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Asset home bias in debtor and creditor countries

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Abstract

Why do debtor countries have on average a less diversified international portfolio than creditor countries? With two symmetric countries, the existing literature has showed why portfolios are home-biased to the same degree across countries. We show that, in a model with debtor and creditor countries, a new hedging motive of net external positions implies a short (long) position of both home and foreign assets in the debtor (creditor) country. Marginally, the debtor (creditor) country loses (gains) the net foreign asset (NFA) as a diversified portfolio on top of the above symmetrically biased portfolio, which intensifies (dilutes) the home bias there. An extended model with both equity and bond assets also yield global two-way capital flows that are in consistent with the data. The theory helps understand the financial capital flows between the debtor developing and creditor developed countries during the financial globalization from 1990s, and receives empirical support.

Keywords: International portfolio choices, Asymmetric asset home bias, Global imbalances, Two-way capital flows.

JEL Codes: F36, F41, O11, O16, O19

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1 Introduction

Despite increased financial integration, assets are mostly held domestically.[1] In developing and emerging (DEV) economies, this asset home bias (EHB) has been even more salient (Coeurdacier and Rey, 2013): the bias degree in DEV countries has been persistently higher than in developed (ADV) countries by around 15% on average.[2] At the same time, although these countries have been experiencing a considerable improvement in their net external position, they are still more of net debtor (compared to ADV countries, see e.g. Alfaro et al., 2014, Lane and Milesi-Ferretti, 2007, 2017). Intriguing by this, we explore the hypothesis that the portfolio bias gap between DEV and ADV countries to some extent reflects that between debtor and creditor countries. That is, we ask, does a debtor have to hold a more "home-biased" portfolio than a creditor in theory? And if so, how much does this help explain the observed bias gap in the data.

Figures 1 to 3 motivate this research. While the home bias gap between DEV and ADV countries has been well documented in the literature,[3] Figure 1 panel (a) finds an analogous gap between debtor and creditor countries - debtors continuously exhibit a stronger home bias than creditors. Panel (b) further shows a tight relation between this bias gap with NFA imbalances over time, i.e. when the NFA imbalances worsen (improve), the bias gap also tends to widen (stabilize). Figures 2 and 3 show that the DEV countries are indeed net debtors. Although their net debt position improves considerably, most of them still possess negative NFAs, with their net equity assets being even lower - the so-called two-way capital flows.

We first show that a typical debtor should hold a more "home-biased" portfolio. To do so, we develop a model of both net and gross country portfolios within a standard international macro framework (Backus et al., 1994, 1995). In such a framework, the portfolios have been shown to be strongly home-biased (Coeurdacier et al., 2010, Heathcote and

[1] See, e.g., French and Poterba, 1991, Cooper and Kaplanis, 1994 and Tesar and Werner, 1995, etc, for early contributions.

[2] Coeurdacier and Rey (2013) find that "emerging markets have less diversified equity portfolios than developed countries": there is an average home bias of 0.9 in emerging and developing countries, which is nearly 20 percent higher than in developed countries. By Sercu and Vanpee (2007, 2008), on average, around 70% of the equity are held locally in developed countries while it is 84% for developing and emerging countries.

[3] See, e.g. Sercu and Vanpee (2007), Coeurdacier and Rey (2013), Mukherjee (2015), and Steinberg (2018) among others.

Perri, 2013, Coeurdacier and Gourinchas, 2016), and various country asymmetries that are able to create autarky interest rate differential would open NFA imbalances (Quadrini, 2013, Gourinchas and Rey, 2014). However, these two strands of literature do not formally interact in the sense that the former focuses on identical countries while the latter typically abstracts from portfolio choices by assuming either only one asset traded internationally or a fully complete asset market (Coeurdacier and Rey, 2013). With both net and gross portfolios being non-trivial, the model makes it possible for unbalanced net positions and otherwise symmetrically biased gross positions to interact, from which the pattern of an asymmetric asset home bias arises endogenously.

Albeit important, this paper does not aim at proposing any new theory of global NFA imbalances or identifying the driving force of NFAs of any particular country. The focus is instead on the non-zero net position's effect on international distribution of portfolio bias. Therefore, when modelling global imbalances, we follow the literature, e.g. Kehoe et al. (2018), by borrowing a country asymmetry. Specifically, we assume a differing factor share of income across countries (Caballero et al., 2008, 2021, Jin, 2012). Like alternative forces in the literature, it yields NFA imbalances as a result of intertemporal choices - the debtor desires to shift resource from the future to the present by borrowing while the creditor does the opposite.[4] And we ask how would this intertemporal consideration affect the relative strength of portfolio home bias across countries, a decision that matters for intratemporal risk-sharing.

Why NFA imbalances would cause a lower diversification in debtor countries? The intuition is straightforward. Consider a marginal case in a 2-country 2-asset economy. A small rise of country asymmetry *relatively* decreases the asset demand in the debtor country - a negative NFA there. When country asymmetry is small, the home and foreign assets are marginally the same. The division of the additional wealth (NFA) between the two assets therefore must be balanced. The debtor country reduces the holdings of the two assets to the same extent. That is, the marginal portfolio, NFA, is a diversified

[4] From an accounting perspective, a negative NFA position is the result of a relatively lower saving, i.e. a relatively lower total asset demand than asset supply, regardless of the deeper reason for the changes in asset demand and supply as highlighted by the literature on global imbalances, see the review by Gourinchas and Rey (2014). Gourinchas and Jeanne (2013) find that the allocation puzzle is a saving puzzle. The negative NFA of the debtor country can be due to a relatively higher foreign saving, global saving glut à la Bernanke (2005), or a relatively lower domestic saving, e.g. Laibson and Mollerstrom (2010). See also Steinberg (2019) on whether domestic or foreign saving movements are the culprits of the NFA position in the case of the US.

portfolio, while the average portfolio - the one with absence of global imbalances - is a home-biased one. The debtor (creditor) country loses (gains) a diversified portfolio on top of the initially home-biased portfolio, which intensifies (dilutes) the home bias in the debtor (creditor) country.

The key underpinning is therefore that, under global imbalances, diversifying the risk due to NFA position requires a portfolio with less home bias than the average portfolio. The marginal portfolio is a diversified one because NFA position only includes financial income (Lucas, 1982). In our baseline model, the average portfolio is a home-biased one because national income includes not only financial (dividend) income but also non-financial (labour) income and the hedging of labour income requires investors to hold more of domestic assets (Coeurdacier et al., 2010, Heathcote and Perri, 2013, Coeurdacier and Gourinchas, 2016).

Therefore, first, the type of structural country asymmetry underlying NFA imbalances does not matter here. Once it opens non-trivial NFA positions, it incentivizes investors in both countries to take into account of net foreign investment income risks.[5] Second, the specific source of home bias in the average portfolio does not matter either. A vast literature highlights the role of many other factors than labour hedging in generating the home bias in the average portfolio, e.g. hedging exchange rate risks (Kollmann, 2006, Benigno and Nisticò, 2012), hedging government risks (Berriel and Bhattarai, 2013), informational frictions (Dziuda and Mondria, 2012), etc. As long as the average portfolio is a home biased one, a marginal debtor would always turn to a more home-biased portfolio. Of course, their quantitative implications may differ. Specifically, the more biased the initial average portfolios, the larger the gap between the portfolio biases of the debtor and creditor. In an extended model, we show that the inclusion of more risks - additional real exchange rate (RER) risks - and more assets - an additional international bond than just equity assets - does not overturn our intuition. In fact, by distinguishing bond and

[5]In a related paper, Zhang (2019) highlights that countries with unbalanced NFA positions need to take into account of the risks associated with non-zero NFA positions, and how would this impact country's external adjustments. The average portfolio there, however, is based on Lucas (1982) and is itself a diversified one. Our intuition here also resonate with Tille and van Wincoop's (2010) finding that the international capital flows along a steady growth path is a home biased one while the allocation of marginal deviations around that path is diversified. Neither of these two papers focuses on the internationally asymmetric distribution of portfolio home bias. Mukherjee (2015) and Steinberg (2018) analyse the differing portfolio biases across countries. They, however, do not involve NFA imbalances' impact. None of these research concern the two-way capital flows.

equity assets, the model yields two-way capital flows - the net debtor country goes short in equities and long in bond while the net creditor country does the opposite, a pattern in alignment with the data as shown in Figures 2 and 3. We find that both a stronger biased average portfolio (due to the additional RER risks) and the presence of two-way capital flows contribute to an even larger gap between the portfolio biases of the two countries.

Will this outcome remain beyond the marginal case? We calibrate our model to the data of 62 countries from 1990 − 2015 and show that the mechanism holds well just as in the marginal case. Through the calibration, we also quantify the extent to which the model accounts for the observed gap of portfolio home bias between different groups of countries. Under our benchmark calibration, out of 18 percentage points of the bias difference between the DEV and ADV countries (whose between-groups average NFA/GDP ratio at 15%), our model explains half of them. Out of 15 points of the bias difference between debtor and creditor countries, the model explains the entire of the difference (with between-groups average NFA/GDP ratio at 37%). The model's quantitative performance is very stable and tends to improve across a series of robustness checks - using differing parameterizations, other types of additional uncertainty, or an alternative country asymmetry in driving NFA imbalances.

We then test the empirical relevance of the model. Two sets of evidence are presented. First, through cross-country regressions, we find a significant and negative effect of a country's NFA position on its portfolio home bias, i.e. on average a debtor has a stronger home bias than a creditor. Given the observed average NFA/GDP ratio at 37%, the estimated coefficient of the NFA position implies a bias gap of approximate 10 percentage point between the two groups of countries, somewhat lower than predicted by the calibrated model, but sufficient to account for 2/3 of those in the data. The results of time-series regressions also suggest a significant relation between the NFA imbalances and the bias gap of debtors and creditors over time, consistent with the theory. Second, to prove the new hedging as the key mechanism at play, for each country in our sample, we use the data to estimate the new hedging as an interaction term between the country's net external position and a key covariance-variance ratio that governs the property of the new hedging. In most countries, the estimated hedging is significant, and corroborates to its theoretical counterpart both qualitatively and quantitatively. Projecting the estimated hedging to each country's portfolio bias, we find that the resulting estimated portfolios bring the otherwise symmetrically distributed portfolios closer to the actual portfolio of the data in the sense that the estimated portfolios of debtor countries do exhibit a higher level of home bias in a statistically significant way. Since the projection is such that the estimated portfolios of countries only differ in their new hedging, we conclude that the new hedging does cause the movement of portfolios in the direction we see in the data: an "excess" home bias in the debtor countries.

The rest of the paper proceeds as follows. In Section 2, we describe our baseline model of net and gross country portfolios. The theoretical and qualitative implications of the model are discussed in Section 3 and 4, respectively. We present the empirical evidence in Section 5 and conclude the paper in Section 6.

2 The baseline model

We develop a model of net and gross country portfolios based on a standard two-country, Home and Foreign, open economy (Backus et al. 1994, 1995). We assume the following demographic structure in order to preserve steady state for per-capita variables given that the two countries are potentially different (Ghironi, 2006). As in Weil (1989), we assume each country is populated by the infinitely lived OLG households of measure 1 at $t = 0$. The population grows at a net (gross) rate, n ($\tilde{n} \equiv 1 + n$). A per-capita variable x_t in the model can therefore be obtained by aggregating individual variables x_t^v via

$$x_t = \frac{x_t^0 + n x_t^1 + n\tilde{n} x_t^2 ... + n\tilde{n}^{t-1} x_t^t}{\tilde{n}^t}$$

where v and t of x_t^v denote vintage and time, respectively. Except for the country asymmetry to be explained later, the two countries are of the same structure. We explain the Home and use a star to denote the Foreign.

2.1 Households

Households maximize the following lifetime utility at time t

$$U_t^v = E_t \sum_{i=0}^{\infty} \beta^i \left[\log \left(c_{t+i}^v \right) + \gamma \log \left(1 - h_{t+i}^v \right) \right]$$

where c_t^v denotes consumption, h_t^v labour supply, γ the relative weight between consumption and leisure, β the intertemporal discount factor, with subject to the budget constraint

$$\alpha_{1t+1}^v + \alpha_{2t+1}^v = r_{1t}\alpha_{1t}^v + r_{2t}\alpha_{2t}^v + l_t^v - c_t^v$$

where the labour income $l_t^v \equiv \frac{g_t}{p_t} h_t^v$ is given by the labour supply, h_t^v, times nominal wage, g_t, divided by home CPI, p_t.

Each country issues a share of the country's intermediate goods-producing firms. α_{1t}^v, α_{2t}^v denote, respectively, households' net holding of the home (asset 1) and foreign asset (asset 2) at the end of $t-1$. The asset gross returns are

$$r_{1t} = \frac{d_t + \tilde{n} z_{1t+1}}{z_{1t}}, \quad r_{2t} = \frac{(d_t^*/s_t) + \tilde{n} z_{2t+1}}{z_{2t}} \tag{1}$$

where z_{1t}, z_{2t} are the asset prices, and d_t, d_t^* the dividends. The real exchange rate, $s_t = p_t/p_t^*$, converts d_t^* into the home basket.

Denote the gross wealth by $w_t^v \equiv \alpha_{1t}^v + \alpha_{2t}^v$ and the excess return of asset 1 by $r_{xt} \equiv r_{1t} - r_{2t}$, the constraint also reads

$$w_{t+1}^v = r_{2t} w_t^v + \alpha_{1t}^v r_{xt} + l_t^v - c_t^v$$

The households' wealth is given by the sum of portfolio returns and saving in each period. Following Weil (1989), we assume that new generations are born with no assets. Under the assumption, an $\tilde{n}$ appears ahead of $t+1$ asset variables in the per-capita budget constraint, which is useful in ensuring model stability.

$$\tilde{n} w_{t+1} = r_{1t}\alpha_{1t} + r_{2t}\alpha_{2t} + l_t - c_t \tag{2}$$

2.2 Production

Each country produces an intermediate good with technology

$$x_t = e^{\varepsilon_t} (k_t)^{\delta} (h_t)^{1-\delta}$$

The technology shock follows $\varepsilon_t = \mu\varepsilon_{t-1} + \epsilon_t$, where $0 < \mu < 1$. ϵ and ϵ^* are zero-mean $i.i.d$ innovations with $var(\epsilon) = var(\epsilon^*) = \sigma^2$ and $cov(\epsilon\epsilon^*) = 0$.

The firm maximizes the sum of the present value of all future dividends

$$d_t = \frac{q_t}{p_t} x_t - l_t - i_t$$

where q_t is the price of the home intermediate good. Investment evolves by $i_t = \tilde{n} k_{t+1} - (1 - \varkappa) k_t$.

The two intermediate goods are traded internationally, and then combined to produce the final goods y and y^* through the CES technology

$$y_t = \left[\kappa^{\frac{1}{\phi}} (x_{ht})^{\frac{\phi-1}{\phi}} + (1-\kappa)^{\frac{1}{\phi}} (x_{ft})^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}$$

$$y_t^* = \left[(1-\kappa)^{\frac{1}{\phi}} (x_{ht}^*)^{\frac{\phi-1}{\phi}} + \kappa^{\frac{1}{\phi}} (x_{ft}^*)^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}$$

where x_{ht}, x_{ft} denote the home demand for home and foreign intermediate goods, and x_{ht}^*, x_{ft}^* the corresponding foreign demand. $\kappa \in (0.5, 1)$ is a measure of goods home preference. The related CPIs are

$$p_t = \left[\kappa (q_t)^{1-\phi} + (1-\kappa) \left(\frac{q_t^*}{s_t} \right)^{1-\phi} \right]^{\frac{1}{1-\phi}}$$

$$p_t^* = \left[(1-\kappa)(s_t q_t)^{1-\phi} + \kappa (q_t^*)^{1-\phi} \right]^{\frac{1}{1-\phi}}$$

where q_t^* denotes the foreign price of the foreign good. The demands for the each goods are

$$x_{ht} = \kappa \left(\frac{q_t}{p_t} \right)^{-\phi} y_t, \;\; x_{ft} = (1-\kappa) \left(\frac{q_t^*}{s_t p_t} \right)^{-\phi} y_t$$

$$x_{ht}^* = (1-\kappa) \left(\frac{s_t q_t}{p_t^*} \right)^{-\phi} y_t^*, \;\; x_{ft}^* = \kappa \left(\frac{q_t^*}{p_t^*} \right)^{-\phi} y_t^*$$

	Home holdings	Foreign holdings	Asset value
Asset 1-Home equity	α_{1t}	α^*_{1t}	$\alpha_{1t}+\alpha^*_{1t}= z_{1t}$
Asset 2-Foreign equity	$\alpha_{2t}= w_t-\alpha_{1t}$	$\alpha^*_{2t}= w^*_t-\alpha^*_{1t}$	$\alpha_{2t}+\alpha^*_{2t}= z_{2t}$
Country wealth	$\alpha_{1t}+\alpha_{2t}= w_t$	$\alpha^*_{1t}+\alpha^*_{2t}= w^*_t$	

Table 1: Net asset holdings across countries

2.3 Market clearing

Market clearing requires $x_{ht} + x^*_{ht} = x_t$, $x_{ft} + x^*_{ft} = x^*_t$, $c_t + i_t = y_t$, $c^*_t + i^*_t = y^*_t$ in the goods market. In the asset market, we have $\alpha_{1t} + \alpha^*_{1t} = z_{1t}$, $\alpha_{2t} + \alpha^*_{2t} = z_{2t}$, which are equivalent to $\alpha_{1t} = z_{1t} - \alpha^*_{1t}$, $w_t - z_{1t} = -(w^*_t - z_{2t})$. While the interpretation of the first expression is obvious, the second expression states that one country's surplus is the other country's deficit. Denoting NFA by f_t, we have $f_t = -f^*_t$.

3 Theoretical analysis

To explain why a debtor would have a stronger home biased portfolio, we first study the steady-state net and gross portfolios in a special case of the model. Throughout the paper, we drop a variable's time subscript to denote its steady state.

In Appendix B, we show that the model admits an analytical solution under the following two assumptions: First, $\varkappa = 0$ to be relaxed in section 4. Second, the two countries have the same GDPs (we normalise the home GDP, ξ_t, to be unity, i.e. $\xi_t = \xi^*_t/s_t = 1$). Under the latter, steady-state variables also gain an interpretation of per-GDP ratios, which facilitates the mapping of the model to data in section 5. We discuss the results for this special case here, and provide all proofs in the Appendix.

3.1 Net capital flows

In absence of country asymmetry, $f = 0$ determines the autarky interest rate in the above OLG economies

$$r^a = \frac{1 + \delta n}{\beta}$$

which positively depends on time preference $\frac{1}{\beta}$, population growth n, and δ. With equal β and n, a country with a higher δ would have a relatively higher r^a, which attracts net capital flows from the rest of the world once the economy opens to the international finance market.

Without loss of generality, we assume $\delta > \delta^*$ for a home debtor. As mentioned earlier, we intend to emphasize in this paper that, for any marginally different countries, the marginal portfolio, i.e. the NFA that would only arise with asymmetric countries, will be more diversified than the average portfolio, i.e. the portfolio that would remain even with identical countries. This explains a more home-biased portfolio in the debtor country, since the debtor loses a marginally more diversified portfolio and the initial home bias is intensified. This holds no matter what is the specific source of external imbalances of country. Therefore, to sharpen the exposition, here we only present "a" model of country's external imbalances, and takes no stance in the root reason for the actual imbalances.

Given this assumption, in a financially open world, the NFAs are going to be non-zero. $f + f^* = 0$ determines the international interest rate

$$r = \frac{1 + \bar{\delta} n}{\beta}$$

with $\bar{\delta} \equiv \frac{(\delta^* + \delta)}{2}$. r lies in the middle of the two autarky interest rates $r^{a*} < r < r^a$, which directs the international capital flows. Specifically,

$$f = -f^* = -\frac{\delta^d}{\left(1 - \bar{\delta}\right)(r - 1)} < 0$$

with $\delta^d = \delta - \bar{\delta} = \bar{\delta} - \delta^* > 0$ being a measure of the magnitude of asymmetry. In the next section, we use δ^d to match NFAs to those of the data, and see how much the observed bias gap in the data can be explained by the model.

As in symmetric models, international assets are still used to smooth (relative) consumption. However, now consumption is financed by not only dividend and labour incomes, but also an interest payment associated with net external positions fs which are non-zero and asymmetric across countries

$$c = d + l + (r - \tilde{n}) f$$

Following Obstfeld and Rogoff (1996), we assume $r > \tilde{n}$ and focus on a case where the debtor pays a positive interest. As one can see from c, again, what matters here is that some country asymmetry generates non-zero fs.[6] The average portfolio hedges against the risks associated with the dividend and labour incomes in c, and is home biased as has been shown by the literature. We will show below that, a marginal portfolio would arise, which hedges against the risks associated with net external interest payment, and is more diversified.

3.2 Gross portfolio composition

To obtain the measure of portfolio bias, we first define and compute gross portfolio position $\alpha \equiv \alpha_1 - z_1 < 0$, the home gross holding of the home asset, and investigate its composition. As the default supplier of asset 1, Home is "selling" the asset. A realistic α satisfies $\alpha \in [-z_1, 0]$. A higher absolute value of α implies larger foreign liabilities of Home, or, equivalently, larger foreign assets of Foreign. Once α is known, all other αs are known (Table 1).

Denote variables with a hat as their log-deviations from steady state. We show in Appendix C and D that the optimal condition for α is

$$E_{t-1}\left[\hat{c}_t^D \hat{r}_{xt}\right] = 0 \tag{3}$$

where $\hat{c}_t^D = \hat{c}_t - \hat{c}_t^* + \hat{s}_t - (1-\tau)\left(\hat{c}_t^n - \hat{c}_t^{n*} + \hat{s}_t\right)$ (with $\tau \equiv \frac{r\beta}{\tilde{n}} < 1$ by the above r) stands for the portfolio-relevant cross-country relative consumption. The condition confirms that households choose a portfolio to achieve optimal risk sharing, the same as in a symmetric model except that a term $(1-\tau)\left(\hat{c}_t^n - \hat{c}_t^{n*} + \hat{s}_t\right)$ appears due to our assumption that the new generations are born with no assets. In the model, population growth only exists to preserve model stability. Later when calibrating the model, we will select a $n \approx 0$ such that τ is close to 1 and population growth does not affect $\hat{c}_t^D$ and α.

In order to find α, we need to understand the behaviour of $\hat{c}_t^D$, which can be shown in

[6] In other words, the specific country asymmetry that is used here does not matter for our main point at least qualitatively (we will assess the model's quantitative performance below). One may find it a bit odd when try to interpret the δ as, for instance, a measure of financial development (Caballero et al. 2008) for the home developing country, since these countries are in fact financially less-developed. However, theoretically, one can have a model where the financially less-developed country sees net capital inflows, e.g. as in the two-sector model of Antras and Caballero, 2009, but this would involves a more complicated set-up (when combined with portfolio decisions) than our existing baseline in Section 2, with it being just another way of generating non-zero fs in c and the key arguement remaining unchanged.

Appendix E to be the households' (relative) permanent income

$$\hat{c}_t^D = \frac{(r - \tau \tilde{n})}{\theta} \left[\alpha \hat{r}_{xt} + f \Sigma_{2t}^{rn} \right] + \frac{r - \tau \tilde{n}}{r} \left[\Delta \Sigma_t^d + \Delta \Sigma_t^l \right] - (1 - \tau) \Delta c_t^n \tag{4}$$

with $\theta \equiv \left[\frac{1}{c} + \frac{s}{c^*}\right]^{-1}$. Ignoring the OLG-related term $\Delta c_t^n = \hat{c}_t^n - \hat{c}_t^{n*} + \hat{s}_t$, the $\hat{c}_t^D$ is given by the sum of the relative dividend, $\Delta \Sigma_t^d = \frac{d}{c} \Sigma_t^d - \frac{d^*}{c^*} \Sigma_t^{d*}$, the relative labour income, $\Delta \Sigma_t^l = \frac{l}{c} \Sigma_t^l - \frac{l^*}{c^*} \Sigma_t^{l*} - \frac{(1-\tau)\tilde{n}}{r - \tau \tilde{n}} \left(\Sigma_{t+1}^{cn} - \Sigma_{t+1}^{cn*} \right)$, and the portfolio return $[\alpha \hat{r}_{xt} + f \Sigma_{2t}^{rn}]$, where Σ denotes the sum of related discounted future income streams, e.g. $\Sigma_t^d = \Sigma_{i=0}^{\infty} \left[\frac{\tilde{n}}{r}\right]^i \hat{d}_{t+i}$, $\Sigma_t^l = \Sigma_{i=0}^{\infty} \left[\frac{\tilde{n}}{r}\right]^i \hat{l}_{t+i}$, $\Sigma_{t+1}^{rn} = \Sigma_{i=0}^{\infty} \left[\frac{\tilde{n}}{r}\right]^i \hat{r}_{t+1+i}$ for the home country. With 2 assets in the model, the portfolio return is given by the NFA return that is denominated by numeraire asset return, $\Sigma_{2t}^{rn} = \hat{r}_{2t} + \frac{\tilde{n}}{r} \Sigma_{t+1}^{rn}$, plus an excess return of the other asset holding, $\alpha \hat{r}_{xt}$.

The fact that the relative consumption $\hat{c}_t^D$ in Eq.(4) also depends on a non-zero net external position f represents the key distinction between our model and the standard country portfolio models of identical countries. In fact, our model nests the symmetric models as a special case. When two countries are identical, NFA must be zero. $\hat{c}_t^D$ would therefore depend only on the relative dividend, the relative labour income, and the excess return $\alpha \hat{r}_{xt}$. When choosing optimal α in order to stabilize $\hat{c}_t^D$, households would only need to take into account of the dividend and labour income risks. This can also be seen by noting that in this case, consumption in each country is confined by its GDP which consists of only dividend and labour incomes. However, with heterogeneous countries, the current model features a non-zero NFA in both countries. As shown at the end of the last section, in this case, consumption in each country is confined by its GNP which consists of not only dividend and labour incomes but also an additional term associated with international interest payment. This corresponds to the presence of an additional term that depends on f in $\hat{c}_t^D$. As a result, when choosing optimal α in order to stabilize $\hat{c}_t^D$, households need to take into account of more risks. In other words, we expect that the optimal portfolio holdings of households in each country capture not only the dividend and labour hedging but also an additional hedging against the risks associated with international interest payment.

To see this, we substitute Eq.(4) into Eq.(3), and obtain the Home's external positions as the sum of a series of hedging motives[7]

$$\alpha \equiv \alpha_1 - z_1 = -\frac{\theta}{r}\Psi_d - \frac{\theta}{r}\Psi_l \underbrace{-f\Psi_f}_{-} \tag{5}$$

$$\alpha_2 = f - \alpha = \frac{\theta}{r}\Psi_d + \frac{\theta}{r}\Psi_l + \underbrace{f\left(1+\Psi_f\right)}_{-} \tag{6}$$

where $\Psi_d = \frac{cov\left(\Delta\Sigma_t^d, \hat{r}_{xt}\right)}{var(\hat{r}_{xt})}$, $\Psi_l = \frac{cov\left(\Delta\Sigma_t^l, \hat{r}_{xt}\right)}{var(\hat{r}_{xt})}$, $\Psi_f = \frac{cov\left(\Sigma_{2t}^{rn}, \hat{r}_{xt}\right)}{var(\hat{r}_{xt})}$.

In the Foreign, the external positions are analogous (Appendix E.1.4)

$$\alpha^* \equiv \alpha_2^* - z_2 = -\frac{\theta}{r}\Psi_d^* - \frac{\theta}{r}\Psi_l^* \underbrace{-f^*\Psi_f^*}_{+} \tag{7}$$

$$\alpha_1^* = f^* - \alpha^* = \frac{\theta}{r}\Psi_d^* + \frac{\theta}{r}\Psi_l^* + \underbrace{f^*\left(1+\Psi_f^*\right)}_{+} \tag{8}$$

where $\Psi_d^* = \frac{cov\left(\Delta\Sigma_t^{d*}, \hat{r}_{xt}^*\right)}{var(\hat{r}_{xt}^*)}$, $\Psi_l^* = \frac{cov\left(\Delta\Sigma_t^{l*}, \hat{r}_{xt}^*\right)}{var(\hat{r}_{xt}^*)}$, $\Psi_f^* = \frac{cov\left(\Sigma_{1t}^{rn}, \hat{r}_{xt}^*\right)}{var(\hat{r}_{xt}^*)}$. Note that the relative incomes and the excess return of local asset are defined from the perspective of the Foreign, i.e. $\Delta\Sigma_t^{d*} \equiv -\Delta\Sigma_t^d$, $\Delta\Sigma_t^{l*} \equiv -\Delta\Sigma_t^l$, $\Sigma_{1t}^{rn} = \hat{r}_{1t} + \frac{\tilde{n}}{r}\Sigma_{t+1}^{rn}$, and $\hat{r}_{xt}^* \equiv \hat{r}_{2t} - \hat{r}_{1t}$. It follows that $\Psi_d = \Psi_d^*$, $\Psi_l = \Psi_l^*$, and

$$\Psi_f = -\left(1+\Psi_f^*\right) \tag{9}$$

Two facts to highlight here. First, one country's foreign liabilities are the other country's foreign assets. This is verified by $\alpha = -\alpha_1^*$ of Eqs.(5) and (8), and $\alpha^* = -\alpha_2$ of Eqs.(6) and (7). Second, besides the traditional self-hedging Ψ_ds and labour hedging Ψ_ls, the structural country asymmetry opens the NFA imbalances and generates a hedging of NFA return, i.e. $-f\Psi_f$ and $-f^*\Psi_f^*$ in α and α^* and $f\left(1+\Psi_f\right)$ and $f^*\left(1+\Psi_f^*\right)$ in α_2 and α_1^*. Since the self-hedging and labour hedging are both symmetric, the reason for a portfolio bias gap between the two countries must be due to the new hedging of NFA return, which are asymmetric.

[7]We omit all terms associated with the relative newborns' consumption, e.g. $\frac{\theta(1-\tau)}{(r-\tau\tilde{n})}\frac{cov(\Delta c_t^n, \hat{r}_{xt})}{var(\hat{r}_{xt})}$ in α that corresponds to the subtraction term $(1-\tau)\left(\hat{c}_t^n - \hat{c}_t^{n*} + \hat{s}_t\right)$ in $\hat{c}_t^D$. As explained, the latter emerges due to the presence of the OLG structure that was only a stability-inducing device in the paper. The term is not focus of the paper and it will be 0 by calibration.

3.3 Bias in debtor and creditor countries

To see our main point, it is useful to focus on a measure $\tilde{\lambda} \equiv \frac{\alpha_1}{\alpha_2}$.[8] For a diversified portfolio, $\tilde{\lambda} = 1$. The higher $\tilde{\lambda}$ relative to 1, the more severe the country overweighs domestic assets in its portfolio, i.e. a stronger home bias.

We first look at the average portfolio bias, the one with absence of country asymmetry. By Eqs.(5)-(8), in both countries, it is:

$$\tilde{\lambda} = \frac{\alpha_1}{\alpha_2} = \frac{rz - \theta\Psi_d - \theta\Psi_l}{\theta\Psi_d + \theta\Psi_l}$$

Note that with identical countries, $z_1 = z_2 \equiv z = \frac{\delta}{(r-1)}$, $\theta = \frac{1}{2}$.

Suppose all incomes are capitalizable, $\delta = 1$, we would return to the case of full diversification (Lucas, 1982). To see this, note that $\Psi_l = 0$ due to the collapse of labour income risks; $\Psi_d = \frac{r}{r-1}$ due to $\Delta\Sigma_t^d = \frac{r}{(r-1)}\hat{r}_{xt}$ (Eq.(1)). Self-hedging governed by Ψ_d is always positive and tends to yield a diversified portfolio. By Eqs.(5)-(6), a positive Ψ_d reduces the holding of home asset α_1 (from z to $\frac{z}{2}$) and increases the holding of foreign asset α_2 (from 0 to $\frac{z}{2}$). It is therefore $\tilde{\lambda} = 1$.

With presence of non-financial income, the average portfolio is home biased, because endogenous adjustments of relative prices and investment deliver a negative labour hedging $\Psi_l < 0$ (Coeurdacier et al., 2010 and Heathcote and Perri, 2013). Take a TFP shock to the home country for instance. The shock raises the labour income. It also increases the supply of home goods and deteriorates the terms of trade (Cole and Obstfeld, 1991). A lower price of home goods combined with households' preference for local goods, $\kappa > 0.5$, imply a significant rise in investment, which reduces the available dividend because the latter is given by the firms' revenue *net of* investment. Relative dividend and labour incomes are therefore negatively correlated, $\Psi_l < 0$. In this case, holding domestic assets offers a good hedge against the labour income risks. By Eqs.(5)-(6), a negative Ψ_l

[8] Note that EHB and $EHB2$ move closely. $EHB2$ equals "share of local assets in home portfolio" minus "share of local assets in the world portfolio" where "share of local assets in the world portfolio" is usually close to zero in the data. "Share of local assets in home portfolio" corresponds to $\lambda \equiv \frac{\alpha_1}{w}$ in the model or equivalently $\tilde{\lambda} = \frac{\lambda}{1-\lambda} = \frac{\alpha_1}{\alpha_2}$. $\tilde{\lambda}$ is more convenient than λ for exposition purposes in our asymmetric-country model here because we can just focus on gross positions, αs as in Eqs.(5)-(8), without considering differing w across countries (while λ is equally convenient in symmetric-country models because w is the same across countries, e.g. Devereux and Sutherland, 2011's Eq.25, Coeurdacier and Rey, 2013's Eq.20, among many others.)

increases the holding of home asset α_1 and reduces the holding of foreign asset α_2. It is therefore $\tilde{\lambda} > 1$.

We then look at the marginal portfolio bias, the one that would appear on top of the average bias when there is a marginal rise in $\delta^d > 0$. In the Home, it is

$$\frac{-f\Psi_f}{f(1+\Psi_f)}$$

which is determined by the hedging of NFA return risks.

The numerator is negative. Consider α as in Eq.(5). $f < 0$, the Home has to pay an external interest payment, which is denominated by $\hat{r}_{2t}$ given our choice of numeraire asset. As explained, with the dynamics of relative prices and investment in the model, when, for instance, the Home experiences a positive shock, the home asset's return is relatively low while the foreign asset's return is relatively high (compared to if the Foreign is shocked), $\hat{r}_{xt}$ declines. The amount of interest payment, denominated by $\hat{r}_{2t}$, is relatively high, i.e. the Home's disposable income and consumption are relatively low because the country pays more. In other words, when the home asset's return is low, the Home's consumption is also low. The home asset is therefore not a good investment for the Home. The asset is shorted, $-f\Psi_f < 0$ in α of Eq.(5), and the Home's foreign liabilities rise. As the two sides of the same coin, the Foreign's foreign assets increase by exactly the same amount, $f^*\left(1+\Psi_f^*\right) = f\Psi_f > 0$ in α_1^* of Eq.(8). The denominator of the above marginal $\tilde{\lambda}$ is also negative by a similar reasoning (when consider α^* as in Eq.(7)).

Now, it is clear that both the self-hedging and labour hedging have opposite signs in α_1 and α_2. Namely, they shift wealth from investing in one asset to another. Because of them, when α_1 rises, α_2 must decline with the country wealth being kept constant $\alpha_1 + \alpha_2 = w$. They therefore determine the average level of portfolio bias in the economy. Unlike these two hedging terms, the new hedging of NFA return has the same sign in α_1 and α_2. In an asymmetric model, the debtor country losses a marginal wealth, f. The new hedging decides the split of this marginal change in wealth f between the two assets. The change in final $\tilde{\lambda}$ therefore depends on how the division of the marginal unit of wealth between assets is different from the division of existing wealth between assets, or whether the marginal $\tilde{\lambda}$ (as implied by the split of f and f^* according to Ψ_fs) is higher or lower than the average $\tilde{\lambda}$ (as implied by the joint effect of Ψ_ds and Ψ_ls).

In the case of two marginally different countries ($\delta^d \to 0$), it must be that $\Psi_f = \Psi_f^*$. This together with Eq.(9) yield $\Psi_f = \Psi_f^* = -\frac{1}{2}$, and therefore a marginal $\tilde{\lambda} = 1$. In other words, following a marginal rise of δ^d, a negative NFA position opens in the home country. The households there will reduce their holdings of the two assets to the same extent, $-f\Psi_f = f(1 + \Psi_f) < 0$. Because the Home initially has a home biased portfolio, average $\tilde{\lambda} > 1$, the removal of a marginally diversified portfolio f leads to a more biased country portfolio than before. By contrast, a marginal rise of δ^d from 0 opens a positive NFA position in the Foreign. Its households increase their holdings of the two assets to the same extent, $-f^*\Psi_f^* = f^*\left(1 + \Psi_f^*\right) > 0$. Because the Foreign also has an initially home biased portfolio, the addition of a marginally diversified portfolio f^* leads to a less biased country portfolio than before.

A hypothetical example of such portfolios is provided below:

$$\alpha_1 = 0.5 + 0.3 - 0.1$$

$$\alpha_2 = 0.5 - 0.3 - 0.1$$

$$\alpha_1^* = 0.5 - 0.3 + 0.1$$

$$\alpha_2^* = 0.5 + 0.3 + 0.1$$

Suppose only the self-hedging remains in the above αs, as in the Lucas' (1982) model of $\delta = 1$, households invest half of their wealth in the home asset and half in the foreign asset. This would be in stark contrast to the actual data that exhibit home bias, i.e. the well known international diversification puzzle. A way to solve the puzzle, as shown in the Heathcote and Perri's (2013) model of $\delta < 1$, is to consider both self-hedging and labour hedging. In this case, only the first two hedging terms remain in the above αs, and households in both countries invest 80% of their total wealth in the domestic asset, which help explain a general lack of diversification across countries. This paper considers a model of $\delta^* < \delta < 1$ where the national income of each country depends on its net external position. To hedge against the related risks, the home debtor loses a marginally more diversified portfolio (here 0.1 v.s. 0.1). Its home bias is intensified. The households in the Home invest 87.5% of their total wealth in the domestic asset. By constrast, the foreign creditor gains a more diversified portfolio. Its home bias is diluted. The households in the Foreign invest 75% of their total wealth in the domestic asset. This therefore helps explain the heterogeneous degree of home bias across countries.

To further appreciate this intuition as well as to explore the specific role played by the adopted country asymmetry, we also consider a more stripped-down version of the model - an endowment economy model - that admits a much simpler analytical solution for both αs and Ψ_fs in Appendix E.3. The analysis there shows that the specific country asymmetry is non-essential for the qualitative result. As long as the average portfolio is home biased, a debtor will see a higher bias because the marginal portfolio is always more diversified.

While for exposition purposes we focused here on the difference between $\tilde{\lambda}$ and 1 as the measure of portfolio bias, the above intuition carries over when we use the following measures

$$EHB \equiv 1 - \frac{\text{Share of foreign equities in the country's portfolio}}{\text{Share of foreign equities in the world market portfolio}}$$

$$\begin{aligned} EHB2 \quad \equiv \quad & \text{Share of local equities in the country's portfolio} \\ & - \text{Share of local equities in the world market portfolio} \end{aligned}$$

in the rest of the paper. To see this, note that "Share of foreign equities in the world market portfolio" and "Share of local equities in the world market portfolio" are usually close to 1 and 0, respectively, see e.g. Sercu and Vanpee (2007) and Coeurdacier and Rey (2013) among others,[9] and as a result, the EHBs are mainly driven by "Share of local equities in the country's portfolio"

$$\lambda = \frac{\alpha_1}{\alpha_1 + \alpha_2} = \frac{\tilde{\lambda}}{\tilde{\lambda} + 1}$$

and are also increasing in $\tilde{\lambda}$.

[9]To fix ideas, besides the mentioned references, in our 62-country data, the median and average "Share of local equities in the world market portfolio" are merely 0.0034 and 0.0161, respectively. Most countries, 82% or 51 out of 62, have a value below 0.02. The fact that "Share of local equities in the world market portfolio" is close to 0 is also the reason why in the literature $EHB2$ is not defined the same way as EHB as the difference between the ratio of "Share of local equities in the country's portfolio" to "Share of local equities in the world market portfolio" and 1.

4 Quantitative analysis

Now we quantify the model's ability in explaining the observed home bias across different groups of countries.

4.1 Model extension

To do so, we first relax the assumption of $\varkappa = 0$. Second, given the presence of non-equity assets in the data, we introduce an additional international bond and, at the same time, consider a more general utility function of the $CRRA$ fashion.[10] To avoid the case in which the number of assets exceeds that of shocks, and the resulting problem of portfolio indeterminacy, we follow Coeurdacier and Rey(2013) by introducing an additional shock ς_t to the investment efficiency via $(1+\varsigma_t)\, i_t = \tilde{n} k_{t+1} - (1-\varkappa)\, k_t$ (Greenwood et al. 1988, 1997; Justiniano et al. 2007) and assuming $\varsigma_t = \mu \varsigma_{t-1} + \epsilon_t^{\varsigma}$. We consider the other types of shocks in the sensitivity analysis.

Let α_t^b denote the bond holding of the Home. With its global net supply of 0, in the Foreign $\alpha_t^{b*} = -\alpha_t^b$. Without loss of generality, we assume that the bond pays the foreign basket.[11] Its rate of return (in terms of home basket) is therefore $\alpha_t^b = \left[(p_t^*/p_t) + z_{t+1}^b\right]/z_t^b$, where z_t^b is the bond price.

With the bond asset, there will be an additional set of optimal conditions for the optimal choice of bond holdings in the two countries. Together with the optimal condition for equity holdings, the optimal condition for portfolio choices $\Pi'_\alpha \equiv \left[\alpha,\ \alpha^b\right]$ reads $E_{t-1}\left[\hat{c}_t^D \Pi_{rx}\right] = 0$ (Appendix D), with the excess return sector $\Pi'_{rx} \equiv \left[\hat{r}_{xt},\ \hat{r}_{xt}^b\right] = \left[\hat{r}_{1t} - \hat{r}_{2t},\ \hat{r}_t^b - \hat{r}_{2t}\right]$. As before, we show in Appendix $E.2$ that we can obtain Π'_α as a

[10] The extension of $\varkappa > 0$ is straightforward. The adoption of $CRRA$ utility function requires some changes to the optimal conditions for labour supply, consumption, and portfolio choices. We explain these changes in Appendix F.

[11] For all calibrations, we switch the relative status of the two countries by considering the case of $\delta < \delta^*$ (instead of our $\delta > \delta^*$), a case where the bond return is denominated in the basket of net debtor country instead of that of the net creditor country. The results are qualitatively the same and quantitatively close, see Figure 4 and the related discussion below.

Variable	Source/Target of data moment
$\beta = 0.9259$	Average real interest rate at 0.08
$n = 10^{-5}$	Small positive number for model stability
$\bar{\delta} = 0.36$	Heathcote and Perri (2013), Average capital to GDP ratio at 2.57
$\varkappa = 0.06$	Heathcote and Perri (2013), Average capital to GDP ratio at 2.57
$\mu = 0.93$	Smets and Wouters (2007), Heathcote and Perri (2013)
$\phi = 0.9$	Heathcote and Perri (2002)
$\rho = 1$	Heathcote and Perri (2013)
$\kappa = 0.68$	Average import and export share of GDP at 0.32

Table 2: Benchmark parameterization

sum of hedging motives[12]

$$\alpha = -\frac{\theta}{r}\Psi_{d|\hat{r}^b_{xt}} - \frac{\theta}{r}\Psi_{l|\hat{r}^b_{xt}} - f\Psi_{f|\hat{r}^b_{xt}} - \frac{\theta}{r}\frac{\tau\left(r-\tilde{n}\right)}{\left(r-\tau\tilde{n}\right)}\left(\rho-1\right)\Psi_{s|\hat{r}^b_{xt}} \tag{10}$$

$$\alpha^b = -\frac{\theta}{r}\Psi^b_{d|\hat{r}_{xt}} - \frac{\theta}{r}\Psi^b_{l|\hat{r}_{xt}} - f\Psi^b_{f|\hat{r}_{xt}} - \frac{\theta}{r}\frac{\tau\left(r-\tilde{n}\right)}{\left(r-\tau\tilde{n}\right)}\left(\rho-1\right)\Psi^b_{s|\hat{r}_{xt}} \tag{11}$$

where $\Psi_{x|\hat{r}^b_{xt}}$ is Ψ_x conditional on $\hat{r}^b_{xt}$, $\Psi_{s|\hat{r}^b_{xt}} = \frac{cov_{\hat{r}^b_{xt}}\left(\Sigma^s_t,\hat{r}_{xt}\right)}{var_{\hat{r}^b_{xt}}\left(\hat{r}_{xt}\right)}$, $\Sigma^s_t = \Sigma^{\infty}_{i=0}\left[\frac{\tilde{n}}{r}\right]^i \hat{s}_{t+i}$; $\Psi^b_{x|\hat{r}_{xt}}$ is the covariance-variance ratio of relative x income and $\hat{r}^b_{xt}$ conditional on $\hat{r}_{xt}$, e.g. $\Psi_{d|\hat{r}_{xt}} = \frac{cov_{\hat{r}_{xt}}\left(\Delta\Sigma^d_t,\hat{r}^b_{xt}\right)}{var_{\hat{r}_{xt}}\left(\hat{r}^b_{xt}\right)}$; ρ is the elasticity of intertemporal substitution.

Below, we calibrate the model, and numerically solve the portfolios Π'_α.

4.2 Calibration

For consistence with the empirical analysis below, we use annual data for 62 countries over $1990-2015$, 41 developing & emerging countries (DEV group) and 21 developed ones (ADV group) by the IMF classification. The data sources are detailed in Appendix *H*.

Our calibration strategy is as follows. As the device for inducing model stability, n needs to be positive. We choose a small number of $n = 10^{-5}$ such that population growth

[12]The expression for α is obtained by combining Eq.(24) of Appendix *E* (with the additional bond) and Eq.(39) of Appendix *F* (with the *CRRA* utility function). As explained, the term due to the OLG structure $\frac{(1-\tau)\theta}{(r-\tau\tilde{n})}\frac{cov_{\hat{r}^b_{xt}}\left(\Delta c^n_{t+1},\hat{r}_{xt}\right)}{var_{\hat{r}^b_{xt}}\left(\hat{r}_{xt}\right)}$ will equal to zero in our calibrations and is omitted. The expression for α^b is obtained in a similar way.

does not drive our results. Given that n is close to 0, $\beta \approx 1/r$ is set at 0.9259 to target an average real interest rate of 8%, corresponding to the data counterpart over the considered period. Following Heathcote and Perri (2013), we choose $\bar{\delta} = 0.36$ and $\varkappa = 0.06$. Together with the above interest rate level, they imply an average capital to GDP ratio of 2.57 (data counterpart 2.56). As a benchmark, we set the persistence of shocks at 0.93 (the average of Smets and Wouters, 2007, and Heathcote and Perri, 2013),[13] $\phi = 0.9$, $\rho = 1$,[14] and $\kappa = 0.68$ (to target the average import and export to GDP ratio of 0.32 in the data).

For δ^d, we set it to target first the average NFA position (as per-GDP ratio) between the DEV v.s. ADV countries (-0.15) and then that between the net debtor v.s. creditor countries (-0.37). The main aim is to investigate how much of the observed bias gap can be accounted for by the model.

4.3 Results

Table 3 reports the resulting Π'_α. When $f = -0.15$, the Home's equity liabilities, $\alpha = \alpha_1 - z_1$, is -0.52 (of GDP, the same unit below), and the Home's bond holding, α^b, is 0.12. Given a negative f, the latter implies an even lower net foreign equity position, $f^e \equiv f - \alpha^b = -0.27$. It therefore implies two-way capital flows between the two countries - that the (net) equity capital flows from the Foreign to the Home while the debt flows the other way around, which corroborates the qualitative pattern depicted in Figures 2 and 3. We now take this benchmark result of the two-way capital flows for granted, and will show that $\alpha^b > 0$ and $f^e < f < 0$ are indeed quite robust in the model.

The portfolio holdings can then be decomposed into the mentioned hedging motives by Eqs.(10)-(11). We focus on α here, and will refer to the ith term of Eq.(10) $\alpha[i]$. The signs of $\alpha[i]$s confirm our analyses in Section 3.3. In particular, the hedging of NFA return is negative, reflecting the fact that (even conditional on $\hat{r}^b_{xt}$ in the extended model) the NFA return (denominated in the numeraire $\hat{r}_{2t}$) comoves negatively with $\hat{r}_{xt}$, i.e. $\Psi_{f|\hat{r}^b_{xt}} < 0$. As analysed, for a δ^d that opens a marginal f, the absolute value of $\Psi_{f|\hat{r}^b_{xt}}$, Ψ, should

[13] Using the data of G7 countries, Coeurdacier et al. (2010) found that the investment efficiency shock is roughly as persistent as the technology shock; the correlations between TFP and investment efficiency innovations are close to zero. We choose the same persistence value for the two shocks and assume the shocks are independent. The portfolio solutions of the model are invariant to the relative volatility among shocks, as explained by e.g. Devereux and Sutherland (2011), Coeurdacier and Gourinchas (2016).

[14] Following Heathcote and Perri (2013), we also set the Frisch labour supply elasticity as in the CRRA utility function $\eta = 1$.

	Benchmark $\rho = 1$		$\rho = 0.9$	
Variable	f =-0.15	f =-0.37	f =-0.15	f =-0.37
$\alpha = \alpha_1 - z_1$	-0.52	-0.64	-0.26	-0.38
$\alpha\,[1]$ Self-hedging	-1.26	-1.23	-1.26	-1.23
$\alpha\,[2]$ Hedging of labour income	0.84	0.84	0.75	0.75
$\alpha\,[3]$ Hedging of NFA return	-0.10	-0.25	-0.10	-0.25
$\alpha\,[4]$ Hedging of exchange rate	0	0	0.35	0.35
α^b	0.12	0.30	0.15	0.36

Table 3: Portfolio holding decomposition

not be very far away from 1/2 (at which the countries are symmetric and $f = 0$). Under our calibration, for a δ^d that generates $f = -0.15$, Ψ equals $\alpha\,[3]\,/f \approx 2/3$; for a δ^d that generates $f = -0.37$, Ψ merely changes to 0.68.[15] Based on our theoretical analyses, this implies the $\tilde{\lambda}$ associated with $\alpha\,[3]$ is roughly $\Psi/\,(1-\Psi) = 2$. It is significantly lower than the $\tilde{\lambda}$ associated with both $\alpha\,[1]$ and $\alpha\,[2]$, the latter of which, as highlighted by the ample existing literature on the (symmetric) home bias, easily exceeds 4 for the model to explain an average locally held equity share of over 80% in the data due to the strong labour hedging $\alpha\,[2]$ in the model.[16] This therefore opens a home bias gap between the two countries for the reason explained in Section 3.

As in symmetric models, the sign of the hedging of real exchange rate risk $\alpha\,[4]$ is governed by two forces going in opposite directions (Coeurdacier and Rey, 2013). When local goods are temporarily more expensive, agents either postpone consumption until the prices are lower (substitution effect) or need to generate more income to maintain their consumption level. Under the benchmark of $\rho = 1$, the two forces offset each other and $\alpha\,[4]$ does not show up. When agents are sufficiently reluctant to substitute consumptions intertemporally, $\rho < 1$, the latter force dominates. $\alpha\,[4]$ will be positive because $\Psi_{s|\hat{r}^b_{xt}} > 0$ - when there is a windfall to the Foreign, the relative price of home goods increases, the real exchange rate appreciates, while $\hat{r}_{xt}$ increases. Like $\alpha\,[2]$, a positive $\alpha\,[4]$ therefore (symmetrically) enhances the home bias in the two countries (Kollmann, 2006, Engel

[15]The value of Ψ seems to be insensitive to f. Even when we set the degree of country asymmetry δ^d such that $f = 1$, Ψ does not exceed 0.73. Except for some financial centres, even the most important contributors of the global imbalances do not have such big net external imbalances. For reference, at the end of 2018, the NFA/GDP ratio is around 25% in China, -40% in U.S., and 60% in Japan and Germany.

[16]See e.g. Coeurdacier et al. (2010), Heathcote and Perri (2013), and Coeurdacier and Gourinchas (2016) among others.

and Matsumoto, 2009). The difference between the marginal $\tilde{\lambda}$ due to just $\alpha[3]$ and the average $\tilde{\lambda}$ due to $\{\alpha[1], \alpha[2], \alpha[4]\}$ will be even larger, by which the model could explain even more of the home bias gap between the two countries. We return to this point when conducting the sensitivity analysis. At the moment, we stick to $\rho = 1$ to eliminate $\alpha[4]$ as the recent literature also point to a lesser role of $\alpha[4]$ in shaping the equity holdings.[17]

A positive α^b and therefore the aforementioned two-way capital flows ($\alpha^b > 0$ and $f^e < 0$) also contribute to a diverging bias gap. To see the intuition, we turn to the partial equilibrium expressions for α_1 and α_2:

$$\alpha_1 = z_1 - \frac{\theta}{r}\Psi_{d|\hat{r}^b_{xt}} - \frac{\theta}{r}\Psi_{l|\hat{r}^b_{xt}} + \left[f^e\Psi + \alpha^b\Psi\right] \tag{12}$$

$$\alpha_2 = f^e - \alpha = \frac{\theta}{r}\Psi_{d|\hat{r}^b_{xt}} + \frac{\theta}{r}\Psi_{l|\hat{r}^b_{xt}} + \left[f^e(1-\Psi) - \alpha^b\Psi\right] \tag{13}$$

in which we break down f of Eq.(10) into $f^e + \alpha^b$ to obtain α_1.[18] The hedging term $f^e\Psi$ then works the same way as $f\Psi$ of Eq.(5) in generating bias gap. Besides, a positive α^b shifts the home wealth from the foreign asset to the home asset and therefore always enhances the home bias in the Home. The higher is δ^d, the larger is α^b, the deeper two-way capital flows for a given level of targeted f, and the wider the bias gap between the two countries. The extended model of both equity and bond is therefore expected to be able to explain more of the bias gap compared to the baseline equity-only model.

Now, we are ready to look at the equity portfolio patterns implied by the obtained Π'_α and compare them to the data, see Table 4. First, as predicted, the model generates a significant difference between the EHBs of the two countries, with the home debtor showing a relatively stronger preference for home equities. This is true for both measures of EHB and it is consistent with the data. Second, when NFA is 15% of GDP, the model predicts a EHB gap of 9 percentage points; when NFA grows to 37% of GDP, the gap grows in an approximately linear way, at 23 points, in both measures. However, in the data, while the DEV & ADV groups have a relatively lower level of (between-groups) NFA imbalances than the Debtor & Creditor groups, -0.15 versus -0.37 respectively, the former set of groups shows an even larger gap of EHB than the latter, 0.18 (0.21)

[17]See, e.g. van Wincoop and Warnock (2010), Coeurdacier and Gourinchas (2016). Benigno and Nisticò (2012) offer an alternative view.

[18]$\alpha_2 = f^e - \alpha$ because $\alpha_2 = w - \alpha_1 - \alpha^b = w - z_1 - (\alpha_1 - z_1) - \alpha^b = f - \alpha - \alpha^b = f^e - \alpha$.

	Model results		Data moments 1990-2015	
	(1)	(2)	(3)	(4)
Variable	δ^d=0.0137	0.0335	DEV v.s. ADV	Debtor v.s. creditor
$(f - f^*)/2$	-0.15	-0.37	-0.15	-0.37
EHB	0.90	1.01	0.97^{**}	0.93^{**}
			(28.60)	(9.23)
EHB^*	0.81	0.78	0.79^{**}	0.78^{**}
			(-5.93)	(-2.75)
ΔEHB=EHB-EHB^*	0.09	0.23	0.18	0.15
EHB2	0.88	1.00	0.97^{**}	0.92^{**}
			(31.11)	(9.97)
EHB2^*	0.79	0.77	0.76^{**}	0.74^{**}
			(-6.66)	(-3.70)
ΔEHB2=EHB2-EHB2^*	0.09	0.23	0.21	0.18

Table 4: Equity home bias: Model v.s. Data. Notes: x^{**} represents that x is significantly different from that of the other group at the level of 0.05. The corresponding t-statistics are in parentheses.

versus 0.15 (0.18) in ΔEHB (ΔEHB2) respectively, which suggests the role of many other types of heterogeneity within the DEV & ADV countries in driving their bias gap than those underlying the NFA imbalances. As a result, the model explains the gap between the Debtor & Creditor relatively better than that between the DEV & ADV from a quantitative point of view. In fact, the model over-explains the former (by more than 30%). In contrast, the model explains around half of the bias gap between the DEV & ADV if using ΔEHB as the measure of the bias gap. When instead using ΔEHB2, the model explains more than 40% of the observed bias gap, given that the EHB2 gap is larger than the EHB gap in the data.

To better see the role of each element in the model, we draw Figure 4 (a) to compare the extent to which the alternative model specification explains the equity bias gap. While we show the result by using ΔEHB, the result for ΔEHB2 is similar. From the figure, the baseline equity-only model of Section 2 and the endowment model of Appendix E.3 performed in a comparable way. They generate a gap of around 6% (14%) when NFA/GDP equals 15% (37%), lower than that by the extended model of $\rho = 1$. The extended model of $\rho < 1$ outperforms that of $\rho = 1$. In our example of $\rho = 0.9$, the model generates a gap of around 11% (30%) when NFA/GDP equals 15% (37%). These findings verify our previous analyses. In the equity-only models, the unequl biases are the result of an interaction between $\{\alpha[1], \alpha[2]\}$ and $\alpha[3]$. The larger is the difference between the $\tilde{\lambda}$ implied by $\{\alpha[1], \alpha[2]\}$ and that by $\alpha[3]$, the larger is the resulting bias gap. By including α^b, the extended model features an additional channel of two-way capital flows in strengthening the bias gap (Eqs.(12)-(13)),[19] in which sense "the bond assets matter" for a better quantitative performance of the model. The bias gap grows, reflected by the yellow and green lines moving up to the blue line. By further allowing for the hedging of exchange rate risks $\alpha[4] > 0$, the extended model of $\rho < 1$ creates an even larger difference between the $\tilde{\lambda}$ implied by $\{\alpha[1], \alpha[2], \alpha[4]\}$ and that implied by $\alpha[3]$. The bias gap grows further, moving the blue line up to the red line.

In Figure 4 (b), we show that the above qualitative results are independent from whether the bond pays the basket of the creditor or that of the debtor. On the left-hand side of 0 on the horizontal axis, we have $f < 0$ (by setting $\delta^d > 0$), and observe an excess home bias in the Home - the net debtor. On the right-hand side of 0, we have $f > 0$ (by setting $\delta^d < 0$), and observe the excess bias in the Foreign (ΔEHB turns to be negative) - the net debtor again.

4.4 Sensitivity analysis

We look at how sensitive the above benchmark results are to: (1) different parameterizations; (2) different sources of the additional uncertainty; and (3) an alternative country asymmetry.

Figure 5 shows how the EHB, EHB*, and α^b (on the y-axis) evolve when we change the value of the following parameters, ρ, ϕ, κ, μ, (on the x-axis). We look at one parameter at a time and keep constant the other parameterization. To facilitate the comparison, we draw a vertical dashed line in each panel to represent the benchmark value of the considered parameter.

We begin with the ρ in (a). The standard ρ in the literature is given by 0.5 (and agents are risk averse, $1/\rho = 2$). As explained, a lower ρ than 1 generates a higher positive $\alpha[4]$,

[19] The labour hedging within such a model of both equity and bond assets, $\alpha[2]$, will also change because it is now conditional on relative bond return, see Coeurdacier et al. (2010), Coeurdacier and Gourinchas (2016). A higher degree of average home bias, and therefore a higher $\tilde{\lambda}$ associated with $\{\alpha[1], \alpha[2]\}$, due to this (a stronger labour hedging in a model of both equity and bond assets), will cause the bias gap to grow in the extended model too.

which tends to drive up the average home bias and widen the bias gap between the two countries. It is also seen that α^b grows in this case, reinforcing the growth in ΔEHB as analysed. The model could therefore explain more of ΔEHB than under the benchmark. On the right-hand side of $\rho = 1$ (the opposite direction of the ρ's standard value), a negative $\alpha[4]$ offsets a positive $\alpha[2]$ in leading to a lower home bias on average. α^b also declines. The bias gap therefore narrows. But as long as both countries exhibit some home bias for us to start with, ΔEHB is positive for $\delta^d > 0$ in the model.

Panel (b) does the experiments when varying the value for ϕ, the elasticity of substitution between the tradable goods. As mentioned, it has been shown by the existing literature of symmetric countries that the labour hedging $\alpha[2]$ in such a framework is usually very strong (as a result of a relatively larger share of labour income as well as a considerable Ψ_l). To avoid an unrealistically high level of home bias, we have chosen $\phi = 0.9$, that is near the lower bound of its estimate. For calibration purposes, ϕ is usually set at around or higher than unity in the literature, e.g. 1.5 by Stockman and Tesar (1995), and Backus et al. (1995). Feenstra et al. (2018) estimate a median of the "macro" elasticity to be close to but higher than 1 and the "micro" elasticity to be even higher (up to 2 times larger). The implication of a higher ϕ is that it generally leads to a higher EHB (in both countries). When the two goods are more substitutable, the resulting price responses to shocks become modest (Cole and Obstfeld, 1991). The weakening of the stabilizing terms-of-trade effect leaves a heavier load of risk-sharing to be achieved through holding portfolios. If optimal portfolios are home biased, the bias needs to be even stronger. As analysed, this would lead to a wider ΔEHB in the model - the difference between the $\tilde{\lambda}$ as implied by non-$\alpha[3]$s and that by $\alpha[3]$ widens.

Panel (c) depicts how our results depend on the choice of κ, the trade openness. Our benchmark is based on the data. It is, however, lower than what appeared in the literature, e.g. around 0.85 as used by Backus et al., 1994, Corsetti et al., 2008, and Heathcote and Perri, 2013. Similar to the case of ϕ, a higher κ implies a higher EHB of both countries via its effect on the terms of trade. Consider, for instance, that the Home experiences a TFP shock. As mentioned, on the supply side, this shock leads to a deterioration in the terms-of-trade, which offers some risk-sharing. However, on the demand side, a higher κ implies an increased demand for the home good, which partially counteracts the terms-of-trade effect. Once more, a less powerful terms-of-trade effect makes portfolio hedging

Variable	Model results	
	(1) f =-0.15	(2) f =-0.37
α	-0.54	-0.68
α^b	0.31	0.75
EHB	0.96	1.30
EHB*	0.82	0.81
EHB gap	0.14	0.49
EHB2	0.94	1.28
EHB2*	0.80	0.80
EHB2 gap	0.14	0.48

Table 5: Sensitivity analysis: alternative country asymmetry in patience

more important in sharing risks. The portfolio home bias will therefore be enhanced. As seen before, ΔEHB tends to grow in this case.

Empirical evidence suggests that the shocks are quite persistent. Panel (d) reports the result where μ varies in the neighbourhood of 0.9. Abstracting from the bond, in the baseline equity-only model, the EHB in both countries would be a monotonically increasing function of shock persistence. To understand, note that the higher is μ, the more volatile are all income streams. Since labour income accounts for a relatively larger fraction of total income, $(1 - \delta) > 1/2$, the rise of volatility in $\Delta\Sigma_t^l$ is more significant than that in $\Delta\Sigma_t^d$. This enhances the role of the positive labour hedging $\alpha\,[2]$ relative to that of the negative self-hedging $\alpha\,[1]$, which yields a more home-biased portfolio in both countries. Other than impacting the absolute level of EHBs in both countries, the μ has little role in determining the relative EHBs. ΔEHB is always positive and is more or less constant across different values of μ. However, in the extended model, the international bond represents a new force through which the μ impacts the size of ΔEHB. When the shocks become more persistent, the positive bond position α^b tends to decline. ΔEHB is reduced in size, but is still larger than 0 even when $\mu = 0.99$.

As explained by Coeurdacier et al. (2010), the use of the investment efficiency shock only serves to create portfolio determinacy, and is not crucial for the portfolio choices in the model. We test by replacing the investment shock with an (intermediate goods) demand shock, a depreciation shock, a redistributive shock (Coeurdacier and Gourinchas, 2016), and a shock to the disutility of labour (which affects the optimal condition of labour supply, see Coeurdacier and Ray, 2012), the portfolio solutions are found to be invariant to the choice of the additional uncertainty.

We have explained in Section 3 why the source of global imbalances does not matter for our qualitative result. It may, however, have different quantitative implications. As an experiment and the final check, we use a different country asymmetry. Specifically, the home households are assumed to be less patient, $\beta < \beta^*$, which yields a lower saving and a higher autarkic interest rate in the home country. Net capital flows in, $f < 0$.[20] Will this undermine the model's ability in explaining the observed ΔEHB? As shown in Table 5, the answer is negative. In fact, the model predicts an even larger bias gap, ΔEHB at 14% when NFA/GDP is −15% and close to 50% when NFA/GDP is −37%. This is partly due to the fact that, on average, more domestic equities are held locally, as indicated by a higher $\bar{\lambda}$, which must be a result of a stronger labour hedging (exchange rate hedging is zero) in the model. On the other hand, the model also predicts two-way capital flows, stronger than those of the δ-asymmetry model as implied by the sizable α^bs. Both channels work towards a rising bias gap between the two countries.

5 Empirical evidence

5.1 Data

We use the following data when conducting our empirical analysis: (1) Country portfolio data that are collated by Lane and Milesi-Ferretti (2007, 2017). (2) To compute EHB and EHB2, one needs to estimate the total value of the capital stock of countries. Following Kraay et al. (2005) and Heathcote and Perri (2013), we extract the capital stock values that prior to 1989 from Dhareshwar and Nehru (1993) and use the perpetual inventory method (PIM) to compute their values after 1989. The PIM is detailed in Appendix H. (3) The other macroeconomic series are obtained from the World Bank development indicators database (WBDI). These include GDP, trade volume, GDP per capita, population that are controlled in our regressions, and also gross investment data that are required to

[20]See Buiter (1981), Chen (2013), Galor and Özak (2016), Falk et al. (2018) among others. Note that, as opposed to the case of δ-asymmetry, now the NFA imbalances are fully caused by relative asset demand (saving), see Appendix E3.3 for an explanation of the role of the δ-asymmetry. Namely, $f = w - z_1$ declines just because $w - w^*$ is reduced while both z_1 and z_2 are always equalised (at $\delta/(r-1)$ since δ is now the same across countries). Therefore, it can be viewed as if $\bar{\delta} = 1$ in Appendix Eqs.(37)-(38), from which the slackness created by the δ-asymmetry to the condition collapses.

construct (2). The data span $1990 - 2015$, and are detailed in Appendix H.[21]

5.2 Cross-country and time-series regressions

The theory predicts a higher EHB in a typical net debtor country than in a creditor country. We first conduct the hypothesis test with the null of the average EHB of debtor countries not being significantly different from that of creditor countries. This null is easily rejected by the data at the standard significance level (of 5%), see Table 4, in support of the theoretical prediction.

Then, we test, as indicated by theory, whether the long-run degree of country's portfolio home bias is negatively associated with the country's NFA/GDP ratio by running the following cross-country regression

$$EHB_i = \alpha + \beta \cdot (NFA/GDP)_i + x_i'\gamma + \varepsilon_i \tag{14}$$

where the variables are those of the time average for each country i.

The result is reported in Table 6. In column (1), we consider the NFA/GDP as the only explanatory variable. Its coefficient turns out to be significant and negative, at around -0.23. In (2)-(4), we add to the regression one at a time the following factors that may be important in determining the portfolio diversification of country (Heathcote and Perri, 2013): trade openness as measured by the average import and export to GDP ratio, development level by GDP per capita, and country size by population. Like them, we find that a country with a higher degree of trade openness, higher income, and smaller country size tends to be associated with a less severe portfolio home bias, in line with general intuition. While the significance and sign of the NFA's coefficient are not affected after controlling for these factors, the coefficient's size experiences an evident reduction - almost halves - in the case of (3), which suggests some other aspects of country underdevelopment (than those underlying net external imbalances) as a complementary and economically important driver of the portfolio home preference. In contrast, while statistically significant, the impact due to trade openness and country size seem to be economically less important. One might also want to control the group difference between

[21] We follow Heathcote and Perri (2013) in picking 1990 as the starting year. The most updated portfolio dataset by Lane and Milesi-Ferretti (2007, 2017) are until 2015. We extend the data as early as 1980 for a robustness check, as explained below.

VARIABLES	(1) EHB	(2) EHB	(3) EHB	(4) EHB	(5) EHB	(6) EHB
NFA/GDP	-0.228***	-0.232***	-0.123**	-0.245***	-0.137**	-0.136***
	(0.050)	(0.039)	(0.053)	(0.044)	(0.052)	(0.048)
Trade openness		-0.002**				-0.002*
		(0.001)				(0.001)
Log GDP per capita			-0.046***			-0.042***
			(0.006)			(0.007)
Log population				0.023**		0.003
				(0.010)		(0.009)
DEV group dummy					0.146***	
					(0.024)	
Observations	61	61	61	61	61	61
Adjusted R-squared	0.359	0.425	0.594	0.403	0.603	0.621

Table 6: Cross-countries: EHB Notes: 61 countries and data sources are in Appendix H. Variables are time average of each country during 1990-2015. Constants are not reported. Robust standard errors in parentheses. *** p¡0.01, ** p¡0.05, * p¡0.1.

VARIABLES	(1) ΔEHB	(2) ΔEHB2	(3) Change in ΔEHB	(4) ΔEHB2
(Change in) $(f^*-f)/2$	0.201**	0.216**	0.338**	0.367***
	(0.078)	(0.082)	(0.131)	(0.127)
(Change in) ΔTrade openness	-0.001	-0.001	0.000	-0.000
	(0.001)	(0.001)	(0.002)	(0.002)
(Change in) ΔLog GDP per capita	-0.040***	-0.050***	-0.070***	-0.077***
	(0.014)	(0.013)	(0.020)	(0.021)
(Change in) ΔLog population	-0.035*	-0.046**	-0.042	-0.055
	(0.020)	(0.020)	(0.032)	(0.032)
Observations	26	26	25	25
Adjusted R-squared	0.581	0.659	0.482	0.535

Table 7: Time series: Portfolio home bias gap and NFA imbalances 1990-2015 Notes: Variables are linearly detrended - columns (1) and (2), or first differenced - columns (3) and (4). Robust standard errors in parentheses. *** p¡0.01, ** p¡0.05, * p¡0.1.

the DEV and ADV groups in the sample. In (5), we add a dummy of DEV group. The result resembles that of per-capita income, i.e. the DEV status enhances a country's EHB and at the same time reduces the role of NFA imbalances. On one hand, this just reflects a high correlation between the DEV status and country income. Therefore, it would be enough to just include one of them in our regressions.[22] On the other hand, as mentioned, the results of (3) and (5) do highlight the role of the other aspects of country development in shaping the country's international diversification. Recall that in Section 4, with only the heterogeneity that matters for the presence of NFA imbalances, the model falls short of fully explaining the EHB gap between the DEV and ADV groups. Incorporating these other types of heterogeneity, e.g. institutional problems (Mukherjee, 2015) and the technological difference in giving investors access to information (Mondria and Wu, 2010; Dziuda and Mondria, 2012), into the existing analysis may improve the explanatory power of the model in this respect. While not necessarily useful in driving net capital flows, these factors are possibly complementary to our mechanism when explaining the high EHB of DEV countries.

In (6), we include all controls. The significance and direction of the NFA's effect (as well as those of the other variables except population) turn out to be unaffected. Quantitatively, a rise of NFA/GDP by 1 percentage point is associated with a reduction of EHB by 0.136. To understand, in the sample the average NFA/GDP ratio of debtor countries is $2 \times 37 = 74$ points lower than that of creditor countries. This implies a higher average EHB of debtor countries than of creditor countries by around $74 \times 0.136 \approx 10$ points due to just the impact of NFA imbalances. Given the size of observed EHB gap at around 15 points, the estimate do suggest a quantitatively important role of NFA in shaping the international EHB gap, with the former accounting for up to 2/3 of the latter in the data.

The results are analogous if one uses EHB2 to measure the home bias (online Appendix). They are also quite robust to changes in time frames. In the Appendix, we show that the results are qualitatively the same when considering the following time frames (based on the existing studies): $1980 - 2007$ (Mukherjee, 2015), $1995 - 2011$ (Steinberg,

[22]Including both of them in, for instance, (6) does not affect the significance and sign of NFA/GDP's coefficient but leads to the insignificance of the coefficient of one of the two measures of the country development level (GDP per capita in this case). However, we follow Heathcote and Perri (2013) by using GDP per capita in (6) to facilitate the comparison. The result of instead using DEV dummy in (6) is very similar.

2018), $1980 - 2015$, and $1995 - 2015$ (their starting years and the end here). However, the results do show that the quantitative importance of the NFA channel improves over time. The deepening global integration during the latter period of the sample might have contributed to this.[23]

Although the model mainly speaks about steady-state αs and is silent on portfolio dynamics, intrigued by Figure 1 (b), we also assess whether our framework can be used to understand the evolution of the EHB gap. We run the following time-series regression:

$$\Delta EHB_t = \alpha + \beta \cdot \bar{f}_t + \Delta x_t' \gamma + \varepsilon_t$$

where the outcome variable ΔEHB is the difference between the average EHB of debtor countries and that of creditor countries. For convenience of exposition, we define our key explanatory variable, a measure of the average size of NFA imbalances between the debtor and creditor countries, to be positive by letting $\bar{f}_t = (f_t^* - f_t)/2 > 0$. According to the theory, when the NFA imbalances between the two groups grow ($\bar{f}_t$ increases), the EHB gap widens. Namely, β should be positive. The other controls, $\Delta x_t'$, of the regression are also in terms of a difference between groups. All variables are linearly detrended, or first differenced.

Table 7 presents the results. The β is found to be significant and positive, consistent with our theory. Quantitatively, the magnitude of the effect is comparable to that of the cross-country evidence. With the linearly detrended data, when $\bar{f}_t$ rises by 37 percentage points (the NFA/GDP difference between the creditor and debtor groups rises by 74 points), the ΔEHB grows by approximately $37 \times 0.201 \approx 7.4$ points. With the first differenced data, the growth of (change in) ΔEHB is stronger. Due to the same amount of (change in) $\bar{f}_t$, the (change in) ΔEHB amounts to $37 \times 0.338 \approx 12.5$ points.

[23]In our model, it is the international financial openness/liberalization that exposes the country asymmetries, and allows them to play the role in generating NFA imbalances. According to the data, it is since the late 1990s and early 2000s that the world witnesses the accelerating financial globalization and the build-up of global imbalances, see Lane and Milesi-Ferretti, 2007, Gourinchas and Rey, 2014, and Caballero et al., 2021.

5.3 Hedging mechanism

Is our new hedging at work behind these results? Now, we estimate the Ψ_f and assess more directly $\alpha\,[3]$'s role in generating the bias gap.

First, we estimate the Ψ_f for each country of our sample.[24] To save space, we defer the discussions on the estimation details to the Appendix G. In short, we follow Coeurdacier et al. (2010) in re-casting the model by using a static instead of a period-by-period budget constraint, so that Ψ_f can be represented by covariance-variance ratios that depend on contemporaneous data observations. Specifically, the $\alpha\,[3]$ in our model can be expressed by either $-f\frac{cov_{\hat{d}_t^*}\left(\hat{d}_t^*-s_t,\,\Delta d_t\right)}{var_{\hat{d}_t^*}(\Delta d_t)}$ (referred by model 1) or $-f^e\frac{cov_{\hat{s}_t}\left(\hat{d}_t^*-s_t,\,\Delta d_t\right)}{var_{\hat{s}_t}(\Delta d_t)}$ (model 2) where the covariance-variance ratios can be estimated with the use of the time-series data, that are either linearly detrended (LD), first differenced (FD), or HP-filtered (HP).

Figures 6 and 7 display those estimates from the LD data. Over $39/52 = 75\%$ estimates show some significance (of at least 0.1). And most Ψ_f values fall between the interval $[-1,\,0]$. The average Ψ_f equals -0.39, not far from -0.5.[25] As analysed, with such a value of Ψ_f, on average there tends to be a relatively higher (lower) EHB in the debtor (creditor) countries because of the reason explained in Section 3. The estimates from the FD and HP data are also analogous. All these results are broadly consistent with the model.

Second, to test if the new hedging really moves the portfolio in the "right" way, for each country i, we map the obtained Ψ_f to its country portfolios and examine whether the resulting portfolios exhibit the same pattern as the observed data. In principle, the labour hedging and real exchange rate hedging can also yield heterogeneous EHBs (with their differing strength across countries, see Coeurdacier and Gourinchas, 2016). To ensure that they do not drive our final results, we consider the average of the whole sample as the starting baseline and allow only the new hedging to vary across countries.

Specifically, our test proceeds as follows: First, we compute the average $\bar{\alpha}_1$, $\bar{w}^e = \bar{\alpha}_1 + \bar{\alpha}_2$ (total value of equity assets, $w - \alpha^b$, in our equities+bond model), and $\bar{\lambda} = \bar{\alpha}_1/\bar{w}^e$

[24] 9 countries are excluded from the original 61 country sample because the constructed dividends for these countries are negative in some years, see the discussions in Appendix G.1 and the country list in Appendix H.

[25] For debtor countries, average $\Psi_f = -0.38$ (model 1) and -0.41 (model 2). For creditor countries, average $\Psi_f = -0.25$ (model 1) and -0.38 (model 2). The Ψ_f of debtor countries is the one with a relatively higher absolute value than that for creditor countries, in line with the calibrated model.

of all countries. Theoretically, the average degree of home bias is mainly because of the other hedging (labour hedging and, if any, real exchange rate hedging) than $\alpha[3]$. One can view this $\bar{\lambda}$ as the portfolio without the presence of NFA imbalances and the associated hedging. To understand, by summing up Eqs.(5) and (7), the new hedging terms offset each other (for marginal country asymmetry). Second, for each country i, we construct the following counterfactual portfolio measures using the estimated Ψ_f and the actual f^e of that country: $\alpha_1(\Psi_f) = \bar{\alpha}_1 + \alpha[3](\Psi_f)$, $w^e(\Psi_f) = \bar{w}^e + f^e$, and $\lambda(\Psi_f) = \alpha_1(\Psi_f)/w^e(\Psi_f)$. The estimated $\lambda(\Psi_f)$ therefore differ across countries ($\lambda_i(\Psi_f)$ for country i), which fully reflects the impact of country-specific NFA imbalances and the associated hedging - for a country whose total equity wealth changes by f^e, its demand for home asset changes by $\alpha[3](\Psi_f)$.

For the new hedging to be a cause of the facts that we have seen, one needs to show that: (1) the estimated $\lambda_i(\Psi_f)$s do become "closer" to the actual λ_is than $\bar{\lambda}$, and (2) the estimated portfolio gaps are also "closer" to their data counterparts than to 0. We show that both (1) and (2) are true below.

For (1), we subtract $\bar{\lambda}$ from both estimated $\lambda_i(\Psi_f)$ and actual λ_i to construct the corresponding λ deviations. We show that the actual λ deviation $\lambda_i - \bar{\lambda}$ is positively correlated with the estimated λ deviation $\lambda_i(\Psi_f) - \bar{\lambda}$. Figure 8 depicts these two measures.[26] Most observations appear in the upper-right and bottom-left quadrants. Therefore, for a country whose actual λ_i is higher (lower) than average, its estimated $\lambda_i(\Psi_f)$ is generally also higher (lower) than $\bar{\lambda}$. The new hedging moves $\lambda_i(\Psi_f)$ "closer" to λ_i. We then regress the actual λ_i deviations on the estimated $\lambda_i(\Psi_f)$ deviations, see Table 8. It can be seen that the positive correlation is in fact statistically significant.

For (2), we first compute each country i's EHB$_i$ based on the country's estimated $\lambda_i(\Psi_f)$ and actual capital/GDP share, and then the average EHBs of debtor and creditor countries as well as the EHB gap between the two groups. Table 9 compares the estimated results to those of the data.

Panel (A) conducts the comparison using the measure of EHB. While there is a ΔEHB of 17 percentage points in the data, using the constructed data, we obtain a size of ΔEHB that ranges between 5 to 8 points and averages at 7 points. Namely, thanks to the new

[26] To illustrate, we present the results of using the linearly detrended data and model 2 in this figure. The figures of using the other specifications are analogous.

	Dependent variable is $\lambda_i - \bar{\lambda}$					
	Linearly detrend		First difference		HP-filter	
	(1)	(2)	(3)	(4)	(5)	(6)
Explanatory variable	model 1	model 2	model 1	model 2	model 1	model 2
$\lambda_i(\Psi_f) - \bar{\lambda}$	0.509**	0.865***	0.735***	0.969***	0.687***	0.932***
	(0.226)	(0.289)	(0.212)	(0.325)	(0.186)	(0.293)
Observations	52	52	52	52	52	52
Adjusted R-squared	0.080	0.152	0.166	0.171	0.151	0.155

Table 8: Cross-country evidence: variations in the actual lambda deviation v.s. variations in the estimated lambda deviation. Notes: Data are linearly detrended, or first differenced, or HP-filtered. In model 1, the hedging is conditional on relative bond return. In model 2, the hedging is conditional on bond return (i.e. real exchange rate). Constants are not reported. Robust standard errors in parentheses. *** p¡0.01, ** p¡0.05, * p¡0.1.

		Linearly detrend		First difference		HP-filter		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel (A)	Data	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model avg.
EHB	0.920	0.901	0.933	0.915	0.933	0.920	0.934	0.923
EHB^*	0.750	0.853	0.856	0.841	0.859	0.844	0.861	0.852
ΔEHB	0.170	0.049	0.077	0.074	0.074	0.076	0.073	0.070
$\frac{\Delta\text{EHB by model}}{\Delta\text{EHB in data}}$		0.287	0.452	0.434	0.427	0.447	0.431	0.415
Panel (B)	Data	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model avg.
EHB2	0.909	0.889	0.920	0.903	0.921	0.909	0.921	0.911
EHB2^*	0.712	0.823	0.826	0.812	0.829	0.816	0.830	0.823
ΔEHB2	0.197	0.066	0.094	0.091	0.092	0.093	0.091	0.088
$\frac{\Delta\text{EHB2 by model}}{\Delta\text{EHB2 in data}}$		0.336	0.480	0.462	0.468	0.474	0.463	0.447

Table 9: Estimated and observed EHB gaps between the debtor and creditor countries

Panel (A)	Dependent variable is EHB						
		Linearly detrend		First difference		HP-filter	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Data	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
NFA/GDP	-0.120***	-0.082***	-0.103***	-0.103***	-0.099***	-0.103**	-0.100***
	-0.042	-0.027	-0.027	-0.026	-0.025	-0.039	-0.025
Observations	52	52	52	52	52	52	52
Adjusted R^2	0.691	0.344	0.554	0.441	0.580	0.427	0.587
Panel (B)	Dependent variable is EHB2						
VARIABLES	Data	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
NFA/GDP	-0.118***	-0.079**	-0.103***	-0.103***	-0.098***	-0.106***	-0.100***
	-0.040	-0.030	-0.027	-0.027	-0.025	-0.038	-0.025
Observations	52	52	52	52	52	52	52
Adjusted R^2	0.715	0.450	0.625	0.540	0.652	0.551	0.658

Table 10: Estimated and observed EHB gaps projected on NFA/GDP Notes: Constants and the other controls - trade openness, Log GDP per capita, and Log population - are included in the regressions but are not reported. Robust standard errors in parentheses. *** p¡0.01, ** p¡0.05, * p¡0.1.

hedging, the constructed data account for up to $29-45\%$ (on average 42%) of the observed ΔEHB in the sample. The results by using the measure of EHB2 are analogous, see panel (B). While there is a ΔEHB2 of 20 percentage points in the data, the constructed data yield a size of ΔEHB2 that ranges between 7 to 9 points (on average 9). The fraction of the ΔEHB2 that can be "explained" by the model is between $34-48\%$ (and on average 45%).

Finally, we show that the constructed data are also characterized by a negative relation between a country's EHB and its NFA/GDP levels, as is seen in both the actual data and our quantitative model. Because the only source of EHB heterogeneity in the constructed data comes from the NFA imbalances and the associated hedging, this provides additional support for our theory.

In Table 10 column (1), we run the same regression as Eq.(14) for the smaller sample.[27]

[27]Recall in this sub-section, some countries were removed from the sample due to a negative constructed

VARIABLES	(1) EHB	(2) EHB2
NFA/GDP	-0.309***	-0.300***
	(0.004)	(0.004)
Observations	798	798
Adjusted R-squared	0.891	0.889

Table 11: Cross-countries regression with the model simulated data Notes: The extended model in Section 4 was simulated for 400 times, which yields 798 sets of data sample (the pair of data where the Home and Foreign NFAs equal to 0 is eliminated). EHB and EHB2 are regressed on NFA/GDP. Constants are not reported. Robust standard errors in parentheses. *** p¡0.01, ** p¡0.05, * p¡0.1.

The results are analogous to the previous ones, i.e. (6) of Table 6, with the estimated coefficient of NFA/GDP being slightly revised downward. In columns $(2)-(7)$, we repeat the regression, however, by making use of the projected portfolio biases. It is obvious that the constructed portfolios "mimic" the actual portfolios quite well in capturing the significantly negative NFA's effect on the EHBs. And the magnitude of such an effect is comparable to that of the actual data.

It is also convenient to compare the relation with that in our quantitative model. To do so, we simulate our model in Section 4 for 400 times, and obtain 798 sets of data (with NFA/GDP ranging from -45% to 45%). We run again the above regression with the model-simulated data, and report the result in Table 11. As shown, we continue to observe a significantly negative effect of NFA/GDP on EHBs, qualitatively similar to the one obtained from the constructed data (although quantitatively somewhat more pronounced possibly due to the fact that our model is free of such frictions as the costs associated with portfolio adjustments).

dividend in these countries. We rerun the regression with the smaller sample to show that the missing of these countries does not affect the validity of the significant and negative relation between EHB and NFA/GDP that found within a larger country sample of Table 6.

6 Conclusion

A country's net external imbalance and lack of portfolio diversification can be causally correlated. For a debtor, households have a motive to hedge against the interest payments to abroad, which involves a short position of both home and foreign assets, a marginally more diversified portfolio that is lost from the initially home-biased average portfolio. The final portfolio bias is therefore intensified, in consistent with the data. The portfolio models of hedging motives (with identical countries) have been quite successful in accounting for the general "lack" of portfolio diversification in the international financial market (Coeurdacier and Rey, 2013), while our results with country differences show that the deeply rooted reasons for external imbalances of debtors could also have caused their more noticeable portfolio biases (Gourinchas and Rey, 2014). Although we emphasize the important role of differing net external positions and the associated risks in shaping portfolio biases, we do not regard it as the sole factor that matters. Instead, we view it to be complementary to many other potential explanations for heterogeneous portfolio biases. While our theory fits relatively well the data of debtors and creditors as a group, it does not necessarily conform with the experience of every single country over the considered period. As one example of such exception, China kept seeing a relatively poor portfolio diversification even after turning into a prominent net creditor from the 2000s, which suggests the role of other, possibly more forceful, frictions.

Our extended model also yields a positive net bond position together with a negative net equity position of the debtor, in consistent with the so-called two-way capital flows between the DEV and ADV countries (Ju and Wei, 2010, von Hagen and Zhang, 2014, Wang et al., 2015). Unlike these previous studies in which asset return differentials drive debt and equity's (net) flows, the distinct hedging property of these assets matters here, which deserves further exploration. The quantitative and empirical analysis based on this model also suggests that to fully understand the excess bias in developing countries, additional elements that are complementary to ours may be useful. Besides those discussed in the text, the roles of geography, culture and institutions (e.g., Portes and Rey, 2005, Chan et al., 2005, Daude and Fratzscher, 2008 among others) are also probable candidates. While we focus on positive implication of the model, the normative considerations and policy issues were left aside. We leave these extensions to future research.

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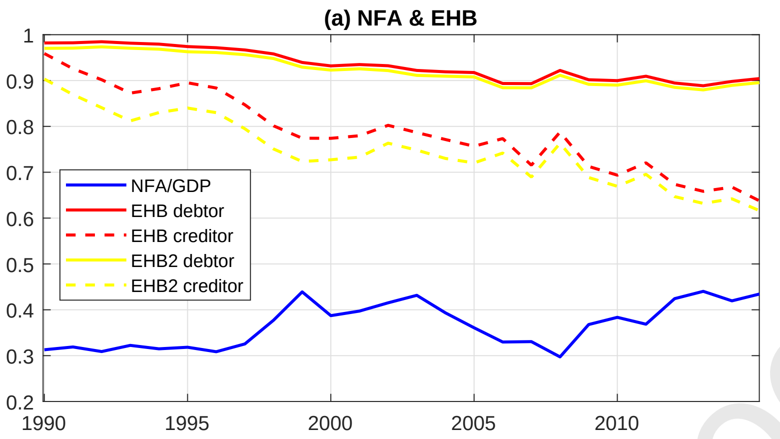

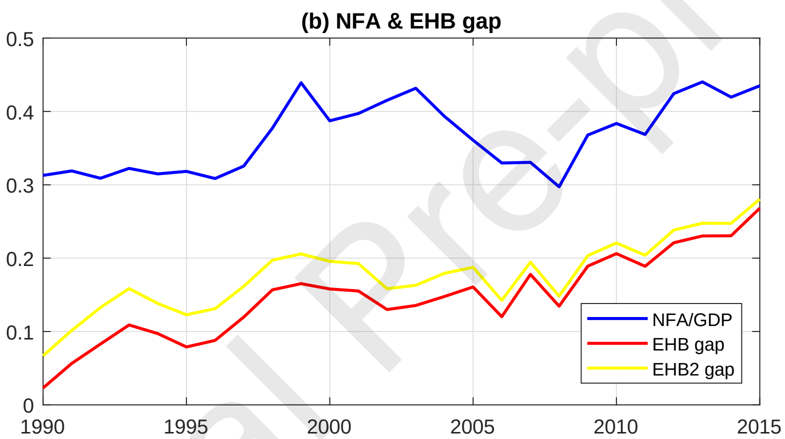

Figure 1: Panel (a) "EHB debtor" is "average equity home bias (EHB) of net debtor countries", "EHB creditor" is "average EHB of net creditor countries", NFA/GDP is "(average NFA/GDP ratio of creditor countries - average NFA/GDP ratio of debtor countries)/2", series are over 1990-2015. To compute the two measures of EHB, for each country i in year j, $\text{EHB}_{ij} \equiv$ "$1 - \frac{\text{Share of foreign equities in country } i\text{'s equity portfolio in year } j}{\text{Share of foreign equities in the world market portfolio in year } j}$", $\text{EHB2}_{ij} \equiv$ "Share of home equities in country i's equity portfolio in year j − Share of home equities in the world market portfolio in year j". Panel (b) EHB gap is "average EHB of net debtor countries - average EHB of net creditor countries", EHB2 gap is "average EHB2 of net debtor countries - average EHB2 of net creditor countries", NFA/GDP is the same as in panel (a), series are over 1990-2015. Country sample and data source: see Appendix H.

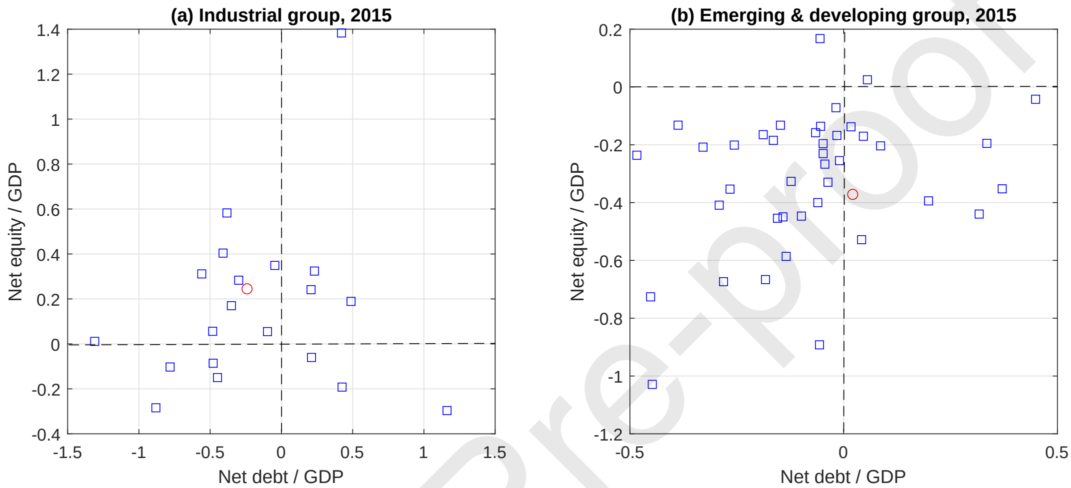

Figure 2: Net equity position versus net debt position: industrial countries on panel (a) v.s. emerging markets and developing countries on panel (b), 2015. Each blue square represents a country. In each group, the red circle represents the country with the median NFA/GDP ratio of the group. The median industrial country has a positive NFA, a positive net equity position, and a negative net debt position. The median emerging & developing country has a negative NFA, a negative net equity position, and a positive net debt position. Data source: Lane and Milesi Ferretti's (2007) (2017) extended data set. Country sample: see Appendix H.

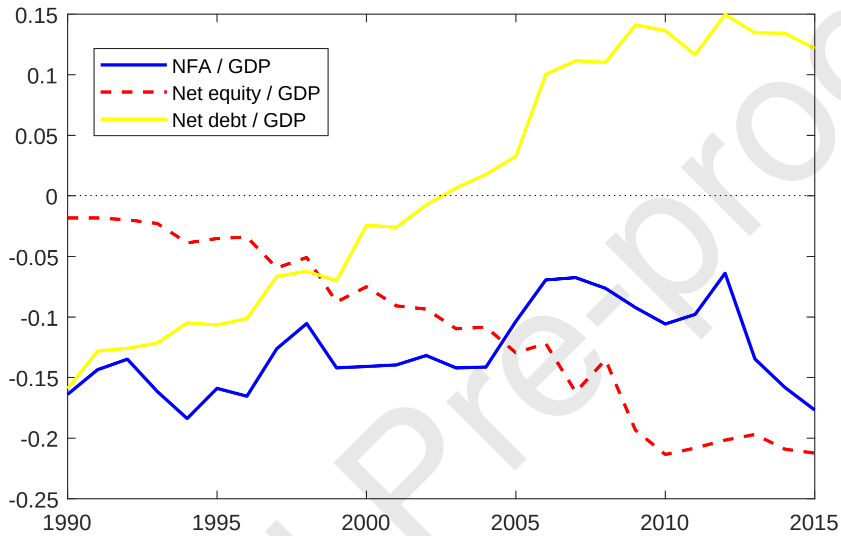

Figure 3: Capital flows between the industrial and emerging & developing groups, 1990-2015. NFA/GDP = "(median NFA/GDP ratio of emerging & developing countries - median NFA/GDP ratio of industrial countries)/2". Net equity/GDP and Net debt/GDP are defined analogously. Data source: Lane and Milesi Ferretti's (2007) (2017) extended data set. Country sample: see Appendix H.

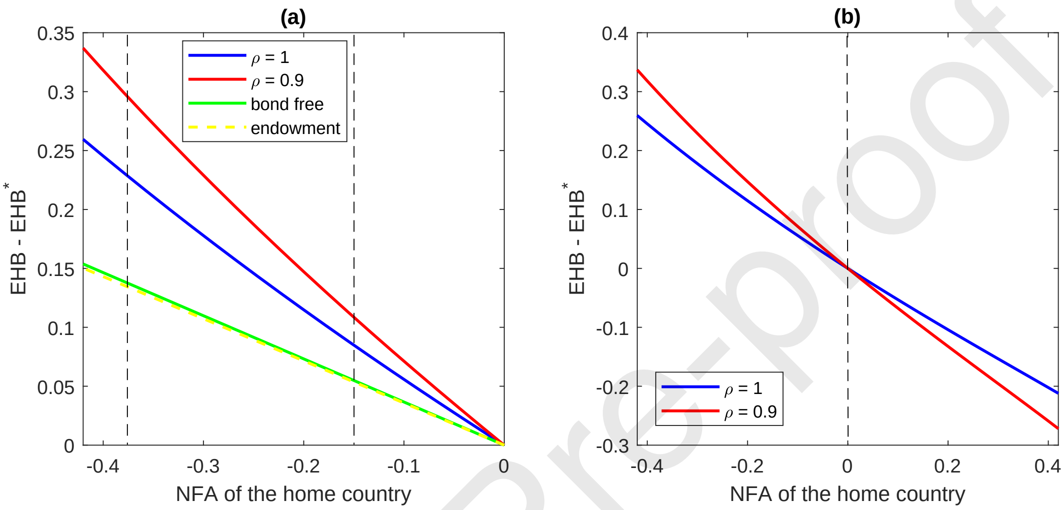

Figure 4: Model calibration: EHB gap v.s. NFA of the home country (a) alternative specifications: extended model for $\rho = 1$ (benchmark) and $\rho = 0.9$, baseline bond-free model of section 2, and endowment model of section 3. (b) switching the status of the home (foreign) country from net debtor (creditor) to net creditor (debtor) by setting $\delta^d > 0$ ($\delta^d < 0$). The dashed vertical lines depict some key NFA/GDP values: -0.37, -0.15, and 0. For the baseline and endowment models, because $\delta_k = 0$, $\bar{\delta}$ is set at 0.206 to target the capital GDP ratio of 2.57. v in the endowment model is set to the value at which the average EHB equals to 0.9 when $\delta^d = 0$. The values of the other parameters are the same as in the extended model.

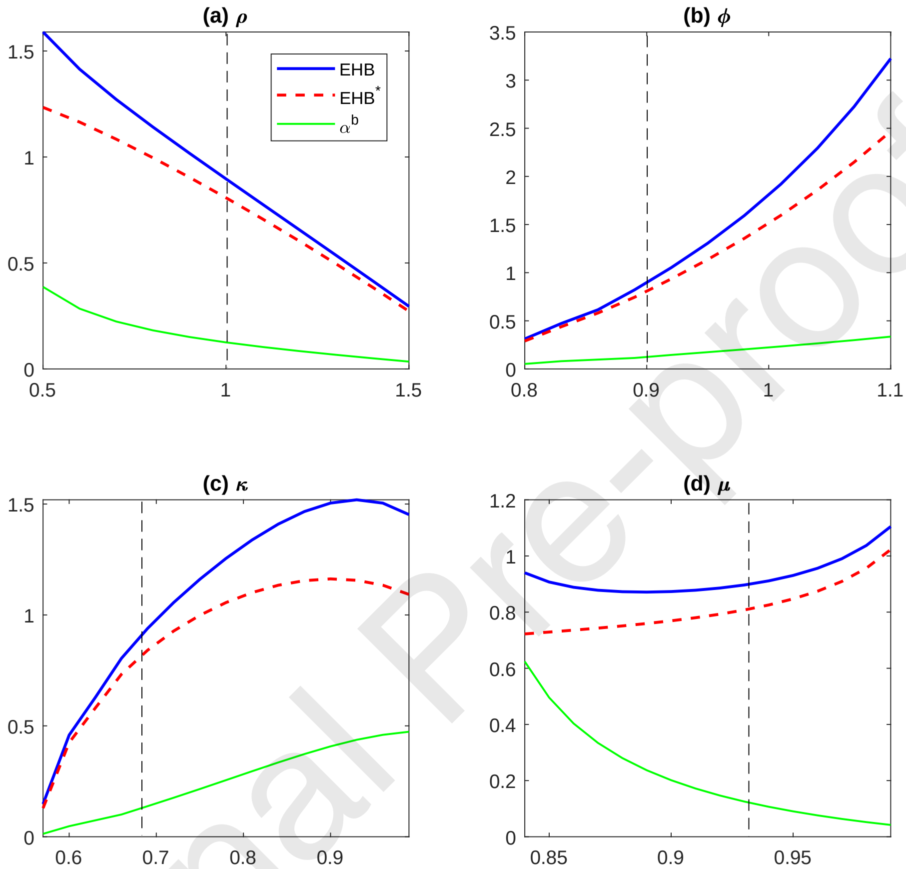

Figure 5: Robustness checks: parameterization (a) elasticity of intertemporal substitution, ρ; (b) elasticity of substitution between tradable goods, ϕ; (c) degree of goods home bias, κ; (d) persistence of shocks, μ. The vertical dashed black line in each panel depicts the value of corresponding parameter that is under the benchmark calibration.

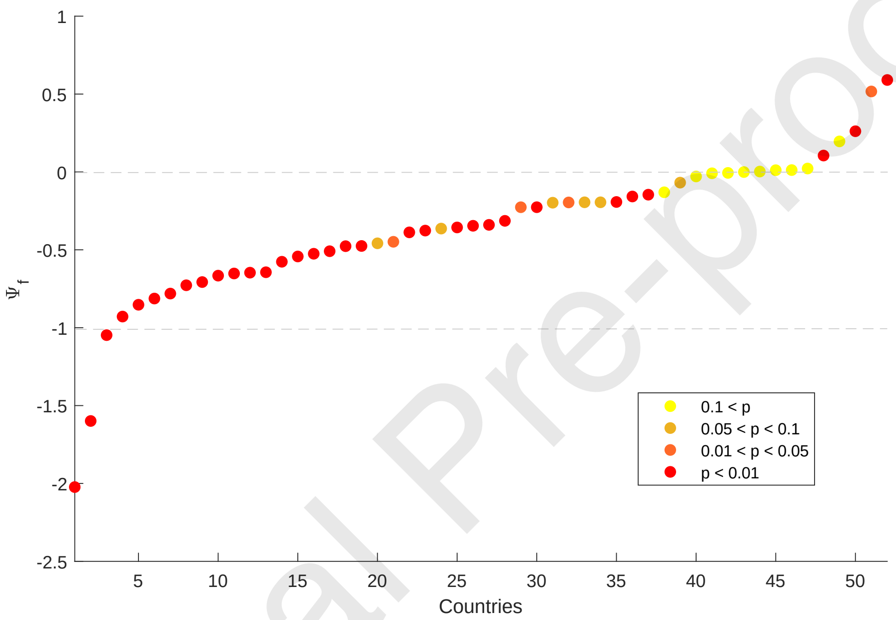

Figure 6: Estimate of Ψ_f that is conditional on relative bond return $\hat{r}^b_{xt}$ (y-axis) for each country (x-axis). Linearly detrended data.

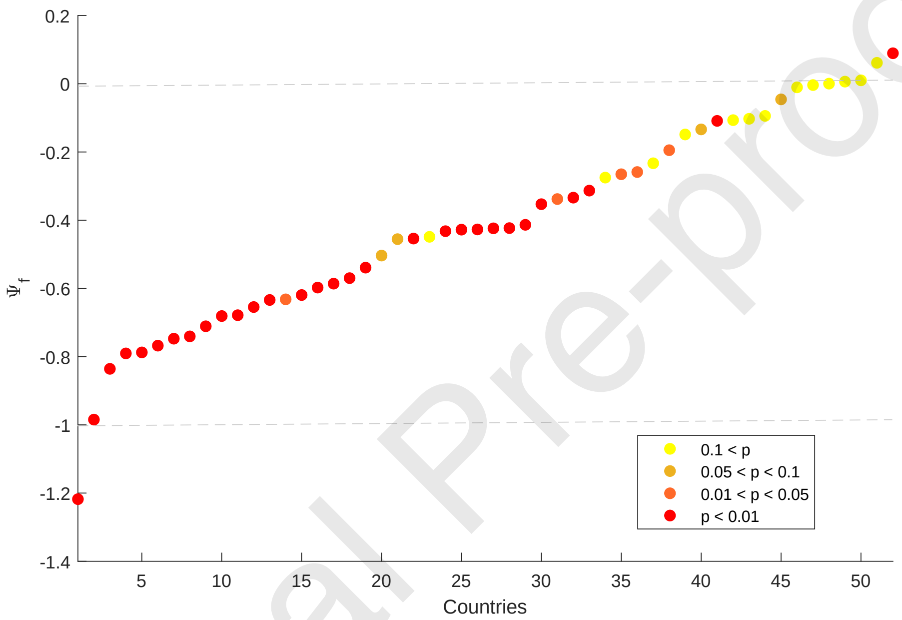

Figure 7: Estimate of Ψ_f that is conditional on bond return $\hat{r}_t^b$ (y-axis) for each country (x-axis). Linearly detrended data.

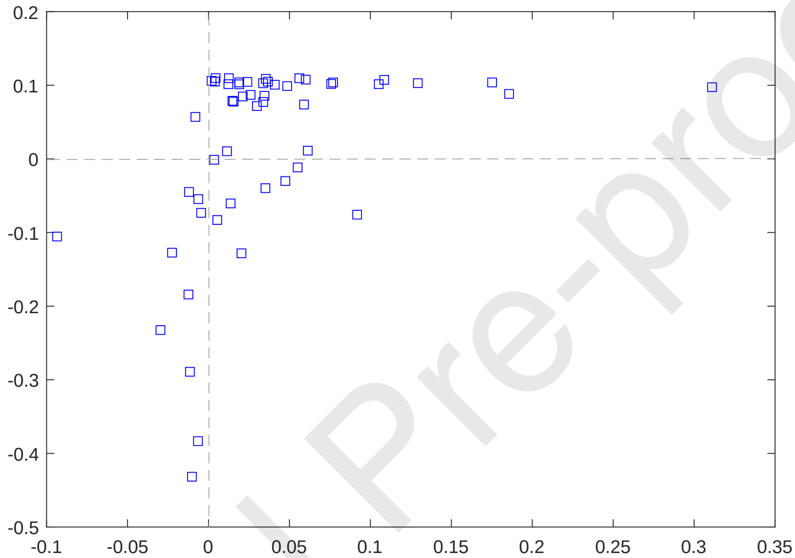

Figure 8: The actual lambda deviation $\left[\lambda_i - \bar{\lambda}\right]$ (y-axis) against the estimated lambda deviation $\left[\lambda_i\left(\Psi_f\right) - \bar{\lambda}\right]$ (x-axis) for each country i. Notes: The linearly detrended data and the model 2 are used in this figure.