Beyond Home Bias: Portfolio Holdings and Information Heterogeneity

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January 9, 2018

Abstract

We investigate whether information frictions are important determinants of banks' sovereign debt portfolios. Going beyond the classic home versus foreign distinction in holdings, we study the heterogeneity within the foreign sovereign portfolio. First, we propose a modified version of the Van Nieuwerburgh and Veldkamp (2009) model with a two-tiered information structure that links portfolio holdings and information acquisition. Second, we find strong support for the key predictions of the model in the data: if a bank makes a forecast for a given country, it is more likely to hold debt of that country. Moreover, more optimistic and more precise forecasts predict larger portfolio holdings.

JEL classification: G11, G21, F30.

Keywords: Home bias, Information frictions, Portfolio choice, Banks.

We are grateful to Andrea Beltratti, Kimberly Cornaggia, Gregorio De Felice, Alvaro Pedraza, Hannes Wagner, Francesco Saita, Andrea Vedolin and conference participants at the AFFI 2017 in Valence for helpful comments. Jamie Grasing provided excellent research assistance. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Board of Governors or the Federal Reserve System.

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1 Introduction

The portfolio home bias puzzle is a well documented empirical phenomenon in international finance. It has given rise to a large and active literature that has analyzed a number of potential explanations.[1] Largely due to the lack of appropriate data, the primary focus of prior work has been on understanding the basic dichotomy between home and foreign assets at the aggregate level, while the heterogeneity among individual foreign holdings has received less attention. Recent work by Hau and Rey (2008), Coeurdacier and Rey (2013), however, has highlighted the potentially important role such heterogeneity can play in discriminating between different theories of the home bias.

In this study, we go beyond the classic home versus foreign distinction in holdings, and study both theoretically and empirically how information frictions affect the entire portfolio allocation, including across individual foreign assets. We focus in particular on models of portfolio choice with information frictions because of two reasons. First, they have proven quite successful in explaining the puzzle and as a result have become a common benchmark in the literature (Van Nieuwerburgh and Veldkamp (2009), Coeurdacier and Rey (2013)). Second, our dataset allows us to construct proxies for the information of each individual economic agent (in our case a bank) and link them to their holdings of individual foreign assets, making it a natural laboratory for testing the implications of information models.

In order to analyze the link between information frictions and portfolio holdings empirically, we take advantage of a unique dataset that matches European banks' sovereign debt holdings and credit amounts from the European Banking Authority (EBA) with banks' forecasts on the same countries' 10-year sovereign debt yields, obtained from Consensus Economics. This dataset allows us to analyze not only the relative relationship between home assets and the aggregate of all foreign assets owned by a bank, but to also look at the

[1]For the empirical documentation of the puzzle see, among others, French and Poterba (1991), Tesar and Werner (1998), and Ahearne et al. (2004). In terms of theories of the home bias see for example Obstfeld and Rogoff (2001), Van Nieuwerburgh and Veldkamp (2009), Coeurdacier and Gourinchas (2016), Heathcote and Perri (2007), Huberman (2001). Coeurdacier and Rey (2013) provide an excellent survey.

holdings of specific foreign assets. Moreover, it allows us to track a bank's beliefs about the economic fundamentals underlying individual portfolio holdings.[2]

As a first step, we document three stylized facts about the portfolio biases exhibited in our data set. First, we find a large and significant bias towards holdings of the home sovereign bonds: this is the well-known portfolio home bias. Second, we find that the foreign portion of a typical bank portfolio is sparse, in the sense that banks tend to hold positive quantities of only a few foreign sovereigns.[3] The sparseness in portfolios is decreasing in the overall size of the bank, with larger banks making investments in a larger number of individual countries. Third, the foreign investments that banks do make are in fact made in relatively similar proportion to their CAPM weights, i.e. there is little bias within the foreign portion of the non-zero holdings of a bank's portfolio. Thus, although the foreign portion of a bank's portfolio is still very different from the CAPM benchmark, the allocation across the subset of non-zero foreign holdings is actually fairly *close* to CAPM. In conclusion, it seems that the typical bank sovereign portfolio could be characterized as follows: a large domestic exposure, relatively small exposures to few foreign countries (with no clear preference over any of them), and zero exposures to many other countries. It is an interesting pattern that, to the best of our knowledge, has not been documented before. Thus, our stylized facts provide a new look at the basic nature of international portfolios and capital flows.

For a model to be able to fit these stylized facts, it needs to be able to generate both an *extensive* margin (which countries to invest in) and an *intensive* margin (how much to invest in each of the chosen countries) of portfolio adjustment. To do that, we modify the benchmark model in the information literature, Van Nieuwerburgh and Veldkamp (2009), in two ways. First, in order to generate an extensive margin, we make the information choice and cost structure two tiered by including Merton (1987) style fixed cost of acquiring priors about the unconditional distribution of returns. The benchmark model only features an

[2]We focus in particular on holdings of the European Economic Area (EEA) sovereign debt, as those assets form a substantial part of the security investments portfolio of European banks, and are relatively homogeneous assets with similar liquidity and virtually identical regulatory treatment.

[3]Hau and Rey (2008) find similar sparseness in portfolios of mutual funds.

intensive margin, in terms of a cost of increasing the precision of beliefs about the actual future return realization. As a result, in the Van Nieuwerburgh and Veldkamp (2009)'s model, although home investors tilt their portfolio towards home assets, they still hold *all* other world assets for diversification purposes. Second, we use CRRA preferences (as opposed to CARA) which introduce a wealth effect and thus make the optimal portfolio potentially sparse, since banks with lower initial wealth levels are optimally less likely to choose to pay the prior information fixed cost. Thus, the model features both extensive and intensive margins of portfolio adjustment, and an explicit role for the size of the bank.

Intuitively, the fixed cost of acquiring priors, together with decreasing marginal utility from additional information, creates the possibility that banks invest only in a subset of all available assets, which generates the *extensive* margin of portfolio adjustment. Conditional on the set of priors acquired, the agents also choose the optimal precision of their beliefs about the future realization of returns, which generates the *intensive* margin of portfolio adjustment, since the assets about which agents choose to acquire more precise beliefs are held in larger proportions. In order to generate home bias, we follow the typical assumption in the literature that the agents' prior beliefs over their home asset are slightly more precise than their priors over foreign assets. The home advantage in information, combined with the key result that the intensive information choice features increasing returns, leads agents to optimally choose to acquire additional informative signals only for the home assets. This additional information shrinks the posterior uncertainty, and thus on average increases the holdings of home assets, generating a portfolio home bias effect. Putting everything together, the model is able to rationalize not only the large home bias evident in our data, but does so by implying a largely sparse foreign portfolio, where the few foreign holdings with positive weight are in fact held in accordance with CAPM (relative to one another).

With the model's predictions in hand, we use our data set that links bank forecasts and bank sovereign portfolio holdings to empirically document the importance of information frictions in determining both the *extensive margin* and the *intensive margin* of the portfolio allocation problem. First, we show that indeed banks have an information advantage on their home country relative to foreign ones, in the sense of producing more accurate forecasts about their domestic country, than foreign banks do.[4] This justifies the basic economic intuition of our model that portfolio bias is due to information differences across potential investments. Second, we show that producing a forecast about a country strongly predicts the likelihood of investing in that country; in other words, information acquisition seems to determine portfolio sparseness, just as it does in the model. These facts support the link between information frictions and the *extensive margin* of portfolio choice.

We then turn our attention to the link between the intensive margin of information and the intensive margin of portfolio bias. We show that, conditional on producing forecasts on a set of countries, the precision and relative optimism of these forecasts have statistically and economically significant effects on a bank's holdings in these countries. Specifically, both more optimistic expectations about a country and more precise information (lower squared forecast errors) strongly predict larger portfolio holdings of that country's sovereign debt. In addition, and as implied by the model, there is a significant interaction effect between the precision and the relative optimism of the forecasts. We find that banks that make more precise forecasts also have a higher sensitivity of portfolio holdings to the particular point forecasts they make – a given improvement in the bank's forecast about a country produces a larger portfolio reallocation towards that country's sovereign debt, the more precise the information is.

Lastly, we find that while information frictions can very well explain the heterogeneity in the foreign portion of the sovereign portfolio, they cannot fully explaining the significant overweighting of domestic assets relative to foreign assets as a whole. Indeed, when we run the intensive margin regressions including home exposure dummies, the latter show positive and significant coefficients, especially for peripheral European banks. The home exposure

[4]Similar local information advantages are also documented in other settings by prior work. For instance, Bae et al. (2008) and Malloy (2005) study how geographical and cultural proximity affects accuracy for analysts, while Grinblatt and Keloharju (2001) find similar patterns for Finnish stock investors. Cornaggia et al. (2016) confirm that proximity leads credit rating analysts to issue more favorable ratings.

dummies have explanatory power over and above what can be attributed to any home advantage in information. Thus, we conclude that information frictions play an important role in determining the heterogeneity in banks' portfolio holdings, but they are not quite enough by themselves to explain the full extent of the classic home bias puzzle.

This paper contributes to the large literature on home bias in asset holdings. The basic observation has been extensively documented for both equities (French and Poterba (1991), Tesar and Werner (1998), Ahearne et al. (2004)) and bonds (Burger and Warnock (2003), Fidora et al. (2007), Coeurdacier and Rey (2013)), and is a robust feature of both the aggregate data and the micro, individual investor data (Huberman (2001), Ivković and Weisbenner (2005), Massa and Simonov (2006), Goetzmann and Kumar (2008)). Recently, the European debt crisis has specifically emphasized the role of home bias in European banks' sovereign portfolios in transmitting credit risk from sovereign to the real economy (Altavilla et al. (2017), Popov and Van Horen (2014), DeMarco (2017)).

In terms of potential theoretical explanations, the idea of information frictions that create information asymmetry between home and foreign agents is a well-established hypothesis with a long tradition in the literature (Merton (1987), Brennan and Cao (1997), Hatchondo (2008), Van Nieuwerburgh and Veldkamp (2009), Mondria (2010), Valchev (2017)). Another set of mechanisms study frameworks in which home assets are good hedges for real exchange rate risk (Adler and Dumas (1983), Stockman and Dellas (1989), Obstfeld and Rogoff (2001), Serrat (2001)) and/or non–tradable income risk (Heathcote and Perri (2007), Coeurdacier and Gourinchas (2016)). Yet another strand of the literature analyzes corporate governance issues (Dahlquist et al. (2003)), political economy mechanisms (DeMarco and Macchiavelli (2015), Ongena et al. (2016)) and behavioral biases (Huberman (2001), Portes and Rey (2005), Solnik (2008)).

The contribution of this paper in terms of the home bias literature is twofold. On the empirical side, we provide new stylized facts about both extensive and intensive margins in banks' portfolio holdings. Crucially, we also empirically link both margins to information frictions. These results add to the literature that attempts to test and quantify the predictions of information-based models.[5] To the best of our knowledge, we are the first to directly link investors' information sets with their portfolio holdings; in other words, we are able to match individual bank holdings of country's sovereign debt with the same bank forecast about the country's 10-year sovereign debt yield. Previous empirical studies on information frictions, even those at the investor level, cannot match each asset in the investor's portfolio with his or her expectation (and its accuracy) about the performance of the asset. Therefore, we are able to provide direct evidence in favor of the main implications of portfolio choice models with information frictions. Also, many of the aforementioned studies focus on individual household investors that may not be very sophisticated. Our work suggests that information frictions are pervasive even among large European banks.

On the theoretical side, we add an extensive margin of information acquisition and power utility preferences that generate wealth effects to a standard portfolio choice model with information frictions *a' la* Van Nieuwerburgh and Veldkamp (2009). Our augmented model is able to rationalize the newly available evidence on the link between the extensive margin of information acquisition and the extensive margin (sparseness) of portfolio holdings. Moreover, its more detailed implications are also well supported by our empirical tests.

The paper is organized as follows. Section 2 describes the data and presents stylized facts. Section 3 presents the model and Section 4 the empirical tests the implications from the model. Section 5 concludes.

[5] Guiso and Jappelli (2006) estimate a negative correlation at the investor level between the portfolio Sharpe ratio and time spent acquiring financial information, consistent with overconfident investors. Guiso and Jappelli (2008) trace portfolio under-diversification to the lack of financial literacy. Ahearne et al. (2004) document that countries with a larger share of companies publicly listed in the U.S. attract larger weights in the U.S. equity portfolio. Massa and Simonov (2006) show that Swedish investors do not hedge risk but invest in stocks they are more familiar with, and earn higher returns. Grinblatt and Keloharju (2001) provide evidence that cultural and geographical proximity determines trading patterns among Finnish investors.

2 Data and Stylized Facts

2.1 Data

For our purposes, it is key to have data on portfolios and expectations on sovereign debt returns at the investor level. To this end, we merge information on European banks' sovereign portfolios from the EBA to banks' forecasts from Consensus Economics.

The EBA data, collected for the bank stress tests, is a semi-annual dataset of credit and sovereign exposures at the bank level for 28 countries belonging to the European Economic Area (EEA) from 2010Q1 to 2013Q4.[6] The EBA sample covers the largest banking groups in Europe (61-123 banks) and contains data at the consolidated level, not the subsidiary. For example, we know the amount of French sovereign bonds held by HSBC Holdings plc at a specific point in time, but not those of HSBC France. In order to keep our assets under study relatively homogeneous in characteristics other than the expectation over economic fundamentals, we focus on the holdings of EBA sovereigns. Those assets as homogeneous, with very similar liquidity characteristics and virtually identical regulatory treatment. They are also highly relevant asset class, as they form a significant proportion of the total security portfolio of the typical bank.

We then hand-match the banks in the EBA sample to Consensus Economics, a survey of professional forecasters which includes many of the banks in our sample as participants. At the beginning of each month, Consensus surveys analysts working for banks, consulting firns, non-financial corporations, rating agencies, universities and other research institutions (see

[6]The stress tests were held at irregular intervals, thus we have the following exposure dates available: 2010Q1, 2010Q4, 2011Q3, 2011Q4, 2012Q2, 2012Q4, 2013Q2 and 2013Q4. We treat the dataset as a semi-annual dataset, and consider 2010Q1 and 2011Q3 exposures as if they were from 2010Q2 and 2011Q2. Furthermore, we exclude all the sovereign debt holdings from countries that are not part of the EEA, such as the US or Japan. We do so for several reasons. First of all, the EBA exposure data are available for non–EEA countries only in 2010Q4 and 2013Q4, not for other time periods. Second, restricting the sample to EEA countries yields an homogeneous group in terms of regulatory treatment: in fact, all exposures to EEA central governments denominated in local currency (98% of total debt outstanding) are assigned a 0% risk–weight (ESRB (2015)). The different regulatory treatment may explain why European banks hold so little non–EEA debt, but cannot account for the home bias even among EEA countries. We would also like to emphasize that we are being conservative with this approach: all the stylized facts presented in this section hold even stronger if we were to include non–EEA countries in the analysis.

Table 9 in the Appendix for a detailed list of forecasters). These analysts provide forecasts for a set of key macroeconomic and financial variables for all major industrialized countries and some emerging markets. The forecasters include both domestic and foreign institutions. We match by name the banks in Consensus Economics to those in the EBA dataset. In case these appear through their international subsidiaries, we match the subsidiary's forecast to the portfolio share of the banking group it belongs to (*i.e.* HSBC France forecasts for the French economy is matched with HSBC Holdings plc portfolio share).

In the empirical analysis we use the 10–year sovereign yields as the forecasting variable, because it is most relevant in determining expected returns of sovereign debt, while at the same time guaranteeing good coverage by analysts.[7] It is highly relevant, since expecting a higher future yield on a debt instrument (which provides a fixed stream of payments) translates into expecting a lower future price, and thus a lower return.

We construct bank b's squared forecast error (SFE) for country c at horizon h as follows: $SFE^h_{bct} = (E_{bt}(X_{c,t+h}) - X_{c,t+h})^2$. Since the SFE may be a noisy measure of the average forecast precision of a given bank for a given country, our preferred measure of information precision is the *average* squared forecast error for the whole sample period of forecasts as $\overline{SFE}^h_{bc} = \frac{1}{T}\sum_{t=1}^{T}(E_{bt}(X_{c,t+h}) - X_{c,t+h})^2$. Due to its superior explanatory power, we only use short-term horizon forecasts (3-month ahead); we therefore omit the h superscript hereafter.

Table 1 contains the list of variables that we use in the empirical analysis. The forecasts on 10–year yields are available for 180 forecasters at the monthly frequency from September 2006 to December 2014 for 14 different countries (see the Appendix for a list of countries and all forecasters). We are able to match 40 such forecasters to the sample of EBA banks, from which we obtain information on sovereign bond holdings and credit exposures for all 14 destination countries. Table 2 displays some summary statistics for the dataset. In Panel A we report summary statistics about 10–year yield forecast from all forecasters available on Consensus Economics. The average point forecast for 10–year yields is 3.44% for all 14

[7]GDP growth forecasts have the most coverage by analysts, but are less relevant for sovereign debt holdings than 10-year sovereign debt yield forecasts.

countries between 2006 to 2014. The average squared forecast error is 0.36, which translates into a 0.6 percentage points standard deviation error. The time-averaged squared forecast error per forecaster is a bit higher on average (0.46), but has smaller standard deviation (0.56 vs 0.60).

In Table 2, Panel B and C, we report the summary statistics for the matched EBA-Consensus sample either for all bank-country pairs, including those that are not held in positive quantity (extensive margin, Panel B), or those only held in positive quantities (intensive margin, Panel C). The share of sovereign debt are markedly different across panels. In Panel B, we see that the average sovereign's portfolio share, including the domestic exposure, is about 4.53%, with a large standard deviation (14.32%). About 40% of the bank-country pairs observations show no exposure at all ($\mathbf{1}(ShareSovEEA_{b,c,t}) = 0$). If we exclude the holdings of domestic sovereign debt, both the average share of each investment and its standard deviation are halved compared to before (2% and 6%), highlighting the large domestic exposures most banks have. Finally, banks on average make a forecast on 10–year yields for only about 3% of all available countries throughout the sample period. In Panel C, where we restrict the sample to countries for which banks have positive exposures, the average exposure to EEA countries, including the home exposure, increases to 20% (12% for foreign positive exposures only). The point forecast and squared forecast errors remain similar to Panel B.

2.2 Stylized Portfolio Facts

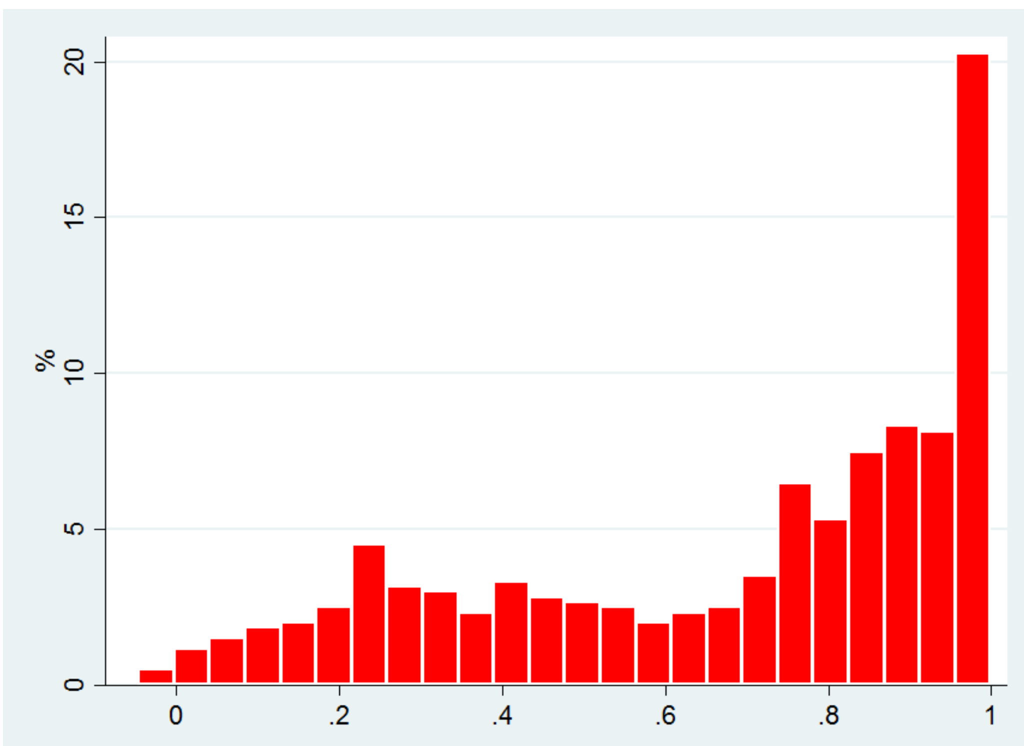
In our first set of empirical results, we exploit the heterogeneity in our data set, both across banks and across foreign assets, to better understand the main drivers of the overall phenomenon of portfolio bias in sovereign debt holdings. To quantify this bias, we use the standard measure in the literature, the Home Bias Index (HB Index):

$$\mathrm{HB} = 1 - \frac{1 - x_H}{1 - x_H^*}$$

where x_H is the portfolio share of a bank's holdings of domestic sovereign debt and x_H^* is the share of home country's debt as a fraction of total world debt (the CAPM portfolio). The HB index takes the value of 0 when the investor holds domestic assets in the same proportion as the benchmark CAPM portfolio ($x_H = x_H^*$), is positive when domestic assets are over-weighted, with a limiting value of 1 when the whole portfolio is composed exclusively of domestic assets ($x_H = 1$). It can be negative if domestic assets are under–weighted compared to the CAPM portfolio ($x_H < x_H^*$) . The histogram of HB values for the different banks in our dataset pooling across all dates (2010Q1-2013Q4) is presented in Figure 1.

Figure 1: Home Bias Index Histogram

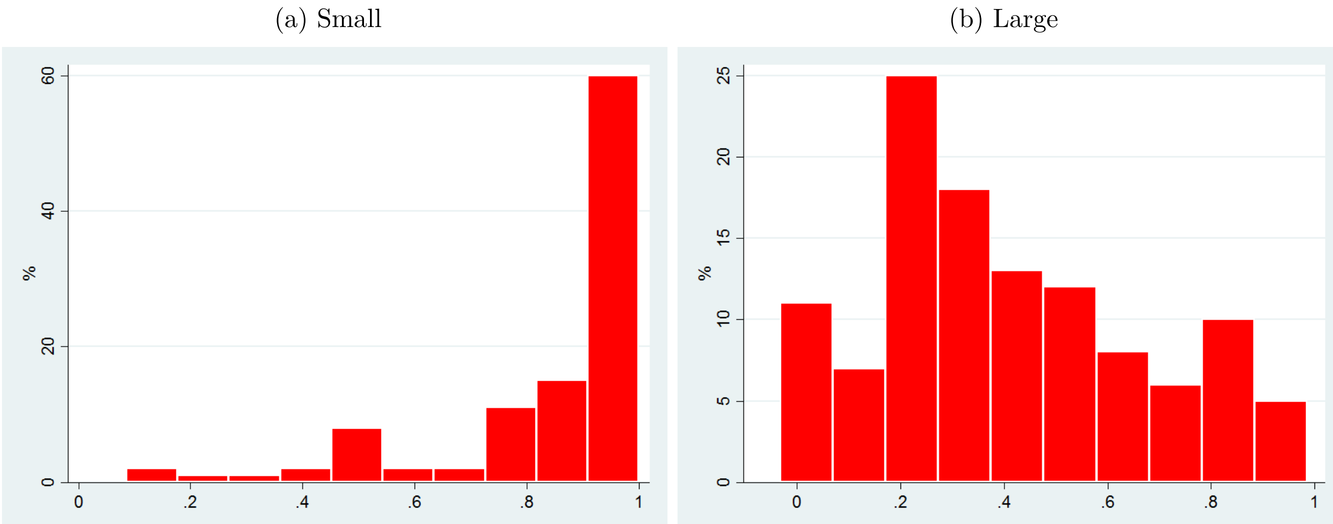
This figure plots the distribution for the home bias index, HB $= 1 - (1 - x_H)/(1 - x_H^*)$, for all EBA banks in 2010Q1-2013Q4.



Virtually all banks display at least some home bias (except for one bank, BNP Paribas, that has a slight negative HB index) and the median (mean) at 0.85 (0.72) is quite high. This is the basic observation of the home bias that has also been documented extensively in many previous studies. Size is a big driver of the overall level of home bias, but cannot alone

Figure 2: Home Bias Index: Small vs. Large Banks

This figure plots the distribution for the home bias index, $\text{HB} = 1 - (1 - x_H)/(1 - x_H^*)$, by bank size. Panel (a) plots the distribution for banks in the bottom quintile of total assets in 2010 (<€38 billion), while Panel (b) for banks in the top quintile of total assets in 2010 (>€550 billion).



explain it. In Figure 2 we sort banks according to the quintiles of total assets in 2010: while practically all banks in the bottom quintile of assets (<€38 billion in assets) hold almost exclusively domestic debt, even large banks (>€550 billion in assets) show significant home bias.

For the next set of results, it is useful to rewrite the HB index as:

$$\text{Home Bias} = 1 - \frac{\sum_{j \neq H} x_j}{\sum_{j \neq H} x_j^*}$$

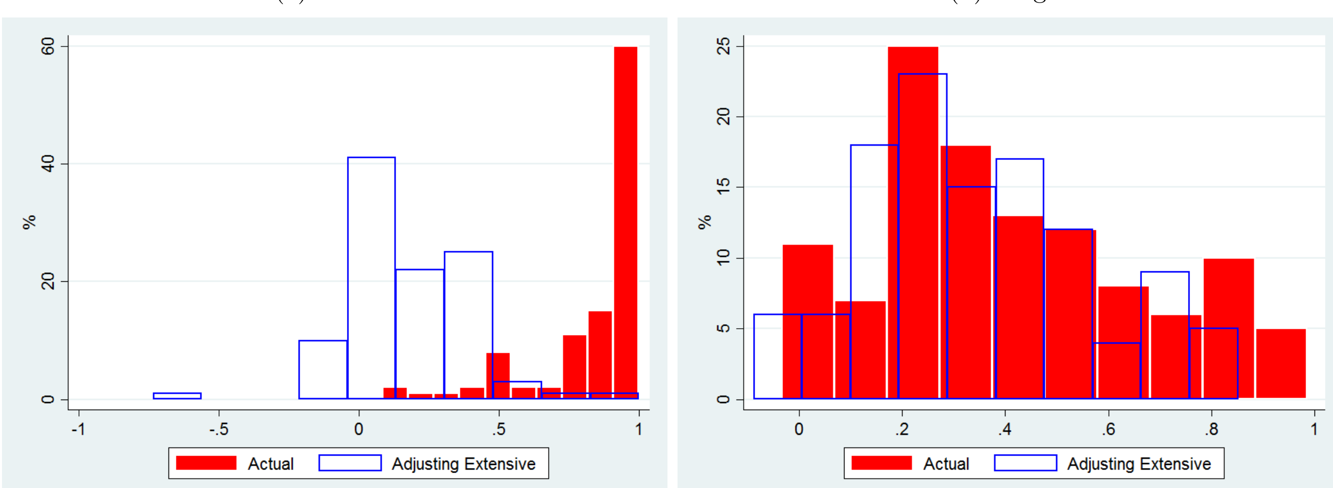
where x_j is the share of country j bonds in the bank's portfolio, and x_j^* is the share of country j bonds in total world debt. That is, rather than subtracting the domestic exposure from one, we sum over all foreign holdings ($1 - x_H = \sum_{j \neq H} x_j$). This alternative expression will be useful in the counter-factual measures of home bias considered below.

Extensive Margin: Another prominent feature of the data is that portfolios are sparse – the average bank only invests in 11 out of the 28 potential foreign countries. To quantify this *extensive margin* of the home bias, for each bank we construct a counter-factual home bias index by setting the portfolio share of foreign sovereigns held in non-zero quantities equal to their world market share. Thus, the counter-factual portfolio deviates from the market portfolio in terms of foreign investments only through its 0s, i.e. its sparseness. The results are presented in Figure 3 below, with panel (a) and (b) showing the results for small and large banks respectively. We see that the extensive margin is indeed a major driver of the home bias for small banks – correcting it leads to a strong shift of the HB distribution towards zero, with a median (average) home bias of just 0.06 (0.09). Thus, correcting the extensive margin of foreign investment virtually eliminates home bias for smaller banks, suggesting that the main driver of the home bias for them is the fact that those institutions do not invest at all in many foreign countries. On the other hand, correcting the extensive margin has a small effect on the home bias distribution for the largest banks. Those institutions tend to invest in the sovereign debt of all EU countries already, and only a small portion of their overall home bias can be attributed to portfolio sparseness.

Figure 3: Home Bias Index: Adjusting the Extensive Margin, Small and Large Banks

This figure plots the distribution for a counterfactual home bias index replacing all zero exposures with the optimal portfolio shares ($x_j = x_j^*$ if $x_j = 0$). Panel (a) plots the distribution for banks in the bottom quintile of total assets in 2010 (<€38 billion), while Panel (b) for banks in the top quintile of total assets in 2010 (>€550 billion).

(a) Small (b) Large

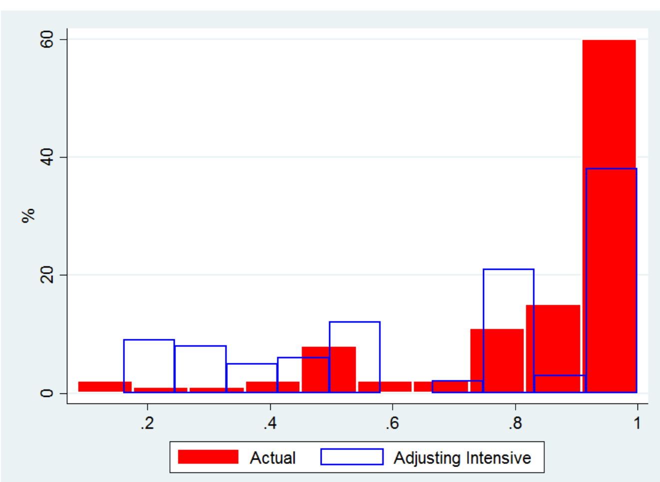


Intensive Margin: To measure the extent to which the home bias is driven by the *intensive margin* of portfolio adjustment, we construct a different counter-factual home bias index, where we set the portfolio share of all non-zero foreign investments equal to their respective market share, while leaving any zeros unchanged. We plot the results in panels (a) and (b) of Figure 4. It is striking to see how in this case the home bias for large banks is almost entirely eliminated, while it is still significant for small banks. This is the flip side of the adjustment on the extensive margin we saw previously. Taking both results together, we can conclude that while small banks do underweight the foreign investment they hold in positive quantities, most of the home bias is explained by the fact that they do not invest at all in many countries (the 'extensive margin' is most important). Large banks, on the other hand, tend to invest in all countries, but significantly underweight their foreign investments compared to holdings of domestic assets.

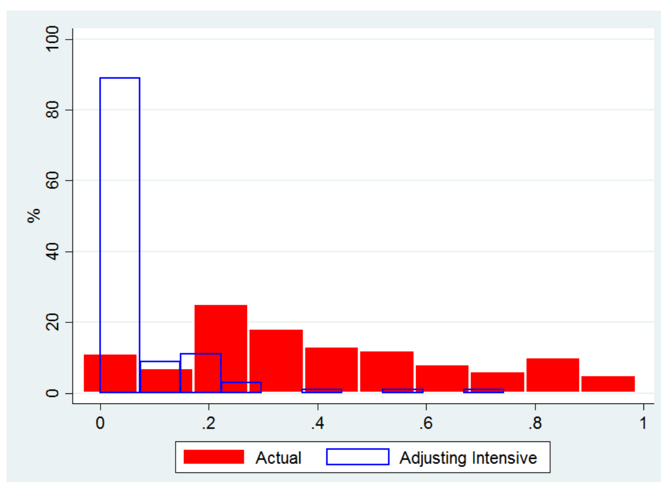
Figure 4: Home Bias Index: Adjusting the Intensive Margin, Small and Large Banks

This figure plots the distribution for a counterfactual home bias index replacing all non-zero exposures with the optimal portfolio shares ($x_j = x_j^*$ if $x_j > 0$). Panel (a) plots the distribution for banks in the bottom quintile of total assets in 2010 (<€38 billion), while Panel (b) for banks in the top quintile of total assets in 2010 (>€550 billion).

(a) Small



(b) Large



Biases among Foreign Holdings: The results so far indicate that there is significant heterogeneity among individual foreign assets. In particular, we have seen that foreign holdings are sparse, hence some foreign investments are held in positive quantities, while many are not held at all. Next, we focus on the heterogeneity among the individual foreign assets that are held in non-zero quantities.

We would like to know if there are any biases in the relative portfolio weights of the foreign investments the banks do hold. Essentially, we ask the question if there is differential treatment (and thus holdings) among the foreign investments that are held in positive quantities. To shed light on this question, we compute a bias index for each (positive) foreign holding of a given bank and define:

$$Bias_j = 1 - \frac{1 - \tilde{x}_j}{1 - \tilde{x}_j^*}$$

where $\tilde{x}_j$ is the holdings of country j's sovereign debt, as a share of all positive *foreign* holdings of the particular bank in question, defined as

$$\tilde{x}_j = \frac{x_j}{\sum_{i \in \mathcal{H}} x_i},$$

where $\mathcal{H}$ is the set of foreign countries that the bank has positive holdings in. Similarly, $\tilde{x}_j^*$ is country j's debt as a share of the total market capitalization of sovereign debt of the countries in the set $\mathcal{H}$ (the foreign countries that the bank invests in). Thus, the $Bias_j$ variable measures the extent to which an individual foreign investment is under- or over-weighted compared to the other non-zero foreign holdings. This cleans out the strong home bias effect we found previously, and focuses squarely on the deviations from CAPM among the foreign holdings of a given bank. We then analyze the distribution of $Bias_j$ for all j such that $x_j > 0$ – this gives us the heterogeneity in the relative biases amongst all foreign holdings that are held in positive quantities. This index follows the same logic of the standard home bias index: e.g. a positive value means that country j is overweighted in the foreign portion of a bank's portfolio.

Figure 5: Foreign Bias

This figure plots the distribution of the foreign bias index, $1-(1-\tilde{x}_j)/(1-\tilde{x}_j^*)$, for non-domestic exposures

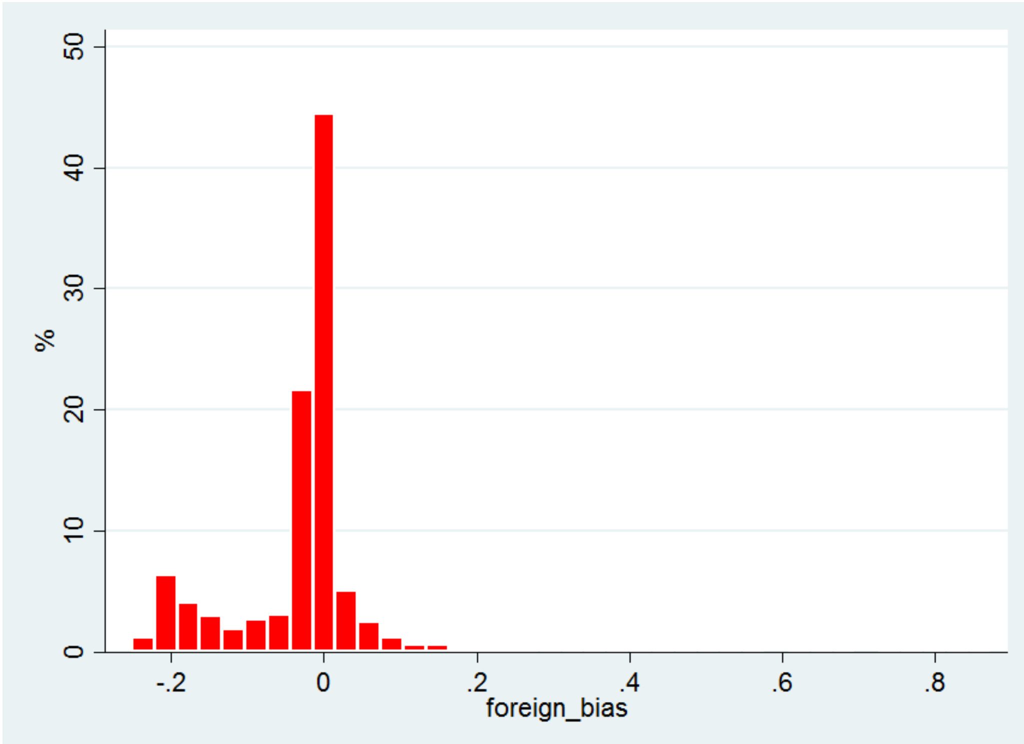


Figure 5 presents the histogram of $Bias_j$ pooling across banks. Notice that the median (average) bias towards an individual foreign asset is practically zero, -0.008 (-0.03), and the entire distribution is squeezed tightly around zero, with a standard deviation of just 0.09. There are a few outliers (maximum of 0.78 and minimum of -0.25), but by and large the mass of portfolio bias among foreign holdings is concentrated right around zero. This suggests that the foreign assets banks do hold are in roughly the 'right' proportions relative to each other. There is little bias within the group of foreign assets held in positive quantities, in the sense that within this subgroup, all assets are held in proportions close to their relative CAPM weights. We would like to note that 'relative to each other' is key here: as a group, foreign assets are under-weighted compared to domestic assets. However, there appears to be no differential treatment among the individual foreign assets held in positive quantities.

In conclusion, it seems that the typical bank sovereign portfolio could be characterized as follows: a large domestic exposure, relatively small exposures to few foreign countries (with no clear preference over any of them), and zero exposures to many other countries.

2.3 Stylized Facts: Home Bias in Information

The previous section analyzed the basic structure of bank's portfolios. In this section, we turn our attention to the basic structure of the typical bank's forecast precision. The main finding is that banks display a similar home bias in information.

We want to examine whether forecasts about future domestic sovereign yields are any more or less accurate than forecasts of foreign sovereign yields. One way to look at this is to see if, for a given sovereign, domestically domiciled forecasters are more accurate than foreign forecasters. But since we have data on both foreign and domestic forecasts for the *same* forecaster, we can also compare the accuracy of home and foreign forecasts for a *given forecaster*. This is a powerful test of whether individual forecasters indeed have superior information about home yields (Bae et al. (2008)). We run the following panel regression:

$$\overline{SFE}(Y10_{bct}) = \beta Home_{bc} + \alpha_b + \alpha_c + \varepsilon_{bct} \tag{1}$$

where $\overline{SFE}(Y10_{bct})$ is the average squared squared forecast error on 10–year yields, $Home_{bc}$ is a dummy variable that equals one when country c is the "home" country for forecaster b. $Y10_{bct}$ is the 3-month ahead forecast made by bank b regarding the 10–year yield on country c's sovereign debt. α_b and α_c are forecaster and destination country fixed–effects.

Table 3 shows the result for this specification. The sample contains all types of forecasters available in Consensus Economics (detailed in the Appendix in Table 9). In columns (1) to (3) we estimate the precision of home forecasts for all forecasters, while columns (4) to (6) show the incremental home-precision effect for the EBA banks over and above the home-precision effect of the non-EBA-bank forecasters. Moving from columns (1) to (3) (similarly from (4) to (6)) we progressively saturate the cross-sectional regressions with forecaster and destination country fixed effects. In particular, forecaster fixed effects allow us to estimate, within each forecaster, the additional precision of the home forecast relative to a foreign-country forecast; this eliminates concerns about the potential selection of ex-ante better forecasters into only forecasting their home country. Destination country fixed–effects absorb the aggregate ability of all forecasters to forecast any specific country.

The estimates in column (1) imply that home forecasters have an average squared forecast errors about one half of a standard deviation smaller than foreign forecasters. Controlling for a forecaster fixed-effect, the coefficient doubles in magnitude but remains negative (column (2)). Even after controlling for the average uncertainty around each country, the coefficient of the *Home* dummy is always negative and significant (column (3)). Noteworthy also, column (4) reveals that EBA banks have more precise information than the other forecasters (the EBA bank coefficient is negative), even if not significantly so. Moreover, the home-precision effect for the EBA banks is not statistically different from the home-precision effect of the other forecasters (the Home $\times$ EBA-bank coefficient is not statistically significant). Thus, EBA banks seem not to be significantly different from other forecasters in terms of their information structure; the only marked feature of the data is that home forecasts are on average more precise than foreign ones, identifying a home bias in information.

3 Model

In this section, we turn our attention to a model that can explain the stylized facts we have documented. We consider a simple three period model where agents can trade risky and risk-free assets and can acquire costly information about the asset payoffs. In period 0 agents choose their information acquisition strategy, and in period 1 new information arrives according to the chosen information strategy, agents update their beliefs and form optimal portfolios. In period 3 shocks realize and the agents consume the resulting returns on their portfolios. To keep things tractable, we work with generic "risky" assets with uncertain payoffs, but those can be viewed as long-term bonds which have uncertain payoffs due to uncertainty in their future price.

We first describe the asset market structure and then explain the information choice of the agents. There are N different countries of equal size, with a continuum of agents of mass $\frac{1}{N}$ living in each. There are N risky assets, one associated with each country, and a risk-free savings technology with an exogenous rate of return R^f. Thus, in period 1 agent i in country j faces the budget constraint

$$W_{1j}^{(i)} = \sum_{k=1}^{N} P_k x_{jk}^{(i)} + b_j^{(i)},$$

where P_k is the price of the risky asset of country k, $x_{jk}^{(i)}$ are the portfolio holdings of risky assets, $b_j^{(i)}$ the holdings of the risk-free asset and $W_{1j}^{(i)}$ is the investible wealth of the agent. It is useful to rewrite the budget constraint in terms of portfolio shares $\alpha_{jk}^{(i)} = \frac{P_k x_{jk}^{(i)}}{W_{1j}^{(i)}}$, instead of the absolute holdings $x_{jk}^{(i)}$, in which case the budget constraint can be expressed as

$$1 = \sum_{k=1}^{N} \alpha_{jk}^{(i)} + \frac{b_j^{(i)}}{W_{1j}^{(i)}} \tag{2}$$

Each asset yields a stochastic payoff D_k, and hence the return on an agent i's portfolio is

$$R_j^{p,(i)} = \sum_{k=1}^{N} \alpha_{jk}^{(i)} \frac{D_k}{P_k} + \frac{b_j^{(i)}}{W_{1j}^{(i)}} R = \boldsymbol{\alpha}_j^{(i)\prime} \mathbf{R} + \frac{b_j^{(i)}}{W_{1j}^{(i)}} R^f \tag{3}$$

where all bold letters denote N-by-1 vectors, and we define the gross return on asset k as $R_k = \frac{D_k}{P_k}$. We can use this portfolio return to express agent i's terminal, period 2 wealth as $W_{2j}^{(i)} = W_{1j}^{(i)} R_j^{p,(i)}$. To reduce clutter, from now we will suppress the i index if there is no chance of confusion.

In period 0, agents choose their information acquisition strategy, which helps them reduce the uncertainty in the stochastic asset payoffs $\mathbf{d}$. We assume that the payoffs follow a joint Normal distribution: $\mathbf{d} \sim N(\mu_d, \Sigma_d)$. For tractability purposes, we assume that the variance matrix is diagonal, and thus fundamentals of different countries are independent of one another. This assumption has no effect on the qualitative results of the model, and could be relaxed by introducing a factor structure to payoffs. Intuitively, if we were to introduce a global factor (or more generally common factors), then learning about that factor would not affect the relative portfolio weights of different assets. It is the differential learning about individual country factors that drives portfolio concentration and home bias. Thus, for the sake of clarity of the exposition, we consider a framework where we abstract from common factors, and simply focus on the agent's incentives to learn about country specific factors.

Agents can purchase two types of costly information. First, as in Merton (1987), we assume that the knowledge of the unconditional distribution of the asset payoffs is not available to the agents for free, but rather they have to "purchase" their priors. In particular, the agents know that the return distribution is joint normal with a known diagonal variance matrix Σ_d, but do not know the values of the mean returns of the different assets. They can purchase information about the unconditional mean of each element of $\mathbf{d}$ separately, at a fixed cost c. Crucially, we assume that without acquiring this prior information on the unconditional mean of the payoffs of a given asset, the agents will not hold any of that asset. This is the Merton (1987) view of information, which postulates that agents must first acquire the basic information about an asset, before holding any of it. We view this as a modeling device for the standard due diligence procedures and basic vetting that a bank engages in before acquiring an asset. Without having done such initial due diligence for asset k, the agents will not enter that market at all and set $\alpha_k = 0$.[8,9]

In addition to learning the unconditional distribution of payoffs, the agents can also

[8] We view this as a good description of the actual investment decision process of banks. To get initial approval to invest in a given asset (i.e. debt of country k) the investment team needs to do a lot of due diligence work up front – e.g. the bank will need to first carry out an initial study for a given country at a cost c. But once such approval is granted, future portfolio adjustments do not require to go through extensive initial approval procedures.

[9] The reason that agents do not hold assets that are unfamiliar to them can also be further micro-founded by introducing ambiguity that can be reduced by doing the due diligence step.

purchase unbiased signals about the actual realization of any d_k:

$$\eta_{jk}^{(i)} = d_{jk} + u_{jk}^{(i)},$$

where $u_{jk}^{(i)} \sim iidN(0, \sigma_{u_{jk}}^{(i)2})$. The precision of these signals is not exogenously given, but the agents choose it optimally, subject to an increasing and convex cost $C(\kappa)$ of the total amount of information, κ, encoded in their chosen signals. Information, κ, is measured in terms of entropy units (Shannon (1948)). This is the standard measure of information flow in information theory and is also widely used by the economics and finance literature on optimal information acquisition (e.g. Sims (2003), Van Nieuwerburgh and Veldkamp (2010)). It is defined as the reduction in uncertainty, measured by the entropy of the unknown asset payoffs vector $\mathbf{d}$, that occurs after observing the vector of noisy signals $\boldsymbol{\eta}_j^{(i)} = [\eta_{j1}, \ldots, \eta_{jN}]'$:

$$\kappa = H(\mathbf{d}|\mathcal{I}_j^{(i)}) - H(\mathbf{d}|\mathcal{I}_j^{(i)}, \boldsymbol{\eta}_j^{(i)}).$$

$H(X)$ denotes the entropy of random variable X and $H(X|Y)$ is the entropy of X conditional on knowing Y.[10] Moreover, $\mathcal{I}_j^{(i)}$ is the prior information set of agent i, which contains both the subset of priors on $\mathbf{d}$ which he has purchased and the public information that is observed for free by all agents (such as the equilibrium prices). Thus, κ measures the total amount of information about the vector of asset returns $\mathbf{d}$ contained in the vector of private signals, $\boldsymbol{\eta}_j^{(i)}$, over and above the agent's priors and any publicly available information. Given our assumption that asset payoffs are uncorrelated across countries, we can express κ as the sum of the informational contents of the country-specific signals $\eta_{j1}^{(i)}, \ldots, \eta_{jN}^{(i)}$: $\kappa = \kappa_1 + \cdots + \kappa_N$. The information content of each individual signal is similarly defined as the information about the underlying fundamental over and above the publicly available information:

$$\kappa_k = H(d_k|\mathcal{I}_j^{(i)}) - H(d_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)}).$$

[10]Entropy is defined as $H(X) = -E(\ln(f(x)))$, where $f(x)$ is the probability density function of X.

Finally, we also assume that agents have an arbitrarily small information advantage over their home assets, which is modeled by assuming that they receive one unbiased signal with exogenously fixed precision $\frac{1}{\sigma_\eta^2}$ about the domestic asset payoff for free. As it will become clear later, this gives home information a slight edge that the optimal information choice endogenously amplifies, and leads to home bias in portfolios. This wedge needs to be only arbitrarily small, hence for simplicity we introduce it exogenously. However, it can be endogenized in a number of ways, such as for example by modeling the fact that the agents can also make non-tradable investments in the home country, and hence value home information slightly more than foreign information. See for example Valchev (2017).

After observing all of their chosen signals, the agents use standard Bayesian updating to update their beliefs about the asset payoffs. Thus, acquiring more informative signals $\boldsymbol{\eta}_j^{(i)}$ reduces the posterior variance of the asset payoffs. This is the Grossman and Stiglitz (1980) view of information, and can also be seen as an "intensive" margin of information acquisition, whereas the Merton (1987) view represents the "extensive" margin of information acquisition. Our model combines both of these views of information. Intuitively, the framework captures the idea that before buying an asset banks need to pay an upfront cost for an initial due diligence study that would reveal the unconditional distribution of payoffs of the given asset. Once that is done, they can then also form a dedicated analysis team that can devote more or less resource to following the fundamentals of that country, and produce more or less precise forecasts of the particular future realization of the payoff d_k.

Lastly, the agents maximize expected CRRA utility $u(W) = \frac{W_j^{1-\gamma}}{1-\gamma}$ over their terminal wealth $W_{2j}^{(i)}$. We solve the model by backward induction, by starting with the optimal portfolio choice in period 1, and then solving for the optimal information choice in period 0.

3.1 Period 1: Portfolio Choice

In period 1, agents observe the unconditional payoff distributions and additional informative signals $\boldsymbol{\eta}$ that they chose in period 0, and update their beliefs accordingly. Conditional on those beliefs, agents pick the portfolio composition that maximizes their expected utility:

$$\max_{\boldsymbol{\alpha}_j^{(i)\prime}} E\left[\frac{(W_{2j}^{(i)})1-\gamma}{1-\gamma}|\mathcal{I}_j^{(i)},\boldsymbol{\eta}_j^{(i)}\right]$$

s.t.

$$W_{2j}^{(i)} = \underbrace{(W_0 - \Psi_j^{(i)} - C(K_j^{(i)}))}_{W_{1j}^{(i)}} R_j^{p,(i)} = W_{1j}^{(i)}(\boldsymbol{\alpha}_j^{(i)\prime}\mathbf{R} + (1-\boldsymbol{\alpha}_j^{(i)\prime}\mathbf{1})R^f)$$

where $\Psi_j^{(i)} = \sum_k \iota_k^{(i)} c$ is the total expenditure on prior information (ι_k is 1 if the agent purchases information about the k-th country, and zero otherwise), $C(K_j^{(i)}$ is the cost of the additional noisy signals, and thus $W_{1j}^{(i)} = W_0 - \Psi_j^{(i)} - C(\kappa_j^{(i)})$ is the wealth of the agent at the beginning of period 1. This is his investible wealth – it is equal to his initial wealth, W_0, minus all information costs he incurred in period 0. Substituting the constraint out, the maximization problem is equivalent to

$$\max_{\boldsymbol{\alpha}_j^{(i)\prime}} \frac{(W_{1j}^{(i)})^{1-\gamma}}{1-\gamma} E\left[\exp((1-\gamma)r_j^{(i),p})|\mathcal{I}_j^{(i)},\boldsymbol{\eta}_j^{(i)}\right] \tag{4}$$

where lower case letters denote logs. Next, we follow Campbell and Viceira (2001) and use a second-order Taylor expansion to express the log portfolio return as

$$r_j^{(i),p} \approx r^f + \boldsymbol{\alpha}_j^{(i)\prime}\left(\mathbf{r} - r^f + \frac{1}{2}diag(\hat{\Sigma}_j)\right) - \frac{1}{2}\boldsymbol{\alpha}_j^{(i)\prime}\hat{\Sigma}_j\boldsymbol{\alpha}_j^{(i)} \tag{5}$$

where we have used $\hat{\Sigma}_j = \text{Var}(\mathbf{r}|\mathcal{I}_j^{(i)},\boldsymbol{\eta}_j^{(i)})$ to denote the posterior variance of the risky asset payoffs, and have dropped the subscript i since second moments are the same for all agents within a country (information sets differ only in he iid noise in the η signals). For future reference, note also that since $\mathbf{r} = \mathbf{d} - \mathbf{p}$ and $\mathbf{p}$ is in the information set of the agent, it follows that $\hat{\Sigma}_j = \text{Var}(\mathbf{d}|\mathcal{I}_j^{(i)},\boldsymbol{\eta}_j^{(i)})$.

We can then plug (5) into the objective function (4), and take expectations over the resulting log-normal variables and obtain a closed form objective function. Taking first order conditions, and solving for the portfolio shares $\boldsymbol{\alpha}$ yields:

$$\boldsymbol{\alpha} = \frac{1}{\gamma}\hat{\Sigma}_j^{-1}(E(\mathbf{r}_{t+1}|\mathcal{I}_j^{(i)}, \boldsymbol{\eta}_j^{(i)}) - r^f + \frac{1}{2}diag(\hat{\Sigma}_j))$$

Given the assumption that all factors are independent, this simplifies further to show that the holdings of agent i in country j of asset k are:

$$\alpha_{jk}^{(i)} = \frac{E(r_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)}) - r^f + \frac{1}{2}\hat{\sigma}_{kr}^2}{\gamma\hat{\sigma}_{jk}^2} \tag{6}$$

where $\hat{\sigma}_{jk}^2$ is the k-th diagonal element of $\hat{\Sigma}_j$. Thus, agents invest more heavily in assets they expect to do better and have high expected log-returns, and invest less in more uncertain assets, that have higher posterior variance on their log-returns.

3.2 Asset Market Equilibrium

In addition to the informed traders, there are also noise traders that trade the N assets for reasons orthogonal to the fundamentals $\mathbf{d}$. They are needed in order to ensure that there are more shocks than asset prices, otherwise the prices will fully span the uncertainty facing the agents. In that case, they will be able to back out the actual values of all shocks and there will be no role for private information, and no incentive to do information production (i.e. the Grossman-Stiglitz paradox). Market clearing requires that the sum of the asset demands of all informed traders equals the net demand of noise traders for each asset,

$$\sum_{j=1}^{n}\int \frac{W_{1j}^{(i)}}{N}\alpha_{jk}^{(i)} di = z_k \tag{7}$$

where we denote the net demand of noise traders for asset k as $z_k \sim iidN(\mu_{zk}, \sigma_{zk}^2)$. One can think of z_k as the "effective" supply of asset k. For example, at any given point in time, only a fraction of the total amount of government bonds outstanding are available for active trade on the open market. A large number of bonds is held for liquidity and hedging purposes, and to the extent to which those extra reasons for holdings bonds are unrelated to the financial payoffs of the bonds, they are modeled by z_k.

We guess and verify that the equilibrium price is linear in the states and of the form

$$p_k = \bar{\lambda}_k + \lambda_{dk} d_k + \lambda_{zk} z_k.$$

Thus, the price itself contains useful information about the unknown d_k, and the agents can extract the following informative signal from it,

$$\tilde{p}_k = d_k + \frac{\lambda_{zk}}{\lambda_{dk}}(z_k - \mu_z).$$

The agents combine this signal together with their private signals η and the priors, and use Bayes' rule to form posterior beliefs, leading to the following expressions for the conditional expectation and variance:

$$E(d_k|\mathcal{I}_j^{(i)}, \boldsymbol{\eta}_j^{(i)}) = \left(\frac{1}{\sigma_{dk}^2} + (\frac{\lambda_{dk}}{\lambda_{zk}}\sigma_{zk})^2 + \frac{1}{\sigma_{\eta jk}^2}\right)^{-1} \left(\frac{\mu_{dk}}{\sigma_{dk}^2} + (\frac{\lambda_{dk}}{\lambda_{zk}\sigma_{zk}})^2 \tilde{p}_k + \frac{1}{\sigma_{\eta jk}^2}\eta_{jk}^{(i)}\right)$$

$$\hat{\sigma}_{jk}^2 = \left(\frac{1}{\sigma_{dk}^2} + (\frac{\lambda_{dk}}{\lambda_{zk}}\sigma_{zk})^2 + \frac{1}{\sigma_{\eta jk}^2}\right)^{-1}$$

Note that we drop the i index on all variance terms because all agents within the same country face identical problems and hence choose the same information acquisition strategy. We can then substitute back everything into the market clearing conditions and solve for the equilibrium asset price's coefficients. The details are given in the appendix, and here we just highlight the resulting coefficients λ_{dk} and λ_{zk} which determine the informativeness of the prices. The resulting coefficients are:

$$\lambda_{zk} = -\gamma \bar{\sigma}_k^2 \left(1 + \frac{\bar{\phi}_k \bar{q}_k}{\gamma^2 \sigma_z^2}\right)$$

$$\lambda_{dk} = \bar{\sigma}_k^2 \bar{q}_k \left(1 + \frac{\bar{\phi}_k \bar{q}_k}{\gamma^2 \sigma_z^2}\right)$$

where

$$\bar{q}_k = \sum_j \frac{W_{1j}^{(i)}}{N} \frac{\hat{\sigma}_{jk}^2}{\hat{\sigma}_{jk}^2 + \sigma_e^2} \frac{1}{\sigma_{\eta_{jk}}^2}$$

is a weighted-average of the signal precisions of all market participants,

$$\bar{\sigma}_k^2 = \left(\frac{1}{N} \sum_j \frac{W_{1j}^{(i)}}{\hat{\sigma}_{jk}^2}\right)^{-1}$$

is the weighted-average posterior variance of returns.

3.3 Period 0: Information Choice

Information choice is made ex-ante, before asset markets open and agents see the actual realizations of their private signals η. However, they fully take into account how different potential information choices affect their optimal portfolio holdings and resulting wealth. Given that all country factors are independent, we can construct the agent's objective function by evaluating the expected benefits of acquiring information for each country separately and then summing over all of them. Details are given in the appendix, but by doing appropriate evaluations of expectations, we can show that the time 0 expectation of the log-objective function of an agent in country j is given by:

$$U_{0j} = (1-\gamma)\ln(\frac{W_{1j}}{\gamma - 1}) + \sum_{k \in \mathcal{H}} \frac{1}{2} \ln\left(1 + (\gamma - 1)\frac{\sigma_k^2}{\hat{\sigma}_{jk}^2}\right) + \frac{\gamma - 1}{2} \sum_{k \in \mathcal{H}} \frac{m_k^2}{\hat{\sigma}_{jk}^2 + (\gamma - 1)\sigma_k^2} \qquad (8)$$

where $m_k = E(d_k - p_k)$ is the ex-ante unconditional expected excess return on asset k based only on prior information on the unconditional distribution of asset payoffs. The set $\mathcal{H}$ is the set of countries for which the agent has decided to purchase priors and hence holds positive investments in. Note also that we drop the i index on the resulting period 1 wealth of agents, because all agents within the same country make the same information choice, hence pay the same information costs.

We solve the information choice problem in three steps. First, we solve for the optimal allocation of intensive information, given a choice of total intensive information acquired K and the set of countries that the agent has chosen to learn about $\mathcal{H}$, by solving:

$$\max_{\hat{\sigma}_{jk}^2} \sum_{k \in \mathcal{H}} \frac{1}{2} \ln \left(1 + (\gamma - 1) \frac{\sigma_k^2}{\hat{\sigma}_{jk}^2} \right) + \frac{\gamma - 1}{2} \sum_{k \in \mathcal{H}} \frac{m_k^2}{\hat{\sigma}_{jk}^2 + (\gamma - 1)\sigma_k^2} \tag{9}$$

s.t.

$$\sum_{k \in \mathcal{H}} \kappa_k \leq K$$

The details are given in the appendix, but the main result is that the agents find it optimal to allocate all intensive information to the payoff of the domestic asset so that for agents in country j, $\kappa_j = K$ and $\kappa_i = 0$ for all $i \neq j$. Intuitively, the result is due to the fact that the objective function is convex in the information allocated to any given country κ_k. Thus, agents find it optimal to specialize in acquiring intensive information about only one country. Given our assumption that the agents also get one free signal on the payoff of the domestic assets, this tips the scale towards home information, and thus agents choose to specialize in home information.

Next, taking the optimal allocation of intensive information as given, we solve for the optimal choice of the total intensive information acquired K. Since all intensive information is allocated to the home asset, the question is simply to figure out what is the optimal precision of home information. The first-order condition for this choice simplifies down to:

$$\frac{C'(K_j^*)}{W - C(K_j^*) - \Psi_j} = \frac{(\gamma - 1) \left[4\hat{\sigma}_j^2 (m_j^2 + \sigma_j^2 - (\gamma - 1) m_j \sigma_j^2) + 4(\gamma - 1)\sigma_j^4 - \hat{\sigma}_j^6 - 2(\gamma - 1)\sigma_j^2 \hat{\sigma}_j^4 \right]}{8(\hat{\sigma}_j^2 + (\gamma - 1)\sigma_j^2)^2}.$$

Given a convex information cost function $C(K)$, this defines a unique solution for total intensive information K_j^* acquired by agents in country j.

Last, we determine the optimal number of countries about which agents choose to purchase information on the unconditional distribution of asset payoffs, i.e. the extensive margin information choice. The cost of adding an asset to the learning (and hence investment portfolio) is a fixed amount c that agents need to pay for the due diligence study. The gain is derived from expecting to earn positive excess returns on the asset (on average). The detailed characterization of this choice is presented in the Appendix, but the key intuition for why it is uniquely determined is the fact that the marginal cost of adding an additional asset to the learning portfolio is increasing.

This happens for two reasons. First, marginal utility of investable wealth W_{1j} is declining, and the more resources an agent spends on due diligence studies (Ψ_j) the fewer are left for portfolio investment. As a result, even though all due diligence studies cost the same fixed amount c in terms of wealth, each additional study has an increasing utility cost because it decreases investable wealth further and further. Second, lower investable wealth also translates to a lower optimal choice of K^* and therefore lower utility from the home asset holdings (the ones you purchase extra intensive information about). Thus, increasing the breadth of the portfolio carries increasing costs but a fixed benefit – the expected gain of adding one more asset to your portfolio. As a result, unless the fixed cost of acquiring priors is very small relative to the agent's initial wealth, it is unlikely that the agent will learn about all available assets. This generates sparse foreign portfolios, with the level of sparseness varying with the wealth level of the agent.

3.4 Model Implications

The model is able to match the stylized portfolio facts that we documented earlier, and Proposition 1 formalizes these implications.

Proposition 1. *In a symmetric world where all countries are ex-ante identical, the equilibrium portfolio holdings of an agent in country j, $\boldsymbol{\alpha}_j = [\alpha_{j1}, \ldots, \alpha_{jN}]$, display the following features:*

1. ***Sparseness:*** *Agents do not necessarily invest in all available foreign assets, i.e. $\alpha_{jk} = 0$ for some k.*

2. ***Sparseness decreases with wealth:*** *The number of countries k for which $\alpha_{jk} = 0$ is decreasing with $W_{1j}^{(i)}$, i.e. the size of the agent's investment portfolio*

3. ***Foreign bias concentrated around zero:*** *All foreign assets that the agent invests a positive quantity in are held in the same proportions relative to one another, as their market weights. Formally, if $k, k' \in \mathcal{H}$, then*

$$\alpha_{jk} = \alpha_{jk'}$$

and hence the expected Foreign Bias index for those holdings is zero:

$$E(Bias_j) = 1 = \frac{1 - \frac{1}{\tilde{N}}}{1 - \frac{1}{\tilde{N}}} = 0$$

where $\tilde{N} = |\mathcal{H}|$ is the cardinality of the set of foreign countries that the agent learns about and thus has a positive exposure to.

Proof. Intuition sketched in the text, details in the Appendix. □

The first result, sparseness, is a direct consequence of the two-tiered information structure of the model. Since agents need to first acquire a basic understanding of a given market before they enter it (i.e. learn the unconditional mean of the asset payoff), they do not necessarily enter all markets and as a result portfolios tend to be sparse and feature cases of $\alpha_{jk} = 0$. The agent will add new assets to their portfolio up to the point at which the cost of doing a new initial country study exceeds the gain of doing so. The gain is pretty straightforward – the agent likes to add new assets to his portfolio because they offer (1) positive excess returns and (2) diversification benefits.

The cost is simply c in financial terms, and its effect on utility works directly through reducing the portfolio wealth of the individual – the $\ln(W_{1j})$ term in equation (8). Since the log is a concave function, the cost of learning about more countries (i.e. the reduction in $\ln(W_{1j})$ caused by spending c on a new due diligence study) is increasing in the number of countries one has already learned about. In the symmetric equilibrium of Proposition 1, the gain of learning about an additional country is constant, hence there is an optimal number of foreign countries that the agent will learn about. This could be zero (i.e. only invest in the home country) if the agent's wealth is sufficiently low. But at higher levels of wealth, the utility cost of adding new countries is lower, hence richer agents would learn about at least some of the foreign countries, and possibly all foreign countries given enough wealth. This last observation is also behind the second result that the sparseness of the portfolio is decreasing in the agent's wealth.

Lastly, consider the positive foreign holdings of the agent and how they relate to one another. Recall that the agent finds it optimal to specialize in acquiring additional intensive information only about the home asset. Thus, for all foreign assets he relies only on publicly available information and his priors. In a symmetric world where all countries are ex-ante identical, the relative informativeness of the equilibrium prices of the different assets will be the same as well. Therefore, the posterior variance of foreign assets payoffs, which only relies on priors and the information contained in prices, is the same. Thus, the expected optimal portfolio weight of a foreign asset k is:

$$E(\alpha_{jk}) = \frac{m - r^f + \frac{1}{2}\tilde{\sigma}^2}{\gamma\tilde{\sigma}^2}$$

where $m = m_k$ for all k is the expected excess return on the risky assets. As a result, the foreign bias of any foreign holding is the same, and is in fact zero.[11]

[11] For now we have only proved this last result on zero foreign bias in the symmetric world case. However, we conjecture that the bias would be heavily concentrated around zero in an asymmetric world as well, because of the same intuition that agents would rely only on public information about all foreign assets. They will not specifically generate any excess information asymmetry through their private learning.

4 Empirical Tests

As we have seen, this model with two-tiered information cost structure can rationalize the stylized portfolio facts documented in Section 2.2, but is this mechanism empirically relevant? To examine this question, we directly test the model's key implications in the data. We derive two sets of implications that are crucial to the inner-workings of the mechanism, and examine each of them in the following sections. First we test whether portfolio sparseness follows sparseness in information (extensive margin). Second, we test whether optimism and accuracy of forecasts matter for actual portfolio holdings (intensive margin).

4.1 Extensive Margin of Information and Portfolios

In our model, the sparseness of portfolios follows directly from the sparseness of information. In our two-tiered information structure, we follow Merton (1987) and assume that agents only hold assets for which they have done due diligence and performed an initial country study. Due to the fixed costs of those initial studies, agents may optimally choose to not acquire any information about certain countries and, as a result, do not invest anything in them, leading to sparse portfolios. In this section, we examine whether sparseness of information is indeed associated with sparseness of portfolios in our dataset.

Since every bank invests in its domestic country, we restrict the sample to foreign holdings only and estimate the following regression:

$$Share_{bct} = \beta ForeignFcst_{bct} + \mu_{bt} + \gamma_{ct} + \varepsilon_{bct} \tag{10}$$

where $Share_{bct}$ is the share of country c in bank b's portfolio at time t and $ForeignFcst_{bct}$ is a dummy variable that equals 1 if bank b makes a 10–year yield forecast about country c at time t, and 0 otherwise. Finally, μ_{bt} and γ_{ct} represent bank-time and country-of-destination-time fixed effects, respectively.

The results are presented in Table 4 – Panel A: when a bank makes a forecast for a foreign country, it has a sovereign exposure to that country about two standard deviations higher. We progressively saturate the model with fixed effects in order to make sure that unobserved heterogeneity does not affect the main result. We start with no fixed effects in column (1), we then add time (column (2)), bank (column (3)), destination country (column (4)) and finally bank–time (column (5)) and country–time (column (6)) fixed effects. Basically, in the last specification we are only using variation across foreign holdings for the same bank at the same time, absorbing all other country–level shocks. In all cases the coefficient on $ForeignFcst_{bct}$ is remarkably stable. The results are a strong indication that information acquisition is a key driver of bank foreign exposures.

Next, in Table 4 – Panel B we specifically examine if sparseness of portfolios is associated with sparseness in information sets. To this purpose, we replace the continuous dependent variable, $Share_{b,c,t}$, with a dummy, $\mathbf{1}(Share_{b,c,t})$, that is equal to 1 if bank b holds any positive amount of country c's sovereign debt, and zero otherwise. Here the results indicate that if a bank makes a foreign forecast for a country it is around 20–40% more likely to hold sovereign bonds from that country.

Our model covers only tradable portfolio assets such as a government bond, which is why we focus on sovereign debt holdings in most of the empirical analyses. However, we also have data on another important asset class on a bank's balance sheet − loans. Loans are illiquid and not easily tradable assets, hence our model does not apply directly to them. However, one could argue that the decision to enter a foreign credit market also hinges on information acquisition about the country. In particular, banks pay a fixed-cost, presumably larger than for sovereign debt, to acquire information about the country before they lend to the private sector. Thus, in Table 5 we replicate the extensive margin regressions we presented above but changing the dependent variable to foreign credit. The results are largely unchanged.

4.2 Intensive Margin of Information and Portfolios

Lastly, we look at the specific relationship between the precision of beliefs and portfolio shares in the data. In the model, the optimal portfolio share for an asset k for which an agent pays the fixed information cost c is:

$$\alpha_k = \frac{E(r_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)}) - r^f}{\gamma\hat{\sigma}_k^2} + \frac{1}{2\gamma} \tag{11}$$

This puts specific restrictions on the relationship between portfolio shares, expected returns and the precision of those expectations as summarized in Proposition 2 below.

Proposition 2. ***(Comparative Statics)*** *The optimal portfolio share of asset k in the portfolio of agent i in country j is*

1. ***Increasing in the conditional expected return*** $E(r_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)})$***:***

$$\frac{\partial \alpha_{jk}}{\partial E(r_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)})} = \frac{1}{\gamma\hat{\sigma}_{jk}^2} > 0$$

2. ***Increasing (decreasing) in the precision of beliefs:***

$$\frac{\partial \alpha_{jk}}{\partial \hat{\sigma}_k^2} = -\frac{E(r_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)}) - r^f}{\gamma\hat{\sigma}_k^4} < 0 \iff E(r_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)}) - r^f > 0$$

3. ***More elastic to expected returns the higher the precision of beliefs:***

$$\frac{\partial^2 \alpha_{jk}}{\partial E(r_k|\mathcal{I}_j^{(i)}, \eta_{jk}^{(i)})\partial\hat{\sigma}_{jk}^2} = -\frac{1}{\gamma\hat{\sigma}_{jk}^4} < 0$$

Proof. Follows directly from derivating equation (6). □

Thus, as demonstrated in Proposition 2, agents will hold more of a given asset the more optimistic they are about its returns ($\frac{\partial\alpha}{\partial E(r)} > 0$), and the more certain they are in their expectation – i.e. the lower the dispersion of their beliefs is ($\frac{\partial\alpha}{\partial\sigma^2} < 0$); moreover, the portfolio sensitivity to beliefs ($\frac{\partial \alpha}{\partial E(r)}$) increases with the precision of beliefs – i.e. when a bank becomes optimistic about a country, it reallocates more of its portfolio towards that country the more precise its beliefs about that country are ($\frac{\partial^2 \alpha}{\partial E(r)\partial \sigma^2} < 0$).[12]

In the rest of the section, we seek to test these implications of the information model. In particular, we estimate the following regression:

$$Share_{bct} = \beta_1 \overline{SFE}(Y10_{bct}) + \beta_2 Y10_{bct} + \beta_3 \overline{SFE}(Y10_{bct}) \times Y10_{bct} + \mu_{bt} + \gamma_{ct} + \varepsilon_{bct} \quad (12)$$

where $Share_{bct}$ is the share of country c in bank b's portfolio at time t, $Y10_{bct}$ is the 3-month ahead forecast made by bank b regarding the 10–year yield on country c's sovereign debt, and $\overline{SFE}(Y10_{bct})$ is bank b's average squared forecast error regarding $Y10$. Finally, μ_{bt} and γ_{ct} are bank-time and country-of-destination-time fixed effects, respectively.

Given the results in Proposition 2, the model puts sign restrictions on the β coefficients in the above regression. First, it implies that $\beta_1 < 0$ because portfolio shares are decreasing in the uncertainty of banks' forecasts – hence the higher is the average squared forecast error of a bank's forecast about a particular country, the lower should that bank's investments in that country be. Second, $\beta_2 < 0$ since investments in a given country's sovereigns are increasing in the expected return on that sovereign bond, and higher expected yields are associated with lower future prices, and hence lower expected returns. And third, $\beta_3 > 0$ since the portfolio shares' sensitivity to expected returns is increasing in the precision of the return forecast. In the above regression, the sensitivity of the portfolio share to changes in the forecast of future yields is given by:

$$\frac{\partial Share_{bct}}{\partial Y10_{bct}} = \beta_2 + \beta_3 \overline{SFE}(Y10_{bct})$$

Since we expect $\beta_2 < 0$ and the model predicts that more precise information (lower SFE)

[12] Although the above equations and comparative statics are only partial equilibrium expressions, they are still useful to gain intuition as the results carry over to general equilibrium as well. For more details see the Appendix.

would further add to this negative effect, we therefore expect that β_3 is positive. To sum up, the model predicts that $\beta_1 < 0$, $\beta_2 < 0$, and $\beta_3 > 0$.

The intensive margin results are displayed in Tables 6 and 7. The two tables differ as to their treatment of domestic exposures, and we split the analysis in two like this because of the large home bias in the data. Table 6 sidesteps the home bias issue and tests the model's implications outlined above using only foreign holdings (thus it does not ask the model to fully explain the large amount of home bias we observe in the data). On the other hand, Table 7 uses the full sovereign portfolio and controls for any potentially unexplained home bias by including two additional dummy variables: $Home$ for domestic exposures and $Home \times GIIPS$ for domestic exposures of banks located in peripheral countries. Indeed, the European sovereign debt crisis highlighted how sovereign distress feeds back into distress of the domestic banking sector; this is primarily due to the considerable home bias of banks located in the periphery (DeMarco and Macchiavelli (2015), Ongena et al. (2016)). The sample is restricted to be the same in both tables, so that these are banks that have at least one foreign exposure in addition to the domestic one.

Consistent with the predictions of our model, more precise information impacts portfolio holdings both directly and indirectly: more accuracy (lower SFE) not only leads to higher holdings (direct effect), but it also amplifies the effect of expectations on holdings, making portfolio shares more sensitive to changes in forecasts (indirect/amplification effect). Regardless of how we deal with home bias, the intensive margin results are unaffected and strongly support the model's predictions. More importantly, no matter how much we saturate the model with fixed effects, results are robust. Except for β_2 which loses significance in the last column when we include both country-time and bank-time fixed-effects, all coefficients remain statistically significant and with the correct sign as predicted by the model.

The estimated coefficients are also economically significant; let us consider the last column of Table 6 which uses foreign holdings only and includes both bank-time and destination country-time fixed effects. The effect of uncertainty is large: a one standard deviation decrease in $\overline{SFE}$ (0.32) at the average 10-year yield forecast (3.75%) is associated with a 1.2 percentage points increase in sovereign debt holdings, which is about one tenth of a standard deviation increase in portfolio holdings.[13] The economic significance of the amplification effect of information precision (β_3) is also sizable. To illustrate return to the previous example of a one standard deviation decrease in $\overline{SFE}$ – had the point forecast of the 10–year yield been one standard deviation (2%) below the mean (so that expected returns would have been one standard deviations above their mean), holdings would have further increased by an additional 2.77%, more than doubling the original effect of 1.2%.

Finally, Table 7 shows that the results are robust to using the full sovereign debt portfolio of banks, including their heavily overweighted home investments. Moreover, those results also suggest that while relevant, information frictions alone cannot explain the full extent of the home bias we observe in the data. We can see that from the fact that the extra home dummies are highly significant and positive, especially for the peripheral banks, meaning that home exposures are larger than what can be attributed to the greater precision and possibly greater optimism of the domestic forecasts relative to the foreign ones. Thus, we can conclude that information frictions matter particularly strongly for understanding the composition of foreign holdings, but are only part of the story of the apparent heavy preference for home assets.

5 Conclusion

In this paper we study whether information frictions can explain the heterogeneity in banks' sovereign debt holdings. We go beyond the standard home versus foreign divide, and analyze the entire portfolio allocation. In order to empirically connect information frictions with portfolio holdings, we take advantage of banks' sovereign exposure data from EBA, matched with banks' forecasts from Consensus Economics. The empirical findings suggest

[13] The relevant summary statistics for the sample on the intensive margin are found in Table 2, Panel C, third to last row.

that information frictions are at the core of both extensive (which countries to invest in) and intensive (how much to allocate in each chosen country) margins of the portfolio allocation problem.

Regarding the extensive margin, we show that the typical bank sovereign portfolio is sparse: it has a large exposure to its domestic sovereign, a few other foreign countries and no exposure to most other countries. Moreover, having acquired information on a certain country strongly predicts the likelihood of investing in such country. We also confirm previous results that banks have more precise information about their own domestic country relative to foreign countries.

Turning to the intensive margin, we show that optimism and accuracy of information about a country strongly predict higher portfolio holdings of that country's sovereign debt. Moreover, we also document that precise information amplifies the sensitivity of portfolio holdings to changes in expectations: for a given improvement in bank's forecasts about a country, receiving more accurate information predicts a larger portfolio allocation towards that country's sovereign debt.

Finally, we show that a model with information frictions and a two–tiered information structure with a fixed–cost of acquiring information can rationalize all of these findings: stylized facts about portfolio sparseness, the connection between information acquisition and sparseness (extensive margin), and the role of optimism and information precision in determining the intensity of portfolio holdings (intensive margin).

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Table 1: Variable Definition

This table contains the definition of variables used in all the empirical analyses.

Variable	Definition	TimePeriod	Data source
$\text{Y10}_{b,c,t}$	3–months ahead forecast for 10 –year sovereign bond yield of country c from forecaster b at time t	2006M9–2014M12	Consensus
$\text{SFE}(X_{b,c,t})$	Squared Forecast Error = $(\mathbb{E}_{t-h}(X_t) - X_t)^2$	2006M9–2014M12	Consensus
$\overline{SFE}(X_{b,c})$	Average SFE $=\sum_t SFE(X_{b,c,t})$	2006M9–2014M12	Consensus
$\text{Home}_{b,t}$	Dummy = 1 for domestic forecast		Consensus
$\text{ForeignFcst}_{b,c,t}$	Dummy = 1 if forecaster b makes a 10–year yield forecast for country c at time t		EBA–Consensus match
$\text{ShareSovEEA}_{b,c,t}$	Share of sovereign bonds of country c (EEA only) in bank b sovereign portfolio	2010Q1–2013Q4	EBA
$\text{ShareCredEEA}_{b,c,t}$	Share of credit to country c (EEA only) in bank b lending portfolio	2010Q1–2013Q4	EBA

Table 2: Summary Statistics

This table provides summary statistics for all variables used in the empirical analyses.

Variable	Mean	Std. Dev.	25th pct.	50th pct.	75th pct.	90th pct.	99th pct.	N
Panel A. Consensus Economics (all forecasters)								
$Y10_{b,c,t}$	3.44	1.52	2.2	3.5	4.35	5.2	7.88	15204
$SFE(Y10_{b,c,t})$	0.36	0.60	.02	0.12	0.41	1	3.45	15187
$\overline{SFE}(Y10_{b,c})$	0.46	0.56	0.17	0.32	0.48	0.88	3.19	340
Home	0.60	0.48	0	1	1	1	1	15187
Panel B. EBA–Consensus Economics (extensive margin - including the 0s)								
$ShareSovEEA_{b,c,t}$	4.53	14.32	0	0.11	1.62	9.35	88.77	5830
$\mathbf{1}(ShareSovEEA_{b,c,t})$	0.613	0.487	0	1	1	1	1	5830
$ShareSovEEA_{b,c,t}$|Home=0	2.08	6.28	0	0.08	1.22	4.89	28.57	5570
$\mathbf{1}(ShareSovEEA_{b,c,t})$|Home=0	0.595	0.490	0	1	1	1	1	5830
$ForeignFcst_{b,c,t}$	0.031	0.162	0	0	0	0	1	5909
Panel C. EBA–Consensus Economics (intensive margin - excluding the 0s)								
$ShareSovEEA_{b,c,t}$	20.46	23.95	3.2	9.50	27.87	58.57	90.73	285
$\overline{SFE}(Y10_{b,c})$	0.46	0.29	0.29	0.36	0.52	0.84	1.58	285
$Y10_{b,c,t}$	3.50	1.54	2.3	3.1	4.3	5.8	8.1	285
$ShareSovEEA_{b,c,t}$|Home=0	12.37	17.73	1.41	5.72	13.8	33.2	72.3	206
$\overline{SFE}(Y10_{b,c})$|Home=0	0.49	0.32	0.30	0.37	0.49	1.10	1.58	206
$Y10_{b,c,t}$|Home=0	3.75	1.65	2.4	3.5	4.8	6.2	8.1	206

Table 3: Are Home Forecasters Better?

This table provides estimates for equation (1). The dependent variable is the average squared forecast error of bank b regarding the 3-month ahead forecast on country c's 10–year yield ($\overline{SFE}$(Y10)). Home is a dummy equal to one if the forecaster is domestic, zero otherwise. EBA_bank is a dummy equal to one if the forecaster is an EBA bank. Standard errors are clustered at the forecaster level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Home	-0.241***	-0.436***	-0.294**	-0.295***	-0.515**	-0.441**
	(0.068)	(0.133)	(0.123)	(0.091)	(0.192)	(0.199)
EBA_bank				-0.132		
				(0.124)		
Home ×				0.171	0.218	0.364
EBA_bank				(0.133)	(0.238)	(0.227)
Observations	335	197	197	335	197	197
N of Forecasters	182	44	44	182	44	44
Forecaster FE	no	yes	yes	no	yes	yes
Destination Country FE	no	no	yes	no	no	yes

Table 4: Extensive Margin: Foreign Sovereign Exposures and Foreign Forecast

This table provides the estimates for equation (10). The dependent variable is the share of EEA country c in bank b sovereign portfolio in Panel A and a dummy equal to one if bank b holds a positive amount of sovereign bonds of EEA country c in Panel B. The sample is restricted to foreign countries only. $\text{ForeignFcst}_{b,c,t}$ is a dummy equal to one if bank b makes a 10–year yield forecast for country c in year t and zero otherwise. Standard errors are two–way clustered at the bank and country level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Panel A: Dependent variable $ShareSovEEA_{b,c,t}$ for non–domestic exposures

	(1)	(2)	(3)	(4)	(5)	(6)
ForeignFcst	13.64**	13.64**	13.56**	12.47**	12.52**	12.70**
	(4.879)	(4.888)	(5.271)	(5.170)	(5.207)	(5.270)
Observations	5566	5566	5566	5566	5566	5566
Adj. R^2	0.121	0.120	0.147	0.258	0.243	0.216
N of Banks	35	35	35	35	35	35
N of Countries	23	23	23	23	23	23

Panel B: Dependent variable $\mathbf{1}(ShareSovEEA_{b,c,t})$ for non–domestic exposures

	(1)	(2)	(3)	(4)	(5)	(6)
ForeignFcst	0.457***	0.459***	0.322***	0.219*	0.220*	0.219*
	(0.060)	(0.061)	(0.076)	(0.117)	(0.117)	(0.119)
Observations	5566	5566	5566	5566	5566	5566
Adj. R^2	0.0219	0.0269	0.224	0.385	0.386	0.379
N of Banks	35	35	35	35	35	35
N of Countries	23	23	23	23	23	23
Time FE	no	yes	yes	yes	yes	yes
Bank FE	no	no	yes	yes	no	yes
Destination country FE	no	no	no	yes	yes	yes
Country–Time FE	no	no	no	no	yes	yes
Bank–Time FE	no	no	no	no	no	yes

Table 5: Robustness: Extensive Margin: Foreign Credit Exposures and Foreign Forecast

This table provides the estimates for equation (10). The dependent variable is the share of credit to EEA country c in bank b lending portfolio in Panel A and a dummy equal to one if bank b lends a positive amount to EEA country c in Panel B. The sample is restricted to foreign countries only. $\text{ForeignFcst}_{b,c,t}$ is a dummy equal to one if bank b makes a 10–year yield forecast for country c in year t and zero otherwise. Standard errors are two–way clustered at the bank and country level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Panel A: Dependent variable $ShareCredEEA_{b,c,t}$ for non–domestic exposures

	(1)	(2)	(3)	(4)	(5)	(6)
ForeignFcst	0.122^{**}	0.122^{**}	0.127^{**}	0.119^{**}	0.119^{**}	0.122^{**}
	(0.051)	(0.051)	(0.056)	(0.057)	(0.057)	(0.057)
Observations	4114	4114	4114	4114	4114	4114
Adj. R^2	0.138	0.138	0.170	0.213	0.192	0.165
Time FE	no	yes	yes	yes	no	no
Bank FE	no	no	yes	yes	no	no
Destination country FE	no	no	no	yes	no	no
Country–Time FE	no	no	no	no	yes	yes
Bank–Time FE	no	no	no	no	no	yes

Panel B: Dependent variable $\mathbf{1}(ShareCredEEA_{b,c,t})$ for non–domestic exposures

	(1)	(2)	(3)	(4)	(5)	(6)
ForeignFcst	0.380^{***}	0.382^{***}	0.471^{***}	0.316^{***}	0.323^{***}	0.351^{***}
	(0.102)	(0.105)	(0.081)	(0.108)	(0.106)	(0.109)
Observations	4114	4114	4114	4114	4114	4114
Adj. R^2	0.0181	0.104	0.222	0.352	0.369	0.443
N of Banks	36	36	36	36	36	36
N of Countries	26	26	26	26	26	26
Time FE	no	yes	yes	yes	no	no
Bank FE	no	no	yes	yes	no	no
Destination country FE	no	no	no	yes	no	no
Country–Time FE	no	no	no	no	yes	yes
Bank–Time FE	no	no	no	no	no	yes

Table 6: Intensive Margin – Foreign Exposures Only

This table provides the estimates for equation (12). The dependent variable is the share of EEA country c sovereign bonds in bank b sovereign portfolio. The independent variables are defined in Table 1. Standard errors are two–way clustered at the bank and country level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)
$\overline{SFE}(Y10)$	-35.47**	-13.02*	-17.67*	-22.48***	-22.68**
	(15.367)	(6.707)	(8.173)	(6.618)	(6.426)
Y10	-3.867*	-1.705**	-2.030***	-2.745*	-2.369
	(2.000)	(0.612)	(0.520)	(1.341)	(1.222)
$\overline{SFE}(Y10) \times Y10$	5.946**	2.589**	3.606**	4.438***	4.799***
	(2.456)	(0.822)	(1.107)	(1.017)	(0.788)
Observations	206	206	148	192	125
Adj. R^2	0.797	0.853	0.739	0.852	0.580
N of Banks	17	17	7	17	7
N of Destination Countries	11	11	11	9	8
Time FE	yes	yes	yes	yes	yes
Bank FE	yes	yes	yes	yes	yes
Destination Country FE	no	yes	yes	yes	yes
Bank–Time FE	no	no	yes	no	yes
Destination Country–Time FE	no	no	no	yes	yes

Table 7: Intensive Margin – Domestic and Foreign Exposures

This table provides the estimates for equation (12). The dependent variable is the share of EEA country c sovereign bonds in bank b sovereign portfolio. The three main independent variables are defined in Table 1; Home equals one for domestic forecasts only; GIIPS equals one only for banks located in either Greece, Ireland, Italy, Portugal or Spain. Standard errors are two–way clustered at the bank and country level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)
$\overline{SFE}(Y10)$	-13.80	-43.87*	-54.66*	-59.59**	-60.57**
	(25.706)	(21.056)	(25.458)	(24.596)	(26.056)
Y10	-3.167	-4.200**	-4.026*	-3.530	-1.581
	(2.657)	(1.487)	(1.810)	(2.384)	(3.516)
$\overline{SFE}(Y10) \times Y10$	3.361	6.989**	9.226**	10.28**	11.09**
	(3.844)	(2.624)	(3.399)	(3.780)	(3.954)
Home	21.52**	10.64	10.62	9.636	11.42
	(9.121)	(7.312)	(8.706)	(7.911)	(9.182)
Home × GIIPS		68.82***	70.46***	74.54***	70.44***
		(14.436)	(16.775)	(14.073)	(16.612)
Observations	285	285	234	274	222
Adj. R^2	0.609	0.809	0.644	0.780	0.468
N of Banks	17	17	14	17	14
N of Destination Countries	11	11	11	11	10
Time FE	yes	yes	yes	yes	yes
Bank FE	yes	yes	yes	yes	yes
Destination Country FE	no	yes	yes	yes	yes
Bank–Time FE	no	no	yes	no	yes
Destination Country–Time FE	no	no	no	yes	yes

Appendix

A Solving the Model

In period 2, the agents face the problem

$$\max_{\boldsymbol{\alpha}_j^{(i)\prime}} E\left[\frac{(W_{2j}^{(i)})1-\gamma}{1-\gamma}|\mathcal{I}_j^{(i)},\boldsymbol{\eta}_j^{(i)}\right]$$

s.t.

$$W_{2j}^{(i)} = \underbrace{(W_0 - \Psi_j^{(i)} - C(K_j^{(i)}))}_{W_{1j}^{(i)}} R_j^{p,(i)} = W_{1j}^{(i)}(\boldsymbol{\alpha}_j^{(i)\prime}\mathbf{R} + (1-\boldsymbol{\alpha}_j^{(i)\prime}\mathbf{1})R^f)$$

where $\Psi_j^{(i)} = \sum_k \iota_{jk} c$ is the total expenditure of the agents in country j on prior information (ι_{jk} is 1 if the agent purchases information about the k-th country, and zero otherwise), and $K_j^{(i)}$ is the total amount of intensive information acquired. Thus, the wealth available for investing at the beginning of period 1 is

$$W_{1j}^{(i)} = W_0 - \Psi_j^{(i)} - C(K_j^{(i)})$$

Substituting the constraint out, the maximization problem is equivalent to

$$\max_{\boldsymbol{\alpha}_j^{(i)\prime}} \frac{(W_{1j}^{(i)})^{1-\gamma}}{1-\gamma} E\left[\exp((1-\gamma)r_j^{(i),p})|\mathcal{I}_j^{(i)},\boldsymbol{\eta}_j^{(i)}\right] \tag{13}$$

where lower case letters denote logs. Next, we follow Campbell and Viceira (2001) and use a second-order Taylor expansion to express the log portfolio return as

$$r_j^{(i),p} \approx r^f + \boldsymbol{\alpha}_j^{(i)\prime}\left(\mathbf{r} - r^f + \frac{1}{2}diag(\hat{\Sigma}_j)\right) - \frac{1}{2}\boldsymbol{\alpha}_j^{(i)\prime}\hat{\Sigma}_j\boldsymbol{\alpha}_j^{(i)} \tag{14}$$

where we have used $\hat{\Sigma}_j = \text{Var}(\mathbf{r}|\mathcal{I}_j^{(i)}, \boldsymbol{\eta}_j^{(i)})$ to denote the posterior variance of the risky asset payoffs, and have dropped the subscript i since second moments are the same for all agents within a country (information sets differ only in he iid noise in the η signals). For future reference, note also that since $\mathbf{r} = \mathbf{d} - \mathbf{p}$ and $\mathbf{p}$ is in the information set of the agent, it follows that $\hat{\Sigma}_j = \text{Var}(\mathbf{d}|\mathcal{I}_j^{(i)}, \boldsymbol{\eta}_j^{(i)})$.

Lastly, plugging (14) into the objective function (13) and taking expectations over the resulting log-normal variable yields the following objective function:

$$\frac{(W_{1j})^{1-\gamma}}{1-\gamma} \exp\left((1-\gamma)\left(r^f + \boldsymbol{\alpha}'\left(E_{1j}(\mathbf{r}) - r^f + \frac{1}{2}diag(\hat{\Sigma}_j)\right) - \frac{1}{2}\boldsymbol{\alpha}'\hat{\Sigma}_j\boldsymbol{\alpha}\right) + \frac{(1-\gamma)^2}{2}\boldsymbol{\alpha}'\hat{\Sigma}_j\boldsymbol{\alpha}\right)$$

where with a slight abuse of notation we have dropped the i subscript for convenience, and use the notation $E_{1j}(.) = E(.|\mathcal{I}^{(i)})$ to denote the conditional expectation of the agent using all of the information available to him at time 1. All agents in the same country face identical information choice problems, hence make identical information choices. Thus, their beliefs only differ in their means as a result of the idiosyncratic noise in the informative signals η. This washes out in equilibrium and does not affect most of the relationships we are interested in solving for, hence we can for now ignore the i subscript.

Taking first order conditions, and solving for the portfolio shares $\boldsymbol{\alpha}$ yields:

$$\boldsymbol{\alpha} = \frac{1}{\gamma}\hat{\Sigma}_r^{-1}(E_1(\mathbf{r}) - r^f + \frac{1}{2}diag(\hat{\Sigma}_r))$$

Furthermore, given the assumption that all factors are independent, this reduces to

$$\alpha_k = \frac{E_1(r_k) - r^f}{\gamma\hat{\sigma}_k^2} + \frac{1}{2\gamma}$$

for all assets k.

A.1 Asset Market Equilibrium

The market clearing condition for asset k is:

$$z_k = \frac{1}{N}\sum_{j\in\mathcal{B}_k} W_{1j}\frac{\hat{\sigma}^2_{jk}\left(\frac{m_k}{\sigma^2_{dk}} + (\frac{\lambda_{dk}}{\lambda_{zk}\sigma_{zk}})^2(d_k + \frac{\lambda_{zk}}{\lambda_{dk}}(z_k - \mu_{zk})) + \frac{1}{\sigma^2_{\eta jk}}d_k\right) - (\bar{\lambda}_k + \lambda_{dk}d_k + \lambda_{zk}z_k) - r^f + \frac{1}{2}(\hat{\sigma}^2_{jk})}{\gamma\hat{\sigma}^2_{jk}}$$

where the set $\mathcal{B}_k$ is the set of all countries whose agents choose to purchase prior information about asset k. Matching coefficients, we get

$$\bar{\lambda}_k = \underbrace{\left(\frac{1}{N_k}\sum_{j\in\mathcal{B}_k}\frac{W_{1j}}{\hat{\sigma}^2_{jk}}\right)^{-1}}_{=\bar{\sigma}^2_k}\left[\underbrace{\left(\frac{1}{N_k}\sum_{j\in\mathcal{B}_k} W_{1j}\right)}_{=\bar{\phi}_k}(\frac{m_{dk}}{\sigma^2_{dk}} - \frac{\lambda_{dk}}{\lambda_{zk}\sigma^2_{zk}}\mu_{zk}) + \sum_{j\in\mathcal{B}_k}\frac{W_{1j}}{2N}\right] - r^f$$

where we define two useful quantities for later use – 1) the (wealth-weighted) posterior variance of the average market participant in the market of asset k, $\bar{\sigma}^2_k$, and 2) the average wealth of the market participants in the market for ass k, $\bar{\phi}_k$. Similarly,

$$\lambda_{zk} = -\gamma\bar{\sigma}^2_k\left(1 + \frac{\bar{\phi}_k\bar{q}_k}{\gamma^2\sigma^2_z}\right)$$

$$\lambda_{dk} = \bar{\sigma}^2_k\bar{q}_k\left(1 + \frac{\bar{\phi}_k\bar{q}_k}{\gamma^2\sigma^2_z}\right)$$

where

$$\bar{q}_k = \sum_{j\in\mathcal{B}_k}\frac{W_{1j}}{N_k}\frac{1}{\sigma^2_{\eta_{jk}}}$$

is a weighted-average of the signal precisions of the different agents, and $N_k = |\mathcal{B}_k|$ is cardinality of $\mathcal{B}_k$ – i.e. the number of countries whose agents choose to learn about asset k.

Thus, we have confirmed that the equilibrium price is linear and solved for its equilibrium coefficients.

A.2 Information Choice

In period 0 agents solve for the optimal information strategy, given their knowledge of optimal portfolios as a function of information (the solution to period 1 problem discussed above). First, we compute the time 1 expected utility conditional on an information choice. Using the optimal portfolio shares computed before, and evaluating the expected utility, conditional on the agent's full information set gives

$$E_{1j}\left[\frac{W_{1j}^{1-\gamma}}{1-\gamma}\exp\left((1-\gamma)r_j^p\right)\right]=\frac{W_{1j}^{1-\gamma}}{1-\gamma}\exp\left((1-\gamma)r^f+\frac{1-\gamma}{2\gamma}\hat{\mu}_j'\hat{\Sigma}_j^{-1}\hat{\mu}_j\right) \tag{15}$$

where $\hat{\mu}_j = E_{1j}(\mathbf{r}) - r^f + \frac{1}{2}diag(\hat{\Sigma}_j)$. Conditional on just the priors of agents in country j (i.e. ex-ante), this is a Normal random variable, with the distribution $\hat{\mu}_j \sim N(\mathbf{m}_j, \Sigma - \hat{\Sigma}_j)$ where $\mathbf{m}_j$ is a Nx1 vectors with the following elements:

$$m_k = \bar{\sigma}_k^2\left(\gamma\mu_{zk} - \frac{1}{2}\bar{\phi}_k\right) + \frac{1}{2}\hat{\sigma}_{jk}^2$$

Thus, ex-ante excess return is increasing in the effective supply of the asset μ_{zk} and decreasing in the average invested wealth $\bar{\phi}_k$. Moreover, the variance of $\hat{\mu}_j$ is a diagonal matrix with the following diagonal elements

$$(\Sigma - \hat{\Sigma}_j)_{kk} = \underbrace{\bar{\sigma}_k^2(\bar{\phi}_k + (\gamma^2\sigma_z^2 + \bar{\phi}_k\bar{q}_k)\bar{\sigma}_k^2)}_{\sigma_k^2} - \hat{\sigma}_{jk}^2$$

To get better intuition, note that $\sigma_k^2 = \mathrm{Var}(d_k - p_k)$; thus σ_k^2 is the unconditional volatility of the excess return. Lastly, the above expected utility (15) was *conditional* on a choice of $\hat{\Sigma}_j$ and particular realizations of the informative signals. To compute the optimal information choice, we need to take its ex-ante expectation (meaning expectation over the actual realizations of signals and resulting asset prices). Doing so gives us

$$\begin{aligned}
E_{0j}\left[\frac{W_{1j}^{1-\gamma}}{1-\gamma}\exp\left((1-\gamma)r_j^p\right)\right] &= \frac{W_{1j}^{1-\gamma}}{1-\gamma}E_{0j}\left[E_{1j}[\exp((1-\gamma)r_j^p)]\right] \\
&= \frac{W_{1j}^{1-\gamma}}{1-\gamma}\exp((1-\gamma)r^f)E_0\left[\exp\left(\frac{1-\gamma}{2\gamma}\hat{\mu}_j'\hat{\Sigma}_j^{-1}\hat{\mu}_j\right)\right] \\
&= \frac{W_{1j}^{1-\gamma}}{1-\gamma}\exp((1-\gamma)r^f))|\frac{1}{\gamma}I-\frac{1-\gamma}{\gamma}\Sigma\hat{\Sigma}_j^{-1}|^{-\frac{1}{2}}* \\
&\exp\left(\frac{1-\gamma}{2\gamma}\left[(1-\gamma)\mathbf{m}'\hat{\Sigma}_j^{-1}(I-(1-\gamma)\Sigma\hat{\Sigma}_j^{-1})^{-1}(\Sigma\hat{\Sigma}_r^{-1}-I)+I\right]\mathbf{m}\right)
\end{aligned}$$

where we have applied the formula for the expectation of a Wishart variable to get from the second-to-last, to the last line. And finally, given the assumption that all variance matrices are diagonal, the log-objective function is

$$\begin{aligned}
U_{0j} &= -\ln\left(-\frac{W_{1j}^{1-\gamma}}{1-\gamma}E_0[\exp((1-\gamma)r_j^p)]\right) \\
&= (1-\gamma)\ln\left(\frac{W_{1j}}{\gamma-1}\right)+\sum_{k\in\mathcal{H}}\frac{1}{2}\ln\left(1+(\gamma-1)\frac{\sigma_k^2}{\hat{\sigma}_{jk}^2}\right)+\frac{\gamma-1}{2}\sum_{k\in\mathcal{H}}\frac{m_k^2}{\hat{\sigma}_{jk}^2+(\gamma-1)\sigma_k^2}+A \qquad (16)
\end{aligned}$$

where we perform the transformation $-\ln(-U)$ to avoid taking the logarithm of a negative number (recall we assume $\gamma > 1$), and A is a constant that does not depend on the posterior variances. $\mathcal{H}$ denotes the set of countries for which the agent has purchased priors, and hence holds positive investments in.

For notational convenience, for the rest of the analysis of an individual agent's problem, we will drop the j subscript since the problems of agents in different countries are symmetric. Given that the risky factors are all Gaussian, the information content of the private signal about the asset return of country k (in terms of entropy units) is $\kappa_k = \frac{1}{2}\left(\ln(\text{Var}(d_k|p_k) - \ln(\text{Var}(d_k|\mathcal{I}_j^{(i)})\right)$. This follows from the expression for the entropy of Gaussian variables, and the fact that the only relevant public signal is the equilibrium market price p_k. Defining the variance of the risky payoffs conditional on public information only as $\tilde{\sigma}_k^2$, and the conditional variance using all information as $\hat{\sigma}_k^2$, we have that $\hat{\sigma}_k^2 = \exp(-\kappa_k)\tilde{\sigma}_k^2$; this shows us that the conditional variance of the agent is decreasing in the amount of information, κ_k, that he acquires.

We solve the information choice problem in three steps – a choice of allocation of intensive information, a choice of the total amount of intensive information acquired, and a choice of extensive information. First, note that given choices of the extensive information $\mathcal{H}$ and total intensive information K, agents solve the problem

$$\max_{\kappa_k} \sum_{k\in\mathcal{H}} \frac{1}{2} \ln\left(1 + (\gamma-1)\frac{\sigma_k^2}{\exp(-\kappa_k)\tilde{\sigma}_k^2}\right) + \frac{\gamma-1}{2}\sum_{k\in\mathcal{H}} \frac{m_k^2}{\exp(-\kappa_k)\tilde{\sigma}_k^2 + (\gamma-1)\sigma_k^2} \tag{17}$$

s.t.

$$\sum_{k\in\mathcal{H}} \kappa_k \leq K$$

A.2.1 Step 1: Choice of κ_k

The partial derivative of the objective function, $\frac{\partial U_0}{\partial \kappa_k}$, is

$$\frac{(\gamma-1)\left[4\hat{\sigma}_k^2(m_k^2+\sigma_k^2-(\gamma-1)m_k\sigma_k^2)+4(\gamma-1)\sigma_k^4-\hat{\sigma}_k^6-2(\gamma-1)\sigma_k^2\hat{\sigma}_k^4\right]}{8(\hat{\sigma}_k^2+(\gamma-1)\sigma_k^2)^2}$$

and the second derivative, $\frac{\partial^2 U_0}{(\partial \kappa_k)^2}$, is

$$\frac{(\gamma-1)\left[\hat{\sigma}_k^6+3(\gamma-1)\hat{\sigma}_k^4\sigma_k^2+4(\gamma-1)\sigma_k^2(\sigma_k^2+(\gamma-1)m_k\sigma_k^2-m_k^2)+4\hat{\sigma}_k^2(m_k^2+\sigma_k^2(1+(\gamma-1)^2\sigma_k^2)-(\gamma-1)m_k)\right]}{8(\hat{\sigma}_k^2+(\gamma-1)\sigma_k^2)^3}$$

Notice that the unconditional Sharpe Ratio (SR) being less than 1 ($\frac{\bar{m}}{\sigma_k} < 0$), which is true in the data, is a sufficient condition for $\frac{\partial^2 U_0}{(\partial \kappa_k)^2} > 0$. Thus, assuming the SR is less than one implies that information choice is a convex problem. Moreover, if $4 > \gamma\tilde{\sigma}_k^2$, which is also true under realistic parameters, we can show that the partial derivative with respect to information about asset k is positive when the agent's posterior variance equals the unconditional variance of the asset k:

$$\left.\frac{\partial U_0}{\partial \kappa_k}\right|_{\hat{\sigma}_k^2=\sigma_k^2} > 0$$

Together with the fact that the second derivative is also positive, we can conclude that the partial derivative in respect to information is always positive and increasing. Thus, the optimal information allocation is where $\kappa_k = K$ for one specific k, and all others are equal to zero. Given the fact that the agent has slightly tighter priors over his home asset (due to the free unbiased signal), the optimal choice is to acquire additional information only about the home country. Hence, we have that for agents in country j, $\kappa_j = K$ and $\kappa_i = 0, \forall j \neq i$.

A.2.2 Step 2: Choice of K

Choosing K amounts to choosing the amount of total additional information to acquire about the home asset (which we denote by j). The problem (16) becomes

$$\max_K (\gamma-1)\ln(W_1) + \frac{1}{2}\ln\left(\frac{\exp(-K)\tilde{\sigma}_j^2 + (\gamma-1)\sigma_j^2}{\exp(-K)\tilde{\sigma}_j^2}\right) + \frac{\gamma-1}{2}\frac{m_j^2}{\exp(-K)\tilde{\sigma}_j^2 + (\gamma-1)\sigma_j^2} + \\ + \sum_{k\in\mathcal{H}/j}\frac{1}{2}\ln\left(\frac{\tilde{\sigma}_k^2 + (\gamma-1)\sigma_k^2}{\tilde{\sigma}_k^2}\right) + \frac{\gamma-1}{2}\sum_{k\in\mathcal{H}/j}\frac{m^2}{\tilde{\sigma}_k^2 + (\gamma-1)\sigma_k^2}$$

The first order condition of this problem is

$$\frac{C'(K^*)}{W_1} = \frac{(\gamma-1)\left[4\hat{\sigma}_j^2(m_j^2 + \sigma_j^2 - (\gamma-1)m_j\sigma_j^2) + 4(\gamma-1)\sigma_j^4 - \hat{\sigma}_j^6 - 2(\gamma-1)\sigma_j^2\hat{\sigma}_j^4\right]}{8(\hat{\sigma}_j^2 + (\gamma-1)\sigma_j^2)^2}.$$

where $\hat{\sigma}_j^2 = \tilde{\sigma}_j^2\exp(-K^*)$ and $\hat{\sigma}_k^2 = \tilde{\sigma}_j^2$, for all $k \neq j$. Given a convex information cost function $C(.)$, this defines a unique solution for total intensive information K^*.

A.2.3 Step 3: Choice of the set $\mathcal{H}$

Lastly, we need to find the cutoff point at which adding new assets is not worth it anymore. The cost of adding an asset is that the investable wealth W_{1j} goes down by c. The gain for acquiring priors on asset k and adding it to your portfolio is given by the term

$$\ln\left(1+(\gamma-1)\frac{\sigma_k^2}{\tilde{\sigma}_k^2}\right)+\frac{\gamma-1}{2}\frac{\sigma_k^2+m_k^2}{\tilde{\sigma}_k^2+(\gamma-1)\sigma_k^2} \tag{18}$$

The first term captures the expected benefit of holding an additional asset with positive expected returns, and the second captures the diversification benefit of adding a new, independent asset to the portfolio. To arrive at that take the agent's ex-ante beliefs that $m_k \sim N(m_k, \sigma_k^2)$ and take expectations over the terms specific to asset k in U_0.

The marginal cost of purchasing priors is increasing in the amount of assets you already learn about. This works through two different effects. First, note that

$$\frac{\partial^2 \ln(W_{1j})}{(\partial \Psi_j)^2} = -\frac{1}{W_{1j}^2}$$

which comes from the fact that marginal utility of investible wealth is declining, and further prior information acquisition, and thus incurring an additional fixed cost c, is becoming increasingly costlier in utility terms. Second, increases in Ψ_j leads to lower investible wealth, and hence a lower optimal intensive information choice K^* and therefore lower utility from trading home assets (the ones you are informed about). Both of those effects combine to lead to the conclusion that there are increasing costs to increasing the breadth of information, and hence the portfolio. As a result, unless the fixed cost of acquiring priors is very small relative to the bank's wealth, it is unlikely that the bank will learn about all available assets. This generates sparse foreign portfolios, with the level of sparseness varying with the wealth level of the bank.

B Proof of Proposition 1

1. In a symmetric world where all fundamental terms have the same variance $\sigma_k^2 = \sigma^2$ for all k and the ex-ante expected return on all assets is the same, $m_k = m$ for all k, all

asset prices are symmetric in the sense that they are the same linear function of their respective state variables. Thus, all price coefficients are the same, $\lambda_{dk} = \lambda_d$, $\lambda_{zk} = \lambda_z$, and $\bar{\lambda}_k = \bar{\lambda}$ for all k , and the price only differ from each other because of different realizations of the state variables:

$$p_k = \bar{\lambda} + \lambda_d d_k + \lambda_z z_k.$$

As a result, the precision of information that can be acquired from the price signal, $\frac{\lambda_d^2}{\lambda_z^2 \sigma_z^2}$ is the same for all prices. Combined with the fact that all fundamentals have the same prior variance, this implies that the variance conditional on public information is also the same for all assets:

$$\tilde{\sigma}_k^2 = \tilde{\sigma}^2$$

for all k. Thus, in this symmetric world assets are symmetric not only ex-ante, but also conditional on all publicly available information.

Then, turning to the information choice of agents, note that the gain (in utility terms) of doing a due diligence study and adding a new asset to your portfolio is:

$$\ln\left(1 + (\gamma - 1)\frac{\sigma^2}{\tilde{\sigma}^2}\right) + \frac{\gamma - 1}{2}\frac{\sigma^2 + m^2}{\tilde{\sigma}^2 + (\gamma - 1)\sigma^2}$$

which is again the same for all k.

The financial cost of doing the due diligence study is simply c, and in terms of utility it is the decrease in log financial wealth (the first term of the objective function in equation (16)). The marginal utility cost of spending an extra c, when you have already spent the amount $\Psi = \sum_{k \in \mathcal{H}} c$ on prior information and have chosen the resulting optimal intensive information $K^*(|\mathcal{H}|)$ is: :

$$\ln(W-C(K^*(|\mathcal{H}|))-\Psi)-\ln(W-C(K^*(|\mathcal{H}|+1))-\Psi-c) = \ln(\frac{W-C(K^*(|\mathcal{H}|))-\Psi}{W-C(K^*(|\mathcal{H}|+1))-\Psi-c})$$

Since the log function is concave, this utility cost is increasing in the total amount of resources spent on due diligence studies.

Thus, we can conclude that if

$$\ln(\frac{W-C(K^*(0))}{W-C(K^*(1))-c}) < \ln\left(1+(\gamma-1)\frac{\sigma^2}{\tilde{\sigma}^2}\right)+\frac{\gamma-1}{2}\frac{\sigma^2+m^2}{\tilde{\sigma}^2+(\gamma-1)\sigma^2}$$

then the gain from adding the first foreign asset to their learning portfolio exceeds the cost of doing so, hence the agents will invest in at least one foreign asset. However, since the log function is concave, the utility cost of due diligence studies is increasing in the total amount of due diligence studies already done. So as long as the initial wealth of an agent W is low enough so that

$$\ln(\frac{W-C(K^*(N-1))-(N-1)c}{W-C(K^*(N))-Nc}) > \ln\left(1+(\gamma-1)\frac{\sigma^2}{\tilde{\sigma}^2}\right)+\frac{\gamma-1}{2}\frac{\sigma^2+m^2}{\tilde{\sigma}^2+(\gamma-1)\sigma^2}$$

then the agents will not invest in all foreign assets and hence

$$\alpha_k = 0 \text{ for some } k$$

2. For the same reason that the log financial wealth function is concave, it follows that increasing W lowers the cost of doing an additional due diligence study i.e.:

$$\frac{\partial\ln(\frac{W-C(K^*(|\mathcal{H}|))-\Psi}{W-C(K^*(|\mathcal{H}|+1))-\Psi-c})}{\partial W} < 0$$

Thus, as W increases the agents will add new assets to their learning portfolio, and hence the sparseness of portfolios will decrease.

3. Because the agent optimally chooses to not acquire any extra intensive information about his foreign portfolio holdings, his optimal portfolio is purely driven by the unconditional expectation and variance of returns. Since agents are rational, as long as they did the due diligence, they all see the true unconditional expectation, hence share the same beliefs over the foreign countries. Then, the optimal portfolio holdings of all foreign countries that the agent chooses to learn and invest in are the same:

$$\alpha_k = \alpha = \frac{E(r|p) - r^f}{\gamma \tilde{\sigma}^2} + \frac{1}{2\gamma}$$

   Hence, since all foreign holdings are the same as a share of the total portfolio of the agent, as a share of just the *foreign* portion of the portfolio they are all equal to $\frac{1}{\tilde{N}}$:

$$x_j^{-H} = \frac{1}{\tilde{N}},$$

   where $\tilde{N} = |\mathcal{H}|$ is the total number of foreign countries that the agent chooses to invest in. But in the symmetric world, this is also the share of the total supply of each country's risky asset in the market portfolio of the assets in $\mathcal{H}$ – hence:

$$Bias_j = 1 = \frac{1 - \frac{1}{\tilde{N}}}{1 - \frac{1}{\tilde{N}}} = 0$$

C Portfolio Comparative Statics: PE vs GE

Although the comparative statics exercises in Proposition 2 are only partial equilibrium expressions, they are still useful to gain intuition and the results carry over to general equilibrium as well. In general equilibrium, if everyone revises their expectations about asset k upwards, it clearly cannot be the case that everyone also increases their holdings of asset k. The price will adjust to this increase in demand, and in fact only the agents who increased their beliefs more than the average belief are the ones who will increase their portfolios. Substituting in the expression for the equilibrium price, p_k, in the optimal holdings expression, we can show that the equilibrium portfolio holdings of asset k of bank j are given by

$$\alpha_{jk} = \frac{E_{1j}(d_k)) - \bar{E}_1(d_k)}{\gamma \hat{\sigma}_{jk}^2} + \frac{1}{2\gamma}\left(1 - \frac{\bar{\sigma}_k^2}{\hat{\sigma}_{jk}^2}\bar{\phi}_k\right) + \gamma z_k \frac{\bar{\sigma}_k^2}{\hat{\sigma}_{jk}^2} \tag{19}$$

where we define the average market expectation (wealth-weighted) $\bar{E}_1(d_k)$ as

$$\bar{E}_1(d_k) = \bar{\sigma}_k^2 \left(\sum_{j \in \mathcal{B}_k} \frac{W_{1j}}{N_k} \frac{\int E_{1j}^{(i)}(d_k) di}{\hat{\sigma}_{jk}^2} \right)$$

As we can see, the basic results of the partial equilibrium comparative statics still remain true as long as you control for the average market beliefs. Agents will hold more of a given asset the more optimistic they are about its return *relative* to the average market belief, the higher the precision of their beliefs *relative* to the average market precision, and their portfolio holdings will be more responsive to their relative optimism, the greater is the precision of their beliefs. In our empirical tests we control for all of this market effects by including the appropriate fixed effects.

D Additional Tables

Table 8: Number of forecasters per country

This table contains the number of forecasters for each country in Consensus Economics. Observations refers to the number of forecasters × number of months in the sample.

Country	Obs.	min	p25	p50	p75	max
France	1645	2	14	15	16	18
Germany	2396	9	24	25	27	30
Hungary	1408	4	7	8	10	13
Italy	1201	2	7	8	9	13
Japan	1742	12	16	18	19	22
Netherlands	784	4	7	7	8	9
Norway	744	2	5	6	7	9
Poland	1454	5	9	10	11	13
Slovakia	989	0	5	6	7	9
Spain	1328	3	10	12	13	16
Sweden	1215	4	10	12	13	15
Switzerland	1278	8	11	12	12	14
UK	2015	4	16	17	19	23
USA	2313	16	23	25	27	32
Total	16184	5	10	12	13	15

Table 9: Forecasters

ABI	DIW - Berlin	ISAE	OFCE
ABN AMRO	DIW Berlin	ITEM Club	OTP Bank
AFI	DNB	ITOCHU Institute	Oddo Securities
AXA Investment Managers	DTZ Research	IW - Cologne Institute	Oxford - LBS
Action Economics	DZ Bank	IfW - Kiel Institute	Oxford Economics
Allianz	Daiwa Institute of Research	Inforum - Univ of Maryland	PAIR Conseil
American Int'l Group	Danske Bank	Inst Estud Economicos	PKO Bank
BAK Basel	DekaBank	Inst L R Klein (Gauss)	PNC Financial Services
BBVA	Deutsche Bank	Institut Crea	Pictet & Cie
BHF-Bank	Dresdner Bank	Institute EIPF	Prometeia
BIPE	DuPont	Instituto de Credito Oficial	RBS
BNP Paribas	EFG Eurobank	Intesa Sanpaolo	RDQ Economics
BPCE	ENI	JP Morgan	REF Ricerche
BPH	Eaton Corporation	Japan Ctr for Econ Research	RWI Essen
Banca Com Romana	Econ Institute SAV	Japan Tech Info Services Corp	Rabobank
Banca IMI	Econ Intelligence Unit	KOF Swiss Econ Inst	Raiffeisen
Banesto	Econ Policy Institute	KUKE	Rexecode
Bank America Corp	Economic Perspectives	Kempen & Co.	Roubini Global Econ
Bank Julius Baer	Erik Penser Bank	Kiel Economics	SBAB Bank
Bank Vontobel	Erste Bank	Kopint-Tarki	SEB
Bank Zachodni	Est Inst of Econ Rsrch	La Caixa	Sal Oppenheim
Bank of America	Euler Hermes	Landesbank Berlin	Santander
Bank of Tokyo-Mits. UFJ	Euromonitor	Lehman Brothers	Schroders
Bankia	Exane	Liverpool Macro Research	Skandiabanken
Barclays	Experian	Lloyds TSB Financial Markets	Slovenska Sporitelna
BayernLB	FERI	Lodz Institute - LIFEA	Societe Generale
Beacon Econ Forecasting	FUNCAS	Lombard Street Research	Standard & Poor's
Bear Stearns	Fannie Mae	MESA 10	Statistics Norway
CASE	Feri EuroRating	MM Warburg	Svenska Handelsbanken
CEOE	First Securities	Macroeconomic Advisers	Swedbank
CEPREDE	First Trust Advisors	Merrill Lynch	Swiss Life
CIB Budapest	Fitch Ratings	Millennium Bank	Swiss Re
CSOB	Ford Motor Company	Mitsubishi Research Institute	Takarek Bank
Caja Madrid	Fortis	Mitsubishi UFJ Research	Tatra Banka
Cambridge Econometrics	GAMA	Mizuho Research Institute	The Conference Board
Capital Economics	GKI Econ Research	Mizuho Securities	Theodoor Gilissen
Capitalia	Gdansk University	Moody's Analytics	Total
Centre Prev l'Expansion	General Motors	Morgan Stanley	Toyota Motor Corporation
Centro Europa Ricerche	Georgia State University	NHO Conf Nor Enterprise	UBS
Chamber of Commerce	Global Insight	NHO Confed Nor Enterprise	UniCredit
Chrysler	Goldman Sachs	NIBC	United Bulgarian Bank
Citigroup	HBOS	NIESR	United States Trust
Coe-Rexecode	HQ Bank	NLI Research Institute	Univ of Michigan - RSQE
Commerzbank	HSBC	NYKredit	Vienna Institute - WIIW
Concorde Securities	HSH Nordbank	Nat Assn of Home Builders	WGZ Bank
Confed of British Industry	HWWI	National Institute - NIER	Wachovia Corp
Confed of Swed Enterprise	Helaba Frankfurt	Natixis	Wells Capital
Confindustria	Hypo Alpe Adria	Nippon Steel	Wells Fargo
Credit Agricole	IFL-Univers Carlos III	Nomura	WestLB
Credit Suisse	IFO - Munich Institute	Nordea	ZÃijrcher Kantonalbank
D&B	ING	Northern Trust	Öhman
Type	%	Type	%
Bank	51.50	University	2.88
Consulting Firm	21.15	Business Association	2.59
Research Institute	11.25	Corporation	2.02
Financial Services	8.32	Total	100

Table 10: Intensive Margin – Foreign Exposures Only, Robustness

This table provides the estimates for equation (12). The dependent variable is the share of EEA country c sovereign bonds in bank b sovereign portfolio. The independent variables are defined in Table 1. Standard errors are three–way clustered at the bank, country and year level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)
$\overline{SFE}(Y10)$	-36.88**	-14.86**	-21.69**	-22.67***	-28.48**
	(14.282)	(4.332)	(7.100)	(3.527)	(7.934)
Y10	-3.842*	-1.771*	-2.888***	-3.324**	-4.155**
	(1.763)	(0.807)	(0.623)	(1.192)	(1.418)
$\overline{SFE}(Y10) \times Y10$	5.917**	2.853***	4.134***	4.191***	5.216***
	(2.209)	(0.778)	(1.044)	(0.748)	(1.003)
Observations	209	209	150	192	122
Adj. R^2	0.797	0.854	0.755	0.841	0.521
N of Banks	17	17	7	17	7
N of Destination Countries	11	11	11	9	8
N of Time Periods	8	8	8	8	8
Time FE	yes	yes	yes	yes	yes
Bank FE	yes	yes	yes	yes	yes
Destination Country FE	no	yes	yes	yes	yes
Bank-Time FE	no	no	yes	no	yes
Destination Country-Time FE	no	no	no	yes	yes

Table 11: Intensive Margin – Domestic and Foreign Exposures, Robustness

This table provides the estimates for equation (12). The dependent variable is the share of EEA country c sovereign bonds in bank b sovereign portfolio.The three main independent variables are defined in Table 1; Home equals one for domestic forecasts only; GIIPS equals one only for banks located in either Greece, Ireland, Italy, Portugal or Spain. Standard errors are three–way clustered at the bank, country and year level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

$\overline{SFE}(Y10)$	-35.06	-41.80**	-54.47**	-51.98*	-54.68**
	(21.357)	(18.534)	(22.300)	(23.406)	(23.920)
Y10	-4.461**	-3.657**	-4.055**	-4.050*	1.528
	(1.765)	(1.197)	(1.562)	(1.947)	(3.328)
$\overline{SFE}(Y10) \times Y10^1$	5.604*	6.499**	9.057***	8.255**	9.070**
	(2.963)	(2.215)	(2.800)	(3.185)	(3.243)
Home	17.57**	12.93*	13.41*	12.45	14.43*
	(6.483)	(6.582)	(6.870)	(7.018)	(6.866)
Home × GIIPS	59.58***	64.03***	65.67***	66.75***	65.25***
	(16.532)	(15.016)	(17.179)	(16.600)	(16.517)
Observations	408	408	247	407	226
Adj. R^2	0.870	0.913	0.665	0.907	0.500
N of Banks	34	34	15	34	15
N of Destination Countries	11	11	11	11	10
N of Time Periods	8	8	8	8	8
Time FE	yes	yes	yes	yes	yes
Bank FE	yes	yes	yes	yes	yes
Destination Country FE	no	yes	yes	yes	yes
Bank-Time FE	no	no	yes	no	yes
Destination Country-Time FE	no	no	no	yes	yes