The home bias of the poor: terms of trade effects and portfolios across the wealth distribution

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February 2013

Abstract

This paper documents how poorer and less educated US households hold a smaller fraction of foreign assets in their financial portfolio. This average home bias of the poor is partly due to a lower probability of participating in foreign asset markets, often attributed to fixed costs of market entry. However, portfolio shares also rise with wealth among those households that do hold foreign assets, which fixed participation costs cannot explain. I use a simple, standard two-country general equilibrium model to show that hedging of terms of trade movements and non-financial income risk, commonly employed to explain aggregate country-level home bias, also produces non-trivial heterogeneity in portfolios across wealth levels within countries that is in line with the evidence.

JEL Classification Codes: F36, G11, E21, D11, D31

Keywords: Heterogeneous Agents, Home Bias, Terms of Trade, Inequality, International Asset Diversification, Portfolio Choice

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1 Introduction

It is well-documented that household portfolios become more diversified as wealth increases. Campbell (2006) and Guiso et al. (2003), for example, show that poor households are less likely to invest in risky assets. Also, many authors have found that aggregate country-portfolios have surprisingly low shares of foreign assets, the so-called "home bias in portfolios puzzle" (see Lewis (1999), and Coeurdacier and Rey (2011), for a summary of this literature). Less attention, however, has been devoted to the composition of individual household portfolios between domestic and foreign assets, and its relationship with individual wealth, partly because of the difficulty to account for indirect holdings of foreign assets via mutual funds.[1]

In the empirical part of this paper, I combine data from the US survey of consumer finances (SCF) with information about the portfolio composition of more than 4700 US mutual funds to derive a measure of total foreign asset holdings by US households. Similar to previous studies, I find that wealthier and more educated households are more likely to participate in foreign asset markets. However, the evidence also shows that the portfolio share of foreign assets increases with wealth even for participants. This finding is important, as it cannot be accounted for by fixed costs of participation in sophisticated asset markets, which is one of the most common explanations of investor bias towards safe and home assets.[2]

The theoretical part of the paper then takes a first step to deriving the implications of standard international macroeconomic theory for portfolio heterogeneity across households with different wealth levels. I use a simple, standard two country model of international trade (Cole and Obstfeld, 1991) to show that the aim of hedging fluctuations in the terms of trade and in non-financial incomes, a key element of many recent studies of aggregate home bias in country portfolios, also implies significant variation of portfolios across wealth levels within countries. Particularly, even without fixed costs of investing in foreign assets, agents with lower financial wealth optimally have a higher portfolio share of assets that hedge against fluctuations in their future non-financial income. When returns to domestic capital and labour are positively correlated, this naturally leads to a bias

[1] Christelis and Georgarakos (2008) consider survey of consumer finances (SCF) data on direct holdings of foreign assets only, while Karlsson and Nordén (2007) focus on indirect holdings of foreign assets by Swedish Individuals via pension funds. Hau and Rey (2008a) and Hau and Rey (2008b) look directly at mutual fund portfolios.

[2] See, for example, Christelis and Georgarakos (2008) for an application of this argument to home bias

against domestic equity. I show, however, that general equilibrium terms of trade movements can strongly decrease the attractiveness of foreign investments as a hedge against labour income risk. This is because, by making foreign goods and assets more expensive after an increase in domestic productivity, equilibrium movements in relative goods prices introduce positive comovement betwen domestic labour income and the returns to both foreign bonds and equity, which thus have strongly inferior hedging properties than in simpler models without terms of trade movements. I show how, in a particular model, this effect can be so strong as to bias portfolios of poorer investors towards home assets. Wealthy investors, whose future consumption is less dependent on labour income, care less about this hedging property than poor investors.
The intuition for these results has similarities to Baxter and Jermann (1997), who show that with income from non-marketable human capital the optimal portfolio of assets consists of two sub-portfolios, one completely diversified, the other designed to hedge against volatility of human capital returns. I show that the hedging portfolio can be dominated by safe domestic assets. And its importance relative to the diversified part of the portfolio declines as total wealth rises.
The complexity of the dynamic equilibrium - where optimal portfolios depend on future fluctuations in market-clearing goods prices, which in turn are a function of aggregate demand and thus of the distribution of portfolios across the wealth distribution - limits the analysis to a particularly stylised model of the international economy. The contribution of this paper can thus be viewed as two-fold. First, it establishes, in its empirical part, a new stylised fact that provides additional evidence against which we can test models. Second, in its theoretical section, it takes a first step to illustrating how standard international macroeconomic models with strong terms of trade movements have the potential to pass such a test by predicting variation of portfolios across the wealth distribution in line with the data.

This paper is related to three strands of the literature, namely research on household portfolio decisions, the "home bias" literature in international finance, and studies of heterogeneous agents models in macroeconomics. From studies of household finances, such as Campbell (2006) or Guiso et al. (2003), I take the stylised fact that wealthier individuals have riskier and more diversified portfolios. Using the 2004 wave of the survey of consumer finances, I show how a similar relationship also holds for investments in foreign assets. Importantly, relative to previous studies of individual foreign asset holdings in

SCF data, such as Christelis and Georgarakos (2008) or Kyrychenko and Shum (2009), I am the first to consider both direct and indirect holdings of foreign assets by combining SCF data on individual mutual fund investments with information on the portfolios of more than 4700 US mutual funds provided by Morningstar.[3] Moreover, in contrast to their studies, I estimate jointly the participation decision in the market for foreign assets and their share in the portfolios of participants. The results show how, even conditioning on participation in foreign asset markets, wealthier households have a higher portfolio share of foreign assets on average. This is important, as it suggests that the often-cited threshold effects linked to (pecuniary or non-pecuniary) fixed costs of entering sophisticated financial markets (stressed, for example, in Christelis and Georgarakos (2008) or Nechio (2010)) capture only part of the economic driving forces behind observed variation in financial portfolios of US households.

While previous studies of household investments in foreign assets are entirely empirical, the second part of this paper builds on the literature on "home bias" in country portfolios and proposes a simple stochastic general equilibrium model as a first step to understand the observed pattern of investments in foreign assets by US households. Particularly, a long sequence of studies (see Lewis (1999), and Coeurdacier and Rey (2011) for surveys) has shown that, in an open economy subject to stochastic variation in fundamentals, the resulting equilibrium comovement of asset returns and other sources of income can imply optimal portfolios that depart significantly from the naive benchmark of full diversification. For example, Baxter et al. (1998) show how non-separability of traded and non-tradable goods in preferences can lead home investors to optimally hold more or less than 100 percent of home non-traded sector equity and a diversified portfolio of traded sector equities. When, in addition, traded goods are imperfectly substitutable, a bias in consumption towards foreign traded goods can lead to home bias in traded sector equities (Collard et al., 2007). More generally, with imperfect substitution among tradeable consumption goods, Cole and Obstfeld (1991) point out the importance of equilibrium terms of trade movements by showing that, even in the absence of financial diversification, the fall (rise) in the relative price of domestic goods implied by a positive (negative) productivity shock at home can lead to perfect sharing of country-specific productivity risk. Important for this paper, non-tradable risks, for example due to volatile returns to human capital, introduce country-specific hedging terms in optimal portfolios (Baxter

[3]Nechio (2010) reports some descriptive evidence on indirect ownership of foreign stocks through investment funds from the Investment Company Institute.

and Jermann, 1997) that can lead to home or foreign bias depending on the covariance of returns to labour and capital (Bottazzi et al., 1996). On this issue, Heathcote and Perri (2007) show that in models with capital, the positive correlation of investment with productivity shocks introduces negative comovement of dividends and labour income, which may help explain the large observed portfolio share of domestic equities. While most of this literature focuses on investments in equity, Coeurdacier and Gourinchas (2011) have pointed out the importance of bonds for hedging real exchange rate movements, which can potentially explain the observed home bias in bond portfolios (Tesar and Werner (1995), Burger and Warnock (2007)) as well as a larger share of home equities than in portfolios without bonds.

This paper generalises a simple two-country workhorse model from this literature (Cole and Obstfeld, 1991) to include non-insurable idiosyncratic risk to individual incomes within countries. I show how the equilibrium comovement of bond and equity returns with the terms of trade and non-diversifiable labour market risk leads to important variation in portfolios across individuals. Specifically, the fall in the equilibrium terms of trade in response to a positive domestic productivity shock lowers the real returns of home assets, but increases that of foreign assets. The paper shows how this makes home bonds attractive investments for individuals with important labour income risk. But, crucially, the same terms of trade effect also eliminates the hedging disadvantage of home equity shares, whose local currency returns comove positively with labour income, relative to foreign equity shares, whose returns would be uncorrelated with domestic labour incomes in the absence of equilibrium movements in relative goods prices. The model can thus predict a pattern of portfolios across the wealth distribution that is in line with that observed in US micro-data. Importantly, the presence of wealth heterogeneity and uninsurable idiosyncratic risk within countries makes it impossible to use standard solution methods that rely either on perturbation of aggregate variables around their non-stochastic steady state values (Devereux and Sutherland, 2011) or perfect risk-sharing (Coeurdacier and Gourinchas, 2011). I therefore use a particular model structure that allows a solution of equilibrium movements in the terms of trade and the real exchange rate independently of individual heterogeneity. This enables me to derive, in a second step, analytical portfolio shares as a function of aggregate variables and deviations of individual variables from their agent-specific conditional expectations. The simplified structure allows me to identify the role of equilibrium terms of trade movements and non-diversifiable labour income risk for individual holdings of bonds and equity. However, the independence of the terms of trade

from individual heterogeneity comes at the price of abstracting from capital and assuming identical unit-elastic preferences across domestic and foreign goods. Thus, while this study points out that the economic mechanisms used to analyse "absolute" home bias in country portfolios might also help explain the "relative" home bias of the poor, it should not be viewed as an attempt at a final answer, but rather as a first step to more general models.
Finally, this study is one of the first to include uninsurable idiosyncratic income risk within the two countries of a new open-economy macro model with non-trivial terms of trade movements. I see this as a contribution to the small macroeconomic literature that generalises heterogeneous agents models to the open economy.[4]

Section II analyses portfolio shares of foreign assets across the wealth distribution in the 2004 wave of the SCF. Section III presents a simple two country two good economy, defines the competitive equilibrium and derives the equilibrium terms of trade movements. Section IV contains the results on optimal portfolios and how they vary across the wealth distribution.

2 Portfolios across the wealth distribution: evidence from the SCF

Wealthier and more educated people are more likely to invest in risky assets. This is well-documented for the US (see for example Campbell (2006) for a review and an illustration using 2001 SCF data) and a number of European countries (see Guiso et al. (2003), and Carroll (2002)). Figure 1 illustrates this stylised fact for the case of stock holdings by US households in the 2004 wave of the SCF, whose portfolio share (averaged within every decile of the financial wealth distribution to reduce noise) increases (nearly) monotonically with individual financial wealth.

[Figure 1 somewhere here.]

Equally, it is well-known that average country portfolios have surprisingly low shares of foreign assets - the "home bias in portfolios puzzle". This has been interpreted as a

[4]Other studies in this literature, such as Mendoza et al. (2009), or Broer (2012), usually abstract from aggregate shocks and real exchange rate movements.

consequence of a more general "local bias" of household portfolios, which overweigh local, regional, and national assets (see e.g. Campbell (2006)). But compared to the portfolio shares of risky assets in general, or of domestic equity more in particular, there is relatively little evidence on the home bias of individual households and its determinants.[5] Using SCF data, Christelis and Georgarakos (2008) and Kyrychenko and Shum (2009) find a positive effect of financial wealth, as well as other proxies of investor sophistication, for the likelihood to enter foreign asset markets. Similar to their studies, I document the determinants of foreign asset holdings of US households and their evolution across the wealth distribution using the US survey of consumer finances (SCF), which includes information on the US dollar value of households' holdings of "bonds issued by foreign governments or companies" and "stock in a company headquartered outside of the United States".[6] In contrast to their studies, however, I also include a measure of foreign assets held via mutual funds.[7] Particularly, I derive a measure of total foreign asset holdings for the 2004 SCF sample by summing to households' direct investments in foreign equity and bonds the reported value of their mutual fund shares in equity, bond and combination funds multiplied by the average portfolio weight of foreign bonds and equity in each type of fund.[8] Figure 2 plots the resulting foreign asset portfolio shares (averaged within

[5]For the case of Sweden, Calvet et al. (2007) conclude that international diversification possibilities exist, but are usually exploited only by wealthier individuals, who have a higher share of investments in mutual funds (with an average portfolio share of 25 percent for foreign assets). In contrast, Karlsson and Nordén (2007) find no evidence that individuals with higher net worth or income take different investment decisions in the Swedish defined contribution pension system, although they do find men, public employees, and less educated individuals to invest more in funds dominated by domestic assets.

[6]Question codes x7638 and x7641. An obvious problem of this measure is that it does not refer to non-dollar assets, but to assets issued by foreign issuers, in foreign currency and US dollars.

[7]In other words, I do not consider pension funds. One reason for this is that individuals' decisions on pension fund investments are taken under a very different set of constraints than other investment decisions. Also, most shares in pension funds are not actively managed as a part of regular portfolio decisions. However, both these arguments do not apply to individual mutual fund investments.

[8]To my knowledge, these average portfolio shares of mutual funds are not readily available from published sources. But Morningstar kindly provided data on portfolio shares of non-US assets for more than 4700 US mutual funds, not including funds of funds. From this I calculated weighted averages for portfolio shares of foreign bonds and equity for the three categories of funds for the year 2003. Since equity (bond) funds seem to often not report zero foreign bond (equity) holdings, I made an adjustment by setting missing observations to zero for all funds that reported portfolio shares summing to at least 99.5 percent. The resulting sample included around 2800 observations for shares of international equity and slightly less for bonds. Using this sample, the average US equity mutual fund invested 17.1 percent in foreign shares, while the average bond fund (disregarding funds of government / municipal bonds)

every decile of the financial wealth distribution) as a function of individual financial wealth.[9] The first fact to observe is that the share of foreign assets in the portfolio of US housholds is significantly smaller than that of stocks for all values of financial wealth. It is important to note, however, that the values in figure 2 are not directly comparable to the share of foreign assets in aggregate country portfolios.[10] Important for the question of this paper, figure 2 shows that the portfolio share of foreign assets, like that of stocks in figure 1, increases monotonically across deciles of the financial wealth distribution. Richer households thus seem to have lower home bias on average. To show that the pattern observed in figure 2 is not simply due to an increasing amount of mutual fund investments along the wealth distribution, figure 3 presents the corresponding picture for direct holdings of foreign bonds and equity. The portfolio shares are lower by about a factor four, and the monotonicity is broken for deciles 6 and 9. But the pattern is, overall, similar to that in figure 2.

[Figure 2 and 3 somewhere here.]

Because the limited time span of the data on mutual fund holdings, required to calculate indirect foreign asset holdings, figures 2 and 3 use only data from the 2004 wave of the SCF. Figure 4 and 5 provide evidence that the pattern found there, however, is robust across time periods. Particularly, figure 4 shows the time path of the portfolio share of foreign assets, averaged within quartiles of the SCF wealth distribution, between 1992 and 2007. Agents in the bottom quartile of the wealth distribution hold practically

invested 3.6 percent abroad. Combination funds invested on average 10.7 percent in non-US assets.

[9] Both the deciles and the averages take account of the fact that the SCF oversamples parts of the population, by applying the weights suggested by Kennickell (1999), and the multiple imputation procedure used for the SCF. This is because, to eliminate inconsistencies and missing values, the SCF imputes some values from the other information provided by a household. However, rather than simply reporting one best guess for the imputed values, the SCF provides 5 draws per observation from the distribution of the missing values conditional on observables.

[10] The latter are usually simply the ratio of a country's foreign equity holdings to its domestic market capitalisation. The measure in figure 2 differs from this as it includes bond holdings in the numerator, and use the SCF measure of gross financial wealth as the denominator of the ratio. The later includes a large range of non-equity assets such as insurance contracts, liquid retirement funds, and other assets (such as deposits) that net out across households in aggregate measures of net wealth. Moreover, the aggregate shares of foreign assets in the country portfolio cannot directly be read from the graph. The ratio of total foreign assets to total gross financial wealth in the implied weighted aggregate portfolio is 3 percent.

no foreign assets throughout the sample. Only the average portfolio share of the top quartile shows a clear increasing trend, resulting in an increasing gap with the 3 bottom quartiles. Since direct holdings of foreign assets are small throughout the sample, figure 5 adds to this a measure of indirect holdings obtained by multiplying the time-varying amount of household investments in three categories of mutual funds by the foreign asset share of the latter in 2003. With the caveat that this measure neglects time variation in mutual fund portfolios, the pattern of figure 4 is reinforced: the top quartile has seen a strong increase in their average portfolio share between 1992 and 2007, while the bottom 3 quartiles show no consistent trend. Interestingly, the bottom quartile continues to have a portfolio share of total assets very close or equal to zero, implying zero mutual fund holdings on average. Average mutual fund investments in the middle quartiles, however, are positive, leading to a monotonous increase of the portfolio share of total foreign assets across wealth quartiles throughout the sample period. This evidence suggests that the home bias of the poor has indeed been a robust feature of the data over the last 20 years.

[Figure 4 somewhere here.]

[Figure 5 somewhere here.]

The evidence presented in figures 1 to 5, however, raises several questions. First, there are at least two potential sources of error in the way I measure individual portfolios. One arises from households under- or misreporting their foreign asset holdings. But since there is evidence of variation in foreign asset shares across mutual funds at least for equities (Hau and Rey (2008a) and Hau and Rey (2008b)), another source of error is the use of average mutual fund portfolios, which could lead to a bias in the results. An appendix argues that both kinds of measurement error are likely to bias any positive relationship between portfolio shares and financial wealth towards zero. This is because off-shore investments for tax evasion are likely to make underreporting more severe for foreign assets, and average mutual fund portfolio shares are likely to under-represent the foreign asset holdings by wealthy households' if these systematically choose mutual funds with higher foreign exposure. A second question is whether the rise in average portfolio shares across the wealth distribution could merely be due to a higher participation rate of wealthy individuals in the foreign asset market, rather than a rise in individual portfolio shares of participants as they become richer. The literature often motivates such a pattern by fixed costs of entering sophisticated financial markets (see e.g., for the case of foreign assets,

Christelis and Georgarakos (2008)).
Finally, one might suspect that financial wealth simply captures the effects of other important variables, such as education, age, or income, on portfolios. In this case we would expect an analysis that controls for these variables to yield significantly different results. To investigate these issues in detail, I perform a more formal econometric analysis. Specifically, and contrary to previous studies, I estimate jointly the probability of participation and the optimal portfolio share of participants with the Heckman (1979) method, conditioning on other variables that were found to be important for portfolio decisions of individuals in previous research. To be precise, I estimate the parameters of the following 2 equation system

$$SHARE = \begin{cases} \alpha + \beta_1 ln(FIN) + \beta_2 ln(INCOME) + \epsilon_1 & \text{if } H > 0 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

$$with$$

$$H = a + b_1 FIN_2 + b_2 FIN_3 + b_3 FIN_4 + b_4 AGE + b_5 AGE^2 + b_6 AGE^3$$
$$+ b_7 COL + b_8 BLACK + b_9 HISP + \epsilon_2 \tag{2}$$

Here, SHARE is the portfolio share of foreign assets, equal to the ratio of total foreign assets to FIN, the SCF definition of gross financial wealth, and INCOME is the sum of salaries, wages and income or losses from a professional practice, business, limited partnership, or farming. H is an indicator variable that captures the probability of participation in foreign asset markets. This probability is a function of a set of dummies FIN_x that capture financial wealth, taking the value 1 when total financial assets of the household fall in the (weight-adjusted) xth quartile, as well as a third degree polynomial in AGE (eqal to the age of the household head in years minus 15), a dummy variable “COL” that equals 1 when the household head holds a college degree, and dummies that take the value 1 when she reports her race to be black or hispanic. Only when H is above a threshold, normalised to 0, do agents participate in foreign asset markets and we observe the variable SHARE, their portfolio share of foreign assets. Conditional on participation the portfolio share is a function of income and financial wealth. The errors ϵ_1 and ϵ_2 are assumed to follow a joint normal distribution. The equations are estimated jointly with full maximum-likelihood adjusted for sampling weights. Identification is achieved by restricting the effects of financial wealth to be linear in logs in (1), and constant within quartiles in (2), which I take to be a proxy for different possible participation thresholds.[11]

[11] I also estimated an alternative specification that included income quartiles in the participation equation. While in the presence of fixed costs of entering foreign asset markets we would expect financial

Table 1 to 3 report the results of estimating equations (1) and (2) for three asset classes.[12]

[Table 1 somewhere here.]

To put the evidence on foreign asset holdings into context, table 1 confirms the well-known results in Campbell (2006) or Guiso et al. (2003) about the determinants of household investments in stocks (domestic or foreign-issued):[13] more educated and richer US households are more likely to participate in stock markets, while households with a head who reports her race as black participate less on average. Importantly, and in line with figure 1, even among participants in the stock markets, the portfolio share increases strongly with financial wealth, while there is a negative, but less well defined, effect of non-financial income.

[Table 2 somewhere here.]

Table 2 presents equivalent estimation results for the portfolio share of total foreign asset holdings, including those held indirectly via mutual funds.[14] The effect of financial wealth is significant (at the 1 percent level) in both equations. The probability of participation rises monotonously across quartiles of the financial wealth distribution. Like in the case of total stock holdings, there is a positive effect of a college degree and negative, although not always significant, race effects for the probability of participation. Importantly for the issue of this paper, the estimation results for equation (1) show that higher financial wealth increases significantly the portfolio share of foreign assets even of participants, which cannot be attributed to fixed costs. Again, the effect of rising non-financial income on the portfolio share of foreign assets is negative but insignificant.

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wealth to determine the participation threshold and not income, current income could act as a proxy for future financial wealth. However, the income quartile dummies turned out to be insignificant, so I excluded them from the final specification.

[12] Again, an additional complication for the estimation is the use in the SCF of multiple imputations for missing values. To account for this, I estimate the same model for each of the 5 implicates separately and then aggregate the estimation results. For the coefficients and standard errors reported in Table 1 to 3, I use the formulae suggested in the SCF codebook (http://www.federalreserve.gov/PUBS/oss/oss2/2004/codebk2004.txt). For the χ^2 statistics I report a simple average of the 5 values.

[13] The estimation uses all 6 waves of the *SCF*: 1992,1995,1998,2001,2004 and 2007.

[14] Since the mutual fund portfolio data is only available for 2003, I exclude the other 5 waves of the SCF from the estimation here.

[Table 3 somewhere here.]

To show how the evidence for foreign assets is not just due to the pattern of mutual fund investment across the wealth distribution, Table 3 shows the results for direct foreign holdings.[15] Overall, the same results as for total foreign assets hold in this sub-category. Thus, households in the upper quartile of the wealth distribution are again significantly more likely to hold any foreign bonds. Again, there is a positive education effect. And importantly, there is a significant increase of the bond portfolio share across the wealth distribution even for participants.

3 Partial equilibrium portfolio choice with fixed costs and wealth heterogeneity

This section considers the portfolio decision problem of investors who own both human and financial wealth and can invest in domestic and foreign assets. The analysis is partial equilibrium in nature, in order to highlight two features: first, fixed and variable investment costs do not lead to variation in portfolios of diversified investors across different levels of financial wealth. Second, and more importantly, significant heterogeneity in portfolios along the wealth distribution arises from the fact that the importance for portfolios of the comovement between non-financial income and asset returns declines when financial income increases. The exact nature of this heterogeneity, however, is shown to depend on the covariance between financial returns, non-financial income, and consumer prices. The next section therefore analyses a model where these comovements arise as part of the general equilibrium in the economy.

Consider an economy where there are two countries, Home (H) and Foreign (F), each populated by a continuum of agents of mass 1 who receive stochastic labour income Z_h', Z_f' in each of the two periods they live (where a prime denotes second-period variables). At the end of the first period they trade Home and Foreign assets whose stochastic Home currency net returns R_h, R_f are realised in period 2 together with labour income. I focus on the problem of a Home investor who chooses portfolio shares of home and foreign assets $1-\alpha, \alpha$. To account for costs of investing abroad, any non-zero foreign asset position $a \neq 0$ requires a payment of $K = K_0 + W\ a(1+R_f)(1-K_1)$, where W is total

[15] Again, here the estimation uses all 6 waves of the *SCF*: 1992,1995,1998,2001,2004 and 2007.

financial wealth, K_0 a fixed cost and K_1 a cost proportional to the proceeds of investment in foreign assets.[16] The investor values consumption sequences C_h, C'_h according to the expected value of a CRRA utility function

$$U(c) = \frac{C^{1-\gamma} - 1}{1-\gamma} + \beta E[\frac{C'^{1-\gamma} - 1}{1-\gamma}] \tag{3}$$

$$C = Z_h - W \tag{4}$$

$$C' = \frac{Z'_h + W[(1-\alpha)(1+R_h) + \alpha(1+R_f)(1-K_1)]}{P'_H} \tag{5}$$

where E is the mathematical expectation operator, P'_H is the stochastic period two consumer price index equal to the consumption value of one unit of the numeraire currency, and γ is the coefficient of relative risk aversion, which I assume to be strictly greater than 1.[17] In the remainder of this section I focus on the portfolio problem of the home investor at the end of period 1, and thus drop subscipts and primes of home random variables.
The investor faces three sources of risk: from fluctuations in his endowment Z, from the uncertainty in asset payoffs R_h, R_f, and from fluctuations in the level of consumer prices P'_H. I assume that the logarithms of random variables, denoted by their small letters y, r_h, r_f, p, are jointly normally distributed with means $\overline{y}, \overline{r_h}, \overline{r_f}, \overline{p}$ as well as variances and covariances $\sigma^2_i, \sigma^2_{ij}, \quad i,j \in \{y, r_h, r_f, p\}$. Also, I set $\sigma^2_{r_h r_f} = 0$ for simplicity, so domestic and foreign assets have uncorrelated payoffs.
Investors diversify into foreign assets whenever the expected benefit exceeds the investment cost K. A second-order approximation of expected utilities shows that this is the case whenever

$$\rho \ \{ \underbrace{\overline{r_f} - k_1 - \overline{r_h} + \alpha(1-\alpha)(\sigma^2_{r_f} + \sigma^2_{r_h})}_{\text{Increased nominal return}} + \underbrace{(\gamma-1)\rho[\sigma^2_{r_h} - \alpha\frac{\sigma^2_{r_h} + \sigma^2_{rf}}{2} + \sigma^2_{r_f p} - \sigma^2_{r_h p}]\}}_{\text{Reduced volatility of real Returns}}$$

$$+ \ (1-\rho) \ \underbrace{\{\rho(\gamma-1)[\sigma^2_{r_h y} - \sigma^2_{r_f - y} + \sigma^2_{r_f - p} - \sigma^2_{r_h p}]\}}_{\text{Improved hedge of real endowment risk}} \ \geq -log(1 - \underbrace{\frac{K_0}{\alpha(Z + W(1+R_p))}}_{\text{Scaled fixed cost}}) = -log(1-(1-\rho)\frac{K_0}{\alpha Z}) \tag{6}$$

where $-k_1 = log(1-K_1)$ and $\rho = \frac{W(1+R_p)}{Z+W(1+R_p)} = \frac{\frac{W}{Z}(1+R_p)}{1+\frac{W}{Z}(1+R_p)}$ the ratio of financial claims to total claims on income next period.
The benefits of diversification, the left-hand side of the inequality, comprise three terms:

[16] This specification facilitates the analysis because log returns are additively separable from the log cost $log(1-K_1)$. Making costs proportional to ex ante investments $\alpha * W$ would make the algebraic expressions somewhat more complicated without affecting the results.

[17] Note that I normalise the non-stochastic period 1 home price level to 1.

first, the mean log-portfolio return increases with the differential of nominal log asset-returns and with the sum of their variances weighted by the product of portfolio shares (a Jensen's inequality term reflecting the fact that the log of the average return exceeds the average of log returns). The second term depicts the benefits of reduced volatility in log real returns (through both lower nominal volatility, and improved hedging of price level risk), waited by the risk aversion coefficient. These first two diversification gains come from an improved performance of the financial portfolio, and are thus waited by the ratio of financial wealth to total wealth ρ. The third term depicts improved hedging of endowment risk, waited by risk aversion and the share of labour income in total wealth. All diversification gains are proportional to the product of the portfolio share of foreign assets α and total wealth $(Z + W)$, which thus scales the fixed cost K_0. For any given α, the right-hand side thus decreases to 0 as financial wealth rises. In other words, rich investors do not care about fixed cost of diversification. A rise in wealth, however, also changes the relative importance of improved financial performance versus improved hedging of endowment risk. The participation decision by foreign investors with a significant share of non-financial income ($\rho < 1$) thus depends on the relative covariances of asset returns with real labour income. As long as there are gains of diversification for purely financial investors, equivalent to the sum of the terms in the first line of equation (6) being strictly positive, there is, for any expected labour income, a threshold level of wealth above which investors always invest in foreign assets.

To find the optimal portfolio share α conditional on participation, we can exploit lognormal random variables and the concavity of the problem, to solve the first other conditions associated with foreign and domestic asset holding

$$\alpha = \frac{1}{\rho}\{\underbrace{\frac{r_f - k_1 - r_h + \frac{1}{2}(\sigma^2_{r_f} - \sigma^2_{r_h})}{\gamma(\sigma^2_{r_f} + \sigma^2_{r_h})}}_{\text{Expected return differential}} + \underbrace{\rho\frac{\sigma^2_{r_h}}{(\sigma^2_{r_f} + \sigma^2_{r_h})}}_{\text{Relative return volatility}}$$
$$- \underbrace{\frac{(1-\rho)(\sigma_{r_f y} - \sigma_{r_h y})}{(\sigma^2_{r_f} + \sigma^2_{r_h})}}_{\text{Hedging of endowment risk}} + \underbrace{\frac{\gamma - 1}{\gamma}\frac{(\sigma_{r_f p} - \sigma_{r_h p})}{(\sigma^2_{r_f} + \sigma^2_{r_h})}}_{\text{Hedging of price level risk}}\} \tag{7}$$

As in the participation decision, the relevant determinants of the portfolio shares are the means and variances of returns, and their relative ability to hedge risk arising from fluctuations in labour income and the domestic price level. The share of foreign assets α

increases with their relative expected return (again adjusted for their relative variances due to the Jensen's inequality relationship that links expected log and non-log returns) and decreases with their relative variance. The third and fourth terms on the right-hand-side of equation (7) summarise the relative hedging properties: the more the covariance of labour income and domestic assets exceeds that of labour income and foreign assets, the more attractive is foreign investment for hedging purposes. The reverse is true for the relative covariances of asset returns with domestic prices: foreign assets are better hedges the higher their covariance with the price level, as utility falls with prices as long as the intertemporal elasticity of substitution is lower than 1 (corresponding to a risk aversion parameter $\gamma > 1$).

Equation (7) shows that neither fixed nor variable investment costs lead to variation in portfolio shares across agents that participate in foreign asset markets. But optimal portfolio shares vary in an interesting way with ρ, the ratio of financial wealth to total investor wealth. Investors whose expected labour income is negligible ($\rho \approx 1$) do not care about its covariance with asset returns. In contrast, for a given expected income, as financial wealth decreases and ρ falls, the variance-covariance strcture of real asset returns that determines the riskyness of financial income becomes less of a concern for investors. And crucially, since asset holdings are (approximately) linear in total, not financial, wealth, portfolio shares include a scaling factor $\frac{1}{\rho}$, and therefore become more extreme as ρ falls. This is because at low levels of financial wealth the cost of more extreme portfolio shares in terms of a higher consumption variance (which rises with ρ^2) is of less concern to the investor than the benefits from exploiting the relative performance of assets in terms of mean return and hedging (which rise with ρ).

The evolution of optimal portfolios as financial wealth increases is thus crucially determined by the relative ability of domestic and foreign assets to hedge labour income and price level risk, and by their return differential. For example, when foreign asset returns in Home currency equal a Foreign currency return $R_f^\star$ multiplied by the value of Foreign in Home currency S, the hedging properties of foreign assets crucially depend on the time series properties of the exchange rate. If the latter is essentially noise that is independent of economic fundamentals and returns, higher volatility of (log) foreign asset returns in terms of the numeraire $\sigma_{r_f}^2 = \sigma_{r_f*}^2 + \sigma_s^2$ makes foreign assets less attractive to all domestic investors. If, in contrast, exchange rate fluctuations mainly reflect movements towards purchasing power parity after shocks to domestic consumer prices, implying positive comovement of the exchange rate with domestic prices, foreign assets are a good hedge against movements in the domestic price level since $\sigma^2_{r_f p} = \sigma^2_{r_f * p} + \sigma^2_{sp}$. Yet, this ability to hedge domestic price level risk does not necessarily make foreign assets equally more attractive to all investors. For example, if positive aggregate supply shocks increase labour income but depreciate the exchange rate, "low ρ"-agents, whose wealth is determined by human wealth, may prefer domestic assets, whose real returns are low in times when labour income is high.

According to the partial equilibrium analysis of this section, any model that predicts aggregate consumption and portfolio patterns across countries on the basis of equilibrium comovements between income, asset returns and consumer prices is also likely to have testable implications for the behaviour of individual portfolios across the wealth distribution. The circular relationship between aggregate demand, the stochastic properties of market-clearing prices, and the distribution of optimal portfolios and consumption levels across households, however, makes an extension of international macroeconomic models to idiosyncratic risk and heterogeneous portfolio choice analytically impossible and numerically challenging in most cases. The rest of this paper takes a first step at such an analysis in a very stylised model of the international business cycle. It uses elements from both the classical literature on aggregate home bias in country portfolios, which stresses general equilibrium price and exchange rate movements, and the literature on the macroeconomic role of idiosyncratic income risk and wealth heterogeneity. Particularly, it aims to show how some of the mechanisms that are prominent in the former might help explain results such as those presented in the empirical section, where I showed higher financial wealth to have a significantly positive effect both on the probability of participating in foreign asset markets, and on the portfolio shares of participants.

4 A two country heterogeneous agents endowment economy

Beyond informational or other costs of diversification into foreign assets, the international macroeconomics literature on aggregate home bias has emphasized their relative ability to hedge equilibrium fluctuations in the real exchange rate and in the real value of non-diversifiable sources of income, such as wages, as potential determinants of optimal portfolios across domestic and foreign assets (see, for example, Coeurdacier and Rey

(2011)). In this section, I propose a model that includes several features that have been found to help explain aggregate home bias in portfolios, such as consumption baskets dominated by domestic goods (Stockman and Tesar, 1995), non-diversifiable income risk (Baxter and Jermann, 1997), and investment opportunities in both bonds and equities (Coeurdacier and Gourinchas, 2011). Most importantly perhaps, the general equilibrium nature of the model allows me to quantify the relative determinants of portfolios across home and foreign assets that were found to be important in the partial equilibrium analysis of the previous section, such as the comovement of asset returns with domestic consumer prices or real incomes. To be able to analyse variation in portfolios across individuals, I add to this setup two elements from the macroeconomic literature on heterogeneous agents economies: borrowing constraints and idiosyncratic income risk. Unfortunately, the inclusion of these two elements implies that the standard methods to derive aggregate country-portfolios can not, or only with difficulty, be used as they rely either on perturbation of the model's aggregate variables around their non-stochastic steady state values, potentially very different to expected values of individual variables (Devereux and Sutherland, 2011), or perfect insurance (Coeurdacier and Gourinchas, 2011). The strategy of this paper is therefore to make a number of simplifying assumptions that allow to separate the portfolio problem of households from the general equlibrium movements in real exchange rates and the terms of trade. Particularly, I use a two-period version of a standard two-country model in the home bias literature, first proposed by Cole and Obstfeld (1991). Its assumption of unit-elastic consumption baskets, together with identical preferences and portfolios, conveniently allows me to solve for the general equilibrium terms of trade prior to the portfolio decision of households, which are then solved in a second step.[18]

4.1 The general environment

Consider a version of the model in the previous section where agents receive a sequence of endowments $Z_k, Z'_k, k \in \{h, f\}$ in units of their country-specific perishable good H or F, and define consumption in both countries as an identical Cobb-Douglas aggregate with

[18] I also abstract from capital accumulation, partly because of the two-period nature of the model. I comment further on this below.

symmetric bias towards Home goods.

$$c_k = c_{k,H}^{\theta} c_{k,F}^{1-\theta} \tag{8}$$

$$\theta > \frac{1}{2},\ \gamma > 1 \tag{9}$$

where c_k is the consumption basket of agent k and $c_{k,I}$ denotes consumption by agent k of good I for $k \in \{h, f\}$, $I \in \{H, F\}$. Note that, in line with many papers on home bias, I assume $\gamma > 1$. More generally, notation is as follows: capital letters H,F denote country-specific variables or goods, small letters h,f denote individual variables that can vary across agents of country H,F. First subscripts denote agents or countries, second subscripts goods. Second period values of a variable x are denoted as x', their probability distribution as Ψ^x.

Z'_k, the endowment of individual k in period 2, is the product of two terms: an "individual endowment share" ϵ'_k, and a country-specific "aggregate endowment" Y'_K

$$Z'_k = \epsilon'_k * Y'_K \tag{10}$$

"Idiosyncratic risk" is given by the probability distribution of ϵ'_k, the period 2 endowment shares of individual k, which I denote $\Psi_k^{\epsilon'}$. For simplicity I assume that second period endowments are i.i.d. across agents and independent of all aggregate variables. Also I normalise expected period 2 individual endowments to 1, $\int \epsilon'_k \Psi_k^{\epsilon'} = 1$. By the iid assumption and the law of large numbers this means the sum of realised endowment shares is always 1 and aggregate period 2 output in country K simply equals Y'_K.[19]
"Aggregate risk" is summarized by the probability distribution of Y'_H and Y'_F, the aggregate endowments in period 2, denoted $\Psi_H^{Y'}, \Psi_F^{Y'}$. I assume that these are identically distributed, and independent of each other as well as of individual random variables.[20]
I assume that all period 2 random variables are log-normally distributed. Together with the i.i.d. assumption, this implies
$(\varepsilon'_h, \varepsilon'_f, y'_H, y'_F)' \sim N(\ (\overline{e}, \overline{e}, \overline{y}, \overline{y}',\ \Sigma)$, where $\varepsilon = ln(\epsilon)$ and Σ is a diagonal matrix with entries $\sigma_\epsilon^2, \sigma_\epsilon^2, \sigma_y^2, \sigma_y^2$.

[19]For the derivation of a law of large numbers for continuum economies, see Uhlig (1996).

[20]It is easy to relax the assumption of independence of Y'_H and Y'_F, which, however, makes the algebraic expressions that follow much less cumbersome.

4.2 Incomplete asset markets and borrowing constraints

I impose the simplest structure of asset markets that allows me to analyse two kinds of trade-offs in optimal portfolios: the choice between safe and risky assets on the one hand, and between home and foreign assets on the other.

Like Huggett (1993), agents trade “IOUs”, or non-contingent bonds, that are in zero net supply and denominated in domestic goods. These are “safe” assets in the sense that for 1 unit of H goods invested today, H bonds always pay R^b_H units of good H next period. Equivalently, foreign bonds pay R^b_F units of F goods. In the following, I allow for a proportional cost of foreign investments $(1-K_1)$ as in the previous section, but I abstract from fixed costs for simplicity.

In contrast to Huggett (1993)'s economy, however, agents can also trade shares in national mutual funds, and are allowed to buy shares and bonds from foreigners. Shares are also in zero net supply, and risky in the sense that their payoffs are proportional to the stochastic aggregate endowment, and also include extra noise. Thus, for some constant R^s_H, the return on home shares is $\zeta'_H R^s_H Y'_H$ units of H goods per unit of H goods invested, where ζ' is a noise term. Payoffs to foreign mutual fund shares, denoted in F goods, are equivalently $\zeta'_F R^s_F Y'_F$, where ζ'_H and ζ'_F are identically distributed log-normal random variables with mean 1 and log-variance σ^2_r that are independent of each other and all other random variables. One obvious implication of the exogenous incompleteness of asset markets is that individual claims to future endowments are non-tradable, and that the resulting risk thus is non-diversifiable.

I denote h's holdings of home and foreign bonds by $a^b_{h,H}$ and $a^b_{h,F}$ respectively, and her holdings of shares by $a^s_{h,H}$ and $a^s_{h,F}$. Asset quantities are denoted in endowment goods of the owner. So if h holds a portfolio $a^b_{h,H}, a^b_{h,F}$, she owns $a^b_{h,H}$ units of H bonds and $\frac{a^b_{h,F}}{p}$ units of F bonds, where p is the relative price of home goods.

I assume both bonds and shares have zero default probability. Since the ability to pay of consumers is determined by their second period endowment of domestic goods, I assume that agents can only sell claims denoted in domestic goods up to a fixed borrowing limit for bonds and mutual fund shares, respectively B^b_K, B^s_K. In particular, and similar to for example Coeurdacier and Gourinchas (2011), I assume that agents can only sell claims amounting up to a fraction δ^i of their expected period two endowment[21]

$$a^s_{k,K} \geq B^s_K = -\delta^s \frac{E[Z'_k]}{R^s_K} \tag{11}$$

$$a^b_{k,K} \geq B^b_K = -\delta^b \frac{E[Z'_k]}{R^b_K} \tag{12}$$

$$\tag{13}$$

4.3 The problem of a typical household

A typical home household h maximises expected lifetime utility by choosing in period 1 consumption and a vector of assets $\overrightarrow{a_h}$ subject to her budget constraint, borrowing constraints for domestic assets and the non-negativity of foreign asset holdings, taking as given the relative price of home goods (in units of the foreign good) p this period and the vector of returns $\overrightarrow{R}$. h's problem is thus given as:

$$max_{c_h, c'_h, \overrightarrow{a_h}} \frac{c_h^{1-\gamma} - 1}{1-\gamma} + \beta E[\frac{c_h'^{1-\gamma} - 1}{1-\gamma}] \tag{14}$$

Subject to the constraints

$$\begin{aligned} c_h &= \frac{Z_h - \sum_{i \in \{b,s\}} a^i_{h,H} - \sum_{j \in \{b,s\}} a^j_{h,F}}{p_H} \\ c'_h &= \frac{Z'_h + R^b_H a^b_{h,H} + R^s_H Y'_H a^s_{h,H} + (R^b_F a^b_{h,F} + R^s_F Y'_F a^s_{h,F}) \frac{p'}{p}}{p'_H} \\ a^i_{h,H} &\geq B^i_H, \;\; for \; i \in \{b,s\} \\ a^j_{h,F} &\geq 0, \;\; for \; j \in \{b,s\} \\ Z'_h &= e' Y'_H \end{aligned}$$

where $p_H = \theta^{-\theta}(1-\theta)^{-(1-\theta)} p^{1-\theta}$ is the home consumption price index. The problem of a typical foreign household is symmetric.

[21] The "natural" limit to total borrowing in riskless assets would equal the present discounted value of minimum future income $B_K = b_K \frac{Z'_{K,min}}{R}$, which is the highest amount agents can repay for sure. But with log-normal endowments there is a positive probability of having endowment realisations arbitrarily close to 0, such that this formulation does not lead to a non-zero borrowing limit. The problem can be avoided by introducing a positive non-stochastic minimum endowment level for all agents in a country. This can be chosen such that the resulting natural borrowing limit equals the sum of B^b_K and B^s_K above.

4.4 Definition of competitive equilibrium

A competitive equilibrium is

1. A **Consumption Allocation**:
   For every agent k, a consumption sequence of both goods for both periods: $c_{k,H}, c_{k,F}, c'_{k,H}, c'_{k,F}$, where $c'_{k,J}$ is a random variable depending on the realisation of period 2 uncertainty.

2. A set of **Portfolios**:
   For every agent k, a vector $\overrightarrow{a_k}$ specifying holdings of all assets in the economy at the end of period 1.

3. A **Price System**, consisting of

   - p, p', the relative prices of F goods in terms of H goods in period 1 and 2, where p' is a random variable with distribution $\Psi^{p'}$.
   - $\overrightarrow{R}$, the vector of asset returns.

such that

1. Agents allocate their funds optimally across goods in period 2 given a particular realisation p'.

2. The allocation solves every household's problem (14) in period 1 given a relative price p, a distribution $\Psi^{p'}$, and rates of return $\overrightarrow{R}$.

3. Markets clear:

   - for goods: $\int c_{h,H}dh + c_{f,H}df = Y_H,\ \int c_{h,F}dh + c_{f,F}df = Y_F$ in both periods
   - and assets: $\int a^i_{h,J}dh + \int pa^i_{f,J}df = 0,\ \forall\ i \in \{b, s\},\ \ J \in \{H, F\}$ (each asset is in zero net supply)

4. The distribution of the future relative price $\Psi^{p'}$ is consistent with the joint distribution of random variables $\epsilon'_h, \epsilon'_f, Y'_H, Y'_F$, and individual asset holdings at the end of period 1.

Note that optimal portfolios in this environment depend on the distribution of future relative prices $\Psi^{p'}$. But the latter depends on expenditure patterns tomorrow, and thus on savings and portfolio decisions today. In other words, the model has a complicated circular relationship between savings and portfolio decisions on the one hand, and the process for market clearing relative prices $\Psi^{p'}$ on the other.[22] As the next section shows, the assumption of identical homothetic preferences for all agents implies that a country's demand for goods only depends on their relative price and aggregate country-level ressources (net asset returns plus endowments), and not on the distribution of individual savings or endowments. However, individual uncertainty and heterogeneity still matter for aggregate savings and thus net asset positions. The assumption of identical preferences ensures that even the aggregate net asset positions do not matter for excess demands, so aggregate endowments tomorrow completely determine aggregate demand for goods and thus market-clearing prices. This assumptions comes at a cost, however: while home agents' preferences are biased to domestically produced goods, foreign agents give a larger weight to goods produced abroad. Like most of the literature on home bias in country portfolios, the rest of the analysis focuses on the case of domestic bias in consumption, and therefore concentrates on the Home country.

4.5 How unit-elasticity implies terms of trade movements independent from heterogeneity

To derive the equilibrium process of tomorrow's relative price p', note first that identical homothetic preferences imply identical expenditure shares for all agents. This linearity of the demand functions, together with the zero net supply of all assets, allows us to sum across agents and express excess demand for goods as a function of aggregate expenditure

$$\begin{aligned} &\int \theta s_h dh + \int \theta p s_f df \\ &= \theta[(1-\nu_H)Y_H + \nu_F p Y_F] + \theta[\nu_H Y_H + (1-\nu_F)pY_F] \end{aligned} \tag{15}$$

where s_k is the total expenditure of agent k in domestic goods, and ν_I are the aggregate claims sold by country I. This yields the market clearing price

$$p = \frac{Y_H}{Y_F} \quad \forall \Psi_F^{e\prime}, \Psi_H^{e\prime}, \Psi_F^Z, \Psi_H^Z \tag{16}$$

[22] This is similar to the recursive framework with capital accumulation presented by Krusell and Smith (1998), where agents need to know the law of motion for the joint distribution of individual asset holdings and (aggregate and idiosyncratic) shocks, as this determines aggregate savings and thus the returns to capital tomorrow. In a comparable dynamic setting, the equilibrium in this paper would be significantly more complex, because of the presence of two countries, and the portfolio decision across several assets.

So the relative price is independent of the within-country heterogeneity in the economy. This is essential, as it allows me to solve for the optimal portfolios in closed form.

5 Optimal portfolios

The solution to the general equilibrium relative price of home and foreign goods as a function of aggregate endowments allows us to solve for the real value of home agents' claims to income in the second period as

$$\begin{aligned}
\textit{Real endowment} &: \quad e'_h Y_H'^{\theta} Y_F'^{1-\theta} \\
\textit{Real return on home equity} &: \quad a^s_{h,H} R_{SF} \zeta_H Y_H'^{\theta} Y_F'^{1-\theta} \\
\textit{Real return on foreign equity} &: \quad a^s_{h,F} R_{SF} \zeta_F Y_H'^{\theta} Y_F'^{1-\theta} (1 - K_1) \\
\textit{Real return to home bonds} &: \quad a^b_{h,H} R_{BF} Y_H'^{\theta-1} Y_F'^{1-\theta} \\
\textit{Real return to foreign bonds} &: \quad a^b_{h,F} R_{BF} Y_H'^{\theta} Y_F'^{-\theta}
\end{aligned}$$

The first thing to note is that, although the local currency returns to mutual funds and aggregate endowments are independent across countries, general equilibrium terms of trade movements introduce a collinearity between the real consumption value of fund returns and that of aggregate endowments in both countries that is perfect apart from the country-specific noise terms $\zeta_i, i \in \{F, H\}$. Investors can thus exploit this positive comovement to hedge aggregate endowment risk by short-selling a diversified portfolio of both mutual funds, whose return variability from noise in share returns is lower than that from short-selling just domestic mutual fund shares. Terms of trade movements thus act to reduce the attractiveness of buying foreign mutual fund shares. Moreover, they introduce heterogeneity in portfolios across the wealth distribution, as the hedging of endowment risk is more important for those consumers with small financial wealth, whose period 2 consumption comoves more strongly with endowment income. In contrast to mutual fund shares, the real returns to home and foreign bonds respond differently to aggregate endowment shocks, and both are only an imperfect hedge against endowment risk. Importantly, as $\theta > \frac{1}{2}$ rises to 1, the consumption value of home bond returns becomes less and less volatile for home agents. This is why home bias in consumption leads to home bias in bonds when agents are sufficiently risk-averse. This effect is independent of the relative importance of endowment income. But it makes investors with low financial wealth holdings more likely to be constrained by the impossibility to short-sale foreign assets and invest the proceeds in home bonds.

5.1 Unconstrained portfolios

Assume that there is at least one home agent who is unconstrained by short-selling constraints and holds non-zero amounts of all assets. As in the previous section, we can solve for her portfolio shares analytically by solving the system of first-order conditions and exploiting, as before, the log-normal nature of random variables and approximation of the log-portfolio return, portfolio shares as

$$
\begin{array}{lllll}
\multicolumn{5}{l}{\overrightarrow{\alpha} = [\alpha_h^b, \alpha_f^b, \alpha_h^s, \alpha_f^s]' = \dfrac{1}{\gamma\rho(\sigma_y^2 + \sigma_r^2)}\{} \\
r_h - y - \frac{1}{2}(r_{sh} + r_{sf} - k_1) & + \frac{1}{2}\sigma_y^2 & + \frac{1}{2}\frac{\sigma_r^2}{\sigma_y^2}(r_h - r_f + k_1) & + (\gamma - 1)\theta(\sigma_y^2 + \sigma_r^2) & - \frac{1}{2}\gamma(1-\rho)\sigma_r^2 \\
r_f - y - k_1 - \frac{1}{2}(r_{sh} + r_{sf} - k_1) & + \frac{1}{2}\sigma_y^2 & + \frac{1}{2}\frac{\sigma_r^2}{\sigma_y^2}(r_f - k_1 - r_h) & + (\gamma - 1)(1-\theta)(\sigma_y^2 + \sigma_r^2) & - \frac{1}{2}\gamma(1-\rho)\sigma_r^2 \\
r_{sh} + y - \frac{1}{2}(r_f - k_1 + r_h) & + \frac{1}{2}\sigma_r^2 & + \frac{1}{2}\frac{\sigma_y^2}{\sigma_r^2}(r_{sh} - r_{sf} + k_1) & & - \frac{1}{2}\gamma(1-\rho)\sigma_y^2 \\
r_{sf} + y - k_1 - \frac{1}{2}(r_f - k_1 + r_h) & + \frac{1}{2}\sigma_r^2 & + \frac{1}{2}\frac{\sigma_y^2}{\sigma_r^2}(r_{sf} - k_1 - r_{sh}) & & - \frac{1}{2}\gamma(1-\rho)\sigma_y^2\} \\
\underbrace{\qquad\qquad\qquad}_{\Delta\, r} & \underbrace{\qquad}_{\text{Log-Level } r \text{ Correction}} & \underbrace{\qquad\qquad}_{\Delta r \text{ w/in asset class}} & \underbrace{\qquad\qquad}_{\text{CPI hedge}} & \underbrace{\qquad}_{\text{Endowment hedge}}
\end{array}
\tag{17}
$$

where, again, k_1 is the proportional cost of investing in foreign assets. The portfolio shares of diversified investors are determined by 5 factors: the first term on the left-hand side of equation (17) represents the difference between the log bond return and the average return of the home and foreign shares (and vice versa). The second is a convexity term that makes return differentials in levels increase in the difference of log-return variances. The third term adjusts portfolio shares for the relative return differential within asset classes. For example, the lower the variance of the noise term in returns to mutual funds σ_r^2, the more responsive become their portfolio shares to a given difference in their log-returns. The fourth term describes the relative ability of assets to hedge against fluctuations in the price of consumption. This term is zero for mutual fund shares, as their returns comove perfectly with aggregate real consumption. Home bonds, however, whose payoffs are constant in home goods, are trivially better hedges against fluctuations in consumer prices the stronger is the bias towards home goods in preferences θ. Foreign bonds, however, have worse hedging ability against price risk as θ increases. The final term is a hedge against fluctuations in endowments. Since both mutual fund shares comove perfectly with the aggregate part of endowment risk, in the absence of return noise ζ_i, investors would simply sell off the whole aggregate endowment risk through a diversified short position in mutual funds. When mutual fund returns are noisy, however, neither bonds nor shares are perfect hedges against endowment risk. Investors thus hedge through a short portfolio that comprises diversified positions of both mutual funds and

bonds in proportions equal to one minus the residual variance after a regression of returns on aggregate endowments.
Trivially, the portfolio shares of home assets increase in the proportional investment cost k_1, while those of foreign assets decline. More importantly, the share of home bonds increase with the degree of home bias θ. To see this, note that the sum of the second and fourth terms in equation (17) is $\frac{1}{2}(\sigma_y^2 - \sigma_r^2) + (\gamma - 1)\theta\sigma_y^2 + \gamma\theta\sigma_r^2$ which increases with θ since $\gamma > 1$. The reverse is true for foreign bonds.
The general equilibrium comovements in the model thus have three implications that may help to explain the facts observed in the data: first, portfolio shares of mutual fund shares are lower as consumers would like to take short positions that hedge against endowment risk. Second, the relative share of foreign bonds is reduced whenever there is home bias in consumption, as home bonds are a better hedge against price fluctuations. And third, the diversification benefits from investing in foreign mutual funds is reduced because, in general equilibrium, their comovement with aggregate variables equals that of home mutual fund shares. An appendix contains the portfolio shares for investors that are constrained by one or both short-sale constraints on foreign assets.

To study how the structure of asset holdings changes across the wealth distribution I look at the evolution of portfolio shares with the share of financial in total wealth ρ. Naturally, the results depend on the equilibrium vector of asset returns $r_i^j, i \in \{f, h\}, j \in \{b, s\}$. These depend on the relative demand and supply of assets, which is determined by their relative hedging qualities, but also by the wealth distribution in the first period, the investment cost k_1, and the borrowing constraints $\overline{B}$. For example, as k_1 rises ($\overline{B}$ approaches 0), the share of foreign (home) assets held by home investors trivially goes to zero. To concentrate on the interesting case of interior portfolios, and to rule out cases where the relative supply effect dominates the hedging incentives, I assume that there is at least one home investor with a diversified portfolio consisting of all four assets. Also, for simplicity, I concentrate on a symmetric equilibrium where asset returns are equal within asset class, so $r_f = r_h = r^b$, $r_s f = r_s h = r_s$.[23] The portfolio shares thus become

$$
\begin{aligned}
\overrightarrow{\alpha} = [\alpha_h^b, \alpha_f^b, \alpha_h^s, \alpha_f^s]' = \frac{1}{\gamma\rho(\sigma_y^2+\sigma_r^2)}\{ & \\
-\Delta r + \tfrac{1}{2}(1+\tfrac{\sigma_r^2}{\sigma_y^2})k_1 \quad + \tfrac{1}{2}\sigma_y^2 \quad & + (\gamma-1)\theta(\sigma_y^2+\sigma_r^2) \qquad - \tfrac{1}{2}\gamma(1-\rho)\sigma_r^2 \\
-\Delta r - \tfrac{1}{2}(1+\tfrac{\sigma_r^2}{\sigma_y^2})k_1 \quad + \tfrac{1}{2}\sigma_y^2 \quad & + (\gamma-1)(1-\theta)(\sigma_y^2+\sigma_r^2) - \tfrac{1}{2}\gamma(1-\rho)\sigma_r^2 \\
\Delta r + \tfrac{1}{2}(1+\tfrac{\sigma_y^2}{\sigma_r^2})k_1 \quad + \tfrac{1}{2}\sigma_r^2 \quad & \qquad - \tfrac{1}{2}\gamma(1-\rho)\sigma_y^2 \\
\Delta r - \tfrac{1}{2}(1+\tfrac{\sigma_y^2}{\sigma_r^2})k_1 \quad + \tfrac{1}{2}\sigma_r^2 \quad & \qquad - \tfrac{1}{2}\gamma(1-\rho)\sigma_y^2\}
\end{aligned}
\tag{18}
$$

The immediate implication of these expressions is average home bias in portfolios. Particularly, $\alpha_h^b > \alpha_f^b$ for any k_1, and $\alpha_h^s > \alpha_f^s$ as long as $k_1 > 0$.

5.2 The home bias of the poor

The aim of this section is to derive the implications of standard portfolio theory for the evolution of portfolio shares of home and foreign assets along the distribution of wealth. For this, we have to take into account both the intensive margin, and the extensive margin, as investors may be constrained by borrowing limits for home assets and short-selling constraints for foreign assets. Write portfolio shares as

$$\overrightarrow{\alpha} = \overrightarrow{\alpha}_{\rho=1} + \frac{y}{W(1+R_p)}\overrightarrow{\alpha}_{\rho=0} \tag{19}$$

In other words, for any ρ, the vector of portfolios can be written as the weighted sum of the optimal diversified portfolio absent endowment wealth and a pure hedging portfolio that would be chosen with 0 net financial wealth. The following proposition shows that, if hedging concerns are sufficiently important - or the variability of aggregate endowments relative to the noise in equities sufficiently large - home investors first invest in home bonds and only eventually foreign assets, as net wealth rises.

Proposition 1 *Consider a symmetric equilibrium where there is at least one fully diversified home investor. As long as* $\frac{\sigma_y^2}{\sigma_r^2} > \frac{(1-\theta)(\gamma-1)+\frac{1}{2}}{(2\theta-1)(\gamma-1)} - \widetilde{k_1}$, *where* $\widetilde{k_1} > 0$,[24] *there are cutoff-values* $\rho_1 < 0 < \rho_2, \rho_2 < \rho_3$, *of the financial wealth-to-income ratio* ρ *such that:*

[23] It is easy to show that all results continue to hold as long as the return differential between home and foreign assets satisfy $r_f - r_h \leq [\frac{k_1}{+}2(\gamma-1)(\theta-\frac{1}{2})\sigma_y^2] > 0$ and $r_{sf} - r_{sh} \leq k_1 > 0$.

[24] $\widetilde{k_1} = \frac{1+\frac{\sigma_r^2}{\sigma_y^2}}{(2\theta-1)(\gamma-1)\sigma_r^2}k_1$

1. *Investors with* $\rho < \rho_1$ *have negative positions in both home assets and zero positions in foreign assets.*

2. *Investors with* $\rho : \rho_1 < \rho < \rho_2$ *have positive investments in home bonds only.*

3. *Investors with* $\rho > \rho_3$ *have positive investments in all assets.*

Proof

Ad 1: For there to be trade in all assets, positions in both home bonds and mutual fund shares have to be negative for some value of ρ. Since holdings of both assets are monotonously increasing in wealth and expected income is constant across agents, the result follows.

Ad 2: Note that the condition that there is at least one diversified investor implies

$$\Delta r + \tfrac{1}{2}(1 + \tfrac{\sigma_r^2}{\sigma_y^2})k_1 < \tfrac{1}{2}\sigma_y^2 + (\gamma - 1)(1 - \theta)(\sigma_y^2 + \sigma_r^2) \tag{20}$$

I show that an investor with zero net assets ($\rho = 0$) has positive home bond holdings and negative holdings of home mutual fund shares as long as $\frac{\sigma_r^2}{\sigma_y^2}$ is above a cutoff level. If this investor holds foreign bonds, we are done, since $\alpha_h^b > \alpha_f^b > 0$: since $\rho = 0$, this implies strictly negative home share holdings. Moreover, as both home and foreign bond holdings strictly increase with ρ,there is necessarily a $\rho : 0 > \rho > \rho_1$ such that foreign bond holdings are zero but home bond holdings positive.

If the investor only holds home assets, we can sign the difference in wealth-portfolio shares from (59) as

$$\gamma\rho(\sigma_y^2 + \sigma_r^2)[\alpha_h^b - \alpha_h^s] = 2\{[(\gamma - 1)\theta + \tfrac{1}{2}]\sigma_y^2 - \tfrac{1}{2}\sigma_r^2 - \Delta\} \tag{21}$$

Using (20) we get the following condition for the right-hand side of (21) to be positive

$$[(\gamma - 1)(2\theta - 1)\sigma_y^2 + \frac{1 + \frac{\sigma_r^2}{\sigma_y^2}}{(2\theta - 1)(\gamma - 1)\sigma_r^2}k_1 - [(\gamma - 1)(1 - \theta) + \tfrac{1}{2}]\sigma_r^2 > 0$$

which yields the condition in the text. The third possible case of a portfolio with positive holdings in both mutual funds and negative home bond holdings can be shown to have negative foreign mutual fund holdings under this condition, violating the short-sale constraint.

Ad 3: The statement follows from the monotonicity of asset holdings in total wealth, and the assumption that at least one investor has a fully diversified portfolio.

6 A calibrated example

The previous section derived parameter restrictions under which, in a symmetric equilibrium, wealth-poor investors initially have positive gross investment in home bonds only, while wealth-rich investors are fully diversified. This section takes a numerical approach to consider whether the empirically observed investment patters across the US wealth distribution arise in a realistic calibration of interest rates and relative volatilities of aggregate endowments and share returns.

6.1 Parameter choice

The model suggests two targets for the calibration of σ_y, the standard deviation of aggregate endowments, as a function of either aggregate (total or traded sector) output volatility or the (much more volatile) terms of trade. To give the general equilibrium terms of trade movements a chance to affect equilibrium portfolios, I set σ_y to 3 percent, an upper bound of the standard deviation of US post-war real GDP growth.[25] I then choose the noise parameter σ_r^2 such that the standard deviation of equity returns measured in domestic goods is 2.5 times that of GDP. It is well-known that CRRA preferences only generate realistic equity returns at very high risk-aversion. I therefore set the CRRA parameter γ to 30 in a benchmark calibration. I set the home bias parameter to a conservative 0.85, but analyse the sensitivity of the results to both choices. Finally, I set the equity premium equal to 225 basis points in the benchmark example.

6.2 Results

[Figure 6 somewhere here.]

[Figure 7 somewhere here.]

Figure 6 presents the portfolio shares as a function of the wealth-to-income ratio ρ in the benchmark calibration. The first thing to note is that the equity premium is too high for households to invest a positive fraction of their financial wealth in foreign bonds. This

[25] Calculating the standard deviation of US GDP growth between 2011 Q4 and starting periods between 1948 Q4 and 1985 Q4 yields estimates between 1.7 and 2.5 percent.

is first because, with strong home bias in consumption, foreign bonds are a bad hedge against terms of trade fluctuations. And second, high variability of equity returns makes short positions in bonds a more efficient hedge against endowment fluctuations than short positions in mutual fund shares. The same is not true, however, for home bonds, whose portfolio share we saw comprises a hedging term against terms of trade movements that increases with home bias in consumption. At $\rho = 0$, this term dominates the equity premium, such that agents with no net financial wealth invest in home bonds only. As financial wealth incrases, investors reduce their home bond portfolio share and diversify into home stocks. The fraction of the portfolio invested in home shares, however, remains flat above values of ρ greater than 0.3, when investors start investing in foreign stocks, whose portfolio share rises to just under 20 percent at high values of ρ.
The benchmark calibration can thus replicate two stylised facts observed in US micro data. First, less wealthy investors are less likely to invest in either foreign assets or stocks. Second, the share of foreign assets continues to rise along the wealth distribution even for those that participate in foreign asset markets. The calibration does not, however, predict any positive holdings of foreign bonds. In the data, the average fraction of direct foreign bond holdings was indeed very small. But bond mutual funds were shown to hold a positive fraction of foreign assets. This is a drawback of the model, even if a more general setup, where some foreign bonds carry, for example, default risk and pay premia relative to US treasuries, may be able to predict positive bond positions.

Figure 7 presents the evolution of portfolio shares across the wealth distribution for alternative calibrations of the model. The upper-left hand panel shows how, despite the relative advantage of home bonds in hedging terms of trade and endowment risk, the model does not solve the equity premium puzzle. This is because with an equity premium of 450 basis points, closer to that observed after WW II in the US, investors make leveraged investments in a portfolio of home and foreign equity, financed through issuing home bonds. Only for values of the wealth-to-income ratio ρ above 0.7 do investors make positive investment in home, although not foreign, bonds. A similar pattern of portfolio shares across the wealth-distribution results with lower risk aversion of $\gamma = 15$ (bottom-left hand panel), although the slightly lower net return on foreign shares, due to the small proportional cost of investing in foreign assets, implies a larger difference in the portfolio shares of home and foreign shares when risk-aversion is lower.
In the benchmark calibration, the volatility of equity return was 2.5 times that of GDP. The upper-left hand panel shows results when the return volatility term σ_r^2 is calibrated

to replicate a correlation between GDP and equity returns of 0.3, in line with post-war US data, which results in a higher value of $\sigma_r = 0.095$.[26] The implied greater volatility of the aggregate portfolio return reduces the weight of return differentials, which are scaled by $\sigma_y^2 + \sigma_r^2$ in equation (18), in the determination of portfolio shares. This in turn reduces the return-advantage of home and foreign equities, and thus their portfolio share at high wealth-to-income ratios. The pattern of portfolio-shares across the wealth distribution is thus similar to that in the benchmark calibration, but the fall in the share of home bonds less pronounced. Finally, with a lower home bias in consumption equal to 0.75 (lower right-hand panel), home bonds are a less attractive hedge against terms of trade movements. The portfolio share of home bonds at zero net financial wealth ($\rho = 0$) thus turns negative, as home shares have better combined hedging and return characteristics. Above values of $\rho = 0.2$, however, investors start to invest in foreign shares, and home bond portfolio shares rise above that of home shares.

6.3 Portfolio shares in the absence of terms of trade movements

To highlight the role of terms of trade movements, figure 8 shows portfolio shares in a one-good model, where share returns continue to be the same sum of a component proportional to GDP and a noise term, but where foreign and home goods are perfect substitutes in consumption. This eliminates the hedging advantage of home bonds for terms of trade movements, and gives foreign equity shares a comparative advantage over home shares, as the latter's returns are correlated with domestic GDP, but not those of the former. Investors with zero wealth thus take leveraged positions in foreign shares, financed by issuing home assets. As financial wealth rises relative to human wealth, home portfolio shares rise, until, at high values of ρ, investors invest in a diversified portfolio of home assets and foreign shares. This counterfactual investment pattern highlights the importance of terms of trade movements in generating a behaviour of portfolio-shares along the wealth distribution in line with that observed in US micro-data.

[26]The correlation between annual real GDP growth and real annual returns to the S&P 500 index (deflated by the GDP deflator) ranges between 0.13 and 0.33 over time periods with starting dates from 1963 to 1985 ending in 2011 Q4.

6.4 Generalising the model

The theoretical model of this paper made several simplifying assumptions. Specifically, it abstracted from capital investment, assumed homothetic preferences across goods, and looked at a simplified two-period version of the economy. This section discusses how the results translate to a more general environment.

Coeurdacier and Rey (2011), and similarly Coeurdacier et al. (2010), study aggregate country-portfolios in the general equilibrium of a two-country economy that is similar to the one analysed here, but takes into account capital investment, non-homothetic preferences and allows for more than two periods. Rather than heterogeneity in wealth levels and idiosyncratic income risk, however, the model has two representative agents, one for each country. Nevertheless, for the special case of very small deviations of individual wealth levels from the non-stochastic steady state mean, we can use their approximate solution to gain insights about individual portfolios in a more generally setting. The authors show how, like in the model of this paper, optimal portfolios comprise subportfolios that hedge against real exchange rate fluctutations and non-diversifiable labour income risk, respectively. Again, agents use bonds, not stocks, to hedge exchange rate risk, with home bond positions that (for risk-aversion $\gamma > 1$) exceed those of foreign bonds and are increasing in consumption home bias θ. The subportfolio that hedges against endowment risk, however, differs from that in the simple model of this paper. Particularly, with non-homothetic preferences, home and foreign stocks cease to be equivalent. Moreover, capital investment rises in periods with high productivity and high wages. The implied fall in dividends makes home stocks a good hedge against labour income risk. This implies a hedge portfolio with long stock positions biased towards home stocks, in contrast to the endowment model of this paper that featured a short position in stocks to hedge endowment risks. Also, hedging using stocks is not perfect as it was in the endowment case. Rather, agents hold an additional long position in home (foreign) bonds to hedge against the remaining positive (negative) comovement of real labour income with the terms of trade that results when the elasticity of substitution between home and foreign goods is relatively low (high). For sufficiently small heterogeneity in financial wealth and small idiosyncratic risk, the covariance structure of the terms of trade, labour income and asset returns should remain approximately unchanged. As long as portfolios are linear in wealth, the results should therefore be a guide also to individual portfolios, implying home bias of the poor: poor investors have relatively high expected labour income, and thus a portfolio dominated by hedging concerns, for which they invest mainly in home stocks and (for the case of a low elasticity of substitution) home bonds. This would explain relative home bias of the poor. In contrast to the simpler model of this paper, it does not imply, however, a bias of poor investors towards safe assets, as labour income risk is hedged through long, rather than short, positions in stocks. I leave a rigorous and quantitative investigation of a more general environment like this to future research.

7 Conclusion

In this paper I have shown that, according to the Survey of Consumer Finances, wealthier US households invest a higher share of their portfolio in international assets. This result is due both to the fact that poorer households are less likely to participate in foreign asset markets, and to lower portfolio shares of foreign assets for poorer participants. Importantly, the latter observation is not explained by fixed costs of participating in foreign asset markets.

This new fact provides additional evidence that can be used to test models of the international macroeconomy. In order to analyse the potential of standard models to account for this fact I showed, first, that the aim of hedging fluctuations in nominal income and the domestic price level, often emphasised in models of aggregate home bias, very naturally leads to heterogeneous portfolios along the wealth distribution. In a second step, I showed how the general equilibrium terms of trade movements in a stylised model of the international economy à la Cole and Obstfeld (1991) can make home bonds better hedges against fluctuations in consumer prices than foreign bonds. Moreover, they eliminate the relative attractiveness of foreign equity investments, whose returns, in the absence of terms of trade fluctuations, would lack the correlation with home incomes exhibited by home equity. Under the assumption of log-normal returns, I derived asset portfolios as a function of total investor wealth. I showed analytically that, as long as there are some diversified investors and aggregate fluctuations are strong enough relative to idiosyncratic noise in mutual fund returns, home bias decreases along the wealth distribution. I then showed how this pattern also arises in a realistic calibration of the economy.

The theoretical results of this paper are but a first step in the analysis of portfolio heterogeneity in models of the international macroeconomy. Specifically, the two-period structure and the assumption of identical, unit-elastic preferences, as well as the endowment nature of the economy, should be generalised in future work. And importantly, the implications of the standard theory in general should be contrasted with those from models where constraints to investors such as fixed costs, or behavioural patterns that depart from standard assumptions, play a role.

8 Appendix 1: Measurement error in foreign assets

The measure of total foreign asset holdings used in the empirical part of this study potentially suffers from at least two kinds of measurement error. First, the responses of households to questions on their asset holdings are accurate only insofar individuals both know the accurate dollar value of their assets, and truthfully report it. Since I only look at portfolio investments (in other words I disregard directly owned foreign companies), market values of investments are in principle available, and individuals should report their dollar values at current exchange rates. This may be a strong assumption not only as individuals might not be aware of up-to-date market values for long-term investments or exchange rates, but also, for example, if some of them underreport systematically offshore investments used to evade tax payments. In the latter case, however, the resulting measurement error would tend to dilute the correlation between wealth and the foreign asset share of the portfolio. So a rejection of the Null hypothesis of no relation would be less likely in the presence of this kind of measurement error. To see this, suppose all individuals were to invest x percent of their foreign asset holdings in unreported offshore vehicles. In this case, the difference between true portfolio shares $\widetilde{a_{true}}$ and those calculated from reported asset holdings can easily be shown to be $\frac{x}{1-x}(\widetilde{a_{true}})(1-\widetilde{a_{true}})$. Thus portfolio shares of foreign assets calculated from individual reports are always smaller than the true shares, and the difference is greatest for intermediate portfolios. As we see foreign asset shares rising from zero to single-digit percentages in Figure 2, the bias will increase along the wealth distribution.

A second source of measurement error results from the use of average portfolio shares in the imputation of households' indirect foreign asset holdings via mutual funds. If rich individuals systematically invest in funds with different exposures to foreign assets, this might distort the observed wealth effect on total foreign assets. But again, this error is likely to dampen the observed relationship between wealth and the portfolio share of foreign assets as long as richer individuals choose funds with a higher share of foreign assets. Using average mutual fund portfolios then introduces measurement error that is negative for rich individuals, positive for poor individuals. This biases the wealth effect estimated from observed data towards zero. The bias will be even stronger when richer individuals also have a higher portfolio share of mutual funds. So again, we would be less likely to reject the null of no wealth effect on portfolios in the presence of measurement error, than we would be without it.

9 Appendix 2 (Not For Publication): Derivations

9.1 The partial equilibrium problem

As in Cambpell and Viceira (2002), I adjust the log-portfolio for a Jensen's inequality term

$$log(R_p) = log((1-\alpha)R_h + \alpha R_f) \approx (1-\alpha)r_h + \alpha r_f + \alpha(1-\alpha)(\sigma^2_{r_f} + \sigma^2_{r_h}) \quad (22)$$

The participation decision Note that consumption with and without diversification into foreign assets is, respectively

$$C_{Div} = Y + W(1+R_p) - k(W) = Y + W((1-\alpha)R_h + \alpha(1+R_f)(1-K_1)) - K_0 \quad (23)$$

$$C_{NDiv} = Y + W(1+R_h) \quad (24)$$

$$(25)$$

Thus, the log-consumption-income-ratio approximately equals

$$log(C_{Div}/Y) = log(\frac{\overline{Y} + W(1+R_p)}{\overline{Y}} - \frac{K_0}{\overline{Y}}) + (1-\rho)y + \rho(w + (1-\alpha)r_h + \alpha r_f) + \alpha(1-\alpha)(\sigma^2_{rf} + \sigma^2_{rh}).$$

where the approximation is around $Y = \overline{Y}$, $R_F = R_H = R_p$. The condition for participation requires

$$E[U_{Div}] > E[U_{NDiv}] \Leftrightarrow log(\frac{E[C^{1-\gamma}_{Div}]}{E[C^{1-\gamma}_{NDiv}]}) < 0 \quad (27)$$

$$log(\frac{E[C^{1-\gamma}_{Div}]}{E[C^{1-\gamma}_{NDiv}]}) = (1-\gamma)\{log(1 - \frac{K_0}{\overline{Y} + W(1+R_p)}) + \rho\alpha[r_f - k_1 - r_h + (1-\alpha)(\sigma^2_{rh} + \sigma^2_{rf}]\}$$
$$+\frac{(1-\gamma)^2}{2}\alpha\rho^2[\alpha\frac{\sigma^2_{rh} + \sigma^2_{rf}}{2}]$$
$$+\alpha(1-\gamma)\rho\{(1-\rho)[\sigma^2_{r_f y} - \sigma^2_{r_h y}] - [\sigma^2_{r_f p} - \sigma^2_{r_h p}]\} < 0 \quad (28)$$

which, simplified, yields the expression in the main text.

The portfolio shares of participants

A second order approximation of the Euler equation yields

$$log(\frac{E[C^{-\gamma}_{Div}]}{E[C^{-\gamma}_{NDiv}]}) = 0 \quad (29)$$

$$r_f - k_1 - r_h + \frac{1}{2}[\sigma^2_{r_f} - \sigma^2_{r_h} - 2\gamma[\sigma^2_{c\ r_f} - \sigma^2_{c\ r_h}] \quad (30)$$

$$r_f - k_1 - r_h + \frac{1}{2}[\sigma^2_{r_f} - \sigma^2_{r_h} - \gamma[2\rho\alpha\sigma^2_{r_f} + 2(1-\rho)\sigma^2_{y\ r_f} -$$
$$2\rho(1-\alpha)\sigma^2_{r_h} - 2(1-\rho)\sigma^2_{y\ r_h} - 2\alpha(1-\gamma)(\sigma^2_{r_f p} - \sigma^2_{r_h p})] \quad (31)$$

which, simplified, yields the expression in the main text.

9.2 First order conditions and optimal portfolio shares in the general model

First order conditions can be written in compact form as

$$E[\overrightarrow{R}C^{-\gamma} - \mathbb{I}C^{-\gamma}R_H^b] = 0 \tag{32}$$

where upper arrows denote column vectors that comprise the equivalent terms from the first order conditions for foreign bonds, home and foreign mutual fund shares, and $\overrightarrow{R}$ is the vector of real returns on these three assets.The first-order condition can be written as

$$\overrightarrow{\tilde{r}_{-h}} + \tfrac{1}{2}[\overrightarrow{\sigma^2_{r-h}} - \gamma\overrightarrow{\sigma^2_{cr-h}}] = 0 \tag{33}$$

$$\overrightarrow{\tilde{r}_{-h}} + \tfrac{1}{2}\{\overrightarrow{\sigma^2_{r-h}} - \gamma[\rho(\overrightarrow{\sigma^2_{rr_h}} - \overrightarrow{\sigma^2_{r_h}} + \Sigma_{\Delta r}\overrightarrow{\alpha}) + (1-\rho)\sigma^2_{yr_{-h}}]\} = 0 \tag{34}$$

Here, $\overrightarrow{x}$ is a vector $[x_f^b, x_h^s, x_f^s]'$ of moments or random variables pertaining to foreign bonds, home and mutual fund shares. $\overrightarrow{x_{y_{-h}}}$ is the vector of differences between moment x of variable y for the three assets and that for home bonds. Specifically, $\overrightarrow{\tilde{r}}$ is the expected real log-return differential including terms of trade movements

$$\overrightarrow{\tilde{r}} = \begin{pmatrix} r_h^b + (\theta-1)y_h + (1-\theta)y_f \\ r_f^b + \theta y_h - \theta y_f \\ r_h^s + \theta y_h + (1-\theta)y_f \\ r_s^b + \theta y_h + (1-\theta)y_f \end{pmatrix} \tag{35}$$

$$\overrightarrow{\tilde{r}_{-h}} = \begin{pmatrix} r_f^b + y_h - y_f - r_h^b \\ r_h^s + y_h - r_h^b \\ r_s^b + y_h - r_h^b \end{pmatrix} \tag{36}$$

Also, denoting the variance of home and foreign aggregate incomes as σ_h^2, σ_f^2 respectively, the variance terms are

$$\overrightarrow{\tilde{\sigma}_r^2} = \begin{pmatrix} (\theta-1)^2\sigma_h^2 + (1-\theta)\sigma_f^2 \\ \theta^2\sigma_h^2 - \theta^2\sigma_f^2 \\ \theta^2\sigma_h^2 + (1-\theta)^2\sigma_f^2 \\ \theta^2\sigma_h^2 + (1-\theta)^2\sigma_f^2 \end{pmatrix} \tag{37}$$

$$\overrightarrow{\tilde{\sigma}^2{}_{r-h}} = \overrightarrow{\tilde{\sigma}_r^2} - \overrightarrow{\tilde{\sigma}_{r_h}^2} \begin{pmatrix} (2\theta-1)(\sigma_h^2 + \sigma_f^2) \\ (2\theta-1)\sigma_h^2 + \sigma_r^2 \\ (2\theta-1)\sigma_h^2 + \sigma_r^2 \end{pmatrix} \tag{38}$$

Moreover,

$$\Sigma_{\Delta r} = \sigma^2_{r_i,r_j} - \sigma^2_{r_i,r_h} - \sigma^2_{r_j,r_h} + \sigma^2_{r_h} \tag{39}$$

$$= \begin{pmatrix} \theta^2\sigma_h^2 + \theta^2\sigma_f^2 & \theta^2\sigma_h^2 + \theta(\theta-1)\sigma_f^2 & \theta^2\sigma_h^2 + \theta(\theta-1)\sigma_f^2 \\ \theta^2\sigma_h^2 + \theta(\theta-1)\sigma_f^2 & \theta^2\sigma_h^2 + (1-\theta^2)\sigma_f^2 + \sigma_r^2 & \theta^2\sigma_h^2 + (1-\theta^2)\sigma_f^2 \\ \theta^2\sigma_h^2 + \theta(\theta-1)\sigma_f^2 & \theta^2\sigma_h^2 + (1-\theta^2)\sigma_f^2 & \theta^2\sigma_h^2 + (1-\theta^2)\sigma_f^2 + \sigma_r^2 \end{pmatrix} - \tag{40}$$

$$\begin{pmatrix} \theta(\theta-1)(\sigma_h^2+\sigma_f^2) & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 \\ \theta(\theta-1)(\sigma_h^2+\sigma_f^2) & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 \\ \theta(\theta-1)(\sigma_h^2+\sigma_f^2) & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 \end{pmatrix} - \tag{41}$$

$$\begin{pmatrix} \theta(\theta-1)(\sigma_h^2+\sigma_f^2) & \theta(\theta-1)(\sigma_h^2+\sigma_f^2) & \theta(\theta-1)(\sigma_h^2+\sigma_f^2) \\ \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 \\ \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 & \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 \end{pmatrix} \tag{42}$$

$$+\mathbb{I}_{3x3}(\theta-1)^2(\sigma_h^2+\sigma_f^2) \tag{43}$$

$$= \begin{pmatrix} \sigma_h^2+\sigma_f^2 & \sigma_h^2 & \sigma_h^2 \\ \sigma_h^2 & \sigma_h^2+\sigma_r^2 & \sigma_h^2 \\ \sigma_h^2 & \sigma_h^2 & \sigma_h^2+\sigma_r^2 \end{pmatrix} \tag{44}$$

Notice that $\Sigma_{\Delta r}$ is singular whenever $\sigma_r^2 = 0$ and mutual fund shares thus have equal payoffs for all possible realisations of uncertainty. The covariance vectors of home endowments with real expected log-returns are

$$\sigma^2_{ry_h} = \begin{pmatrix} \theta(\theta-1)\sigma_h^2 + (1-\theta)^2\sigma_f^2 \\ \theta^2\sigma_h^2 - \theta(1-\theta)\sigma_f^2 \\ \theta^2\sigma_h^2 + (1-\theta)^2 \\ \theta^2\sigma_h^2 + (1-\theta)^2 \end{pmatrix} \tag{45}$$

$$\sigma^2_{ry_h-h} = \begin{pmatrix} \theta\sigma_h^2 + (\theta-1)\sigma_f^2 \\ \theta\sigma_h^2 \\ \theta\sigma_h^2 \end{pmatrix} \tag{46}$$

9.3 Unconstrained portfolios

If an investor holds all 4 assets, the vector of portfolio shares is

$$\overrightarrow{\alpha} = \frac{1}{\gamma\rho}\Sigma^{-1}_{\Delta r}\{\overrightarrow{r_{-h}} + \tfrac{1}{2}\{\overrightarrow{\sigma^2_{r-h}} - \gamma\rho\sigma^2_{r_h,r_j} - \gamma(1-\rho)\sigma^2_{ry_{h-h}}]\} \tag{47}$$

Imposing symmetry, so $\sigma_h^2 = \sigma_f^2 = \sigma_y^2$ this can be written as

$$\overrightarrow{\alpha} = \frac{1}{\gamma\rho}\Sigma_{\Delta r}^{-1}\{ \tag{48}$$

$$\overrightarrow{r_{-h}} + \frac{1}{2}\begin{pmatrix} 2(2\theta-1)\sigma_y^2 \\ (2\theta-1)\sigma_y^2+\sigma_r^2 \\ (2\theta-1)\sigma_y^2+\sigma_r^2 \end{pmatrix} - \gamma\rho(\theta-1)\begin{pmatrix} 2\sigma_y^2 \\ \sigma_y^2 \\ \sigma_y^2 \end{pmatrix} - \gamma(1-\rho)\begin{pmatrix} (2\theta-1)\sigma_y^2 \\ \theta\sigma_y^2 \\ \theta\sigma_y^2 \end{pmatrix}\} \tag{49}$$

with

$$\Sigma_{\Delta r}^{-1} = \frac{1}{\sigma_y^2+\sigma_r^2}\begin{pmatrix} 1+\frac{1}{2}\frac{\sigma_r^2}{\sigma_y^2} & -\frac{1}{2} & -\frac{1}{2} \\ -\frac{1}{2} & 1+\frac{1}{2}\frac{\sigma_y^2}{\sigma_r^2} & -\frac{1}{2}\frac{\sigma_y^2}{\sigma_r^2} \\ -\frac{1}{2} & -\frac{1}{2}\frac{\sigma_y^2}{\sigma_r^2} & 1+\frac{1}{2}\frac{\sigma_y^2}{\sigma_r^2} \end{pmatrix} \tag{50}$$

Solving this expression leads to the vector of portfolio shares in the main text, under the assumption that holdings of all 4 assets are unconstrained.

9.4 Constrained holdings of foreign mutual funds $\alpha_f^s = 0$

If agents are constrained in their holdings of foreign mutual fund shares $\alpha_f^s = 0$ but otherwise unconstrained, the corresponding expression is instead

$$\overrightarrow{\alpha} = \frac{1}{\gamma\rho}\Sigma_{\Delta r}^{-1}\{ \tag{51}$$

$$\overrightarrow{r_{-h}} + \frac{1}{2}\begin{pmatrix} (2\theta-1)\sigma_y^2 \\ (2\theta-1)\sigma_y^2+\sigma_r^2 \end{pmatrix} - \gamma\rho(\theta-1)\begin{pmatrix} 2\sigma_y^2 \\ \sigma_y^2 \end{pmatrix} - \gamma(1-\rho)\begin{pmatrix} (2\theta-1)\sigma_y^2 \\ \theta\sigma_y^2 \end{pmatrix}\} \tag{52}$$

with

$$\Sigma_{\Delta r}^{-1} = \frac{1}{\sigma_y^2+2\sigma_r^2}\begin{pmatrix} 1+\frac{\sigma_r^2}{\sigma_y^2} & -1 \\ -1 & 2 \end{pmatrix} \tag{53}$$

which yields portfolio shares as

$$\begin{aligned}
\overrightarrow{\alpha} &= [\alpha_h^b, \alpha_f^b, \alpha_h^s]' = \frac{1}{\gamma\rho(\sigma_y^2+2\sigma_r^2)}\{ \\
&-\Delta r + \frac{\sigma_r^2}{\sigma_y^2}k_1 + \tfrac{1}{2}(\sigma_y^2+\sigma_r^2) \quad + (\gamma-1)\theta(\sigma_y^2+2\sigma_r^2) \quad - \gamma(1-\rho)\sigma_r^2 \\
&-\Delta r - (1+\frac{\sigma_r^2}{\sigma_y^2})k_1 \quad + \tfrac{1}{2}(\sigma_y^2+\sigma_r^2) \quad + (\gamma-1)(1-\theta)(\sigma_y^2+2\sigma_r^2) - \gamma(1-\rho)\sigma_r^2 \\
&\ 2\Delta r + k_1 + \sigma_r^2 \quad - \gamma(1-\rho)\sigma_y^2\}
\end{aligned} \tag{54}$$

9.5 Constrained holdings of foreign bonds $\alpha_f^b = 0$

If agents are constrained in their holdings of foreign bonds $\alpha_f^h = 0$ but otherwise unconstrained, we get

$$\overrightarrow{\alpha} = \frac{1}{\gamma\rho}\Sigma_{\Delta r}^{-1}\{ \tag{55}$$

$$\overrightarrow{r_{-h}} + \tfrac{1}{2}\begin{pmatrix} (2\theta-1)\sigma_y^2+\sigma_r^2 \\ (2\theta-1)\sigma_y^2+\sigma_r^2 \end{pmatrix} - \gamma\rho(\theta-1)\begin{pmatrix} \sigma_y^2 \\ \sigma_y^2 \end{pmatrix} - \gamma(1-\rho)\begin{pmatrix} \theta\sigma_y^2 \\ \theta\sigma_y^2 \end{pmatrix}\} \tag{56}$$

with

$$\Sigma_{\Delta r}^{-1} = \frac{1}{2\sigma_y^2+\sigma_r^2}\begin{pmatrix} 1+\frac{\sigma_y^2}{\sigma_r^2} & \frac{\sigma_y^2}{\sigma_r^2} \\ -\frac{\sigma_y^2}{\sigma_r^2} & \frac{\sigma_y^2}{\sigma_r^2}+1 \end{pmatrix} \tag{57}$$

which yields portfolio shares as

$$\begin{aligned}
&\overrightarrow{\alpha} = [\alpha_h^b, \alpha_f^s, \alpha_h^s]' = \frac{1}{\gamma\rho(2\sigma_y^2+\sigma_r^2)}\{ \\
&-2\Delta r + k_1 + (\sigma_y^2 - \sigma_r^2) \quad + 2(\gamma-1)\theta\sigma_y^2 \quad + \gamma\rho\sigma_r^2 \\
&\Delta r - (1+\frac{\sigma_y^2}{\sigma_r^2})k_1 + \tfrac{1}{2}(\sigma_r^2 - \sigma_y^2) \quad - \theta(\gamma-1)\sigma_y^2 \quad + \gamma\gamma\rho\sigma_y^2 \\
&\Delta r + \frac{\sigma_y^2}{\sigma_r^2})k_1 + \tfrac{1}{2}(\sigma_r^2 - \sigma_y^2) \quad - \theta(\gamma-1)\sigma_y^2 \quad + \gamma\rho\sigma_y^2\}
\end{aligned} \tag{58}$$

9.6 Constrained holdings of foreign mutual funds and bonds $\alpha_f^s = \alpha_f^b = 0$

Finally, if both holdings of foreign bonds and foreign mutual fund shares are constrained, we get

$$\begin{aligned}
&\overrightarrow{\alpha} = [\alpha_h^b, \alpha_h^s]' = \frac{1}{\gamma\rho(\sigma_y^2+\sigma_r^2)}\{ \\
&-\Delta r + \tfrac{1}{2}(\sigma_y^2 - \sigma_r^2) \quad + (\gamma-1)\theta\sigma_y^2 \quad + \gamma\rho\sigma_r^2 \\
&\Delta r + \tfrac{1}{2}(\sigma_r^2 - \sigma_y^2) \quad - (\gamma-1)\theta\sigma_y^2 \quad + \gamma\rho\sigma_y^2\}
\end{aligned} \tag{59}$$

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10 Figures and Tables

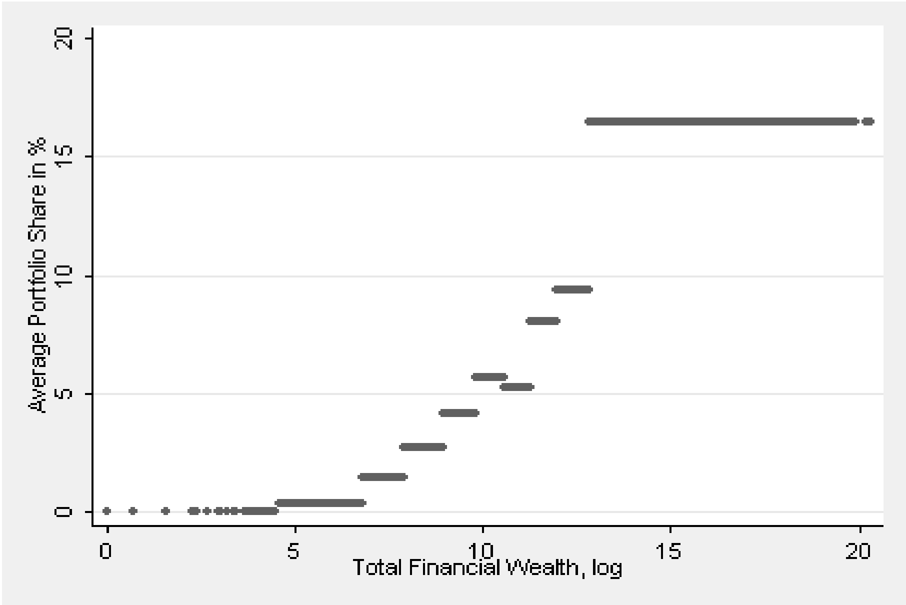

Figure 1: Portfolio share of domestic and foreign stocks (decile average) across the financial wealth distribution. Source: SCF 2004.

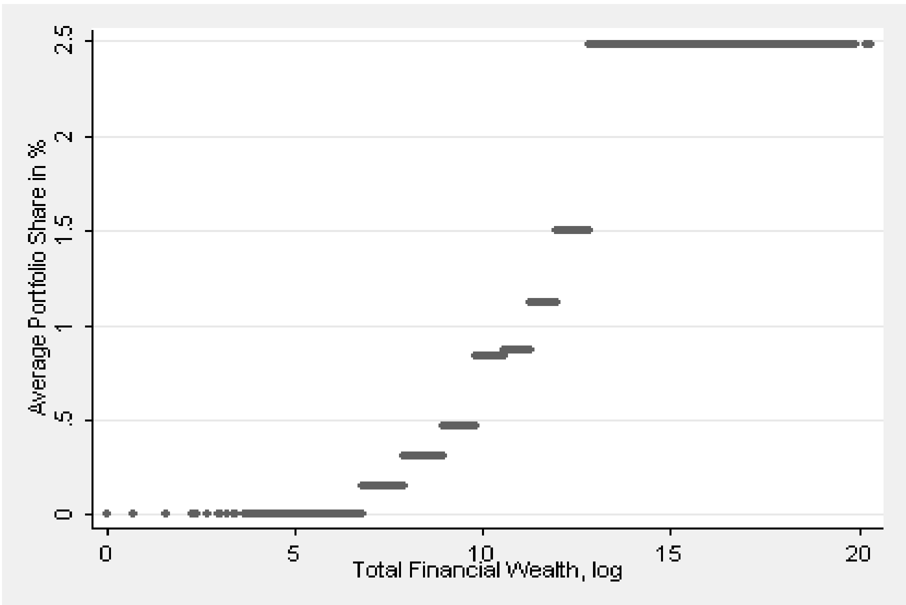

Figure 2: Portfolio share of total foreign assets (decile average) across the financial wealth distribution. Source: SCF 2004, Morningstar.

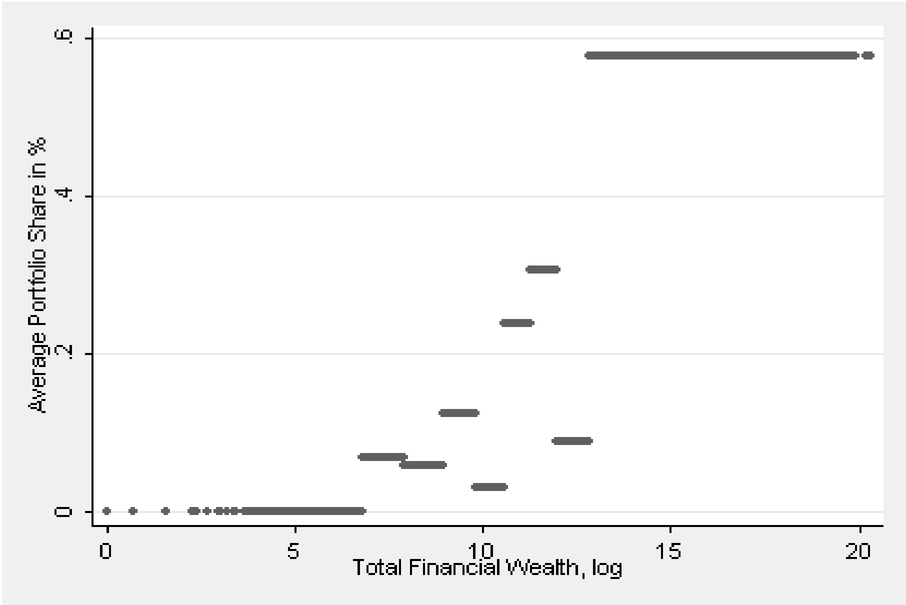

Figure 3: Portfolio share of directly-held foreign assets (decile average) across the financial wealth distribution. Source: SCF 2004, Morningstar.

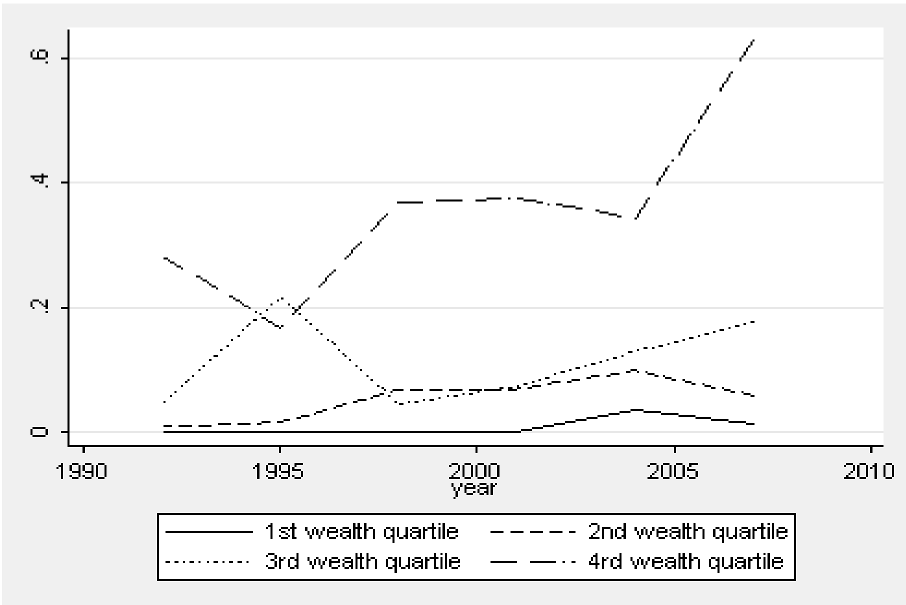

Figure 4: Portfolio share of directly held foreign assets averaged within wealth quartiles. Source: SCF 1992-2007.

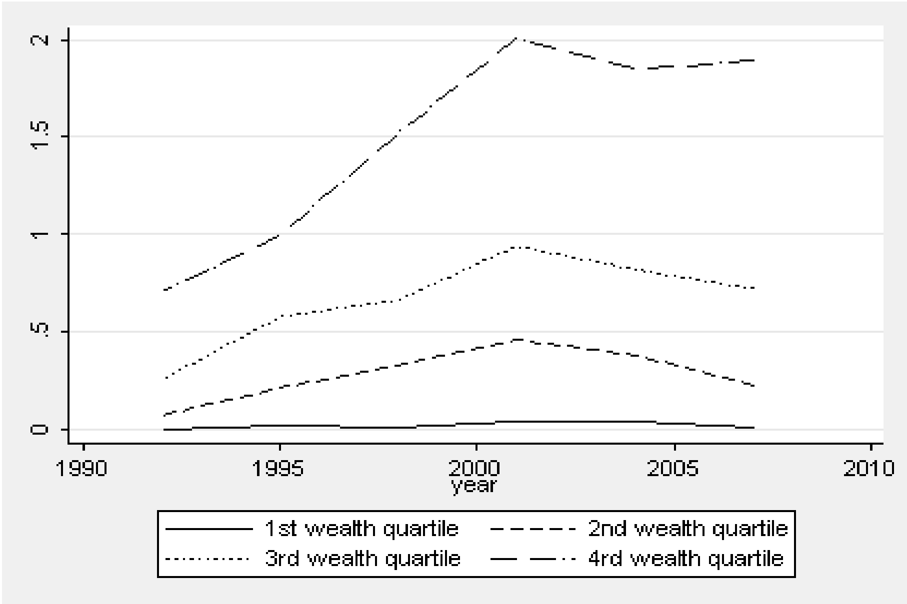

Figure 5: Portfolio share of total foreign assets averaged within wealth quartiles. Source: SCF 1992-2007, Morningstar.

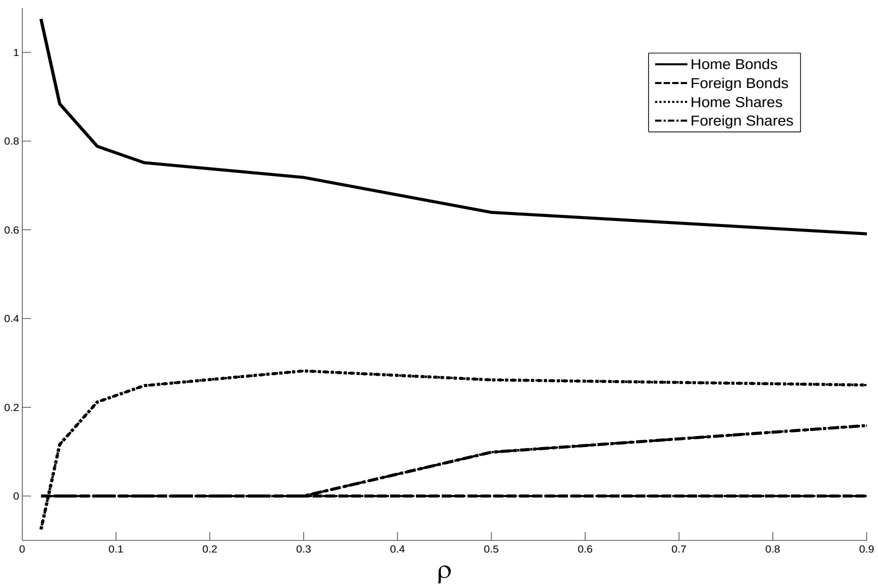

Figure 6: Portfolio shares in the benchmark calibration.

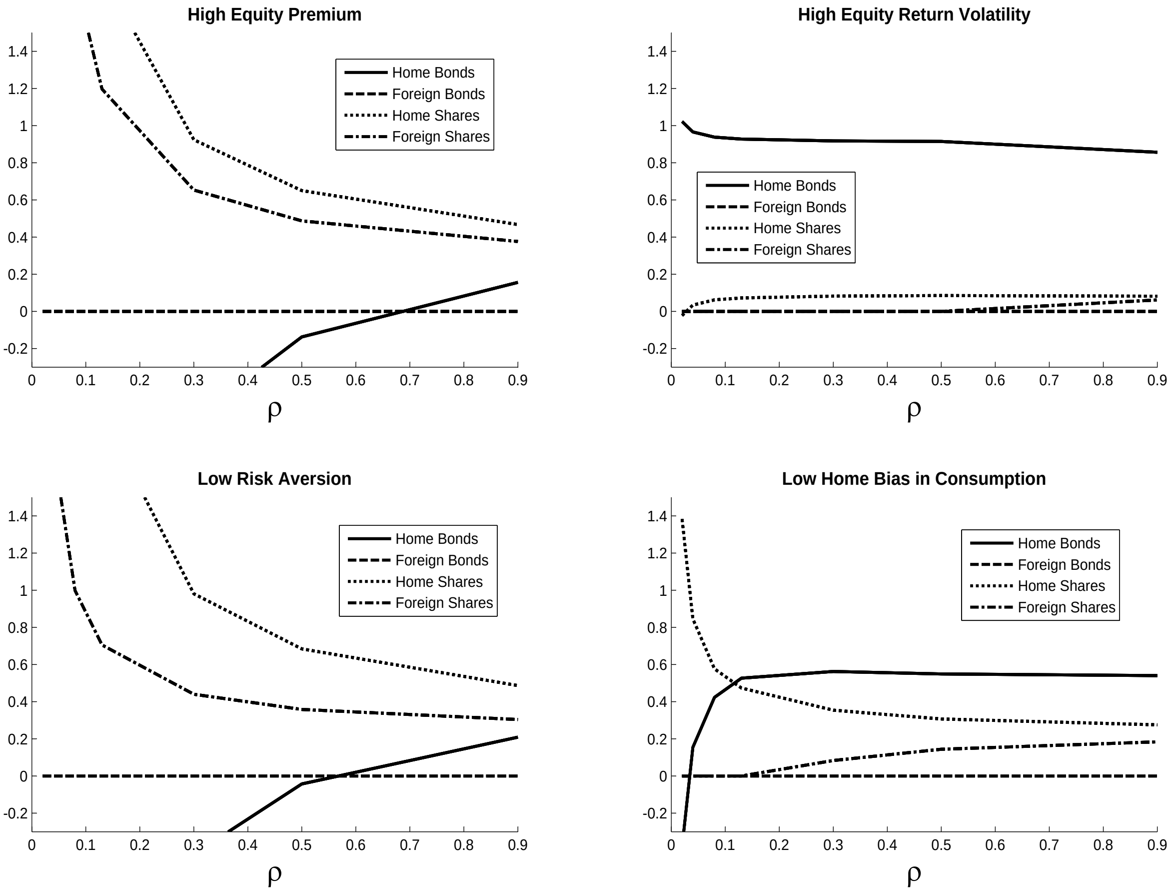

Figure 7: Portfolio shares in alternative calibrations with an equity premium of 450 basis points (upper left panel), a standard deviation of equity returns 4.2 times higher than that of GDP (upper right panel), lower risk aversion of 15 (lower left panel) and lower home bias in consumption of 0.75 (lower right panel).

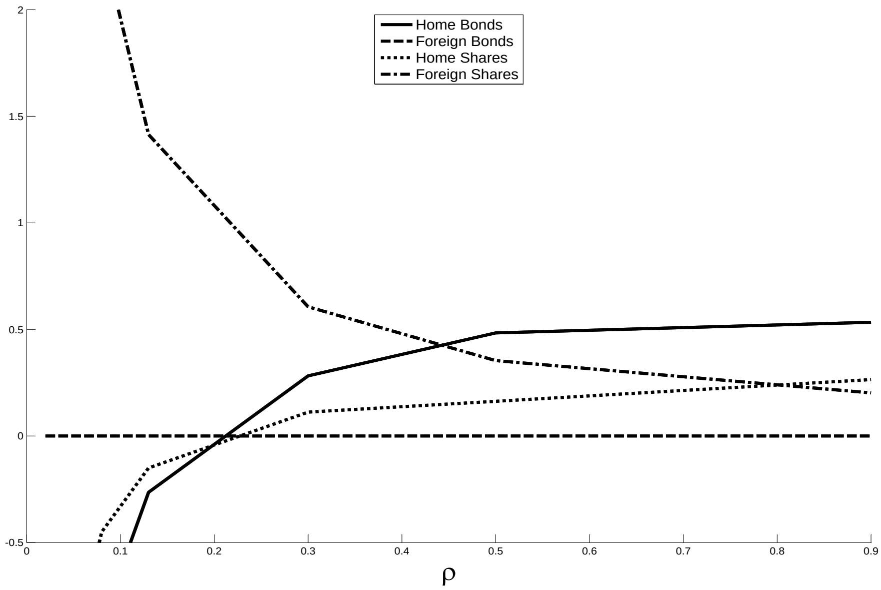

Figure 8: Portfolio shares in the one-good model.

Table 1: Heckman model for participation and portfolio share of stocks

Equation (1)									
ln(FIN)	ln(INCOME)	const							
5.73	-0.31	-80.65							
0.24	*0.15*	*0.42*							
Equation(2)									
FIN_2	FIN_3	FIN_4	AGE	AGE^2	AGE^3	Col	$BLACK$	$HISP$	const
0.83	1.24	1.72	-0.00	0.00	-0.00	0.10	-0.13	-0.15	-0.11
0.05	*0.08*	*0.09*	*0.00*	*0.00*	*0.00*	*0.01*	*0.02*	*0.04*	*0.01*
No of obs	25888	Censored:	15686						
$\chi^2(2)$	1106.8								

The estimation uses 6 waves of the SCF (1992,1995,1998,2001,2004 and 2007). The dependent variable is the portfolio share of stocks; FIN is the SCF measure of total gross financial wealth; INCOME the sum of salaries, wages and income or losses from a professional practice, business, limited partnership, or farming; AGE the age of the household head in years; FIN_x a dummy variable that takes the value 1 when financial wealth falls in the (weight-adjusted) xth quartile of the cumulative distribution; and COL (BLACK,HISP) dummy variables that equal 1 if the head of the household has a college degree (or reports her race as black, or hispanic, respectively). Numbers in italics are standard errors, clustered at the year level. The regression also contains a full set of year dummies in both equations.

Table 2: Heckman model for participation and portfolio share of foreign assets

Equation (1)									
ln(FIN)	ln(INCOME)	const							
0.92	-0.18	-14.14							
0.14	*0.15*	*2.76*							
Equation(2)									
FIN_2	FIN_3	FIN_4	AGE	AGE^2	AGE^3	Col	$BLACK$	$HISP$	const
1.08	1.63	2.07	-0.01	0.00	-0.00	0.11	-0.32	-0.11	-2.39
0.37	*0.34*	*0.32*	*0.02*	*0.00*	*0.00*	*0.05*	*0.14*	*0.14*	*0.35*
No of obs	25888	Censored:	24174						
$\chi^2(2)$	52.7								

The estimation uses the 2004 wave of the SCF. The dependent variable is the portfolio share of foreign bonds and stocks, domestic or foreign. For other variable definitions, see table 1. Numbers in italics are standard errors.

Table 3: Heckman model for participation and portfolio share of directly-held foreign assets

Equation (1)									
ln(FIN)	ln(INCOME)	const							
1.25	-0.13	-43.48							
0.20	*0.17*	*0.59*							
Equation(2)									
FIN_2	FIN_3	FIN_4	AGE	AGE^2	AGE^3	Col	$BLACK$	$HISP$	const
0.44	0.81	1.19	-0.01	0.00	-0.00	0.11	0.09	-0.11	-0.31
0.20	*0.15*	*0.14*	*0.01*	*0.00*	*0.00*	*0.01*	*0.08*	*0.09*	*0.01*
No of obs	4519	Censored:	4190						
$\chi^2(2)$	8.0								

The estimation uses 6 waves of the SCF (1992,1995,1998,2001,2004 and 2007). The dependent variable is the portfolio share of foreign bonds. For other variable definitions, see table 1. The selection equation has dummies for only two quartiles of the financial wealth distribution because no households in the first quartile hold foreign bonds. Numbers in italics are standard errors, clustered at the year level. The regression also contains a full set of year dummies in both equations.