Beyond Home Bias: Heterogeneity in Foreign Holdings and Information Sets

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May 16, 2017

PRELIMINARY AND INCOMPLETE – PLEASE DO NOT CIRCULATE

Abstract

This paper investigates whether information frictions can explain the heterogeneity in bank holdings of sovereign debt. First, using data from the European Banking Authority (EBA), we document that the typical bank sovereign portfolio is 'sparse', *i.e.* banks invest only in a few foreign countries. Next we propose a general equilibrium model of information frictions to rationalize these stylized facts. The model implies that the heterogeneity in portfolios arises because of heterogeneity in the information banks possess about the different countries in which they could invest. Finally, we empirically test the key predictions of the model by matching the EBA portfolio data with forecasts from Consensus Economics. We show that banks are more likely to hold a foreign sovereign bond if they make a forecast for the foreign country (extensive margin) and the more precise the forecast, the higher the portfolio share (intensive margin).

JEL classification: G11, G21, F30.

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

Disclaimer: 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.

We are grateful to Jamie Grasing for the excellent research assistance.

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1 Introduction

The home bias, *i.e.* holding domestic assets in excess of the market portfolio, is a pervasive feature of international financial markets, both across asset classes and types of investors (Coeurdacier and Rey (2013)). In this study, we delve deeper in its determinants and look at the heterogeneity in the holdings of different foreign assets. First, using detailed data on European banks' portfolios, we document some new stylized facts: most banks invest in only a handful of different countries, and thus hold 'sparse' portfolios. This 'extensive margin' is a major driver of the overall home bias, especially among small banks, but is something that has not been analyzed before; we fill in this gap by providing a portfolio theory based on information frictions that rationalizes such facts. Secondly, we take advantage of a unique dataset that matches banks' sovereign portfolios with banks' expectations about the fundamentals of the countries they invest in, to formally test other key implications of the model.

Previous studies predominantly focus on the home vs. foreign divide in portfolios, aggregating all foreign holdings together and ignoring any heterogeneity within them. Instead, we aim to exploit that heterogeneity to better understand the main drivers of portfolio bias. Our first result is to document that there is indeed a tremendous amount of heterogeneity among foreign holdings of sovereign debt: while small banks invest in just a handful of countries, large banks invest in all countries in the market portfolio. This draws a sharp distinction between assets that are actually held, and those that are not. Moreover, even if large banks invest in many countries, as a group they are still under-weighted relative to domestic assets. We then show that the broad pattern of these findings can be rationalized in a properly modified model of information frictions (Van Nieuwerburgh and Veldkamp (2009)). The main mechanism implies that the heterogeneity in portfolios arises because of the heterogeneity in the information banks possess about the different countries in which they could invest.

We then formally test three central prediction of the model, and to this end have augmented our data on bank portfolios with data on banks' expectations from Consensus Economics. First, we confirm, as others have done before (Bae et al. (2008) and Malloy (2005)) that domestic forecasters are better than foreign ones. The results also hold if we restrict the sample only to those forecasters that make predictions for both domestic and foreign macroeconomic variables: home forecasts are more precise even for them. Second, we explore whether the sparseness in portfolio holdings can be explained by a sparseness in information acquisition. Since not many banks make a forecast for a foreign country, we show that making a forecast for a foreign country is correlated with having foreign exposure to that same country, *i.e.* an extensive margin of information acquisition. Finally, since we can measure the accuracy with which banks predict foreign macroeconomic variables, we test whether banks that make more accurate forecasts have larger exposures to those countries.

The paper is organized as follows. Section 2 briefly discusses the literature on home bias, section 3 describes the data and presents stylized facts. Section 4 presents the model and Section 5 the empirical tests and implications from the model. Section 6 concludes.

2 Literature Review

The home bias, the observation that portfolios significantly over-weight domestic assets, is a long-standing puzzle in international finance. It has given rise to a large literature with numerous proposed explanations, such as information frictions, real exchange rate and non-tradable income risks, corporate governance issues and different behavioral models. These varied mechanisms are all successful at explaining why investors might display a strong preference for domestic assets over foreign assets as a whole, but as Coeurdacier and Rey (2013) emphasize, there is now an acute need for additional empirical facts that can help differentiate among this plethora of models.

The literature on the home bias is a long and varied one. 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 (Popov and Van Horen (2014), DeMarco (2016)).

In terms of potential 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), Van Nieuwerburgh and Veldkamp (2009)). 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 (2011)). Yet another strand of the literature analyzes corporate governance issues (Dahlquist et al. (2003)) and political economy mechanisms (DeMarco and Macchiavelli (2015)). In addition to such mechanisms where the home bias arises optimally, the literature has also explored a number of potential behavior avenues, where agents over-weight domestic assets due to behavioral biases (Huberman (2001), Portes and Rey (2005), Solnik (2008)).

While the great majority of the existing mechanisms do not predict that investors will display different preferences over individual foreign assets, models of endogenous information asymmetry do, as discussed in Valchev (2016). In this study we expand on this observation further by incorporating both an extensive and an intensive margin of information acquisition, to better match the newly documented importance of the extensive margin in the data. By augmenting our initial data set on bank portfolios with data on banks' expectations from Consensus Forecast, we then plan to test the specific implications of the information model by seeing if the heterogeneity in information sets matches the heterogeneity in foreign bias.

These results would add to the literature that attempts to specifically test and quantify the effect of information-based models (Grinblatt and Keloharju (2001), Massa and Simonov (2006), Ahearne et al. (2004), Guiso and Jappelli (2006, 2008)).

3 Data and Stylized Facts

3.1 Data

For our purposes, it is key to have data on portfolio shares and expectations on various countries' fundamentals at the investor level. To this end, we merge information on European banks' credit and sovereign portfolios from the European Banking Authority (EBA) to banks' macroeconomic forecasts from Consensus Economics.

The EBA collected data on banks' portfolio holdings, aggregated at the level of the country of the counterparty, in the context of the EU-wide Stress Tests and other regulatory exercises between 2010 and 2013. The EBA sample covers the largest banking groups in Europe (from 61 to 123 institutions, depending on the nature of the regulatory exercise) and contains data at the consolidated, group level. For example, we know the amount of French sovereign bonds or credit to French corporations held by HSBC Holdings plc at a specific point in time, but not those of HSBC France.

We then hand-match the banks in the EBA sample to Consensus Economics. At the beginning of each month, Consensus surveys a wide array of analysts working for banks, consulting companies, non-financial corporations, rating agencies and universities among others. These analysts provide forecasts for a set of key macroeconomic variables for all major industrialized countries, plus Eastern Europe. The forecasters include both domestic and foreign banks. In the case of 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 real GDP growth as the main forecasting variable in order to minimize missing observations in the survey – real GDP growth has the most data coverage across forecasters and countries – but also because economic growth should matter for portfolio allocations. For robustness, we also include the forecast of 10–year sovereign yields.

3.2 Stylized Portfolio Facts

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

$$\text{Home Bias} = 1 - \frac{1 - x_H}{1 - x_H^*}$$

where x_H is the share a bank invests in domestic sovereign debt and x_H^* is the share of home country's debt as a fraction of total world debt (the CAPM portfolio). By definition then:

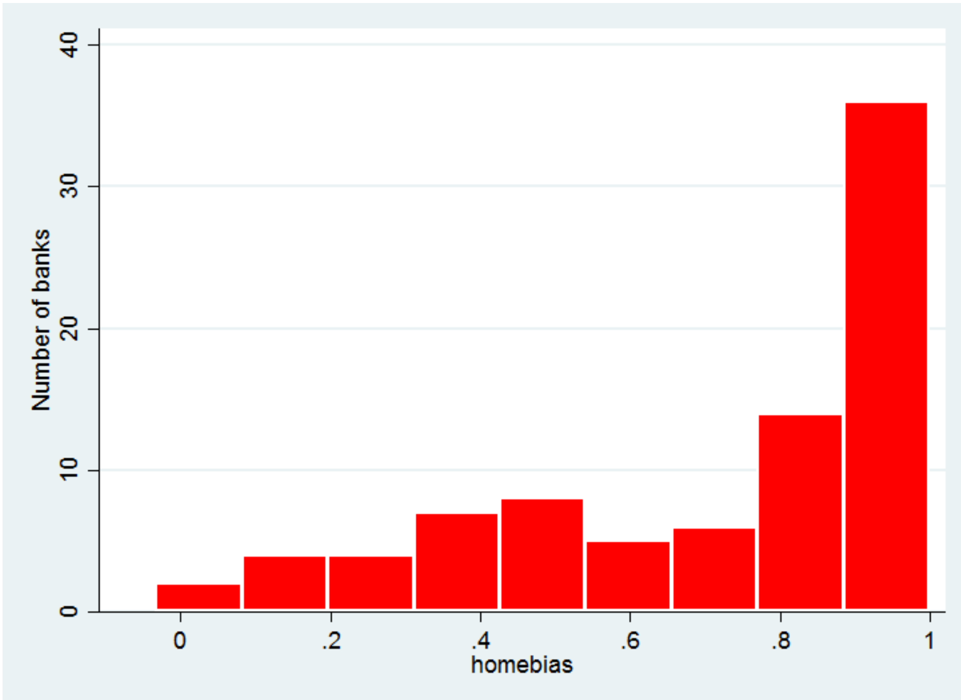
$$\text{Home Bias} = 1 - \frac{\sum_{j \neq H} x_j}{\sum_{j \neq H} x_j^*}$$

for all countries j in the portfolio. The alternative definition will be useful when we construct counter-factual measures of home bias below.

The HB index takes the value of 0 when the portfolio 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 ($x_H = 1$) and is 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 as of December 2010 (2011 Stress Test) is presented in Figure 1.

Almost all banks display at least some home bias – the HB index ranges from slightly negative for one bank (BNP Paribas) all the way to 1, and the median (mean) is 0.85 (0.72).

Figure 1: Home Bias Index Histogram, 2010Q4



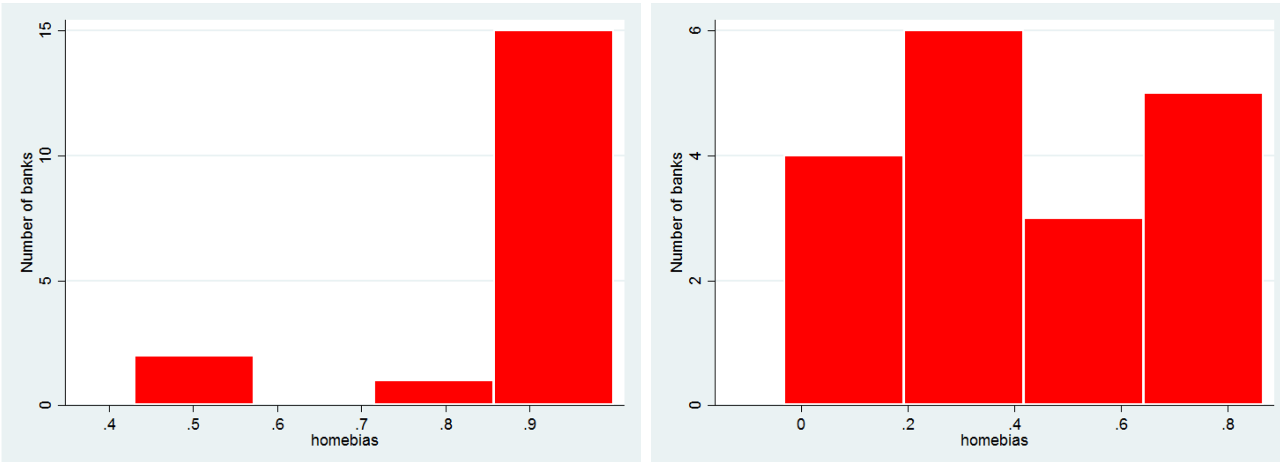
This is the basic observation of the home bias that has also been documented extensively in many previous studies. Size is a big driver of the overall level of home bias, but cannot alone explain it. In Figure 2 we sort banks according to the quintiles of total assets: while virtually all 18 banks in the bottom 20% (<€38 bn. in assets) hold almost exclusively domestic debt, even large banks (>€550 bn. in assets) show significant home bias.

Another feature of the data is that portfolios are sparse – the average bank only invests in 11 out of the 28 potential foreign investments.[1] To quantify this 'extensive margin' of the home bias, we construct a counter-factual home bias index where we set all positive investments equal to their world market share. In this way, any given portfolio only deviates

[1] We exclude all the sovereign debt holdings from countries that are not part of the European Union (EU), such as the US or Japan, leaving us with an overall portfolio of 28 countries. We do so to have an homogeneous group in terms of regulatory treatment: in fact, all exposure to EU central governments denominated in local currency (98%) is assigned a 0% risk–weight. The different regulatory treatment may explain why European banks hold so little non–EU debt, but cannot account for the home bias even among EU 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–EU countries in the analysis. In the Appendix we show that the stylized facts are robust to choosing other dates and other portfolios (for example, restricting the analysis to Euro–area countries only).

Figure 2: Home Bias Index: Small vs. Large Banks, 2010Q4

(a) Bottom 20% (b) Top 20%



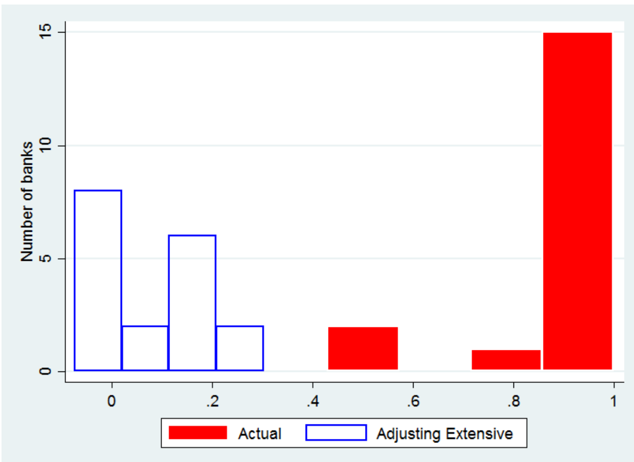
from the market portfolio through any 0s, *i.e.* its sparseness. The results are presented, for both large and small banks, in the left panel (a) of Figure 3 and 4. We see that the extensive margin is indeed a major driver of the home bias for small banks – correcting it leads to a strong shift of the HB distribution towards zero, with a median (average) home bias of 0.06 (0.09). On the other hand, correcting the extensive margin does not change the home bias distribution for the largest banks at all: these banks invest in all EU countries debt already.

Figure 3 and 4 – panel B also displays the home bias after adjusting the 'intensive' margin, *i.e.* setting the banks' positive portfolio shares equal to their market shares but leaving the 0s. 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 mirror image of the adjustment on the extensive margin: small banks underweight the foreign investment they hold in positive quantities, but most of the home bias is explained by the fact that they do not invest in all countries (the 'extensive margin'). Large banks on the other hand invest in all countries in the market portfolio, but still underweight foreign assets compared to domestic assets.

Next, we focus on the heterogeneity in the *foreign* portion of portfolios only. To do so

Figure 3: Home Bias Index: Extensive vs Intensive Margin, Small Banks, 2010Q4

(a) Extensive Margin



(b) Intensive Margin

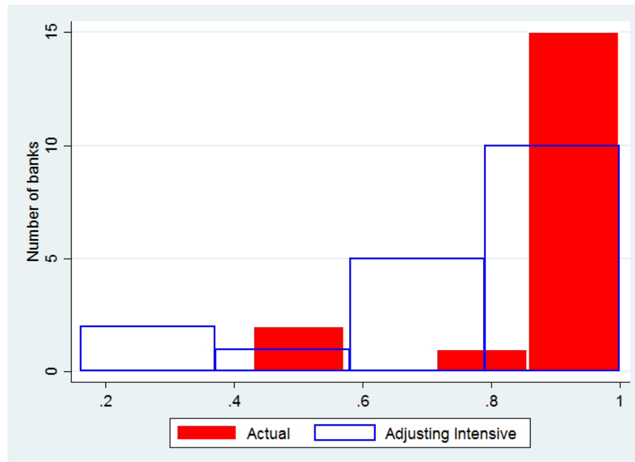
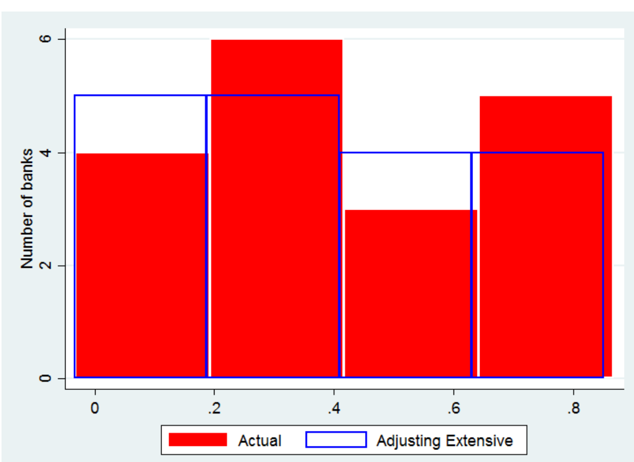
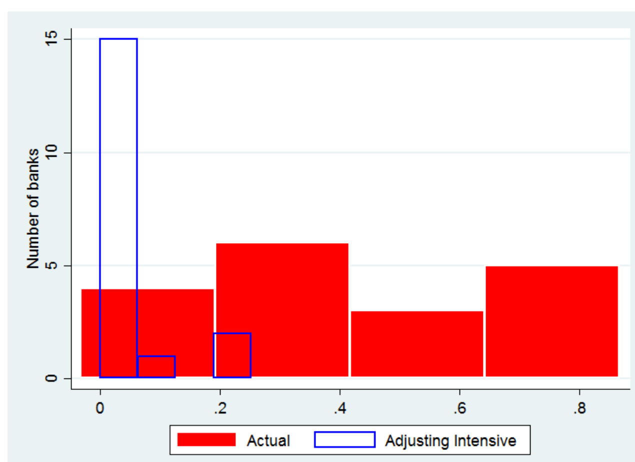


Figure 4: Home Bias Index: Extensive vs Intensive Margin, Large Banks, 2010Q4

(a) Extensive Margin



(b) Intensive Margin

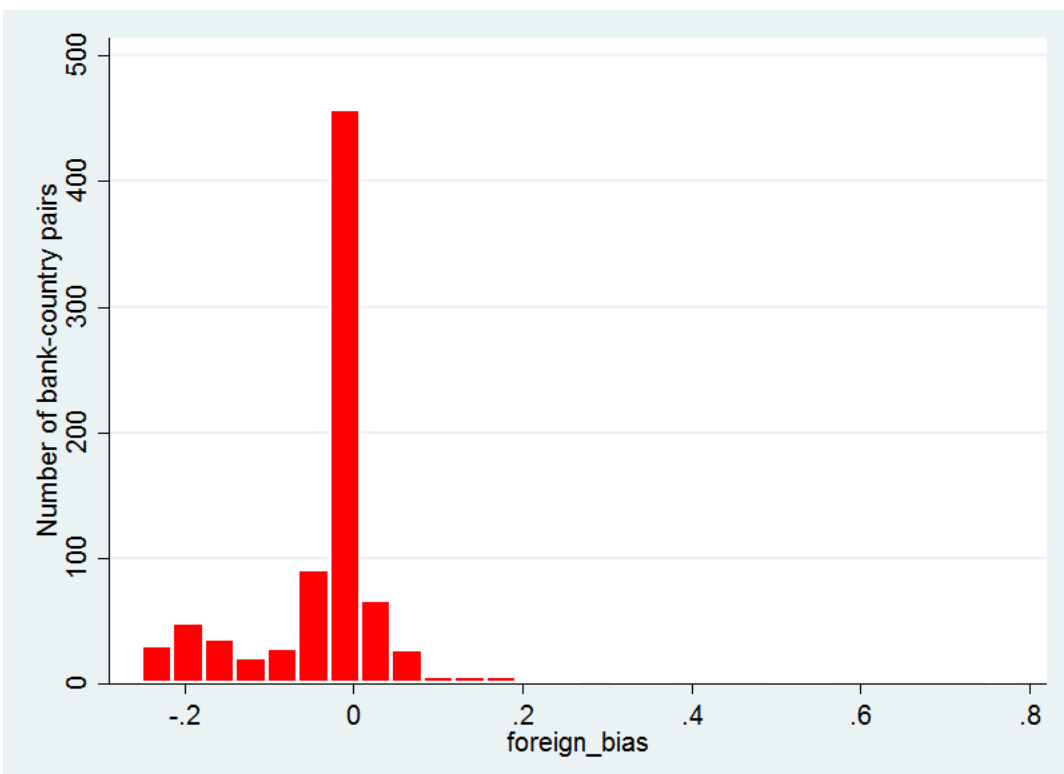


we compute the portfolio bias index for each bank j and country i:

$$Bias_{i,j} = 1 - \frac{1 - x_{i,j}}{1 - x_i^{World}}$$

where $x_{i,j}$ is the share of country i sovereign debt in the total portfolio of sovereign debt of bank j and x_i^{World} is the share of country i's sovereign debt in the world (EU for us) market portfolio. We then analyze the distribution of $Bias_{i,j}$ for all i not being the domestic country of bank j and for which bank j has a positive exposure: the bias in the foreign portfolio of bank j among the assets held in positive quantities. This index follows the same logic of the standard home bias index: a positive value means that country i is overweighted in the foreign portion of bank j's portfolio. Figure 5 presents the histogram for the foreign bias conditional on a positive exposure to the foreign country.

Figure 5: Foreign Bias, 2010Q4



Not only the median (average) foreign bias is practically zero, -0.008 (-0.03), but the entire distribution is squeezed 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 foreign bias is right around zero. If anything, many foreign assets are under–weighted compared to the CAPM prediction. Overall 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. We would like to note that 'relative to each other' is key here: the intensive margin home bias suggests that, as a group, foreign assets are still under-weighted compared to domestic assets.

In conclusion, it seems that the typical bank sovereign portfolio could be characterized as follows: a large domestic exposure, plus a few foreign countries, with no clear preference over any of them, plus a bunch of 0s.

4 Model

We consider a static model, where agents can trade risky assets and can acquire costly information about future asset payoffs. There are N different countries of equal size, with a continuum of mass $\frac{1}{N}$ of agents living in each. There are N risky assets, one associated with each, and a risk-free savings technology with an exogenous rate of return R^f.

The period is divided into two parts – agents first choose their information acquisition, then conditional on their updated information sets they make a portfolio choice. Agents are born with some initial wealth level W, and hence agent i, in country j faces the budget constraint

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

where P_k is the price of the risky asset of country k, $x_{jk}^{(i)}$ are the portfolio holdings of risky assets and $b_j^{(i)}$ the holdings of the risk-free bond. It is useful to rewrite the budget constraint in terms of portfolio shares $\alpha_{jk}^{(i)} = \frac{P_k x_{jk}^{(i)}}{W}$, instead of the absolute holdings $x_{jk}^{(i)}$, then the budget constraint becomes

$$1 = \sum_{k=1}^{N} \alpha_{jk}^{(i)} + \frac{b_j^{(i)}}{W}$$

To reduce clutter, from now we will suppress the i index if there is no chance of confusion. The N risky assets yield stochastic payoff D_k, and hence the return on an agent's portfolio is

$$\begin{aligned} R_j^p &= \sum_{k=1}^{N} \alpha_{jk} \frac{D_k}{P_k} + \frac{b_j}{W} R \\ &= \boldsymbol{\alpha'}_j \mathbf{R} + \frac{b_j}{W} R \end{aligned}$$

where all bold letters denote N-by-1 vectors, and we define the gross return on asset k as:

$$R_k = \frac{D}{P_k}$$

The terminal wealth of the agents is determined by their initial wealth (same for everyone), and the differential portfolio returns they earn:

$$W_{j,t+1} = W R_j^p$$

We assume that the log of the risky asset payoffs follows a joint Normal distribution:

$$\mathbf{d} \sim N(\mu_d, \Sigma_d).$$

For tractability purposes, we assume that the variance-covariance matrix is diagonal, i.e. that the fundamentals of different countries are independent of one another. This assumption has no effect on the qualitative results of the model (as will be discussed later as well), and could easily 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 is most important for generating concentrated portfolios and home bias. The incentives to engage in this sort of differential learning is at the heart of the model, and hence we focus on an environment where all risk is country specific.

Moreover, we will also assume that agents have an arbitrarily small information advantage over their home asset – thus for agents living in country j,[2]

$$\sigma_j^2 < \sigma_k^2 \text{ , for all } k \neq j,$$

where σ_j^2 are the diagonal elements of Σ_d – i.e. the prior variances of the fundamentals of different countries.

In this model, the agents face two different types of information costs. First, as in Merton (1987), the prior information that $\mathbf{d} \sim N(\mu_d, \Sigma_d)$ is not available to the agents for free, but rather they have to "purchase" their priors. In particular, they can purchase information about the unconditional distribution of each element of $\mathbf{d}$ separately, at a cost of c_k. Essentially, in this model no information comes for free – the agents start with perfectly diffuse priors over all stochastic payoffs. Thus, without first acquiring information on the unconditional distribution of the payoffs of asset k, the agents will not hold any of that asset. This is the Merton (1987) view of information, which postulates that agents must first acquire information about an asset, before holding any of it. We view this stage as doing due standard due diligence and obtaining basic information about a country and its fundamentals. Without having done such initial due diligence for asset k, the agents will not enter that market at all and $\alpha_k = 0$.

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

[2]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.

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_k. But once such approval is granted, future portfolio adjustments do not require to go through extensive initial approval procedures.

Second, agents can also acquire information about the actual future realization of d_k. In particular, they receive unbiased signals

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

where $u_{jk}^{(i)} \sim N(0, \sigma_u^2)$. The noise in the private agents signals is assumed to be independent across assets, and agents. They can choose the informativeness of these signals, subject to an increasing and convex cost $C(\kappa)$ of the total amount of information, κ, encoded in the chosen signals. Information, κ, is measured in terms of entropy units (Shanon (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 variable, that occurs after observing the vector of noisy signals $\boldsymbol{\eta}_j^{(i)} = [\eta_{j1}, \ldots, \eta_{jN}]'$:

$$\kappa = H(\mathbf{d}|\mathcal{I}_0^{(i)}) - H(\mathbf{d}|\mathcal{I}^{(i)})$$

where $H(X)$ is the entropy of random variable X and $H(X|Y)$ is the entropy of X conditional on knowing Y.[3] Moreover, $\mathcal{I}_0^{(i)}$ is the prior information set of agent i, which contains public signals (such as equilibrium prices), and the set of priors on $\mathbf{d}$ which he has purchased, and $\mathcal{I}^{(i)} = \mathcal{I}_0^{(i)} \cup \boldsymbol{\eta}_t^{(i)}$ is the information set updated with the private signals $\eta_{jk}^{(i)}$. Thus, κ measures the amount of information about the vector of future fundamentals $\mathbf{d}$ contained in the private signals $\boldsymbol{\eta}_j^{(i)}$, over and above the agent's priors and any publicly available information. Given the prior assumption that all factors are uncorrelated across countries, we can express the total

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

information κ as the sum of the informational contents of the individual signals $\eta_{j1}^{(i)}, \ldots, \eta_{jN}^{(i)}$:

$$\kappa = \kappa_1 + \cdots + \kappa_N$$

where the the information of each individual signal is similarly defined as the information about the underlying fundamental over and above the publicly available information:

$$\kappa_k = H(d_k|\mathcal{I}_0^{(i)}) - H(d_k|\mathcal{I}^{(i)})$$

After observing the signals, the agents use standard Bayesian updating together with the priors they have previously purchased to come up with updated beliefs about future payoffs. Thus, acquiring more informative signals η reduces the posterior variance of the 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 has an "extensive" margin flavor. Our model combines both views of information. The overall information framework is meant to capture the idea that in order to hold any amount of a given asset, banks need to pay an upfront cost for an initial study, to "set their priors" in other words. But in addition, they can also choose to devote more or less resources to the team tasked with following a given country, and hence also face an intensive margin of adjustment on their information acquisition.

The agents maximize a CRRA utility with risk-aversion coefficient γ, hence maximize

$$\max E_t(\frac{W_j^{1-\gamma}}{1-\gamma})$$

As mentioned before the agents solve their problem in two steps. First, conditional on an information choice, they pick optimal portfolios. Second, they choose information ex-ante, before asset markets open, but looking ahead, and knowing the form of their optimal portfolios.

4.1 Portfolio Choice

After making their information choice, which includes both purchasing priors and informative signals η, the agents observe the actual realizations of the signals η and update their beliefs. Conditional on those beliefs, agents pick the portfolio composition that maximizes their utility and hence face the problem

$$\max E_t(\frac{W_j^{1-\gamma}}{1-\gamma})$$

s.t.

$$W_j = (W - \Psi_j - C(\kappa_j))R_j^p = \tilde{W}_j(\boldsymbol{\alpha'}_{jt}\mathbf{R} + (1 - \boldsymbol{\alpha'}_j\mathbf{1})R)$$

where

$$\Psi_j = \sum_k \iota_k c_k$$

is the total expenditure on prior information (ι_k is 1 if the agent purchases information about the k-th country, and zero otherwise), and we define

$$\tilde{W}_j = (W - \Psi_j - C(\kappa_j))$$

as the portfolio wealth of the individual – the wealth left over after accounting for information costs that gets invested in financial assets.

Substituting the constraint out, we have

$$\max \frac{1}{1-\gamma}E_t(\exp((1-\gamma)(\tilde{w} + r_j^p)) = \max \frac{\tilde{W}^{1-\gamma}}{1-\gamma}E_t(\exp((1-\gamma)r_j^p)$$

where lower case letters denote logs, i.e. $r_j^p = \ln(R_j^p)$. Next, we follow Campbell-Viceira(2001) and use a second-order Taylor expansion to express the log portfolio return as

$$r_j^p \approx r^f + \boldsymbol{\alpha}_t'(\mathbf{r} - r^f + \frac{1}{2}diag(\hat{\Sigma}_r)) - \frac{1}{2}\boldsymbol{\alpha}'\hat{\Sigma}_r\boldsymbol{\alpha} \quad (1)$$

where we have used $\hat{\Sigma}_r = \text{Var}(\mathbf{r}|\mathcal{I}^{(i)})$ to denote the posterior variance of the risky asset payoffs. For future reference, note that since $\mathbf{r} = \mathbf{d} - \mathbf{p}$ and $\mathbf{p}$ is in the information set of the agent, it follows that

$$\text{Var}(\mathbf{r}|\mathcal{I}^{(i)}) = \text{Var}(\mathbf{d}|\mathcal{I}^{(i)}) = \hat{\Sigma}_d$$

where we denote the posterior variance of the asset payoffs $\mathbf{d}$ by $\hat{\Sigma}_d$.

Lastly, plugging (1) into the objective function and taking expectations over the resulting log-normal variable yields

$$\begin{aligned} E_t(\exp((1-\gamma)r_j^p) = \exp((1-\gamma)\left(r^f + \boldsymbol{\alpha}_t'(E_t(\mathbf{r}) - r^f + \frac{1}{2}diag(\hat{\Sigma}_r)) - \frac{1}{2}\boldsymbol{\alpha}'\hat{\Sigma}_r\boldsymbol{\alpha}\right) \\ + \frac{(1-\gamma)^2}{2}\boldsymbol{\alpha}'\hat{\Sigma}_r\boldsymbol{\alpha}) \end{aligned}$$

where we use the notation $E_t(.) = E(.|\mathcal{I}^{(i)})$ to denote the conditional expectation of the agent. Taking first order conditions, and solving for the portfolio shares $\boldsymbol{\alpha}_t$ yields:

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

Furthermore, given the assumption that all factors are independent, we have the simpler expression

$$\alpha_k = \frac{E_t(r_k) - r^f + \frac{1}{2}\hat{\sigma}_{kr}^2}{\gamma\hat{\sigma}_{kr}^2} \tag{2}$$

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.

4.2 Asset Market Equilibrium

In addition to the informed traders, there are also noise traders that trade the N assets for reasons orthogonal to return maximization. They are needed in order to ensure that there are more shocks and 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.

Market clearing requires that the sum of the asset demands of all informed traders equals the net demand of noise traders for each asset,

$$\sum_{j=1}^{n} \int \frac{\tilde{W}_j}{N} \alpha_{jk}^{(i)} di = z_k$$

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 time-varying and unrelated to the financial payoffs of the bonds, they are modeled by z_k.

Hence, we have

$$\sum_j \frac{1}{N} \widetilde{W}_j \frac{\bar{E}_{jt}(d_{k,t+1}) - p_k - r^f + \frac{1}{2}\hat{\sigma}_{jkr}^2}{\gamma \hat{\sigma}_{jkr}^2} = z_k$$

where we define the average expectations, within a country $\bar{E}_{jt}(.) = \int E_{jt}^{(i)}(.)di$. We guess and later verify that the equilibrium price is linear in the state variables and is of the form

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

Thus, the price itself contains useful information, and in particular the agents can extract the following unbiased signal from it

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

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:

$$E_{jt}^{(i)}(d_k) = \left(\frac{1}{\sigma_{dk}^2} + (\frac{\lambda_{dk}}{\lambda_{zk}}\sigma_{zk})^2 + \frac{1}{\sigma_{\eta jk}^2}\right)^{-1}\left(\frac{\mu_{dk}}{\sigma_{dk}^2} + (\frac{\lambda_{dk}}{\lambda_{zk}\sigma_{zk}})^2\tilde{p}_k + \frac{1}{\sigma_{\eta jk}^2}\eta_{jk}^{(i)}\right)$$

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

Note that we drop the i index on any variances, because all agents within the same country face identical problems and hence choose the same information acquisition strategy. Substituting everything back into the market clearing condition we have,

$$z_k = \frac{1}{N}\sum_j \widetilde{W}_j \frac{\hat{\sigma}_{jk}^2\left(\frac{\mu_{dk}}{\sigma_{dk}^2} + (\frac{\lambda_{dk}}{\lambda_{zk}\sigma_{zk}})^2(d_k + \frac{\lambda_{zk}}{\lambda_{dk}}(z_k - \mu_{zk})) + \frac{1}{\sigma_{\eta jk}^2}f_k\right) - (\bar{\lambda}_k + \lambda_{dk}d_k + \lambda_{zk}z_k) - r^f + \frac{1}{2}(\hat{\sigma}_{jk}^2 + \sigma_e^2)}{\gamma(\hat{\sigma}_{jk}^2 + \sigma_e^2)}$$

Matching coefficients, we get

$$\bar{\lambda}_k = \underbrace{\left(\frac{1}{N}\sum_j \frac{\tilde{W}_j}{(\hat{\sigma}_{jk}^2 + \sigma_e^2)}\right)^{-1}}_{=\bar{\sigma}_k^2}\left[\underbrace{\left(\frac{1}{N}\sum_j \tilde{W}_j\frac{\hat{\sigma}_{jk}^2}{\hat{\sigma}_{jk}^2 + \sigma_e^2}\right)}_{=\bar{\phi}_k}(\frac{\mu_{dk}}{\sigma_{dk}^2} - \frac{\lambda_{dk}}{\lambda_{zk}\sigma_{zk}^2}\mu_{zk}) + \sum_j \frac{\tilde{W}_j}{2N}\right] - r^f$$

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, $\bar{\sigma}_k^2$, and 2) the (wealth-weighted) average portion of learnable uncertainty facing that average market participant, $\bar{\phi}_k$

(i.e. uncertainty about f vs total residual uncertainty left). Similarly,

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

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

where

$$\bar{q}_k = \sum_j \frac{\tilde{W}_j}{N}\frac{\hat{\sigma}_{jk}^2}{\hat{\sigma}_{jk}^2 + \sigma_e^2}\frac{1}{\sigma_{\eta_{jk}}^2}$$

is a weighted-average of the signal precisions of the different agents. Thus, we have confirmed that the equilibrium price is linear and of the conjectured form.

4.3 Information Choice

Information is chosen before asset markets open, and before the agents see the actual realization of their private signals. In other words, it's chosen ex-ante, based only on agents' priors, but knowing how the information choices will affect their optimal portfolio shares and thus their terminal wealth.

First, we compute the 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

$$E_t(\frac{\tilde{W}^{1-\gamma}}{1-\gamma}\exp((1-\gamma)r_j^p) = \frac{\tilde{W}^{1-\gamma}}{1-\gamma}\exp((1-\gamma)r^f + \frac{1-\gamma}{2\gamma}\hat{\mu}'\hat{\Sigma}_r^{-1}\hat{\mu})$$

where

$$\hat{\mu} = E_{it}(\mathbf{r}) - r^f + \frac{1}{2}diag(\hat{\Sigma}_r)$$

Conditional on just the priors (i.e. ex-ante), this is a Normal random variable, with the distribution $\hat{\mu} \sim N(m, \Sigma - \hat{\Sigma})$ where m is a Nx1 vectors with the following elements:

$$m_k = \bar{\sigma}_k^2(\gamma\mu_{zk} - \frac{1}{2}\sum_j \frac{W_j}{N}) + \frac{1}{2}(\hat{\sigma}_k^2 + \sigma_{ek}^2)$$

Thus, ex-ante excess return is increasing in the effective supply of the asset μ_{zk} and decreasing in the average invested wealth $\frac{1}{2}\sum_j \frac{W_j}{N}$. Moreover, the variance of $\hat{\mu}$ is a diagonal matrix with the following diagonal elements

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

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 expcted utility was *conditional* on a choice of $\hat{\Sigma}$ and particular realizations of the informative signals. To compute the optimal information choice, we need to take the ex-ante expectations of the above utility (meaning expectation over the actual realizations of signals and resulting asset prices). Doing so gives us:

$$\begin{aligned}
E_0(\exp((1-\gamma)r_j^p) &= \frac{\tilde{W}^{1-\gamma}}{1-\gamma}E_0(E_t(\exp((1-\gamma)r_j^p)) \\
&= \frac{\tilde{W}^{1-\gamma}}{1-\gamma}\exp((1-\gamma)r^f))E_0(\exp(\frac{1-\gamma}{2\gamma}\hat{\mu}'\hat{\Sigma}_r^{-1}\hat{\mu})) \\
&= \frac{\tilde{W}^{1-\gamma}}{1-\gamma}\exp((1-\gamma)r^f))E_0(\exp((\hat{\mu}-m)'\hat{\Sigma}_r^{-1}(\hat{\mu}-m) + 2m'\widehat{\Sigma}_r^{-1}(m\hat{u}-m) + m'\widehat{\Sigma}_r^{-1}m)) \\
&= \frac{\tilde{W}^{1-\gamma}}{1-\gamma}\exp((1-\gamma)r^f))|I - \frac{1-\gamma}{\gamma}(\Sigma\hat{\Sigma}_r^{-1} - \hat{\Sigma}\hat{\Sigma}_r^{-1})|^{-\frac{1}{2}} * \\
&\exp(\frac{1-\gamma}{2\gamma}\left[(1-\gamma)m'\hat{\Sigma}_r^{-1}(\gamma I - (1-\gamma)(\Sigma\hat{\Sigma}_r^{-1} - \hat{\Sigma}\hat{\Sigma}_r^{-1}))^{-1}(\Sigma\hat{\Sigma}_r^{-1} - \hat{\Sigma}\hat{\Sigma}_r^{-1}) + I\right]m)
\end{aligned}$$

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

$$
\begin{aligned}
U_0 &= -\ln(-\frac{\tilde{W}^{1-\gamma}}{1-\gamma}E_0(\exp((1-\gamma)r_j^p)) \\
&= A + \sum_{k\in\mathcal{H}} \frac{1}{2}\ln(\frac{\hat{\sigma}_k^2 + (\gamma-1)(\sigma_k^2+\sigma_{ek}^2)}{\hat{\sigma}_k^2+\sigma_{ek}^2}) + \frac{\gamma-1}{2}\sum_{k\in\mathcal{H}}\frac{m^2}{\hat{\sigma}_k^2+(\gamma-1)\sigma_k^2+\gamma\sigma_{ek}^2} \qquad (3)
\end{aligned}
$$

where we perform the transformation $-\ln(-U)$ to avoid taking the logarithm of a negative number, 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.

Note that given the fact that the risky factors are all Gaussian, the information content of the private signal about country k (in terms of entropy units) is:

$$\kappa_k = \frac{1}{2}\left(\ln(\mathrm{Var}(d_k|p_k) - \ln(\mathrm{Var}(d_k|\mathcal{I}^{(i)})\right)$$

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

$$\hat{\sigma}_k^2 = \exp(-\kappa_k)\tilde{\sigma}_k^2$$

showing us that the conditional variance of the agent is decreasing in the amount of information, κ_k, that he acquires.

We are going to 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 κ^*, agents solve the problem

$$\max_{\kappa_k} \sum_{k\in\mathcal{H}} \frac{1}{2}\ln\left(\frac{\exp(-\kappa_k)\tilde{\sigma}_k^2+\sigma_{ek}^2+(\gamma-1)(\sigma_k^2+\sigma_{ek}^2)}{\exp(-\kappa_k)\tilde{\sigma}_k^2+\sigma_{ek}^2}\right)+\frac{\gamma-1}{2}\sum_{k\in\mathcal{H}}\frac{m^2}{\exp(-\kappa_k)\tilde{\sigma}_k^2+(\gamma-1)\sigma_k^2+\gamma\sigma_{ek}^2} \tag{4}$$

s.t.

$$\kappa^* = \sum_{k\in\mathcal{H}} \kappa_k$$

The solution of this problem will tell us the optimal allocation of information across all assets that the agents invest in, given a fixed amount of total private information they have chosen to purchase, κ^*, and a set of assets that they have chosen to invest in $\mathcal{H}$. With that solution in hand, we can solve for κ^* given $\mathcal{H}$, and finally we can find the set $\mathcal{H}$.

To make things simpler, for now we'll work out the case $\sigma_e^2 = 0$.

4.3.1 Step 1: Choice of κ_k

Taking the partial derivative of the objective function

$$\frac{\partial U_0}{\partial \kappa_k} = \frac{(\gamma-1)\left[4\hat{\sigma}_k^2(\bar{m}^2+\sigma_k^2-(\gamma-1)\bar{m}\sigma_k^2)+4(\gamma-1)\sigma_k^4-\hat{\sigma}_k^6-2(\gamma-1)\sigma_k^2\hat{\sigma}_k^4\right]}{8(\hat{\sigma}_k^2+(\gamma-1)\sigma_k^2)^2}$$

And the second derivative is

$$\frac{\partial^2 U_0}{(\partial \kappa_k)^2} = \frac{(\gamma-1)\left[\hat{\sigma}_k^6+3(\gamma-1)\hat{\sigma}_k^4\sigma_k^2+4(\gamma-1)\sigma_k^2(\sigma_k^2+(\gamma-1)\bar{m}\sigma_k^2-\bar{m}^2)+4\hat{\sigma}_k^2(\bar{m}^2+\sigma_k^2(1+(\gamma-1)^2\sigma_k^2)-(\gamma-1)\bar{m})\right]}{8(\hat{\sigma}_k^2+(\gamma-1)\sigma_k^2)^3}$$

Notice that the unconditional Sharpe ratio 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 in 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. This gives a particularly simple solution for information choice for any fixed κ^* – the agent will spent all of the information κ^* on just one asset, and will not acquire intensive information about any other assets. Given the fact that the agent has slightly tighter priors over his home asset, the optimal choice is to acquire additional information only about the home country. Hence we have that for agents in country j:

$$\kappa_j = \kappa^*$$

$$\kappa_i = 0, \forall j \neq i$$

4.3.2 Step 2: Choice of κ^*

Then choosing κ^* amounts to choosing the amount of total information to acquire about the home asset (which we denote by j)

$$\max_{\kappa^*}(\gamma-1)\ln(W - C(\kappa^*) - \Psi_j) + \frac{1}{2}\ln(\frac{\exp(-\kappa^*)\tilde{\sigma}_j^2 + (\gamma-1)\sigma_j^2}{\exp(-\kappa^*)\tilde{\sigma}_j^2}) + \frac{\gamma-1}{2}\frac{m_j^2}{\exp(-\kappa^*)\tilde{\sigma}_j^2 + (\gamma-1)\sigma_j^2}$$
$$+\sum_{k\in\mathcal{H}/j}\frac{1}{2}\ln(\frac{\tilde{\sigma}_k^2 + (\gamma-1)\sigma_k^2}{\tilde{\sigma}_k^2}) + \frac{\gamma-1}{2}\sum_{k\in\mathcal{H}/j}\frac{m^2}{\tilde{\sigma}_k^2 + (\gamma-1)\sigma_k^2}$$

The FOCs of this problem are

$$\frac{C'(\kappa^*)}{W - C(\kappa^*) - \Psi_j} = \frac{(\gamma-1)\left[4\hat{\sigma}_k^2(\bar{m}^2 + \sigma_k^2 - (\gamma-1)\bar{m}\sigma_k^2) + 4(\gamma-1)\sigma_k^4 - \hat{\sigma}_k^6 - 2(\gamma-1)\sigma_k^2\hat{\sigma}_k^4\right]}{8(\hat{\sigma}_k^2 + (\gamma-1)\sigma_k^2)^2}$$

where

$$\hat{\sigma}_j^2 = \tilde{\sigma}_j^2\exp(-\kappa^*)$$

$$\hat{\sigma}_k^2 = \tilde{\sigma}_j^2 \text{ , for all } k \neq j$$

Given a convex cost function $C(\kappa^*)$, this defines a unique solution for total intensive information κ^*.

4.3.3 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 $\tilde{W}_j$ goes down by c_k. The gain for acquiring priors on asset k and adding it to your portfolio is given by the term

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

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

$$\frac{\partial^2 \ln(\tilde{W}_j)}{(\partial \Psi_j)^2} = -\frac{1}{\tilde{W}_j^2} \tag{5}$$

which is essentially observing that marginal utility is declining, hence further information acquisitions are becoming costlier in utility terms. Moreover, increases in Ψ_j leads to lower investible wealth, and hence a lower choice of κ^* 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.

4.4 Model Implications

The model is able to match the stylized portfolio facts that we documented earlier.

Proposition 1. *In a symmetric world where all countries are ex-ante the same, the equilibrium portfolio holdings of agent i 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_j, i.e. the size of the agent's 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 in the market portfolio. Formally, if $k, k' \in \mathcal{H}$, then*

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

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

$$Bias_{jk} = 1 - \frac{1 - \alpha_{jk}}{1 - z_{jk}} = 0$$

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

The first result, sparseness, is a direct consequence of the two-tiered information structure that we have assumed. Since agents need to first acquire a basic understanding of a given market before they enter it (i.e. learn the unconditional distribution of payoffs), they do not necessarily enter all markets and as a result portfolios tend to be sparse and feature a lot of 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. In utility terms, the gain of adding a new asset is given by the term

$$\ln(1 + (\gamma - 1)\frac{\sigma_k^2}{\tilde{\sigma}_k^2}) + \frac{\gamma - 1}{2}\frac{m^2}{\tilde{\sigma}_k^2 + (\gamma - 1)\sigma_k^2} \tag{6}$$

in equation (4). The first term roughly accounts for the diversification benefit of adding the asset, and second for its expected positive excess return.

The cost is simply c_k in financial terms, and it's effect on utility works directly through reducing the portfolio wealth of the individual – the $\ln(\tilde{W})_j$ term in equation (3). Since this is a concave function, this means that the cost of learning about more countries is increasing in the number of countries one has already learned about. And since the benefit of learning about a new country, eq. (6), is constant, this means that there is some optimal amount of 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 also proves the second result – the fact that the sparseness of the portfolios is decreasing with the wealth of the agent.

Lastly, let's turn our attention to the foreign holdings of the agent and how they relate to one another. Recall that the agent faces increasing returns to intensive information and hence finds it optimal to specialize in learning additional intensive information only about the home asset. Thus, for all foreign assets he relies only publicly available information and his priors. In a symmetric world where all countries are the same (and hence the unconditional variance of payoffs is the same, i.e. $\sigma_k^2 = \sigma_{k'}^2$), the relative informativeness of the equilibrium asset prices in all countries will be the same. Therefore, the variance of payoffs, conditional on the public information set is also the same i.e.:

$$\tilde{\sigma}_k^2 = \tilde{\sigma}_{k'}^2$$

Thus, the optimal portfolio weight of a foreign asset k is:

$$\alpha_{jk} = \frac{E(r_k|p_k) - r^f + \frac{1}{2}\tilde{\sigma}_{kr}^2}{\gamma \tilde{\sigma}_{kr}^2}$$

and since the world is symmetric, the expected excess returns and variances are the same, and hence the portfolio weights of any two foreign investments k, k' are the same. As a result, the foreign bias of any foreign holding is the same, and is in fact zero.[4]

5 Empirical Tests

The information model with a two–tiered information cost structure can rationalize the stylized portfolio facts we document earlier, but is this mechanism empirically relevant? To examine this question, we directly test the model's key implications in the data. We derive three sets of implications that are crucial to the inter workings of the mechanism, and examine each of them in the following sections. First we examine whether there is home bias in information acquisition, second we test whether portfolio sparseness follows sparseness in information (extensive margin) and finally whether the accuracy of forecasts matters for portfolio holdings (intensive margin).

Table 1 contains the list of variables that we will use in the empirical analysis. In particular, from Consensus Economics we obtain the forecasts on 10–year sovereign yields and GDP growth for over 200 forecasters at the monthly frequency from September 2006 to

[4] 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. Confirming this conjecture in a numerical exercise is under way.

December 2014 for 26 different countries (see the Appendix for a list of countries and type of forecasters). We are able to match 40 such forecasters to the sample of EBA banks, from which we obtain information on sovereign bond holdings for all 26 countries of exposure.

Forecasts are available at two different horizons. A short–horizon, *i.e.* 3–months ahead and end–of–current year growth rate for 10–year yields and GDP respectively, and a long–horizon, *i.e.* 12–months ahead and end–of–next year growth rate for 10–year yields and GDP respectively. From these forecasts we construct a squared forecast error (SFE) for bank b 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, we also compute the *average* squared forecast error for the whole sample period of forecasts as $\overline{SFE}_{bch} = \frac{1}{T}\sum_{t=1}^{T}(E_{bt}(X_{c,t+h}) - X_{c,t+h})^2$.

5.1 Home bias in information

Our model clearly predicts that the home bias in portfolios is driven by a home bias in information acquisition. Is this true in the data? Specifically, we ask whether home forecasters on average better than foreign ones and moreover whether home forecasts are more accurate than foreign forecasts for a *given forecaster*.

To do so, we examine whether home forecasters are better than foreign forecasters, by running the following regression:

$$SFE(X^h_{bct}) = \alpha + \beta Home_{bc} + \varepsilon_{bc}$$

where $Home_{bc}$ is a dummy variable that equals one when country c is the "home" country for forecaster b. X^h_{bct} is going to be either the 10–year yield or GDP forecast at horizon h (one short and one long) for country c. We also use $\overline{SFE}^h_{bct}$ as an alternative dependent variable. Table 3 shows the result for this specification. In each panel, the first two columns use the SFE at the short–horizon forecast, while the last two look at the SFE longer–horizon forecast.

The coefficient on the home dummy is negative and significant in most specifications, indicating that indeed home forecasters are better at predicting home variables. Moreover, column (2) and (4) include a forecaster fixed–effect, using only variation within a given forecaster. Essentially, the results indicate that home forecasts are more accurate than foreign forecasts for a given forecaster. The results also hold if we restrict the sample to only those forecaster that predict both home and foreign (see Appendix). The last set of results align well with the model where the asymmetry is within a forecaster (bank) specifically.

5.2 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 do not invest anything in them, leading to sparse portfolios. In this section, we therefore examine whether sparseness of information is indeed associated with sparseness of portfolios.

We start by restricting the sample to foreign holdings only and we estimate the following regression:

$$Share_{bct} = a_{bt} + \lambda_{ct} + \beta ForeignFcst_{bct} + \varepsilon_{bct}$$

where $ForeignFcst_{bct}$ is a dummy variable that equals 1 if bank b makes any forecast about country c at time t, and 0 otherwise – most likely the forecast is about GDP, since this is the most frequent object of forecast. $Share_{bct}$ is the portfolio share of country c in bank b's portfolio at time t. The results are presented in Table 4 – Panel A. The results indicate that when a bank makes a forecast for a foreign country, it has a sovereign exposure to that country about one standard deviation 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 from 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 specification in column (6) 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 further specialize our specification to specifically examine if sparseness of portfolios is associated with sparseness in information sets, by running a version of the regression above but replacing the dependent variable with $\mathbf{1}(Share_{b,c,t})$, that is a variable equal to 1 if a bank b holds any assets of country c, and zero otherwise. Here the results indicate that if a bank makes a foreign forecast for a country it is around 30–40% more likely to hold sovereign bonds from that country.

5.3 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 the agent pays the fixed information cost c_k is:

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

This puts strong restrictions on the relationship between portfolio shares, average beliefs and the precision of those beliefs. In particular, agents will hold more of a given asset the more optimistic they are about its returns, and the more certain they are in their expectation – i.e. the higher is the precision of their beliefs.

Although our model is a general equilibrium one, the equation above is only a partial equilibrium expression, which is still useful to gain intuition. However, if everyone were to revise their expectations upwards at the same time, it cannot be the case that in equilibrium *everyone* increases their portfolio holdings since the supply of the asset has not changed. What changes is the asset price – specifically the equilibrium price offsets any common movements in beliefs. Thus, it turns out that what matters for equilibrium portfolio holdings is the deviation of an agent's beliefs from the average market beliefs. 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

$$\alpha_{jkt} = \frac{E_{jt}(d_{k,t+1})) - \bar{E}_t(d_{k,t+1})}{\gamma \hat{\sigma}^2_{jkt}} + \frac{1}{2\gamma}\left(1 - \frac{\bar{\sigma}^2_{kt}}{\hat{\sigma}^2_{jkt}} \sum_j \frac{\tilde{W}_j}{\tilde{N}}\right) + \gamma z_t \frac{\bar{\sigma}^2_{kt}}{\hat{\sigma}^2_{jkt}} \tag{7}$$

where we define the average market expectation (wealth-weighted) $\bar{E}_t(d_{k,t+1})$ as

$$\bar{E}_t(d_{k,t+1}) = \bar{\sigma}^2_{kt}\left(\sum_j \frac{\tilde{W}_j}{N} \frac{\int E^{(i)}_{jkt}(d_{k,t+1}) di}{\hat{\sigma}^2_{jkt}}\right)$$

Still, the basic intuition of the relationship between beliefs and portfolios is the same. Agents will hold more of a given asset the more optimistic they are about its return *relative* to the average market belief, and their portfolio holdings will be more responsive to their relative optimism, the greater is the precision of their beliefs. In the rest of the section, we seek to test these two crucial implications of the information model. In particular, we test whether portfolio holdings are associated with beliefs and their precision in the following regression:

$$Share_{b,c,t} = a + \beta_1 X^h_{b,c,t} + \beta_2 \overline{SFE}(X^h_{b,c,t}) + \beta_3 X^h_{b,c,t} \times \overline{SFE}(X^h_{b,c,t}) + \mu_{bc} + \gamma_t + \varepsilon_{b,c,t}$$

We restrict the sample to *positive* foreign holdings only and allow $X^h_{b,c,t}$ to be either the 10–year yields or GDP forecasts at both long and short horizon as in section 5.1. In this regression, we expect that banks are i) increasing portfolios when they are more optimistic and ii) decreasing the sensitivity of their portfolios to their beliefs, as the beliefs become less precise (i.e. higher $\overline{SFE}_{bct}$). In terms of regression coefficients we thus expect $\beta_1 < 0$ and $\beta_3 > 0$ when the forecast is about 10–year yields and the opposite ($\beta_1 > 0$ and $\beta_3 < 0$) for GDP forecasts. Intuitively in fact, since price and yield are inversely related, if yields are expected to increase in the future, the bank would decrease holdings today as the expected return decreases, thus $\beta_1 < 0$. On the other hand, if the bank makes larger forecast error on 10–year yields, we expect $\beta_2 > 0$ as holdings become less sensitive to movements in 10–year yields. Alternatively, if GDP growth is expected to increase, then we would expect the bank to increase its holdings of sovereign bonds that country today, *i.e.* $\beta_1 > 0$, but the sensitivity would decrease with larger forecast errors ($\beta_2 < 0$). In conclusion, although our preferred measure is the forecast on 10–year yields as this is directly related to market prices and thus asset holdings, we also test for robustness using GDP forecast, which is a more indirect measure of good news about the country.

The results are presented in Table 5 – Panel A and B. We can clearly see that the data strongly support all implications. We progressively saturate the model with an increasing number of fixed–effects, from time effects only (column (1)) to bank (column (2)) and destination country fixed–effects (column (3)). In terms of magnitudes, we notice that i) if the 10–year yields (or growth rate of GDP) is predicted to increase by 1% more in the next 3 or 12 months (end of the current or next year), the bank decreases (increases) its holdings by about 1–2% (0.5%); ii) if a forecast is one standard deviation more inaccurate in terms of SFE, the portfolio share for a more optimistic forecast would increase (decline) by about 0.2% to 1.4% (0.15% to 1.44%) for short and long–horizon respectively.

6 Conclusion

In this paper we have analyzed whether information frictions can explain the heterogeneity in bank sovereign holdings. While the home bias puzzle is often cast in terms of a domestic vs foreign divide in asset holdings, we exploit the heterogeneity in bank foreign holdings to explain why banks hold some countries' sovereign debt more than other. First, 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. We show that a model with information frictions and a two–tiered information structure with a fixed–cost of acquiring information can rationalize these stylized facts. Finally, we empirically test the key predictions of the model using EBA sovereign exposure data matched with bank macroeconomic forecast from Consensus Economics. First of all, we show that there is home bias in information: domestic forecasters are better at predicting the domestic economy, even restricting the sample to those forecasters that make prediction for domestic and foreign economies.

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Table 1: Variable Definition

Variable	Definition	TimePeriod	Data source
$\mathrm{Y10}^1_{b,c,t}$	3–months ahead forecast for 10 –year sovereign bond yield of country c from forecaster b at time t	2006M9–2014M12	Consensus
$\mathrm{Y10}^2_{b,c,t}$	12–months ahead forecast for 10 –year sovereign bond yield of country c from forecaster b at time t	2006M9–2014M12	Consensus
$\mathrm{GDP}^1_{b,c,t}$	end–of year forecast for GDP growth of country c from forecaster b at time t	2006M9–2014M12	Consensus
$\mathrm{GDP}^2_{b,c,t}$	end–of next year forecast for GDP growth of country c from forecaster b at time t	2006M9–2014M12	Consensus
$\mathrm{SFE}(X_{b,c,t})$	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
$\mathrm{Home}_{b,t}$	Dummy = 1 for domestic forecast		Consensus
$\mathrm{ForeignFcst}_{b,c,t}$	Dummy = 1 if forecaster b makes any forecast for country c at time t		EBA–Consensus match
$\mathrm{Share}_{b,c,t}$	Share of sovereign bonds of country c out of total bank b portfolio	2010Q1–2013Q4	EBA
$\mathrm{ShareEEA}_{b,c,t}$	Share of sovereign bonds of country c out of EEA bank b portfolio	2010Q1–2013Q4	EBA
$\mathrm{ShareEuro}_{b,c,t}$	Share of sovereign bonds of country c out of Eurozone bank b portfolio	2010Q1–2013Q4	EBA

Table 2: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
GDP^1	1.048	2.775	-20.4	10.526	27800
GDP^2	1.904	1.507	-11.8	8.773	27421
$Y10^1$	3.437	1.518	0.4	10.9	15204
$Y10^2$	3.661	1.396	0.45	9.6	14872
$SFE(GDP^1)$	1.87	3.869	0	26.112	27800
$SFE(GDP^2)$	9.577	24.697	0	158.76	27421
$SFE(Y10^1)$	0.36	0.602	0	3.456	15187
$SFE(Y10^2)$	1.207	1.712	0	8.700	14865
Home	0.399	0.49	0	1	27806
ForeignFcst	.059	.237	0	1	6152
$\text{Share}_{b,c,t}$	.007	.029	0	1	6415
$\text{ShareEEA}_{b,c,t}$	.008	.031	0	1	6049
$\text{ShareEuro}_{b,c,t}$	.012	.037	0	.933	3870
$\text{Share}_{b,c,t}$ | Home=0	0.004	0.014	0	0.52	6152
$\text{ShareEEA}_{b,c,t}$ | Home=0	0.004	0.014	0	0.523	5786
$\text{ShareEuro}_{b,c,t}$ | Home=0	0.007	0.024	0	0.441	3694
$\mathbf{1}(\text{Share}_{b,c,t})$| Home=0	0.51	0.5	0	1	6152
$\mathbf{1}(\text{ShareEEA}_{b,c,t})$| Home=0	0.545	0.498	0	1	6152
$\mathbf{1}(\text{ShareEuro}_{b,c,t})$| Home=0	0.749	0.433	0	1	6152

Table 3: Are Home Forecasters Better?

Panel A – SFE(GDP)

	(1)	(2)	(3)	(4)
	SFE(GDP^1)	SFE(GDP^1)	SFE(GDP^2)	SFE(GDP^2)
Home	-0.759***	-1.190***	-3.608***	-6.402***
	(0.147)	(0.185)	(0.902)	(1.464)
Intercept	3.965***		13.03***	
	(0.229)		(0.870)	
Observations	27800	27798	27421	27419
N of Forecasters	204	202	204	202
Forecaster FE	no	yes	no	yes

Panel B – SFE(Y10)

	(1)	(2)	(3)	(4)
	SFE(Y10^1)	SFE(Y10^1)	SFE(Y10^2)	SFE(Y10^2)
Home	-0.0503*	-0.0554	-0.0357	-0.0529
	(0.027)	(0.043)	(0.098)	(0.169)
Intercept	0.279***		1.161***	
	(0.025)		(0.105)	
Observations	15187	15185	14865	14863
N of Forecasters	183	181	183	181
Forecaster FE	no	yes	no	yes

Panel C – $\overline{SFE}$(GDP)

	(1)	(2)	(3)	(4)
	$\overline{SFE}$(GDP^1)	$\overline{SFE}$(GDP^1)	$\overline{SFE}$(GDP^2)	$\overline{SFE}$(GDP^2)
Home	-0.837***	-1.137***	-4.472***	-8.533***
	(0.235)	(0.333)	(1.398)	(2.432)
Intercept	2.338***		11.63***	
	(0.207)		(1.340)	
Observations	582	435	582	435
N of Forecasters	204	57	204	57
Forecaster FE	no	yes	no	yes

Panel D – $\overline{SFE}$(Y10)

	(1)	(2)	(3)	(4)
	$\overline{SFE}$(Y10^1)	$\overline{SFE}$(Y10^1)	$\overline{SFE}$(Y10^2)	$\overline{SFE}$(Y10^2)
Home	-0.237***	-0.417***	-0.386**	-0.586**
	(0.067)	(0.130)	(0.148)	(0.246)
Intercept	0.582***		1.547***	
	(0.063)		(0.134)	
Observations	340	202	338	200
N of Forecasters	183	45	183	45
Forecaster FE	no	yes	no	yes

Notes: Standard errors are clustered at the forecaster level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 4: Extensive Margin: Foreign Exposures and Foreign Forecast

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

	(1)	(2)	(3)	(4)	(5)	(6)
ForeignFcst	0.0114***	0.0114***	0.0114***	0.0108**	0.0110**	0.0113**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Observations	6152	6152	6152	6152	6152	6152
Adj. R^2	0.0307	0.0396	0.174	0.366	0.376	0.368
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 $\mathbf{1}(Share_{b,c,t})$ for non–domestic exposures

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{ForeignFcst}_{b,c,t}$	0.392***	0.401***	0.336***	0.314***	0.323***	0.332***
	(0.050)	(0.048)	(0.065)	(0.091)	(0.089)	(0.089)
Observations	6152	6152	6152	6152	6152	6152
Adj. R^2	0.0335	0.0423	0.177	0.368	0.377	0.369
N of Forecasters	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

Notes: Standard errors are two–way clustered at the forecaster and country level. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 5: Intensive margin: Beliefs and Precision

Panel A: 10–year Yields Forecast Beliefs and Precision

	(1) ShareEuro	(2) ShareEuro	(3) ShareEuro	(4) ShareEuro	(5) ShareEuro	(6) ShareEuro
$\overline{SFE}(Y10^1)$	-10.31***	-9.345***	-10.99***			
	(2.259)	(0.746)	(1.149)			
$Y10^1$	-2.155***	-1.431***	-0.825***			
	(0.267)	(0.115)	(0.166)			
$\overline{SFE}(Y10^1) \times Y10^1$	1.397***	1.082***	0.647***			
	(0.520)	(0.185)	(0.184)			
$\overline{SFE}(Y10^2)$				-0.0520	-3.819***	-3.442***
				(0.669)	(0.345)	(0.467)
$Y10^2$				-1.385***	-1.206***	-0.822***
				(0.191)	(0.085)	(0.162)
$\overline{SFE}(Y10^2) \times Y10^2$				-0.269*	0.282***	0.178***
				(0.158)	(0.065)	(0.063)
Observations	435	435	435	417	417	417
Time FE	yes	yes	yes	yes	yes	yes
Bank FE	no	yes	yes	no	yes	yes
Destination country FE	no	no	yes	no	no	yes

Panel B: GDP Forecast Beliefs and Precision

	(1)	(2)	(3)	(4)	(5)	(6)
$\overline{SFE}(GDP^1)$	-0.137***	-0.145***	0.369***			
	(0.016)	(0.024)	(0.058)			
GDP^1	0.566***	0.471***	0.496***			
	(0.052)	(0.041)	(0.082)			
$\overline{SFE}(GDP)^1) \times GDP^1$	-0.0138***	-0.0235***	-0.0199***			
	(0.004)	(0.006)	(0.005)			
$\overline{SFE}(GDP^2)$				-0.0430***	-0.00715	0.0832***
				(0.012)	(0.012)	(0.013)
GDP^2				0.345***	0.384***	0.426***
				(0.095)	(0.068)	(0.094)
$\overline{SFE}(GDP^2) \times GDP^2$				0.00475*	-0.00804**	0.00178
				(0.003)	(0.004)	(0.003)
Observations	1082	1081	1081	1067	1066	1066
Time FE	yes	yes	yes	yes	yes	yes
Bank FE	no	yes	yes	no	yes	yes
Destination country FE	no	no	yes	no	no	yes

Notes: Robust standard errors in brackets. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Online Appendix

Stylized Facts Robustness – Appendix

There are three main facts about the drivers of home bias at the bank level:

1. The *extensive margin*, *i.e.* the fact that banks do not invest at all in many countries, is the main driver of banks' overall home bias.
2. Among the assets that banks do hold in positive quantities, domestic bonds are still overweighted compared to foreign holdings (the *intensive margin* still shows some home bias)
3. The foreign portion of the portfolios held in positive quantities are in the right proportions relative to each other (there is no *foreign bias*)

In the main body of the paper, we presented these facts using data as of 2010Q4 for a sovereign portfolio of EU countries only in order to have an homogeneous group in terms of regulatory treatment (0% risk–weight).

In this appendix we show that the facts are robust to different time periods (2010Q1, 2010Q4) and different portfolios (Euro–area countries). In fact, even though debt from any EU country is identical in terms of regulatory risk–weight, it is not the same in terms of collateral eligibility for private repos or refinancing operation at the ECB. In particular, the ECB normally accepts sovereign debt issued by Euro–area countries denonominated in euros as collateral from euro–area institutions that want to access the standard liquidity operations at the ECB.[5] Hence, a euro–area bank may prefer euro–area debt to EU debt from a non–euro area country: in that case, the three stylized facts we presented for the EU portfolio may be driven by a preference for liquidity and collateral eligibility for the smaller subset of euro–area debt.

[5] Assets denominated in US dollars, pounds and yen are accepted with an additional haircut (Nyborg (2015)).

Table 6: Summary Statistics Home Bias, by year

	N of banks	Mean	Std.Dev.	Min	10^{th} pct.	25^{th} pct.	Median	75^{th} pct.	90^{th} pct.	Max
2010Q1										
HomeBias	88	0,676	0,320	0,006	0,168	0,388	0,799	0,965	1	1
Adj. Int.	88	0,441	0,386	0,000	0,001	0,047	0,362	0,793	1	1
Adj Ext.	88	0,235	0,271	-0,395	-0,073	0,002	0,198	0,398	0,670	0,880
2010Q4										
HomeBias	86	0,718	0,289	-0,032	0,283	0,466	0,851	0,968	0,998	1
Adj. Int.	86	0,452	0,368	0,000	0,003	0,080	0,377	0,789	0,996	1
Adj Ext.	86	0,266	0,242	-0,086	0,000	0,048	0,201	0,445	0,630	0,852
2011Q4										
HomeBias	60	0,644	0,287	0,001	0,227	0,381	0,713	0,895	0,956	1
Adj. Int.	60	0,306	0,304	0,001	0,006	0,040	0,221	0,518	0,806	1
Adj Ext.	60	0,339	0,308	-0,732	-0,003	0,146	0,335	0,537	0,787	0,899
2012Q2										
HomeBias	60	0,665	0,281	0,006	0,248	0,438	0,777	0,896	0,971	1
Adj. Int.	60	0,327	0,306	0,001	0,005	0,052	0,228	0,553	0,806	1
Adj Ext.	60	0,338	0,279	-0,217	-0,007	0,150	0,327	0,529	0,748	0,875
2012Q4										
HomeBias	63	0,670	0,278	0,026	0,251	0,443	0,774	0,904	0,972	1
Adj. Int.	63	0,358	0,302	0,000	0,028	0,094	0,256	0,543	0,812	1
Adj Ext.	63	0,312	0,258	-0,350	-0,007	0,130	0,325	0,503	0,611	0,812
2013Q2										
HomeBias	62	0,662	0,284	0,056	0,234	0,366	0,761	0,902	0,982	1
Adj. Int.	62	0,365	0,319	0,001	0,035	0,073	0,245	0,601	0,898	1
Adj Ext.	62	0,297	0,293	-0,697	-0,041	0,097	0,313	0,518	0,660	0,818
2013Q4										
HomeBias	119	0,715	0,311	-0,046	0,207	0,514	0,842	0,980	1,000	1
Adj. Int.	119	0,493	0,351	0,000	0,057	0,183	0,426	0,819	1,000	1
Adj Ext.	119	0,255	0,334	-0,822	-0,082	0,000	0,209	0,490	0,692	1

Table 7: Summary Statistics Home Bias, by quintile of Assets for all years (1^{st} quintile is the bottom)

	N of banks	Mean	Std.Dev.	Min	10^{th} pct.	25^{th} pct.	Median	75^{th} pct.	90^{th} pct.	Max
1^{st} quintile										
HomeBias	104	0,851	0,204	0,086	0,514	0,810	0,923	0,996	1	1
Adj. Int.	104	0,709	0,287	0,162	0,266	0,461	0,805	0,995	1	1
Adj Ext.	104	0,152	0,220	-0,732	-0,074	0,000	0,132	0,315	0,401	1
2^{nd} quintile										
HomeBias	102	0,812	0,188	0,083	0,648	0,748	0,835	0,953	0,996	1
Adj. Int.	102	0,556	0,307	0,031	0,153	0,263	0,577	0,868	0,982	1
Adj Ext.	102	0,256	0,281	-0,811	-0,046	0,052	0,210	0,488	0,630	0,785
3^{rd} quintile										
HomeBias	114	0,691	0,277	0,093	0,247	0,435	0,811	0,912	0,973	1
Adj. Int.	114	0,399	0,296	0,009	0,045	0,100	0,323	0,652	0,791	1
Adj Ext.	114	0,291	0,316	-0,697	-0,089	0,112	0,241	0,533	0,778	0,899
4^{th} quintile										
HomeBias	109	0,605	0,298	0,043	0,188	0,306	0,682	0,874	0,923	0,994
Adj. Int.	109	0,186	0,173	0,000	0,003	0,044	0,128	0,264	0,452	0,720
Adj Ext.	109	0,420	0,304	-0,376	0,010	0,205	0,456	0,645	0,805	0,880
5^{th} quintile										
HomeBias	115	0,413	0,260	-0,032	0,101	0,225	0,366	0,588	0,800	0,987
Adj. Int.	115	0,063	0,110	0,000	0,001	0,003	0,021	0,073	0,202	0,743
Adj Ext.	115	0,350	0,222	-0,087	0,100	0,190	0,312	0,505	0,704	0,852

Consensus Economics– Appendix

Table 8: Number of Forecasters per Country

Country	N	min	p25	p50	p75	max
Austria	362	6	9	11	12	13
Belgium	397	5	11	12	13	14
Bulgari	1044	8	11	12	12	15
Switzerland	1278	13	14	15	16	17
Germany	2396	9	28	29	30	32
Denmark	358	5	9	11	12	14
Spain	1328	4	15	16	17	19
Estonia	818	7	8	9	10	12
Finland	360	6	9	11	12	13
France	1645	5	18	20	22	25
Greece	437	7	12	13	14	15
Hungary	1408	12	14	15	17	21
Ireland	427	7	12	13	14	14
Italy	1201	5	13	15	16	18
Japan	1742	18	20	21	22	23
Lithuania	721	6	7	8	9	10
Netherlands	784	4	9	9	10	12
Norway	744	4	8	9	10	12
Poland	1454	11	15	16	18	19
Portugal	425	7	12	13	14	15
Romania	1040	7	11	12	13	15
Slovakia	989	8	10	11	12	14
Slovenia	905	7	9	10	11	14
Sweden	1215	4	14	15	16	17
UK	2015	5	23	24	26	28
USA	2313	19	26	27	28	33
Total	27806	4	12	15	23	33

Table 9: Type of Forecasters

Type	Obs.	%
Bank	14320	51.50
Economic Consulting Firm	5881	21.15
Research Institute	3127	11.25
Financial Services, Insurance &Rating Agencies	2314	8.32
University	800	2.88
Institute - Business Association	721	2.59
Corporation	561	2.02
Total	27806	100