The home bias of the poor: foreign asset portfolios across the wealth distribution

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Tobias Broer*

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Abstract

This paper documents how the share of foreign stocks in US household portfolios rises with the ratio of financial wealth to non-financial income. This is both because wealthier households are more likely to participate in foreign asset markets, and because portfolio shares of participants increase with financial wealth but decrease with non-financial income. A simple, standard two-country general equilibrium model shows that hedging of terms of trade movements and non-financial income risk produces non-trivial heterogeneity in portfolios across the wealth and income distribution within countries that is qualitatively in line with this evidence.

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

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*Institute for International Economic Studies, Stockholm University, tobias.broer@iies.su.se. Tel:+46(0)8163056; Fax:+46(0)8161443. A now outdated predecessor of this paper had the title "The home bias of the poor: Terms of trade effects and portfolios across the wealth distribution". I would like to thank David Backus, Per Krusell, John Leahy, and Gianluca Violante for helpful comments, as well as seminar participants at the Bank of England, the European University Institute, Cornell University, the University of Cyprus and NORMAC 2012. I especially thank Morten Ravn and Giancarlo Corsetti for their support with this work. And I am indebted to Federico Cepeda at Morningstar for his generous help with US mutual fund data, and to Mounir Karadja for excellent research assistance. The author gratefully acknowledges financial support from the European Research Council under Advanced Grant 230574.

1 Introduction

Despite the process of financial globalisation since the early 1980s, investors around the globe still seem to hold a disproportionate share of local equities in their portfolios. For example, in 2006 the average US investor had a portfolio share of foreign equities three times smaller than the relative market capitalisation of non-US listed companies.[1] This contrasts with the prediction from basic models of investor difersification that homogeneous investors should simply hold the market portfolio. The vast literature that followed French and Poterba (1991), who first drew attention to this puzzling "home bias" in international equity portfolios, has mainly focused on two mechanisms: higher (fixed or variable) costs of investing in foreign assets (due to, for example, tax disadvantages or more costly information acquisition), and their possibly inferior ability to hedge risks faced by domestic investors (such as fluctuations in their non-financial income or exchange rates).

Virtually all models of home bias in country portfolios rely on the assumption of a single representative agent in each country. This convenient simplification, however, prevents the models from studying any distributional issues, including the distribution of portfolios within countries. The current paper, in contrast, starts from the simple observation that the standard explanations of home bias in the international macro literature imply strong variation in portfolios across households with different wealth and income levels. This is first because, trivially, fixed costs are relatively more costly for individuals with low financial wealth and low income. But even for participants in foreign asset markets, the prominent role that theory gives to the ratio of non-financial income to financial wealth, which determines the importance of hedging fluctuations in non-diversifiable income, implies potentially strong variation in portfolio shares across households that differ in income and financial wealth. The paper then shows, in a simplified framework, that the general equilibrium terms of trade effects emphasized by the home bias literature alone imply portfolio heterogeneity that is qualitatively in line with that observed in US data. It thus takes a first step both towards a new test of

[1] See Coeurdacier and Rey (2013).

the theory using an additional dimension of the data, and towards explaining a previously unappreciated investment pattern in US microdata.

The paper starts by analysing the patterns of foreign asset investment in US micro data. In contrast to previous studies of individual foreign asset holdings, such as Christelis and Georgarakos (2013) or Kyrychenko and Shum (2009), I consider both direct and indirect holdings of foreign assets (by combining data from the Survey of Consumer Finances (SCF) on individual mutual fund investments with information on the portfolios of more than 4700 US mutual funds provided by Morningstar).[2] Also, I estimate jointly the participation decision in the market for foreign assets and their share in the portfolios of participants. The results show how the portfolio share of participants in foreign stock markets rises significantly as the ratio of financial wealth to non-financial income increases, and that the likelihood of participation rises strongly along the wealth distribution.

As a first step to understand the observed investment patterns, the second part of this paper builds on studies of "home bias" in country portfolios.[3] These have pointed out that general equilibrium responses of exchange rates and terms of trade can cause comovement of real asset returns and other sources of income that makes optimal portfolios depart significantly from the naive benchmark of full diversification. I use a version of the two-country environment in Cole and Obstfeld (1991) with trade in bonds (as in Coeurdacier and Gourinchas (2011)) where non-tradable income risk (as in Baxter and Jermann (1997)) introduces country-specific hedging terms in optimal portfolios. While Bottazzi et al. (1996) show that the implied portfolio depends on the covariance of returns to labour and capital, this paper points out that the hedging motive becomes less important as the financial wealth-to-income ratio increases. Together with short-selling constraints on foreign assets, this naturally implies variation in individual portfolios along both the extensive and intensive margin that captures

[2]Christelis and Georgarakos (2013) 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. Nechio (2010) reports some descriptive evidence on indirect ownership of foreign stocks through investment funds from the Investment Company Institute. Hau and Rey (2008a) and Hau and Rey (2008b) look directly at mutual fund portfolios.

[3]See Lewis (1999) and Coeurdacier and Rey (2013) for surveys of the home bias literature.

some key patterns identified in US micro-data. Specifically, there is a threshold level of the financial wealth-to-income ratio beyond which investors start holding foreign equity, whose portfolio share increases as financial wealth rises relative to income. Foreign bond holdings, on the other hand, are zero for most parameter combinations in the model, again approximately in line with US evidence.

The reason for this investment pattern lies in the terms of trade movements pointed out by representative agent models of portfolio home bias. To see this, note that in local currency, home labour income is perfectly correlated with home equity returns, both driven by the same productivity shocks, but uncorrelated with foreign asset returns.[4] In the absence of relative price movements, this would make foreign assets very attractive for hedging labour market risk. The general equilibrium response of the terms of trade, however, makes home goods cheap when home productivity and home labour income are high. This introduces a positive correlation of home labour income with real returns to foreign assets (which are high when high home productivity makes home goods relatively cheap). At the same time, these terms of trade movements imply a negative correlation of home labour income with home bond returns (which are low when high home productivity makes home goods relatively cheap). This makes home bonds an attractive hedge against labour income risk. And this hedge is relatively more attractive for investors with low financial wealth. High wealth investors, on the other hand, invest in a diversified portfolio of home assets and foreign equity. General equilibrium terms of trade movements therefore naturally imply variation of portfolios across investors that differ in their composition of lifetime wealth across financial and human capital.

The contribution of this paper to the literature on household finances and to that on international portfolio choice is thus three-fold. First, it points out how the importance of

[4]Note that this paper abstracts from capital. Heathcote and Perri (2013) 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. 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. Similarly, Engel and Matsumoto (2009) show how, with sticky nominal prices and forward positions in nominal exchange rates, complete risk-sharing can be achieved with low equity diversification.

the wealth-to-income ratio in standard international portfolio theory very naturally leads to heterogeneity in portfolios once the assumption of a representative household is replaced by a distribution of income and wealth levels within countries. Second, it establishes, in its empirical part, new stylised facts that provides additional evidence against which we can test models. Finally, in its theoretical section, the paper takes a first step to illustrating how standard general equilibrium models of the international macroeconomy augmented by wealth heterogeneity and short-sale constraints on foreign assets have the potential to pass such a test by predicting portfolio heterogeneity that is at least qualitatively in line with the data.

Section II analyses portfolio shares of foreign assets across the wealth distribution in 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. Section V illustrates these results through a quantitative example.

2 Portfolios across the wealth distribution: evidence from the SCF

Standard theory gives an important role to the ratio of financial wealth to non-financial income in the determination of optimal household portfolios. To illustrate the relationship between the portfolio share of foreign assets and this financial wealth-to-income ratio among US households, I analyse data from the 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".[5]

The SCF is a triannual survey of US households that asks respondents for a rich variety of information about their finances. Data availability on some of the covariates I use in the estimation below (which are unavailable prior to 2001) restricts me to the waves of the survey

[5]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.

conducted in 2001, 2004, 2007 and 2010. I do not perform any further sample selection apart from that implied by calculating ratios and taking logarithms of financial wealth and income. Particularly, notice that I do include households with 0 foreign asset holdings. The final sample has 18635 observations.

2.1 Average portfolio share of foreign assets

Panel *a*) of figure 1 plots the logarithm of the ratio of gross financial wealth and non-financial income (defined as the sum of wages, business and farm income, and transfers, on the horizontal axis) against the portfolio share of directly owned foreign stocks (averaged within deciles of the financial-wealth-to-income ratio to reduce noise, on the vertical axis).[6] Panel *b*) of figure 1 plots the equivalent for bonds.

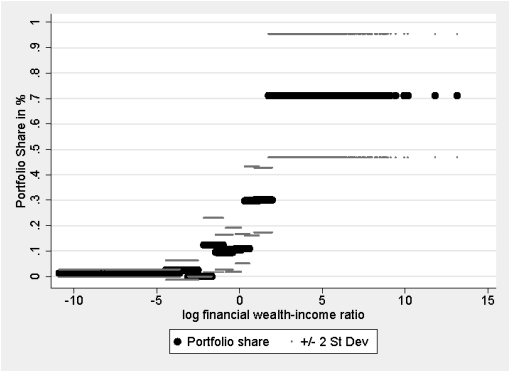
The first thing to note is that direct holdings of foreign bonds play only a small role in the portfolios of US households, with a maximum decile average of about 0.025 percent of financial wealth. The portfolio share of foreign stocks, on the other hand, averages up to 0.7 percent across households in the top decile of the financial wealth-to-income distribution. As the descriptive statistics in table 4 in the appendix show, underlying the small average portfolio share of directly held bonds is a small number of participants of 0.6 percent. Foreign stocks, on the other hand, are held directly by more than 6 percent of households, with an average portfolio share of 7.2 percent.[7] Interestingly, while households in the bottom three deciles (roughly corresponding to those households with positive financial wealth of less than yearly income) own virtually no foreign stocks, the portfolio share rises strongly across deciles

[6]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.

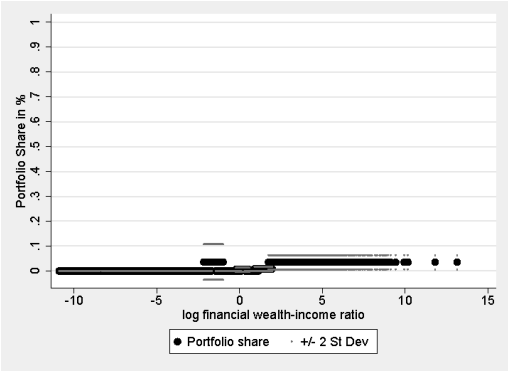
[7]To interpret the magnitudes, it is important to note that the values in panels *a*) and *b*) of figure 1 are not directly comparable to the share of foreign assets in aggregate country portfolios, often calculated simply as the ratio of a country's foreign equity holdings to its domestic market capitalisation. The measure in figure 1 and 2, in contrast, uses the SCF measure of gross financial wealth as the denominator of the ratio, which includes a large range of non-equity-non-bond 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, including indirect holdings, to total gross financial wealth in the implied weighted aggregate portfolio is 3 percent in 2004.

4 to 10, with point estimates of the average portfolio share that cannot be rejected to increase monotonically with the financial-wealth-to-income ratio. The rise for bonds, on the other hand, is less monotonic and less well-defined.

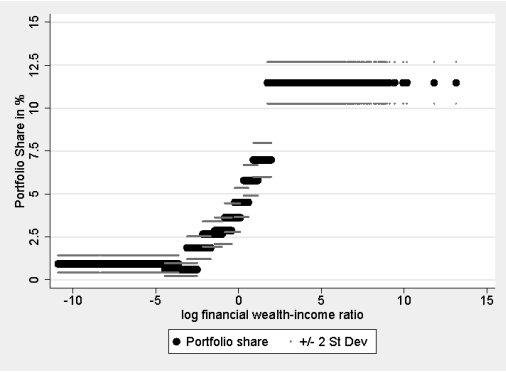
Figure 1: Scatter plots of foreign asset holdings - decile averages



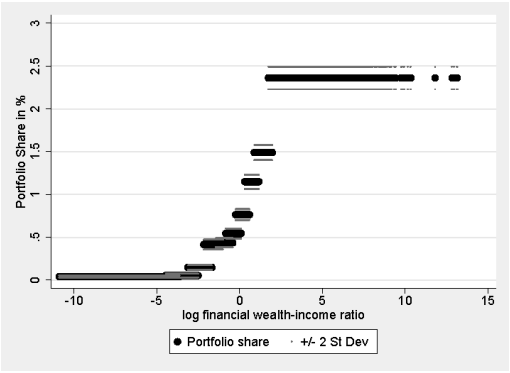
(a) Portfolio shares of directly-held foreign equity



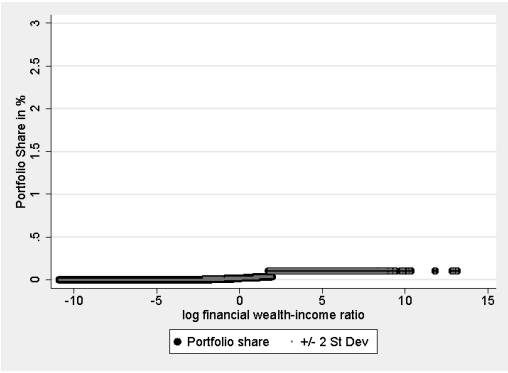
(b) Portfolio shares of directly-held foreign bonds



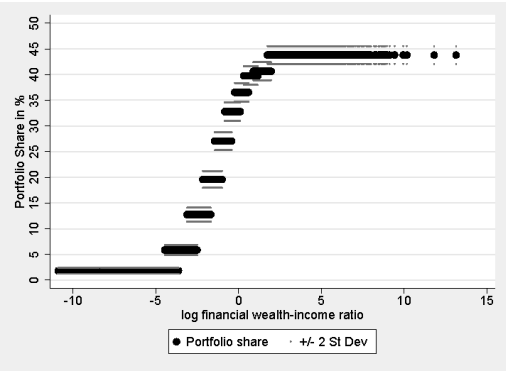
(c) Portfolio shares of directly-held stocks



(d) Portfolio shares of total foreign equity



(e) Portfolio shares of total foreign bonds



(f) Portfolio shares of total stocks

The scatter plots show, on the vertical axis, average portfolio shares, and on the horizontal axis the logarithm of the ratio of gross financial wealth to non-financial income. The top row shows portfolio shares of directly held foreign stocks (panel a)), bonds (panel b)) and foreign plus domestic stocks (panel c)). The bottom row shows portfolio shares of a measure of total foreign stocks (panel d)), bonds (panel e)) and foreign plus domestic stocks (panel f)), including those via mutual funds. The graph uses the average portfolio share for each decile of the financial-wealth-to-income ratio, where the deciles are calculated for each of the four waves and each of their 5 imputations separately taking into account the oversampling of high wealth households. Source: SCF 2001, 2004, 2007, 2010.

Panel c) compares the distributions of foreign asset holdings to that of total stock holdings, both foreign and domestic.[8] As can be seen, foreign stocks are only a small fraction of the overall equity holdings of US households. For example, households in the upper decile of the financial wealth-to-income distribution on average hold about 12 percent of their financial wealth in equity, of which about 94 percent are domestic stocks. The patterns of foreign and domestic stock holdings across the wealth distribution are, however, rather similar, with a level close to 0 for the lower three (in the case of total stocks two) deciles and a strong, approximately monotone increase across the rest of the distribution.

The portfolio shares in the upper panels of figure 1 only paint a partial picture, as they do not take into account that households hold some foreign assets through investment funds. The bottom panels therefore plot a measure of portfolio shares that accounts for foreign assets held via mutual funds,[9] derived by summing to households' direct investments the reported value of their mutual fund shares in equity, bond and combination funds multiplied by an average portfolio weight of foreign bonds and equity in each type of fund.[10] Although this measure suffers from measurement error that will be more important the larger is the variation in portfolio shares across mutual funds and across time, it is conceptually superior, as it accounts for a much larger share of asset holdings and is immune to changes in the composition of direct vs. indirect holdings that are correlated with the financial wealth-to-

[8]Like Christelis and Georgarakos (2013), we compare foreign stock holdings to total stockholdings, domestic and foreign. This is because the imputation procedure for total indirect stockholdings in the SCF and that for indirect foreign stock holdings I use are different. Moreover, the SCF measure of total stock holdings takes into account a wider variety of investment funds. Simply subtracting our measure for total foreign stock holdings from that of the SCF would therefore be inconsistent, which I avoid by comparing foreign to total stock holdings.

[9]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.

[10]These average portfolio shares I derive on the basis of a dataset kindly provided by Morningstar, containing the universe of more than 4700 US mutual fund portfolios, not including funds of funds, in 2003. From this I calculated weighted averages for portfolio shares of foreign bonds and equity for the three categories of funds. 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) invested 3.7 percent abroad. Combination funds invested on average 10.7 percent in non-US assets.

income ratio. The resulting portfolio shares of total foreign stocks, shown in panel d), are larger, with a maximum average of abuot 2.5 percent in the richest decile. Importantly, while the general pattern of portflio shares, including non-participation in the bottom three deciles of the wealth-distribution, is similar for direct foreign stock holdings, the monotonic increase in foreign stock holdings across the distribution of the household financial-wealth-to-income ratio is now even more marked. Foreign bond portfolio shares (in panel e)), in contrast, continue to be small, rising to only about 0.1 percent for the highest-wealth decile, corresponding to about 4 percent of the portfolio share of foreign stocks. This is because bond and hybrid mutual funds present a smaller part of household portfolios than stock funds, and their average share of foreign assets is smaller. Again, panel f) of figure 1 compares these distributions to that of the portfolio share of total equity holdings, foreign and domestic, including indirect holdings via mutual and other funds.[11] As with direct holdings, total equity holdings rise quicker and more strongly across the distribution of the financial wealth-to-income ratio, reaching about 45 percent in the highest decile, about 20 times the share of foreign stocks.

2.2 Joint estimation of portfolio shares and participation

The decile averages presented in figure 1 do not condition on potentially important determinants of portfolio shares other than the financial-wealth-to-income ratio, such as education or age. Nor do they distinguish between a rise in the participation rate and a rise in individual portfolio shares of participants along the distribution of that ratio. The rest of this section presents a more formal econometric analysis that jointly estimates the participation and portfolio decisions of foreign and total equity investment (as bond holdings were shown to play a less important role in household portfolios at all wealth levels). Specifically, to jointly analyse the probability of participation and the optimal portfolio share of participants, I use

[11] In contrast to the author's calculation of a measure of total foreign asset holdings based on individual mutual fund holdings and their average portfolio share of foreign assets in 2003, the total stock holding is provided by the SCF. It is calculated as the sum of direct holdings and indirect holdings via stock mutual funds, 50 percent of combination mutual funds, a fixed fraction of IRAs/Keoghs invested in stock and of other managed assets with equity interest (annuities, trusts, MIAs), and thrift-type retirement accounts invested in stock.

the Heckman (1979) method to estimate the following 2 equation system

$$SHARE = \begin{cases} \alpha + \beta_1 log(FIN/Y) + \beta_2 log(FIN) + b_1 AGE_3 + b_2 X_1 + \epsilon_1 & \text{if } H > 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

with

$$H = a + b_3 X_2 + \epsilon_2 \quad (2)$$

SHARE is the household's portfolio share of (foreign or total) equity, equal to the ratio of equity holdings to the SCF definition of gross financial wealth in percent. When an individual participates in the equity market, which I define as a positive portfolio share, theory predicts one of the main determinants of her portfolio share to be the ratio of her financial to human wealth, which determines the preference for assets that hedge non-diversifiable income risk. As a proxy, equation (1) specifies SHARE as a function of $log(FIN/Y)$, the log ratio of financial wealth to current non-financial income (the sum of wages, business and farm income, and transfers), but also includes the log-level of financial wealth ($log(FIN)$), a vector of individual characteristics X_1 and a cubic function of age (AGE_3) to capture life-cycle effects. Participation only occurs, however, when the indicator variable H is above a threshold normalised to 0. H, which captures the probability of participation in foreign asset markets, is a function of a vector of household characteristics X_2 and a household specific error ϵ_2 that is jointly normally distributed with the error in the portfolio equation ϵ_1, implying that unlikely participants (with high ϵ_1) may have an unexpectedly high portfolio share (high ϵ_2) conditional on observables. The coefficients β_i and coefficient vectors b_i are estimated jointly using full maximum-likelihood adjusted for sampling weights.

Table 3 in the appendix gives a full list of the regressors X_2 and X_1. Apart from financial wealth and non-financial income (both as binary quartile "dummies"), X_2 includes an indicator of the household head's age bracket in decades (to capture life-cycle effects in participation) and a number of binary, or "dummy", variables. Some of these capture standard household characteristics such as the gender of the household head, whether a household head is mar-

ried, has children, or has a college degree (and may thus find complex financial products easier to understand). In addition, X_2 also includes dummy variables for household characteristics that have been found to affect participation in financial markets in previous studies, such as race (as suggested by Bertaut and Starr-McCluer (2000)), poor health of the household head or his or her partner (which may discourage stock investment as found by Rosen and Wu (2004)), self-reported risk-taking behaviour (as a proxy of risk aversion), and two kinds of self-reported financial investment behaviour indicating that an individual shops around for good deals on savings and investments, or uses the internet to gather investment information (as in Christelis and Georgarakos (2013)).

While the specification of the participation equation (2) follows the standard in the literature (see e.g. Christelis and Georgarakos (2013) for a review), there are much fewer studies that jointly estimate participation together with the portfolio share of participants. The specification of the outcome equation (1) is kept explicitly parsimonious,[12] controlling for just the main household characteristics (race, college degree, self-reported risk-taking behaviour) and age effects.[13]

Table 1 reports the results of estimating equations (1) and (2) for our measure of foreign stock holdings adjusted for indirect holdings via mutual funds. Specifically, the table presents the marginal effect of any independent variable in equation (1) on the expected value of the portfolio share conditional on participation, and the marginal effects of the independent variables in (2) on the probability of participation, both evaluated at the median of all independent variables. The point estimates associated to the financial wealth quartile indicators in equa-

[12]This is first because households characteristics such as self-reported shopping around for good financial deals may affect the participation decision but should not impact on the optimal portfolio share of participants. Also, the identification of the Heckman (1979) selection model is problematic when the regressors in equations (1) and (2) are identical. The model is in principle identified as the selection equation variables enter non-linearly in the outcome equation via the probability of selection. In practice, however, the collinearity this implies leads to weak identification and large standard errors.

[13]Note that the two main variables of interest, income and financial wealth, as well as the age of the household head, enter the the outcome equation (1), respectively, as a log-ratio and the log level of financial wealth, and a cubic function of age. In the selection equation (2), in contrast, they appear as dummies for quartiles (and age decades, respectively). This is, first, because the ratio of financial to human wealth is an important variable that determines the portfolio share according to theory. Participation, on the other hand, may depend on the level of financial ressources in a non-linear fashion if fixed costs are important. Second, including the variables in different transformations in both equations attenuates identification problems.

tion (2) indicate that the probability of participation rises monotonically across the wealth distribution. The effect of income on the participation decision is, in contrast, insignificant. Together, this could be interpreted as evidence of fixed costs of foreign asset investment, which play a smaller role for households with high financial wealth. The effect of current income on participation would then derive both from higher current resources (which might increase participation) and from it proxying higher life-time human wealth (which may discourage participation if foreign assets are bad hedges against future fluctuations in non-financial income), potentially explaining the small estimated income effect. Among the household characteristics, above average risk-taking and a college degree increase the probability of participation by similar amounts, and there are significant negative race effects. Somewhat contrary to the previous literature (such as Christelis and Georgarakos (2013)), I find that internet use has little effect on the likelihood of participation, and the same is true for marital status, family size (through the $KIDS$ variable), gender or employment status. In line with previous studies, however, poor health reduces the likelihood of holding foreign stocks, while shopping around for good deals increases it, but both by small amounts.[14] Importantly, the hypothesis of no selection (independent error terms in equations (1) and (2)) is strongly rejected.

Interestingly for the theory in the remainder of the paper, the estimates of equation (1) in table 1 give an important role to the ratio of financial wealth to non-financial income in determining the portfolio share of participants. Specifically, for a given level of financial wealth, households whose non-financial income is higher, resulting in a lower value of $log(FIN/Y)$, are predicted to have a lower portfolio share of foreign stocks. The positive marginal effect of log-financial wealth, however, shows that it also affects the portfolio share beyond its ratio to non-financial income. Broer (2015) shows how, for direct holdings of foreign stocks excluding those via mutual funds, the estimation results are very similar, but financial wealth does in fact not affect portfolio shares significantly other than through this ratio to non-financial income. An equal percentage increase in non-financial income and financial wealth does therefore not

[14]The point estimates of the coefficients in equation 2 should be compared to an unconditional probability of holding foreign stocks of 23 percent in the sample.

have a statistically significant effect on the portfolio share of directly held foreign stocks. One interpretation of these different results for the two measures of foreign stock holdings is that mutual fund holdings, on the basis of which I infer indirect holdings of foreign stocks, are positively related to financial wealth beyond its ratio to non-financial income. Overall, the model explains a highly significant share of the variation in the data, as the F statistic reported in table 1 shows.

The estimates of equations (1) and (2) for the SCF measure of total stock holdings, reported in table 2, are similar to those for foreign stocks, but with larger marginal effects in both the selection equation (2) and outcome equation (1), in line with the larger variation in participation rates across the wealth distribution in panel f) of figure 1, and the higher portfolio shares of total stock holdings in the top deciles. Importantly, as in the case of foreign stocks, there is a significant, monotonic rise in the probability of participation along the wealth distribution, similar in magnitude to that found in Guiso et al. (2003). In contrast to foreign stocks, income has a significantly positive, but still small, effect on participation. The effect of self-reported risk-taking on the likelihood of participation is highly significant, with a point estimate one and a half times that for foreign stocks. A college degree also increases the likelihood of participation in stockmarkets, but, interestingly, the effect is smaller than for foreign stocks, in line with a view of foreign stocks as relatively sophisticated financial investments. Both a college degree, and even more so risk-taking, strongly increase the portfolio share of participants. Race effects on participation are similar to those for foreign stocks, and participating households whose head reports to be black have a significantly lower portfolio share (although not those with hispanic heads, reversing the pattern for foreign stocks). Self-reported internet use and being married increase the likelihood of participation in the stock market, while households whose head has poor health, is unemployed or male are less likely to participate. There is also a small negative effect, somewhat in contrast to the literature, of self-reported shopping around behaviour. And finally, while age effects were small for foreign stocks, the likelihood to participate in the stock market in general is estimated to decline with age, once we condition on income and wealth. As with foreign stocks, among market

participants household portfolio shares of stocks are estimated to increase significantly with their ratio of financial wealth to non-financial income, but again log financial wealth has an additional positive effect of similar magnitude.

Several stylised facts emerge from the analysis: First, foreign bond holdings are small in magnitude, with decile averages below 0.1 percent even when accounting for indirect holdings via mutual funds. Second, there is significant and large heterogeneity in households' foreign stock holdings along the wealth distribution. The probability of participation increases significantly with financial wealth, and so does the portfolio share of participants. Depending on the specific measure of foreign stocks used, the latter effect is captured partly or fully through the ratio of financial wealth to non-financial income, whose prominent role in the theory of international portfolios has been pointed out in the introduction.[15] Third, the coefficient estimates for total stock-holdings show a similar pattern but are larger in magnitude. Also, there is a strong effect of self-reported risk-taking behaviour on the portfolio share of total stocks. Most other household characteristics also have the expected sign in the outcome equation for portfolio shares of foreign and total stocks.

[15]To be precise, apart from its effect via the financial wealth-to- non-financial income-ratio, financial wealth has a significantly positive effect on the portfolio of total, but not directly-held foreign shares.

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

Equ	(1)							
$\log(\frac{FIN}{Y})$	$\log(FIN)$	$RISK$	COL	$BLACK$	$HISP$	age	age^2	age^3
0.27**	0.54***	0.34**	0.61***	−0.22	−0.93*	0.09	−0.00	−0.00
0.11	*0.10*	*0.14*	*0.17*	*0.29*	*0.51*	*0.08*	*0.00*	*0.00*

Equ	(2)																				
$RISK$	COL	$BLACK$	$HISP$	WWW	$SHOP$	UE	MAR	M	Y_l	$KIDS$	PH	FIN_1	FIN_2	FIN_3	Y_1	Y_2	Y_3	30	40	50	60+
0.06***	0.07***	−0.06***	−0.06***	0.00	0.01**	−0.01	−0.00	0.00	−0.00	0.00	−0.01**	−0.14***	−0.10***	−0.05***	−0.01	−0.00	−0.00	0.01**	0.02***	0.03***	0.03***
0.01	*0.01*	*0.01*	*0.01*	*0.00*	*0.00*	*0.01*	*0.00*	*0.01*	*0.01*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.00*	*0.00*	*0.01*	*0.01*	*0.01*

No of obs	18635	Censored:14268
$F(12, 18623)$	23	

The dependent variable is the portfolio share of total foreign stocks in percent. Numbers in italics are standard errors. ***(**,*) denotes a coefficient significantly different from 0 at the 1 (5,10) percent level. The estimation uses 4 waves of the SCF (2001,2004, 2007 and 2010). FIN is the SCF measure of total gross financial wealth; Y nonfinancial income including salaries, wages, income or losses from aprofessional practice, business, limited partnership, or farming and transfer income; dummy variables are defined as: FIN_i and Y_i (total household gross financial wealth (non-financial income) falls in the (weight-adjusted) ith quartile); COL (household head holds a college degree), BLACK / HISP (reports her race to be black / hispanic), WWW (indicates to use the internet for financial information), SHOP (reports to shop around for financial deals), UE (is unemployed), MAR (married), M (male), KIDS (has kids), PH (has poor health), Y_l (reports to have earned unusually low income in the previous year). The regression also contains a full set of year dummies in both equations and a cubic function in AGE (the household's head's age minus 15, in equation (1)) and age decade indicators 20, 30, ...60+ in equation (2). See also table 3 in the appendix for variable definitions.

Table 2: Heckman model for participation and portfolio share of total stocks

Equ	(1)							
$\log(\frac{FIN}{Y})$	$\log(FIN)$	$RISK$	COL	$BLACK$	$HISP$	age	age^2	age^3
1.42***	1.82***	8.01***	1.92**	−2.55*	0.19	1.09***	−0.03***	0.00**
0.49	*0.45*	*0.80*	*0.75*	*1.38*	*1.72*	*0.32*	*0.01*	*0.00*

Equ	(2)																				
$RISK$	COL	$BLACK$	$HISP$	WWW	$SHOP$	UE	MAR	M	Y_l	$KIDS$	PH	FIN_1	FIN_2	FIN_3	Y_1	Y_2	Y_3	30	40	50	60+
0.09***	0.04***	−0.05***	−0.08***	0.03***	−0.01*	−0.03*	0.03***	−0.02**	−0.01	−0.00	−0.06***	−0.70***	−0.40***	−0.15***	−0.11***	−0.03***	−0.02*	−0.04***	−0.06***	−0.15***	−0.19***
0.01	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*

No of obs	18635	Censored:6687
$F(12, 18623)$	41	

For variable explanation see footnote to table 1. The dependent variable here is the portfolio share of total foreign stocks including an estimate of those held via mutual funds

3 A two country heterogeneous agents economy

This section takes a first step to derive the implications of standard theory for the distribution of foreign asset holdings across households. For this, I add within-country heterogeneity in total wealth to a standard general equilibrium model of the international economy with key features from studies of home bias in country portfolios: 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). The results reveal heterogeneity of both extensive and intensive foreign investment decisions across the wealth distribution. Two kinds of shocks drive these results: First, by decreasing the relative price of home goods in times of high Home productivity, aggregate supply shocks make real domestic endowment income comove positively with real returns to foreign assets, and negatively with real home bond returns. This general equilibrium terms of trade effect therefore gives individuals whose wealth is dominated by future income rather than financial assets stronger incentives to invest in home bonds that provide a hedge against endowment risk. Second, country-specific shocks to equity returns provide incentives to diversify into both home and foreign assets, thus identifying the otherwise undetermined equity portfolio.[16]

Unfortunately, once borrowing constraints and idiosyncratic income risk are added to the analysis, 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 on perfect insurance (Coeurdacier and Gourinchas, 2011). The strategy of this section 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

[16]Equity portfolios are undetermined in the original Cole and Obstfeld (1991) model because returns to home and foreign equity are stochastically equal with identical unit-elastic preferences. Note that I also abstract from capital accumulation, partly because of the two-period nature of the model. I comment further on this below.

two-period version of a standard two-country endowment model in the home bias literature, first proposed by Cole and Obstfeld (1991). Its assumption of unit-elastic consumption baskets, together with identical preferences within and across counries, 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.

3.1 The general environment

I consider an economy with two countries, Home (H) and Foreign (F). In each country there is a large number of agents with unit mass that live for two periods, at the beginning of which they receive endowments of a country-specific perishable good H or F.

Notation is as follows: capital letters H,F denote country-specific variables or goods, small letters h,f index individuals and 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 $\Psi^{x'}$.
Agents' preferences are described by a von Neumann-Morgenstern utility function with constant relative risk aversion γ over an identical Cobb-Douglas aggregate with a bias of $\theta > \frac{1}{2}$ towards Home goods.

$$\mathbb{U}_k = U(c_k) + \beta E[U(c'_k)] \tag{3}$$

$$U(c_k) = \frac{c_k^{1-\gamma} - 1}{1-\gamma} \tag{4}$$

$$c_k = c_{k,H}^{\theta} c_{k,F}^{1-\theta} \tag{5}$$

$$\theta > \frac{1}{2},\ \gamma > 1 \tag{6}$$

where c_k is the consumption basket of agent k and $c_{k,I}$ denotes consumption by agent k of good I for $k \in \{h, f\}$, $I \in \{H, F\}$. To make hedging of consumption risk matter, I assume that there is at least moderate risk aversion, and therefore concentrate on values $\gamma > 1$.
There is heterogeneity in initial period 1 endowments $Z_k, k \in \{h, f\}$, described by the dis-

tributions Ψ_k^{ϵ}. The only role of this heterogeneity is to generate differences in the relative importance of current vs future wealth across individuals that is at the origin of portfolio heterogeneity. 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

$$Z'_k = \epsilon'_k * Y'_K \tag{7}$$

"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 aggregate period 2 output in country K simply equals Y'_K.[17]

"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.[18]

I assume that all period 2 random variables are log-normally distributed. Together with the i.i.d. assumption, this implies $\mathrm{x}(\varepsilon'_h, \varepsilon'_f, y'_H, y'_F)' \sim N(\overline{e}, \overline{e}, \overline{y}, \overline{y}', \Sigma)$, where $\varepsilon_i = log(\epsilon_i)$, $y_i = log(Y_i$ and Σ is a diagonal matrix with entries $\sigma_\epsilon^2, \sigma_\epsilon^2, \sigma_y^2, \sigma_y^2$.

3.2 Incomplete asset markets and borrowing constraints

At the end of period 1 agents decide how much to consume and how much to invest in 2 country-specific bonds and in shares of 2 country-specific mutual funds. As in Coeurdacier et al. (2010) or Coeurdacier and Gourinchas (2011), bonds are in zero net supply and denominated in country-specific goods. Thus, home bonds pay R_H^b units of the Home good next period for 1 unit of Home goods invested today. Equivalently, foreign bonds pay R_F^b units of Foreign goods. Shares in national mutual funds are also in zero net supply, with payoffs

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

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

proportional to the stochastic aggregate endowment. I assume, however, that this proportionality is not perfect due to country-specific noise in mutual fund returns. Specifically, for some constant R_H^s, the return on home shares is $\zeta_H' R_H^s Y_H'$ units of H goods per unit of H goods invested, where ζ_K' is a noise term reflecting the imperfect correlation between stock market returns and aggregate products. Payoffs to foreign mutual fund shares, denoted in F goods, are equivalently $\zeta_F' R_F^s Y_F'$, where ζ_H' and ζ_F' are identically distributed log-normal random variables with mean 1 and log-variance σ_r^2 that are independent of each other and all other random variables. This independence assumption is important, as it drives a wedge between the real payoffs to home and foreign mutual fund shares, and thus identifies the mutual fund portfolio. Without noise, returns to both home and foreign mutual fund shares are stochastically equal as in Cole and Obstfeld (1991), thus leaving equity portfolios undetermined. 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 $a_{h,H}^b$ and $a_{h,F}^b$ respectively, and her holdings of shares by $a_{h,H}^s$ and $a_{h,F}^s$. Asset quantities are denoted in endowment goods of the owner. So if h holds a portfolio $a_{h,H}^b, a_{h,F}^b$, she owns $a_{h,H}^b$ units of H bonds and $\frac{a_{h,F}^b}{p}$ 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_K^b, B_K^s.[19] Finally, I also allow for a proportional cost of foreign investments $K_1 > 0$ that reduces the real returns to non-domestic assets by a factor

[19] Apart from their implicit effect on asset supply, these borrowing constraints play little role in the analysis, which concentrates on households whose domestic asset holdings are unconstrained. 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_K^b and B_K^s above.

$\frac{1}{1+K_1}$.

3.3 The household problem

A typical home household h maximises expected lifetime utility by choosing, at the end of 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 joint distribution of the vector of returns $\overrightarrow{R}$. h's problem is thus given as:

$$max_{c_h, c'_h, \overrightarrow{a_h}} \frac{c_h^{1-\gamma} - 1}{1-\gamma} + \beta E[\frac{c_h'^{1-\gamma} - 1}{1-\gamma}] \tag{8}$$

Subject to the constraints

$$c_h = \frac{Z_h - \sum_{i \in \{b,s\}} a^i_{h,H} - \sum_{j \in \{b,s\}} a^j_{h,F}}{p_H} \tag{9}$$

$$c'_h = \frac{Z'_h + R^b_H a^b_{h,H} + R^s_H Y'_H a^s_{h,H} + (R^b_F a^b_{h,F} + R^s_F Y'_F a^s_{h,F})\frac{p'}{p}}{p'_H} \tag{10}$$

$$a^i_{h,H} \geq B^i_H, \ for \ i \in \{b,s\}$$

$$a^j_{h,F} \geq 0, \ for \ j \in \{b,s\}$$

$$Z'_h = e' Y'_H$$

where $p_H = \theta^{-\theta}(1-\theta)^{-(1-\theta)} p^{1-\theta}$ is the home consumption price index. Equations (9) and (10) are the budget constraints that determine period 1 consumption as the real value of endowments minus net investments, and period 2 consumption as the sum of endowments and net portfolio returns. The problem of a typical foreign household is symmetric.

3.4 Definition of competitive equilibrium

A competitive equilibrium is a *consumption allocation* $c_{k,H}, c_{k,F}, c'_{k,H}, c'_{k,F}$, $k = 1, 2$ (where $c'_{k,J}$ is a random variable depending on the realisation of period 2 uncertainty); a set of *portfolio*

vectors $\overrightarrow{a_k}$; a *price system* of relative goods prices p, p' (where p' is a random variable with distribution $\Psi^{p'}$) and the vector of asset returns $\overrightarrow{R}$; *such that* agents allocate their funds optimally across goods in period 2 given a particular realisation p'; the allocation solves every household's problem (8) in period 1 given a relative price p, a distribution $\Psi^{p'}$ and rates of return $\overrightarrow{R}$; markets for goods and assets clear; and 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.

3.5 Terms of trade movements: independent of heterogeneity

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 equilibrium 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.[20] The assumption of identical homothetic preferences ensures that excess demands for Home and Foreign goods are independent of both the within-country wealth distribution and aggregate country net asset positions. Thus aggregate endowments tomorrow completely determine aggregate demand for goods and thus market-clearing prices. To see this algebraically, note that the linearity of the demand functions that follows from identical homothetic preferences, 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

$$\begin{aligned} &\int \theta s_h dh + \int \theta p s_f df \\ &= \theta[Y_H - \nu_H + \nu_F p] + \theta[\nu_H + p(Y_F - \nu_F)] \end{aligned} \tag{11}$$

[20]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.

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

$$p = \frac{Y_H}{Y_F} \quad \forall \Psi_F^{e\prime}, \Psi_H^{e\prime}, \Psi_F^Z, \Psi_H^Z \tag{12}$$

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. The assumption of identical preferences 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 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

$$\begin{aligned}
\textit{Real endowment} &: \quad e_h' Y_H'^{\theta} Y_F'^{1-\theta} \\
\textit{Real return to Home shares} &: \quad a_h^s \zeta_H' R_H^s Y_H'^{\theta} Y_F'^{1-\theta} \\
\textit{Real return to Foreign shares} &: \quad a_f^s \zeta_F' \frac{R_F^s}{1+K_1} Y_H'^{\theta} Y_F'^{1-\theta} \\
\textit{Real return to Home bonds} &: \quad a_H^b R_H^b Y_H'^{\theta-1} Y_F'^{1-\theta} \\
\textit{Real return to Foreign bonds} &: \quad a_F^b \frac{R_F^b}{1+K_1} Y_H'^{\theta} Y_F'^{-\theta}
\end{aligned}$$

where the factor $\frac{1}{1+K_1} < 1$ that multiplies foreign returns reflects the proportional cost of investing in foreign assets. 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 $\zeta_i, i \in \{F, H\}$. Terms of trade movements thus act to reduce the attractiveness of buying foreign mutual fund shares. 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-sell foreign assets and invest the proceeds in home bonds.

4.1 Unconstrained portfolios

We can solve for optimal portfolio shares analytically by solving a second-order approximation of the system of first order conditions and exploiting the log-normal nature of random variables. For this it turns out that it is more convenient to express the relative importance of non-financial income and financial wealth in terms of the ratio of financial claims to total claims on income next period $\rho = \frac{1}{\lambda+1} = \frac{W(1+R_p)}{Z+W(1+R_p)}$, which has the advantage of being bounded between 0 and 1, and is monotonically decreasing in λ, the ratio of financial claims to non-financial income, which the empirical section focused on. For simplicity, I concentrate on a symmetric equilibrium where log asset returns, denoted by their small letters, are equal within asset class, so $r_f = r_h = r_b$, $r_{sf} = r_{sh} = r_s$.[21] Denoting the difference in mean returns

[21] See Broer (2015) for the general expressions. It is easy to show that all results continue to hold as long as the return differential between home and foreign assets satisfy $r_f - r_h \leq [k_1 + 2(\gamma - 1)(\theta - \frac{1}{2})\sigma_y^2] > 0$ and $r_{sf} - r_{sh} \leq k_1 > 0$.

as $\Delta r = r_s - r_b$ this yields the vector of portfolio shares as

$$\begin{aligned}
\overrightarrow{\alpha} = [\alpha_h^b, \alpha_f^b, \alpha_h^s, \alpha_f^s]' = \frac{1}{\gamma\rho(\sigma_y^2+\sigma_r^2)}\{ & \\
-\Delta r + \tfrac{1}{2}(1+\tfrac{\sigma_r^2}{\sigma_y^2})k_1 \quad & + \tfrac{1}{2}\sigma_y^2 \quad + (\gamma-1)\theta(\sigma_y^2+\sigma_r^2) \quad - \tfrac{1}{2}\gamma(1-\rho)\sigma_r^2 \\
-\Delta r - \tfrac{1}{2}(1+\tfrac{\sigma_r^2}{\sigma_y^2})k_1 \quad & + \tfrac{1}{2}\sigma_y^2 \quad + (\gamma-1)(1-\theta)(\sigma_y^2+\sigma_r^2) - \tfrac{1}{2}\gamma(1-\rho)\sigma_r^2 \\
\Delta r + \tfrac{1}{2}(1+\tfrac{\sigma_y^2}{\sigma_r^2})k_1 \quad & + \tfrac{1}{2}\sigma_r^2 \quad - \tfrac{1}{2}\gamma(1-\rho)\sigma_y^2 \\
\Delta r - \tfrac{1}{2}(1+\tfrac{\sigma_y^2}{\sigma_r^2})k_1 \quad & + \tfrac{1}{2}\sigma_r^2 \quad - \tfrac{1}{2}\gamma(1-\rho)\sigma_y^2\} \qquad (13)
\end{aligned}$$

Return differential | Log-Level r Correction | CPI hedge | Endowment hedge

where $k_1 = log(1 + K_1)$ is the log-cost of investing in foreign assets. The portfolio shares of diversified investors are determined by 4 factors: the first term on the left-hand side of equation (13) is the log return differentials between bonds and assets Δr adjusted for the cost of foreign investment k_1. The latter is weighted by the inverse of the return volatility, which increases the sensitivity to return differentials within asset class. 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 second is a convexity term that makes return differentials in levels increase in the difference of log-return variances. The third 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, 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 and thus equals 0 for a purely financial investor with $\rho = 1$. It is this latter term that gives rise to heterogeneity of portfolios across the distribution of financial wealth at the end of period 1. To understand its effect on portfolio shares, note that, 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 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.

Note that the portfolios in 13 imply average home bias, since for all individuals $\alpha_h^b > \alpha_f^b$ for any k_1, and $\alpha_h^s > \alpha_f^s$ as long as $k_1 > 0$. More importantly, the share of home bonds increases with the degree of home bias θ, since $\gamma > 1$. The reverse is true for foreign bonds.

Note how the general equilibrium comovements in the model may help to explain the facts observed in the data for two reasons: First, the relative share of foreign bonds, which was negligible in the data, is reduced whenever there is home bias in consumption, as home bonds are a better hedge against price fluctuations. And second, the diversification benefits from investing in foreign mutual funds are reduced because, in general but not partial equilibrium, their real payoffs comove positively with home income and home share returns. In other words, foreign share returns loose their hedging advantage due to the general equilibrium price movements implied by the model.

4.2 Portfolios across the wealth distribution

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 short-selling constraints for foreign assets. Write portfolio shares as

$$\overrightarrow{\alpha} = \overrightarrow{\alpha}_{\rho=1} + \lambda \overrightarrow{\alpha}_{\rho=0} \tag{14}$$

where, again, λ denotes the non-financial income-to-financial wealth ratio $\frac{y}{W(1+R_p)}$ (defined in terms of the expected payoff to the financial wealth portfolio $W(1+R_p)$). 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 uses the assumption that a purely financial investor with $\lambda = 0$ has a diversified portfolio, which implies strictly positive entries in the vector $\overrightarrow{\alpha}_{\rho=1}$. It shows that, if hedging concerns are sufficiently important (e.g. because risk aversion γ is high) or the variability of aggregate endowments relative to the noise in equities $\frac{\sigma_y^2}{\sigma_r^2}$ sufficiently large, there is home bias of the poor, in the sense that home investors first invest in home bonds and only eventually in foreign assets as the financial-wealth-to-future-income ratio ρ rises. This result is suggested by the portfolio shares in (13), where the final hedging term decreases the portfolio share of foreign mutual fund shares as $\frac{\sigma_y^2}{\sigma_r^2}$ rises, but significantly complicated by the fact that portfolio shares change whenever one or both of the short-selling constraints for foreign assets bind. Broer (2015) reports the portfolio shares for investors that are constrained by one or both short-sale constraints on foreign assets.

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* $\widetilde{k}_1 > 0$,[22] *there are cutoff-values* $\rho_1 < 0$, $\rho_2 > \rho_1$ *and* $\rho_3 > \rho_2$ *of the financial wealth-to-income ratio* ρ *such that:*

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

[22] $\widetilde{k}_1 = \frac{1+\frac{\sigma_r^2}{\sigma_y^2}}{2(2\theta-1)(\gamma-1)\sigma_r^2} k_1$.

shares have to be negative for some value of ρ. Since holdings of both assets are monotonically increasing in wealth and expected income is constant across agents, the result follows.

Ad 2: The aim is to show that an investor with zero net assets ($\rho = 0$) has positive home bond holdings and negative holdings of home mutual fund shares. For this, because within asset classes home portfolio shares always exceed foreign shares and $\rho = 0$ implies some negative home asset holdings, we need to consider 3 possible cases: only home asset investments, positive investments in home and possibly foreign bonds with negative home share holdings and vice versa. First, if the investor holds foreign bonds, we are done, since $\alpha_h^b > \alpha_f^b > 0$: since $\rho = 0$, this implies zero foreign share holdings and strictly negative holdings of home shares. Moreover, as both home and foreign bond holdings strictly increase with ρ, there is necessarily a $\rho_2 : 0 > \rho_2 > \rho_1$ such that foreign bond holdings are zero but home bond holdings positive for any $\rho : \rho_1 < \rho < \rho_2$.

If the investor with $\rho = 0$ only holds home assets and has a positive home bond position we are also done since the statement is then true for $\rho_2 = 0$. To derive the condition under which this holds, we can sign the difference in portfolio shares using the solution to the portfolio problem of investing in home assets only[23]

$$\gamma\rho(\sigma_y^2 + \sigma_r^2)[\alpha_h^b - \alpha_h^s] = 2\{[(\gamma - 1)\theta + \tfrac{1}{2}]\sigma_y^2 - \tfrac{1}{2}\sigma_r^2 - \Delta_r\} \tag{15}$$

From the condition that there is at least one diversified investor and the monotonicity of asset holdings (as opposed to portfolio shares) in ρ, the return differential Δ_r is bounded by the condition that foreign bond holdings be positive at $\rho = 1$, which yields

$$\Delta r + \tfrac{1}{2}(1 + \tfrac{\sigma_r^2}{\sigma_y^2})k_1 < \tfrac{1}{2}\sigma_y^2 + (\gamma - 1)(1 - \theta)(\sigma_y^2 + \sigma_r^2) \tag{16}$$

This implies the following condition for the right-hand side of (15) to be positive

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

[23] See equation (47) in Broer (2015).

which yields the expression in the proposition. Finally, 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.

5 A quantitative example

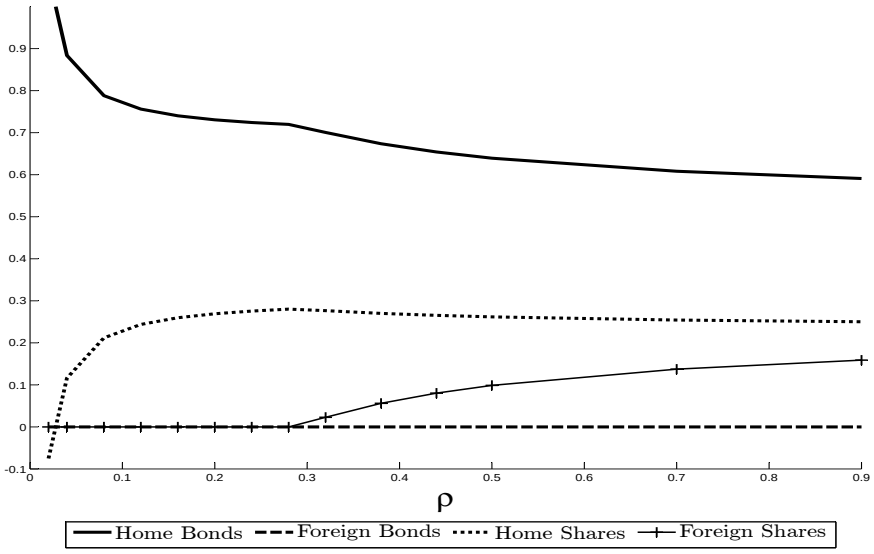
This section studies the quantitative performance of the model in symmetric partial equilibrium at given exogenous values for the risk-less interest rate and the equity premium. The benchmark parameterisation gives rise to rich heterogeneity in portfolios that is broadly in line with the empirical evidence both on the intensive dimension (as investors change their portfolio shares with the relative importance of non-financial income) and the extensive dimension (as some investors are constrained by the short-sale constraint on foreign assets).

5.1 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.[24] 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 0.85 but analyse the sensitivity of the results

[24]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.

Figure 2: Portfolio shares in the benchmark calibration.

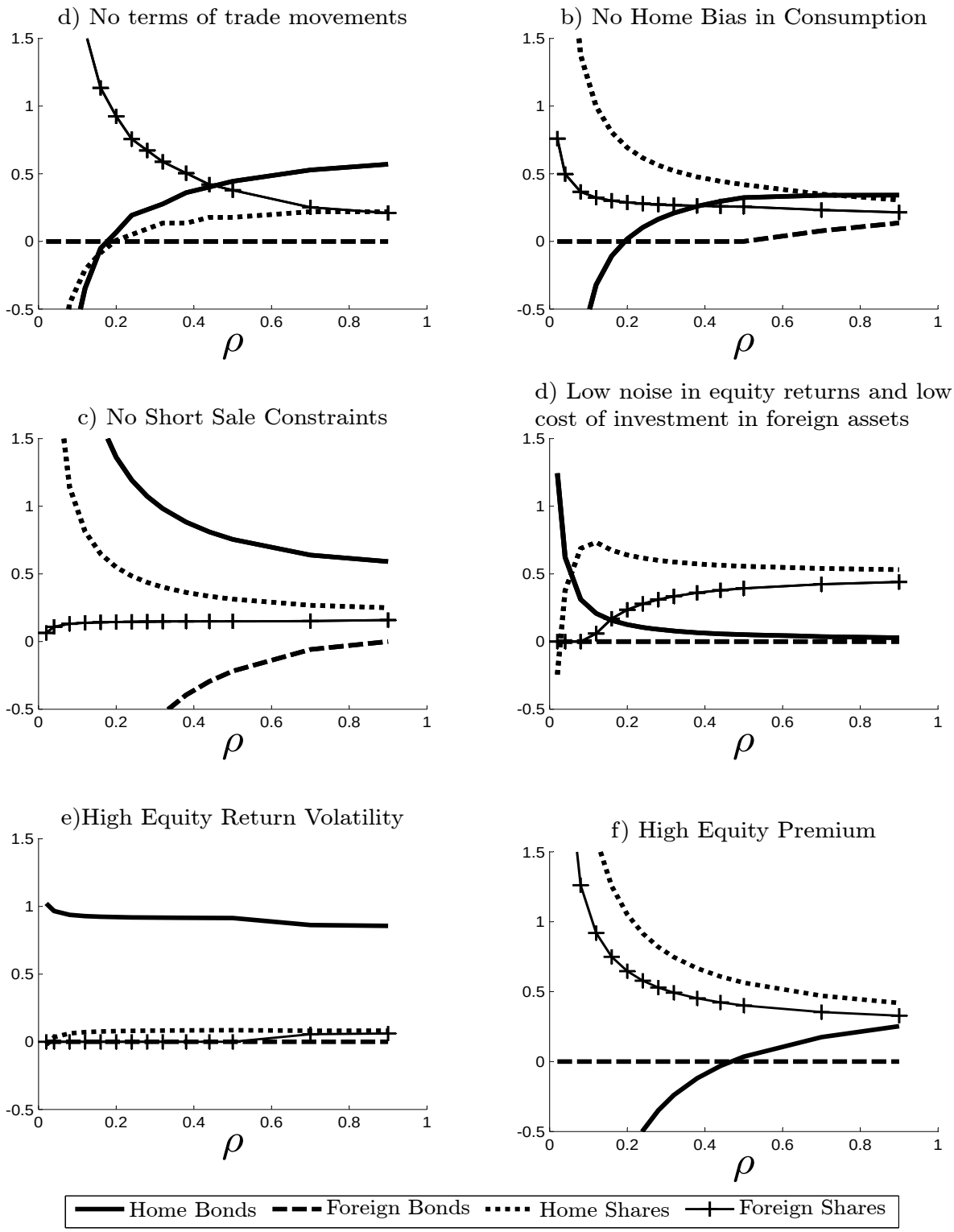


to both choices. I continue to look at the case where asset returns are equal across countries, and set an exogenous equity premium equal to 225 basis points in the benchmark example.

5.2 Results

Figure 2 presents the portfolio shares as a function of the wealth-to-income ratio ρ in the benchmark calibration. It corresponds to the scatter plots in figure 1 (which presented the portfolio shares of foreign assets in US SCF data as a function of the log financial wealth-to-non-financial income ratio, a monotonic transformation of ρ). Broadly in line with an observed portfolio share of foreign bonds in figure 1 of at most 0.1 percent, the model calibration does not predict any positive holdings of foreign bonds. This is because of a substantial equity premium and strong home bias in consumption, which make foreign bonds a low-return investment and a bad hedge against terms of trade fluctuations. 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 or low financial wealth do not

Figure 3: Portfolio shares in alternative versions of the model.



The figure shows portfolio shares in a one-good version of the model (panel a)), without home bias in consumption ($\theta = 0.5$, panel b)), without short sale constraints on foreign assets (panel c)), with low cost of foreign investments and a low variance of equity return noise σ_r^2 (to one hundredth of a percent of their benchmark values) (panel d)), with a standard deviation of equity returns 4.2 times higher than that of GDP (panel e)), and with an equity premium of 450 basis points (panel f)).

invest in stocks or foreign assets.[25] As financial wealth increases, both total and foreign stock holdings rise monotonically, in line with the pattern documented in section 2. And, in line with figure 1, the threshold level of ρ above which agents have positive foreign asset holdings is higher than that for holding domestic, or any, stocks. At high values of ρ, however, the model overpredicts the portfolio share of foreign assets, while its predicted total holdings, domestic and foreign, are close to the 45 percent in figure 1.[26]

Figure 3 presents the evolution of portfolio shares across the wealth distribution for alternative versions of the model. Its first three panels show how its ability to replicate observed portfolio patterns hinges crucially on terms of trade movements, home bias in consumption, and short-sale constraints on foreign asset holdings. Specifically, panel *a*) presents portfolio shares in a one-good-model, where foreign and home goods are perfect substitutes in consumption and terms of trade movements therefore absent. This eliminates the hedging advantage of home bonds, and makes foreign mutual fund shares, whose returns are uncorrelated with home endowments, a more attractive hedge of non-financial income than home shares. In contrast to the empirical evidence, investors with a low wealth-to-income ratio ρ are thus predicted to hold a non-diversified portfolio of foreign mutual fund shares leveraged by issuing home assets.

In a version of the two-good model without home bias in consumption ($\theta = 0.5$), in contrast, terms of trade movements make foreign and home asset investments equally good hedges against movements in non-financial income. At low ρ, in panel *b*) of figure 3, investors are thus, again counterfactually, predicted to hold a diversified stock portfolio leveraged by issuing home bonds, which are less powerful a hedge against endowment fluctuations in the absence of home bias in consumption. At high ρ, they hold positive positions in all assets. Panel *c*) of Figure 3 illustrates the role of short-selling constraints on foreign assets: in their

[25] In fact, as we do not restrict short-sales of home assets, agents with no financial wealth are predicted to hold a negative amount of home shares.

[26] For the interpretation of these results, one should bear in mind that the more comprehensive definition of gross assets in the SCF acts to reduce the portfolio shares of foreign assets with respect to the model. This brings the predicted portfolio share of foreign stocks closer to that observed in the data, but moves that of total stocks further away.

absence, agents would hedge their income movements by borrowing in foreign bonds, which are cheap to redeem when home endowment income is low, and by making leveraged investments mainly in home assets.

While terms of trade movements, home bias in consumption and short-selling constraints on foreign bonds are thus crucial ingredients of the model, panel d) shows that the qualitative investment pattern in figure 2 does not depend on the magnitude of two auxiliary parameters we introduced to make the simple model more realistic, namely the proportional cost of foreign investment k_1 and the extra noise in Home and Foreign equity returns ζ_H and ζ_F respectively. In fact, even when reducing both the proportional cost of foreign investments and the variance of equity return noise σ_r^2 to one hundredth of a percent of their benchmark values, the model predicts non-diversified portfolios of home bonds at $\rho = 0$ and diversified portfolios of home assets and foreign stocks at high ρ. The threshold of ρ beyond which investors buy foreign stocks is reduced, however, as lower costs of investing abroad bring the portfolio shares of home and foreign stocks closer together. Moreover, the home bond share is strongly reduced in magnitude when ρ rises as less volatile returns make shares a more attractive investment.[27] In comparison, panel e) illustrates the results for an alternative calibration of equity return volatility that replicates a correlation between GDP and equity returns of 0.3, and results in a higher value of $\sigma_r = 0.095$. Again, the qualtitative patterns are unchanged. But with equity returns now more volatile than in the benchmark case, their portfolio shares remain at lower levels even at high ρ.[28] Finally, panel f) 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 the post-war average 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,

[27]Note that, when the standard deviation of noise shocks σ_r is reduced to 0, Home and Foreign mutual fund payoffs are stochastically equal, and their portfolio shares no more identified.

[28]The correlation between annual real US 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.

bonds.[29]

6 Conclusion

To explain the puzzlingly low holdings of foreign assets in many country portfolios, standard international macroeconomic theory has argued that foreign assets may be more costly investments and inferior hedges against the risks faced by domestic consumers. This paper has started from the observation that both explanations have observable implications for the participation and portfolio share patterns across domestic households with different wealth and income levels. I therefore analysed data from the US Survey of Consumer Finances, and found that US households with a higher financial wealth-to-nonfinancial income ratio invest a higher share of their portfolio in international stocks on average. Foreign bond holdings, however, are small, with a portfolio share that averages less than 0.1 percent even in the highest wealth decile. The pattern for foreign equity holdings is due both to the fact that wealth-poorer households are less likely to participate in foreign equity markets, and because portfolio shares for participants increase with the ratio of financial wealth to non financial income. More generally, the finding of significant effects in the outcome equation of a Heckman (1979) selection model points to systematic variation in households' international investments over and above the participation effects pointed out in previous studies.

This new fact provides additional evidence that can be used to test models of the international macroeconomy. The second part of the paper took a first step towards a general equilibrium analysis of portfolio heterogeneity by analysing a stylised model of the international economy à la Cole and Obstfeld (1991). It showed how heterogeneity in the financial wealth-to-income ratio together with borrowing constraints leads to non-trivial portfolio heterogeneity along both the intensive and extensive margin even without fixed costs of investing abroad. The reason is that equilibrium terms of trade movements can make home bonds better hedges

[29] A very similar pattern of portfolio shares across the wealth-distribution results with lower risk aversion. For example, for $\gamma = 15$, the model predicts portfolios very similar to those in panel f) of Figure 3.

against fluctuations in non-diversifiable income than foreign assets or home equity. This makes the former more attractive for agents with relatively low financial wealth. Under the assumption of log-normal returns, I derived asset portfolios as a function of investor financial wealth and income. 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 with the share of financial wealth in total wealth. A quantitative example showed how the model can replicate the patterns observed in the data in a partial equilibrium with a moderate equity premium and realistic levels of volatilities.

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 In this context, it is worth noting that Coeurdacier and Rey (2013), and similarly Coeurdacier et al. (2010), find that, depending on parameters, the general equilibrium of an infinite horizon two-country economy with capital investment and more general preferences predict home bias in bonds and stocks that is partly due to their hedging properties against fluctuations in non-financial income. For sufficiently small levels of heterogeneity, and a therefore approximately unchanged covariance structure of the terms of trade, labour income and asset returns, their results should be a guide also to individual portfolios, implying stronger home bias for households with low financial wealth-to-income ratios whose portfolios are determined more strongly by hedging concerns.

Finally, while this paper has focused on the implications for portfolio heterogeneity of general equilibrium macroeconomic models of home bias, an interesting alternative approach would be to estimate covariances of asset returns, exchange rates, and labour incomes from empirical data and compare the implied optimal portfolios to those observed in the data.[30] I leave a rigorous and quantitative investigation of these issues to future research.

[30]I thank an anonumous referee for suggesting this alterantive approach.

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7 Appendix 1: Variable definitions and descriptive statistics

Table 3: Variable definitions

Abbreviation	Full name	Definition	Equation (1)
$\log(Y)$	log non-financial income	(log of) sum of wages, business farm income, and transfers	
$\log(\frac{FIN}{Y})$	log wealth-income ratio	log ratio of financial wealth to Y	YES
$\log(FIN)$	log financial wealth		YES
Age	Age	Age in years minus 15	YES
Age decade indicator	equals 1 if age is $30-39, 40-49, 50-59, \geq 60$	YES	
$FIN_i,\ i=1,...,3$	Financial wealth quartiles	=1 if FIN falls in the ith quartile	
$Y_i,\ i=1,...,3$	Non-financial income quartiles	=1 if Y falls in the ith quartile	
Dummy variables		Equals 0 unless the following is true for the HH head	
$RISK$	Risk-taking	indicates to take "substantial" or "above average" risk in financial decisions	YES
COL	College	has a college degree	YES
$BLACK$	Black	is black / African American	YES
$HISP$	Hispanic	is hispanic	YES
WWW	Internet use	indicates to use an online service / internet for financial information	YES
$SHOP$	Shop around	reports more than "moderate" "shopping around for the very best terms" (4 or 5 on scale from 1 (no) to 5 (a great deal))	
UE	Unemployed	indicates to be "unemployed and looking for work"	
MAR	Married	is married	
M	Male	is male	
Y_l	low income	reports unusually low income in the previous year	
$KIDS$	KIDS	has kids	
PH	Poor Health	chooses "poor" to describe own or partner's health rather than "excellent", "good" or "fair"	

Table 4: Descriptive Statistics

Sample size after deleting missing observations and taking logarithms	18635		
Portfolio Shares			
Asset	Participants (%)	Mean for part. (%)	St Dev (pp)
Directly held foreign stocks	6.3	7.2	21.1
Total foreign stocks incl. via Mutual Funds	23.4	5.1	8.9
Directly held foreign bonds	0.58	6.8	27.9
Total foreign bonds incl. via Mutual Funds	6.3	0.7	4.1
Total directly held stocks	39.5	22.6	35.5
Total stocks incl. via Mutual Funds	64.0	47.4	36.6
Other Variables			
	Mean	St Dev	
log financial wealth	9.8	3.1	
log wealth-income ratio	-0.91	2.8	
Age	50	22	
Dummy Variables			
	Percent true		
$RISK$	20		
COL	38		
$BLACK$	12		
$HISP$	8.1		
WWW	15		
$SHOP$	34		
UE	3.5		
MAR	60		
M	74		
Y_l	18		
$KIDS$	43		
PH	7.6		

The table presents descriptive statistics of the estimation sample for 4 rounds of the SCF (2001,2004,2007,2010).