.44	0.04	0.01	0.04	-0.03
Switzerland	0.42	2.89	1.21	0.79	-0.07	0.9	-0.22	-0.43	0.45	0.85	-0.03	-0.07	0.83	0.94	-0.03	0.16	0.78	-0.18	-0.23	0.05
Thailand	0.17	1.59	-0.18	-0.1	-0.47	-0.01	-0.09	-0.17	-0.29	-0.05	-0.04	0.02	-0.07	0.01	-0.02	0.01	0.01	-0.07	0.01	-0.08
Turkey	-0.47	4.22	-0.4	-0.34	-0.18	-0.09	-0.24	-0.05	-0.14	-0.16	-0.15	-0.05	-0.1	-0.01	-0.08	-0.01	0	-0.14	-0.04	-0.1
UK	-0.05	2.56	-0.09	-0.39	0.25	-0.27	-0.04	0.01	0.15											

Note: Country specific averages (and standard deviation of Δs) for the period 4/2002/-12/2019 for most countries with the exception of India (INR) 4/2002-8/2013, Switzerland (CHF) 4/2002-8/2011 and 4/2015-12/2019, and Turkey (TRY) 4/2002-12/2015. All net positions are ratios to GDP.

Table A2: Country specific descriptive statistics