Who Holds Sovereign Debt and Why It Matters*

Xiang Fang
University of Hong Kong

Bryan Hardy
Bank for International Settlements

Karen K. Lewis
University of Pennsylvania, NBER, and CEPR

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Abstract

The behavior of the investors in sovereign debt can have important implications for the ability of governments to borrow during distress periods, such as the on-going Covid crisis. To study this issue, we construct an aggregate data set of sovereign debt holdings by foreign and domestic investors, further disaggregated into banks and non-bank private, and official investors for 95 countries over twenty years. Analyzing these holdings leads to several important findings. First, increases in the outstanding supply of sovereign debt is largely absorbed by private non-bank investors. Per additional unit of debt, these non-bank investors absorb 69% despite accounting for only 46% of the outstanding amounts on average. Utilizing a more granular data set of euro area investors, we find that investment funds play the largest role among private non-bank investors, rather than insurance and pension funds or non-financial investors. Second, many countries tend to have a dominant investor group, and each investor group exhibits distinct behavior with respect to local and global factors. For global shocks, non-bank investors tend to react similarly whether they are foreign or domestic, whereas banks react distinctly along those lines. Finally, for the sovereign debt of emerging markets (EMs), we estimate investor demand functions using a market-clearing identification. Implied counterfactual analysis shows that an increase in debt for an average EM country will lead to a proportionally higher increase in borrowing costs across their overall creditors, but an out-sized increase if private non-bank investors disappear. Taken together, our analysis suggests that EM sovereign borrowing is highly vulnerable to non-bank investors such as hedge funds and mutual funds.

JEL-Codes: F34, G11, G15, F41
Keywords: Sovereign debt, Banks and Nonbanks, Advanced Economies and Emerging Markets

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1 Introduction

The ability to issue debt is an important instrument at the government's disposal. Sovereign borrowing can help buffer the economy from the impact of adverse macroeconomic shocks. Conversely, indebtedness can also make a country vulnerable to financial distress as crisis episodes have illustrated. Indeed, the sharp increase in fiscal expenditures and debt issuance during Covid-19 has brought more urgency to understanding how a government can borrow. Answering this question requires knowledge of who invests in sovereign debt and how these investors behave.

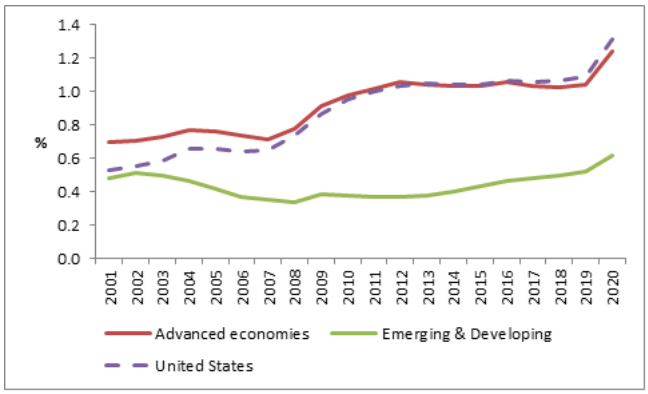
Therefore, this paper provides an analysis of who holds government debt and the implicit vulnerabilities to future funding by governments. We begin by documenting the investor base of government debt around the world and establishing some new empirical regularities. For this purpose, we first assemble a dataset with a balanced sample of 95 countries spanning 1996-2018 that distinguishes the holders of each country's sovereign debt by foreign and domestic investors and into subgroups within those categories.[1] Specifically, within the foreign and domestic groups, the data set categorizes private investors into banks, other private investors that we term "non-banks", and official creditors consisting largely of central banks and international organizations like the World Bank.[2]

Looking at how the composition of investors changes with the supply of debt and other factors sheds light on the likely response of these investors to future developments. Figure 1 motivates this analysis by showing both the growing importance of government debt as well as how the domestic versus foreign investor base has changed. Specifically, Panel (a) shows that aggregate government debt as a proportion of GDP has increased to the highest levels in recent history, spurred on by the Covid-19 pandemic for both for advanced and emerging economies.

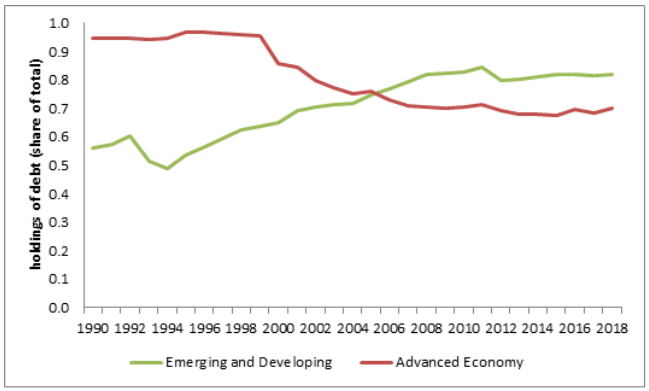
Furthermore, the types of investors have changed significantly over time. For example, as Panel (b) shows, the share of domestic versus foreign investors has evolved with marked

[1] The full, unbalanced sample includes 152 sovereigns over 1991-2018.
[2] This decomposition follows that of Arslanalp and Tsuda (2012) and Arslanalp and Tsuda (2014).

Figure 1: Trends in Sovereign Debt



(a) Public Debt to GDP



(b) Domestic Investor Share

Note: Panel (a) of this figure plots the time-series of public debt-to-GDP ratio for the advanced economies, emerging market and developing countries, and the US from 2001 to 2020. Panel (b) plots the share of public debt held by domestic investors in advanced economies and emerging market and developing countries.

differences between advanced economies (AEs) and emerging markets (EMs). In particular, the share of aggregate debt holdings by foreigners has increased for AEs while that same share has decreased for EMs. Moreover, as will be shown below, during the Global Financial Crisis (GFC) and the Covid-19 pandemic, domestic central bank purchases of advanced economy sovereign debt has dramatically expanded, shifting the composition of the investor base towards official creditors. These relationships highlight how the investor base may evolve, either from long term trends or short term shocks.

To document such changes, we first use our data to ask how increases in the supply of debt are absorbed by each of the six aggregate investor groups: Foreign Bank, Foreign Non-Bank, Foreign Official, Domestic Bank, and Domestic Non-Bank, and Domestic Official (Central Banks). Strikingly, we find that Non-Bank private investors increase their holdings of sovereign debt at significantly higher rates than any other group, including private banks, and this rate is more than proportional to their average holdings. Across all countries for instance, when there is an increase in debt held by foreigners, 75% of the increase is due to Non-bank investors, even though they make up 42% of all foreign holdings. Foreign Banks on the other hand account for 14% of the foreign holdings but only by 10% of the expansion. Moreover, this pattern holds for increases in domestically held debt as well as in

subsamples of AEs and EMs separately. Thus, the responses of Private Non-Bank investors play a significant role in variations of supply in the government debt market.

These aggregate results highlight the importance of Non-bank private investors, a large and heterogeneous group. We turn to a more granular data set of Euro Area investors to disentangle the behavior of different investors within this group. This data set allows us to disaggregate the Non-Bank investor group into non-financial corporations, pensions and insurance companies, households, and a category of other financial institutions, largely representing investment funds. With this more disaggregated group of investors, we find once again the importance of Non-bank private investors as the largest marginal investor group. Furthermore, our analysis indicates that within this group, other financial institutions (i.e. investment funds) drive the large response of non-banks.[3] Overall, this provides some insight into which institutions' behavior is important for sovereign debt markets.

We next explore determinants of the investor composition for different countries. We do this in two ways: 1) grouping countries according to their composition, to document which investors are dominant; and 2) examining the correlation of country characteristics with holdings for each investor group. For 1), we use a clustering analysis to examine whether some groups of countries share similar ownership patterns.[4] The analysis points to four distinct clusters of countries with dominant investor groups: one group dominated by domestic banks, another by domestic non banks, a third by foreign non-banks, and a fourth with a more even spread across investor types. These results can help guide research that incorporates investor behavior by highlighting which investors may play a larger role.[5] For 2), we use the method of Fama and MacBeth (1973) to examine cross-sectional relationships of holding patterns with country characteristics. We see a higher participation by foreign investors when the exchange rate is stable, institutional quality is high, and capital accounts

[3]By contrast, households and non-financial corporations appear to play little to no part in sovereign debt holdings.

[4]Our primary analysis is based upon the "k-means" algorithm initially published by Lloyd (1982) and improved by Arthur and Vassilvitskii (2007), among others.

[5]For example, some papers treat the drivers of equilibrium debt characteristics as being the interplay of domestic households and banks (e.g., Bocola and Lorenzoni (2020)) while others focus on the role of large global banks facing heterogeneous sovereign borrowers (e.g., Morelli, Ottonello, and Perez (2020)).

are more open. Foreign non-bank participation is higher in AEs with higher GDP growth and EMs with greater trade openness.

To better understand the dynamics of investor allocations to sovereign debt, the paper develops a conceptual framework for how investors decide on sovereign debt holdings. Initially, investors decide how much of their portfolio to allocate to sovereign debt holdings in total. Given this decision, investors then choose the countries in which to lend based upon country-specific variables.

We analyze the initial stage in this framework by considering how total holdings by investors of AE and EM sovereign debt depend upon global factors.[6] Across investor groups, holdings decline when the dollar depreciates and when world GDP grows. However, greater uncertainty, as captured by the VIX, has different effects across foreign investors in AE and EM countries' debt. Specifically, higher uncertainty is related to an increase in AE debt holdings but a decrease in EM debt holdings.[7] We test for whether the responses across investor groups differ, finding that Non-bank investors react the same to global shocks regardless of whether they are domestic or foreign.

Next, to identify investor preferences for country-specific factors, we exploit the market clearing identity in our data set. Specifically, for each country, our data set provides a breakdown of all investor group holdings for each country's book value of debt. Therefore, we use this condition to construct a pseudo-yield that would hold by investor type in order to instrument the demand equations. We restrict this identification approach to Emerging Market countries since Advanced Economy domestic investors are likely also foreign investors to other countries in the data set.

Our analysis provides striking results. While banks have relatively inelastic demand, Non-bank investors have higher elasticities. Combined with the higher response of Non-bank investors to increases in supply, exposure measures indicate a very high reliance of

[6]The impact of global uncertainty has been noted in a number of papers including Miranda-Agrippino and Rey (2021) and Forbes and Warnock (2012) for AE and EM countries, respectively.

[7]Intermediary liquidity constraints such as these have been proposed to help explain exchange rate and credit markets more generally. See for example, include He and Krishnamurthy (2013)),Bruno and Shin (2015), Gabaix and Maggiori (2015), and Fang and Liu (2020).

debt costs to Non-bank investors. Indeed, a 1% increase in EM sovereign debt would correspond to almost a 1.5% increase in borrowing costs, a higher response than for official creditors.

In addition, our analysis demonstrates how investor demand depends upon key country characteristics that have been highlighted in the literature. For all investor groups, the demand for a country's sovereign debt depends positively on GDP growth and exports-to-GDP but negatively on inflation. However, these groups differ in their responses to local currency variables, a finding potentially related to the currency denomination of debt. For example, while Eichengreen, Hausmann, and Panizza (2003) noted that many EMs denominated their debt in foreign currency through the 1990s, Du and Schreger (2016a) have shown an increase in local currency debt by many sovereigns over time. We therefore ask how the sovereign debt demand by investor group is related to the local currency-denominated share of debt issued in international markets. Our estimates show that for countries that increase this share of local currency-denominated debt, the holdings by domestic non-bank investors increase, while foreign investor holdings are essentially unchanged.[8] Once again, the non-bank investor group appears to exhibit a different preference to demand characteristics than other groups.

The structure of the papers is as follows: Section 2 describes the data and some basic stylized facts, including a decomposition that highlights how much government debt each investor group absorbs on the margin. It also reports the same decomposition using disaggregated non-bank investor holdings in the Euro Area. Section 3 examines determinants of the investor composition and sets up a simple conceptual framework to explore investor demand in the sovereign debt market. Section 4 provides the country-level investor demand identification and counterfactual analysis. Concluding remarks follow.

[8] Although we do not have direct evidence on who holds these increases in foreign currency denominated debt, our results do suggest how variations in foreign currency debt covary with the overall holdings by investor group. As such, it relates to the literature on how domestic versus foreign investors relate to local currency debt issuances including Du and Schreger (2016b), and Ottonello and Perez (2019), among others.

2 Evolving Composition of Sovereign Debt Investor Groups

We begin with a general discussion of the investor groups, their definitions, and the data construction. This section then demonstrates some basic empirical regularities about how government debt ownership varies with issuances.

2.1 Investor Group Definitions

In order to focus on the evolving behavior of foreign and domestic holders of government debt, we consider three basic investor groups categorized as: (1) banks; (2) private non-banks; and (3) official creditors. These investors are ordered throughout the paper below as: $i = 1, 2, 3$. We describe briefly these three categories below before detailing their construction in the data.

The first investment group identified by $i = 1$ is comprised of private banks. These institutions are often considered primary intermediaries for debt markets and have therefore been the focus of both the Emerging Market (EM) and Advanced Economy (AE) branches of sovereign debt studies. In the literature on emerging market borrowing, foreign global banks are often modeled as the primary creditor. In advanced economies, capital regulation typically incentivizes domestic banks to hold domestic government debt due to their zero risk weight.[9] It has been argued that these holdings give rise to the bank-sovereign doom loop Fahri and Tirole (2018). Below, we call these investors "Foreign Banks" and "Domestic Banks", accordingly. For expositional purposes, we define the bank holdings of the debt of country j as H_j^1 for domestic "Home" banks and as F_j^1 for "Foreign" banks.

A second group of private investors identified by $i = 2$ is a combination of all private investors who are not banks. These investors are not subject to bank regulatory restrictions but may face other constraints depending on the nature of their business. Overall, this investor group encompasses financial institutions such as pension funds and insurance firms,

[9] Bank regulation typically uses risk-weighted assets to compute capital ratios. So, acquiring an asset with a zero risk weight does not reduce the bank's regulatory capital ratios, though it can affect other bank constraints like the leverage ratio.

endowments, mutual funds, and hedge funds, as well as non-financial entities like corporations and households. In our aggregate results, we refer to this diverse investor group simply as "Foreign Non-Banks" and "Domestic Non-Banks".[10] Similarly, using the notational convention above, the private non-bank holdings of the debt of country j are defined as H_j^2 for "Home" non-bank investors and as F_j^2 for "Foreign" non-banks.

Finally, we consider official creditors, primarily central banks, an investor group we identify as $i = 3$. In other words, the home official creditor is simply the "Domestic Central Bank" while the "Foreign Official" investor group includes foreign central banks, other governments, and international organizations such as the World Bank and International Monetary Fund. Holdings of country j's debt by this investor group is defined as H_j^3 for the "Home" central bank and as F_j^3 for the "Foreign" official creditors. Since this group of investors is likely motivated by different incentives than the private creditors, we largely focus on the other two investor groups in the rest of the paper. Nevertheless, this group comprises an important part of sovereign debt holdings and we therefore document its behavior in this section.

The investor groups for the government debt of a given country j can then be aggregated across these three groups to provide a measure of the holdings of the Home and Foreign creditors, respectively, as:

$$\begin{aligned} \overline{H}_j &\equiv \sum_{i=1}^{3} H_j^i \\ \overline{F}_j &\equiv \sum_{i=1}^{3} F_j^i \end{aligned} \tag{1}$$

Moreover, since these holdings account for the outstanding debt of sovereign j, the total supply of debt D_j must equal the holdings of debt held by Home and Foreign investors through the accounting identity:

$$D_j = \overline{H}_j + \overline{F}_j, \forall j \tag{2}$$

Thus, these holdings allow for a decomposition of domestic and foreign investor groups using the shares of banks, non-banks, and official holdings. Specifically, letting lower cases

[10] Below, we study these individual groups on a more disaggregated basis using data for euro area investors.

refer to the shares of each sovereign's debt held by investor group i as

$$h_j^i \equiv \frac{H_j^i}{D_j}; \; f_j^i \equiv \frac{F_j^i}{D_j}, \tag{3}$$

then clearly these investor shares sum to the share held by home and foreign creditors and these investor shares sum to one. That is,

$$\begin{aligned} 1 &\equiv \frac{\overline{H}_j}{D_j} + \frac{\overline{F}_j}{D_j} \\ &= \sum_{i=1} h_j^i + \sum_{i=1}^{3} f_j^i \end{aligned} \tag{4}$$

We will use the decompositions of the shares in equations (3) and (4) below to uncover the changing patterns of ownership over time. Before doing so, we first describe the data.

2.2 Data

The annual data series for the debt and holding groups come from various sources. Here we describe briefly the overall approach in constructing these data series, although a more complete discussion can be found in Appendix A. The general approach follows the work of Arslanalp and Tsuda (2012) and Arslanalp and Tsuda (2014). We make some deviations from their methodology in order to broaden the time period and sample of countries, but we point interested researchers to their database.

The overall total debt levels D_j are derived primarily from the IMF Historical Public Debt Database (HPDD), that provides debt-to-GDP for a large number of countries over a long time horizon. To recover the value of debt in current USD, we multiply this series by GDP from the World Bank.[11] The foreign total holdings $\overline{F}$ are constructed following the methodology in Avdjiev, Hardy, Şebnem Kalemli-Özcan, and Servén (2018) (AHKS). Constructing the foreign holdings with this methodology relies on data such as the IMF International Investment Position (IIP) data, the Quarterly External Debt Statistics (QEDS), and the BIS international banking and international debt securities statistics. The domestic

[11] For some countries, the HPDD data stops in 2015. For these countries, we obtain post-2015 values by applying the growth rate in total debt from the Quarterly Public Debt Statistics (QPSD), which has excellent coverage of the recent period, to the last available level computed from the HPDD.

total holdings $\overline{H}$ are the complement of this series to total debt, and are computed as the difference between total debt and foreign debt.

The holdings of the domestic and foreign debt are further decomposed into the three groups described above. Data for foreign bank holdings, F_j^1, are estimated using the approach in AHKS. Foreign official holdings, F_j^3, for advanced economies and China are taken directly from Arslanalp and Tsuda (2012, 2014), capturing the use of such debt as foreign reserves. For other countries, we use the sum of bilateral and multilateral lending from the World Bank Debtor Reporting System (DRS). Foreign Non-Bank holdings F_j^2 are the difference between these measures and total foreign holdings.

Turning to domestic investors, domestic sovereign debt holdings of domestic banks, H_j^1, and domestic central banks, H_j^3, are taken from the IMF's International Financial Statistics (IFS) dataset, supplemented with data from the official websites of central banks when the data was incomplete. The domestic total is computed as the difference between the total debt and the foreign-held debt. Domestic Non-Bank holdings, H_j^2, are computed as the difference between the domestic total and the sum of domestic banks and domestic central banks. We express all data in current US dollars.

Overall, this construction provides a balanced sample of 95 countries from 1996 to 2018 and a full unbalanced sample beginning in 1991 for 152 countries. For the analysis, we split the sovereigns into 3 groups: advanced economies (AEs), emerging markets (EMs), and developing countries (DCs).

2.3 Investor Trends and Marginal Holders

Given these definitions, we now examine the relative behavior of each investor group's holdings as government debt changes. Panel (a) of Figure 2 begins by showing the average holdings-to-GDP shares of advanced economy (AE) investors while Panel (b) of the same figure shows the same for the emerging and developing economies (EMDC). These figures show distinctive differences within the groups. For both groups, the foreign bank

and non-bank shares have been stable, though small, over time.[12] However, the proportion of foreign official holdings has become larger for AEs, as central banks have increased their holdings of safe haven government debt for reserve purposes, while that proportion has declined for emerging markets. Strikingly, the share of domestic non-banks has increased over time for EMs relative to AEs, perhaps reflecting growing financial development within these economies. By contrast, the AE holdings of domestic central banks has expanded over time, likely due to the use of unconventional monetary policies.

These trends raise an important question. When the size of debt increases, which investors absorb the additional amount? In other words, who are the marginal investors for the sovereign? To explore this question, we regress the change in debt held by each investor group on the change in total debt:

$$\begin{aligned} \frac{H^i_{jt} - H^i_{jt-1}}{D_{jt-1}} &= \alpha^i_j + \alpha^i_t + \beta^i_0 \frac{D_{jt} - D_{jt-1}}{D_{jt-1}} + \varepsilon^i_{jt}, \quad \forall i \\ \frac{F^i_{jt} - F^i_{jt-1}}{D_{jt-1}} &= a^i_j + a^i_t + b^i_0 \frac{D_{jt} - D_{jt-1}}{D_{jt-1}} + e^i_{jt}, \quad \forall i \end{aligned} \tag{5}$$

where the subscript t indicates time, where α^i_j and a^i_j represent country fixed effects and where α^i_t and a^i_t represent time fixed effects. Note that the sum of the investor groups add up to the total so that the growth rate of debt is reflected in the accounting identity:

$$\frac{D_{jt} - D_{jt-1}}{D_{jt-1}} = \sum_{i=1}^{3} \frac{H^i_{jt} - H^i_{jt-1}}{D_{jt-1}} + \sum_{i=1}^{3} \frac{F^i_{jt} - F^i_{jt-1}}{D_{jt-1}}. \tag{6}$$

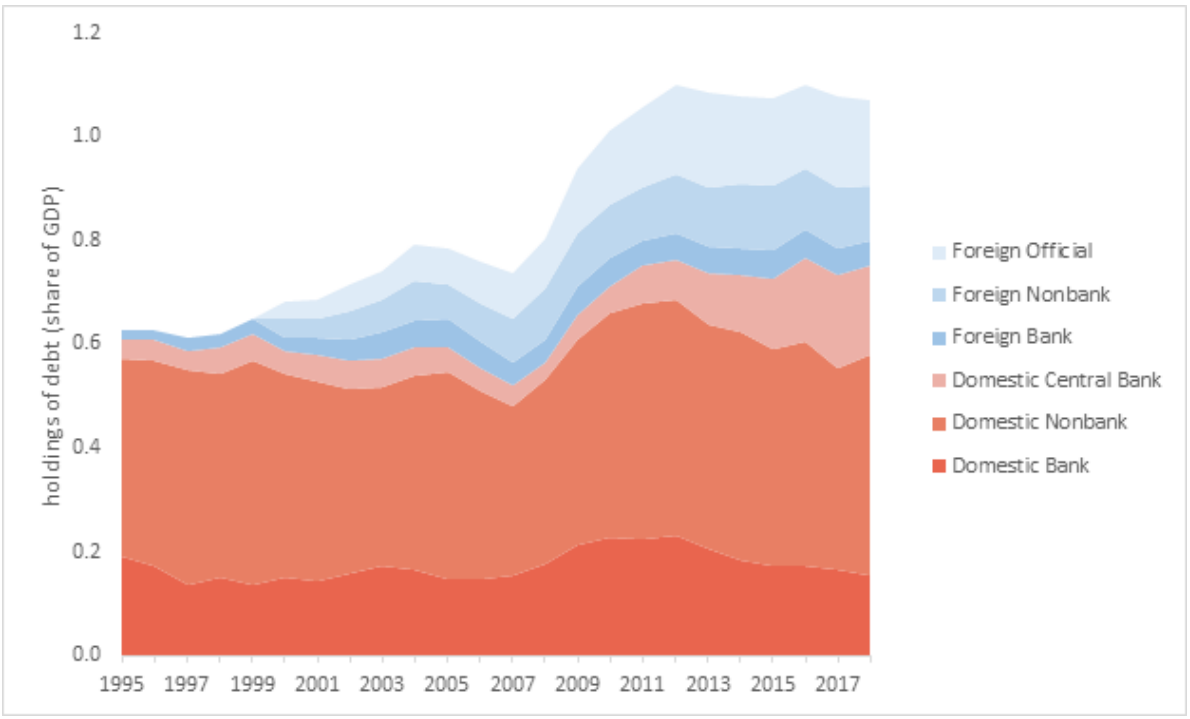
Therefore, since all of the debt is absorbed by some investor, the coefficients estimated from this regression will sum to 1: $\sum_{i=1}^{3} \beta^i_0 + \sum_{i=1}^{3} b^i_0 = 1$. As a result, each coefficient reflects the marginal holding response of each investor group to variations in the supply of debt.

Table 1 shows the results of this regression. Panel A provides a baseline estimate labeled "All" based upon a balanced sample of countries.[13] The first two columns provide these results for an aggregated group of domestic and foreign investors, respectively. Columns

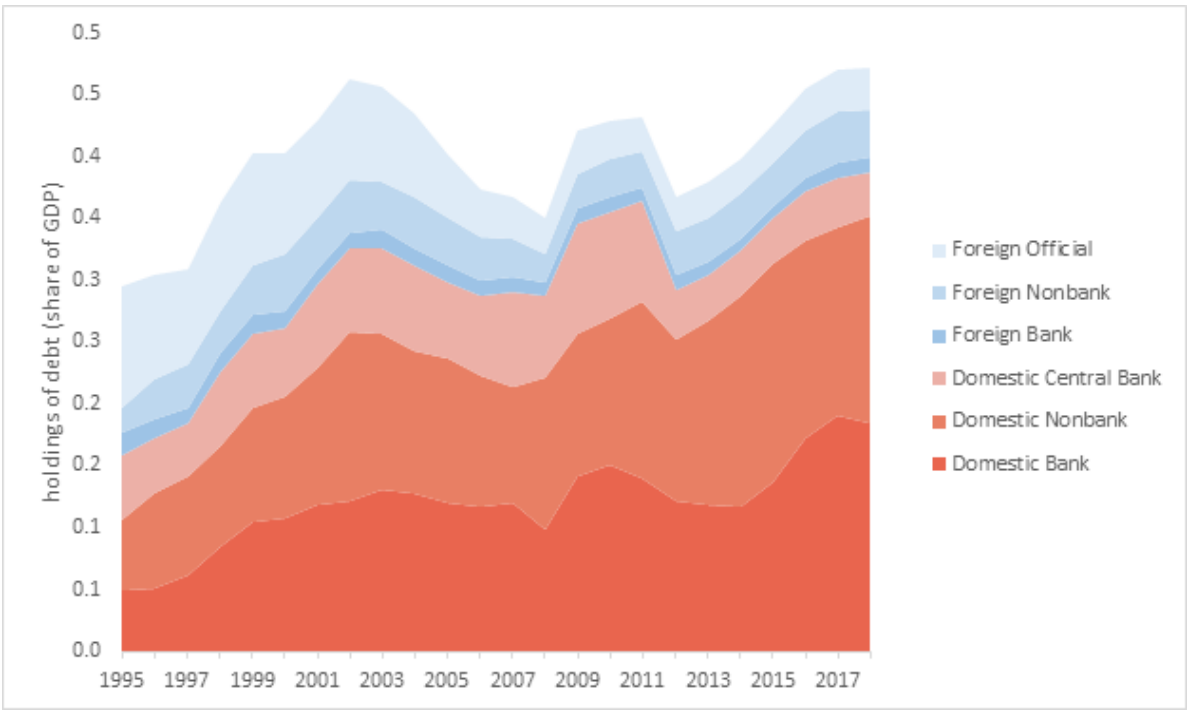
[12] Foreign official data for advanced economies are not available until 2000, so foreign holdings are not fully reported before that point.

[13] See Table B1 in the appendix for results utilizing an unbalanced sample.

Figure 2: Trends in Sovereign Debt



(a) AEs



(b) EMs and DCs

Note: This Figure plots the debt-to-GDP ratio held by different investor groups for advanced economies (Panel a) and emerging market and developing countries (Panel b).

(1) and (2) show that for every an additional unit of debt supplied, 60% is absorbed by domestic investors while the other 40% is picked up by foreign investors. In AEs and DCs, this split is roughly equal, whereas for EM sovereign debt, domestic investors take over two-thirds of additional debt.

Breaking down foreign and domestic investors by type in columns (3) through (8) reveals additional insights. For the "All" country estimates, non-bank investors tend to be the most important, taking on 39% and 30% of additional debt holdings for domestic and foreign entities, respectively. As reported in the following rows, decomposing estimates into country groups shows the relative importance of investor groups across these countries. In particular, foreign non-banks are more important for AEs and DCs, while domestic non-banks matter more for EMs.

More important, however, is the role of investor groups relative to each other. Here, Non-bank investors again demonstrate the most striking results. For example, Foreign Non-banks play a much stronger role in expanding holdings in response to new debt than do Foreign Banks. In particular, the takeup of new EM debt by foreign non-bank investors is 24% in contrast to only 5% by foreign banks. These findings are in stark contrast to a view that foreign banks play the biggest role in the EM debt market. And lastly, foreign official investors are more important as marginal investors for DCs, where they serve as an important source of financing (9% of the increased supply). These patterns are illustrated in panel (a) of Figure 3.

These results consider the marginal decomposition of investor groups in response to an expansion in country debt and therefore one might wonder whether these holdings are consistent with average holdings. To answer this question, Pane B of Table 1 reports the average holdings by investor group over the period. As these numbers show, the large marginal contribution of nonbank investor holdings are greater than the average holdings. For example, in the baseline "All" results, the average holdings of Domestic Nonbanks and Foreign Nonbanks sum to only 46% (that is, $0.28 + 0.18$). At the same time, the marginal

Table 1: Marginal Holders of Sovereign Debt

	(1) Dom	(2) For	(3) DomBK	(4) DomNB	(5) DomCB	(6) ForBK	(7) ForNB	(8) ForCB
Panel A: Marginal Share								
All	0.60***	0.40***	0.16***	0.39***	0.05***	0.04***	0.30***	0.06***
	(0.05)	(0.05)	(0.04)	(0.05)	(0.01)	(0.01)	(0.05)	(0.02)
AE	0.50***	0.50***	0.02	0.39***	0.09	0.06**	0.40***	0.04
	(0.12)	(0.12)	(0.03)	(0.09)	(0.07)	(0.02)	(0.12)	(0.03)
EM	0.68***	0.32***	0.21***	0.43***	0.04**	0.05***	0.24***	0.04
	(0.05)	(0.05)	(0.05)	(0.07)	(0.02)	(0.02)	(0.05)	(0.03)
DC	0.50***	0.50***	0.11***	0.34***	0.05***	0.01	0.40***	0.09***
	(0.09)	(0.09)	(0.03)	(0.09)	(0.02)	(0.02)	(0.10)	(0.02)
Panel B: Average Share								
All	0.57	0.43	0.22	0.28	0.07	0.06	0.18	0.19
AE	0.55	0.45	0.19	0.32	0.04	0.10	0.21	0.14
EM	0.61	0.39	0.26	0.28	0.07	0.06	0.17	0.16
DC	0.49	0.51	0.16	0.24	0.09	0.04	0.17	0.30

Note: Panel A of the table reports the regression coefficients for Equation (5) for each investor group. The first two columns represent domestic and foreign investors, respectively. Columns (3) through (8) correspond to the six investor groups. Standard errors clustered at country and year level are reported in the parentheses. Panel B of the table reports the average share of holding by each investor group.

holdings reported in Panel A are jointly 69% ($0.39 + 0.30$). This pattern is clearly robust across all the remaining decompositions including AE, EM, and DC.

2.4 Marginal investors during different circumstances

While these relationships consider the responses of investor holdings over all periods, the composition of marginal investors may change depending on the time period or circumstance. Indeed, the literature on marginal investors has highlighted their importance and differences during crises and recessions (e.g., Bruno and Shin (2015) and Miranda-Agrippino and Rey (2021).) During these times, banks may cut back lending and central banks may

intervene to stabilize the economy. Moreover, these cut-backs may impact the overall responses of investor holdings of government debt. Therefore, we examine the sensitivity of investor group holdings to crises and other special circumstances. To examine marginal investor responses during these time periods, we augment the regression above to test for interactions with these events, illustrated for domestic holders in the following equation:

$$\frac{H^i_{jt} - H^i_{jt-1}}{D_{jt-1}} = \alpha^i_j + \alpha^i_t + \beta^i_0 \frac{D_{jt} - D_{jt-1}}{D_{jt-1}} + \beta^i_1 I_{jt} + \underbrace{\beta^i_2 \left(\frac{D_{jt} - D_{jt-1}}{D_{jt-1}} \times I_{jt} \right)}_{\text{interactions}} + \varepsilon^i_{jt}, \quad \forall i \tag{7}$$

$$\frac{F^i_{jt} - F^i_{jt-1}}{D_{jt-1}} = a^i_j + a^i_t + b^i_0 \frac{D_{jt} - D_{jt-1}}{D_{jt-1}} + b^i_1 I_{jt} + \underbrace{b^i_2 \left(\frac{D_{jt} - D_{jt-1}}{D_{jt-1}} \times I_{jt} \right)}_{\text{interactions}} + e^i_{jt}, \quad \forall i \tag{8}$$

where I_{jt} are indicator variables that identify whether the country faced a recession, a recent banking crisis, or are dummies for different time periods in our sample (e.g. before vs after the Global Financial Crisis (GFC) of 2008-09). We consolidate the results of these regressions into Figure 4 and relegate detailed regression coefficients in Table B2, B3, and B4 in Appendix B. Advanced economies show marked differences in the marginal investors across different circumstances. During recessions or crises, domestic investors absorb much more of the debt, driven by non-banks and a notably large role of central banks. By contrast, domestic banks decrease their holdings of their sovereign's debt during a crisis. After the GFC, both domestic banks and domestic non-banks increase the share of debt they absorb, as well as foreign official lenders. This latter trend may reflect increased holdings of foreign reserves by foreign central banks, particularly those in EM countries.[14]

Patterns in EMs are somewhat different. Domestic investors play a smaller role during a recession. Domestic banks' share actually increases, but the domestic non-bank sector absorbs a much smaller share of any increased debt. Foreign banks and non-banks pick up the remaining slack. During a crisis, the domestic investors absorb more debt, which is driven by the domestic non-bank sector. Like AEs, EMs do see an increase in domestic

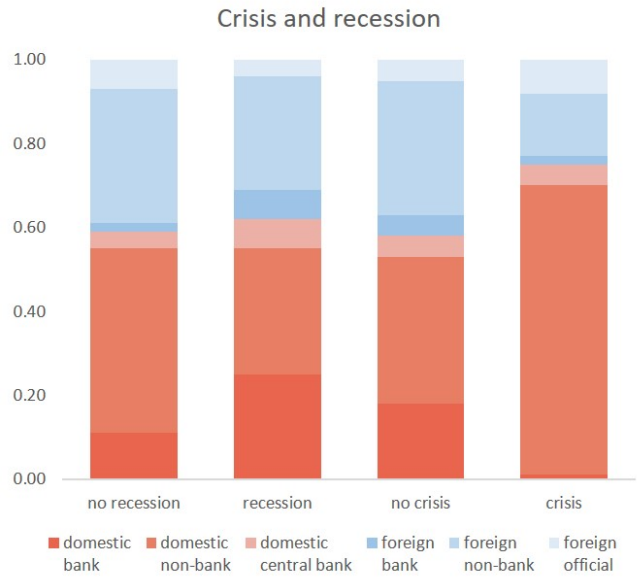
[14] If these data were extended through 2020, we might see a much higher marginal share for the domestic central bank, as some in AEs purchased amounts roughly equal to the net issuance of debt during that year. See the IMF Fiscal Monitor.

absorption after the GFC.

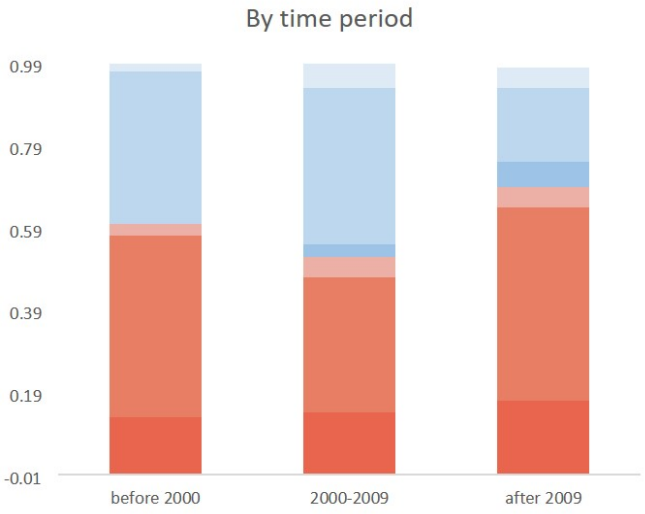
For DCs, the role of domestic investors also expands during recessions and crises. The pattern in marginal investors in these markets over time is also interesting. After 2000, foreign investors play a larger role in picking up debt issued by DC sovereigns, but after the GFC domestic investors' share increases substantially as foreign non-bank investors contract. The share of foreign official has been increasing over time.

Overall, despite differences over crisis periods, the basic finding that Non-bank investors are important marginal investors continues to hold over these periods. During crises, domestic and foreign non-bank investors take on a larger share of the government debt though they retreat from those holdings during general recessions.

Figure 3: Marginal Holders



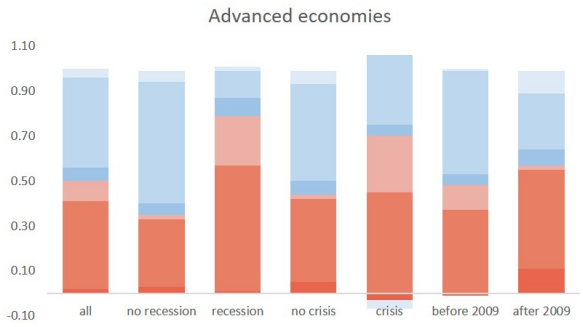
(a) Crisis and recession



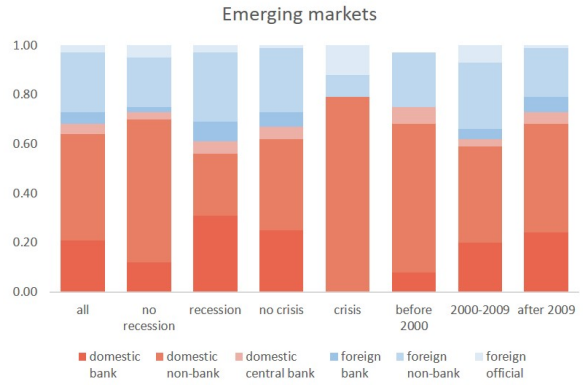
(b) By time period

Note: This figure plots the regression coefficients in Equation (7) and (8) for all countries under different circumstances. Panel (a) shows the coefficients for each investor group during recession and non-recession times, and during crisis and non-crisis times. A recession is defined by a negative real GDP growth rate. A crisis is identified following Laeven and Valencia (2020), which includes a banking crisis, a currency crisis, and a debt crisis. Panel (b) shows the coefficients for each investor group in three subsamples: pre-2000, 2000-2009, and post-2009.

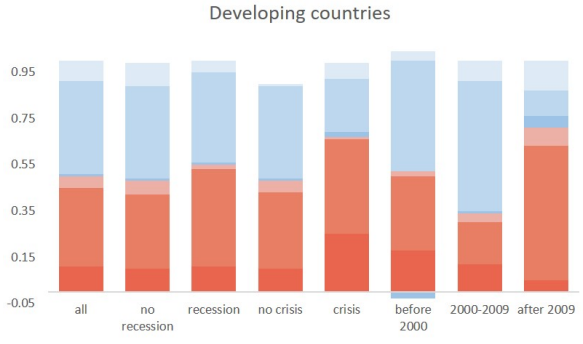
Figure 4: Marginal Holders



(a) Advanced economies



(b) Emerging market economies



(c) Developing countries

Note: This figure plots the regression coefficients in Equation (7) and (8) under difference circumstances for advanced economies, emerging market economies, and developing countries in Panels (a) through (c). **A recession is defined by a consecutive two-quarter of real GDP growth that is .... (to be checked)**. A crisis is identified following Laeven and Valencia (2020), which includes a banking crisis, a currency crisis, and a debt crisis.

2.5 The Role of Non-Bank Investors

As we showed above, private investors who are not banks play an important role in the sovereign debt market. The important role of non-bank private investors implied by these results raises the obvious questions: who are these investors and what are their motivations in holding debt? To shed light on this question, we turn to a more disaggregated data set: the Euro area securities holding statistics produced by the European Central Bank. This source provides data on the holdings of securities by sector of the holder, by the type and sector of the security, and by the residence of the security issuer. Thus, we can observe the holdings of individual government debt for all Euro area investors within a given holder group. Specifically, the non-bank sector in this data has the more granular breakdown: (a) households and non-profits, (b) insurance and pensions, (c) non-financial corporations; and (d) "other financial institutions" which includes entities like hedge funds and mutual funds. As above, we also study the holdings by banks and the official sector. However, in this data source, the official sector is just the government, excluding the central bank. These data are quarterly and span 2013 Quarter 4 to 2020 Quarter 3.

Using these data, we replicate the decomposition of marginal investors in the government debt market. One issue for the Euro Area data that is different from the aggregate data, however, is that the data are collected as a group of investors across countries. Therefore, there is no natural counterpart to domestic investors. For this reason, we focus only on holdings by Euro area investors of sovereign debt from countries outside of the Euro area. As a result, our decomposition only relates to the foreign investor results above. Moreover, since the Euro area investors only hold a portion of total government debt by these countries, we aggregate across debt holdings within the area to measure "total" debt. Thus, the estimates provide a decomposition of overall holdings by Euro area investors only, and do not represent the aggregate debt outstanding.[15]

Table 2 shows the results of the regression. Similar to the aggregate data, Columns (1)

[15] As with the aggregate analysis, we include all countries of the sovereign in the decomposition, including the US. For the Euro area investors, the US provides an important potential Advanced Economy for debt holdings.

to (3) show that Non Bank private investors generally take on additional sovereign debt held in the Euro area. For the base case of all countries, 77% of every additional unit of sovereign debt is held by NonBanks, while only 23% is held by Banks, and that amount is *de minimis* for Governments. These general patterns hold for all cases except for Advanced Economies in the baseline estimates in Panel A, where banks seem to absorb the largest share of the increase. However, when we weight by size of borrowing country debt in Panel B, non-banks are again the larger marginal investor in aggregate among this set of Euro area investors. This difference can be driven by the large role played by banks in Europe, as well as increasing holdings of U.S. Treasuries by euro area non-banks.

Table 2: Marginal Holders of Sovereign Debt - Euro Area

	(1) Gov	(2) Banks	(3) NonBank	(4) HH	(5) InsurPens	(6) NFC	(7) OthFin
Panel A: Equal weighted							
All	0.00***	0.23***	0.77***	0.01	0.14**	0.00*	0.85***
	(0.00)	(0.07)	(0.07)	(0.01)	(0.06)	(0.00)	(0.12)
AE	0.00	0.53***	0.47***	0.02	0.12*	0.01	0.85**
	(0.00)	(0.14)	(0.14)	(0.01)	(0.06)	(0.01)	(0.29)
EM	0.00***	0.10*	0.90***	0.01	0.14*	0.00	0.85***
	(0.00)	(0.05)	(0.05)	(0.01)	(0.07)	(0.00)	(0.12)
Panel B: Weighted by D_{jt-1}							
All	0.01	0.23***	0.77***	0.01	0.07***	0.03	0.89***
	(0.00)	(0.06)	(0.06)	(0.00)	(0.02)	(0.03)	(0.11)
AE	0.01	0.27**	0.73***	0.00	0.06**	0.04	0.89***
	(0.01)	(0.09)	(0.09)	(0.00)	(0.02)	(0.04)	(0.17)
EM	0.01***	0.11**	0.89***	0.02	0.10***	0.00*	0.88***
	(0.00)	(0.04)	(0.04)	(0.01)	(0.03)	(0.00)	(0.06)

Note: This table reports regression coefficients of Equation (5) on sovereign debt issued by non-European countries for different investor groups within Europe. Columns (1) through (3) reports coefficients for government, banks and Nonbank sector. Columns (4) through (7) disaggregates Nonbanks into households (HH), insurance and pension funds (insurPens), non-financial corporations (NFC), and other financial institutioins (OthFin). Standard errors clustered at country and year level are reported in the parentheses.

Importantly, columns (4) to (7) provide a decomposition within the Non-bank investor group. In the Baseline case, Insurance and Pensions take on roughly 14% of the additional debt holdings of non-bank investors. This is dwarfed by the 85% absorbed by "other financial institutions" such as hedge funds and mutual funds. By contrast, the other two

categories of Households and Non-financial companies essentially take on little to none of the additional government debt. This pattern is similar across both AEs and EMs.

Overall, these disaggregated data suggest that the Nonbank investor group is largely driven by the behavior of mutual funds and hedge funds. Only the insurance and pension funds have a significant impact on Nonbank responses to debt, and even these institutions contribute much less.

3 Investors and Sovereign Debt Allocations

The analysis above demonstrates how the composition of investor holdings in sovereign debt varies across the types of issuers, showing the importance of the Non-bank private investor group. However, these results do not address how this ownership is related to characteristics of a borrowing country. Therefore, in this section, we begin to examine this question by focusing on the behavior of investor holdings and their respective debtor countries.

Specifically, we develop this analysis in three parts. Section 3.1 begins with a broad look at the investor groups and the corresponding countries in which they invest. Clustering analysis shows that groups of countries are dominated by different types of investors. To better understand what might determine which investor group is dominant, We examine how the investor composition relates to general macroeconomic characteristics of the country. Next, Section 3.2 develops a conceptual framework that relates investor sovereign debt allocations to variations in global and country-specific variables. Finally, Section 3.3 considers the impact of global shocks on the differences in investor holdings. The behavior of these shocks have been central to discussion of how investors in both AE and EM government debt respond to global uncertainty (e.g., Miranda-Agrippino and Rey (2021), Gourinchas and Rey (2007), Aguiar and Gopinath (2007)).

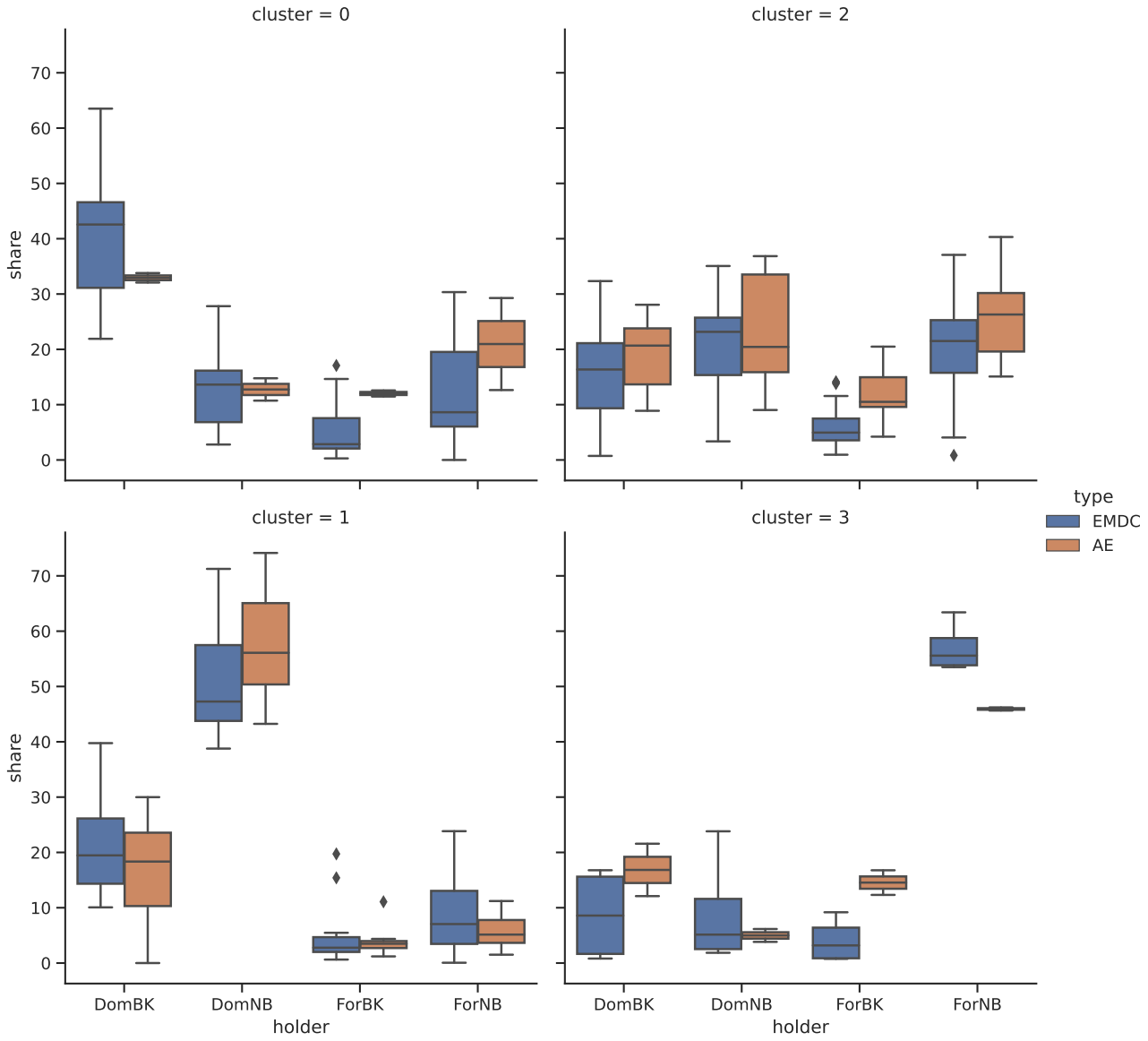
3.1 General Patterns between Holdings and Countries

We begin by looking at the overall cross-sectional patterns between investor holdings and countries. For this purpose, we use the "k-means" algorithm (Lloyd (1982), and more recently Arthur and Vassilvitskii (2007)). This algorithm minimizes the deviation between vectors of variables and groups variables that are close together into clusters. To consider whether certain investor types are dominant in countries, we use this algorithm to cluster countries by the share of holdings for the four private investor groups using the balanced data set. We first determine the number of distinct groups by calculating the decay function and finding the kink in the relationship. As described in Appendix C, this analysis shows that the number of clusters is 4. We then use the algorithm to sort the countries into cluster groups according to investors.

The results are illustrated in Figure 5. The boxes show the 90% confidence intervals of investor shares while the bands provide the high and low observations. In order to show potential differences, EM countries are plotted in blue while AE countries are in orange. These clusters show clear pattern of countries based upon investor groups. Specifically, the Cluster 0 group of countries is dominated by a higher share of Domestic Bank ownership, particularly for Emerging Markets. By contrast, the sovereign debt for Cluster 1 and Cluster 3 countries are mostly held by Domestic NonBanks and Foreign Nonbanks, respectively. Cluster 2 is the only set of countries that appear to have a more mixed investor based. In Appendix C, we illustrate these groupings in a world map.

While these groupings demonstrate the average dominant investor groups by country, they do not inform us what characteristics across countries are related to the different investors' demand. To answer this question, we use the Fama and MacBeth (1973) approach of regressing the holdings on the macro variables for each year and then averaging the coefficients over time, correcting for time-series correlation. Tables 3 and 4 report these basic cross-sectional relationships of investor holdings of AE and EM country sovereign debt, respectively. The tables report the responses of investor group holdings in response to a

Figure 5: Shares of Investor Group Holdings by Country Clusters



Note: This figures shows the average share held by the four private investor groups in each cluster of countries, and the 90% confidence interval. The blue bars represent emerging economies and developing countries. The orange bars represent advanced economies. The analysis uses a balanced sample of 95 countries and is based on the k-means algorithm.

set of macro variables as well as measures of country openness and stability. In particular, real GDP growth and exchange rate stability comprise proxies for the economy, while the openness of the country is captured by an institutional quality variable, a capital account openness index, and exports-to-GDP.[16]

[16]Institutional quality is proxied by the Polity V index, which captures democratic and autocratic tendencies in governments. Capital account openness and exchange rate stability are indices ranging from 0 to 1, taken from

Comparing investor responses across Advanced and Emerging Market countries in Tables 3 and 4 highlights interesting similarities and differences. Columns (1) and (2) show that both AE and EM foreign investor groups generally increase their holdings of sovereign government debt when the exchange rate is stable, institutional quality is high and capital accounts are more open. By contrast, foreigners tend to increase holdings when the growth rate is high for AE countries, though that relationship is negative (albeit insignificant) for EM countries. More strikingly, AE domestic investors tend to decrease their holdings of their own government debt while EM domestic investors increase these holdings when the real GDP growth is high. Columns (3) and (4) consider aggregations of investor groups into Total Banks and Total Non Banks as the sum of Domestic and Foreign investors in these categories, while columns (5) to (8) report these groups separately. These results show that with better institutions, the holdings shares by foreign banks increase most consistently in AEs, but in EMs foreign non-banks drive the patterns. Foreign banks' share responds positively to exchange rate stability in AEs, but not in EMs. In both AE and EM countries, domestic banks drive the domestic patterns with real GDP growth, but with a decreasing share in AEs and an increasing share in EMs.

Aizenman, Chinn, and Ito (2010).

Table 3: Investor Holdings and Country Factors - Advanced Economies

	(1) DomPriv	(2) ForPriv	(3) BK	(4) NB	(5) DomBK	(6) DomNB	(7) ForBK	(8) ForNB
r_gdp_gr	-2.79**	3.82***	-1.91***	2.93**	-1.97**	-0.82	0.064	3.75***
	(1.13)	(1.16)	(0.62)	(1.05)	(0.75)	(0.68)	(0.33)	(0.95)
exp_ratio	-0.06	-0.01	0.03	-0.10	0.01	-0.07	0.02	-0.03
	(0.05)	(0.08)	(0.03)	(0.08)	(0.03)	(0.05)	(0.02)	(0.09)
CA opennness	80.51***	23.73	29.25**	74.98***	43.99***	36.52***	-14.74*	38.46*
	(14.00)	(22.95)	(11.71)	(15.26)	(5.126)	(12.52)	(7.72)	(20.31)
FX stability	-37.15***	34.43***	10.66***	-13.38***	1.29	-38.44***	9.37***	25.06***
	(3.48)	(2.96)	(3.03)	(3.18)	(2.17)	(2.19)	(2.15)	(2.78)
Inst quality	-3.28***	2.34*	0.44	-1.38	-0.16	-3.12***	0.60***	1.74
	(0.96)	(1.19)	(0.31)	(1.10)	(0.31)	(0.85)	(0.21)	(1.32)
Obs	358	358	358	358	358	358	358	358
R^2	0.601	0.532	0.253	0.376	0.192	0.548	0.503	0.486

Note: This table reports coefficients on holding shares of different investor groups on a set of borrower country (advanced economies) characteristics using a Fama-MacBeth approach. Observations are at the country level. Each column represents one group of investors. "DomPriv" is the sum of domestic banks' and nonbanks' holding, and "ForPriv" is the sum of foreign banks' and nonbanks' holding. "BK" is the sum of domestic and foreign banks' holding, and "NB" is the sum of domestic and foreign nonabnks' holding. Standard errors are Newey-West adjusted. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Investor Holdings and Country Factors - Emerging Markets

	(1) DomPriv	(2) ForPriv	(3) BK	(4) NB	(5) DomBK	(6) DomNB	(7) ForBK	(8) ForNB
r_gdp_gr	0.87*	-0.46	0.11	0.31	0.34*	0.54	-0.23***	-0.23
	(0.49)	(0.36)	(0.18)	(0.37)	(0.19)	(0.50)	(0.07)	(0.32)
exp_ratio	0.16**	0.16***	0.07	0.24***	0.04	0.11***	0.03	0.13***
	(0.06)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)	(0.02)	(0.04)
CA openness	-1.14	13.39***	10.15***	2.10	4.34*	-5.48*	5.81***	7.59***
	(3.41)	(2.34)	(2.60)	(2.99)	(2.28)	(3.10)	(0.61)	(1.89)
FX stability	-32.06***	10.60***	-7.41	-14.04***	-7.77	-24.29***	0.36	10.24***
	(5.86)	(3.53)	(5.14)	(4.01)	(4.55)	(5.89)	(1.07)	(3.37)
Inst quality	-1.26***	0.99***	-1.09***	0.82***	-0.98***	-0.28*	-0.11*	1.10***
	(0.20)	(0.14)	(0.11)	(0.11)	(0.13)	(0.16)	(0.06)	(0.13)
Obs	800	800	800	800	800	800	800	800
R^2	0.314	0.459	0.289	0.234	0.253	0.243	0.353	0.415

Note: This table reports coefficients on holding shares of different investor groups on a set of borrower country (emerging economies) characteristics using a Fama-MacBeth approach. Observations are at the country level. Each column represents one group of investors. "DomPriv" is the sum of domestic banks' and nonbanks' holding, and "ForPriv" is the sum of foreign banks' and nonbanks' holding. "BK" is the sum of domestic and foreign banks' holding, and "NB" is the sum of domestic and foreign nonabnks' holding. Standard errors are Newey-West adjusted. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These relationships demonstrate how the cross-sectional holdings of sovereign debt by various investor groups relate to country-specific variables. In this analysis, we do not include a crucial variable, the cost of borrowing for the government. The cost of borrowing is driven by both the investors' demand of debt so that a reduced-form regression cannot obtain the true elasticity of demand. To understand the relationships among debt, borrower countries' characteristics, and the cost of borrowing, as well as their implications for borrowing countries, we provide a conceptual framework of investor behavior that will guide our estimation in the following Section 4.

3.2 A Conceptual Framework

To provide a guide to the empirical relationships between borrowers and their investors, we now describe a conceptual framework of investor behavior that we analyze below. Since our data provides the full investor base for each country, we focus on understanding differences in demand for sovereign debt holdings across these groups. For parsimony, we denote the debt from country j held by a generic investor group i as $H^i_{j,t}$ for the rest of the paper, subsuming foreigners into the investor set. We then consider the investor's decision to hold a given country's debt as the outcome of a two-step decision.[17] Appendix D describes this structure in more detail.

In the first step, investors decide their total allocation to sovereign debt as a share of total assets, defined as: $h^{i,N}_t \equiv H^i_t / N^i_t$ where N^i_t is the net wealth of investor group i. Following the literature, we postulate that investors allocate their overall portfolio to sovereign bonds depending upon "global factors" $\mathbf{X}^w_t$.[18] In this case, the desired portfolio share of aggregate sovereign bonds for investor of group i can be written in the form:

$$h^{i,N}_t = h^{i,N}[\mathbf{X}^w_t] \tag{9}$$

In the second step, investors decide which countries to invest in as a share of total sovereign

[17] Koijen and Yogo (2020) use a similar two- step decision to summarize investor decisions at the country level across an allocation into total short term debt, long term debt, and equity.

[18] See for example Gabaix and Maggiori (2015), Fang and Liu (2020), and Morelli et al. (2020).

debt holdings defined as: $h_{jt}^{i,H} \equiv H_{jt}^{i} / H_{t}^{i}$. This decision for holdings of country j government debt by that same investor *within* the sovereign allocation depends upon country-specific macro-variables $\mathbf{X}_{j,t}$ and the pricing characteristics of the debt, $\mathbf{Z}_{j,t}$. In other words, this share can be written as:

$$h_{j,t}^{i,H} = h^{i,H}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}_{t}^{w}] \tag{10}$$

Substituting these portfolio share decisions into the overall portfolio share identity provides the desired holdings by investor groups in terms of country and global variables:

$$H_{jt}^{i} \equiv h_{t}^{i,N} h_{j,t}^{i,H} N_{t}^{i} = h^{i,N}[\mathbf{X}_{t}^{w}] h^{i,H}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}_{t}^{w}] N_{t}^{i}. \tag{11}$$

While sovereign debt demand depends upon characteristics related to the return, the supply of debt depends upon a governments desire to borrow at given costs. A large literature has studying this government behavior. Our data summarizes this supply as a book value of debt at the end of each year. As described in Appendix (E), debt-to-GDP can be written as a policy function that relates macro and other country-specific variables and their prices to the supply of government debt as in:

$$d_{t} \equiv d(\mathbf{X}_{j,t}; \mathbf{Z}_{j,t}) \tag{12}$$

That is, the share of government debt to output depends upon a vector of country-specific macro-economic variables, $\mathbf{X}_{j,t}$, and borrowing cost characteristics, $Z_{j,t}$. Clearly, then, the supply of debt by country can be written as:

$$D_{j,t} \equiv d(\mathbf{X}_{j,t}; \mathbf{Z}_{j,t}) Y_{j,t} \tag{13}$$

The individual investor group demands for sovereign debt of country j together with the supply implied by equation (13) imply a market clearing condition that we use below. Specifically, we equate the supply of debt in equations (13) to the sum across all investor groups $i = 1, .., I$ of demand given in equation (11):

$$D_{j,t} \equiv d(\mathbf{X}_{j,t}; \mathbf{Z}_{j,t}) Y_{j,t} = \sum_{i=1}^{I} h^{i,N}[\mathbf{X}_{t}^{w}] h^{i,H}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}_{t}^{w}] N_{t}^{i} \tag{14}$$

Since both the supply and demand for this country-specific debt debts upon the characteristics of the debt, $\mathbf{Z}_t^j$, then these variables are in general endogenous as well. For this reason, our analysis in the next section will use pre-determined prices and consider the endogenous impact of variations in the supply of debt. Before doing so, we first consider more carefully the impact of global shocks on the aggregate levels of sovereign debt holdings.

3.3 Investor Holdings of Total Sovereign Debt and Global Shocks

Fluctuations in global financial markets can have a large effect on cross-border financial flows and therefore on the decision about how much sovereign debt to hold in total.[19] Indeed, as has been argued in a large literature since the Global Financial Crisis (GFC) of 2008-09, intermediation constraints are likely to be binding during periods of global credit tightness. Conversely, during periods of strong global financial growth, these constraints are less severe.

The investor framework above highlighted this behavior in Equation (9) as a portfolio allocation decision that depends upon global financial shocks. To examine the relationship between these global conditions and changes in holdings, we run the following regression:

$$\frac{H_{j,t}^i - H_{j,t-1}^i}{D_{j,t-1}} = \alpha^i + \beta^i X_t^w + \gamma_j + \varepsilon_{j,t}^i, \forall i \tag{15}$$

For the global variables, X_t^w, we use three measures: a broad dollar index (Avdjiev, Bruno, Koch, and Shin (2019)); the growth in the VIX index; and world GDP growth as a proxy of global prosperity. An increase in either of the first two variables is an indication that global financial conditions are tighter, although they can capture different aspects/roots of such a tightening. For instance, the VIX is typically thought to capture global risk aversion or investor sentiment, whereas rises in the dollar may generate binding financial constraints for global intermediaries exposed to many different currencies (Bruno and Shin (2015)).

Tables 5 displays the results of these regressions for the AE and EM debt holders in Panels A and B, respectively. For expositional clarity, this table focuses upon a more aggre-

[19] See for example, Miranda-Agrippino and Rey (2021).

gate set of holdings by Domestic versus Foreign Private investors in the second and third columns. Similarly, the fourth and fifth columns report the aggregate results for Bank Total (Domestic + Foreign Banks) and NonBank Total (Domestic + Foreign NonBanks.) The more disaggregated breakdown in provided in Table B5 in Appendix B.

As the table shows, the responses of AE and EM investors to the dollar index are broadly similar. For example, when the dollar appreciates and world GDP grows, sovereign debt holdings generally decline. By contrast, foreign investors in sovereign debt respond differently to increases in the VIX depending upon whether the issuer is an AE or EM country. Specifically, AE holdings increase, but EM holdings decrease.

Table 5: Total Sovereign Holdings and Global Factors

	(1) All	(2) DomPriv	(3) ForPriv	(4) BK	(5) NB
Panel A. Advanced economies					
Dollar	-0.85***	-0.11	-0.75***	-0.47***	-0.15*
	(0.06)	(0.08)	(0.10)	(0.05)	(0.08)
VIX	9.29***	6.37***	2.33	1.46**	8.05***
	(1.78)	(0.98)	(1.45)	(0.65)	(1.80)
GDP	-0.73	0.05	-0.74	-1.30***	0.24
	(0.52)	(0.36)	(0.51)	(0.18)	(0.47)
Obs	366	366	366	366	366
R^2	0.18	0.10	0.26	0.34	0.10
Panel B: Emerging Market Economies					
Dollar	-0.42***	-0.09	-0.34***	-0.23***	-0.07
	(0.11)	(0.09)	(0.06)	(0.05)	(0.09)
VIX	3.53*	4.69**	-0.90	-0.91	3.77**
	(1.89)	(1.75)	(0.94)	(0.79)	(1.53)
GDP	-0.74*	-0.33	-0.37	-0.55***	0.58
	(0.42)	(0.30)	(0.26)	(0.20)	(0.43)
Obs	779	779	779	779	779
R^2	0.11	0.10	0.18	0.18	0.06

Note: This table reports the regression coefficients of Equation (15). Panel A reports results for the advanced economies and Panel B reports results for the emerging market economies. Each column represents an investor group. The three regressors are USD growth, log VIX growth, and the world GDP growth rate. Country fixed effects are included and standard error clustered at the country level are reported in the parentheses.

These results highlight the general behavior of the four aggregate private investor groups in response to the global factors. To test more formally whether the investor groups differ in responses, we return to clustering analysis. For this purpose, we use the k-means ap-

proach to ask whether investor groups differ. For this purpose, we estimate equation (15) for each country in our balanced sample and each of the private investor group holdings, providing a set of 95 countries times 4 private investor groups. We then repeat the clustering analysis without restricting the holdings to a particular country. This analysis provides a contingency table of investor clusters, irrespective of country. We then test whether the other investor groups behave differently. Appendix C reports these results. The hypothesis that Foreign and Domestic NonBanks investor groups react differently to global shocks is strongly rejected.

Overall, these results summarize how investor groups respond to total sovereign holdings and global factors. Investor groups respond differently to these global events depending upon whether they are bank or nonbank investors, and within those groups, whether they are domestic or foreign. Importantly, however, nonbank investors respond similarly as a group whether they are domestic or foreign.

The analysis so far only provides general information for total sovereign debt holdings, however. Therefore, in the next section, we further use the framework above to identify investor demand for country-level characteristics.

4 Investor Demand and Sovereign Borrowing Exposure

The analysis above has demonstrated important empirical regularities about investor holdings of government debt. These holdings in the data represent the joint decision of investor demand and issuer supply as illustrated in the framework of the prior section. In order to analyze more specifically the borrowing cost exposure that governments face, we estimate the government debt demand elasticity with respect to yield and other features of the sovereign borrower. The estimates of demand elasticities imply that the EM countries are particularly exposed to Non-bank investors, which is consistent with our findings regarding the marginal investors above.

Throughout this section, we assume that all the debt issued by the Emerging Market

Economies are in their local currencies, and thus use the 5-year local currency government bond yield as the relevant price variable.[20] Ideally, we should examine the local currency and foreign currency debt separately, but there lacks detailed data of currency denomination of debt available. We argue that this is a plausible approximation, as the Emerging Market governments are increasingly issuing debt in local currencies in the recent decades that our sample spans.[21]

4.1 Demand for Emerging Market Government Debt

We estimate the following demand function:

$$\frac{H^i_{j,t}}{Y_{j,t}} = \beta^i_0 + \beta^i_1 \ln y_{j,t} + (\gamma^i)' X_{j,t} + \theta^i_j + \theta^i_t + \varepsilon^i_{j,t}, \tag{16}$$

where $H^i_{j,t}$ is the book value of country j's debt held by investor group i, $Y_{j,t}$ is the nominal GDP of country h. $y_{j,t}$ is the five-year local-currency government bond yield. Our goals in this analysis are two-fold. First, we provide insights into the differences in investor preferences by investor group. Second, by measuring the implicit elasticity of demand to the price of debt, we can evaluate the borrowing cost exposure faced by the country borrowers. Given the volatility of EM borrowing costs over crisis periods, these countries typically are the most vulnerable to investors' willingness to lend.

4.2 The Instrument

The challenge in estimating the demand function above is the correlation between bond yield $y_{j,t}$ and the latent demand $\varepsilon^i_{j,t}$. Thus, we begin by discussing the instrument constructed from the market clearing condition of government debt for the demand estimation. Our instrument is constructed utilizing the market clearing condition of government debt, which follows the literature of Koijen and Yogo (2020), and Jiang, Richmond, and Zhang (2020). The instrument for yield needs to satisfy two conditions. First, the instrument should

[20] The implicit assumption in the analysis above is that the maturity of the yield matches the maturity of the outstanding debt. We use five-year yields because the coverage of countries is greater than for ten-year yield.

[21] See Table C4 in the BIS Debt Securities Statistics for evidence that many emerging markets borrow primarily in local currency.

be strongly related to the observed yield $y_{j,t}$. Second, the instrument does not directly affect holdings of government debt besides through the yield and all other controls in the regression.

We construct the instrument with the following steps.

1. Calculate the market value of country j's government debt by investor group i as $H_{j,t}^{i,m} = \frac{H_{j,t}^{i}}{(1+y_{j,t})^T}$, where T equals 5 years. The superscript m indicates the market value.

2. Run the reduced-form regression of each investor's holding in market value onto a set of characteristics $\tilde{X}_{j,t}$. $\tilde{X}_{j,t}$ is a subset of $X_{j,t}$. We choose real GDP growth, inflation, and log export-to-GDP ratio as the set of characteristics.

$$\ln \frac{H_{j,t}^{i,m}}{Y_{j,t}} = \alpha_0 + \alpha_1 \tilde{X}_{j,t} + \delta_j^i + \delta_t^i + u_{j,t}^i. \tag{17}$$

3. Get the fitted value of $\ln \frac{\hat{H}_{j,t}^{i,m}}{Y_{j,t}}$ from the regression for each investor group i, and impose the following market clearing condition

$$\sum_{i=1}^{6} \exp\left(\ln \frac{\hat{H}_{j,t}^{i,m}}{Y_{j,t}}\right) = \frac{D_{j,t}}{Y_{j,t}(1+\tilde{y}_{j,t})^T}, \tag{18}$$

where $D_{j,t}$ is the total book value of debt issued by the government of country j. $\tilde{y}_{j,t}$ is the hypothetical yield that clears the market given the implicit market demand and the book value of debt. $\tilde{y}_{j,t}$ is our constructed instrument for yield $y_{j,t}$.

The instrument is valid under the assumption that the subset of characteristics $\tilde{X}_{j,t}$ and the ratio of total debt-to-GDP in book value are exogenous.

As the Equation (18) shows, the instrument is a nonlinear function of the set of characteristics $\tilde{X}_{j,t}$, and fixed effects, and the total debt to GDP ratio in book value $\frac{D_{j,t}}{Y_{j,t}}$. By construction, the instrument contains information about yield driven by nonlinear transformation of characteristics of $\tilde{X}_{j,t}$. As for the exogeneity condition, $\tilde{y}_{j,t}$ is determined by exogenous $\tilde{X}_{j,t}$ as well as fixed effects, which are controlled in the demand estimation regression.

To construct the instrument, we need to make a decision on the choice of variables that are included in $\tilde{X}_{j,t}$. In particular, the identification requires characteristic variables $\tilde{X}_{j,t}$ that impact demand for debt but that individual investors consider exogenous. Given that the sovereign debt returns are payment for debt, these creditors will naturally care about characteristics that are related to the likelihood of the default. For this reason, $\tilde{X}_{j,t}$ includes three country characteristic variables based on the literature. Our first variable is real GDP growth since this variables has been a key indicator of economic growth in the emerging market debt literature (e.g., Eaton and Gersovitz (1981), Arellano (2008)). Second, we include inflation as it devalues nominal debt depreciates to investors. As our third characteristic, Exports-to-GDP proxy for the openness of the economy.

A large literature on emerging market sovereign debt has provided a rich set of variables $X_{j,t}$ that may impact investor demand. In general, investors like a higher yield, as established above. However, they dislike variables related to potential default risk. As such, creditors are more likely to invest in countries with higher growth, but dislike inflation or currency depreciation.[22] We therefore consider a more general demand estimation using a number of characteristics variables, including real GDP growth ("r_gdp_gr"), inflation ("infl"), log export-to-GDP ratio ("l_exp_ratio"), currency return ("fx_ret"), local currency share ("lc_share") defined as the share of local currency bonds in the international market.

The OLS estimates in Panel A represent basic reduced form relationships between variations in the holdings by groups and yield and other characteristics. As the estimates show, variations in the holdings are positively related to holdings for some investors, but are negative for domestic central banks. None of the positive coefficients is statistically significant. As we illustrate before, the OLS estimates are biased because the yield is correlated with the latent demand. By contrast, using the instrumental variable approach above, Panel B reports the instrumented relationships. In all cases, the coefficients are positive and significant. Thus, investors respond to higher yield by demanding more holdings, consistent with

[22] See for example Arellano (2008) and Aguiar and Gopinath (2007) on output growth; Arellano, Bai, and Mihalache (2020) and Reinhart and Rogoff (2011) on inflation and depreciation. Aguiar, Chatterjee, Cole, and Stangebye (2020) provides a survey.

standard economic patterns.

As the second validity check, we conduct the Stock-Yogo test for weak instruments (Stock and Yogo (2005)). The F-statistics exceeds 20, which is greater than the 10% critical value of 16.38 in the Stock-Yogo test. Thus, we infer that both on economic and econometric grounds, the instrument appears to be valid.

The coefficient estimate for log yield in Panel B represent the slope of the "demand function" by capturing how desired investor holdings vary with the yield; that is the inverse price. It will be useful in our borrowing exposure counterfactuals below to convert these estimates into a demand elasticity. For this purpose, we construct the sovereign debt demand elasticities by investor group as reported in the table's Panel C.[23]

As the estimates show, the foreign Nonbanks have the highest elasticity among the private investors at a value of 1.676, followed by domestic banks and nonbanks, while foreign banks' elasticity of demand is the smallest. The official sector's demand elasticity lies between domestic private investors and Foreign Nonbanks. The impact of each of these respective investor groups on total demand have strong implications for the vulnerability of sovereign borrowers, a point we discuss below. However, we first examine more carefully the impact of characteristics on investor demand.

As noted earlier, all investor groups increase holdings in response to a higher yield. Moreover, most investor groups increase demand for a country's sovereign debt when GDP grows, inflation declines, and exports increase, although insignificantly so for some groups. However, the impact of currency is more varied across investor groups, particularly for NonBanks. Specifically, variation in the local currency denomination of internationally issued debt, "lc_share", is insignificantly related to demand by domestic private investors, but reflects a decrease in demand by Foreign NonBanks and Central Banks. Furthermore, in contrast to the other investment groups, Domestic NonBanks increase holdings of sovereign debt with the currency depreciates. Again, these results point to an important role for Non-

[23]Specifically, the elasticity is defined as: $\eta^i = \frac{d\left(H_j^i/Y_j\right)}{dy_j}\frac{y_j}{\left(H_j^i/Y_j\right)}$. For y_j and H_j^i/Y_j, we use the averages over time and country in the sample, as reported in the table.

Banks as differentiated investor groups than the other creditors.

Table 6: Demand Estimation of Government Debt Holding by Different Investor Groups

	(1) DomBK	(2) DomNB	(3) DomCB	(4) ForBK	(5) ForNB	(6) ForCB
			Panel A: Raw Estimates			
l_yield	0.004	0.009	-0.006	0.001	0.008	0.004
	(0.008)	(0.007)	(0.006)	(0.002)	(0.012)	(0.009)
r_gdp_gr	-0.100	-0.166	0.041	-0.059*	0.213	-0.077
	(0.082)	(0.107)	(0.055)	(0.032)	(0.147)	(0.093)
infl	0.090**	-0.026	0.090***	0.001	0.087	-0.040
	(0.040)	(0.053)	(0.028)	(0.011)	(0.051)	(0.055)
l_exp_ratio	-0.012	-0.034	-0.005	-0.002	0.041	0.065***
	(0.029)	(0.034)	(0.016)	(0.008)	(0.029)	(0.023)
fx_ret	-0.070***	0.137***	-0.035***	-0.003	-0.022	-0.004
	(0.019)	(0.030)	(0.009)	(0.003)	(0.018)	(0.008)
lc_share	-0.017	0.026	-0.060**	-0.005	-0.147*	-0.056
	(0.035)	(0.016)	(0.025)	(0.006)	(0.079)	(0.047)
Obs	362	362	362	362	362	362
			Panel B: IV Estimates			
l_yield	0.082***	0.094***	0.024**	0.010*	0.114***	0.057***
	(0.023)	(0.029)	(0.012)	(0.005)	(0.030)	(0.018)
r_gdp_gr	0.202	0.221	0.147**	-0.020	0.588***	0.117
	(0.139)	(0.171)	(0.071)	(0.032)	(0.177)	(0.109)
infl	-0.010	-0.128*	0.050*	-0.012	-0.058	-0.108**
	(0.058)	(0.071)	(0.030)	(0.013)	(0.074)	(0.046)
l_exp_ratio	0.012	-0.012	0.005	0.002	0.082***	0.082***
	(0.022)	(0.027)	(0.011)	(0.005)	(0.028)	(0.017)
fx_ret	-0.077***	0.127***	-0.038***	-0.004	-0.031	-0.010
	(0.018)	(0.022)	(0.009)	(0.004)	(0.023)	(0.014)
lc_share	-0.048	-0.029	-0.071***	-0.003	-0.169***	-0.070**
	(0.037)	(0.045)	(0.019)	(0.008)	(0.046)	(0.029)
Obs	339	339	339	339	339	339
			Panel C: Shares and Demand Elasticity			
Mean $\frac{H^i_{j,t}}{Y_{j,t}}$	0.128	0.156	0.029	0.020	0.068	0.070
Elasticity	0.641	0.603	0.826	0.50	1.676	0.814

Note: This table reports the OLS and IV estimates of the demand function in Equation (16), with the control of country and year fixed effects. The sample spans 1996-2018 at annual frequency. The dependent variable is holding of the group indicated in the column title to GDP. The standard errors are reported in the parentheses. Panel A reports the simple OLS regression estimates. Panel B reports the instrumental variable estimates. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3 Borrower Country Exposure and Counterfactuals

Above, we have estimated demand functions of sovereign debt by investor groups. We now use these estimates to ask what they imply about the exposure that countries have to the implied costs of borrowing. This question is clearly an important one given the projected rise of debt-to-GDP in the next few years.

A standard interpretation of "exposure" to risks faced by an economic entity is the percentage change in an outcome of concern as a result of a percentage change in the variable of exposure. This measure has been used in a literature studying the risk faced by companies involved in international trade. For example, Bartov and Bodnar (1994), Bodnar, Dumas, and Marston (2002), and, more recently, Adams and Verdelhan (2021) study the exposure of firm profitability to currency. In the case of a company's profit exposure to currency, this exposure is measured as the percentage change in profits that would happen if there were a percentage change in the exchange rate.

For our analysis, we consider the exposure a country faces to its financing costs. In this case, the exposure measure is the percentage change in borrowing costs due to a percentage change in shocks that would impact the country's need to borrow. To see this exposure calculation, consider the accounting identity that the present value of the cost of borrowing to the country is equal to the present value of debt to the creditors. For expositional simplicity, we subsume the dependence on variables, and write the demand function for holdings of country j for each investor group i generally as $H^i_{j,t}$ and the price function for these holdings as $P^i_{j,t}$. Then this accounting identity under market clearing implies:

$$P_{j,t}D_{j,t} \quad = \quad \sum_{i=1}^{I} P^i_{j,t}H^i_{j,t} \tag{19}$$

We next use the fact that the price of debt is the discounted yield. As an approximation, we denote the yield corresponding to the inverse demand as $y^i_{j,t}$ in the the identity $P^i_{j,t} = exp(-Ty^i_{j,t})$, where $y^i_{j,t}$ is the yield faced by investor group i. Appendix F.2 shows that the

borrowing cost exposure faced by country j is measured by:

$$\delta_{j,t} \equiv \frac{\%\Delta y_{j,t}}{\%\Delta d_{j,t}} = \sum_{i=1}^{I} \left(\frac{\%\Delta y^i_{j,t}}{\%\Delta d_{j,t}} \right) a^i_j = \sum_{i=1}^{I} (\eta^i_j)^{-1} a^i_j \tag{20}$$

where η^i_j is the elasticity of demand by investor group i for sovereign debt for a country with the characteristics of country j and where a^i_j is the change in holdings by investor group i in response to changes in debt of country j. As this relationship shows, a country's financing exposure is a weighted average of inverse demand elasticities η^i_j, where the weights are the marginal financing-shares, $a^i_j \equiv \frac{dH^i_j}{dD_j}$, which we report in Section 2.

The Exposure Delta measure provides a useful benchmark for understanding the underlying risk. If δ_j is less than one, then an increase in borrowing is related to an increase than is less than proportionate to that increase. However, if δ_j is greater than one a country faces an out-sized increase in borrowing costs in response to higher borrowing.

Table 7 shows these exposures using the exposure delta measure in equation (20). The first two columns report the implied exposures and the associated percentage cost increase assuming the financing shares a^i_j being equal to the marginal share reported in Table 1. The %Cost corresponds to the percentage change in financing cost given the projected increase in borrowing by the IMF of 25% between 2018 and 2022. This increase corresponds to a 34.5% increase in borrowing costs. Clearly, these estimates suggest a high degree of vulnerability for EM countries.

We consider several other counterfactual cases as well. The row labeled "No Domestic" shows the implied Exposure Delta if there are no domestic investor groups to absorb the extra debt, but rather foreign investors take up the shares proportionally. With an Exposure Delta of 0.89, the country is the least exposed to variations in investor demand. By contrast, the following line labeled "No Official" reports the effect on Exposure Delta when there are no additional official holdings by domestic central banks or foreign official agencies such as the World Bank. In this case, the Delta is 1.38 corresponding to an even higher source of exposure. Finally, the row labeled "No Non-banks" shows the Delta when Non-Bank investors are not present. In this case, the degree of exposure is the highest at 1.54.

The next four columns report Delta and %Cost increase based on the marginal financing shares in a recession and during a banking crisis. These financing shares are reported in Appendix B.2. Generally, during the recession, domestic banks and foreign non-banks increase their financing share, while domestic non-banks reduce their marginal financing share. The pattern of Delta and %Cost are similar with the unconditional scenarios. In the last two columns, we use the marginal financing shares during a crisis reported in Appendix B.2. Both domestic and foreign banks' marginal financing shares shrink greatly during the banking crisis, which is taken up by the increase in both nonbanks and central banks. The exposure is smaller than the unconditional scenario, especially under the scenario of No Domestic and No Nonbanks, mainly during the more active role played by the central banks.

Comparing the different counterfactual scenarios highlights some other important features when taking into account how investors respond to changes in the supply of debt. Strikingly, the countries face the highest risk to investors in the "Non-Bank" group. As the last row of Table 7 shows, the Exposure Delta is by far the highest measure both unconditionally and during the recession. This exposure is the result of two effects. First, the elasticities of these groups is the higher than their bank counterparts. And second, these groups absorb proportionally more of the increase in the supply of debt. During the crisis, banks absorb less debt and if nonbanks are absent, the official sector becomes the major holder of debt. In general, if the Nonbank investor group were absent, the countries would face considerably more volatily in borrowing costs in response to changes in debt-to-GDP.

Table 7: Emerging Market Borrowing Exposures and Counterfactuals

	Unconditional		Recession		Banking crisis	
	Delta	%Cost	Delta	%Cost	Delta	%Cost
Tot Share	1.38	34.5%	1.32	33.1%	1.51	37.7%
No Domestic	0.89	22.1%	0.93	23.3%	0.96	23.9%
No Official	1.38	34.5%	1.33	33.3%	1.55	38.7%
No Non-banks	1.54	38.6%	1.58	39.4%	1.23	30.7%

Note: This table shows the exposure of the sovereign's financing cost to the increase in government debt. Delta corresponds to the exposure measure δ in Equation (20). %Costs column reports the percentage change in financing cost in response to a 25% debt-to-GDP increase, the projection of 2022 by the IMF. Each row represents one counterfactual scenario.

5 Concluding Remarks

The rising levels of government debt worldwide in the wake of the Covid-crisis have made urgent the answers to questions about their repayment. At the front of those questions is: who holds this debt and does it matter to borrowers in this market? In this paper, we address these questions by analyzing a unique data set that decomposes sovereign debt into investor holding groups for a large number of countries over almost three decades.

Based upon our analysis, the answers to these questions are striking. First, private financial institutions that are not banks absorb substantially more of the variation in outstanding government debt than other investor groups. Across all countries, they take on 69% on the margin of increases in the debt. Further decomposing this Non-bank investment group using Euro Area data, we find that investment funds are the drivers of this larger group.

Second, many countries can be grouped according to their dominant investor type. Characteristics of these countries, such as their exchange rate stability of growth trajectory, may help determine this composition. Moreover, total holdings of sovereign debt by each investor group responds strongly to global shocks. For example, when the dollar appreciates and world GDP grows, sovereign debt holdings generally decline. Furthermore, increases in uncertainty measured by the VIX growth rate leads to increases in holdings of AE government debt but decreases in decreases for EM sovereigns. Despite these differences, we show

that domestic and foreign Non-bank investors have similar responses to global shocks.

Next, we identify a demand function for EM investor groups by exploiting a feature of our data. In particular, our data provides the full set of investor groups by country allowing us to solve for the market clearing condition. Using these estimates, we find that the elasticity of demand by Non-bank investors is higher than other groups.

Finally, we use these demand estimates to calculate the implied government debt exposure measured by variations in borrowing costs in response to variations in sovereign debt. As we show, an average EM country faces significant borrowing exposure since a percentage increase in debt-to-GDP leads to a greater than proportional cost across existing investor groups. Even more remarkable, these countries face the greatest exposure against Non-bank investors compared to any other investment groups. We conclude that EM sovereign investors are highly vulnerable to Non-bank investors.

References

Adams, P., & Verdelhan, A. (2021). Exchange rate transaction and translation risk. *MIT Sloan Working Paper*.

Aguiar, M., Chatterjee, S., Cole, H., & Stangebye, Z. (2020). Self-fulfilling debt crises, revisited. *Federal Reserve Bank of Philadelphia Working Paper*, *No 20-03*.

Aguiar, M., & Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *Journal of Political Economy*, *115*(1), 69-102.

Aizenman, J., Chinn, M., & Ito, H. (2010). The emerging global financial architecture: tracing and evaluating the new patterns of the Trilemma's configurations. *Journal of International Money and Finance*, *29*(4), 615-641.

Arellano, C. (2008). Default risk and income fluctuations in emerging economies. *American Economic Review*.

Arellano, C., Bai, Y., & Mihalache, G. P. (2020). *Monetary policy and sovereign risk in emerging economies (nk-default)* (Tech. Rep.). National Bureau of Economic Research.

Arellano, C., & Ramanarayanan, A. (2012). Default and the maturity structure in sovereign bonds. *Journal of Political Economy*, *120*(2), 187-232.

Arslanalp, S., & Tsuda, T. (2012). Tracking global demand for advanced economy sovereign debt. *IMF Working Paper*, *No. 12/284*.

Arslanalp, S., & Tsuda, T. (2014). Tracking global demand for emerging market sovereign debt. *IMF Working Paper*, *No. 14/39*.

Arthur, D., & Vassilvitskii, S. (2007). k-means++:the advantages of careful seeding. In *Proceedings of the 18th annual acm-siam symposium on discrete algorithms* (p. 1027-1035).

Avdjiev, S., Bruno, V., Koch, C., & Shin, H. (2019). The dollar exchange rate as a global risk factor: Evidence from investment. *IMF Economic Review*, *67*, 151-173.

Avdjiev, S., Hardy, B., Şebnem Kalemli-Özcan, & Servén, L. (2018). Gross capital flows by banks, corporates, and sovereigns. *BIS Working Papers*, *No 760*.

Bai, Y., Kehoe, P. J., & Perri, F. (2019). World financial cycles. In *2019 meeting papers* (Vol. 1545).

Bartov, E., & Bodnar, G. M. (1994). Firm valuation, earnings expectations, and the exchange

rate exposure effect. *Journal of Finance*, *44*(5), 1755-1785.

Bocola, L. (2016). The pass-through of sovereign risk. *Journal of Political Economy*, *124*(4), 879–926.

Bocola, L., & Lorenzoni, G. (2020). Financial crises, dollarization, and lending of last resort in open economies. *American Economic Review*, *110*(8), 2524–57.

Bodnar, G. M., Dumas, B., & Marston, R. C. (2002). Pass-through and exposure. *Journal of Finance*, *57*(1), 199-231.

Bruno, V., & Shin, H. S. (2015). Cross-border banking and global liquidity. *Review of Economic Studies*, *82*(2), 535-564.

Du, W., Pflueger, C. E., & Schreger, J. (2020). Sovereign debt portfolios, bond risks, and the credibility of monetary policy. *The Journal of Finance*, *75*(6), 3097–3138.

Du, W., & Schreger, J. (2016a). Local currency sovereign risk. *Journal of Finance*, *71*(3), 1027-1069.

Du, W., & Schreger, J. (2016b). Sovereign risk, currency risk, and corporate balance sheets. *Harvard Business School BGIE Unit Working Paper*(17-024).

Eaton, J., & Gersovitz, M. (1981). Debt with potential repudiation: Theoretical and empirical analysis. *Review of Economic Studies*, *48*(2), 289–309.

Eichengreen, B., Hausmann, R., & Panizza, U. (2003). The pain of original sin. In B. Eichengreen & R. Hausmann (Eds.), *Other people's money: debt denomination and financial instability in emerging market economies.* University of Chicago Press.

Fahri, E., & Tirole, J. (2018). Deadly embrace: Sovereign and financial balance sheets doom loops. *Review of Economic Studies*, *85*(3), 1781–1823.

Fama, E. F., & MacBeth, J. D. (1973). Risk, return, and equilibrium: Empirical tests. *The Journal of Political Economy*, *81*(3), 607-636.

Fang, X., & Liu, Y. (2020). Volatility, intermediaries, and exchange rates. *Journal of Financial Economics*.

Forbes, K. J., & Warnock, F. E. (2012). Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of International Economics*, *88*(2), 235-251.

Gabaix, X., & Maggiori, M. (2015). International liquidity and exchange rate dynamics. *Quar-*

terly Journal of Economics, 1369-1420.

Gamba, A., Hakobyan, S., Lusinyan, L., Meads, N., & Wu, Y. (2021). Reserve currencies in an evolving international monetary system.

Gourinchas, P.-O., & Rey, H. (2007). International financial adjustment. *Journal of Political Economy*, *115*(4), 665-703.

He, Z., & Krishnamurthy, A. (2013). Intermediary asset pricing. *American Economic Review*, *103*(2), 732-70.

Jiang, Z., Richmond, R., & Zhang, T. (2020). A portfolio approach to global imbalances. *Available at SSRN*.

Koijen, R. S., & Yogo, M. (2020). *Exchange rates and asset prices in a global demand system* (Tech. Rep.). National Bureau of Economic Research.

Laeven, L., & Valencia, F. (2020). Systemic banking crises database ii. *IMF Economic Review*, *68*(2), 307–361.

Lloyd, S. R. (1982). Least squares quantization in pcm. *IIEE Transactions on Information Theory*, *28*(2), 129-137.

Miranda-Agrippino, S., & Rey, H. (2021). Us monetary policy and the global financial cycle. *Review of Economic Studies*.

Morelli, J., Ottonello, P., & Perez, D. J. (2020). Global banks and systemic debt crises. *Working Paper*.

Ottonello, P., & Perez, D. (2019). The currency composition of sovereign debt. *American Economic Journal: Macroeconomics*, *11*(3), 174-208.

Reinhart, C. M., & Rogoff, K. S. (2011). This time is different: Eight centuries of financial folly. In *This time is different: Eight centuries of financial folly.*

Stock, J. H., & Yogo, M. (2005). Testing for weak instruments in linear iv regression. In D. W. Andrews & J. H. Stock (Eds.), *Identification and inference for econometric models: Essagys in honor of thomas rothenberg* (Vol. 6, p. 109-120). Cambridge University Press: Cambridge.

A Data construction

The dataset is annual, it covers the years between 1990 and 2018, denominated in US dollars.[24] Debt for each category refers to general government debt, which consists of state, local, and central government debt.

Total Total debt holdings are estimated by combing the data from the IMF Historical Public Debt Database (debt-to-GDP) and GDP series from The World Bank. In addition, there are 96 countries[25] for which the debt-to-GDP series ends in 2015. For these countries, we forecast the total debt level using the forward-looking growth rates from QPSD total debt series in years 2016-2018.

Foreign Total The methodology for estimating foreign total holdings is based on that in Avdjiev et al. (2018). This is derived first from international investment position (IIP) data (sum of external portfolio debt liabilities and external other investment debt liabilities for the general government sector), complemented when missing with data from the Quarterly External Debt Statistics (QEDS) (external debt of general government), and the remaining missing values being filled by estimates derived from the BIS international banking statistics (IBS) and BIS international debt securities (IDS) datasets.

Foreign Official Foreign official holdings for advanced economies and China are taken from Arslanalp and Tsuda (2012) and Arslanalp and Tsuda (2014), which consists mostly of foreign official reserves held abroad. The remaining countries are populated with the data from the

[24] If data was reported in local currency, it is converted to US dollars using the end of period exchange rate from the IMF.

[25] Afghanistan, Algeria, Angola, Anguilla, Antigua and Barbuda, Argentina, Armenia, Aruba, Azerbaijan, Bahamas, Bahrain, Belize, Benin, Bermuda, Bhutan, Bolivia, Botswana, Brunei Darussalam, Burkina Faso, Burundi, Cabo Verde, Cameroon, Cayman Islands, Central African Republic, Chad, Comoros, Republic of Congo, Cote d'Ivoire, Curacao, Djibouti, Dominica, Ecuador, Republic of Equatorial Guinea, Eritrea, Eswatini, Gabon, Gambia, Ghana, Grenada, Guinea, Guinea-Bissau, Guyana, Haiti, Hong Kong SAR, Iran, Iraq, Jamaica, Jordan, Kenya, Kuwait, Lao People's Democratic Republic, Lesotho, Liberia, Libya, Liechtenstein, Macao SAR, Madagascar, Malawi, Maldives, Mali, Mauritania, Morocco, Mozambique, Myanmar, Namibia, Nepal, New Zealand, Niger, Oman, Pakistan, Papua New Guinea, Qatar, Rwanda, Samoa, San Marino, São Tomé and Príncipe, Saudi Arabia, Senegal, Sierra Leone, Singapore, Solomon Islands, South Africa, Sri Lanka, Sudan, Suriname, Syrian Arab Rep., Togo, Tonga, Trinidad and Tobago, Tunisia, Uganda, Uruguay, Vanuatu, Venezuela, Zambia, Zimbabwe.

World Bank debtor reporting system (DRS) data on bilateral and multilateral official lending to emerging and developing economy governments.

Foreign Bank The methodology for estimating foreign bank holdings is based on Avdjiev et al. (2018). We compute estimates for share of official holdings from international claims in CBS and apply that share to cross-border bank lending from the LBS. In addition, we make a correction for Switzerland where holdings by external banks are significantly overestimated with our methodology.[26]

Foreign Nonbank Foreign Nonbank series is computed as a residual from subtracting Foreign Official and Foreign Bank series from the Foreign Total.

Domestic Total Domestic Total series is computed as a residual from subtracting Foreign Total from the Total.

Domestic Central Bank For the most part, domestic central bank holdings are taken from the IMF's International Financial Statistics (IFS) dataset. This data has the debt level from the standardized reporting form (SRF) immediately available but only from 2001 onwards. In turn, debt levels prior to 2001 are backcasted with annual growth rate taken from the non-standardized reporting form (non-SRF) in the same dataset. For the countries[27] where the IFS data was incomplete, additional data was taken from the official websites of respective central banks. For these cases, the IFS data was supplemented using the backward-looking growth rates taken from central banks' websites.

Domestic Bank Same procedure as for Domestic Central Bank.[28]

[26] Specifically, the ratio from consolidated banking statistics (CBS) is close to 30% around 2014, while updated data from the locational banking statistics (LBS), which includes a sector breakdown for government lending in recent years, suggests the true ratio is closer to 10%, but not more than 20%.

[27] Austria, Belgium, Bulgaria, Finland, France, Germany, Greece, Iceland, Ireland, Korea, Latvia, Portugal, Spain, Sweden, UK.

[28] The list of countries for which additional data from the official Central Bank websites was used: Belgium, Finland, France, Germany, Korea, Luxembourg, Mexico, Netherlands, Portugal, Serbia, Spain, Sweden.

Domestic Nonbank Domestic Nonbank series is computed as a residual from subtracting Domestic Central Bank and Domestic Bank series from the Domestic Total.

Inconsistencies and Cleaning When combining data across different sources, inconsistencies are inevitable. While most of the dataset fits together, there are some cases where the sum of some of the components (e.g. domestic central bank and domestic bank) add to more than the total (e.g. domestic total). This produces some negative observations for residually computed groups (e.g. domestic non-banks). In general, we followed the following procedure in order to ensure there were no negative observations and maintain internal consistency in the dataset (i.e. the sum of the parts add up to the whole).

- If foreign official + foreign bank $>$ foreign total $\rightarrow$ replace foreign total = foreign bank + foreign official
  - E.g. replace Foreign = maxForeign total, foreign official + foreign bank
- If foreign total + domestic bank + domestic CB $>$ total debt $\rightarrow$ replace total debt = foreign total + domestic bank + domestic central bank
  - E.g. replace Total debt = maxTotal debt, foreign total + domestic bank + domestic CB
- Then, compute the residual categories (Foreign non-bank, domestic total, domestic non-bank)

After doing this, then all of our data series will be greater than or equal to zero, including the residual categories, and the data will be internally consistent. Before applying this procedure en masse, we manually examine cases where the negative values were large to make sure that this procedure made since, as this implicitly assumes that the negative values are 0s. In a few cases where it appears driven by low data quality, we replace the observation with linear interpolation.

B Additional Results

B.1 Marginal Holders with Unrestricted Sample

Table B1: Marginal Holders of Sovereign Debt - Unrestricted Sample

	(1) Dom	(2) Dom Bank	(3) Dom NB	(4) Dom CB	(5) For	(6) For Bank	(7) For NB	(8) For Off
All	0.48***	0.13**	0.41***	0.26*	0.52***	0.03	0.28***	0.10***
	(0.13)	(0.06)	(0.04)	(0.15)	(0.13)	(0.02)	(0.05)	(0.03)
AE	0.07	0.08	0.33***	0.04	0.93***	0.04	0.39***	0.04
	(0.17)	(0.09)	(0.08)	(0.03)	(0.17)	(0.04)	(0.12)	(0.03)
EM	0.75***	0.10	0.44***	0.12*	0.25***	0.02	0.22***	0.04*
	(0.06)	(0.10)	(0.07)	(0.06)	(0.06)	(0.03)	(0.04)	(0.02)
DC	0.54***	0.15*	0.40***	0.31*	0.46***	0.03***	0.37***	0.12***
	(0.05)	(0.09)	(0.06)	(0.18)	(0.05)	(0.01)	(0.10)	(0.04)

B.2 Marginal Holders under Different Circumstances

B.2.1 Recessions and Non Recessions

Table B2: Marginal Investors: Recession and Non Recessions

	(1) Dom	(2) For	(3) DomBK	(4) DomNB	(5) DomCB	(6) ForBK	(7) ForNB	(8) ForCB
Panel A: Recession								
All	0.62***	0.38***	0.25***	0.30***	0.07**	0.07***	0.27***	0.04**
	(0.06)	(0.06)	(0.05)	(0.08)	(0.03)	(0.01)	(0.06)	(0.02)
AE	0.79***	0.21**	0.01	0.56***	0.22*	0.08***	0.12*	0.02
	(0.08)	(0.08)	(0.09)	(0.06)	(0.11)	(0.02)	(0.06)	(0.03)
EM	0.61***	0.39***	0.31***	0.25***	0.05	0.08***	0.28***	0.03
	(0.07)	(0.07)	(0.04)	(0.08)	(0.03)	(0.02)	(0.06)	(0.02)
DC	0.55***	0.45***	0.11	0.42***	0.02	0.01	0.39**	0.05
	(0.12)	(0.12)	(0.07)	(0.12)	(0.03)	(0.01)	(0.15)	(0.03)
Panel B: Non Recession								
All	0.58***	0.42***	0.11***	0.44***	0.04***	0.02**	0.32***	0.07***
	(0.06)	(0.06)	(0.01)	(0.05)	(0.01)	(0.01)	(0.07)	(0.02)
AE	0.36***	0.64***	0.03**	0.30***	0.02**	0.05*	0.54***	0.05*
	(0.10)	(0.10)	(0.01)	(0.10)	(0.01)	(0.02)	(0.11)	(0.03)
EM	0.73***	0.27***	0.12***	0.58***	0.03*	0.02**	0.20***	0.05
	(0.06)	(0.06)	(0.02)	(0.05)	(0.02)	(0.01)	(0.07)	(0.03)
DC	0.48***	0.52***	0.10***	0.32***	0.06***	0.01	0.40***	0.10***
	(0.07)	(0.07)	(0.03)	(0.06)	(0.02)	(0.02)	(0.09)	(0.03)

Note: This figure plots the regression coefficients in Equation (7) and (8) for all countries (All), advanced economies (AE), emerging market economies (EM), and developing countries (DC) under recession (Panel A) and non-recession times (Panel B). A recession is defined by a year with a negative real GDP growth rate. Double clustered standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.2.2 Crisis and Non Crisis

Table B3: Marginal Investors: Crisis and Non Crisis

	(1) Dom	(2) For	(3) DomBK	(4) DomNB	(5) DomCB	(6) ForBK	(7) ForNB	(8) ForCB
Panel A: Crisis								
All	0.75***	0.25***	0.01	0.69***	0.05***	0.02	0.15***	0.08***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.01)	(0.01)	(0.04)	(0.02)
AE	0.68***	0.32***	-0.03	0.45***	0.25***	0.05**	0.31***	-0.04
	(0.06)	(0.06)	(0.04)	(0.06)	(0.02)	(0.02)	(0.06)	(0.04)
EM	0.78***	0.22***	0.00	0.79***	-0.01	0.00	0.09**	0.12***
	(0.05)	(0.05)	(0.04)	(0.06)	(0.02)	(0.02)	(0.04)	(0.02)
DC	0.68***	0.32**	0.25***	0.41**	0.01	0.02	0.23	0.07
	(0.15)	(0.15)	(0.09)	(0.16)	(0.06)	(0.04)	(0.16)	(0.07)
Panel B: Non-crisis								
All	0.58***	0.42***	0.18***	0.35***	0.05***	0.05***	0.32***	0.05***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.00)	(0.01)	(0.01)
AE	0.45***	0.55***	0.05**	0.37***	0.02	0.06***	0.43***	0.06***
	(0.04)	(0.04)	(0.02)	(0.04)	(0.01)	(0.02)	(0.04)	(0.02)
EM	0.66***	0.34***	0.25***	0.37***	0.05***	0.06***	0.26***	0.02***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
DC	0.49***	0.51***	0.10***	0.33***	0.05***	0.01*	0.40***	0.10***
	(0.03)	(0.03)	(0.02)	(0.03)	(0.01)	(0.01)	(0.03)	(0.01)

Note: This figure plots the regression coefficients in Equation (7) and (8) for all countries (All), advanced economies (AE), emerging market economies (EM), and developing countries (DC) under crisis (Panel A) and non-crisis times (Panel B). A crisis is identified following Laeven and Valencia (2020), which includes a banking crisis, a currency crisis, and a debt crisis. Double clustered standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.2.3 Different Subsamples

Table B4: Marginal Investors: Different Subsamples

	(1) Dom	(2) For	(3) DomBK	(4) DomNB	(5) DomCB	(6) ForBK	(7) ForNB	(8) ForCB
				Panel A: Before 2000				
All	0.61***	0.39***	0.14***	0.44***	0.03*	-0.00	0.37***	0.02***
	(0.10)	(0.10)	(0.05)	(0.09)	(0.02)	(0.02)	(0.11)	(0.01)
EM	0.75***	0.25	0.08***	0.60***	0.07	0.04	0.22	-0.00
	(0.16)	(0.16)	(0.03)	(0.19)	(0.04)	(0.04)	(0.18)	(0.01)
DC	0.51***	0.49***	0.18**	0.32**	0.02	-0.03*	0.48***	0.04**
	(0.08)	(0.08)	(0.07)	(0.11)	(0.01)	(0.02)	(0.08)	(0.02)
				Panel B: 2000-2009				
All	0.52***	0.48***	0.15***	0.33***	0.05***	0.03*	0.38***	0.06**
	(0.08)	(0.08)	(0.05)	(0.09)	(0.02)	(0.02)	(0.09)	(0.03)
AE	0.48***	0.52***	-0.01	0.37***	0.11*	0.05**	0.46***	0.01**
	(0.14)	(0.14)	(0.01)	(0.11)	(0.06)	(0.02)	(0.15)	(0.01)
EM	0.63***	0.37***	0.20**	0.39***	0.03**	0.04	0.27***	0.07
	(0.08)	(0.08)	(0.08)	(0.14)	(0.02)	(0.03)	(0.09)	(0.04)
DC	0.35***	0.65***	0.12*	0.18***	0.04*	0.01	0.56***	0.09**
	(0.11)	(0.11)	(0.06)	(0.07)	(0.02)	(0.01)	(0.15)	(0.04)
				Panel C: After 2009				
All	0.70***	0.30***	0.18***	0.47***	0.05**	0.06***	0.18***	0.05**
	(0.03)	(0.03)	(0.04)	(0.07)	(0.02)	(0.02)	(0.03)	(0.02)
AE	0.57***	0.43***	0.11*	0.44***	0.02	0.07***	0.25***	0.10
	(0.09)	(0.09)	(0.06)	(0.10)	(0.02)	(0.02)	(0.05)	(0.08)
EM	0.73***	0.27***	0.24***	0.44***	0.05	0.06**	0.20***	0.01
	(0.05)	(0.05)	(0.04)	(0.10)	(0.03)	(0.02)	(0.04)	(0.01)
DC	0.71***	0.29***	0.05	0.58***	0.08*	0.05	0.11**	0.13***
	(0.07)	(0.07)	(0.05)	(0.09)	(0.04)	(0.04)	(0.05)	(0.04)

Note: This figure plots the regression coefficients in Equation (7) and (8) for all countries (All), advanced economies (AE), emerging market economies (EM), and developing countries (DC) before 2000 (Panel A), from 2000 to 2009 (Panel B), and post-2009 (Panel C). Double clustered standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.2.4 Sovereign Debt Holders and Global Cycles

Table B5: Sovereign Debt Holders and Global Cycles

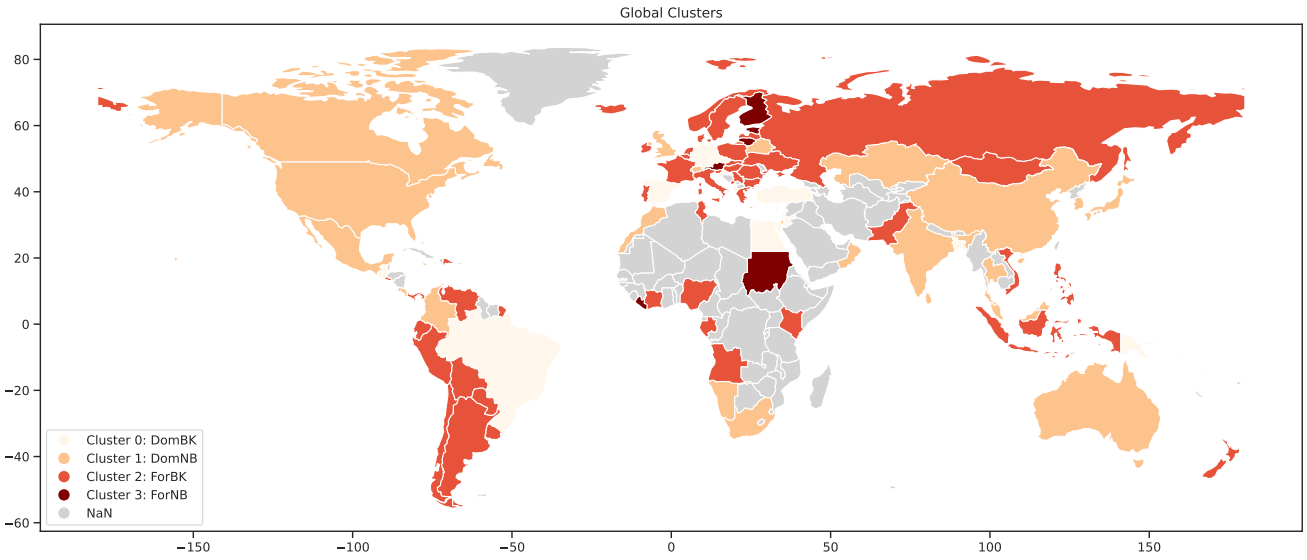
	(1) All	(2) DomPriv	(3) ForPriv	(4) BK	(5) NB	(6) DomBK	(7) DomNB	(8) ForBK	(9) ForNB
				Panel A: Advanced Economies					
Dollar	-0.85***	-0.11	-0.75***	-0.47***	-0.15*	-0.33***	0.18**	-0.13***	-0.35***
	(0.06)	(0.08)	(0.10)	(0.05)	(0.08)	(0.04)	(0.08)	(0.03)	(0.06)
VIX	9.29***	6.37***	2.33	1.46**	8.05***	1.24**	5.99***	0.18	1.41
	(1.78)	(0.98)	(1.45)	(0.65)	(1.80)	(0.56)	(0.72)	(0.29)	(1.33)
GDP	-0.73	0.05	-0.74	-1.30***	0.24	-0.93***	0.78***	-0.35**	-0.41
	(0.52)	(0.36)	(0.51)	(0.18)	(0.47)	(0.21)	(0.27)	(0.14)	(0.42)
Obs	366	366	366	366	366	366	366	366	366
R^2	0.18	0.10	0.26	0.34	0.10	0.30	0.16	0.14	0.09
				Panel B: Emerging Market Economies					
Dollar	-0.42***	-0.09	-0.34***	-0.23***	-0.07	-0.18***	0.11	-0.05***	-0.19***
	(0.11)	(0.09)	(0.06)	(0.05)	(0.09)	(0.04)	(0.06)	(0.02)	(0.06)
VIX	3.53*	4.69**	-0.90	-0.91	3.77**	-0.70	5.10***	-0.15	-1.28*
	(1.89)	(1.75)	(0.94)	(0.79)	(1.53)	(0.67)	(1.58)	(0.36)	(0.65)
GDP	-0.74*	-0.33	-0.37	-0.55***	0.58	-0.52***	0.67**	0.02	0.02
	(0.42)	(0.30)	(0.26)	(0.20)	(0.43)	(0.16)	(0.30)	(0.08)	(0.23)
Obs	779	779	779	779	779	779	779	779	779
R^2	0.11	0.10	0.18	0.18	0.06	0.20	0.10	0.06	0.11

Note: This table reports the regression coefficients of Equation (15). Panel A reports results for the advanced economies and Panel B reports results for the emerging market economies. Each column represents an investor group. The three regressors are USD growth, log VIX growth, and the world GDP growth rate. Country fixed effects are included and standard error clustered at the country level are reported in the parenthese.

C Clustering Analysis

The clustering analysis in the text is based upon the "k-means" algorithm that minimizes the difference between a vector of variables. The holding clusters reported in Figure 5 can be seen in the following world map. These estimates are based upon the balanced sample of 95 countries and, as a result, much of Africa is missing. Clustering based upon the full unbalanced sample provides a fuller world map.

Figure C1: World Map of Country Clusters



Note: Based on Balanced Sample of 95 countries

In order to understand how investor groups respond to global shocks, we also use cluster analysis to study how similar or different these responses are across investor-country pairs. Table C6 reports the Pearson Chi-Squared test for each pairwise comparison of investor groups for different assumptions about the number of clusters. The null hypothesis is that the two groups of investors are different. As the table shows, the test does not reject the hypothesis that most of the investor groups react differently, with the exception of the Foreign and Domestic NonBanks. Indeed, the hypothesis that the Nonbanks behave similarly is significantly rejected whether $k = 3, 4, 5$.

Table C6: Pearson χ^2 Test on Contingency Tables

	k = 3		k = 4		k = 5	
Holder Comparison	**chi2**	**p**	**chi2**	**p**	**chi2**	**p**
DomNB DomBK	2.03	0.73	6.23	0.72	14.76	0.54
ForBK DomBK	1.21	0.88	10.24	0.33	17.54	0.35
ForNB DomBK	1.23	0.87	6.82	0.65	22.29	0.13
ForBK DomNB	3.96	0.41	9.95	0.36	18.88	0.28
ForNB DomNB	27.10**	0.00	27.89**	0.00	41.02**	0.00
ForNB ForBK	3.70	0.45	13.77	0.13	23.85	0.09

D Investor Decision Process

To explain in more detail what this two-step process means at the investor group level, we illustrate the example with the decisions of the foreign investor groups. The domestic investors generally follow the same format, although with important differences in interpretation as described later.

First consider the decision of the investors to hold an allocation of their portfolio in sovereign debt compared to other assets. Defining the net wealth of foreign investor group i as N^i_{Ft}, this share is given as:

$$f^{i,N}_t \equiv F^i_t / N^i_{Ft} \tag{21}$$

Specifically, the superscript N signifies that this variable represents total holdings by the investor group as a share of its total net wealth. Similarly, the portfolio share of country j sovereign debt as a share of total sovereign debt holdings by foreign investor i is defined as the share:

$$f^{i,F}_{jt} \equiv F^i_{jt} / \ F^i_t \tag{22}$$

In this case, the superscript F denotes that this variable is a share of the overall holdings of sovereign debt by this investor group. Clearly, the holdings of each investor group can then

be rewritten as:

$$F_{jt}^{i} \equiv f_{t}^{i,N} f_{j,t}^{i,F} N_{F,t}^{i}. \tag{23}$$

We next use these definitions to consider some of the economic relationships that have been described in the literature. For that purpose, consider the first decision, the decision to hold sovereign debt. Following the literature, we postulate that foreign investors allocate their overall portfolio to sovereign bonds depending upon "global factors" $\mathbf{X}_t^w$.[29] That is, the desired portfolio share of sovereign bonds for foreign investor of group i has the form:

$$f_{t}^{i,N} = f^{i,N}[\mathbf{X}_t^w] \tag{24}$$

At the same time, the decision for holdings of country j government debt by that same investor *within* the sovereign allocation depends upon country-specific macro-variables and the characteristics of the debt.

$$f_{j,t}^{i,F} = f^{i,F}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}_t^w] \tag{25}$$

To illustrate, consider $i = 1$ *"Global Banks."* These banks make loans and take deposits. They may hold sovereign debt as reserves (e.g., AEs) but also make loans internationally. Their overall allocation to this asset group depends upon factors such as the spread between deposits and loans as well as capital restrictions. Thus, their demand decisions may be summarized as:

$$f_{t}^{1,N} = f^{1,N}[\mathbf{X}_t^w] \tag{26}$$

where, as defined above, $\mathbf{X}_t^w$ is a vector of global variables that impact banks willingness to hold sovereign debt relative to other assets such as private debt or cash. By contrast, the global banks' holdings to country debt with specific characteristics j within this government debt allocation is given by:

$$f_{j,t}^{1,F} = f^{1,F}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}_t^w] \tag{27}$$

Thus, the holdings of country j debt by foreign banks can be written as the combination of this

[29] See for example Gabaix and Maggiori (2015), Fang and Liu (2020), and Morelli et al. (2020).

two-step decision process:

$$F^i_{1,t} \equiv f^{1,N}[\mathbf{X}^w_t] f^{1,F}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}^w_t] N^1_{F,t} \tag{28}$$

Consider next the demand by *"Global Non-Banks"* identified by $i = 2$. These investors comprise the large and diverse group of private investors. However, the Euro Area data analyzed above suggests that the marginal behavior of these Non-Banks are largely driven by mutual funds and hedge funds. We summarize the decision along the same dimensions as the two-step analysis as summarized in equation (22) above with similar variables but different responses given by:

$$f^{2,N}_t = f^{2,N}[\mathbf{X}^w_t] \tag{29}$$

and by demand for country debt with specific characteristics j given by:

$$f^{2,F}_{j,t} = f^{2,F}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}^w_t] \tag{30}$$

Finally, we consider the investor group $i = 3$ "Foreign Official." This official holder group is a combination of foreign central banks who may hold sovereign debt for various reasons that differ from the private investors and, moreover, are likely to depend upon the countries. For example, foreign central banks may hold Advanced Economy sovereign debt for reserve reasons, as epitomized by U.S. Treasuries.[30] At the same time, official holdings of the sovereign debt for Emerging Markets is likely to be driven by international aid considerations, particularly during crisis times (e.g., IMF and World Bank bailouts.) Despite these differences, official institutions may also implicitly incorporate target allocations for groups of countries in response to global events. Thus, the framework above provides a natural framework to assess these relationships in the data, as well.

By contrast, domestic investors decide directly how much of their own government debt to hold. They decide on these allocations as a consequence of local macro variables, conditional on global variables. Defining the net wealth of domestic "home" investor group i as N^i_{Ht}, this

[30] See Gamba, Hakobyan, Lusinyan, Meads, and Wu (2021).

share is defined as:

$$h_t^{i,N} \equiv H_t^i / N_{Ht}^i = h^{i,N}[\mathbf{X}_{j,t}, \mathbf{Z}_{j,t}; \mathbf{X}_t^w], \tag{31}$$

where as above the superscript N signifies that this variable represents total holdings by the investor group as a share of its total net wealth.

Domestic creditor groups require a different interpretation of the relationships above. Consider first the holdings $h_t^{1,N}$ for $i = 1$ *"Domestic Banks."* These banks typically hold domestic government debt either in response to capital requirements or other macroprudential policies (as they are generally safer, more liquid assets).[31] Similarly, the holdings $h_t^{2,N}$ for $i = 2$ *"Domestic Non-Banks"* captures the holdings by the heterogeneous group of domestic private investors who are not banks. Finally, the holdings, $h_t^{3,N}$ for $i = 3$ *"Domestic Central Banks"* give the shares of their own government debt in the central bank balance sheets.

As this description highlights, the demand for holdings by both foreign and domestic investors can be summarized by the functions, $h_t^{i,N}$ and $f_t^{i,N}$ that depend upon a vector of country-level variables and global shocks.

E Borrower Function

Government borrowers provide the "supply" of sovereign debt. Although this statement is clearly true in general, it will prove convenient to illustrate the relationship in the context of the emerging market debt literature. In this literature beginning with Eaton and Gersovitz (1981) and adapted by Arellano (2008), the government conducts all borrowing for the economy. Under the additional assumption that all debt is one period, then the aggregate per period resource constraint of the government can be written as:

$$C_{j,t} + B_{j,t-1} = Y_{j,t} + q_{j,t} B_{j,t} \tag{32}$$

[31] Note that while these banks may also hold foreign government debt, our aggregate data does not provide information on those holdings. As such, domestic banks for some advanced economies may also be foreign banks for other countries.

where for country j, $C_{j,t}$ and $Y_{j,t}$ are consumption and output, respectively, and where $B_{j,t}$ is an internationally traded pure discount bond and q_t^j is the price of that bond. Allowing for longer term coupon debt as in Arellano and Ramanarayanan (2012), Bai, Kehoe, and Perri (2019) generalize this relationship by specifying that the government pays out existing debt as a coupon payment given by: ϕB_t for the first period, $\phi(1-\phi)B_t$ for the second period, $\phi(1-\phi)^2 B_t$ for the third period, etc. This stylized approach includes as special cases the one period debt above as $\phi = 1$ and, on the other extreme, a perpetuity as $\phi = 0$. In this case, the budget constraint becomes:

$$C_{j,t} + [q_{j,t}(1-\phi_j) + \phi_j]B_{j,t-1} = Y_{j,t} + q_{j,t}B_{j,t} \tag{33}$$

Thus, consumption is income $Y_{j,t}$ net of paying current borrowing obligations from the prior period $\phi_j B_{t-1}^j$ and rolling over next period debt with new borrowings, $B_{j,t} - (1-\phi_j)B_{j.t-1}$ at price q_j. More generally, allowing for investment, government spending, and net exports, the basic balance of payments identity in equation (33) can be generalized to include investment and government spending. For this more general aggregate budget constraint, we can redefine C as domestic absorption and recognize that net current account balances equal the change in the value of bond holdings. We use this interpretation in our empirical measures of openness below.

Consider now an economy in steady state, and thus paying off debt if $B_{j,t} > 0$. Dividing equation (33) by lagged income, defining the ratio to output for any variable X as $x_t \equiv X_t/Y_t$ and dropping j subscripts for parsimony, the relationship can be rewritten as:

$$q_t b_t(1+\eta_t) - b_{t-1} = (c_t - 1)(1+\eta_t) \tag{34}$$

where η_t is the growth rate of output, $\ln(Y_t/Y_{t-1})$ Moreover, defining the change in the value of the net foreign position as $\widetilde{D}_t - \widetilde{D}_{t-1} = q_t B_t - [q_t(1-\phi) + \phi]B_{t-1}$ implies that the value of

the country debt raised per period is:

$$\widetilde{d}_t = (c_t - 1) + \widetilde{d}_{t-1}(1 + \eta_t)^{-1} \tag{35}$$

Note that this debt includes the total debt of the economy so that sovereign and private debt may offset each other; that is, private debt-to-GDP = $\widetilde{d}_t - d_t$. Indeed, some have argued that sovereign debt may play important roles in ameliorating or exacerbating welfare costs of private debt.[32]

These equilibrium relationships imply that the supply of sovereign debt depends upon a number of country-specific macroeconomic variables that we define as a vector process at time t as: $\mathbf{X}_{j,t}$. In particular, this set of variables is a vector of country-specific characteristics that may impact the desire to borrow, including the growth rate of the economy, η_t, and prior sovereign debt-to-output share d_{t-1}.

Another set of variables that impact sovereign debt supply relates to the price of borrowing and the characteristics of these obligations. Clearly, the supply of debt depends negatively upon the direct cost of borrowing. In addition, however, borrowing may entail indirect costs if the debt must be repaid in foreign currency or at undesirable maturity durations. Indeed, recent literature has argued that domestic sovereigns preferred to borrow in their own local currencies rather than foreign currency borrowing that entails greater exchange rate risk.[33] Similarly, countries may face a trade-off of lower borrowing costs in short term maturities that incur greater roll-over risk versus a higher cost of borrowing long term.[34] We combine these direct and indirect costs of borrowing in a vector of pricing variables defined as: $\mathbf{Z}_{j,t}$. Thus, this vector includes, not only the direct cost of debt, $q_{j,t}$, but also indirect costs such as a disadvantageous maturity of debt $\phi_{j,t}$, a higher share of debt denominated in foreign currency, and a higher value of foreign currency that impacts that share.

Overall these basic relationships can be then summarized in a general supply of debt-to-GDP relationship given by equation (12) in the paper and repeated here for convenience:

[32] See for example, Bocola (2016), Du and Schreger (2016b) and Bocola and Lorenzoni (2020).
[33] See for example Ottonello and Perez (2019), Arellano et al. (2020), and Du, Pflueger, and Schreger (2020).
[34] See Arellano and Ramanarayanan (2012) for a development of this argument.

$$d_t \equiv d(\mathbf{X}_{j,t}; \mathbf{Z}_{j,t})$$

That is, the share of government debt to output depends upon a vector of country-specific macro-economic variables, $\mathbf{X}_{j,t}$, and borrowing cost characteristics, $Z_{j,t}$. Clearly, then, the supply of debt by country can be written as in equation (13) of the paper as in:

$$D_{j,t} \equiv d(\mathbf{X}_{j,t}; \mathbf{Z}_{j,t}) Y_{j,t}$$

Clearly, these relationships reflect basic borrowing functions that map the country-specific variables and their pricing characteristics into the supply of debt.

F Details of Investor Demand and Exposure

F.1 Reduced-form Estimates of IV Construction

This section reports the regression coefficients in Equation (17).

Table F7: Reduced-form regression for the instrument in log with FE

	(1) DomBK	(2) DomNB	(3) DomCB	(4) ForBK	(5) ForNB	(6) ForCB
r_gdp_gr	0.56	-3.86	2.96	-2.75	1.92	-1.82
	(1.04)	(2.27)	(2.77)	(1.92)	(2.12)	(1.97)
infl	-1.65***	0.26	-0.44	-2.19***	0.93**	-0.56
	(0.49)	(0.44)	(1.14)	(0.37)	(0.35)	(0.36)
l_exp_ratio	0.11	-0.16	-0.37	0.11	0.98*	0.68*
	(0.22)	(0.25)	(0.56)	(0.37)	(0.54)	(0.40)
Obs	406	367	339	406	353	396
r2	0.86	0.82	0.71	0.84	0.78	0.88

Note: This table reports the reduced-form estimates of Equation (17), with the control of country and year fixed effects. The sample expands 1996-2018 at annual frequency. Each column represents an investor group. The standard errors clustered at country and year level are reported in the parentheses. * p $<$ 0.10, ** p $<$ 0.05, *** p $<$ 0.01.

F.2 Exposure

This section provides the detailed algebra that yields Equation (20) in the main text.

The exposure analysis is based on the following equation:

$$P_{j,t}D_{j,t} = \sum_{i=1}^{6} P_{j,t}^{i} H_{j,t}^{i}$$

where $P_{j,t}^{i}$ is the price faced by investor i. In equilibrium $P_{j,t} = P_{j,t}^{i}$ for all i. For ease of notation, we write $P_{j,t} = \exp(-y_{j,t})$ and $P_{j,t}^{i} = \exp(-y_{j,t}^{i})$ and abstract away the maturity. Therefore,

$$y_{j,t} = -\ln D_{j,t}^{-1} - \ln \sum_{i=1}^{6} \exp(-y_{j,t}^{i}) H_{j,t}^{i}$$

Thus:

$$\frac{dy_{j,t}}{dD_{j,t}} = \frac{1}{D_{j,t}} - \frac{1}{\sum_{i=1}^{6} \exp(-y_{j,t}^{i}) H_{j,t}^{i}} \left[\sum_{i=1}^{6} \frac{d\left(\exp(-y_{j,t}^{i}) H_{j,t}^{i}\right)}{dH_{j,t}^{i}} \frac{dH_{j,t}^{i}}{dD_{j,t}} \right]$$

Let investor group i's marginal financing share $\frac{dH_{j,t}^{i}}{dD_{j,t}} = a_{j}^{i}$ and $\frac{dH_{j,t}^{i}}{dy_{j,t}^{i}} \frac{y_{j,t}^{i}}{H_{j,t}^{i}} = \eta_{j}^{i}$.

$$\frac{dy_{j,t}}{dD_{j,t}} = \frac{1}{D_{j,t}} - \frac{1}{\sum_{i=1}^{6} \exp(-y_{j,t}^{i}) H_{j,t}^{i}} \left[\sum_{i=1}^{6} a_{j}^{i} \left(\exp(-y_{j,t}^{i}) - H_{j,t}^{i} \exp(-y_{j,t}^{i}) \frac{1}{\eta_{j}^{i}} \frac{y_{j,t}^{i}}{H_{j,t}^{i}} \right) \right]$$

We define exposure δ_{j} as

$$\delta_{j} = \frac{dy_{j,t}}{dD_{j,t}} \frac{D_{j,t}}{y_{j,t}} = \frac{1}{y_{j,t}} - \frac{1}{y_{j,t} \sum_{i=1}^{6} \exp(-y_{j,t}^{i}) \frac{H_{j,t}^{i}}{D_{j,t}}} \left[\sum_{i=1}^{6} a_{j}^{i} \exp(-y_{j,t}^{i}) - a_{j}^{i} \exp(-y_{j,t}^{i}) y_{j,t}^{i} \frac{1}{\eta_{j}^{i}} \right]$$

Plug in $y_{j,t}^{i} = y_{j,t}$, $\sum_{i=1}^{6} a_{j}^{i} = 1$, and $\sum_{i=1}^{6} H_{j,t}^{i} = D_{j,t}$, we obtain Equation (20).

$$\delta_{j} = \frac{dy_{j,t}}{dD_{j,t}} \frac{D_{j,t}}{y_{j,t}} = \sum_{i=1}^{6} \frac{a_{j}^{i}}{\eta_{j}^{i}}.$$