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# Which Exchange Rate Matters to Global Investors? *

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**Abstract**

How do exchange rates affect global bond portfolios? Using security-level holdings data, we find that euro area investors systematically shed emerging-market and small-open-economy sovereign bonds as the US dollar strengthens, confirming the dollar's role as a global risk factor even for euro-based investors. More distinctively, as the euro strengthens, investors shed bonds denominated in an issuer's local currency while maintaining exposure to the same issuer's foreign currency bonds. This behavior is consistent with currency mismatches on investors' balance sheets. We explain these findings with a Value-at-Risk portfolio choice model that brings out separate roles for local, foreign and reference currencies.

Keywords: currency mismatch, balance sheet effects, bond yields, emerging markets, exchange rates, institutional investors, sovereign bonds.
*JEL classifications*: F31, G11, G15, G23.

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## I. Introduction

How do exchange rates affect the portfolio decisions and risk-taking behavior of global investors? A common response, especially for securities issued by emerging market economies (EMEs), invokes the currency mismatch EMEs take on when borrowing abroad in a major currency, notably the US dollar. Such borrowers are exposed to higher debt burdens when their currencies depreciate against the dollar. Foreign investors would then reduce their bond holdings in response to heightened credit risk.

This paper shows that several forces shape how portfolios respond to exchange rates. Investors hold assets in a range of currencies, and evaluate gains and losses in terms of their reference currency. They typically do not hedge currency risk when investing in local currency bonds denominated in all but the major currencies.[1] There, it is the *investors* who face the currency mismatch. They face narrow losses when a single currency depreciates, and broader losses when their reference currency appreciates against many currencies.[2] We show empirically that this currency mismatch manifests in investors' portfolio adjustments when exchange rates change bond valuations measured in their reference currency. Hence, the issue is multi-faceted, with reference currencies playing a distinct role beyond that of bilateral exchange rates.

Previous studies provide a partial view when focusing on dollar-based investors and fluctuations in exchange rates referencing the dollar. Doing so confounds the role of the *reference currency* with the role of the dollar as a *global risk factor* where a stronger dollar works through diminished risk-taking in the financial channel of exchange rates (e.g., Bruno and Shin 2015b; Avdjiev et al. 2019; Georgiadis et al. 2024). This flows from the dominant role of the US dollar in global trade and finance. Our innovation is to introduce a distinction between the investor's reference currency and the dollar's role as a global risk factor. We

[1] Throughout the paper, we refer to *local currency bonds* from the perspective of the sovereign borrower (issuing bonds in the domestic currency); these are *foreign currency bonds* to foreign investors.

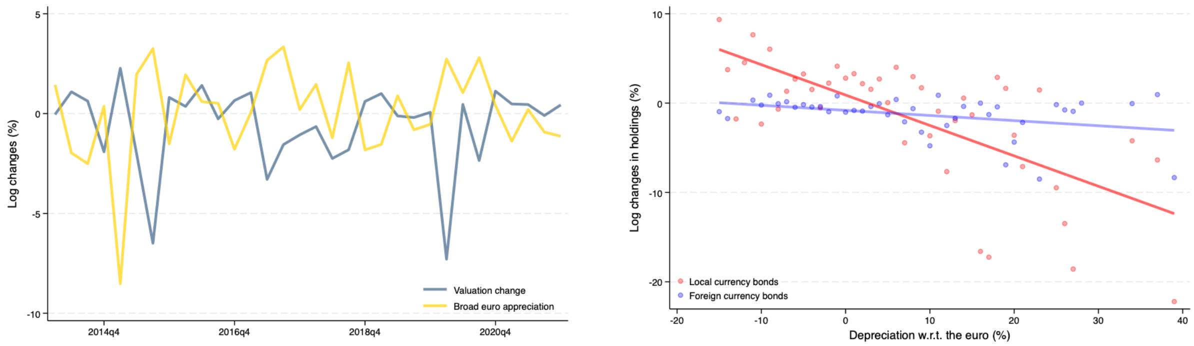
[2] Conceptually, this currency mismatch relates to investor preferences for home goods in general equilibrium frameworks of exchange rates and asset prices (e.g., Pavlova and Rigobon 2007, 2008).

do so through a granular analysis of the portfolio choices of *euro-based investors*: rotating the reference currency away from the dollar toward the euro allows for a novel identification. In this way, we decouple the investor's reference currency (euro) from fluctuations in global financial conditions (dollar).

Using security-level holdings of sovereign bonds, our analysis reveals that particular exchange rates come into play at different levels of the portfolio choice problem. At the level of *individual country exposures*, euro-based investors shed local currency bonds of a sovereign whose currency depreciates against the euro, reflecting the fact that the depreciation implies losses in terms of their reference currency. A broader appreciation of the euro, on the other hand, curbs the value of non-euro positions when expressed in euro, and leads investors to shed local currency bonds across their *local currency portfolio*; yet, they retain foreign currency bonds of the *same* sovereign issuers, suggesting that the retrenchment is not due to credit risk. Separately, consistent with recent studies, we find that episodes of dollar strength have the broadest effect on the *overall portfolio*, since tighter global financial conditions lead investors to retrench from all types of bonds, regardless of their currency of denomination.

Our empirical analysis is grounded in granular statistics on bond holdings in the euro area. We exploit security-level detail on the issuer, the currency and the holder of each bond to define the relevant exchange rates for currency mismatches facing borrowers and lenders. Euro-area investors make up a substantial portion of the investor pool for EME sovereign bonds, amounting to 5% of local and 20% of foreign currency bonds outstanding, respectively. They are exposed to fluctuations in exchange rates (Figure 1, left panel): valuation losses can be high when the euro strengthens against many currencies (as reflected in the broad euro index).

Figure 1. **Local versus foreign EME bond holdings by EA investors**




(a) Valuation gains and losses (b) Changes in nominal holdings (constant FX)

Panel (a) shows the percentage change in portfolio valuation in response to exchange rate fluctuations for euro area investors, taken relative to the total EME portfolio. Specifically, we compute: $\Delta \text{Value FX}_t = \frac{-\sum_c N_{c,LC,t-1} \times \Delta BER^{€}_{c,t}}{\sum_c N_{c,t-1}}$, where $N_{c,LC,t-1}$ is the total nominal amount held by euro area investors in local currency bonds issued by country $c$, $N_{c,t-1}$ the total nominal amount held in all EME bonds (both local and foreign currency bonds) in country $c$, and $BER^{€}_{c,t}$ the change in the log bilateral exchange rate for country $c$ with respect to the euro. Panel (b) shows a bin-scatter plot of EME depreciations (w.r.t. the euro) against the percentage changes in nominal holdings (keeping the exchange rate constant over time), separately for local and foreign currency bonds. The quarterly sample period is 2013q4-2021q4.

For instance, currency valuation losses amounted to 7.3% of the euro area's EME portfolio at the onset of the pandemic in March 2020 when EME currencies depreciated sharply against major currencies, notably the euro. At the same time, the right panel shows that investors shed local currency bonds when the euro strengthens, while we do not observe that effect for foreign currency bonds.

The analysis confirms in greater detail that investors shed local currency bonds to mitigate portfolio losses resulting from currency mismatches on their balance sheets. Our dataset affords an ideal laboratory for studying the financial channel of exchange rates, and the role of the currency mismatch channel on the lender side. For better identification, our focus on euro-based investors decouples the lender's reference currency (euro) from the borrower's currency for invoicing and external debt (mostly dollar), and from global financial conditions more generally (dollar).

Our empirical findings highlight systematic and distinct responses of euro-based investors to three types of exchange rates. An increase in the broad dollar index ($BDI$) leads to net selling across the board, since a stronger dollar reflects tighter global financial conditions. In contrast, a rise in the broad euro index ($BEI$), on the other hand, triggers selling of local currency bonds, in line with the valuation losses a stronger euro implies for assets in other currencies. Moreover, investors sell more local currency bonds of those sovereigns that depreciate more strongly against the euro ($BER_c$), precisely where the currency mismatch bites hardest.[3]

Importantly, these results are not confounded by bond-specific characteristics: they are robust to including issuer country × maturity × time fixed effects. That is, when comparing, at the same point in time, local and foreign currency bonds with the same maturity and issued by the same country, investors sell local as opposed to foreign currency bonds in response to euro appreciation. This identification strategy rules out alternative explanations related to country risk, bond duration, or time-varying macro conditions. These results are also robust to variations in specifications and samples. Importantly, they are not limited to EMEs: we find similar results for bonds issued by advanced economies outside the euro area.

The selling of bonds in response to euro strength has important implications for bond yields. When the euro appreciates, local currency bonds with greater ownership by euro area investors experience larger yield increases than foreign currency bonds do. These results are again robust to comparing, at the same point in time, local and foreign currency bonds with the same maturity and issued by the same country. This finding suggests that the strength of an international currency, by inducing selling pressure among global investors, raises borrowing costs on local currency debt.

To corroborate currency mismatch on the lender side as the main channel behind our results, we perform further tests that exploit heterogeneity across investors. Specifically, using

[3]Since our specifications are linear, we observe the opposite responses – investors buying sovereign bonds – when the dollar or the euro weaken, or when EME currencies appreciate.

international bond mutual fund holdings data from Morningstar, we show that an increase in the $BEI$ leads to selling of local currency bonds by euro-denominated mutual funds only when they do not hedge their currency exposure. The effect disappears for funds that hedge their exposures, consistent with the fact that hedged funds do not face a currency mismatch. While the absence of this effect among hedged funds is telling, our main findings pertain to unhedged funds, because most institutional investors do not hedge their currency exposures. Sialm and Zhu (2024) find that US international fixed income mutual funds hedge only 18% of their currency risk, while Dutch pension funds hedge a small fraction of currency exposures outside the major currencies (see Figure A1 in the Appendix).

Hence, the locus of currency risk we observe is very specific, tied to lenders' balance sheets. When a country's currency depreciates, the rise in its debt burden may increase credit risk on foreign currency bonds; the same depreciation makes no difference for servicing local currency debt. Yet we find that investors primarily sell local currency bonds when the currency depreciates against the euro. Investors first react to the currency mismatch on their *own* balance sheet: the relevant exchange rate to global investors is the currency of the bond they hold, not the currency of the issuer country. Currency mismatch on the lender side turns out to be an important driver of international capital flows.

Based on our findings, we formulate a model of portfolio choice that captures the features uncovered in the data. The key is to incorporate the relevant currency dimensions, allowing separate roles for local, foreign and reference currencies. Bond investors in the model are subject to a Value-at-Risk (VaR) constraint and choose between local and foreign currency bonds across issuer countries, evaluating returns in their own reference currency (euro) which differs from the dominant global currency (dollar). Their available capital depends on realized returns, and we assume that the stringency of their VaR constraint depends on global financial conditions (the dollar). Crucially, local-currency returns exhibit persistence, so that a depreciation today lowers both realized returns and the expected return on local-currency bonds in the next period.

The model provides several insights consistent with the empirical findings. First, a tightening of global financial conditions reduces bond holdings across the board by constraining investors' risk-taking capacity. Second, the model captures the empirical regularity that a country-specific depreciation leads to selling of the local currency bond issued by that country, while a broad appreciation of the euro leads to selling of *all* local currency bonds. The underlying mechanism is that a depreciation erodes available capital, and more so with a broader appreciation of the euro, tightening investors' risk constraints and forcing a reduction in overall bond holdings; the effect centers on local currency bonds, whose future expected returns fall on account of return persistence.

Our findings shed new light on the mechanisms underlying the financial channel of exchange rates. Beyond the financial channel associated with borrowers (e.g., Chang and Velasco 2001; Bruno and Shin 2015b, 2023), the currency mismatch faced by investors plays a key role in explaining portfolio flows. While the previous literature has documented a link between global risk appetite or risk-taking capacity and capital flows (e.g., Bertaut et al. 2023; Lilley et al. 2022; Georgiadis et al. 2024), we disentangle the generalized risk-taking effect from the lender-side currency mismatch by moving the reference currency away from the dollar.

We also contribute to the literature on the importance of currency denomination in explaining investor portfolios. Maggiori et al. (2020) show that investor holdings are biased toward their own currencies to such an extent that corporations borrow abroad in bonds denominated in US dollars or in the currency of foreign investors. We also find that euro area investors disproportionately invest in bonds denominated in their own currency or in the US dollar, in line with Boermans and Vermeulen (2016); Burger et al. (2018); Boermans and Burger (2023); Faia et al. (2022); Florez-Orrego et al. (2023); Zhou (2023); Beck et al. (2023). Boermans and Burger (2023) use euro area holdings data and document a strong preference for euro-denominated bonds. Faia et al. (2022) show that this preference is mainly driven by pension funds and insurers, rather than investment funds. Kubitza et al. (2024) argue that frictions in foreign exchange derivatives markets may explain currency preferences. We contribute to this literature by showing that the investors' reaction to currency mismatch on their balance sheets is consistent with investors' preference for their own currency.

Finally, we contribute to the literature on capital flows and exchange rates in equilibrium (e.g., Hau and Rey 2004, 2006; Gabaix and Maggiori 2015; Lilley et al. 2022; Camanho et al. 2022; Koijen and Yogo 2020; Pandolfi and Williams 2019; Aldunate et al. 2023). Our paper complements this work by showing which exchange rate fluctuations ultimately matter in driving capital flows.

The behavior we observe has important implications for EMEs and small open economies. Since the 1990s, major EME sovereigns have made substantial progress in borrowing abroad in their local currency; they are overcoming "original sin" in the original sense of the term (Eichengreen et al. 2005; Onen et al. forthcoming). But the flipside is that currency mismatches migrate to the balance sheets of global investors, leading to volatile capital flows or flight risk (e.g., Calvo 1998; Caballero and Simsek 2020; Coppola 2025; Zhou 2023). For lenders to hold local currency bonds, borrowers pay a sizeable yield spread over US Treasuries, mainly to compensate for currency risk (Du and Schreger 2016; Lee 2022).[4] Even so, investors exposed to currency risk may sell at the first sign of depreciation regardless of the underlying credit risk. As a result, most countries borrowing abroad in their own currency face risks that mirror those of foreign currency debt. The problem changes shape, but countries remain vulnerable to the ebb and flow of global liquidity.

The paper is structured as follows. Section II reviews the main channels through which exchange rates affect lenders and borrowers, and explains how we disentangle confounding effects by focusing on euro-based investors. Section III describes how we combine two granular databases to enable our empirical approach. Section IV presents the baseline regressions at three levels of aggregation, along with robustness tests and extensions. Section V further examines the currency mismatch channel, taking hedging into account. Section VI lays out

[4]For EMEs, the currency risk accounts for about three quarters of the local currency yield spread over US Treasuries, while the borrower's intrinsic credit risk accounts for one quarter (Du and Schreger 2016).

a model to rationalize our empirical findings. Section VII concludes.

## II. Channels and Identification

This section reviews the main channels through which exchange rates affect global investors in view of testable hypotheses. We examine the role of currency mismatches on foreign and local currency debt, respectively, as featured in the literature on the financial channel of exchange rates. We then explain how we identify the effects of different exchange rates by focusing our empirical analysis on euro-based investors.

### *A. Exchange Rate Channels in the Literature*

We classify various exchange rate effects to infer the expected response of foreign investors' portfolio allocation across countries. For concreteness, consider a generic open economy (country $c$) that trades goods invoiced in US dollars with many countries, and borrows abroad in dollars, unhedged. Global investors lend or invest on the basis of prospective returns across a number of borrower countries, including $c$. They can invest in either the local currency bonds or foreign currency bonds of country $c$. Throughout the paper, we refer to *local currency bonds* from the perspective of the sovereign issuer; they are *foreign currency bonds* to foreign investors.

Several types of exchange rates or indices can be relevant in this context. The bilateral exchange rate ($BER$) is the nominal exchange rate against the reference currency, quoted in terms of local currency units per US dollar ($BER_c^{\$}$) or per euro ($BER_c^{€}$). An increase represents a depreciation of country $c$'s currency. The broad dollar index ($BDI$) is a weighted average of the foreign exchange value of the US dollar against the currencies of a broad group of major US trading partners; an increase represents a stronger US dollar. The broad euro index ($BEI$) is the corresponding index measuring the value of the euro against the euro area's main trading partners.

We briefly describe the traditional **trade channel** of exchange rates. Exchange rate fluctuations impact a country's trade competitiveness due to nominal rigidities. In traditional models, depreciations are expansionary (Dornbusch 1980; Obstfeld and Rogoff 1995). When country $c$'s currency depreciates, it boosts net exports by making imports costlier and exports cheaper, which in turn attracts more foreign investment. In reality, most trade is invoiced in major currencies, notably the US dollar (Boz et al. 2020): hence, mainly a depreciation against the US dollar ($BER_c^{\$} \uparrow$) will be expansionary, since it reduces country $c$'s imports from all other countries. When many countries depreciate simultaneously, however, the broad-based strengthening of the US dollar ($BDI \uparrow$) tends to depress world trade (Gopinath et al. 2020). As the trade channel is not the objective of our study, we examine *sovereign bonds* to reduce any confounding effects between the trade and financial channels of exchange rates. Corporates are subject to *both* channels: a depreciation of currency $c$ has expansionary effects (trade channel) as well as adverse balance sheet effects – especially with respect to the dollar, the currency of choice for most corporates issuing international bonds (e.g., Salomao and Varela 2022; Gutierrez et al. 2023).

The **financial channel** of exchange rates describes how exchange rate movements affect economic outcomes through their effect on balance sheets. The traditional focus is on the ***borrower side***, since most countries' external debt is denominated in foreign currency (Bénétrix et al. 2019; Eichengreen et al. 2022). A depreciation raises the burden of foreign currency debt in terms of the borrower's own currency, with adverse effects on the economy and the financial system. Most countries borrow internationally in US dollars; the relevant exchange rate for country $c$ is that against the dollar. A depreciation ($BER_c^{\$} \uparrow$) is contractionary and raises the borrower's credit risk (e.g., Chang and Velasco 2001; Bruno and Shin 2015b). Hence, foreign investors are likely to react by cutting exposures.

A generalized strengthening of the dollar in this context leads to a broad-based reduction in credit because borrowers' balance sheets become weaker, thereby reducing financial intermediary lending activities (Bruno and Shin 2015b, 2023). In that sense, the $BDI$ gauges global risk-taking capacity or risk-appetite (e.g., Avdjiev et al. 2019; Miranda-Agrippino and Rey 2022; Lilley et al. 2022; Obstfeld and Zhou 2023; Georgiadis et al. 2024) and a generalized strengthening of the dollar ($BDI \uparrow$) can reduce investments abroad (Bruno and Shin 2015a). Indeed, the $BDI$ has been found to exhibit attributes of a global risk factor (e.g., Lustig et al. 2014; Jiang et al. 2020).

Currency mismatches also occur on the ***lender side***. Most advanced economies and major EMEs increasingly borrow abroad in their own currency (Bénétrix et al. 2019; Du and Schreger 2022; Onen et al. forthcoming). In this case, a depreciation can be inconsequential for borrowers servicing their local currency debt. But the currency mismatch now sits on the balance sheets of foreign lenders: since they measure returns in their own currency, the depreciation of currency $c$ causes valuation losses.

A generalized strengthening of the reference currency leads to tighter financial constraints for the lender. Such an appreciation represents the simultaneous depreciations of many currencies in their portfolios, implying valuation losses in terms of the reference currency, tightening lenders' VaR constraints (as we formally show in Section VI).

From the lender side, we thus expect foreign holders to reduce their locally denominated investments across the board in the event of a broad-based depreciation across many borrower countries ($BDI \uparrow$), and to cut their local currency positions on individual countries facing larger depreciations ($BER_c^{\$} \uparrow$).

### *B. Identification through Euro-based Sovereign Bond Investors*

We now define the data dimensions best suited for capturing the financial channel of exchange rates, with the aim of identifying the effects of currency mismatches on global investors' bond portfolios.

First, in our main tests we focus on sovereign bonds issued by **major EMEs**. These countries stand out for attracting external finance in both foreign and local currencies.[5] They primarily do so by issuing sovereign bonds, the main instrument for government borrowing – in contrast to the 1970s and 80s when bank loans were dominant.

Second, our review above makes clear that the US dollar plays a central role in all aspects of the financial channel of exchange rates because of its dominance in trade invoicing and global finance. From the perspective of **dollar-based or global investors** evaluating returns in US dollars, exchange rates referencing the dollar affect all levels of the portfolio allocation problem: the level of individual country exposures, the level of currency portfolios (major currencies vs local currencies), and the level of the overall portfolio. At the *country level*, the relevant exchange rate is $BER_c^{\$}$ for foreign currency bonds because of the borrower-side currency mismatch, as well as for local currency bonds because of the lender-side effect. At the *currency portfolio level*, all bilateral exchange rates against the dollar – hence the $BDI$ overall – matter, for both foreign and local currency bonds, because a broad-based increase in borrowers' debt burdens affects foreign currency bonds and a stronger dollar induces valuation losses across the local currency bonds in the portfolio. For the *overall portfolio*, a stronger dollar tends to depress holdings of foreign and local currency bonds because of reduced risk-taking capacity or risk-appetite in markets. Figure 2 (upper panel) summarizes these effects, highlighting the confounding effects of the dollar.

We therefore focus on **euro-based investors** to disentangle the various channels. Rotating the reference currency away from the US dollar allows for better identification of lender-specific effects, because doing so decouples the investor's reference currency (euro) from the borrower's currency for invoicing and external debt (mostly dollar) and from global financial conditions (dollar).

Figure 2 (lower panel) summarizes the expected effects of EME depreciations on foreign bond holdings according to the financial channel of exchange rates, identified in our setting

[5]By contrast, advanced economies tend to borrow in their own currency, while small EMEs and developing countries rely almost exclusively on foreign currency when borrowing abroad (Eichengreen et al. 2022).

at three levels of the portfolio allocation problem. Episodes of dollar strength ($BDI \uparrow$) are still expected to have the broadest effect, since tighter global financial conditions lead investors to shed bonds across all currency denominations. Bilateral rates referencing the dollar ($BER_c^{\$}$) have a narrower effect on foreign currency bonds only, as EMEs face rising debt burdens when their currencies fall against the dollar. Few EMEs owe as much external debt in euro, hence depreciations against the euro do not raise credit risk across many borrowers; as such, investors need not shed foreign currency bonds when individual EMEs depreciate *against the euro*. We expect no reaction in foreign currency bond holdings to changes in $BER_c^{€}$ and $BEI$.

By contrast, exchange rates referencing the euro are highly relevant to the *lender* side, notably for local currency bond holdings. Euro-based investors face losses on local currency bonds for any EME that depreciates against the euro ($BER_c^{€} \uparrow$). Moreover, a broad-based euro appreciation ($BEI \uparrow$) should lead to more extensive selling across EMEs than the equivalent depreciation of a single EME ($BER_c^{€} \uparrow$), because of broader losses and the reduction in their risk-taking capacity. Euro-based investors will thus adjust their local currency bond holdings to $BER_c^{€}$ and the $BEI$, just as dollar-based investors respond to $BER_c^{\$}$ and the $BDI$.

Hence, our focus on euro-based investors helps identification (Figure 2). The $BEI$ and $BER_c^{€}$ only affect *local currency* denominated bonds, and should not matter for *foreign* denominated bonds. As such, we can contrast local versus foreign currency bonds and should find that the exchange rates relative to the euro are relevant only for local currency bonds. Our set-up thus promises to identify the lender-specific currency mismatch effects separately from borrower-side mismatches and the generalized risk-taking channel.

Figure 2. **Financial channel of exchange rates**

| **Dollar-based investors** | Foreign currency bonds | Local currency bonds |
|---|---|---|
| Exposure to country c | **$BER_c^{\$}$ (borrower)** | **$BER_c^{\$}$ (lender)** |
| Currency portfolio | **BDI** | **BDI** |
| Overall portfolio | **BDI** | |

| **Euro-based investors** | Foreign currency bonds | Local currency bonds |
|---|---|---|
| Exposure to country c | **$BER_c^{\$}$ (borrower)** | **$BER_c^{€}$ (lender)** |
| Currency portfolio | **BDI** | **BEI** |
| Overall portfolio | **BDI** | |

Figure 2 summarizes the expected negative effects of various exchange rates on foreign holdings of sovereign bonds, contrasting the cases of dollar-based (upper) with euro-based (lower panel) investors. The columns split bonds by currency denomination, where local currency bonds are in the domestic currency of borrower country $c$. The rows show at which level of the portfolio choice problem each type of exchange rate is expected to play a role. Bilateral exchange rates are quoted in local currency units per dollar ($BER_c^{\$}$) or per euro ($BER_c^{€}$); indices express the trade-weighted value of the US dollar ($BDI$) or of the euro ($BEI$). In all cases, an increase represents a strengthening of the dollar (or euro), and a corresponding depreciation of other currencies.

## III. Data and Methodology

### A. *Granular Statistics on Bond Holdings*

We use the euro area Securities Holdings Statistics by Sector (SHS-S) that record securities holdings for each country and sector in the euro area over the period 2013q4-2021q4.[6] For each country and sector, the statistics contain information on the quarter-end holdings at the ISIN level; for instance, the SHS-S data reports the aggregate holdings of German insurance companies in a specific security.

The SHS-S are connected to the Centralised Securities Database (CSDB). The CSDB holds

[6]For more details on the SHS-S data, see for instance https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R1011, Koijen et al. (2017), Koijen et al. (2021), and Jansen (2024).

accurate information on all individual securities relevant for the statistical purposes of the European System of Central Banks (ECB 2010). For a large number of debt securities, the CSDB contains data on debt type, maturity dates, coupon rates, yield-to-maturity, prices, amount outstandings, etc.

We also merge the SHS-S with data on exchange rates and macroeconomic series. The bilateral nominal exchange rates against the US dollar and the euro (BER) are from the BIS (end of period). The BDI is the broad nominal US dollar index against 26 major trading partners from the Federal Reserve, and the volatility index (VIX) is from the Chicago Board Options Exchange (both retrieved from FRED). The BEI is the nominal effective euro exchange rate against 41 main trading partners from the ECB. Credit ratings are from Fitch Ratings. We also merge the data with sovereign bond yields from JP Morgan indices.[7] The yield differentials are computed with respect to the German Bund yield (euro). Macroeconomic series such as GDP growth, fiscal capacity, and inflation for each country are from the IMF WEO.

For debt securities, the focus of this paper, the SHS-S report bond holdings in both nominal and market values expressed in euros. To isolate active changes in allocations from fluctuations in prices and exchange rates, we focus on nominal bond holdings and express nominal values at constant exchange rates.[8] This ensures that the quarterly changes in nominal values reflect active changes in holdings, rather than currency valuation effects.

For the reasons elaborated above, we focus on EME sovereign bonds held by euro-based investors for our main analysis. Our empirical approach takes advantage of the bilateral nature of the bond holdings statistics. On the lender side, the data comprises bond holdings in the 19 euro area countries.[9] On the borrower side, we focus on 27 major emerging markets

[7]We use individual country series from the GBI-EM Broad Diversified Index for local currency bonds; the EMBI Global Diversified Index for dollar-denominated government bonds, and the Euro EMBIG Diversified Index for euro-denominated government bonds.

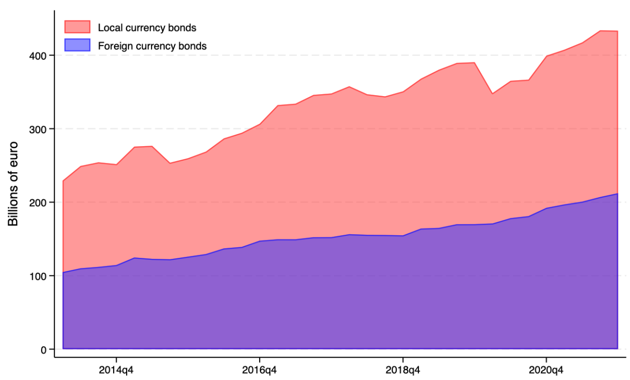
[8]We convert nominal holdings to their original currencies using current exchange rates against the euro, and convert them back to euros at constant exchange rates as of 2021q4.

[9]Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania,

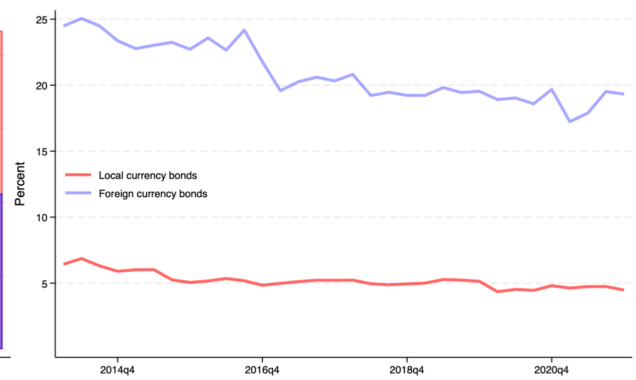
that make up most of the investible EM bond universe.[10]

Panel (a) of Figure 3 shows the corresponding slice of SHS-S. At end-2021, euro area investors held €433 billion in EME sovereign bonds, €221 in local currency and €212 billion in foreign currency bonds. Panel (b) shows that these holdings amount to approximately 20% of the foreign and 5% of the local currency bonds outstanding, consistent with the finding in Maggiori et al. (2020) that foreign investors mainly hold bonds in their own currency or in USD.

Figure 3. **Local versus foreign EME bond holdings by EA investors**




(a) Total Holdings Billions EUR




(b) Fraction TAO by EA investors

Panel (a) shows the total nominal amount of EME bonds held by euro area investors (in billion EUR), separately for local and foreign currency bonds. Panel (b) shows the fraction of the total amount outstanding (TAO) of EME bonds held by euro area investors (in percentage points), separately for local and foreign currency bonds. The quarterly sample period is 2013q4-2021q4.

### *B. Empirical Design*

Our analysis proceeds from general to specific. We first combine all euro area investors, and present regressions at three levels of aggregation on the borrower side: all EMEs combined at the aggregate level (time series), at the EME country level (panel), and at the individual security level (large panel). This intends to show that the effects we identify are relevant in

Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, Spain. This list excludes Croatia, which entered the euro area in January 2023.

[10] Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Hong Kong SAR, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Singapore South Africa, Taiwan (Chinese Taipei), Thailand, and Turkey.

the aggregate while being robust at the granular level.

The dependent variable is the change in log nominal values (as in, e.g., Timmer 2018), corrected for exchange rate fluctuations. The main regressors of interest are the different exchange rates outlined in Section A. Formally, we run the following regressions, separately for bonds denominated in local and in foreign currencies:

1. **Aggregate level** (time series):

$$\Delta \ln N_{FD,t} = \alpha + \beta_1 \Delta BDI_t + \beta_2 \Delta BEI_t + \beta_3 \Delta C_{FD,t} + \epsilon_{FD,t}, \tag{1}$$

   where $\Delta BDI_t$ equals the change in the log $BDI$ from time $t-1$ to $t$; $\Delta BEI_t$ the change in the log $BEI$ from time $t-1$ to $t$; and $C_{FD,t}$ the controls for foreign/local bonds at time $t$.

2. **Country level** (panel):

$$\begin{aligned} \Delta \ln N_{c,d,t} &= \alpha + \beta_1 \Delta BDI_t + \beta_2 \Delta BEI_t + \beta_3 \Delta BER^{€}_{c,d,t} \\ &+ \beta_4 C_{c,d,t} + \gamma_{c,d} + \epsilon_{c,d,t}, \end{aligned} \tag{2}$$

   where $\Delta BER^{€}_{c,d,t}$ equals the change in the log bilateral exchange rate for country $c$ and currency of denomination $d$ with respect to the euro from time $t-1$ to $t$, $C_{c,d,t}$ the controls for country $c$ and currency of denomination $d$ at time $t$, and $\gamma_{c,d}$ are fixed effects at the country-currency level. We orthogonalize $\Delta BER^{€}_{c,d,t}$ with respect to the $BEI$ when combined in the regression with the $BEI$.

3. **Security level** (large panel):

$$\begin{aligned} \Delta \ln N_{s,t} &= \alpha + \beta_1 \Delta BDI_t + \beta_2 \Delta BEI_t + \beta_3 \Delta BER^{€}_{s,t} \\ &+ \beta_4 C_{s,t} + \gamma_s + \epsilon_{s,t}, \end{aligned} \tag{3}$$

where $\Delta BER^{€}_{s,t}$ equals the change in the log bilateral exchange rate for the currency of denomination of security $s$ with respect to the euro from time $t-1$ to $t$, $C_{s,t}$ are controls for security $s$ at time $t$, and $\gamma_s$ are security fixed effects.

In our regressions, we control for several factors distinct from currency effects ($C$). First, we control for the change in log total amount outstandings (TAO) of EME bonds in all three specifications. The reason is to take into account that the growth in the TAO in sovereign bonds of a specific EME will lead to more investors moving towards that EME, notably due to benchmarking (Pandolfi and Williams 2019; Beltran and He 2024). We also control for changes in the VIX to capture uncertainty in the economic outlook. Likewise, at the country and security level, to control for changes in country-specific macro fundamentals we include changes in yield differentials, credit ratings, GDP, fiscal capacity, and inflation. We further include changes in the yield differentials and credit ratings separately for bonds denominated in local versus foreign currencies. The yield differentials capture the local rate component of bond returns separately from the exchange rate effects. Finally, at the security level regressions, we also control for the remaining time to maturity of the bond to capture that investors typically target a specific duration of their portfolios; investors will buy bonds with longer time to maturities over time.

Table IA1 and IA2 in the Internet Appendix summarize our main variables of interest. An important point to note is that the low correlations across the different types of exchange rates helps support our identification of the different financial channels. First, dollar strength and euro strength are quite distinct: the correlation between $\Delta BDI$ and $\Delta BEI$ at the quarterly frequency equals -0.36. Since the euro area and the US are major trade partners to each other, the EUR-USD exchange rate tends to push the $BDI$ and $BEI$ in opposite directions; moreover, each currency area has a different set of other major trade partners. Note also that depreciations of specific EME currencies are different from the general movement in the BDI: the correlation between changes in $BER^{€}$ and $BDI$ is 0.00. Therefore, an EME depreciation against the euro (which affects euro-based lenders holding local currency bonds) can occur independently of the broad effects associated with a strong dollar.

## IV. Empirical Results at three Levels of Aggregation

This section presents our baseline results. As described, we run analogous regressions at each level of granularity: for all EMEs combined (Table 1), at the country level (Table 2) and at the security level (Table 3 and 4). Each table distinguishes local from foreign currency bonds in order to test the various expressions of the financial channel of exchange rates set out in Figure 2, focusing on the significance of the different exchange rates referencing the dollar and the euro, respectively. The section ends with robustness tests and extensions.

### *A. Aggregate Analysis*

Treating all EMEs as an aggregate reduces the analysis to a simple time-series regression (Table 1). Even at this coarse level the importance of exchange rates for foreign holdings of sovereign bonds is evident. The coefficient on the $BDI$ is negative and significant throughout. Taking the point estimate at face value, when the dollar strengthens by 1%, investors sell about 0.8% of their EME bond holdings (Column "All").[11] For local currency bonds, the response is more than one for one, whereas foreign currency bonds appear less sensitive to the dollar index.

A strengthening of the euro ($\Delta BEI > 0$) is also associated with net selling of EME sovereign bonds. The effect is similar, if weaker, to that of the dollar index. However, the key difference is that the effect only appears for bonds denominated in EMEs' local currencies (Column "Local"). This is a first sign that euro-based investors face a currency mismatch on local, not on foreign, currency bonds (Figure 2). To explore this channel, we need more variation in exchange rates available in the country-level regressions.

**[Place Table 1 about here]**

[11] As described in the data section, the log change in holdings represents active allocation decisions, since the series excludes currency and other valuation effects by construction.

*B. Country-level Analysis*

The country-level regressions treat each EME separately in a panel setting, and thus provide more heterogeneity across currency pairs (Table 2). We examine how investors adjust their bond holdings vis-à-vis every EME, depending how that EME's currency moves against the euro over each quarter ($BER_c^{€}$).

Dollar strength tends to reduce bond holdings, as is apparent from all specifications of Table 2. A broad appreciation of the euro has a similar effect, but confined to local currency bonds ("Local" columns). For both indices, the effect is strong: when the dollar or the euro strengthens by 1% , investors reduce their holdings of EME bonds by 1% on average. Again, these estimated responses exclude currency valuation effects. The size of the euro-index effect drops to about a third when replacing the $BEI$ by the bilateral rate between the euro and each EME currency ($BER_c^{€}$), indicating that investors do not respond one-to-one to each EME country.

The right columns include both indices along with the bilateral exchange rates with respect to the euro. The coefficients on both indices are consistent with earlier results, after orthogonalising $BER_c^{€}$ with respect to the $BEI$ to avoid multicollinearity. That means $\Delta BER^{€,ort}$ measures by how much *more* an EME depreciates against the euro than what the broader euro appreciation implies. The columns reveal that changes in holdings of local currency bonds at the country level are better explained by the broad euro index than by individual EME depreciations.

**[Place Table 2 about here]**

*C. Security-level Analysis*

In the security-level regressions we can make use of the rich dimensionality of the matched SHS-S-CSDB dataset (Section III). The sample size jumps from 1,751 (country-level) to almost 44,000 observations in Table 3. The granular data allow us to control for security fixed effects, which leaves only *within* variation for each individual bond to be explained by the time-varying regressors.

The results in Table 3 confirm our earlier findings with greater precision. Dollar strength leads to net selling of all types of EME sovereign bonds, with a greater effect on local than on foreign currency bonds. The elasticities are smaller in magnitude than for the country-level regression, but highly significant in most specifications. Global financial conditions, as gauged by the $BDI$, play a considerable role – even for euro area investors.

When EMEs depreciate against the euro, euro-based investors tend to shed bonds of the respective sovereign. The reaction to $BER_c^{€}$ is systematic for local currency bonds where investors face the currency mismatch; it is insignificant for foreign currency bonds, where borrowers face the mismatch. Euro-based investors also sell local currency bonds when the euro appreciates more broadly (against euro area trade partners). Their holdings of foreign-currency bonds do not react in measurable ways.

**[Place Table 3 about here]**

To further exploit the granularity of the data, we also perform a test that includes all EME bond holdings (both local and foreign debt), while controlling for maturity bucket-country-quarter fixed effects. Importantly, by construction, the inclusion of these fixed effects absorbs the average impact of $BEI$ on bond holdings. These aggregate responses are already captured in the previous specifications. The new specification instead allows us to study how much more of a local denominated bond euro area investors sell relative to foreign currency bonds, keeping the maturity, country (or issuer) and time of the security fixed. Specifically, we run the following regression:

$$\begin{aligned}\Delta \ln N_{s,t} &= \alpha + \beta_1 \Delta BEI_t \times \text{Local}_s + \beta_2 \Delta BER_{s,t}^{€} \times \text{Local}_s + \beta_3 \text{Local}_s \\ &+ \beta_4 C_{s,t} + \gamma_{m(s),c(s),t} + \epsilon_{s,t}, \end{aligned} \tag{4}$$

where $\text{Local}_s$ equals a dummy variable equal to one if security $s$ is denominated in local currency and zero otherwise, and $\gamma_{m(s),c(s),t}$ indicate maturity bucket $m(s)$–country $c(s)$–time $t$ fixed effects. We divide the maturity spectrum into five buckets: $T < 3Y$, $3Y \leq T < 5Y$, $5Y \leq T < 10Y$, $10Y \leq T < 15Y$, $T \geq 15Y$. We include the same controls as before, except for those that vary only over time, as they are absorbed by the fixed effects.

Table 4 shows the results: euro area investors sell more of local currency bonds relative to foreign currency bonds of the same issuer country, same maturity bucket and at the same point in time. In terms of economic magnitude, focusing on the last column, euro area investors sell 0.59% more of local denominated bonds when the euro strengthens by 1%, and sell an additional 0.15% if a given EME country depreciates by 1% more relative to average euro strength.

[**Place Table 4 about here**]

The fact that foreign currency bonds are retained while local currency bonds are sold in response to depreciations is indicative of a lender-specific effect. Euro-based investors face valuation losses only on local currency bonds, not on the foreign currency bonds they hold. If investors viewed local currency bonds as risky on account of the sovereign's dollar borrowing, they would sell both types. But they might be unconcerned about a depreciation against the euro since most EMEs borrow predominantly in dollars, not euros.

Our results also highlight the strength and consistency of the $BDI$ across all specifications. This finding is consistent with changes in global financial conditions (as measured by the $BDI$) affecting euro-based investors via funding availability and risk appetite.

*D. Robustness*

The results at all levels of aggregation so far suggest that global investors systematically react to different types of exchange rates. A stronger dollar ($BDI$) has the broadest effect on bond holdings, akin to a global risk factor; a stronger euro ($BEI$) affects local currency bonds specifically, consistent with its role in euro-based investors' financial constraints; and bilateral depreciations against the euro trigger net selling of specific local currency bonds on which euro-based investors face a currency mismatch – identified without confounding dollar related effects. These findings are consistent with the channels illustrated in Figure 2. This section shows that our results remain robust to specifications designed to address various caveats.

**EMEs borrowing euro.** One concern is that the separation between borrower currency risk (mostly dollar) and investor currency mismatch (with respect to the euro) is not as clear-cut as we think. Several major EMEs in Europe rely to a large extent on euro-denominated borrowing, notably Bulgaria, Croatia, Czech Republic, Hungary, Poland, and Romania.[12] In those cases, depreciations against the euro play a dual role: causing losses on investors' local currency bond holdings *and* raising borrowers' debt burdens. Table IA3 in the Internet Appendix shows that excluding this set of borrowers from the baseline regression leaves results qualitatively unchanged. Hence, there is little evidence that euro borrowing among some EMEs undermines our identification of the channels in Figure 2.

**Currency of bond vs issuer.** Another possible concern is that country risk may blur the line between the reactions to local and foreign currency bonds of the same sovereign. It is possible that the burden that, say, Chile faces on its external dollar debt also makes its Chilean peso bonds more risky – defaults need not be selective. The specifications so far treated local and foreign currency bonds as distinct investments; holdings were assumed to react to the currency denomination of the bond, i.e. to dollar-euro rate for dollar bonds, and to the Chilean peso-euro rate for Chile's local currency bonds. However, if depreciations hurt a sovereign's creditworthiness overall, perhaps *all* bond holdings (also those of foreign currency bonds) respond to a depreciation of that issuer's currency.

[12] Each of these sovereigns has half or more of the government bonds issued as international debt securities (IDS) government bonds denominated in euros. More generally, the euro also accounts for a large share of their overall external debt liabilities at the country level (Bénétrix et al. 2019).

To test this idea, we align the bilateral euro rate with the issuer country: in the example above, holders of Chilean bonds now face the peso-euro exchange rate, even on Chilean bonds issued in dollars or euros. Table IA4 in the Internet Appendix leaves several earlier results unchanged: we still observe net selling in response to dollar strength, and the shedding of local currency bonds when the euro appreciates and when specific EME currencies depreciate. However, a novel result is that euro-based investors buy foreign-currency bonds in those circumstances, as evidenced by the positive and significant signs on $\Delta BEI$ and $BER_c^{€}$. These opposite signs suggest that investors shift from local to foreign currency bonds of the same sovereign when its currency depreciates, leading to an even larger contrast between local versus foreign currency bond holdings in response to euro strength.

**Investment funds and custodians.** Belgium, Luxembourg, and Ireland are well-known for their funds industry and custodians that invest or hold financial assets on behalf of investors in other jurisdictions (Tabova and Warnock 2022). If the ultimate investors reside outside the euro area, the relevant currency mismatch may not relate to the euro. Indeed, Beck et al. (2023) show that UK investors often invest through investment funds in Luxembourg and Ireland. Moreover, in Figure A2 in the Appendix, we show that only 55% of EME bond funds in the euro area (mostly in Luxembourg and Ireland) have at least 60% of their investor base residing in the euro area.[13] Table IA5 of the Internet Appendix shows that excluding these financial centers does not alter our findings. In fact, the reaction to euro-based exchange rates strengthen – an intuitive result, given that the modified investor base contains fewer investors with other reference currencies. Additionally, when exploring the mechanism in Section V, we show that our main results remain unaltered for a subset of EME bond funds that are explicitly designated as euro-denominated.

**Analysis by sector.** Finally, the channels we have in mind may not be relevant for all

[13] As in Beck et al. (2023), we merge SHS data with Morningstar data to compute the fraction of EME bond funds in the euro area that are held by euro area investors. Specifically, we obtain the ISINs of all EME bond funds that reside in the euro area through Morningstar. We link these ISINs to the holdings in SHS data to compute the total holdings of euro area investors in each EME bond fund.

types of lenders. Some institutions mark to market continuously, others realise valuation losses only when bonds are sold or redeemed. To account for such differences, we compute total nominal holdings by sector and interact the exchange rates with indicator variables that define the major investor types in EME sovereign debt: banks, investment funds, and insurance companies and pension funds (ICPFs).

Table A1 of the Appendix summarizes the results. We find the strongest effects for investment funds and ICPFs. This is intuitive, given the practice of marking to market the assets on a daily (investment funds) or quarterly (ICPFs) basis. These results are consistent to those in Bertaut et al. (2023): mutual funds are more sensitive to exchange rates than other investors in local currency bonds. The findings are also consistent with Fang et al. (2025), who find that non-bank investors' demand for emerging market debt is most responsive to its price. These results highlight the potential of exploiting the heterogeneity across lenders for better identification, an approach we pursue in the next section.

### *E. Extensions*

This section studies the effect of bond sales induced by euro strength on bond yields, and then shows that our results are not limited to EMEs by finding similar effects in advanced economies.

**Euro strength induced bond sales and bond yields.** An important question that remains is whether the effect we identify has implications for the cost of borrowing of EMEs. To address this, we regress changes in bond yields at the security level on bilateral exchange rates ($\text{BER}_c^{€}$), interacted with the ex-ante share of euro area investors holding the bond. If euro strength induced sales affect bond yields, we should observe that bonds held more heavily by euro area investors experience larger increases in local bond yields compared to those held less by euro area investors. Specifically, we run the following triple interaction regression:

$$\Delta y_{s,t} = \alpha + \beta_1 \Delta BER^{€}_{c,t} \times \text{Local}_s \times \theta^{EA}_{s,t-1} + \beta_2 C_{s,t} + \gamma_{m(s),c(s),t} + \epsilon_{s,t}, \tag{5}$$

with $\theta^{EA}_{s,t-1}$ the share of TAO held by euro area investors for bond $s$ at time $t-1$, $C_{s,t}$ includes all lower-order interactions and the same controls as before, and $\gamma_{m(s),c(s),t}$ indicate maturity bucket $m(s)$–country $c(s)$–time $t$ fixed effects.

The interaction coefficient $\beta_1$ measures the sensitivity of changes in local bond yields to $BER^{€}$ on the ex-ante share of euro area investors. By including maturity bucket $m(s)$–country $c(s)$–time $t$ fixed effects, the coefficient $\beta_1$ captures the effect of euro strength induced sales of local bonds while holding constant the maturity, issuer, and time period of the bonds.

Note that for foreign currency bonds, we also use the bilateral exchange rate of country $c$ relative to the euro, rather than the bond's currency of denomination. The rationale is that we aim to compare the effects on local versus foreign currency bonds: euro area investors do not sell foreign currency bonds in response to a strengthening of the euro against country $c$'s currency, and therefore, we should not observe a significant effect on yields.

Table 5 summarizes the results for both local and foreign currency debt. The results are in line with our hypothesis: local bond yields rise more when an EME currency depreciates against the euro if the bond is held predominantly by euro area investors compared to foreign-currency bonds. Hence, this finding indicates that euro strength induced sales by euro area investors raises local currency bond yields, increasing the borrowing costs on local denominated debt. In terms of magnitude, when country $c$ depreciates by 5%, a one standard deviation increase in $\theta^{EA}_{s,t-1}$ (12%) coincides with an additional rise in local bond yields of 4.5 basis points. This finding is consistent with Coppola (2025), who shows that corporate bonds that are held more by investors prone to selling those bonds during crises suffer larger losses during downturns. It also aligns with Lee (2022), who argues that global investors require a higher exchange rate risk premium when they lend in local denominated debt.

**[Place Table 5 about here]**

**Advanced economies.** The analysis so far focused on a particular slice of the securities holdings statistics for reasons of identification, namely euro-based investors' holdings of sovereign bonds issued by major EMEs. The same mechanism could be at play for bonds issued by advanced economies (AEs), in particular for non-major currencies that are unlikely to be hedged. Table 6 runs the security-level regressions for sovereign bonds issued by major AEs outside of the euro area; we also exclude the United States to avoid confounding effects from the US dollar. As major AE sovereigns issue mostly in their own currency, the table presents estimates for local currency bonds and omits the foreign currency column.

The results again show that euro area investors sell local currency bonds when the $BEI$ rises, consistent with the notion of tightening financial constraints when assets in other currencies lose value in terms of euros. In addition, the $BER_c^{€}$ has a negative impact on holdings, indicating that investors sell more of those AEs that depreciate more against the euro.

**[Place Table 6 about here]**

## V. Exploring the Mechanism - Currency Mismatch Lender Side

Our findings so far suggest that currency mismatches on the lender side shape global investors' bond holdings. This interpretation hinges on the assumption that investors do not hedge the underlying currency exposure when investing in EMEs or in small advanced economies. In view of the channels discussed in Section II.A, if investors systematically hedged all foreign currency exposures, the currency mismatch channel should be absent and euro strength should not affect their portfolio decisions.

Standardized data on currency hedging activities across countries and sectors are generally unavailable (Du and Huber 2025). As data become available, an emerging literature on hedging practices sheds light on the share of currency risk being hedged. Du and Huber

(2025) collect filings from institutional investors outside the United States to measure the hedge ratio on their holdings of US dollar-denominated securities (fixed income and equities). They find that investors hedge a meaningful amount of their US dollar exposure, with sectors that have active hedging strategies exhibiting hedge ratios of 29% overall, averaging at 21% (mutual funds), 35% (pension funds) and 44% (insurance companies), respectively. Cheema-Fox and Greenwood (2024) further document that most non-US-domiciled fixed income investors hedge nearly all of their dollar exposure, with average hedge ratios close to one. On the other hand, Sialm and Zhu (2024) document that US-domiciled international fixed-income mutual funds hedge only 18% worth of their foreign currency portfolios on average, even though 90% of funds use currency forwards for various purposes.

For EMEs, in particular, there is evidence that investors typically incur EME exposures on an unhedged or partially hedged basis (Siddiqui et al. 2020; Chen and Zhou 2025; De Leo et al. 2025), since EME currencies are costly to hedge and the currency exposure is part of the return play. To illustrate, Figure A1 in the Appendix uses regulatory data to show that Dutch pension funds hedge at most a small fraction of their local currency sovereign bonds. The left panel plots their overall portfolio exposure by currency, showing that they mostly hedge major currencies, including dollar exposures (this is consistent with the findings in Du and Huber (2025) and Cheema-Fox and Greenwood (2024)); by contrast, "Other" currencies, including all EME currencies, remain almost entirely unhedged. The right panel zeros in on holdings of EME sovereign bonds by region, again showing that the respective exposures must be largely unhedged since the derivatives positions are much smaller than their sovereign bond holdings.

That said, the available data on hedging affords another test of the mechanism, based on the differential behavior of hedged vs unhedged investors. It speaks to the currency mismatch channel if only unhedged investors react to exchange rates in the way described above, whereas investors who hedged their currency exposure with respect to the euro do not. To test for such differences, we obtain security-level data on euro-denominated EME bond funds located in the euro area, with two important characteristics. First, the data reveal whether funds hedge the underlying currency exposure or not. Second, the data identify the currency of denomination of the fund. This, combined with the selected funds' domiciles being in the euro area, ensures that the fund investors are euro-based.

We use granular data on EME bond mutual funds from Morningstar, Inc. Mutual funds are a key driver of our findings, judging by the analysis by sector (Table A1). Similar to the SHS-S data, funds report all their positions at the security (ISIN) level. Importantly, Morningstar discloses the currency of denomination of each fund, enabling us to zero in on euro-denominated mutual funds to ensure that the reference currency is indeed the euro. Furthermore, we provide evidence that euro funds are primarily held by euro area residents: for 80% of euro-denominated EME bond funds, at least 70% of fund investors reside in the euro area (Figure A2). If anything, this is a lower bound for the euro-based investor base, since investors outside the euro area may still use the euro as a reference currency, e.g. when their currency is pegged to the euro (as the Danish krone). Importantly, Morningstar provides information on whether these funds are unhedged or hedged, and if so, against which currency.[14]

Isolating euro-based EME mutual funds in the Morningstar data therefore allows us to compare hedged with unhedged funds. In terms of size, the bulk of EME bonds held by euro-based EME mutual funds is with unhedged funds (Figure 4): the aggregate market value of unhedged funds ($25 billion in 2021q4) is substantially larger than that of hedged funds ($7.5 billion). This is consistent with evidence that investors typically prefer holding local currency debt on an unhedged basis.

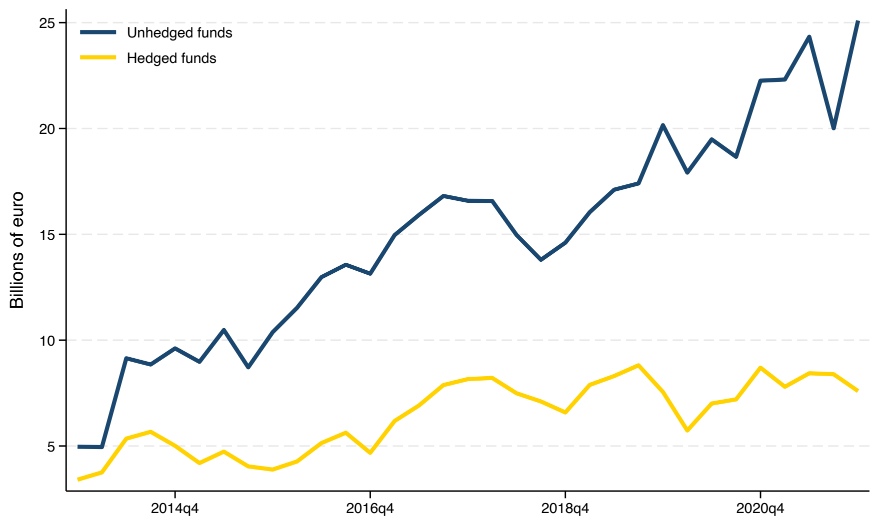
We next run the following regression to test whether the response of unhedged funds to exchange rate movements differs systematically from that of hedged mutual funds:

$$\Delta \ln N_{i,s,t} = \alpha + \beta_1 \Delta BEI_t \times \text{Local}_s \times \text{Unhedged}_i + \beta_2 C_{i,s,t} + \gamma_{m(s),c(s),t} + \epsilon_{i,s,t}, \quad (6)$$

[14] We solely focus on the fund's main share class and whether its fully hedged relative to the euro.

Figure 4. **Total holdings EME bonds – hedged vs unhedged mutual funds**

This figure shows the total market value (in billions) of EME bonds held by euro-denominated EME bond mutual funds, separately for funds that hedge their currency exposure with respect to the euro (hedged) and those that do not (unhedged). The quarterly sample period is 2013q4-2021q4.




where $N_{i,s,t}$ denotes the total amount invested by all $i \in \{\text{hedged}, \text{unhedged}\}$ funds in security $s$, $\text{Unhedged}_i$ a dummy variable equal to one if $i = \text{unhedged}$, $C_{i,s,t}$ includes all the lower-order interactions and the same controls as before, and $\gamma_{m(s),c(s),t}$ indicate maturity bucket $m(s)$–country $c(s)$–time $t$ fixed effects.

Table 7 summarizes the results.[15] As before, Columns (1), (3), and (5) show that mutual funds shed local currency bonds in response to euro strength. More distinctively, the negative and statistically significant triple interaction terms $\beta_1$ in Columns (2), (4), and (6) shows that it is the unhedged funds that respond to euro strength, rather than the hedged funds. Indeed, hedged funds show no reaction to euro strength, as indicated by the insignificant coefficients on the interaction terms of the exchange rates with the local currency bond indicators. This result aligns precisely with the currency mismatch channel: exchange rates referencing the euro induce valuation effects for unhedged investors, but leave hedged investors unfazed. This systematic difference in behavior helps corroborate that currency mismatches on the

[15] We again convert the holdings to their original currencies using current exchange rates, and convert them back to euros at constant end-2021 exchange rates.

lender side are an important driver of international portfolio allocation.

**[Place Table 7 about here]**

## VI. A Mean-Variance Model of Sovereign Bond Portfolios

This section sets out a model to rationalize our empirical findings. We allow exchange rates to play a role at each level of the portfolio allocation problem: at the exposure or country level, the currency portfolio level, and the overall portfolio, as sketched in Figure 2 (lower panel). To do so, we extend a standard model of portfolio choice to incorporate the currency dimensions relevant for global investors holding emerging market or small open economy bonds. Bond investors chose between local currency and foreign currency bonds across different issuers, and value the returns in their own reference currency (e.g. euro) that differs from the dominant global currency (dollar). We first set out a generic portfolio choice problem, and then specify return processes amendable to a closed-form solution in the presence of covariance across bonds.[16] We then show that the comparative statics match our empirical findings on the effect of different exchange rates on investors' bond portfolios.

### *A. Generic Portfolio Choice Problem*

Consider an institution or investor who maximizes expected returns subject to a Value-at-Risk (VaR) constraint of the form

$$\alpha\sigma_r \leq \kappa,$$

where $\sigma_r$ denotes the standard deviation of the investor's portfolio, the parameter $\alpha \in (0, 1)$ measures the stringency of the VaR constraint, and $\kappa$ represents available capital.[17] Our

[16]The set-up generalizes Aramonte et al. (2022) in several ways. We expand the investment choice to local and foreign currency bonds while allowing for a separate reference currency, and introduce endogenous capital.

[17]VaR is a given percentile of the profit-and-loss (PnL) experienced by an institution so that, any loss larger than VaR happens with some given small probability: for $\alpha \in (0, 1)$, VaR at level $\alpha$ is the smallest number $X$ such that the probability that $\mathbb{P}(PnL < X) = 1 - \alpha$.

rationale for assuming a VaR constraint is grounded in its widespread use in internal risk management practices (Basak and Shapiro 2001; Adrian and Shin 2014). As demonstrated in Section E, our findings are primarily driven by mutual funds and ICPFs. In the euro area, ICPFs are explicitly subject to VaR constraints (Jansen 2024), while mutual funds– particularly those using derivatives or complex financial instruments— are required to implement VaR models to manage market risk, with strict limits and regular backtesting.[18]

Squaring the VaR constraint gives rise to the traditional mean-variance approach of maximizing expected portfolio returns subject to a constraint on the variance of the portfolio,

$$\sigma_r^2 = w'\Sigma w \leq \left(\frac{\kappa}{\alpha}\right)^2. \tag{7}$$

The investor chooses portfolio weights $w$ at the beginning of $t$. The terms $\alpha$ and $\kappa$ will be endogenous, but do not depend on the current choice of $w$. Denoting expected returns by $\mu$, we obtain the first-order conditions from the Lagrangian:

$$\mathcal{L} = w'\mu - \lambda \left[ w'\Sigma w - \left(\frac{\kappa}{\alpha}\right)^2 \right].$$

The optimal choice equates the expected return from increased bond holdings to the marginal cost of additional risk,

$$\mu = 2\lambda \Sigma w \quad \Rightarrow \quad w = \frac{1}{2\lambda}\Sigma^{-1}\mu. \tag{8}$$

Using the binding VaR constraint (7) allows us to solve for the Lagrange multiplier, $\lambda = \frac{\alpha}{2\kappa}\sqrt{\mu'\Sigma^{-1}\mu}$. Substituting $\lambda$ into (8) yields the optimal portfolio,

$$w^* = \frac{\kappa/\alpha}{\sqrt{\mu'\Sigma^{-1}\mu}}\Sigma^{-1}\mu. \tag{9}$$

[18] See the European Commission Guidelines on Risk Measurement for Mutual Funds (UCITS).

Optimal bond holdings are proportional to the effective capital available for managing portfolio risk, given the structure of expected returns and covariances.

**Proposition 1. Optimal Bond Holdings.**

1. The optimal portfolio allocation across individual bonds is proportional to their risk-adjusted expected returns, $\Sigma^{-1}\mu$.
2. The size of the overall bond portfolio is:
   (a) proportional to available capital, $\kappa$;
   (b) inversely proportional to the stringency of the VaR constraint, $\alpha$;
   (c) inversely proportional to the generalized Sharpe ratio, $\sqrt{\mu'\Sigma^{-1}\mu}$.

   Specifically, for a given VaR risk budget $\kappa/\alpha$, a higher generalized Sharpe ratio $\sqrt{\mu'\Sigma^{-1}\mu}$ indicates greater return per unit of risk, meaning that the same expected return can be achieved with proportionally smaller exposures (or, equivalently, lower portfolio risk).

Before specifying returns and covariances, we discuss the role of capital and the VaR constraint. They are predetermined, not exogenous. The stringency of the capital constraint $\alpha$ can vary with global financial conditions over time. Since the $BDI$ has attributes of a barometer of global risk-taking capacity, we allow the VaR constraint to tighten as the US dollar rises in value: $\alpha_t = f(v_t)$ with $f'(v_t) > 0$, where $v_t$ is a weighted average of the value of the US dollar against other currencies ($BDI$). This assumption is equivalent to assuming that the level of risk aversion of a risk-averse investor depends on the $BDI$.[19]

The investor solves a sequence of static portfolio choice problems every period. The portfolio $w_t$ is chosen in period $t$, based on the expected returns from $t$ to $t+1$, $E_t(r_{t+1}) = \mu_{t+1}$. The

[19]Note that the multiplicative forms we use correspond to our empirical specification. Specifically, given expected returns and covariances, the log-linearized percentage change in holdings, $\Delta \ln(w_t)$, will be linear in the corresponding percentage changes in capital and exchange rates.

quantity of capital available $\kappa_t$ is a function of the realized return on the previous portfolio with $\kappa_{t-1}$ fully invested,

$$\kappa_t = f(w'_{t-1}\, r_t). \tag{10}$$

In this model, a shift in returns induced by exchange rates will have two effects. When realized returns on a subset of assets (e.g., LC bonds) are low, the loss reduces risk capacity and lowers weights $w_t$ across the entire portfolio. Furthermore, when returns are persistent, the expected returns on those assets remain subdued, which leads to reduced allocations to those assets in particular.

*B. Return Process, Expected Returns, and Covariances*

We now specify the structure of returns and covariances in equation (9) in a way that brings out separate roles for local, foreign and reference currencies. With $n$ sovereign issuers, portfolio choice is over $2n$ bonds denominated in local currency (LC) and in foreign currency (FC). For emerging market sovereign bonds, it would be unrealistic to posit independent and identically distributed returns. Our approach allows for linkages across bond returns, yet admits an explicit solution for $\Sigma^{-1}\mu$ in (9). We incorporate two forms of covariance on top of idiosyncratic risk: (1) A common drift induces covariance across all bonds (denoted $\rho$ below); and (2) LC bonds have a common component reflecting the currency risk associated with emerging market currencies (denoted $c$). Formally, the log-returns for bonds issued by country $c$ follow:

$$\begin{aligned} \text{LC bonds} \quad &: \quad r^L_{c,t+1} = \chi^L_c + \delta_{t+1} + \gamma_{c,t+1} \\ \text{FC bonds} \quad &: \quad r^F_{c,t+1} = \chi^F_c + \varepsilon_{c,t+1}. \end{aligned}$$

The variables in the model relate to the exchange rates in our empirics as follows. Euro-based investors evaluate all returns in terms of their reference currency (euro).

- FC bonds, if not denominated in euro, are hedged into euro to yield a return of $r^F_{c,t+1}$; the drift $\chi^F_c$ captures the risk premium of FC bonds issued by country $c$.
- LC bonds are denominated in emerging market currencies and held unhedged; on top of the risk premium in local currency, $\chi^L_c$, foreign investors face currency risk.
  - The country-specific component $\gamma_{c,t+1}$ (if positive) captures the return-enhancing appreciation of the local currency of country $c$, reflecting its bilateral exchange rate with respect to the euro, $BER_c$.
  - EME currencies tend to appreciate or depreciate together; to allow for this, the common component $\delta_{t+1}$ captures an appreciation across local currencies in terms of the investor's reference currency. Hence $\delta_{t+1}$ (when positive) represents the joint appreciation of EME currencies, equivalent to a decline in the $BEI$; conversely, $\delta_{t+1} < 0$ captures euro strength relative to EME currencies. The common component induces covariance among LC bond returns.

Following Proposition 1, the vector $\Sigma^{-1}\mu$ is the key ingredient for the comparative statics of how investors differentiate between bonds of different countries and currencies. To derive an explicit solution to equation (9), we specify expected returns and covariances as follows.

First, we take expected returns on LC and FC bonds to be equal except for the exchange rate risk of LC bonds being denominated in local currency, setting $\chi^L = \chi^F = \chi$.[20] Next, we assume that the covariance of the country-specific return components across all bonds equals $\rho$. For **FC bonds**, $\varepsilon_{c,t+1}$ captures idiosyncratic variation in the risk premium $\chi$, with $\varepsilon^F_{c,t+1} \sim \mathcal{N}(0, \rho+z)$ i.d. (identically, not independently, distributed).[21] With this, the returns on foreign currency bonds are distributed as $r^F_{c,t+1} \sim \mathcal{N}(\chi, \rho + z)$.

[20] This comes with little loss of generality, since the effects specific to individual countries and to LC bonds, $\gamma_c$ and $\delta$, can be interpreted to include more than exchange rate risk.

[21] This is for tractability: $\text{Cov}(r^F_{c,t}, r^F_{j,t}) = \rho$, hence $\text{Var}(r^F_{c,t}) = \text{Cov}(r^F_{c,t}, r^F_{c,t}) = \rho + z$.

For **LC bonds**, we assume that the common component $\delta_{t+1}$ follows an AR(1) process,

$$\delta_{t+1} = \varphi\delta_t + \eta_{t+1}, \text{ with } \varphi > 0 \text{ and } \eta_{t+1} \sim \mathcal{N}(0, c) \text{ i.d.d.} \tag{11}$$

This is a reasonable approximation: regressing exchange rate changes on their own lags yields an AR(1) coefficient of $\varphi = 0.31$ on average (Table IA6 in the Internet Appendix).

We allow for equal persistence in the country-specific component of LC bonds, and posit $\gamma_{c,t+1} = \varphi\gamma_{c,t} + \nu_{c,t+1}$, with $\nu_{c,t+1} \sim \mathcal{N}(0, \rho + c)$ i.d. This component includes both country-specific appreciations and idiosyncratic variation in the LC risk premium $\chi_c^L$. Combining the various components, LC returns follow $r_{c,t+1}^L \sim \mathcal{N}(\chi + \varphi\delta_t + \varphi\gamma_{c,t}, \rho + c + z)$.[22] The term premia of LC and FC bonds and their volatilities are thus equal up to the exchange rate risk, where LC bonds feature the additional term $c$ reflecting the co-movement across EME exchange rates.

### *C. Model solution*

In every period, investors solve a problem of the same form. We drop time subscripts to highlight the differential returns across countries and currency denominations, and write expected returns and covariances as

$$\mu = \left(\begin{array}{c} \chi + (\delta + \gamma_1)\varphi \\ \chi + (\delta + \gamma_2)\varphi \\ \ldots \\ \chi + (\delta + \gamma_n)\varphi \\ \hline \chi \\ \ldots \\ \chi \end{array}\right), \Sigma = \left[\begin{array}{ccc|ccc} \rho + c + z & \cdots & \rho + c & \rho & \cdots & \rho \\ \cdots & \ddots & \cdots & \cdots & \ddots & \cdots \\ \rho + c & \cdots & \rho + c + z & \rho & \cdots & \rho \\ \hline \rho & \cdots & \rho & \rho + z & \cdots & \rho \\ \cdots & \ddots & \cdots & \cdots & \ddots & \cdots \\ \rho & \cdots & \rho & \rho & \cdots & \rho + z \end{array}\right]. \tag{12}$$

[22]This is again for tractability. In particular, we have $\text{Cov}(r_{c,t}^L, r_{j,t}^L) = \rho + c$, hence $\text{Var}(r_{c,t}^L) = \text{Cov}(r_{c,t}^L, r_{j,t}^L) = \rho + c + z$.

The solution to the portfolio problem in equation (9) involves the vector $\Sigma^{-1}\mu$, while the remaining terms scale the entire portfolio (Proposition 1). Hence, this vector governs how investor holdings of LC bonds and FC bonds respond to exchange rates differentially. We characterize the optimal portfolio allocation as follows:

**Proposition 2. Solution and Comparative Statics.**

The optimal bond portfolio weights (9) under our return and covariance assumptions are proportional ($\propto$) to the vector $\Sigma^{-1}\mu$:

$$\begin{aligned} &\text{Foreign currency bonds:} \quad w_c^{FC} \propto \quad \tfrac{\phi}{\omega}\chi - \tfrac{n\rho}{\omega}\left(\delta + \overline{\gamma}\right)\varphi \\ &\text{Local currency bonds:} \quad\;\; w_c^{LC} \propto \quad \tfrac{z}{\omega}\chi + \tfrac{z+n\rho}{\omega}\left(\delta + \overline{\gamma}\right)\varphi + \tfrac{1}{z}(\gamma_c - \overline{\gamma})\varphi \end{aligned} \tag{13}$$

where $\phi \equiv nc + z$ and $\omega \equiv \phi z + (\phi + z)n\rho$ collect covariance parameters $c$, $z$, $\rho > 0$, and $n \geq 1$. The proportionality reflects the scaling of all weights by $\frac{\kappa/\alpha}{\sqrt{\mu'\Sigma^{-1}\mu}}$ (Proposition 1). This solution has the following comparative statics properties:

1. Bond holdings $w_c$ rise in their own expected **returns**, and fall in those of other bonds.
2. Bond holdings fall in a bond's **variance**. The **covariance** between bonds decreases bond holdings: $c$ reduces holdings of LC bonds, and $\rho$ lowers all bond holdings.
3. **Exchange rates** affect optimal bond holdings as follows:
   (a) A negative $\delta$ (rise in $BEI$) reduces $w_c^{LC}$ and increases $w_c^{FC}$ across countries; the magnitude of the change in $w_c^{LC}$ exceeds that in $w_c^{FC}$.
   (b) A negative $\gamma_c$ (rise in $BER_c$) reduces $w_c^{LC}$ without significantly affecting $w_c^{FC}$.
4. The **capital constraint** scales the entire bond portfolio:
   (a) A tighter VaR constraint $\alpha$, including from an increase in $v$ (rise in $BDI$), reduces all bond holdings $w_c^{LC}$ and $w_c^{FC}$.
   (b) Currency depreciations ($\delta < 0$ or $\gamma_c < 0$) reduce $\kappa$ with the same effect. A

negative $\delta$ tightens the capital constraint $n$ times as much as a single country's depreciation $\gamma_c < 0$ does.

(c) Persistent depreciations induce negative feedback effects. Currency depreciations ($\delta < 0$ or $\gamma_c < 0$) cause losses to LC bond investors, reducing $w_c^{LC}$ and $w_c^{FC}$ via $\kappa$; they further lower expected returns and holdings of LC bonds $w_c^{LC}$. This feedback effect reduces total LC bond holdings more for $\delta < 0$ than for the same $\gamma_c < 0$.

The Proof in Appendix A is in four parts. The differential responses of LC and FC bonds to exchange rates are given by $\Sigma^{-1}\mu$. Part A1 makes use of a result in linear algebra known as the Sherman-Morrison formula to obtain the inverse $\Sigma^{-1}$. Part A2 derives the functional form of the optimal bond allocations $w_c^{FC}$ and $w_c^{LC}$ based on $\Sigma^{-1}\mu$, and Part A3 proves the comparative statics, given that the optimal weights (13) are linear functions of the individual return components. These responses are proportional to $\Omega \equiv \frac{\kappa v^{-\pi}}{\sqrt{\mu'\Sigma^{-1}\mu}}$, which scales all portfolio weights equally. Appendix A4 thus examines the dynamic effects through the dependency of $\Omega$ on capital $\kappa$ and expected returns $\mu$.

The comparative statics reveal which exchange rates matter to global investors. An increase in the $BDI$ ($v \uparrow$) reduces bond holdings across the board by tightening the capital constraint, even for euro-based investors holding local currency bonds denominated in EME or small open currencies (i.e. where the respective exchange rates do not involve the dollar). Euro strength, or a rise in the $BEI$ ($\delta < 0$), reduces LC bond holdings ($w_c^{LC} \downarrow \forall c$) since EME depreciations induce losses ($\downarrow \kappa$) and lower expected returns on LC bonds as a group ($\varphi > 0$). And for sovereigns issuing bonds in their own currency $c$, euro investor demand is lower for LC bonds denominated in currencies that depreciate more ($\gamma_c < \overline{\gamma}$), since the bilateral exchange rate against the reference currency ($BER_c$) is expected to be persistent.

The way investors differentiate between bonds can be characterized by comparing portfolio weights across issuers and bond types for a given $\Omega$,

$$
\begin{array}{lrl}
\text{LC bonds of country } c \text{ vs } c'\text{:} & w_c^{LC} - w_{c'}^{LC} = & \frac{1}{z}(\gamma_c - \gamma_{c'})\varphi\ \Omega \\
\text{FC bonds of country } c \text{ vs } c'\text{:} & w_c^{FC} - w_{c'}^{FC} = & 0 \\
\text{LC vs FC bonds of issuer } c\text{:} & w_c^{LC} - w_c^{FC} = & \left[\frac{1}{z}(\gamma_c - \overline{\gamma})\varphi + \frac{z+2n\rho}{\omega}(\delta + \overline{\gamma})\,\varphi - \frac{cn}{\omega}\chi\right]\Omega.
\end{array}
\tag{14}
$$

In line with the empirical findings in the previous section, the model also predicts that euro area investors systematically shed local currency bonds after a depreciation of these currencies against the euro, while retaining foreign currency bonds of the same sovereign issuers (equation (14), last line). Thus, a currency mismatch on the *lender* side is an important channel driving the asset allocation of global investors.

Finally, the model has interesting dynamic implications, summarized in Proposition 2. Our approach to studying the dynamics, as detailed in Appendix A4, is to (a) start from a steady state where $\delta = 0$ and $\gamma_c = 0\ \forall c$ up to that point, and (b) consider the deviations from the steady state when either $\delta$ or $\gamma_c$ change by a given amount $x$, all else being equal. Comparing the respective deviations helps to differentiate the portfolio response to country-specific exchange rates ($BER_c$) and a broad effect of the reference currency ($BEI$). The optimal portfolio in deviation form can be written as

$$
w = \frac{\kappa/\alpha}{\sqrt{\mu'\Sigma^{-1}\mu}}\Sigma^{-1}\mu = \frac{\kappa_0 + \Delta\kappa}{\alpha\sqrt{(\overline{\mu} + \Delta\mu)'\Sigma^{-1}(\overline{\mu} + \Delta\mu)}}\left(\Sigma^{-1}\chi + \Sigma^{-1}\Delta\mu\right),
$$

where the steady state portfolio is given by

$$\overline{w} = \frac{\kappa_0 \chi}{\alpha^2 \omega} \begin{pmatrix} z \\ \dots \\ z \\ \hline \phi \\ \dots \\ \phi \end{pmatrix}.$$

The scale of the steady state portfolio is proportional to available capital and expected returns, weighed down by VaR tightness $\alpha$.[23] All LC bonds are held in the same quantities, since expected returns equal in steady state; the same holds for FC bonds, but higher covariance among LC bonds tends to favor FC bonds ($\phi \equiv nc + z > z$).

Substituting the deviations derived in Appendix A4 yields the optimal portfolio weights for each case. When $\delta = x$, the allocations to LC and FC bonds will shift as follows

$$\begin{aligned} w^{LC} &= \widehat{\Omega} \left[ \frac{z}{\omega} \chi + \frac{z + n\rho}{\omega} \varphi x \right] \\ w^{FC} &= \widehat{\Omega} \left[ \frac{\phi}{\omega} \chi - \frac{n\rho}{\omega} \varphi x \right] \\ \text{where } \widehat{\Omega} &= \frac{\kappa_0 + \frac{\kappa_0 \chi}{\alpha^2 \omega} nzx}{\alpha \sqrt{\alpha^2 + \frac{nz}{\omega}(2\chi + \varphi x)\varphi x}} \end{aligned} \tag{15}$$

By contrast, when $\gamma_c = x$, investors shift their holdings of country $c$ bonds differently from

[23]The steady state portfolio is consistent with equation (13) with $\delta$ and $\gamma_c = 0$, and $\Omega$ taking its steady state value.

LC bonds issued by other countries $i \neq c$,[24]

$$\begin{aligned}
w_c^{LC} &= \widetilde{\Omega}\left[\frac{z}{\omega}\chi + \left(\frac{z+n\rho}{\omega} + \frac{n-1}{z}\right)\frac{\varphi x}{n}\right] \\
w_{i\neq c}^{LC} &= \widetilde{\Omega}\left[\frac{z}{\omega}\chi - \left(\frac{1}{z} - \frac{z+n\rho}{\omega}\right)\frac{\varphi x}{n}\right] \\
w^{FC} &= \widetilde{\Omega}\left[\frac{\phi}{\omega}\chi - \frac{\rho}{\omega}\varphi x\right] \qquad (16) \\
\text{where } \widetilde{\Omega} &= \frac{\kappa_0 + \frac{\kappa_0 \chi}{\alpha^2 \omega} z x}{\alpha\sqrt{\alpha^2 + \frac{z}{\omega}(2\chi + \varphi x)\varphi x}}
\end{aligned}$$

These expressions reveal the forces at play in the dynamic model. Note that the expressions nest the steady state ($x = 0$). Next, parametrizing the persistence of returns ($\varphi$) helps to clarify the channels through which exchange rates affect global bond portfolios.

First, if expected returns did not depend on past returns ($\varphi = 0$), exchange rates affect holdings only via the capital constraint: a drop in LC returns scales down capital and lowers *all* bond holdings below their steady state weights $\overline{w}$ proportionally. This effect is $n$ times larger for $\delta$ than for $\gamma_c$, as is clear from comparing the effect of $x$ on $\widehat{\Omega}$ and $\widetilde{\Omega}$.

Second, return persistence $\varphi > 0$ gives rise to additional effects via expected returns and covariances. These effects differ in the case of $\delta$ and $\gamma_c$. For expected returns, euro strength has a broader effect than the depreciation of a single currency by the same amount. In equation (15), $x < 0$ lowers the attractiveness of all LC bonds (while raising that of FC bonds by less in relative terms); holdings of LC and FC bonds diverge accordingly. A single country's depreciation has more contained effects: equation (16) makes clear that investors only shed LC bonds of the affected country ($w_c^{LC}$ falls) while holdings of other LC bonds may rise ($w_{i\neq c}^{LC}$ rises), by a small amount if at all. And any rise in holdings of FC bonds is muted at best, $n$ times less in (16) than in (15). Such potential increases in holdings are curbed by the losses investors suffer when the currencies they hold depreciate in terms of their reference currency.

[24]This because $\gamma_c = x$, whereas $\gamma_{i\neq c} = 0$, hence $\overline{\gamma} = x/n$ in equation (13).

We conclude the proof in Appendix A4 by showing that a broad euro appreciation ($\delta < 0$) leads to a larger total reduction in LC bond holdings than a country-specific depreciation ($\gamma_c < 0$) of the same magnitude ($\gamma_c = \delta = x < 0$). To establish this, we take the derivative of $w^{LC}$ with respect to $x$ in both (15) and (16) and sum across all $n$ countries.

## VII. Conclusions

This paper has shed new light on how international investors adjust their bond holdings in response to exchange rate movements across reference currencies, local currencies and the dollar as a global risk factor. By focusing on euro area-based investors for whom the euro is the reference currency, we rotate the reference currency away from the dollar, to identify the impact on the reference currency (euro) without the confounding effects from the dominant role of the dollar in global finance and trade invoicing. This allows us to exploit granular security-level detail on the issuer, the holder and the currency of each bond to define the relevant exchange rates for the currency mismatch on either side.

We find that euro-based investors sell local currency bonds as an asset class when there is a broad-based depreciation of EME currencies against the euro, and sell more local currency bonds of those sovereign issuers whose currency depreciate more against the euro, precisely those bonds on which investors' currency mismatch bites hardest. In this sense, the locus of currency risk we observe is very specific, tied to the lender's balance sheet. When an EME depreciates, the rise in its debt burden may increase credit risk on foreign currency bonds; the same depreciation is inconsequential in terms of servicing local currency debt. Yet we find that investors primarily sell local currency bonds in response to a depreciation of an EME against the euro. Investors react to the currency mismatch on their *own* balance sheet: the relevant exchange rate is the currency of the bond they hold, not the currency of the issuer country. The results underscore the importance of currency mismatches with respect to lenders' reference currencies.

Table 1. **Time-series regressions**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI) and the Broad Euro Index (BEI). Column headings indicate whether the sample includes bonds denominated in all, in local or in foreign currencies (from the perspective of the EME sovereign). Controls include the change in log total amount outstanding (TAO), and the change in the VIX. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the foreign-local level and reported in brackets. Significance: ***99%, **95%, *90%.

| | All | Local | Foreign |
|---|---|---|---|
| | (1) | (2) | (3) |
| ΔBDI | -0.842*** | -1.170*** | -0.499*** |
| | [0.147] | [0.258] | [0.165] |
| ΔBEI | -0.475*** | -0.783*** | -0.098 |
| | [0.171] | [0.265] | [0.145] |
| ΔTAO | 0.004 | -0.252 | 0.15 |
| | [0.232] | [0.634] | [0.090] |
| ΔVIX | 0.001 | 0.006 | -0.003 |
| | [0.010] | [0.015] | [0.010] |
| Constant | 2.637*** | 3.884** | 1.981*** |
| | [0.489] | [1.813] | [0.350] |
| $N$ | 64 | 32 | 32 |
| $R$-sq | 0.31 | 0.36 | 0.51 |

Table 2. **Panel regressions at the country level**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and EME bilateral exchange rates against the euro ($BER^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI ($BER^{€,ort}$). Column headings indicate whether the sample includes bonds denominated in local or in foreign currencies (from the perspective of the EME sovereign). For foreign currency bonds, our analysis is at the country-currency level. Controls include the change in log total amounts outstanding, credit ratings, yield differentials, VIX, GDP, fiscal, and inflation. Country and country-currency fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the country-currency level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BDI vs BEI | | BDI vs $BER^{€}$ | | BDI vs BEI vs $BER^{€}$ | |
|---|---|---|---|---|---|---|
| | **Local** | **Foreign** | **Local** | **Foreign** | **Local** | **Foreign** |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔBDI | -1.245*** | -0.549** | -1.119*** | -0.471 | -1.258*** | -0.591** |
| | [0.297] | [0.266] | [0.297] | [0.354] | [0.307] | [0.282] |
| ΔBEI | -0.860*** | -0.123 | | | -0.861*** | -0.147 |
| | [0.292] | [0.327] | | | [0.294] | [0.331] |
| $\Delta BER^{€}$ | | | -0.268* | 0.033 | | |
| | | | [0.157] | [0.199] | | |
| $\Delta BER^{€,ort}$ | | | | | -0.029 | -0.105 |
| | | | | | [0.174] | [0.107] |
| ΔTAO | 0.217*** | 0.621*** | 0.210*** | 0.623*** | 0.217*** | 0.620*** |
| | [0.069] | [0.092] | [0.069] | [0.092] | [0.069] | [0.092] |
| ΔYield diff | -0.388 | 0.767 | -0.231 | 0.763 | -0.37 | 0.783 |
| | [0.254] | [0.491] | [0.274] | [0.491] | [0.280] | [0.495] |
| ΔVIX | 0.022 | -0.008 | 0.012 | -0.011 | 0.022 | -0.007 |
| | [0.016] | [0.017] | [0.017] | [0.017] | [0.016] | [0.017] |
| ΔCredit rating | -3.525 | 2.034 | -3.09 | 1.979 | -3.475 | 2.109 |
| | [2.275] | [1.422] | [2.339] | [1.428] | [2.354] | [1.400] |
| ΔGDP | -0.004 | 0.013 | -0.13 | 0.018 | -0.019 | -0.026 |
| | [0.097] | [0.080] | [0.137] | [0.082] | [0.132] | [0.105] |
| ΔFiscal | 0.299 | -0.898 | 0.541 | -0.846 | 0.302 | -0.867 |
| | [0.965] | [0.839] | [0.962] | [0.823] | [0.965] | [0.843] |
| ΔInflation | 0.177 | -0.368 | 0.376 | -0.351 | 0.191 | -0.328 |
| | [0.542] | [0.378] | [0.563] | [0.376] | [0.568] | [0.381] |
| Country FE | Yes | No | Yes | No | Yes | No |
| Country-curr FE | – | Yes | – | Yes | – | Yes |
| $N$ | 779 | 972 | 779 | 972 | 779 | 972 |
| $R$-sq | 0.09 | 0.28 | 0.08 | 0.28 | 0.09 | 0.28 |

Table 3. **Panel regressions at the security level**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and EME bilateral exchange rates against the euro ($BER^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI ($BER^{€,ort}$). Column headings indicate whether the sample includes bonds denominated in local or in foreign currencies (from the perspective of the EME sovereign). For foreign currency bonds, our analysis is at the country-currency level. Controls include the change in log total amounts outstanding, credit ratings, yield differentials, VIX, GDP, fiscal, inflation, and the remaining time-to-maturity (of security $s$, TTM). Security fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BDI vs BEI | | BDI vs $BER^{€}$ | | BDI vs BEI vs $BER^{€}$ | |
|---|---|---|---|---|---|---|
| | **Local** | **Foreign** | **Local** | **Foreign** | **Local** | **Foreign** |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔBDI | -0.671*** | -0.469*** | -0.660*** | -0.476*** | -0.691*** | -0.493*** |
| | [0.096] | [0.115] | [0.098] | [0.136] | [0.100] | [0.118] |
| ΔBEI | -0.278*** | 0.083 | | | -0.284*** | 0.074 |
| | [0.104] | [0.119] | | | [0.105] | [0.120] |
| $\Delta BER^{€}$ | | | -0.114** | 0.03 | | |
| | | | [0.056] | [0.097] | | |
| $\Delta BER^{€,ort}$ | | | | | -0.143** | -0.032 |
| | | | | | [0.067] | [0.052] |
| ΔTAO | 0.278*** | 0.287*** | 0.277*** | 0.287*** | 0.278*** | 0.287*** |
| | [0.018] | [0.039] | [0.018] | [0.039] | [0.018] | [0.039] |
| TTM | 2.481*** | 0.847*** | 2.479*** | 0.848*** | 2.481*** | 0.843*** |
| | [0.129] | [0.126] | [0.129] | [0.126] | [0.129] | [0.126] |
| ΔYield diff | -0.434*** | 0.434*** | -0.353** | 0.437*** | -0.403** | 0.439*** |
| | [0.168] | [0.114] | [0.176] | [0.114] | [0.179] | [0.115] |
| ΔVIX | 0.001 | -0.016** | -0.002 | -0.015** | 0.001 | -0.016** |
| | [0.006] | [0.007] | [0.006] | [0.007] | [0.006] | [0.007] |
| ΔCredit rating | -3.119*** | -1.362** | -2.897*** | -1.338** | -3.036*** | -1.324** |
| | [0.839] | [0.581] | [0.849] | [0.582] | [0.851] | [0.587] |
| ΔGDP | 0.074** | -0.04 | 0.03 | -0.043 | 0.056 | -0.06 |
| | [0.036] | [0.032] | [0.041] | [0.032] | [0.042] | [0.042] |
| ΔFiscal | -0.227 | 0.116 | -0.168 | 0.09 | -0.231 | 0.133 |
| | [0.348] | [0.362] | [0.347] | [0.356] | [0.348] | [0.363] |
| ΔInflation | 0.062 | 0.416*** | 0.106 | 0.416*** | 0.083 | 0.424*** |
| | [0.179] | [0.105] | [0.181] | [0.105] | [0.179] | [0.115] |
| Security FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 29916 | 13908 | 29916 | 13908 | 29916 | 13908 |
| $R$-sq | 0.13 | 0.1 | 0.13 | 0.1 | 0.13 | 0.1 |

Table 4. **Panel regressions at the security level - Robustness**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Euro Index (BEI), EME bilateral exchange rates against the euro ($BER^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI ($BER^{€,ort}$), all three interacted with a dummy that indicates if the bond is denominated in local currency (Local). Controls include the change in log total amounts outstanding, credit ratings, and yield differentials of security $s$. In all specifications, we control for maturity bucket × country × quarter fixed effects. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BDI vs BEI | BDI vs $BER^{€}$ | BDI vs BEI vs $BER^{€}$ |
|---|---|---|---|
| | (1) | (2) | (3) |
| $\Delta$BEI × Local | -0.648*** | | -0.593*** |
| | [0.212] | | [0.213] |
| $\Delta BER^{€}$ × Local | | -0.230* | |
| | | [0.139] | |
| $\Delta BER^{€,ort}$ × Local | | | -0.152* |
| | | | [0.082] |
| Local | 2.655*** | 2.784*** | 2.836*** |
| | [0.424] | [0.429] | [0.431] |
| $\Delta$TAO | 1.022*** | 1.022*** | 1.022*** |
| | [0.038] | [0.038] | [0.038] |
| $\Delta$Yield diff | -0.322 | -0.138 | -0.189 |
| | [0.256] | [0.266] | [0.269] |
| $\Delta$Credit rating | 1.263 | 1.607 | 1.417 |
| | [2.575] | [2.577] | [2.568] |
| Maturity bucket × Country × Quarter FE | Yes | Yes | Yes |
| $N$ | 43859 | 43859 | 43859 |
| $R$-sq | 0.19 | 0.19 | 0.19 |

Table 5. **Extensions - Impact of euro strength induced selling on bond yields**: This table reports regressions of quarterly changes in bond yields on EME bilateral exchange rates against the euro ($BER^{€}$) interacted with the lagged share of the TAO held by euro area investors in the bond (Share EA) and with an indicator whether the bond is locally denominated. The bilateral exchange rates for both local and foreign currency bonds are at the country-currency level. Controls include the change in log total amounts outstanding, credit ratings (local and foreign separately), and yield differentials (local and foreign separately). Country, maturity bucket × quarter, country × quarter, and maturity bucket × country × quarter fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Share EA $(t-1) \times \Delta BER^{€} \times$ Local | 0.104*** | 0.098*** | 0.070** | 0.072** |
| | [0.026] | [0.028] | [0.031] | [0.031] |
| Share EA $(t-1) \times \Delta BER^{€}$ | 0.005 | 0.003 | 0.011 | 0.012 |
| | [0.010] | [0.010] | [0.010] | [0.011] |
| Share EA $(t-1) \times$ Local | -0.089 | -0.08 | -0.044 | -0.024 |
| | [0.059] | [0.057] | [0.053] | [0.052] |
| $\Delta BER^{€} \times$ Local | -0.517 | -0.455 | 2.739*** | 2.618*** |
| | [0.490] | [0.496] | [0.644] | [0.666] |
| Share EA $(t-1)$ | 0.060* | 0.047 | 0.006 | -0.003 |
| | [0.034] | [0.035] | [0.029] | [0.034] |
| $\Delta BER^{€}$ | 2.315*** | 2.308*** | | |
| | [0.306] | [0.312] | | |
| Local | 6.133*** | 6.720*** | 4.934*** | 5.447*** |
| | [1.842] | [1.861] | [1.536] | [1.560] |
| Controls | Yes | Yes | Yes | Yes |
| Country FE | Yes | - | - | - |
| Maturity bucket × Country FE | No | Yes | Yes | - |
| Country × Quarter FE | No | No | Yes | - |
| Maturity bucket × Country × Quarter FE | No | No | No | Yes |
| $N$ | 32777 | 32775 | 34780 | 34520 |
| $R$-sq | 0.30 | 0.30 | 0.38 | 0.46 |

Table 6. **Extensions - Advanced economies**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and bilateral exchange rates against the euro (BER$^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI (BER$^{€,ort}$). The sample includes major advanced economies outside of the euro area and excluding the United States, namely Australia, Canada, Denmark, Japan, Norway, New Zealand, Sweden, Switzerland and the United Kingdom. As these countries primarily issue bonds in their own currencies, we show the results for local currency bonds only. Controls include the change in log total amounts outstanding, credit ratings, yield differentials, VIX, GDP, fiscal, inflation, and the remaining time-to-maturity (of security $s$). Security fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BDI vs BEI | BDI vs BER$^{€}$ | BDI vs BEI vs BER$^{€}$ |
|---|---|---|---|
| | (1 ) | (2) | (3) |
| ΔBDI | -0.111 | -0.274*** | -0.263*** |
| | [0.087] | [0.098] | [0.098] |
| ΔBEI | -0.370*** | | -0.390*** |
| | [0.101] | | [0.101] |
| ΔBER$^{€}$ | | -0.338*** | |
| | | [0.074] | |
| ΔBER$^{€,ort}$ | | | -0.273*** |
| | | | [0.086] |
| Controls | Yes | Yes | Yes |
| Security FE | Yes | Yes | Yes |
| $N$ | 39568 | 39568 | 39568 |
| $R$-sq | 0.07 | 0.07 | 0.07 |

Table 7. **EME bond funds - Morningstar**: This table reports regressions of quarterly changes in foreign bond holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and EME bilateral exchange rates against the euro ($BER^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI ($BER^{€,ort}$), all three interacted with a dummy that indicates if the bond is denominated in local currency (Local) and with a dummy that indicates the funds are unhedged with respect to the euro (Unhedged). Controls include the change in log total amounts outstanding, credit ratings, and yield differentials of security $s$. In all specifications, we control for maturity bucket × country × quarter fixed effects. Section V provides more details on the construction of the Morningstar mutual fund sample. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BEI | | $BER^{€}$ | | BEI vs $BER^{€}$ | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔBEI × Local | -1.597*** | 0.417 | | | -1.608*** | 0.408 |
| | [0.336] | [0.504] | | | [0.336] | [0.505] |
| $\Delta BER^{€}$ × Local | | | -0.054 | 0.125 | | |
| | | | [0.108] | [0.141] | | |
| $\Delta BER^{€,ort}$ × Local | | | | | 0.139 | 0.039 |
| | | | | | [0.120] | [0.168] |
| ΔBEI × Local × Unhedged | | -3.143*** | | | | -3.141*** |
| | | [0.557] | | | | [0.557] |
| $\Delta BER^{€}$ × Local × Unhedged | | | | -1.133*** | | |
| | | | | [0.230] | | |
| $\Delta BER^{€,ort}$ × Local × Unhedged | | | | | | 0.164 |
| | | | | | | [0.191] |
| ΔBEI × Unhedged | | 1.038*** | | | | 1.039*** |
| | | [0.363] | | | | [0.363] |
| $\Delta BER^{€}$ × Unhedged | | | | 0.899*** | | |
| | | | | [0.185] | | |
| $\Delta BER^{€,ort}$ × Unhedged | | | | | | -0.118 |
| | | | | | | [0.113] |
| Local × Unhedged | | 0.461 | | -0.143 | | 0.194 |
| | | [1.091] | | [1.093] | | [1.113] |
| Unhedged | | 1.853*** | | 2.323*** | | 2.088*** |
| | | [0.715] | | [0.712] | | [0.740] |
| Local | 3.365*** | 2.896*** | 3.185*** | 2.887*** | 3.170*** | 2.870*** |
| | [0.683] | [0.995] | [0.694] | [1.008] | [0.693] | [1.017] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Maturity bucket × Country × Quarter FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 30879 | 30879 | 30879 | 30879 | 30879 | 30879 |
| $R$-sq | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |

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# Appendix

## A. Model derivation

This appendix derives the solution for $\Sigma^{-1}\mu$ in equation (9), and proves the comparative statics summarized in Proposition 2 for the general case of $n$ countries.

### *A1.* ***The Covariance Matrix Inverse*** $\Sigma^{-1}$

Under the assumptions of the model, the expected returns and the covariance matrix equal

$$\mu = \left( \begin{array}{l} \chi + (\delta + \gamma_1)\varphi \\ \chi + (\delta + \gamma_2)\varphi \\ \ldots \\ \chi + (\delta + \gamma_n)\varphi \\ \hline \chi \\ \ldots \\ \chi \end{array} \right), \Sigma = \left[ \begin{array}{llll|lll} \rho + c + z & \rho + c & \cdots & \rho + c & \rho & \cdots & \rho \\ \rho + c & \rho + c + z & \cdots & \rho + c & \rho & \cdots & \rho \\ \cdots & \cdots & \ddots & \rho + c & \rho & \cdots & \rho \\ \rho + c & \rho + c & \cdots & \rho + c + z & \rho & \cdots & \rho \\ \hline \rho & \rho & \rho & \rho & \rho + z & \cdots & \rho \\ \cdots & \cdots & \cdots & \cdots & \cdots & \ddots & \rho \\ \rho & \rho & \rho & \rho & \rho & \rho & \rho + z \end{array} \right].$$

The matrix consists of four blocks defining the variances and covariances within and between bonds denominated in local currency (LC) and in foreign currency (FC), respectively. If there was zero covariance between LC and FC bonds ($\rho = 0$), $\Sigma$ would have a block-diagonal form,

$$S = \left[\begin{array}{cccc|ccc} c+z & c & \cdots & c & 0 & \cdots & 0 \\ c & c+z & \cdots & c & 0 & \cdots & 0 \\ \cdots & \cdots & \ddots & c & 0 & \cdots & 0 \\ c & c & \cdots & c+z & 0 & \cdots & 0 \\ \hline 0 & 0 & 0 & 0 & z & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \ddots & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & z \end{array}\right] \tag{A1}$$

The top left block defining the covariances between LC bonds, $S_{LC}$, is a diagonal matrix $z\, I_n$ with a constant $c$ added to each element. In the general case with $\rho > 0$, $\Sigma$ can also be written in this form, where $S$ is augmented by a so-called rank-1 update, in this case the matrix of constants $\rho$,

$$\Sigma = S + \rho\; uu^T,$$

where $u$ is a conformable vector of ones, so the outer product $uu^T$ is a matrix of ones.

This form allows us to find the inverse by means of the Sherman-Morrison formula (Bartlett 1951), which states that the inverse of a matrix of the form $B = A + uv^T$ has a similar structure,

$$B^{-1} = A^{-1} - \frac{A^{-1}uv^TA^{-1}}{1 + v^TA^{-1}u}.$$

Applied to $\Sigma$, $u$ is a $2n$ long vector of ones, $v = \rho\, u$, and $A$ equals $S$ from equation (A1). With this, the inverse of the full covariance matrix $\Sigma^{-1}$ can be obtained from

$$\Sigma^{-1} \;=\; S^{-1} - \frac{\rho\, S^{-1}uu^TS^{-1}}{1 + \rho\, u^TS^{-1}u}. \tag{A2}$$

In the basic case where LC and FC bonds do not covary ($\rho = 0$), $\Sigma^{-1}$ simplifies to $S^{-1}$. In the general case ($\rho > 0$) deriving the inverse $\Sigma^{-1}$ involves four steps: (1) Inverting $S$,

(2) computing the scalar dividing the shift matrix, $1+\rho\, u^T S^{-1} u$, (3) deriving the shift matrix $\rho\, S^{-1} u u^T S^{-1}$, and (4) combining those elements in the Sherman-Morrison formula (A2).

**Step 1. Inverse of** $S$. Note that $S$ is block-diagonal, so the inverse $S^{-1}$ equals

$$S^{-1} = \begin{bmatrix} S_{LC}^{-1} & 0 \\ 0 & S_{FC}^{-1} \end{bmatrix},$$

where $S_{FC}$ is an $(n, n)$ diagonal matrix with variance $z$ on the diagonal, so $S_{FC}^{-1} = I_n/z$. $S_{LC}$ is a full matrix that can be written in the form of a rank-1 update,

$$S_{LC} = z\, I_n + c\, \iota\, \iota^T,$$

where $c$ is a constant variance, and $\iota$ is the unit vector of length $n$. Hence, $S_{LC}^{-1}$ can itself be found via the Sherman-Morrison formula,

$$S_{LC}^{-1} = A^{-1} - \frac{c\, A^{-1} \iota\, \iota^T A^{-1}}{1 + c\, \iota^T A^{-1} \iota} \quad \text{with} \quad A^{-1} = I_n/z.$$

The negative shift term is matrix divided by a scalar. For the scalar, $\iota^T A^{-1} \iota$ sums up all elements of $A^{-1}$, so the scalar equals $1 + n\, c/z$. For the matrix, since $\iota\, \iota^T$ is a matrix of ones, $\iota\, \iota^T A^{-1}$ is simply a matrix of constants all equal to $1/z$. Pre-multiplying this matrix by $c\, I_n/z$ again yields a matrix of constants equal to $c/z^2$. Hence the shift term is an $(n, n)$ matrix of constants $\frac{c}{(nc+z)z}$. Subtracting this matrix from $A^{-1} = I_n/z$ yields

$$S_{LC}^{-1} = \frac{1}{(nc+z)z} \begin{bmatrix} z + (n-1)c & -c & \ldots & -c \\ -c & z + (n-1)c & \ldots & -c \\ \ldots & \ldots & \ldots & -c \\ -c & -c & \ldots & z + (n-1)c \end{bmatrix}.$$

With this, $S^{-1}$ is a block-diagonal matrix consisting of $S_{FC}^{-1} = I_n/z$ and $S_{LC}^{-1}$, each of size $(n, n)$.

For notational convenience, we will characterise matrices by their on- and off-diagonal terms. For $S_{LC}^{-1}$, on defining $\phi \equiv (nc + z)$, this reads as

$$S_{LC}^{-1} = \frac{1}{\phi z} \begin{cases} z + (n-1)c & \text{on the diagonal} \\ -c & \text{off the diagonal.} \end{cases} \tag{A3}$$

**Step 2. The scalar dividing the shift matrix** $1 + \rho\, u^T S^{-1} u$. Since $u$ is the unit vector, $u^T S^{-1} u$ sums up the elements of $S^{-1}$; from Step 1, this is the sum of the elements of $I_n/z$, i.e. $n/z$, and those of $S_{LC}^{-1}$. From equation (A3), the sum of elements of $S_{LC}^{-1}$ includes $n$ diagonal terms and $n(n-1)$ off-diagonal terms, yielding $n/\phi$. Hence,

$$1 + \rho\, u^T S^{-1} u = 1 + \rho\, n \left( \frac{1}{\phi} + \frac{1}{z} \right) = \frac{\phi z + (\phi + z) n \rho}{\phi z}, \tag{A4}$$

or simply $\frac{\omega}{\phi z}$ when defining $\omega \equiv \phi z + (\phi + z) n \rho$.

**Step 3. The shift matrix** $\rho\, S^{-1} u\, u^T S^{-1}$. The shift matrix equals $\rho$ times the outer product of the column vector $S^{-1}u$ with itself, since $(S^{-1}u)^T = u^T S^{-1}$. Post-multiplying a matrix by the unit vector yields a vector containing the row sums of the matrix. From Step 1, we know that $S^{-1}$ is block-diagonal, so $S^{-1}u$ consists of $n$ row sums of $S_{LC}^{-1}$ followed by $n$ row sums of $S_{FC}^{-1}$. The unit vector $u$ (length $2n$) comprises two unit vectors $\iota$ (length $n$), so

$$S^{-1} u = \begin{bmatrix} S_{LC}^{-1}\, \iota \\ S_{FC}^{-1}\, \iota \end{bmatrix} = \begin{bmatrix} \frac{1}{\phi}\, \iota \\ \frac{1}{z}\, \iota \end{bmatrix},$$

where the latter equality uses the fact that each row sum of $S_{LC}^{-1}$ involves $z + (n-1)c$ plus $(n-1)$ times the off-diagonal term $-c$, from equation (A3). With this, the shift matrix is found by forming the outer product,

$$\rho\, S^{-1}u\,(S^{-1}u)^T = \rho \begin{bmatrix} \frac{1}{\phi}\,\iota \\ \frac{1}{z}\,\iota \end{bmatrix} \begin{bmatrix} \frac{1}{\phi}\,\iota & \frac{1}{z}\,\iota \end{bmatrix} = \rho \begin{bmatrix} \frac{1}{\phi^2} & \frac{1}{\phi z} \\ \frac{1}{\phi z} & \frac{1}{z^2} \end{bmatrix} \otimes \iota\,\iota^T,$$

which is simply four submatrices of constants, each of size $(n, n)$.

**Step 4. Applying the Sherman-Morrison formula to obtain $\Sigma^{-1}$.** Sherman-Morrison formula (A2) allows to derive $\Sigma^{-1}$ from $S^{-1}$ (from Step 1) minus the shift matrix (Step 3) divided by the scalar found in Step 2,

$$\Sigma^{-1} = \begin{bmatrix} S_{LC}^{-1} & 0 \\ 0 & S_{FC}^{-1} \end{bmatrix} - \rho\,\frac{\phi z}{\omega} \begin{bmatrix} \frac{1}{\phi^2} & \frac{1}{\phi z} \\ \frac{1}{\phi z} & \frac{1}{z^2} \end{bmatrix} \otimes \iota\,\iota^T.$$

Hence, $\Sigma^{-1}$ is the difference between two partitioned matrices, each with four $(n, n)$ submatrices that represent the covariances within and between LC and FC bonds. Each submatrix has a simple structure: $S_{FC}^{-1}$ is diagonal, $S_{LC}^{-1}$ is diagonal with the same constant off-diagonal elements, and the shifter matrix consists of four arrays of constants. For any number of countries $n$ in the model, computing $\Sigma^{-1}$ boils down to forming the following differences:

- The off-diagonal submatrices of $\Sigma^{-1}$ have all elements equal to $-\frac{\rho}{\omega}$.
- The lower-right submatrix $\Sigma_{FC}^{-1}$ has

$$\Sigma_{FC}^{-1} = \begin{cases} \frac{1}{z} - \frac{\phi}{z}\frac{\rho}{\omega} & \text{on the diagonal} \\ -\frac{\phi}{z}\frac{\rho}{\omega} & \text{off the diagonal.} \end{cases}$$

- The upper-left submatrix $\Sigma_{LC}^{-1}$ has, from equation (A3),

$$\Sigma_{LC}^{-1} = \begin{cases} \frac{1}{z} - \frac{c}{\phi z} - \frac{z}{\phi}\frac{\rho}{\omega} & \text{on the diagonal} \\ \frac{-c}{\phi z} - \frac{z}{\phi}\frac{\rho}{\omega} & \text{off the diagonal.} \end{cases}$$

The full inverse of the covariance matrix $\Sigma^{-1}$ thus consists of four submatrices with these terms as their typical elements.

### *A2.* ***The Vector of Optimal Holdings*** $\Sigma^{-1}\mu$

The full solution, equation (9) in the text, is proportional to the vector $\Sigma^{-1}\mu$, where $\Sigma^{-1}$ has just been derived, and expected returns $\mu$ were specified in (12). In view of the common terms in the vector $\mu$ (notably $\chi$ and $\delta$), the coefficients on expected returns will be closely related to the row sums of $\Sigma^{-1}$.

**LC bonds.** The first $n$ rows of $\Sigma^{-1}$ multiplied into $\mu$ determine the optimal weights on LC bonds; the row sums are all equal to

$$
\begin{aligned}
& \left(\frac{1}{z} - \frac{c}{\phi z} - \frac{z}{\phi}\frac{\rho}{\omega}\right) - (n-1)\left(\frac{c}{\phi z} + \frac{z}{\phi}\frac{\rho}{\omega}\right) - n\frac{\rho}{\omega} \\
= \; & \frac{1}{z} - n\left(\frac{c}{\phi z} + \frac{z}{\phi}\frac{\rho}{\omega}\right) - n\frac{\rho}{\omega} && \text{(A5)} \\
= \; & \left(\frac{1}{z} - \frac{nc}{\phi z}\right) - n\left(\frac{z}{\phi} + 1\right)\frac{\rho}{\omega} \\
= \; & \frac{1}{\phi} - \left(\frac{z}{\phi} + 1\right)\frac{n\rho}{\omega} \\
= \; & \frac{1}{\phi\omega}\big(\omega - (\phi + z)n\rho\big) \\
= \; & \frac{z}{\omega} && \text{(A6)}
\end{aligned}
$$

where the last step makes use of $\omega \equiv \phi z + (\phi + z)n\rho$. Hence, for LC bonds, the full row sum $z/\omega$ will be the coefficient on $\chi$, the common term in $\mu$. The coefficient on $\varphi\delta$ only lacks $-n\frac{\rho}{\omega}$ from the full row sum, hence it equals $\frac{z+n\rho}{\omega}$. In turn, the coefficient on $\gamma_c$ picks up the diagonal of $\Sigma^{-1}$, while those on other $\gamma_i$ multiply the $(n-1)$ off-diagonal elements,

$$\begin{aligned}
& \left(\frac{1}{z} - \frac{c}{\phi z} - \frac{z}{\phi}\frac{\rho}{\omega}\right)\varphi\gamma_c - \left(\frac{c}{\phi z} + \frac{z}{\phi}\frac{\rho}{\omega}\right)\varphi\sum_{i\neq c}\gamma_i \\
= \; & \frac{\varphi}{z}\gamma_c - \left(\frac{c}{\phi z} + \frac{z}{\phi}\frac{\rho}{\omega}\right)\varphi\sum_{i}\gamma_i \\
= \; & \frac{\varphi}{z}\gamma_c - \left(\frac{c}{\phi z} + \frac{z}{\phi}\frac{\rho}{\omega}\right)\varphi n\overline{\gamma} \\
= \; & \frac{1}{z}(\gamma_c - \overline{\gamma})\varphi + \frac{z+n\rho}{\omega}\varphi\overline{\gamma}
\end{aligned}$$

where the last step uses the equality between (A5) and (A6). The coefficients on $\varphi\overline{\gamma}$ and $\varphi\delta$ are closely related, since they play equivalent roles. Collecting the coefficients on the respective return components, the optimal weight $w_c^{LC}$ on LC bond $c$ is – as stated in Proposition 2 – proportional to

$$\frac{z}{\omega}\chi + \frac{z+n\rho}{\omega}\left(\delta + \overline{\gamma}\right)\varphi + \frac{1}{z}(\gamma_c - \overline{\gamma})\varphi. \tag{A7}$$

**FC bonds.** The analogous derivation for optimal weight $w_c^{FC}$ comes from multiplying row $n+c$ of $\Sigma^{-1}$ into $\mu$. The coefficient on $\chi$ equals the full row sum,

$$\begin{aligned}
& \left(\frac{1}{z} - \frac{\phi}{z}\frac{\rho}{\omega}\right) - (n-1)\frac{\phi}{z}\frac{\rho}{\omega} - n\frac{\rho}{\omega} \\
= \; & \frac{1}{z} - n\left(\frac{\phi}{z} + 1\right)\frac{\rho}{\omega} \\
= \; & \frac{1}{\omega z}\big(\omega - (\phi + z)n\rho\big) \\
= \; & \frac{\phi}{\omega}
\end{aligned}$$

on using the definition of $\omega$ to cancel terms in parentheses. The return components specific to LC bonds, $\varphi\delta + \gamma_i$, are each multiplied by $-\frac{\rho}{\omega}$, so

$$-\frac{\rho}{\omega}\sum_i(\delta + \gamma_i)\varphi = -\frac{n\rho}{\omega}\left(\delta + \overline{\gamma}\right)\varphi$$

Collecting terms, the relative weights $w_c^{FC}$ on FC bonds, for each $c$, are proportional to

$$\frac{\phi}{\omega}\chi - \frac{n\rho}{\omega}\left(\delta + \overline{\gamma}\right)\varphi. \tag{A8}$$

Substituting (A8) and (A7) into equation (9) yields optimal bond holdings $w^*$ presented in Proposition 2.

### *A3.* ***Comparative Statics***

We now elaborate on each of the comparative statics results presented in Proposition 2, keeping in mind that the coefficients on each return component consist of positive covariance parameters ($c$, $z$, $\rho$) and $n$, with compound terms $\omega \equiv \phi z + (\phi + z)n\rho$, and $\phi \equiv (nc + z)$.

1. *Bond holdings $w_c$ rise in their own expected* ***returns****, and fall in those of other bonds.*

   This is evident from the functional forms of the optimal weights in equation (13). Expected returns specific to LC bonds ($\delta$, $\overline{\gamma}$ and $\gamma_c$), when $\varphi > 0$, raise holdings of the respective LC bonds, and reduce those of FC bonds. The common return ($\chi$) raises all bond holdings, with a greater effect on FC bonds (equations (13) and (14)).

2. *Bond holdings fall in a bond's* ***variance****. The* ***covariance*** *between bonds decreases bond holdings: $c$ reduces holdings of LC bonds, and $\rho$ lowers those of all bonds.*

   For bonds' **own variance**, the parameter $z$ is key, where $\phi$ is linear in $z$, and $\omega$ convex. A greater $z$ thus reduces each of the coefficients on returns, $\frac{1}{z}$, $\frac{\phi}{\omega}$ and $\frac{z}{\omega}$ (provided $z > n\sqrt{c\rho}$, which is plausible since $\rho$ can be arbitrarily close to 0). Hence, $w_c^{LC}$ falls in $z$, and so does $w_c^{FC}$ if $\chi$ is not too small relative to $\delta$ and $\overline{\gamma}$ (a reasonable restriction for expected returns). The **covariance** across all bonds, $\rho$, unambiguously reduces $w_c^{LC}$

since $\omega$ is linear in $\rho$, and $\rho$ also reduces $w_c^{FC}$. Finally, greater volatility of the common component in exchange rates, $c$, reduces LC bond holdings, since the first two terms of $w_c^{LC}$ fall in $\omega$ (which increases linearly in $c$). By contrast, $w_c^{FC} = (\phi\chi - n\rho\varphi(\delta + \overline{\gamma}))/\omega$ increases in $c$, as the effect on $\phi$ outweighs that on $\omega$.

3. **Exchange rates** affect optimal bond holdings as follows:

   (a) *a negative $\delta$ (rise in BEI) reduces $w_c^{LC}$ and increases $w_c^{FC}$ across countries; the magnitude of the change in $w_c^{LC}$ exceeds that in $w_c^{FC}$.*

   The signs are evident from the linear form of $w_c^{LC}$ (increasing in $\delta$) and of $w_c^{FC}$ (decreasing in $\delta$). That the effect on $w_c^{LC}$ exceeds that on $w_c^{FC}$ follows from comparing the respective coefficients on $\delta$, given that $z > 0$.

   (b) *a negative $\gamma_c$ (rise in $BER_c$) reduces $w_c^{LC}$ without significantly affecting $w_c^{FC}$.*

   Only $w_c^{LC}$ is increasing in $\gamma_c$; its indirect effects via $\overline{\gamma}$ are $n$ times smaller. Hence, $\gamma_c < 0$ reduces $w_c^{LC}$, while it has a small (negative) effect on $w_c^{FC}$.

4. *The **capital constraint** scales the entire bond portfolio:*

   (a) *A tighter VaR constraint $\alpha$, including from an increase in $v$ (the BDI), reduces all bond holdings $w_c^{LC}$ and $w_c^{FC}$.*

   This is evident from the solution (9) being proportional to the ratio $\kappa/\alpha$.

   (b) *Past losses, notably from $\delta < 0$ or $\overline{\gamma} < 0$, reduce $\kappa$ to the same effect. A negative $\delta$ tightens the capital constraint $n$ times as much as a single country's depreciation $\gamma_c < 0$ does.*

   The value of available capital $\kappa_t$ in (10) falls equally when $\delta < 0$ or $\gamma_c < 0$. A single $\gamma_c < 0$ only affects the holdings of bonds issued by country $c$, which is $1/n$ of all LC bond holdings when starting from steady state holdings (see Appendix A4).

   (c) *Persistent depreciations induce negative feedback effects.*

Currency depreciations ($\delta < 0$ or $\gamma_c < 0$) induce losses to LC bond investors, reducing all $w^*$ via $\kappa_t$; they further lower expected returns and holdings of LC bonds $w_c^{LC}$. The total reduction in LC bond holdings is larger for $\delta < 0$ than for the same $\gamma_c < 0$. The proof of these dynamics follows next.

### *A4.* ***Dynamics***

As described in the text, we (a) start from a steady state where $\delta = 0$ and $\gamma_c = 0$ $\forall c$ up to that point, and (b) consider the deviations from the steady state when either $\delta$ or $\gamma_c$ change by a given amount $x$, all else being equal.

*(a) The steady state portfolio*

Every period, investors choose their optimal bond portfolio according to equation (9). To find steady state holdings $\overline{w}$, note that expected returns in steady state, $\overline{\mu}$, have every element equal to $\chi$, on both LC and FC bonds for all $n$ countries. Recall from Appendix A2 that the elements of $\Sigma^{-1}$ in each row sum to $\frac{z}{\omega}$ of first $n$ rows, and to $\frac{\phi}{\omega}$ for the next $n$ rows, so

$$\Sigma^{-1}\overline{\mu} = \frac{1}{\omega}\begin{pmatrix} z \\ \dots \\ z \\ \hline \phi \\ \dots \\ \phi \end{pmatrix}\chi \quad \text{and} \quad \overline{\mu}'\Sigma^{-1}\overline{\mu} = \frac{n}{\omega}(\phi + z)\chi^2.$$

With this, we can write the steady state portfolio as,

$$\overline{w} = \frac{\overline{\kappa}}{\alpha\omega\sqrt{\frac{n}{\omega}(\phi+z)}} \begin{pmatrix} z \\ ... \\ z \\ \hline \phi \\ ... \\ \phi \end{pmatrix}. \tag{A9}$$

At the same time, $\kappa$ follows the law of motion (10), which is $\overline{\kappa} = (\chi\ \chi\ ...\ \chi)\ \overline{w}$ in steady state. So $\overline{w}$ and $\overline{\kappa}$ are directly proportional to each other. Using $\overline{w}$ from (A9), we have

$$\begin{aligned} \overline{\kappa} &= \frac{\overline{\kappa}}{\alpha\omega\sqrt{\frac{n}{\omega}(\phi+z)}} n(z+\phi)\chi, \text{ or} \\ 1 &= \frac{1}{\alpha}\sqrt{\frac{n}{\omega}(\phi+z)}\chi. \end{aligned}$$

This holds for any $\overline{\kappa}$, since nothing in the model pins down the initial capital available to invest; we can assume an initial endowment $\kappa_0$. Regardless of its value, the equation implies a parameter restriction, $\chi = \frac{\alpha}{\sqrt{\frac{n}{\omega}(\phi+z)}}$. Intuitively, portfolio holdings can be constant in steady state only if the state variable $\kappa$ is, which requires a parameter restriction between returns and variance terms.[1] Using this restriction to replace the root in (A9) by $\alpha/\chi$ yields

$$\overline{w} = \frac{\kappa_0\chi}{\alpha^2\omega} \begin{pmatrix} z \\ ... \\ z \\ \hline \phi \\ ... \\ \phi \end{pmatrix}. \tag{A10}$$

[1]Plugging this value of $\chi$ into $\overline{\kappa} = \overline{w}'\chi$ returns the same $\overline{\kappa}$, implying that capital remains constant.

*(b) Deviations from the steady state*

We now compare the differential effects of various exchange rates on optimal portfolio weights (9) as deviations from steady state holdings (A10). We contrast:

- an idiosyncratic appreciation or depreciation of currency $c$ against the reference currency, $\gamma_c$, where only $\gamma_c$ takes a value $x \neq 0$ (and $\gamma_i = 0 \ \forall i \neq c$).
- a change in the value of the reference currency, equivalent to a generalised $\delta = x$ on the returns on all LC bonds.

Each case gives rise to three deviations (denoted $\Delta$ below) that will affect bond holdings: (1) a change in realized returns, hence capital; (2) a change in expected returns (if persistent $\varphi > 0$); and (3) a change in the generalized Sharpe ratio. In this, FC bond returns remain unaffected and variance parameters (hence $\Sigma$) remain unchanged.

1. **Available capital**

First, *actual* returns $r_t$ shift by the full amounts $\delta$ and $\gamma_c$ away from $\chi$, affecting available capital going forward. Since $\kappa_t = \overline{w}' r_t$, with $\overline{w}$ predetermined by (A10) in the steady state prevailing up to this point, investors see a gain (or loss) proportional to the shift in realized returns, $\kappa_t = \kappa_0 + \overline{w}' \Delta r_t$, which takes the form

$$\begin{array}{rccc} & \text{if } \delta = x & \text{or} & \text{if } \gamma_c = x \\ \Delta\kappa = & \frac{\kappa_0 \chi}{\alpha^2 \omega} n z x & \text{or} & \frac{\kappa_0 \chi}{\alpha^2 \omega} z x \end{array}$$

Importantly, when $\gamma_c = x$, only the bonds from country $c$ are directly affected; when $\delta = x$, all LC bonds are affected (for $n$ countries). Since the effect on capital is a sum across realized returns, the effect of $\delta$ is $n$ times that of $\gamma_c$ for given change of size $x$.

## 2. **Expected returns**

Next, *expected* returns change to the extent to which returns are persistent ($\varphi > 0$), so

$$\begin{array}{ccc} \delta = x & \text{or} & \gamma_c = x \\ \Delta\mu = \begin{pmatrix} \varphi x \\ \cdots \\ \varphi x \\ \hline 0 \\ \cdots \\ 0 \end{pmatrix} & \text{or} & \begin{pmatrix} 0 \\ 0 \\ \varphi x \\ \hline 0 \\ \cdots \\ 0 \end{pmatrix} \end{array}$$

The choice of next period's portfolio will be based on these updated values, with $\mu = \overline{\mu} + \Delta\mu$. Hence, investors use $\Sigma^{-1}\mu = \Sigma^{-1}\overline{\mu} + \Sigma^{-1}\Delta\mu$, or

$$\Sigma^{-1}\mu = \frac{\chi}{\omega} \begin{pmatrix} z \\ \cdots \\ z \\ \hline \phi \\ \cdots \\ \phi \end{pmatrix} + \begin{pmatrix} \frac{z+n\rho}{\omega} \\ \cdots \\ \frac{z+n\rho}{\omega} \\ \hline \frac{-n\rho}{\omega} \\ \cdots \\ \frac{-n\rho}{\omega} \end{pmatrix} \varphi x \quad \text{when } \delta = x.$$

Note that the coefficients on $x$ here are equal to those on when $\delta$ in equation (13) of Proposition 2. Since all LC bonds are held in the same quantities (and likewise for FC bonds), it is sufficient to write the allocation to each type of bond in a single equation, as in (13). The same holds for $\gamma_c = x$; but (13) except that the affected bond $c$ ($\gamma_c = x$) is set apart from the other LC bonds ($\gamma_i = 0 \ \forall i \neq c$) as follows,

$$\begin{aligned} w_c^{LC} &\propto \frac{z}{\omega}\chi + \left(\frac{z+n\rho}{\omega} + \frac{n-1}{z}\right)\frac{\varphi x}{n} \\ w_{i\neq c}^{LC} &\propto \frac{z}{\omega}\chi + \left(\frac{z+n\rho}{\omega} - \frac{1}{z}\right)\frac{\varphi x}{n} \\ w^{FC} &\propto \frac{\phi}{\omega}\chi - \frac{\rho}{\omega}\varphi x, \end{aligned}$$

where we use the fact that $\overline{\gamma} = x/n$ when only $\gamma_c = x$ while all other $\gamma_i = 0$ in (13).

### 3. The generalized Sharpe ratio

The deviation from steady state shifts $\mu$ without affecting $\Sigma^{-1}$, Hence

$$\begin{aligned} \sqrt{\mu'\Sigma^{-1}\mu} &= \sqrt{(\overline{\mu}+\Delta\mu)'\Sigma^{-1}(\overline{\mu}+\Delta\mu)} \\ &= \sqrt{\alpha^2 + 2(\Delta\mu)'\Sigma^{-1}\overline{\mu} + \Delta\mu'\Sigma^{-1}\Delta\mu}. \end{aligned}$$

As before, since $\delta$ affects all LC bonds, the term appears $n$ times in each sum, unlike the case of of a single bond ($\gamma_c$). Accordingly, $\sqrt{\mu'\Sigma^{-1}\mu}$ equals

$$\begin{aligned} &\text{for } \gamma_c = x\text{:} && \sqrt{\alpha^2 + \frac{z}{\omega}(2\chi + \varphi x)\varphi x} \\ &\text{for } \delta = x\text{:} && \sqrt{\alpha^2 + \frac{nz}{\omega}(2\chi + \varphi x)\varphi x} \end{aligned} \quad ,$$

where the fact that the sums of the first $n$ rows of $\Sigma^{-1}$ equal $\frac{z}{\omega}$ helps to compute $\Delta\mu'\Sigma^{-1}\Delta\mu$.

### 4. Combining deviation terms

The optimal portfolio, written in deviation form, equals

$$w = \frac{\kappa/\alpha}{\sqrt{\mu'\Sigma^{-1}\mu}}\Sigma^{-1}\mu = \frac{\kappa_0 + \Delta\kappa}{\alpha\sqrt{(\overline{\mu}+\Delta\mu)'\Sigma^{-1}(\overline{\mu}+\Delta\mu)}}\left(\Sigma^{-1}\chi + \Sigma^{-1}\Delta\mu\right).$$

Substituting the deviations with the terms derived in the previous subsections yields the optimal portfolio weights for each case, as in equations (15) and (16) in the text.

When $\delta = x$, LC and FC bonds will be held in the quantities

$$\begin{aligned} w^{LC} &= \widehat{\Omega}\left[\frac{z}{\omega}\chi + \frac{z+n\rho}{\omega}\varphi x\right] \\ w^{FC} &= \widehat{\Omega}\left[\frac{\phi}{\omega}\chi - \frac{n\rho}{\omega}\varphi x\right], \\ \text{where } \widehat{\Omega} &= \frac{\kappa_0 + \frac{\kappa_0 \chi}{\alpha^2\omega} nzx}{\alpha\sqrt{\alpha^2 + \frac{nz}{\omega}(2\chi+\varphi x)\varphi x}}. \end{aligned}$$

When $\gamma_c = x$, FC and LC bonds are held as follows, where holdings of country $c$ bonds differs from those LC bonds issued by other countries $i \neq c$

$$\begin{aligned} w_c^{LC} &= \widetilde{\Omega}\left[\frac{z}{\omega}\chi + \left(\frac{z+n\rho}{\omega} + \frac{n-1}{z}\right)\frac{\varphi x}{n}\right] \\ w_{i\neq c}^{LC} &= \widetilde{\Omega}\left[\frac{z}{\omega}\chi - \left(\frac{1}{z} - \frac{z+n\rho}{\omega}\right)\frac{\varphi x}{n}\right] \\ w^{FC} &= \widetilde{\Omega}\left[\frac{\phi}{\omega}\chi - \frac{\rho}{\omega}\varphi x\right], \\ \text{where } \widetilde{\Omega} &= \frac{\kappa_0 + \frac{\kappa_0 \chi}{\alpha^2\omega} zx}{\alpha\sqrt{\alpha^2 + \frac{z}{\omega}(2\chi+\varphi x)\varphi x}}. \end{aligned}$$

Note that in each case the optimal holdings are of the functional form

$$w_c(x) = [A + Bx]\,\Omega(x) = [A + Bx]\,\frac{N(x)}{D(x)}$$

with the numerator $N(x)$ linear in $x$. Only the parameters of $B$, $N(x)$ and $D(x)$ differ in the various cases, not their functional forms – this will be useful when deriving $w_c'(x)$ next.

5. **Taking derivatives $\hat{\Omega}(x)$ and $\widetilde{\Omega}(x)$ with respect to x**

When $\delta = x$, define

$$N(x) = \kappa_0 + \frac{\kappa_0 \chi}{\alpha^2 \omega} nzx, \qquad D(x) = \alpha \sqrt{Q(x)}, \quad Q(x) = \alpha^2 + \frac{nz}{\omega}(2\chi + \varphi x)\varphi x.$$

Then $\hat{\Omega}(x) = N(x)/D(x)$, so by the quotient rule

$$\hat{\Omega}'(x) = \frac{N'(x)D(x) - N(x)D'(x)}{D(x)^2} = \frac{nz}{\omega} \frac{\frac{\kappa_0 \chi}{\alpha^2} D(x)^2 - \alpha N(x) \varphi(\chi + \varphi x)}{\alpha^2 D(x)^3}.$$

Evaluated around $x = 0$, $D(0) = \alpha^2$ and $N(0) = \kappa_0$, implying $\hat{\Omega}'(0) = \frac{\kappa_0}{\alpha^2} \frac{\chi nz}{\alpha^2 \omega} (1 - \varphi)$. As $0 < \varphi < 1$, we have $\hat{\Omega}'(0) > 0$. Thus $\hat{\Omega}(x)$ increases with $x$, and decreases when $x < 0$.

Similarly, when $\gamma_c = x$, the only change is that $N(x)$ and $Q(x)$ have $n = 1$ only, so

$$\tilde{N}(x) = \kappa_0 + \frac{\kappa_0 \chi}{\alpha^2 \omega} zx, \qquad \tilde{Q}(x) = \alpha^2 + \frac{z}{\omega}(2\chi + \varphi x)\varphi x, \qquad \tilde{D}(x) = \alpha \sqrt{\tilde{Q}(x)}.$$

$$\tilde{\Omega}'(x) = \frac{z}{\omega} \frac{\frac{\kappa_0 \chi}{\alpha^2} \tilde{D}(x)^2 - \alpha \tilde{N}(x) \varphi(\chi + \varphi x)}{\alpha^2 \tilde{D}(x)^3}.$$

At $x = 0$: $\tilde{D}(0) = \alpha^2$ and $\tilde{N}(0) = \kappa_0$ again. Hence $\tilde{\Omega}'(0) = \frac{\kappa_0}{\alpha^2} \frac{\chi z}{\alpha^2 \omega} (1 - \varphi)$. As $0 < \varphi < 1$ we have $\tilde{\Omega}'(0) > 0$. Note the weaker effect in this case: $\tilde{\Omega}'(0)$ is $n$ times smaller than $\hat{\Omega}'(0)$.

6. **Taking derivatives of $w^{LC}(x)$ and $w_c^{LC}(x)$ with respect to x**

For $\delta = x$, using the product rule at $x = 0$:

$$\left. \frac{dw^{LC}}{dx} \right|_{x=0} = \hat{\Omega}'(0)A + \hat{\Omega}(0)B = \frac{\kappa_0}{\alpha^4} \left[ \frac{nz^2 \chi^2}{\omega^2}(1 - \varphi) + \alpha^2 \frac{z + n\rho}{\omega} \varphi \right] > 0,$$

since all terms are positive for $0 < \varphi < 1$. Because $\frac{dw^{LC}}{dx} > 0$ in a neighborhood of $x = 0$, $w^{LC}(x)$ is locally increasing in $x$. Therefore, for small negative $x$, $w^{LC}(x) < w^{LC}(0)$. That is, an appreciation of the euro $\delta = x < 0$ lowers the allocation to LC bonds.

Likewise, for $\gamma_c = x$, using the product rule at $x = 0$,

$$\left.\frac{dw_c^{LC}}{dx}\right|_{x=0} = \tilde{\Omega}'(0)A + \tilde{\Omega}(0)B_c = \frac{\kappa_0}{\alpha^4}\left[\frac{z^2\chi^2}{\omega^2}(1-\varphi) + \alpha^2 B_c\right] > 0,$$

since all terms are positive for $0 < \varphi < 1$. Therefore, $w_c^{LC}(x)$ is locally increasing in $x$ around $x = 0$. Hence, for small negative $x$, $w_c^{LC}(x) < w_c^{LC}(0)$. Thus a negative country-specific depreciation $\gamma_c = x < 0$ reduces the allocation to the LC bond of country $c$.

## 7. A broad $\delta$ impacts ***total*** LC bonds more than a country-specific $\gamma_c$ does

For $\delta = x$, the LC holdings in the portfolio sum to

$$L_\delta(x) \equiv \sum_{i=1}^{n} w_i^{LC}(x) = n\,\hat{\Omega}(x)\,\left[\frac{z}{\omega}\chi + \frac{z+n\rho}{\omega}\varphi x\right].$$

For $\gamma_c = x$, LC holdings are

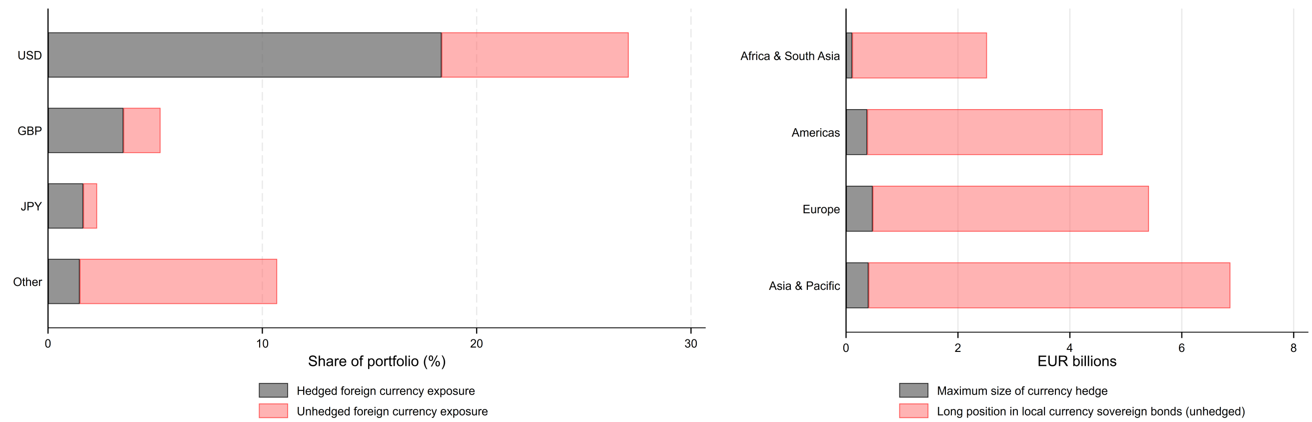
$$L_\gamma(x) \equiv \sum_{i=1}^{n} w_i^{LC}(x) = n\,\tilde{\Omega}(x)\,\left[\frac{z}{\omega}\chi + \frac{z+n\rho}{\omega}\varphi x\right].$$

Note that the two terms in parentheses are equal for any $x$, and the only difference between the cases is their respective portfolio scaling factor $\Omega$. Evaluated at $x = 0$, they both simplify to $\frac{z}{\omega}\chi$. It was shown already that $\hat{\Omega}'(0) = n\,\tilde{\Omega}'(0)$. Hence, $\delta$ impacts *total* LC bond holdings $n$ times more than $\gamma_c$ of the same magnitude,

$$L'_\delta(0) = n\,L'_\gamma(0).$$

## B. Additional Figures and Tables

Figure A1. **Hedging practices of Dutch pension funds**

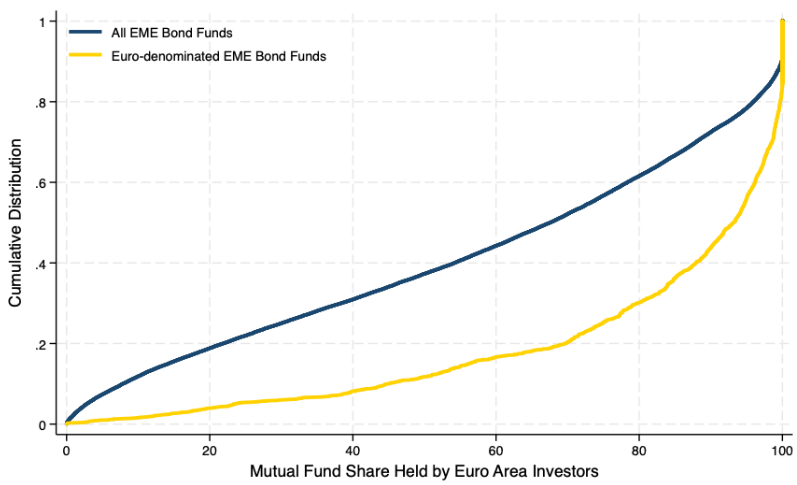



(a) Hedging by currency

(b) Hedging of EME sovereign bonds

Panel (a) shows a breakdown of the total assets held by Dutch pension funds to different currencies: USD, GBP, JPY, and the rest. The graph also shows the fraction of the total currency exposure that is hedged. Both data points are from mandatory regulatory filings that pension funds report to the Dutch Central Bank, and we take the time-series and cross-sectional averages over all pension funds from 2012q1-2021q4. The average share of the portfolio that is invested in the euro area equals 55%, hence the breakdown to currencies covers the remaining 45% of the portfolio. Panel (b) sets the nominal value of local EME sovereign bonds held by Dutch pension funds (from SHS-S), aggregated by region, against the maximum size of their currency hedges. The latter are computed by aggregating the overall derivatives notional positions in each of the respective EME currencies that pension funds are mandated to report to trade repositories (EMIR). The calculations are based on average quarterly positions in 2021.

Figure A2. **Ownership of euro area investors in Morningstar EME bond funds**




This figure shows the cumulative distribution of the share of Morningstar EME bond funds held by euro area investors, separately for all EME bond funds residing in the euro area and a subset of those that are euro-denominated. The quarterly sample period is 2013q4-2021q4.

Table A1. **Robustness - Analysis by sector**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and EME bilateral exchange rates against the euro orthogonalized with respect to the BEI ($BER^{€,ort}$), *interacted* with dummies indicating the following investor types: banks (baseline), mutual funds, and insurance companies and pension funds (ICPFs). All results are for local currency bonds. Controls include the change in log total amounts outstanding, credit ratings, yield differentials, VIX, GDP, fiscal, inflation, and the remaining time-to-maturity (of security $s$). Security fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | (1) | (2) | (3) |
|---|---|---|---|
| $\Delta$BDI | -0.165 | -0.11 | -0.1405 |
| | [0.2941] | [0.2763] | [0.2986] |
| $\Delta$BDI × Mutual funds | -0.6291*** | -0.5527*** | -0.5920*** |
| | [0.0842] | [0.0759] | [0.0845] |
| $\Delta$BDI × ICPFs | -0.8005*** | -0.7047*** | -0.8170*** |
| | [0.0979] | [0.0899] | [0.0984] |
| $\Delta$BEI | -0.0579 | | -0.0467 |
| | [0.3830] | | [0.3837] |
| $\Delta$BEI × Mutual funds | -0.3213*** | | -0.3054*** |
| | [0.1032] | | [0.1033] |
| $\Delta$BEI × ICPFs | -0.3433** | | -0.3480** |
| | [0.1404] | | [0.1403] |
| $\Delta BER^{€}$ | | -0.1265 | |
| | | [0.1385] | |
| $\Delta BER^{€}$ × Mutual funds | | -0.2018*** | |
| | | [0.0433] | |
| $\Delta BER^{€}$ × ICPFs | | -0.0159 | |
| | | [0.0537] | |
| $\Delta BER^{€,ort}$ | | | -0.0527 |
| | | | [0.1530] |
| $\Delta BER^{€,ort}$ × Mutual funds | | | -0.1873*** |
| | | | [0.0521] |
| $\Delta BER^{€,ort}$ × ICPFs | | | 0.0614 |
| | | | [0.0617] |
| Controls | Yes | Yes | Yes |
| Security FE | Yes | Yes | Yes |
| Investor FE | Yes | Yes | Yes |
| $N$ | 53618 | 53618 | 53618 |
| $R$-sq | 0.07 | 0.07 | 0.07 |

# Internet Appendix of
# "Which Exchange Rate Matters to Global Investors?"

## IA. Additional Figures and Tables

Table IA1. **Summary statistics**: This table shows summary statistics for the variables used in the main analysis. Panel A shows variables at the time-level: changes in Broad Dollar Index (BDI), changes in Broad Euro Index (BEI), changes in the VIX, and total amount outstanding (TAO). Panel B shows variables at the country-level: bilateral exchange rates with respect to the euro ($BER^{€}$), GDP, fiscal (net lending/borrowing as % of GDP), inflation, yield differentials (yield on EME country $c$ minus German yield), credit ratings, and TAO. Panel C shows variables at the security-level: remaining time to maturity and TAO. TAO, yield differentials, credit ratings, and time to maturity are reported separately for local and foreign currency bonds. For foreign currency bonds, our analysis is at the country-currency level. BDI, BEI, BERs, VIX, inflation, and yield differentials are in percentage points. TAO is in millions EUR and GDP in billions USD. Fiscal is in percent of GDP. Credit ratings are numerical, and range from 1 (lowest rating) to 21 (highest rating). The quarterly sample period is 2013q4-2021q4.

Panel A: Time level

| | mean | std.dev. | p5 | p50 | p95 |
|---|---|---|---|---|---|
| ΔBDI | 0.59 | 2.94 | -3.07 | 0.29 | 5.26 |
| ΔBEI | 0.18 | 2.27 | -2.51 | 0.38 | 3.25 |
| ΔVIX | 0.06 | 37.38 | -56.50 | -13.49 | 74.07 |
| TAO *domestic* | 3397 | 921 | 1757 | 3701 | 4708 |
| TAO *foreign* | 710 | 199 | 427 | 716 | 1074 |

Panel B: Country level

| | mean | std.dev. | p5 | p50 | p95 |
|---|---|---|---|---|---|
| ΔBER€ | 0.87 | 5.48 | -6.09 | 0.06 | 9.02 |
| GDP | 1131 | 2500 | 64 | 382 | 2729 |
| Fiscal | -2.73 | 3.06 | -7.74 | -2.50 | 2.38 |
| Inflation | 4.12 | 6.96 | -0.64 | 2.62 | 13.53 |
| Yield differential *domestic* | 5.12 | 6.49 | 0.61 | 3.52 | 11.96 |
| Yield differential *foreign* | 3.29 | 3.32 | 0.36 | 3.05 | 6.75 |
| Credit rating *domestic* | 12.92 | 3.43 | 8 | 12 | 19 |
| Credit rating *foreign* | 12.10 | 3.47 | 6 | 12 | 17 |
| TAO *domestic* | 131 | 222 | 5 | 59 | 571 |
| TAO *foreign* | 38 | 39 | 2 | 25 | 119 |

Panel C: Security level

| | mean | std.dev. | p5 | p50 | p95 |
|---|---|---|---|---|---|
| Time to maturity *domestic* | 7.27 | 7.51 | 0.44 | 4.81 | 23.89 |
| Time to maturity *foreign* | 11.73 | 16.42 | 0.71 | 7.34 | 29.58 |
| TAO *domestic* | 3 | 5 | 0 | 2 | 12 |
| TAO *foreign* | 1 | 2 | 0 | 1 | 3 |

Table IA2. **Correlation table**: This table shows the correlation table of the main variables introduced in Table IA1. For all variables, we take log changes to construct the correlation table. The quarterly sample period is 2013q4-2021q4.

| Correlation table | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ΔBDI | 1.00 | | | | | | | | | |
| ΔBEI | -0.36 | 1.00 | | | | | | | | |
| $\Delta BER^{€}$ | 0.00 | 0.42 | 1.00 | | | | | | | |
| ΔVIX | 0.42 | 0.16 | 0.18 | 1.00 | | | | | | |
| ΔTAO | 0.00 | 0.02 | -0.01 | -0.04 | 1.00 | | | | | |
| ΔYield diff | 0.12 | -0.04 | 0.29 | 0.05 | 0.03 | 1.00 | | | | |
| ΔCredit rating | 0.00 | 0.01 | 0.01 | 0.02 | -0.04 | -0.25 | 1.00 | | | |
| ΔGDP | -0.54 | 0.12 | -0.54 | -0.19 | 0.01 | -0.18 | 0.07 | 1.00 | | |
| ΔFiscal | 0.10 | -0.19 | -0.11 | -0.10 | 0.00 | 0.05 | 0.04 | 0.08 | 1.00 | |
| ΔInflation | -0.06 | -0.02 | 0.12 | -0.01 | -0.03 | 0.06 | 0.08 | 0.04 | 0.04 | 1.00 |

Table IA3. **Robustness - EMEs borrowing euro**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and EME bilateral exchange rates against the euro ($\text{BER}^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI ($\text{BER}^{€,ort}$), *excluding* the following EMEs: Bulgaria, Croatia, Czech Republic, Hungary, Poland, and Romania. Column headings indicate whether the sample includes bonds denominated in local or in foreign currencies (from the perspective of the EME sovereign). For foreign currency bonds, our analysis is at the country-currency level. Controls include the change in log total amounts outstanding, credit ratings, yield differentials, VIX, GDP, fiscal, inflation, and the remaining time-to-maturity (of security $s$). Security fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BDI vs BEI | | BDI vs $\text{BER}^{€}$ | | BDI vs BEI vs $\text{BER}^{€}$ | |
|---|---|---|---|---|---|---|
| | **Local** | **Foreign** | **Local** | **Foreign** | **Local** | **Foreign** |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta$BDI | -0.670*** | -0.493*** | -0.658*** | -0.401** | -0.691*** | -0.504*** |
| | [0.101] | [0.129] | [0.103] | [0.168] | [0.105] | [0.132] |
| $\Delta$BEI | -0.272** | -0.036 | | | -0.281** | -0.041 |
| | [0.110] | [0.137] | | | [0.111] | [0.137] |
| $\Delta\text{BER}^{€}$ | | | -0.105* | 0.067 | | |
| | | | [0.057] | [0.117] | | |
| $\Delta\text{BER}^{€,ort}$ | | | | | -0.041 | -0.015 |
| | | | | | [0.068] | [0.054] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Security FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 25903 | 10771 | 25903 | 10771 | 25903 | 10771 |
| $R$-sq | 0.13 | 0.1 | 0.13 | 0.1 | 0.13 | 0.1 |

Table IA4. **Robustness - Currency of bond vs issuer**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and EME bilateral exchange rates against the euro ($BER^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI ($BER^{€,ort}$), using bilateral euro rates with respect to the *issuer country*. Column headings indicate whether the sample includes bonds denominated in all, in local or in foreign currencies (from the perspective of the EME sovereign). For foreign currency bonds, our analysis is at the country-currency level. Controls include the change in log total amounts outstanding, credit ratings, yield differentials, VIX, GDP, fiscal, inflation, and the remaining time-to-maturity (of security $s$). Security fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BDI vs BEI | | BDI vs $BER^{€}$ | | BDI vs BEI vs $BER^{€}$ | |
|---|---|---|---|---|---|---|
| | **Local** | **Foreign** | **Local** | **Foreign** | **Local** | **Foreign** |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta$BDI | -0.671*** | -0.538*** | -0.660*** | -0.048 | -0.691*** | -0.139 |
| | [0.096] | [0.116] | [0.098] | [0.122] | [0.100] | [0.124] |
| $\Delta$BEI | -0.278*** | 0.227* | | | -0.284*** | 0.333*** |
| | [0.104] | [0.122] | | | [0.105] | [0.122] |
| $\Delta BER^{€}$ | | | -0.114** | 0.499*** | | |
| | | | [0.056] | [0.062] | | |
| $\Delta BER^{€,ort}$ | | | | | -0.143** | 0.542*** |
| | | | | | [0.067] | [0.068] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Security FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 29916 | 13908 | 29916 | 13908 | 29916 | 13908 |
| $R$-sq | 0.13 | 0.16 | 0.13 | 0.16 | 0.13 | 0.16 |

Table IA5. **Robustness - Investment funds and custodians**: This table reports regressions of quarterly changes in foreign holdings (log nominal amounts) on log changes in the Broad Dollar Index (BDI), Broad Euro Index (BEI), and EME bilateral exchange rates against the euro ($BER^{€}$) and the same bilateral exchange rates orthogonalized with respect to the BEI ($BER^{€,ort}$), *excluding* the following holder countries: Belgium, Luxembourg, and Ireland. Column headings indicate whether the sample includes bonds denominated in local or in foreign currencies (from the perspective of the EME sovereign). For foreign currency bonds, our analysis is at the country-currency level. Controls include the change in log total amounts outstanding, credit ratings, yield differentials, VIX, GDP, fiscal, inflation, and the remaining time-to-maturity (of security $s$). Security fixed effects are included as reported. The quarterly sample period is 2013q4-2021q4. Standard errors are clustered at the security level and reported in brackets. Significance: ***99%, **95%, *90%.

| | BDI vs BEI | | BDI vs $BER^{€}$ | | BDI vs BEI vs $BER^{€}$ | |
|---|---|---|---|---|---|---|
| | **Local** | **Foreign** | **Local** | **Foreign** | **Local** | **Foreign** |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔBDI | -0.912*** | -0.338*** | -0.853*** | -0.467*** | -0.921*** | -0.387*** |
| | [0.108] | [0.119] | [0.109] | [0.139] | [0.112] | [0.122] |
| ΔBEI | -0.536*** | 0.095 | | | -0.539*** | 0.076 |
| | [0.119] | [0.123] | | | [0.119] | [0.124] |
| $\Delta BER^{€}$ | | | -0.175*** | -0.091 | | |
| | | | [0.061] | [0.101] | | |
| $\Delta BER^{€,ort}$ | | | | | -0.019 | -0.068 |
| | | | | | [0.073] | [0.054] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Security FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 26516 | 13724 | 26516 | 13724 | 26516 | 13724 |
| $R$-sq | 0.13 | 0.09 | 0.13 | 0.09 | 0.13 | 0.09 |

Table IA6. **Persistence depreciations/appreciations**: This table reports regressions of monthly changes in EME bilateral exchange rates against the euro ($BER^{€}$) on its own lag(s). We report the results for the average across all EME countries (Column 1) and a panel of EME countries (Columns 2-4). The monthly sample period is 2013m12-2021m12. Standard errors reported in brackets and are clustered at the time level for the time-series regressions and double clustered at the time and country level for the panel regressions. Significance: ***99%, **95%, *90%.

| | $BER^{€}$ | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $BER^{€}$ $(t-1)$ | 0.310*** | 0.338*** | 0.284*** | 0.308*** |
| | [0.084] | [0.063] | [0.049] | [0.056] |
| $BER^{€}$ $(t-2)$ | | | | -0.083 |
| | | | | [0.050] |
| $BER^{€}$ $(t-3)$ | | | | -0.057 |
| | | | | [0.049] |
| $BER^{€}$ $(t-4)$ | | | | 0.02 |
| | | | | [0.040] |
| Country FE | - | No | Yes | Yes |
| $N$ | 126 | 2867 | 2867 | 2789 |
| $R$-sq | 0.097 | 0.115 | 0.149 | 0.16 |

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