Asset home bias in debtor and creditor countries

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Abstract

A workhorse two-country portfolio model that embeds net foreign asset (NFA) imbalances rationalizes the following observation: debtor countries have on average a less diversified international portfolio than creditor countries. Abstracting from NFA imbalances, the model would feature a symmetrically home-biased portfolio in the two countries. The presence of NFA imbalances gives rise to a new hedging motive of net external positions that implies a short (long) position of both home and foreign assets in the debtor (creditor) country. Marginally, the debtor (creditor) country loses (gains) the NFA as a diversified portfolio on top of the initially symmetrically biased one, which leads to a stronger (weaker) home bias in the debtor (creditor) country. 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 over the last few decades of financial globalization, 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 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 overall net debtors over the last few decades (Lane and Milesi-Ferretti, 2007, 2017, Alfaro et al., 2014). This paper explores the hypothesis that the portfolio bias gap between DEV and ADV countries reflects the different preferences for local assets between debtor and creditor countries. That is, relative to a creditor, a debtor needs to hold more intensively domestic assets to achieve optimal risk-sharing, which translates into a divergent bias gap between the two groups of countries.

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.

To uncover the casual link between the degree of home bias and net external imbalances, we model both net and gross country portfolios in a workhorse 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 Perri,

[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.

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, 2020, 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 other factors than labour income hedging in generating the home bias in the average portfolio, e.g. hedging exchange rate risk (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 marginally larger debtor would always turn to a more home-biased portfolio. Of course, their quantitative implications may differ. Specifically, the more biased the initial portfolios, the larger the gap between the portfolio biases of the debtor and creditor countries. 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 equity assets, the model yields two-way capital flows - the net

[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. 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 concerns 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.

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 of the model than the benchmark, 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 country has a stronger home bias than a creditor country. 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 (creditor) countries do exhibit a higher (lower) 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

Consider an open economy of two countries, Home and Foreign, à la Backus et al. (1994, 1995) (BKK henceforth). Each country is populated by the infinitely lived *OLG* households of measure 1 at $t = 0$ (Weil, 1989). The population grows at a net (gross) rate of n ($\tilde{n} \equiv 1 + n$). A per-capita variable x_t in the model can be obtained by aggregating individual variables x_t^v via

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

where v and t of x_t^v denote vintage and time, respectively.

Except for the country asymmetry to be explained, the two countries are of the same structure. We focus on the home country and use a star superscript to denote the foreign variables.

2.1 Households

Households of vintage v maximize the lifetime utility

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

at time t, where c_t^v denotes consumption, h_t^v labour supply, γ the relative weight between consumption and leisure, and β the intertemporal discount factor.

The households face 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 their labour income equals $l_t^v \equiv \frac{g_t}{p_t} h_t^v$, i.e. 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 (asset 1) and the foreign asset (asset 2) at the end of $t-1$. r_{1t}, r_{2t} represent the asset gross returns from $t-1$ to t

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

where z_{1t}, z_{2t} denote 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 can be rewritten as

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

The households' wealth is given by the sum of portfolio returns and saving in each period.

In the foreign country, households maximize an analogous utility function subject to

$$s_t \left(\alpha_{1t+1}^{v*} + \alpha_{2t+1}^{v*}\right) = s_t \left(r_{1t}\alpha_{1t}^{v*} + r_{2t}\alpha_{2t}^{v*}\right) + l_t^{v*} - c_t^{v*}$$

s_t appears here because portfolio returns are in terms of the home basket.

Following Weil (1989), we assume that new generations are born with no assets. With this assumption, an $\tilde{n}$ appears ahead of $t+1$ asset variables in the per-capita budget constraint, which is useful in ensuring model stability.

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

$$s_t \tilde{n} w_{t+1}^* = s_t \left(r_{1t}\alpha_{1t}^* + r_{2t}\alpha_{2t}^*\right) + l_t^* - c_t^* \tag{3}$$

2.2 Production

In both countries, a Cobb-Douglas technology is used to produce the intermediate good

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

Here ε_t and ε_t^* represent technology shocks that follow

$$\varepsilon_t = \mu\varepsilon_{t-1} + \epsilon_t, \quad \varepsilon_t^* = \mu\varepsilon_{t-1}^* + \epsilon_t^*$$

where $0 < \mu < 1$. ϵ and ϵ^* are zero-mean $i.i.d$ innovations with $var(\epsilon) = var(\epsilon^*) = \sigma^2$ and $cov(\epsilon\epsilon^*) = 0$. By country asymmetry, we mean $\delta > \delta^*$. We explain its role in the model in the next section.

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 denotes the price of the home intermediate good. q_t/p_t is the good's price in terms of the home basket. Investment evolves according to $i_t = \tilde{n}k_{t+1} - (1-\delta_k) k_t$, where δ_k is the capital depreciation rate.

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

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

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

where x_{ht}, x_{ft} denote the home demand for home and foreign intermediate goods, and x_{ht}^*, x_{ft}^* the corresponding foreign demand. ϕ is the elasticity of substitution between the two traded goods, and κ a measure of goods home preference, $1/2 < \kappa < 1$.

Given the production functions, the related consumption-based CPIs are

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

	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

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

where q_t^* denotes the foreign price of the foreign good. The law of one price holds for the two traded goods, so that the foreign price of the home good is given by $s_t q_t$ and the home price of the foreign good $\frac{q_t^*}{s_t}$. The demands for the intermediate goods are

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

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

2.3 Market clearing

Market clearing requires $x_{ht} + x_{ht}^* = x_t, \;\; x_{ft} + x_{ft}^* = x_t^*$ in the intermediate goods market, and $c_t+i_t = y_t$, $c_t^*+i_t^* = y_t^*$ in the final goods market. For the asset market, it requires $\alpha_{1t}+\alpha_{1t}^* = z_{1t}, \;\; \alpha_{2t}+\alpha_{2t}^* = z_{2t}$. These are equivalent to $\alpha_{1t} = z_{1t}-\alpha_{1t}^*, \;\; w_t - z_{1t} = -\left(w_t^* - z_{2t}\right)$. 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 $f_t = -f_t^*$.

We drop a variable's time subscript to denote its steady state. Next, we compute the steady-state net and gross portfolios, f and αs, in the model.

3 Theoretical analysis

We first characterize the net and gross portfolios in the non-stochastic steady state of the model, and then explain why there tends to be a stronger home bias in the home country.

3.1 Net capital flows

To make the model tractable, we assume $\delta_k = 0$ in this section and relax it in section 4. We also assume that the two countries have the same GDPs and normalise the home GDP, ξ_t, to be unity, i.e. $\xi_t = \xi_t^*/s_t = 1$. Under these assumptions, we show below that the model admits analytical expressions for steady-state f and r as a function of the country asymmetry. Besides, steady-state variables gain an interpretation of per-GDP ratios, which facilitates the mapping of the model to data in section 5. As before, we mainly show the equations for the home country. The foreign equations are analogous, see Appendix B.

We solve the households' utility maximization problem for the individual consumption function and aggregate the latter over v to obtain the per-capita consumption

$$c_t = (1-\beta)\left[rw_t + \Sigma_{i=0}^{\infty}\frac{1}{r^i}l_{t+i}\right] \tag{4}$$

Substitute it into the aggregate budget constraint $\tilde{n}w_{t+1} = rw_t + l_t - c_t$ to yield the law of motion for w_t

$$w_{t+1} = \frac{r\beta}{\tilde{n}}w_t + \frac{(r\beta-1)}{\tilde{n}\,(r-1)}l_t$$

Under the stability condition (verified below)

$$\tau \equiv r\beta/\tilde{n} < 1$$

and using the fact of $l = (1-\delta)$ from the optimal conditions of the labour market, we obtain the steady-state asset demand w

$$w = \frac{(r\beta-1)\,(1-\delta)}{(\tilde{n}-r\beta)\,(r-1)}$$

Because $\tau < 1$ and $r\beta > 1$ (verified below), w is a positive function of $(1-\delta)$. On the other hand, from the asset pricing relation, the asset supply (capital stock) can be found to be a positive function of δ

$$z_1 = k = \frac{d}{(r-\tilde{n})} = \frac{\delta}{(r-1)} \tag{5}$$

The NFA f is therefore

$$f = w - z_1 = \frac{r\beta - 1 - n\delta}{(\tilde{n} - r\beta)(r-1)}$$

In autarky, $f = 0$, which determines the interest rate at $r^a = \frac{1+\delta n}{\beta}$. It positively depends on time preference $\frac{1}{\beta}$, population growth n, and δ. With time preference and population growth being equal across countries, the country with a higher δ would feature a relatively higher r^a, which tends to attract net capital flows from the rest of the world once the economy opens to the international financial market.

Formally, in a financially open world, $f + f^* = 0$. The interest rate will be

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

with $\bar{\delta} \equiv \frac{(\delta^* + \delta)}{2}$. First, $\frac{1}{\beta} < r < \frac{\tilde{n}}{\beta}$ is verified. Second, r lies in the exact middle of the two autarky interest rates $r^{a*} < r < r^a$, which means $f < 0$ and $f^* > 0$. Substituting r into w and f yields

$$w = \frac{\bar{\delta}(1-\delta)}{\left(1-\bar{\delta}\right)(r-1)}, \; f = -\frac{\delta^d}{\left(1-\bar{\delta}\right)(r-1)} = -f^* < 0 \tag{6}$$

with $\delta^d = \delta - \bar{\delta} = \bar{\delta} - \delta^* > 0$ representing a country's δ gap to the world average. Capital flows from the foreign to the home country in net terms.

Substituting w and r into budget constraint yields consumptions

$$c = [1 - \bar{\imath}]\left[1 + \frac{\delta^d}{1-\bar{\delta}}\right], \; c^* = [1 - \bar{\imath}]\left[1 - \frac{\delta^d}{1-\bar{\delta}}\right]$$

where the average investment $\bar{\imath} = \frac{n\bar{\delta}}{(r-1)}$. Denote the new-born's consumption $c_t^n \equiv c_t^t$. Eq.(4) and the assumption that new generations are born with no assets imply $c^n = \frac{n}{(\tilde{n} - r\beta)} c$.[6] Since the new-born households only account for $n/\tilde{n}$ of the whole economy in each period, the fraction of consumption that is due to new-born households is $\frac{n}{\tilde{n}} \frac{(\tilde{n} - r\beta)}{n} = 1 - \tau$. Therefore, the previous stability condition, $\tau < 1$, just requires that the existing households and newly born households both consume some positive fraction of the total

[6] Alternatively, combining the Euler equation and the aggregation relation yields $c_t = \frac{r\beta}{\tilde{n}} c_{t-1} + \frac{n}{\tilde{n}} c_t^n$. So in steady state, $c^n = \frac{n}{(\tilde{n} - r\beta)} c$.

resource in steady state.

By the budget constraint, c also equals $l+d+(r-\tilde{n})\,f=1-i+(r-\tilde{n})\,f$, where $i=\frac{n\delta}{(r-1)}$. From the right-hand-side, the home expenditure $(c+i)$ is given by national income, i.e. the sum of GDP $(\xi=1)$ and the net portfolio return $(r-\tilde{n})\,f$. Throughout the paper, we assume $r>\tilde{n}$ and focus on a case where the debtor country pays a positive interest.[7] From the left-hand-side, consumption consists of labour income, dividend income, and net portfolio return. So, when choosing portfolios to smooth consumption, each country needs to not only consider the risks of labour and dividend incomes but also those of net portfolio return, a key feature of the portfolio determination in the current model. We explore these aspects next in more detail.

3.2 Gross portfolio composition

Following Devereux and Sutherland (2011), we first define and compute $\alpha\equiv\alpha_1-z_1$, the home gross holding of the home asset. Because the home country is the default supplier of the home asset, a realistic α satisfies $\alpha\in[-z_1,\,0]$. A higher absolute value of α implies larger foreign liabilities of the home country or, equivalently, larger foreign assets of the foreign country. Once α is known, all other αs are known (Table 1).

Denote variables with a hat as their log-deviations from the steady state. The optimal portfolio condition is[8]

$$E_{t-1}\left[\hat{c}_t^D\hat{r}_{xt}\right]=0 \tag{7}$$

where $\hat{c}_t^D=\hat{c}_t-\hat{c}_t^*+\hat{s}_t-(1-\tau)\left(\hat{c}_t^n-\hat{c}_t^{n*}+\hat{s}_t\right)$ stands for the portfolio-relevant cross-country relative consumption. $\hat{r}_{xt}\equiv\hat{r}_{1t}-\hat{r}_{2t}$ is the excess return of asset 1 over asset 2. The above condition states 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

[7] The same as in e.g. Obstfeld and Rogoff (1996) Chapter 3. When calibrating the model, this is guaranteed by selecting an n that is close to 0.

[8] As a standard procedure, we approximate non-portfolio equations around the above steady-state to the first-order accuracy (Appendix C), and the Euler equations to the second-order accuracy (Appendix D).

the model, we will select a very small n (that is close to 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 $\hat{c}_t^D$ in response to shocks. Specifically, we express $\hat{c}_t^D$ as a function of $\alpha\hat{r}_{xt}$, and substitute it into Eq.(7) to solve for α. Since consumption is determined by permanent income, this is done in two steps. We briefly explain these steps here and provide details in Appendix E.

First, after a shock, one country's total resources (over infinite horizon) will change. The amount of this change, $\Sigma_t^c \equiv \Sigma_{i=0}^{\infty}\left[\frac{\tilde{n}}{r}\right]^i \hat{c}_{t+i}$, can be obtained by aggregating the country's intertemporal budget constraints, Eq.(2), and then imposing the standard no-Ponzi condition. For the home country, we have

$$\Sigma_t^c = \frac{d}{c}\Sigma_t^d + \frac{l}{c}\Sigma_t^l + \frac{r\alpha_2}{c}\left[\hat{r}_{2t} + \frac{\tilde{n}}{r}\Sigma_{t+1}^{rn}\right] + \frac{(\alpha_1 - z_1)\, r}{c}\left[\hat{r}_{1t} + \frac{\tilde{n}}{r}\Sigma_{t+1}^{rn}\right] \tag{8}$$

where $\Sigma_t^c = \Sigma_{i=0}^{\infty}\left[\frac{\tilde{n}}{r}\right]^i \hat{c}_{t+i}$, $\Sigma_t^d = \Sigma_{i=0}^{\infty}\left[\frac{\tilde{n}}{r}\right]^i \hat{d}_{t+i}$, $\Sigma_t^l = \Sigma_{i=0}^{\infty}\left[\frac{\tilde{n}}{r}\right]^i \hat{l}_{t+i}$, $\Sigma_{t+1}^{rn} = \Sigma_{i=0}^{\infty}\left[\frac{\tilde{n}}{r}\right]^i \hat{r}_{t+1+i}$.[9] After a shock, the movement of the home total consumption consists of those movements in total dividend income, total labour income, and total portfolio income.

The total portfolio income, $\frac{r\alpha_2}{c}\left[\hat{r}_{2t} + \frac{\tilde{n}}{r}\Sigma_{t+1}^{rn}\right] + \frac{(\alpha_1 - z_1)r}{c}\left[\hat{r}_{1t} + \frac{\tilde{n}}{r}\Sigma_{t+1}^{rn}\right]$, is the sum of the country's two external positions that are multiplied by the corresponding asset return, i.e. the external assets α_2 times $\hat{r}_{2t}$s, plus the external liabilities $\alpha = (\alpha_1 - z_1)$ times $\hat{r}_{1t}$s. Since the two gross positions add up to f, i.e. $\alpha_2 = f - \alpha$,[10] to eliminate the number of αs, we substitute out α_2 and write the portfolio income as the sum of the NFA return and the excess return on α:

$$\Sigma_t^c = \frac{d}{c}\Sigma_t^d + \frac{l}{c}\Sigma_t^l + \frac{rf}{c}\left[\hat{r}_{2t} + \frac{\tilde{n}}{r}\Sigma_{t+1}^{rn}\right] + \frac{\alpha r}{c}\hat{r}_{xt} \tag{9}$$

That is, we let the home country take the foreign asset as the numeraire asset. Alternatively, one can let the country take the home asset as the numeraire asset, denominate

[9] By the Euler equations, asset returns will adjust to be the same from the second period after the shock, i.e. $\hat{r}_{1t+i} = \hat{r}_{2t+i}$ for $i \geq 1$. So aggregated discounted returns for asset 1 and asset 2 are both $\Sigma_{t+1}^{rn} = \Sigma_{i=0}^{\infty}\left[\frac{\tilde{n}}{r}\right]^i \hat{r}_{t+1+i}$.

[10] In symmetric models, $f = 0$ so $\alpha_2 = -\alpha$. Existing literature that focuses on the modelling of symmetric countries also uses this fact to reduce the number of portfolio holdings when solving the model. Because w and z are also equal, the literature use, for instance, λ and $(1 - \lambda)$, to represent the share of local asset and that of abroad asset in each country's portfolio, respectively.

NFA by $\hat{r}_{1t}$s, and then compute α_2 first. In either case, the portfolio solutions will be the same.

Second, to find $\hat{c}_t$s, we need to know how the lifetime resources, Σ_t^c, are distributed across time. Namely, how much of Σ_t^c is spent at t, a question governed by the Euler equations, i.e. $\hat{c}_{t+1} = \tau\hat{c}_t + (1-\tau)\,\hat{c}_{t+1}^n + \tau\hat{r}_{t+1}$ in log-linearized form. We aggregate the Euler equation from t to ∞, and rearrange to get

$$\hat{c}_t = \frac{r - \tau\tilde{n}}{r}\Sigma_t^c - \frac{(1-\tau)\,\tilde{n}}{r}\Sigma_{t+1}^{cn} - \frac{\tau\tilde{n}}{r}\Sigma_{t+1}^{rn} \tag{10}$$

with $\Sigma_{t+1}^{cn} = \Sigma_{i=0}^{\infty}\left[\frac{\tilde{n}}{r}\right]^i \hat{c}_{t+1+i}^n$. By this expression, current consumption is given by average total consumption, minus the (average) consumption of the yet unborn, and minus the interest rate tilting effect. The tilting effect is familiar, through which a higher interest rate Σ_{t+1}^{rn} reduces current consumption. The term of yet unborn is again due to the existence of population growth. As mentioned, when calibrating the model, this term will collapse. So the aggregated Euler equation is very much the same as its counterpart in a symmetric model that is free of the OLG structure.

Substitution of Eq.(9) into Eq.(10) yields $\hat{c}_t$ as a function of $\alpha\hat{r}_{xt}$. Foreign consumption $\hat{c}_t^*$ is obtained similarly. $\hat{c}_t^D$ therefore is

$$\hat{c}_t^D = \frac{(r - \tau\tilde{n})}{\theta}\left[\alpha\hat{r}_{xt} + f\Sigma_{2t}^{rn}\right] + \frac{r - \tau\tilde{n}}{r}\left[\Delta\Sigma_t^d + \Delta\Sigma_t^l\right] - (1-\tau)\,\Delta c_t^n \tag{11}$$

where $\theta \equiv \left[\frac{1}{c} + \frac{s}{c}\right]^{-1}$. Ignoring the OLG-related term $\Delta c_t^n = \hat{c}_t^n - \hat{c}_t^{n*} + \hat{s}_t$, the relative consumption of the home country, $\hat{c}_t^D$, 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 $[\alpha\hat{r}_{xt} + f\Sigma_{2t}^{rn}]$. As explained, with 2 assets in the country portfolio, 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, $\alpha\hat{r}_{xt}$.

Substituting Eq.(11) into Eq.(7), the home country's foreign liabilities are obtained as the sum of a series of hedging terms[11]

$$\alpha \equiv \alpha_1 - z_1 = -\frac{\theta}{r}\Psi_d - \frac{\theta}{r}\Psi_l \underbrace{-f\Psi_f}_{-} \tag{12}$$

where $\Psi_d = \frac{cov\left(\Delta\Sigma_t^d, \hat{r}_{xt}\right)}{var(\hat{r}_{xt})}$, $\Psi_l = \frac{cov\left(\Delta\Sigma_t^l, \hat{r}_{xt}\right)}{var(\hat{r}_{xt})}$, $\Psi_f = \frac{cov\left(\Sigma_{2t}^{rn}, \hat{r}_{xt}\right)}{var(\hat{r}_{xt})}$. The home country's foreign assets are

$$\alpha_2 = f - \alpha = \frac{\theta}{r}\Psi_d + \frac{\theta}{r}\Psi_l + \underbrace{f\left(1 + \Psi_f\right)}_{-} \tag{13}$$

In the foreign country, the external asset positions are analogous (Appendix $E.1.4$)

$$\alpha^* \equiv \alpha_2^* - z_2 = -\frac{\theta}{r}\Psi_d^* - \frac{\theta}{r}\Psi_l^* \underbrace{-f^*\Psi_f^*}_{+} \tag{14}$$

$$\alpha_1^* = f^* - \alpha^* = \frac{\theta}{r}\Psi_d^* + \frac{\theta}{r}\Psi_l^* + \underbrace{f^*\left(1 + \Psi_f^*\right)}_{+} \tag{15}$$

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 country, 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

$$\Psi_f = -\left(1 + \Psi_f^*\right) \tag{16}$$

Two facts to highlight before we proceed to further analysis. First, one country's foreign liabilities are the other country's foreign assets. This is verified by $\alpha = -\alpha_1^*$ of Eqs.(12) and (15), and $\alpha^* = -\alpha_2$ of Eqs.(13) and (14).

Second, besides the traditional self-hedging Ψ_ds and labour hedging Ψ_ls, the structural country asymmetry that opens the NFA imbalances gives rise to a hedging of the 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^*.

[11] We omit a term of the relative newborns' consumption, $\frac{\theta(1-\tau)}{(r-\tau\tilde{n})}\frac{cov(\Delta c_t^n, \hat{r}_{xt})}{var(\hat{r}_{xt})}$, 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, it 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.

While self-hedging and labour hedging are in general also different than if countries are identical, they are symmetric across countries in the current model, i.e. $-\frac{\theta}{r}\Psi_d - \frac{\theta}{r}\Psi_l = -\frac{\theta}{r}\Psi_d^* - \frac{\theta}{r}\Psi_l^*$ in α and α^* and $\frac{\theta}{r}\Psi_d + \frac{\theta}{r}\Psi_l = \frac{\theta}{r}\Psi_d^* + \frac{\theta}{r}\Psi_l^*$ in α_2 and α_1^*, and therefore cannot be the source of possible unbalanced portfolio bias. The reason must therefore relate to the new hedging of NFA return, which are asymmetric across countries.

3.3 Bias in debtor and creditor countries

To measure equity home bias, we use two standard $CAPM$-based indices, i.e. "$EHB \equiv 1 - \frac{\text{Share of foreign assets in country i's portfolio}}{\text{Share of foreign assets in the world portfolio}}$" and "$EHB2 \equiv$ Share of home assets in country i's portfolio $-$ Share of home assets in the world portfolio" in the paper.[12] Theoretically, a positive value of these indices implies that the share of home assets in the country portfolio exceeds that of the world portfolio, i.e. a home bias. Empirically, as shown in Figure 1, the two indices move in a very close way. So we focus on one of them when explaining the qualitative prediction of the model here. $EHB2$ is more convenient for this purpose. Moreover, because "Share of home assets in the world portfolio" is usually very small, what matters for the size of $EHB2$ is essentially "$\lambda \equiv$ Share of home assets in country i's portfolio".

For our purpose, we would like to show that when $\delta^d > 0$, $\lambda = \frac{\alpha_1}{w} > \lambda^* = \frac{\alpha_2^*}{w^*}$, or equivalently, $\tilde{\lambda} \equiv \frac{\lambda}{1-\lambda} = \frac{\alpha_1}{\alpha_2} > \tilde{\lambda}^*$. Unlike in symmetric models, country wealth ws differ across countries in the current model. So here, it is more convenient for us to compare $\tilde{\lambda}$s instead of λs by just focusing on Eqs.(12)-(15) instead of considering also differing ws. 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.(12)-(15), 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, $z_1 = z_2 \equiv z = \frac{\delta}{(r-1)}$, $\theta = \frac{1}{2}$.

[12] Note that because the share of home assets in the world market is usually very small, as in the literature, see e.g. Sercu and Vanpee (2007), (2008), Coeurdacier and Gourinchas (2016), $EHB2$ is defined as shown in the main text instead of as "$EHB2 \equiv \frac{\text{Share of home asset in country i's portfolio}}{\text{Share of home asset in the world market portfolio}} - 1$".

Suppose all incomes are capitalizable, $\delta = 1$, we would return to the case of full diversification, i.e. $\tilde{\lambda} = 1$ (Lucas, 1982). Too 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.(12)-(13), a positive Ψ_d reduces the holding of home asset α_1 and increases the holding of foreign asset α_2.

With presence of non-financial income, the average portfolio is home biased, i.e. $\tilde{\lambda} > 1$, 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 the goods home bias imply a significant rise in investment, which reduces the available dividend because the latter is given by the firms' revenue *net of* investment expenditure. 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.(12)-(13), a negative Ψ_l increases the holding of home asset α_1 and reduces the holding of foreign asset α_2.

We then look at the marginal portfolio bias, the one that would appear due to a marginal rise in $\delta^d > 0$. In the home country, it is

$$\tilde{\lambda} = \frac{-f\Psi_f}{f\,(1+\Psi_f)}$$

which is determined by the hedging of NFA return risks in a model of global imbalances.

We look at the sign for both numerator and denominator of this marginal $\tilde{\lambda}$.

The numerator is negative. Following the literature, we consider how α is structured by looking at Eq.(12). In the home country, $f < 0$, the home country 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 country 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 country is shocked), $\hat{r}_{xt}$ declines. The amount of interest payment, denominated by $\hat{r}_{2t}$, is relatively high, i.e. the home country'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 country's consumption is also low. The home asset is therefore not a good investment for the home country. The home asset is shorted, $-f\Psi_f < 0$ in α of Eq.(12), and the home country's foreign liabilities rise. As the two sides of the same coin, the foreign country's foreign assets increase by exactly the same amount, $f^*\left(1+\Psi_f^*\right) = f\Psi_f > 0$ in α_1^* of Eq.(15).

The denominator is also negative. To see this, consider how α^* is structured by looking at Eq.(14). In the foreign country, $f^* > 0$, the foreign country receives an external interest payment, which is denominated by $\hat{r}_{1t}$, the overseas asset from the perspective of the foreign country as its numeraire asset.[13] After the same home productivity shock, the home asset's return is once more relatively low while the foreign asset's return is relatively high. The amount of interest payment that the foreign country can claim, as a positive function of $\hat{r}_{1t}$, becomes low. In other words, when the foreign asset's return is high, the foreign country's consumption is, however, low, which makes the local asset in the foreign country a good investment. This delivers a long position of its holding, $-f^*\Psi_f^* > 0$ in α^* of Eq.(14), and the foreign country's foreign liabilities are reduced. Correspondingly, the home country's foreign assets are reduced by exactly the same amount, $f\left(1+\Psi_f\right) = f^*\Psi_f^* < 0$ in α_2 of Eq.(13).

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.(16) yield $\Psi_f = \Psi_f^* = -\frac{1}{2}$, and therefore a marginal $\tilde{\lambda} = 1$. Fol-

[13] This is analogous to the home country and is more formally derived in Appendix E.1.

lowing a marginal rise of δ^d, a negative NFA position opens in the home country. The home country will choose to reduce its holdings of the two assets to the same extent, $-f\Psi_f = f(1+\Psi_f) < 0$. Because the home country initially holds 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 country. The foreign country will choose to increase its holdings of the two assets to the same extent, $-f^*\Psi_f^* = f^*\left(1+\Psi_f^*\right) > 0$. Because the foreign country also holds an initially home biased portfolio, the addition of a marginally diversified portfolio f^* leads to a less biased country portfolio than before.

3.4 Closing the model: the case of an endowment economy

To better appreciate the intuition, we consider a further stripped-down version of the model that admits analytical solutions for both αs and Ψ_fs. Readers interested in the quantitative implications of the model can proceed directly to Section 4.

Consider a one-good ($s_t = 1$) economy where endowments are a white noise, i.e. $\hat{y}_t = \epsilon_t$, $\hat{y}_t^* = \epsilon_t^*$. To be consistent with the baseline model, we assume that the total endowment y_t consists of a perishable part, $l_t = ly_t$, and a non-perishable part, $d_t = dy_t - v\epsilon_t$, both with the familiar steady states, i.e. $l = (1-\delta)$ and $d = \frac{(r-\tilde{n})}{(r-1)}\delta$, see Eq.(5). To ensure a negative comovement between l_t and d_t, we introduce a term $-v\epsilon_t$ in d_t, a shortcut to capture the role of alternative endogenous mechanisms in generating a home bias. As before, the two assets represent the claims on the non-perishable yields. The foreign economy is analogous except that $\delta^* < \delta$. By construct, the economy's steady state is the same as described in Section 3.1.

By Eq.(11), the optimal condition for α requires $\hat{c}_t^D$ to be stabilized, the latter of which is proportional to

$$\theta\left[\frac{d-v}{c}\epsilon_t - \frac{d^*-v}{c^*}\epsilon_t^*\right] + \theta\left[\frac{l}{c}\epsilon_t - \frac{l^*}{c^*}\epsilon_t^*\right] + f\Sigma_{2t}^{rn} \tag{17}$$

that represents the risks associated with the (relative) non-perishable yield, the perishable yield, and the NFA return, respectively.

The expressions for the aggregated asset returns are simply: $\Sigma_{1t}^{rn} = \frac{r-\tilde{n}}{r}\frac{d-v}{d}\epsilon_t$ and

$\Sigma_{2t}^{rn} = \frac{r-\tilde{n}}{r}\frac{d^*-v}{d^*}\epsilon_t^*$, which means

$$\hat{r}_{xt} = \frac{r-\tilde{n}}{r}\left[\frac{d-v}{d}\epsilon_t - \frac{d^*-v}{d^*}\epsilon_t^*\right] \tag{18}$$

While we used the hedging arguement to explain why both $-f\Psi_f$ and $f\left(1+\Psi_f\right) = f^*\Psi_f^*$ are negative in the last section, these results can be proved here because by Σ_{1t}^{rn}, Σ_{2t}^{rn}, and $\hat{r}_{xt}$, the Ψ_f and Ψ_f^* must be negative unless $d = v$, a less interesting case where the assets are of no use in sharing risks.

Substituting Eqs.(17) and (18) into Eq.(7), we obtain[14]

$$\alpha_1 = z_1 - \frac{\theta}{(r-\tilde{n})}\left[(1-\Psi)\frac{d}{c}\left[1+\frac{l}{d-v}\right] + \Psi\frac{d^*}{c^*}\left[1+\frac{l^*}{d^*-v}\right]\right] + \Psi f \tag{19}$$

$$\alpha_2 = \frac{\theta}{(r-\tilde{n})}\left[(1-\Psi)\frac{d}{c}\left[1+\frac{l}{d-v}\right] + \Psi\frac{d^*}{c^*}\left[1+\frac{l^*}{d^*-v}\right]\right] + (1-\Psi)f \tag{20}$$

where we define Ψ as the absolute value of Ψ_f, whose analytical solution is

$$\Psi \equiv -\Psi_f = \frac{(d^*-v)^2}{(d^*)^2}\left[\frac{(d-v)^2}{(d)^2} + \frac{(d^*-v)^2}{(d^*)^2}\right]^{-1} \in [\frac{1}{2}, 1) \text{ for } \delta^d \geq 0 \tag{21}$$

In the foreign country, the expressions of portfolios are analogous (with Ψ and f of Eq.(19)-(20) to be replaced by $\Psi^* = (1-\Psi)$ and f^*, respectively).

To find the average $\tilde{\lambda}$, consider two identical countries by letting $\delta^d \to 0$. It is easy to verify that $\Psi \to \frac{1}{2}$, $\theta = \frac{1}{2}$, and $w = z_1 = \frac{d}{(r-\tilde{n})} = \frac{\bar{\delta}}{(r-1)}$. In both countries, the shares of local and overseas assets are

$$\lambda = \frac{\alpha_1}{w} = \frac{1}{2}\left[1-\frac{l}{d-v}\right], (1-\lambda) = \frac{\alpha_2}{w} = \frac{1}{2}\left[1+\frac{l}{d-v}\right] \tag{22}$$

The hedging of NFA return does not show up and only the hedging of d_t and l_t matters. The result echoes those that appear in the literature of an equalised home bias.[15] For

[14] As before, we omit a OLG term, $-\frac{\theta(1-\tau)}{(1-\beta)}\left(\hat{c}_t^n - \hat{c}_t^{n*}\right)$, in Eq.(17), and therefore a related term in αs, i.e. $\frac{\theta}{r}\frac{1-\tau}{1-\beta}\frac{r-1}{r-\tilde{n}}\left[(1-\Psi)\frac{d}{d-v} + \Psi\frac{d^*}{d^*-v}\right]$ and its reverse, respectively, in α_1 and α_2 of Eq.(19)-(20). All correspond to the term $(1-\tau)\Delta c_t^n$ of Eq.(11). Throughout the paper, population growth n is set to be close to 0, so all these terms are effectively 0.

[15] Under the assumption of country symmetry, because there is no difference between ws and zs ($f =$

home bias to emerge, we impose the following condition: v is big enough such that the (relative) non-perishable yield and the perishable yield covary negatively, i.e.

$$\tilde{\Psi}_l \equiv \frac{l}{d-v} \in (-1,\, 0), \text{ so that } (1-\lambda) = \frac{1}{2}\left[1 + \frac{l}{d-v}\right] < \frac{1}{2} \tag{23}$$

The average $\tilde{\lambda}$ therefore converges to

$$\tilde{\lambda} = \frac{\lambda}{1-\lambda} = \frac{1-\tilde{\Psi}_l}{1+\tilde{\Psi}_l} > 1$$

To fix ideas, suppose $\tilde{\Psi}_l < 0$ is such that countries hold $\lambda = 4/5$ of wealth in terms of their local asset, the average $\tilde{\lambda}$ would be 4.

Now, consider the effect of a marginal rise of δ^d on $\tilde{\lambda}$s. The symmetry between $\tilde{\lambda}$ and $\tilde{\lambda}^*$ breaks down because a marginally diversified portfolio ($\frac{\Psi f}{(1-\Psi) f} = 1$ from Eqs.(19)-(20)) is removed from the above biased average portfolio in the home country, which increases $\tilde{\lambda}$, while the same marginally diversified portfolio is added into the biased average portfolio in the foreign country, which reduces $\tilde{\lambda}^*$.

The role of the country asymmetry in δ In the endowment economy, we can see more clearly the condition under which a rise of δ^d reduces $1-\lambda$ in the debtor country. Making use of Eqs.(6) and (20) yields

$$(1-\lambda) = \frac{\alpha_2}{w} = \frac{\frac{\theta}{(r-\tilde{n})}\left[(1-\Psi)\frac{d}{c}\left[1+\frac{l}{d-v}\right] + \Psi\frac{d^*}{c^*}\left[1+\frac{l^*}{d^*-v}\right]\right] - (1-\Psi) f^*}{\bar{w} - \bar{\delta} f^*} \tag{24}$$

$f^* = 0$) both within and across countries, one can compute λ and $(1-\lambda)$ more directly, i.e. by making use of relative static budget constraints together with the optimal portfolio conditions, and no need to compute αs first and then λs like we do here for asymmetric countries of differing ws and zs. The simple approach is widely adopted when solving symmetric portfolio models, see Coeurdacier and Rey (2013) for a survey, but inapplicable for the current asymmetric model. To use the conventional approach to solve λs for the special case of two identical countries of the described endowment economy, note that by the static budget constraints, consumption in the two countries is respectively

$$c_t = \lambda\,(d-v)\,\epsilon_t + (1-\lambda)\,(d-v)\,\epsilon_t^* + l\epsilon_t$$

$$c_t^* = (1-\lambda)\,(d-v)\,\epsilon_t + \lambda\,(d-v)\,\epsilon_t^* + l\epsilon_t^*$$

Consumption equalization requires $\lambda\,(d-v) + l = (1-\lambda)\,(d-v)$, and immediately, $\lambda = \frac{1}{2}\left[1 - \frac{l}{d-v}\right]$.

where w is written as the sum of its value prior to the change in δ^d, $\bar{w} = \frac{\bar{\delta}}{(r-1)}$, and δ^d's marginal impact on w, $-\bar{\delta} f^*$, see Eq.(6). In other words, under the δ-asymmetry, the home country's $f < 0$ is caused by a combination of a reduction in savings by $\bar{\delta} f^*$ and a rise in asset supply by $\left(1 - \bar{\delta}\right) f^*$.

When $\delta^d \to 0$, the average $(1 - \lambda) = \frac{1}{2}\left[1 + \frac{l}{d-v}\right] < \frac{1}{2}$. Following an analogous argument as before, a marginal rise of δ^d reduces $(1 - \lambda)$ as long as the average $(1 - \lambda)$ is smaller than the marginal one

$$\frac{1}{2}\left[1 + \frac{l}{d - v}\right] < \frac{(1 - \Psi) f^*}{\bar{\delta} f^*} = \frac{1}{2\bar{\delta}} \tag{25}$$

where the equality follows from $(1 - \Psi) \to \frac{1}{2}$ by Eq.(21).[16] It is obvious that this condition is guaranteed by Eq.(23) because $\bar{\delta} < 1$, i.e. the change in the country's net wealth is partially caused by the change in savings. The use of the δ-asymmetry therefore does introduce some slackness to the condition for our qualitative result, but is non-essential. Even if we use a country asymmetry under which f is fully caused by a reduction in w, our previous intuition remains.[17] Namely, as long as the average portfolio is home biased, a debtor (creditor) will see a higher (lower) bias because the marginal portfolio is always diversified.

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

We extend our baseline model along two margins when confronting it with the data. First, we allow for a positive rate of capital depreciation, δ_k. Second, to account for the presence of non-equity assets in the data, we introduce an additional international bond

[16] It can be shown that the same condition is required for the marginal rise of δ^d to increase the foreign country's diversification $(1 - \lambda^*)$. Specifically, it is required that $\frac{1}{2}\left[1 + \frac{l}{d-v}\right] < \frac{\Psi f^*}{\bar{\delta} f^*} = \frac{1}{2\bar{\delta}}$ with $\Psi \to \frac{1}{2}$ when $\delta^d \to 0$.

[17] We consider such a country asymmetry in patience when evaluating the model's quantitative performance in the next section.

to the model and, at the same time, consider a more general utility function of the $CRRA$ fashion.[18] To avoid the case in which the number of assets exceeds that of (independent) shocks, and the resulting problem of portfolio indeterminacy, we follow the literature by introducing an additional source of uncertainty. Specifically, we follow Coeurdacier et al. (2010) in assuming an exogenous shock, ς_t, to the investment efficiency (Greenwood et al. 1988, 1997; Justiniano et al. 2007), i.e. $\varsigma_t i_t = \tilde{n} k_{t+1} - (1 - \delta_k) k_t$. We consider the other types of shocks in the sensitivity analysis.

Let α_t^b denote the bond holding of the home country. With the global net supply of 0, in the foreign country $\alpha_t^{b*} = -\alpha_t^b$. Without loss of generality, we assume that the bond pays the foreign basket.[19] Its rate of return (in terms of home basket) is therefore given by $\alpha_t^b = \left[(p_t^*/p_t) + z_{t+1}^b\right]/z_t^b$, where z_t^b is the bond price at the end of $t-1$.

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 express $\hat{c}_t^D$ as the function of $\Pi'_\alpha \Pi_{rx}$ as well as a series of relative income risks to be hedged, and then substitute the resulting $\hat{c}_t^D$ into $E_{t-1}\left[\hat{c}_t^D \Pi_{rx}\right] = 0$ to obtain a partial equilibrium expression for Π'_α (Appendix $E.2$). Specifically,[20]

$$\alpha = -\frac{\theta}{r}\Psi_{d|\hat{r}_{xt}^b} - \frac{\theta}{r}\Psi_{l|\hat{r}_{xt}^b} - f\Psi_{f|\hat{r}_{xt}^b} - \frac{\theta}{r}\frac{\tau\left(r - \tilde{n}\right)}{\left(r - \tau\tilde{n}\right)}\left(\rho - 1\right)\Psi_{s|\hat{r}_{xt}^b} \tag{26}$$

$$\alpha^b = -\frac{\theta}{r}\Psi_{d|\hat{r}_{xt}}^b - \frac{\theta}{r}\Psi_{l|\hat{r}_{xt}}^b - f\Psi_{f|\hat{r}_{xt}}^b - \frac{\theta}{r}\frac{\tau\left(r - \tilde{n}\right)}{\left(r - \tau\tilde{n}\right)}\left(\rho - 1\right)\Psi_{s|\hat{r}_{xt}}^b \tag{27}$$

[18] The extension of $\delta_k > 0$ 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.

[19] 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.

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

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
δ_k= 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

where $\Psi_{x|\hat{r}^b_{xt}}$ is Ψ_x conditional on $\hat{r}^b_{xt}$, $\Psi_{s|\hat{r}^b_{xt}} = \frac{cov_{\hat{r}^b_{xt}}(\Sigma^s_t, \hat{r}_{xt})}{var_{\hat{r}^b_{xt}}(\hat{r}_{xt})}$, $\Sigma^s_t = \Sigma^{\infty}_{i=0}\left[\frac{\tilde{n}}{r}\right]^i \hat{s}_{t+i}$; $\Psi^b_{x|\hat{r}_{xt}}$ 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.

Like the existing literature, we find that, first, by including the bond asset, the hedging terms of the equity positions are conditional on the (relative) bond return; second, when $\rho \neq 1$, agents are exposed to the real exchange rate risks. Thus, a related hedging of exchange rate risks emerges in the portfolios. Below, we calibrate the model, and numerically solve the portfolios Π'_α.

4.2 Calibration

To be consistent with the empirical analysis below, we use 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 are annual. 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 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 $\delta_k = 0.06$. 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),[21] $\phi = 0.9$, $\rho = 1$,[22] 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 excess home bias in the net debtor country can be accounted for by the model.

4.3 Results

Table 3 reports the resulting Π'_α. When $f = -0.15$, the home country's external equity liabilities, $\alpha = \alpha_1 - z_1$, is -0.52 (of GDP, the same unit below), and the home country'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 country 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.(26)-(27). We focus on α here, and will refer to the ith term of Eq.(26) $\alpha[i]$. 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 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.[23] Based on our theoretical analyses, this

[21] 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).

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

[23] The value of Ψ seems to be insensitive to f. Even when we set the degree of country asymmetry δ^d

	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

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.[24] 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 less expensive, agents are allowed to generate lower income while still maintain the income's purchasing power or they can take advantage of the lower price by consuming more. 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 former force dominates. $\alpha\,[4]$ will be positive because $\Psi_{s|\hat{r}^b_{xt}} > 0$ in the model - when there is a technology shock to the home country, the price of home goods declines, the real exchange rate depreciates ($\hat{s}_t$ reduces), while $\hat{r}_{xt}$ is reduced. Like $\alpha\,[2]$, a positive $\alpha\,[4]$ therefore (symmetrically) enhances the home bias in the two countries (Kollmann, 2006, Engel 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

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.

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

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.[25]

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 between the two countries. To see the intuition, we turn to the partial equilibrium expressions for α_1 and α_2:

$$\alpha_1 = z_1 - \frac{\theta}{r}\Psi_{d|\hat{r}^b_{xt}} - \frac{\theta}{r}\Psi_{l|\hat{r}^b_{xt}} + \left[f^e\Psi + \alpha^b\Psi\right] \tag{28}$$

$$\alpha_2 = f^e - \alpha = \frac{\theta}{r}\Psi_{d|\hat{r}^b_{xt}} + \frac{\theta}{r}\Psi_{l|\hat{r}^b_{xt}} + \left[f^e\left(1-\Psi\right) - \alpha^b\Psi\right] \tag{29}$$

in which we break down f of Eq.(26) into $f^e + \alpha^b$ to obtain α_1.[26] The hedging term $f^e\Psi$ then works the same way as $f\Psi$ of Eq.(12) in generating bias gap. Besides, a positive α^b (negative α^{b*}) shifts the home (foreign) wealth from the foreign asset to the home asset and therefore always enhances (dampens) the home bias in the home (foreign) country. 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 country 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) versus 0.15 (0.18) in ΔEHB (ΔEHB2) respectively, which suggests the role of many other types

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

[26] $\alpha_2 = f^e - \alpha$ 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.

of heterogeneity within the DEV & ADV countries in driving their bias gap than those underlying the NFA imbalances between them. As a result, the model explains the gap between the Debtor & Creditor countries relatively better than that between the DEV & ADV countries 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 countries 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, it is obvious that the endowment model of Section 3.4 and the baseline equity-only model of Section 2 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 $\rho = 1$. In contrast, 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 asymmetric 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 in the model. By including α^b, the extended model features an additional channel of two-way capital flows in pushing up the bias gap (Eqs.(28)-(29)),[27] 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 country or that of the debtor country. 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 country - 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 country (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 $\alpha[4]$,

[27] 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 (EHBs being greater than 1), 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 country 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

	Model results	
Variable	(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

partially counteracts the terms-of-trade effect. Once more, a less powerful terms-of-trade effect makes portfolio hedging 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.[28] Net capital flows in, $f < 0$. Note that, as opposed to the case of δ-asymmetry, now the NFA imbalances are fully caused by relative asset demand (saving). 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 Eqs.(24)-(25), from which the slackness created by the δ-asymmetry to the condition collapses. Will this undermine the model's ability to explain 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. To sum up, as long as the condition for the emergence of an asymmetric home bias holds, the additional slackness for the condition is also irrelevant from the quantitative point of view.

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

[28] See Buiter (1981), Chen (2013), Galor and Özak (2016), Falk et al. (2018) among others.

that prior to 1989 from Dhareshwar and Nehru (1993) and then use the perpetual inventory method (PIM) to compute their values in our sample period. 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 construct (2). The final sample consists of 62 countries, see Appendix H, and spans $1990 - 2015$.[29]

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

$$EHB_i = \alpha + \beta \cdot (NFA/GDP)_i + x_i'\gamma + \varepsilon_i \tag{30}$$

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 -0.22. 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

[29] 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	-0.219***	-0.224***	-0.116**	-0.243***	-0.131**	-0.134***
	(0.051)	(0.040)	(0.051)	(0.044)	(0.051)	(0.048)
Trade openness		-0.002**				-0.002*
		(0.001)				(0.001)
Log GDP per capita			-0.047***			-0.043***
			(0.006)			(0.007)
Log population				0.025***		0.005
				(0.009)		(0.009)
DEV group dummy					0.150***	
					(0.024)	
Observations	62	62	62	62	62	62
Adjusted R-squared	0.336	0.409	0.591	0.401	0.599	0.621

Table 6: Cross-countries: EHB Notes: 62 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) $(f^{*}-f)/2$	0.253**	0.265**	0.362***	0.374***
	(0.094)	(0.103)	(0.111)	(0.108)
(Change in) ΔTrade openness	-0.004*	-0.004*	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)
(Change in) ΔLog GDP per capita	-0.001	-0.010	-0.063***	-0.072***
	(0.010)	(0.011)	(0.016)	(0.018)
(Change in) ΔLog population	0.011	0.007	-0.040**	-0.046**
	(0.019)	(0.020)	(0.016)	(0.018)
Observations	26	26	25	25
Adjusted R-squared	0.451	0.512	0.503	0.561

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.

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 an 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 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.[30] 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 0.134. 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 $74 \times 0.134 \approx 10$ 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

[30]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.

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, 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.[31]

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 $\bar{f}_t = \left(f_t^* - f_t\right)/2 > 0$. 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 $37 \times 0.253 \approx 9.4$ points. With the first

[31] 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., 2020.

differenced data, the growth of (change in) ΔEHB is even stronger. Due to the same amount of (change in) $\bar{f}_t$, the (change in) ΔEHB amounts to $37 \times 0.362 \approx 13.4$ points.

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.

We first estimate the key covariance-variance ratio Ψ_f. To simplify the task, following the literature, we show that the period-by-period household budget constraint of the model, Eqs.(2)-(3), can be replaced by a "static" constraint.[32] When a first-order approximation of the "static" constraint holds at all t, then a first-order approximation of the period-by-period household budget constraint holds likewise. It is therefore sufficient to consider the "static" constraint when solving for portfolios. In Appendix G, we show that the previous portfolio condition, $E_{t-1}\left[\hat{c}_t^D \Pi_{rx}\right] = 0$, together with these "static" constraints yield the equity holding, α, in which the covariances that define the asset's hedging properties are related to contemporaneous incomes instead of unobserved returns.[33]

In particular, we express the resulting $\hat{c}_t^D$ as a function of α, net foreign bonds α^b, and NFA, i.e. $\left[\frac{r\alpha}{\theta}\Delta d_t + \frac{r\alpha^b}{\theta}\left(-\hat{d}_t^*\right) + \frac{rf}{\theta}\left(\hat{d}_t^* - \hat{s}_t\right)\right]$ (Eq.(**??**) of Appendix G). Conditional on α^b's (relative) return, we express α as a partial equilibrium where the key hedging of our interest, i.e. previously $\alpha[3] = -f\Psi_{f|\hat{r}_{xt}^b} = -f\frac{cov_{\hat{r}_{xt}^b}\left(\Sigma_{2t}^{rn}, \hat{r}_{xt}\right)}{var_{\hat{r}_{xt}^b}\left(\hat{r}_{xt}\right)}$ as in Eq.(26), now takes the form of $-f\frac{cov_{\hat{d}_t^*}\left(\hat{d}_t^* - s_t, \Delta d_t\right)}{var_{\hat{d}_t^*}\left(\Delta d_t\right)}$.[34] Below, we refer to this as model 1. In this case, $\alpha[3]$ is a (negative) interaction term between NFA and Ψ_f that is conditional on the relative bond return (to that of the numeraire asset).

Alternatively, one can express $\hat{c}_t^D$ as a function of α, α^b, and net foreign equities $f^e \equiv$

[32] See Coeurdacier et al.'s (2010) online Appendix A.1. We follow them to show this for our model of asymmetric countries in Appendix G. The "static" budget constraints in the home and foreign countries can be found to be Eqs.(**??**) and (**??**) of the Appendix, respectively.

[33] Coeurdacier et al. (2010), Coeurdacier and Rey (2012), Heathcote and Perri (2013), Mukherjee (2015), among others follow this approach. Baxter and Jermann (1997), Coeurdacier and Gourinchas (2016), however, take up a more complicated task of estimating the unobserved returns (to human and non-human capitals) first and then the relevant covariances.

[34] Contemporaneous (relative) incomes, $\hat{d}_t$, $\hat{d}_t^* - s_t$, $\Delta d_t \equiv \hat{d}_t - \hat{d}_t^* + \hat{s}_t$, $-\hat{s}_t$, $-\hat{d}_t^*$, now replace the roles that have previously been played by the following (relative) returns, respectively, Σ_{1t}^{rn}, Σ_{2t}^{rn}, $\hat{r}_{xt} = \Sigma_{1t}^{rn} - \Sigma_{2t}^{rn}$, $\Sigma_{bt}^{rn} = \hat{r}_t^b + \frac{\tilde{n}}{r}\Sigma_{t+1}^{rn}$, $\hat{r}_{xt}^b = \Sigma_{bt}^{rn} - \Sigma_{2t}^{rn}$.

$f-\alpha^b$, i.e. $\left[\frac{r\alpha}{\theta}\Delta d_t+\frac{r\alpha^b}{\theta}\left(-\hat{s}_t\right)+\frac{rf^e}{\theta}\left(\hat{d}_t^*-\hat{s}_t\right)\right]$ (Eq.(**??**) of Appendix G). Conditional on α^b's return, $\alpha[3]$ takes the form of $-f^e\frac{cov_{\hat{s}_t}\left(\hat{d}_t^*-s_t,\Delta d_t\right)}{var_{\hat{s}_t}(\Delta d_t)}$. We refer to this as model 2. In this case, $\alpha[3]$ is a (negative) interaction term between net foreign equities f^e and Ψ_f that is conditional on the bond return, i.e. the real exchange rate $\hat{s}_t$. The existing symmetric models highlight the equity positions as the hedging of remaining risks after the bond positions taking care of real exchange rate risks, and therefore mainly rely on this specification. We present the results of model 2 in addition to model 1 to facilitate the comparison.

To estimate Ψ_f, we use the WBDI data for all countries of our sample from 1990-2015. The GDP data are PPP adjusted and correspond exactly to the real quantities of the model that are measured in a common currency, e.g $\hat{d}_t$ and $\hat{d}_t^*-\hat{s}_t$. Following the literature, we measure dividends as aggregate capital income less aggregated investment, where capital income is a constant fraction 0.36 of GDP, consistent with the model. Some countries are excluded because the constructed dividends are negative in some years.[35] For each country, we construct a measure of foreign dividends by taking a weighted average of log dividends of all the other countries in the sample, where weights are given by relative shares in the world GDP net of the home one. Next, the resulting series are linearly detrended (LD), or first differenced (FD), or HP-filtered (HP, smoothing parameter 6.25 based on Ravn and Uhlig, 2002) to cross-check. Finally, for model 1, we first regress log foreign dividends and relative log dividends on (contemporaneous) relative bond return, i.e. $-\hat{d}_t^*$ that is in the other currency than the aforementioned common currency (international US dollar in the WBDI data),[36] and then compute the covariances-variances ratio Ψ_f using the residuals. For model 2, we first regress log foreign dividends and relative log dividends on (contemporaneous) bond return, i.e. real exchange rate $\hat{s}_t$, and then compute the Ψ_f using the residuals.

We store the estimated Ψ_f for all countries to Appendix H. Figures 6 and 7 display those 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,

[35] See e.g. Mukherjee (2015) for the same procedure. The final sample of 52 countries can be found in Appendix H. The negative correlation between home bias and NFA position as seen in the benchmark sample of countries remains in the smaller sample, as will be shown in Table 10 below.

[36] The conversion is undertaken using the real exchange rates of the same source, i.e. those used to construct the PPP-adjusted GDP in the first place.

not far from -0.5.[37] 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 $\bar{\lambda} = \bar{\alpha}_1 / \bar{w}^e$ 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.(12) and (14), 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 cor-

[37]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.

	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.

related with the estimated λ deviation $\lambda_i(\Psi_f) - \bar{\lambda}$. Figure 8 depicts these two measures.[38] 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 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

[38] 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.

		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

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 the data. 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.(30) for the smaller sample.[39] 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 model-generated 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 data.

[39]Recall when evaluating hedging mechanisms, some countries were lost due to a negative constructed dividend in these countries. 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.

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. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

6 Conclusion

The international NFA imbalances and the heterogeneous portfolio diversification of countries can be causally correlated. By extending a standard international macro model with both net and gross country portfolios, we show that: under global NFA imbalances, agents have a motive to hedge against the unbalanced net external wealth, which involves a short (long) position of both home and foreign assets in the debtor (creditor) country. Given that the otherwise symmetric portfolio allocation is home-biased, this means that the debtor (creditor) country loses (gains) a more diversified portfolio. The resulting portfolio allocation therefore features a cross-country heterogeneity: the debtor (developing) countries generally hold domestic assets more intensively than the creditor (advanced) countries, in line with the data.

The models of country portfolios that are based on hedging motives have been quite successful in accounting for the general "lack" of portfolio diversification in the international financial market (Coeurdacier and Rey, 2013). Our results show that the potentially important country heterogeneity in leading to global imbalances could also have caused the internationally distribution of such diversification among different groups of countries (Gourinchas and Rey, 2014).

Our extended model also yields a positive net bond position together with a negative net equity position of the debtor country, 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 different hedging property of distinct 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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VARIABLES	(1) EHB2	(2) EHB2	(3) EHB2	(4) EHB2	(5) EHB2	(6) EHB2
NFA/GDP	-0.248***	-0.252***	-0.133***	-0.263***	-0.148***	-0.131***
	(0.043)	(0.035)	(0.042)	(0.040)	(0.042)	(0.048)
Trade openness		-0.002*				-0.001
		(0.001)				(0.001)
Log GDP per capita			-0.053***			-0.052***
			(0.007)			(0.009)
Log population				0.015		-0.006
				(0.011)		(0.010)
DEV group dummy					0.170***	
					(0.026)	
Constant	0.822***	0.878***	1.317***	0.554***	0.740***	1.458***
	(0.023)	(0.037)	(0.059)	(0.193)	(0.027)	(0.234)
Observations	62	62	62	62	62	62
Adjusted R-squared	0.374	0.402	0.652	0.388	0.668	0.654

Table 11: Cross-countries: EHB2 Notes: 62 countries and data sources are in Appendix H. Variables are time average of each country during 1990-2015. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

VARIABLES	(1) EHB_1	(2) EHB_2	(3) EHB_3	(4) EHB_4
NFA/GDP_1	-0.081**			
	(0.031)			
Trade openness_1	-0.001*			
	(0.001)			
Log GDP per capita_1	-0.023***			
	(0.005)			
Log population_1	-0.000			
	(0.005)			
NFA/GDP_2		-0.131***		
		(0.049)		
Trade openness_2		-0.001		
		(0.001)		
Log GDP per capita_2		-0.047***		
		(0.008)		
Log population_2		0.007		
		(0.009)		
NFA/GDP_3			-0.121***	
			(0.037)	
Trade openness_3			-0.002**	
			(0.001)	
Log GDP per capita_3			-0.031***	
			(0.005)	
Log population_3			0.001	
			(0.006)	
NFA/GDP_4				-0.145***
				(0.052)
Trade openness_4				-0.002*
				(0.001)
Log GDP per capita_4				-0.051***
				(0.008)
Log population_4				0.006
				(0.010)
Obs.	62	62	62	62
Adj. R^2	0.573	0.604	0.637	0.628

Table 12: Cross-countries: different sample periods EHB Notes: 4 sample periods are reported. The period 1 is 1980-2007 (Mukherjee, 2015); period 2 is 1995-2011 (Steinberg, 2018); period 3 is 1980-2015; period 4 is 1995-2015. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

VARIABLES	(1) EHB2_1	(2) EHB2_2	(3) EHB2_3	(4) EHB2_4
NFA/GDP_1	-0.077**			
	(0.032)			
Trade openness_1	-0.001			
	(0.001)			
Log GDP per capita_1	-0.034***			
	(0.007)			
Log population_1	-0.011			
	(0.007)			
NFA/GDP_2		-0.130***		
		(0.047)		
Trade openness_2		-0.001		
		(0.001)		
Log GDP per capita_2		-0.056***		
		(0.009)		
Log population_2		-0.004		
		(0.010)		
NFA/GDP_3			-0.117***	
			(0.038)	
Trade openness_3			-0.001	
			(0.001)	
Log GDP per capita_3			-0.042***	
			(0.007)	
Log population_3			-0.010	
			(0.008)	
NFA/GDP_4				-0.143***
				(0.051)
Trade openness_4				-0.001
				(0.001)
Log GDP per capita_4				-0.060***
				(0.009)
Log population_4				-0.005
				(0.011)
Obs.	62	62	62	62
Adj. R^2	0.618	0.642	0.666	0.658

Table 13: Cross-countries: different sample periods EHB2 Notes: 4 sample periods are reported. The period 1 is 1980-2007 (Mukherjee, 2015); period 2 is 1995-2011 (Steinberg, 2018); period 3 is 1980-2015; period 4 is 1995-2015. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Country Name	Linearly detrended		First differenced		HP-filtered	
	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$
Australia	-0.36*	-0.28*	-0.18*	-0.34***	-0.11**	-0.31**
	-0.2	-0.16	-0.09	-0.1	-0.05	-0.13
Austria	-0.65***	-0.57***	-0.45***	-0.66***	-0.30***	-0.75***
	-0.07	-0.09	-0.08	-0.14	-0.09	-0.12
Bangladesh	-0.67***	-0.63***	-0.79***	-0.85***	-0.70***	-0.94***
	-0.06	-0.1	-0.09	-0.07	-0.2	-0.09
Belgium	-1.05***	-0.79***	-0.37	-0.78***	-0.08	-0.86***
	-0.16	-0.12	-0.23	-0.16	-0.16	-0.15
Bolivia	-0.36***	-0.26**	-0.12	-0.32***	-0.02	-0.33**
	-0.11	-0.11	-0.08	-0.11	-0.1	-0.14
Brazil	-0.53***	-0.54***	-0.50***	-0.51***	-0.67***	-0.66***
	-0.16	-0.16	-0.15	-0.15	-0.14	-0.12
Cameroon	-0.23***	-0.41***	-0.15*	-0.39***	-0.09	-0.41***
	-0.08	-0.06	-0.08	-0.1	-0.07	-0.11
Canada	-0.81***	-0.68***	-0.55***	-0.78***	-0.31**	-0.84***
	-0.24	-0.21	-0.16	-0.15	-0.14	-0.18
Chile	-0.16***	-0.09	-0.06	-0.19**	-0.05	-0.19
	-0.05	-0.14	-0.04	-0.07	-0.04	-0.12
Colombia	-0.34***	-0.42***	-0.24***	-0.38***	-0.22**	-0.41***
	-0.07	-0.1	-0.06	-0.13	-0.09	-0.13
Costa Rica	-0.48***	-0.65***	-0.32***	-0.39***	-0.33***	-0.39*
	-0.14	-0.14	-0.08	-0.14	-0.1	-0.19
Denmark	-0.73***	-0.59***	-0.40*	-0.70***	-0.02	-0.69**
	-0.15	-0.14	-0.21	-0.2	-0.11	-0.28
Dominican Republic	-0.13	-0.01	-0.14	-0.07	-0.15	-0.03
	-0.11	-0.07	-0.09	-0.09	-0.12	-0.1
Ecuador	-0.58***	-0.43***	-0.53***	-0.55***	-0.52***	-0.59***
	-0.11	-0.09	-0.11	-0.11	-0.08	-0.1
Egypt, Arab Rep.	0.01	0.01	-0.06	-0.12	-0.05	-0.08
	-0.14	-0.14	-0.08	-0.12	-0.08	-0.14

Table 14: Loadings on NFA returns: part (1)

Country Name	Linearly detrended		First differenced		HP-filtered	
	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$
El Salvador	-0.65***	-0.74***	-0.35***	-0.57***	-0.22*	-0.51**
	-0.05	-0.12	-0.11	-0.18	-0.11	-0.21
Finland	0.52**	-0.46*	0.28**	-0.47**	0.03	-0.44
	-0.19	-0.23	-0.13	-0.22	-0.08	-0.26
France	-2.02***	-1.22***	-0.99***	-1.04***	-0.59**	-1.10***
	-0.19	-0.08	-0.24	-0.13	-0.23	-0.08
Germany	-0.71***	-0.62***	-0.65***	-0.85***	-0.35*	-0.87***
	-0.14	-0.1	-0.13	-0.1	-0.19	-0.1
Ghana	-0.15***	-0.11***	-0.07	-0.07	-0.08	-0.07
	-0.03	-0.03	-0.05	-0.06	-0.05	-0.05
Greece	-0.01	-0.45***	0.01	-0.16**	0.03	-0.12
	-0.14	-0.09	-0.08	-0.07	-0.05	-0.12
Guatemala	-0.19*	-0.42***	-0.29***	-0.53***	-0.28***	-0.55***
	-0.1	-0.06	-0.07	-0.11	-0.1	-0.16
India	0	0.01	0	0	0	0.01**
	-0.01	-0.01	-0.01	-0.01	0	-0.01
Indonesia	0.01	0.06	-0.10*	-0.11	-0.17***	-0.20*
	-0.09	-0.06	-0.05	-0.07	-0.06	-0.11
Iran, Islamic Rep.	-0.01	-0.05*	-0.01	0	-0.01	0
	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01
Israel	-0.39***	-0.71***	-0.13	-0.4	-0.08	-0.48*
	-0.06	-0.15	-0.11	-0.24	-0.12	-0.26
Italy	-1.60***	-0.98***	-0.92***	-0.90***	-0.65***	-0.92***
	-0.2	-0.06	-0.15	-0.07	-0.21	-0.06
Jamaica	-0.07*	-0.13*	-0.03	-0.09	0	-0.06
	-0.04	-0.07	-0.05	-0.08	-0.03	-0.06
Japan	0.26***	-0.23	0.18**	-0.33*	0.05	-0.26
	-0.09	-0.14	-0.08	-0.18	-0.09	-0.24
Jordan	-0.03	0	-0.05*	-0.05	-0.05***	-0.09**
	-0.04	-0.03	-0.03	-0.03	-0.01	-0.04

Table 15: Loadings on NFA returns: part (2)

Country Name	Linearly detrended		First differenced		HP-filtered	
	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$
Kenya	-0.51***	-0.79***	-0.34***	-0.43**	-0.35***	-0.39*
	-0.06	-0.15	-0.05	-0.17	-0.05	-0.22
Malawi	0	0	-0.06**	-0.05*	-0.09**	-0.08**
	-0.07	-0.06	-0.03	-0.03	-0.03	-0.04
Mali	-0.35***	-0.34**	-0.22**	-0.28**	-0.19**	-0.28**
	-0.09	-0.13	-0.08	-0.1	-0.08	-0.13
Mexico	-0.64***	-0.77***	-0.43***	-0.55***	-0.41***	-0.50***
	-0.09	-0.11	-0.07	-0.15	-0.11	-0.16
Morocco	0.11***	0.09***	0.02	0	0.03***	0.02
	-0.03	-0.03	-0.02	-0.06	-0.01	-0.03
New Zealand	-0.54***	-0.43***	-0.37***	-0.50***	-0.18**	-0.51**
	-0.08	-0.1	-0.12	-0.15	-0.08	-0.19
Norway	-0.19*	-0.15	-0.06	-0.20*	0.04	-0.21
	-0.1	-0.12	-0.07	-0.1	-0.05	-0.13
Pakistan	-0.85***	-0.84***	-0.56***	-0.67***	-0.48***	-0.69***
	-0.07	-0.16	-0.07	-0.1	-0.09	-0.13
Peru	-0.20*	-0.27**	-0.38***	-0.41***	-0.49***	-0.51***
	-0.11	-0.12	-0.08	-0.1	-0.14	-0.17
Philippines	-0.48***	-0.60***	-0.30***	-0.45***	-0.28***	-0.47***
	-0.05	-0.07	-0.06	-0.11	-0.03	-0.12
Portugal	-0.19***	-0.33***	-0.04	-0.47***	0.03	-0.49***
	-0.06	-0.06	-0.11	-0.13	-0.06	-0.17
Senegal	-0.31***	-0.31***	-0.13	-0.23***	-0.08	-0.23*
	-0.1	-0.07	-0.08	-0.06	-0.07	-0.12
South Africa	-0.45**	-0.45	-0.13	-0.52***	-0.03	-0.46*
	-0.2	-0.32	-0.1	-0.15	-0.07	-0.24
Spain	0.02	-0.11	0.05	-0.09	0.02	0.08
	-0.06	-0.06	-0.04	-0.18	-0.03	-0.14
Sri Lanka	-0.23**	-0.1	-0.12**	-0.15*	-0.04	-0.08
	-0.09	-0.09	-0.05	-0.08	-0.03	-0.07

Table 16: Loadings on NFA returns: part (3)

Country Name	Linearly detrended		First differenced		HP-filtered	
	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$	$\Psi_{f\|\hat{r}^b_{xt}}$	$\Psi_{f\|\hat{r}^b_t}$
Sweden	0.59***	-0.50*	0.18	-0.44*	-0.08	-0.51
	-0.13	-0.25	-0.14	-0.25	-0.08	-0.34
Switzerland	0.2	-0.43***	0.1	-0.43*	-0.09	-0.47*
	-0.26	-0.15	-0.18	-0.23	-0.06	-0.25
Tunisia	-0.38***	-0.35***	-0.22***	-0.36***	-0.11*	-0.32***
	-0.1	-0.11	-0.06	-0.09	-0.06	-0.09
Turkey	-0.20**	-0.19**	-0.17	-0.16	-0.14*	-0.09
	-0.08	-0.08	-0.1	-0.13	-0.08	-0.1
United Kingdom	-0.93***	-0.68***	-0.58**	-0.78***	-0.56***	-0.93***
	-0.17	-0.11	-0.24	-0.16	-0.16	-0.15
United States	-0.78***	-0.75***	-0.78***	-0.89***	-0.41**	-0.95***
	-0.07	-0.12	-0.1	-0.05	-0.17	-0.14
Uruguay	-0.46*	-0.63**	-0.43***	-0.57***	-0.35*	-0.62***
	-0.25	-0.27	-0.15	-0.16	-0.17	-0.2

Table 17: Loadings on NFA returns: part (4) Notes: Estimating the covariance-variance ratio of hedging NFA return for 52 countries. Data are linearly detrended, or first differenced, or HP-filtered. HP-filter smoothing parameter is 6.25 (Ravn and Uhlig, 2002). Sample period is 1990-2015. Data sources are in Appendix H. Constants are not reported. Robust standard errors are below the estimates. *** p<0.01, ** p<0.05, * p<0.1.

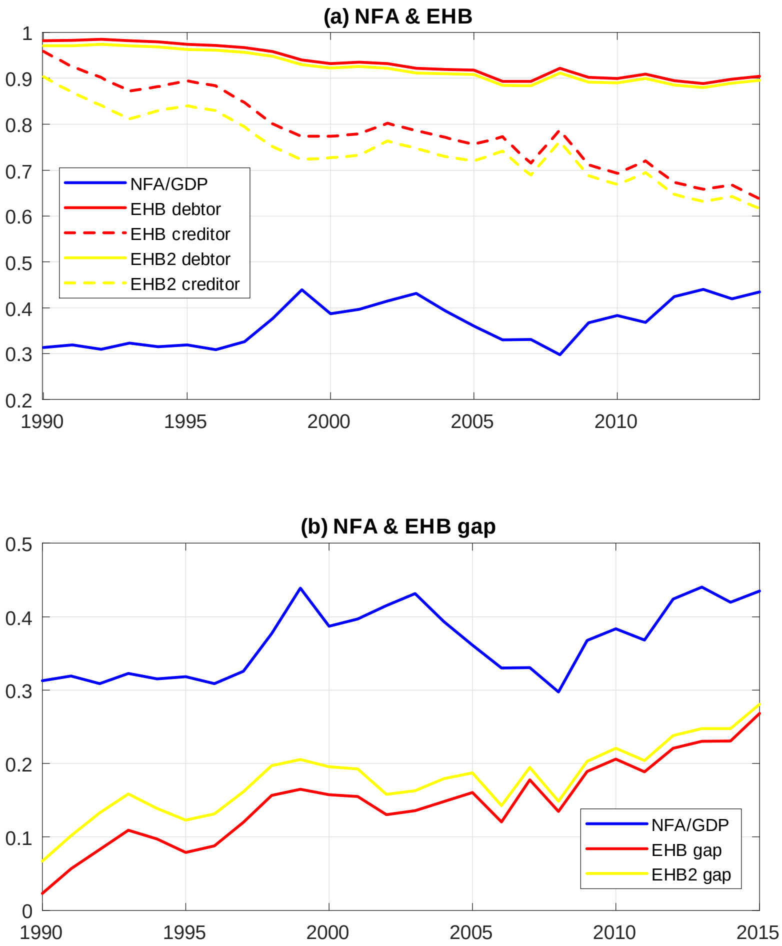

Figure 1: Panel (a) "EHB debtor" is "average equity home bias (EHB) of net debtor countries", "EHB creditor" is "average EHB of net creditor countries", NFA/GDP is "(average NFA/GDP ratio of creditor countries - average NFA/GDP ratio of debtor countries)/2", series are over 1990-2015. To compute the 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.

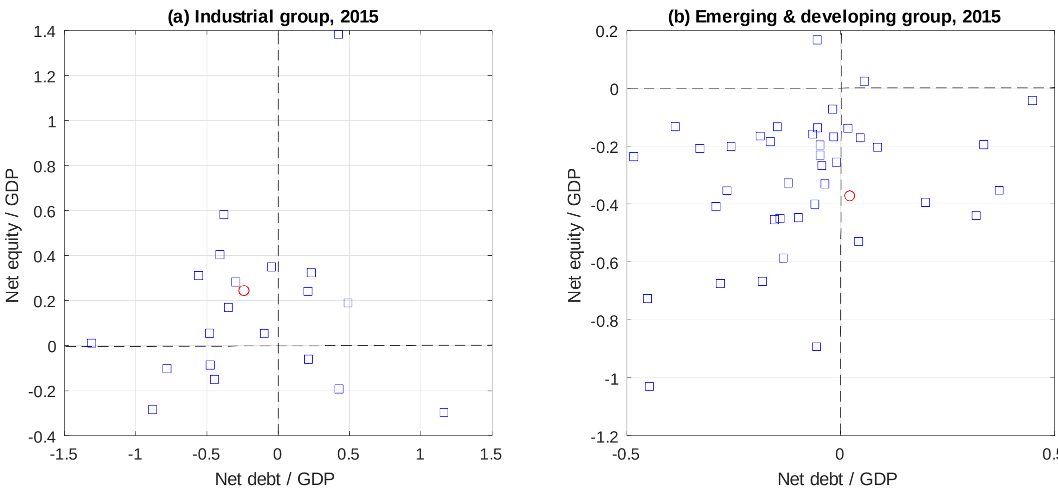

Figure 2: Net equity position versus net debt position: industrial countries on panel (a) v.s. emerging markets and developing countries on panel (b), 2015. Each blue square represents a country. In each group, the red circle represents the country with the median NFA/GDP ratio of the group. The median 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.

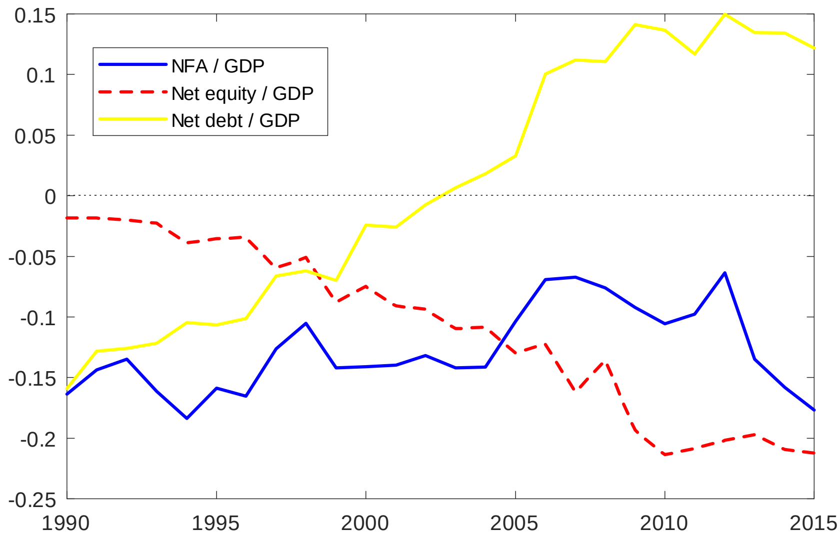

Figure 3: Capital flows between the industrial and emerging & developing groups, 1990-2015. NFA/GDP = "(median NFA/GDP ratio of emerging & developing countries - median NFA/GDP ratio of industrial countries)/2". Net equity/GDP and Net debt/GDP are defined analogously. Data source: Lane and Milesi Ferretti's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

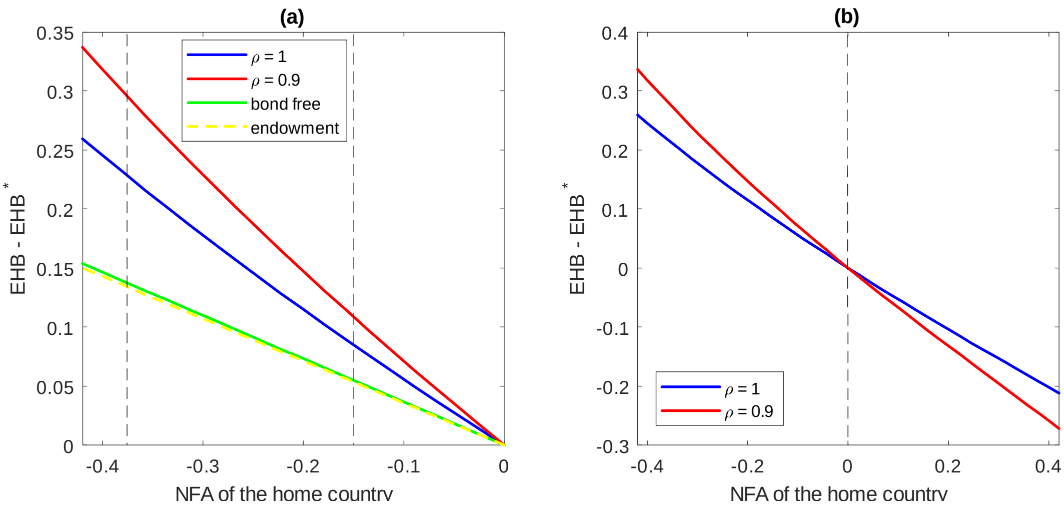

Figure 4: Model calibration: EHB gap v.s. NFA of the home country (a) alternative specifications: extended model for $\rho = 1$ (benchmark) and $\rho = 0.9$, baseline bond-free model of section 2, and endowment model of section 3. (b) switching the status of the home (foreign) country from net debtor (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.

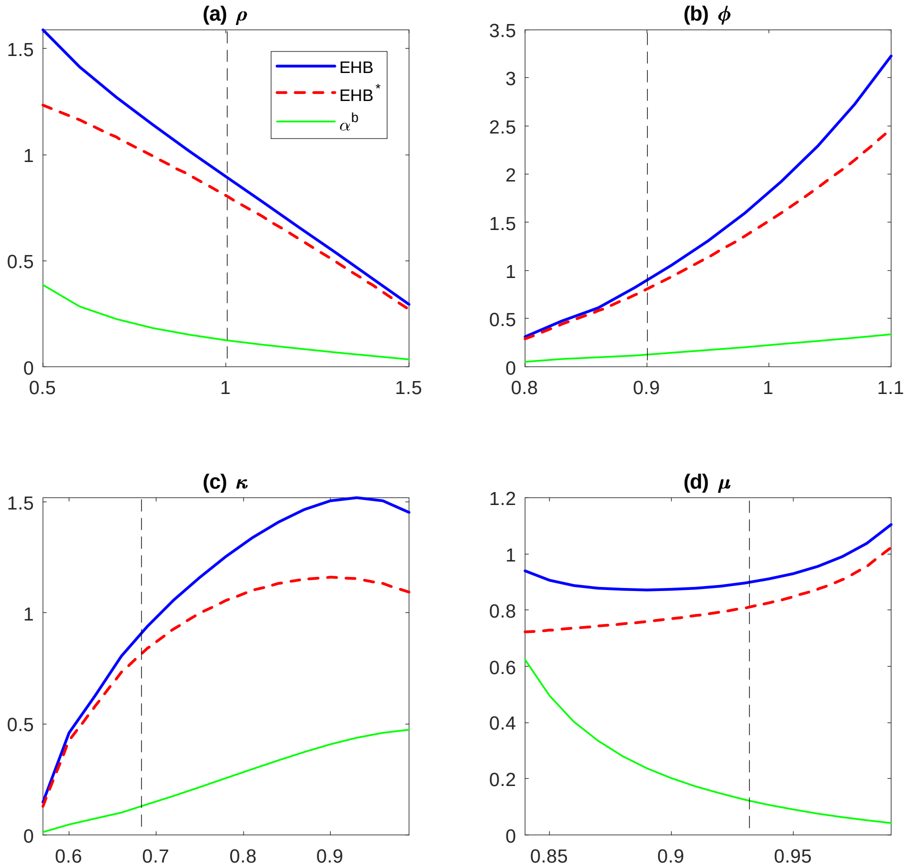

Figure 5: Robustness checks: parameterization (a) elasticity of intertemporal substitution, ρ; (b) elasticity of substitution between tradable goods, ϕ; (c) degree of goods home bias, κ; (d) persistence of shocks, μ. The vertical dashed black line in each panel depicts the value of corresponding parameter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

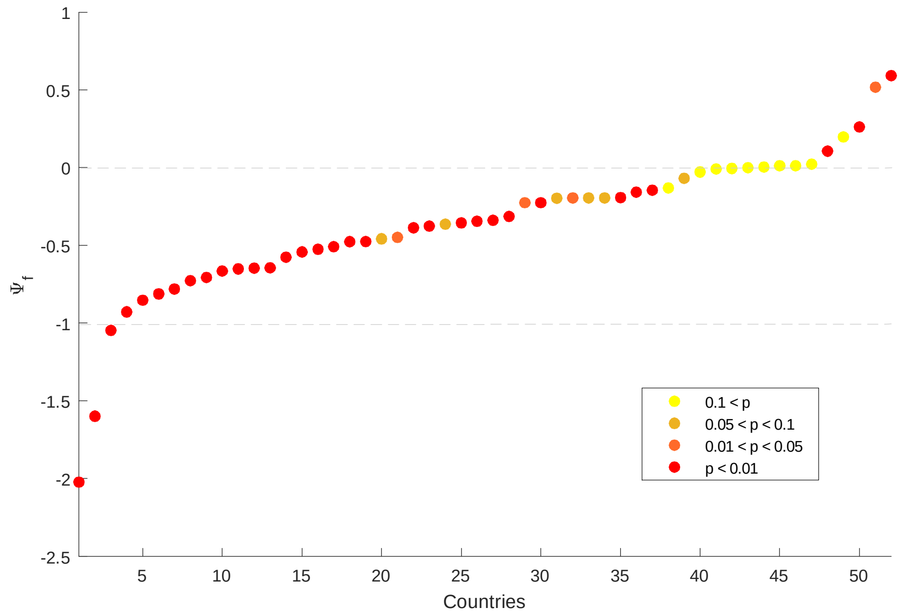

Figure 6: Estimate of Ψ_f that is conditional on relative bond return $\hat{r}^b_{xt}$ (y-axis) for each country (x-axis). Linearly detrended data.

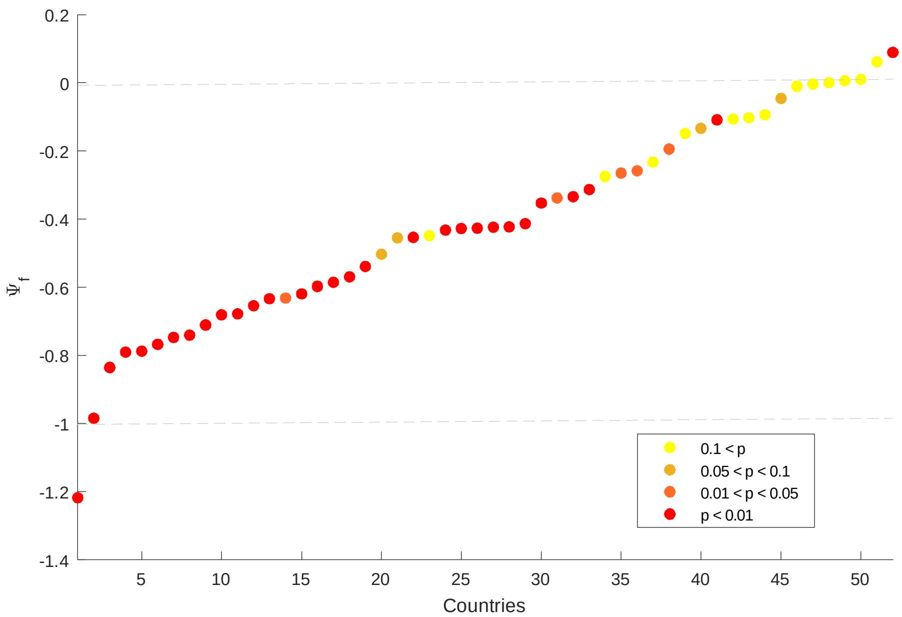

Figure 7: Estimate of Ψ_f that is conditional on bond return $\hat{r}^b_t$ (y-axis) for each country (x-axis). Linearly detrended data.

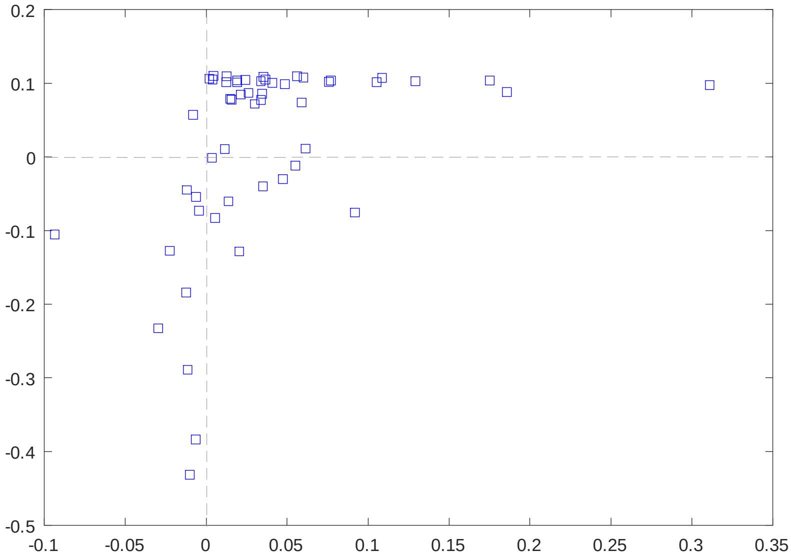

Figure 8: The actual lambda deviation $\left[\lambda_i - \bar{\lambda}\right]$ (y-axis) against the estimated lambda deviation $\left[\lambda_i\left(\Psi_f\right) - \bar{\lambda}\right]$ (x-axis) for each country i. Notes: The linearly detrended data and the model 2 are used in this figure.