Sectoral Productivity Matters: A New Angle on Equity Home Bias

Chenyue Hu

University of California, Santa Cruz

Abstract

This paper theoretically and empirically examines how industrial structure impacts equity home bias at both the industry and country level. I build a two-country two-sector model to examine how the differences in sectoral productivity affect a country's risk exposure and hence influence its investors' portfolio choice. First, the model contends that investors show stronger home bias in unproductive sectors than in productive sectors where they face more risks. Using a unique dataset on equity holdings, I calculate the industry level home bias of 26 sectors in 43 countries and empirically confirm the model's prediction. A second model prediction is that investors avoid highly-specialized countries as a consequence of their risk-hedging motives. I confirm the prediction in the data by finding that national home bias is negatively correlated with a country's degree of industrial specialization. Third, the model uncovers the relationship between investors' sectoral preference and country bias which sheds light on the interaction between intra-national risk hedging across sectors and inter-national risk hedging across countries.

KEYWORDS: Home bias, Portfolio choice, Sectoral productivity, Industrial specialization

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1 Introduction

International finance models typically show that investors can reap substantial benefits from international portfolio diversification. Yet the data indicate that domestic equity accounts for a predominant share of investors' portfolios, despite the current integration of the world capital market. The phenomenon of 'equity home bias', documented by French and Poterba (1991) and Tesar and Werner (1995), continues to be a puzzle in international economics.

Various attempts have been made to explain home bias by analyzing investors' risk-hedging motives, but most papers abstract from industrial structure and as a consequence ignore within- and across-industry productivity differences across countries. In this paper, I contend that sectoral productivity differences matter significantly for investors' risk-hedging pattern and portfolio choice. I identify and explain two novel facts about home bias by adding the sectoral dimension to the current literature. First, I show that *sectoral* home bias is stronger in unproductive sectors where investors face fewer risks than in productive sectors. Second, I find that *national* home bias is stronger in the countries with diversified industrial structures because intra-national risk hedging across industries replaces the need for inter-national risk hedging across countries.

A large body of literature has focused on home bias at the national level, but little is known at the industry level about investors' preference between domestic and foreign assets. Using a unique dataset on institutional investors' equity holdings complemented by information on sectoral stock market values, I compute the sectoral home bias of 26 industries from 43 countries. Furthermore, I empirically find that sectoral home bias is negatively correlated with sectoral productivity.

My explanation for the variation in sectoral home bias is as follows. International investors hold financial assets to hedge against two specific kinds of risks: labor income risk and real exchange rate risk. Productivity differences affect both a sector's labor force and its trade pattern. As a consequence, industries have distinct exposure to these two kinds of risks. A sector with greater productivity is exposed to more risks because the country's labor income and real exchange rate are more correlated with the returns to that sector than the returns to an unproductive sector. Therefore, investors hold fewer home assets in productive sectors and hence show weaker sectoral home bias.

In order to better understand what drives the difference in sectoral home bias, I build a model in a two-country two-sector dynamic stochastic general equilibrium (DSGE) setting. The model embeds Eaton and Kortum (2002)'s framework to capture the effect of productivity on sectoral size and trade. In order to derive analytical solutions to the portfolio choice problem in a baseline case with symmetric countries and complete markets, I follow the approach in Coeurdacier (2009) by analyzing the correlations of returns from different assets around the steady state of the economy. I also extend the model by incorporating nontradable sectors. In deriving static and dynamic equity holdings in extended models, I follow the method of Devereux and Sutherland (2007, 2011), who employ a higher degree of approximation of an investors' objective function to capture lower-order portfolio behavior.

The solution to the model also enriches our understanding of *national* home bias. In this multi-sectoral setting, investors are able to risk-hedge not only by holding assets in different countries (inter-country risk-hedging) but also by holding domestic assets in different sectors (intra-country risk-hedging). If the covariance across domestic assets ensures efficient risk-hedging, there is less need for investors to hold foreign equities. Thus, there is an interesting interaction between the choice over sectors and the choice over countries.

The interaction predicts that industrial specialization has a negative effect on national home bias. More diversified countries exhibit higher degrees of intra-national risk hedging such that sectoral shocks in an individual industry do not affect the whole economy in a substantial way. In contrast, highly-specialized countries incur greater risks due to their few productive sectors. There is limited intra-national risk hedging since other domestic sectors are susceptible to the loss of returns once the key industries are in peril. Consequently, national home bias in those countries is low as their investors hold fewer domestic assets and rely more heavily on international risk hedging by holding foreign assets.

To account for intra- versus inter-national risk hedging patterns, I empirically test the relationship between national home bias in equity holdings and countries' industrial specialization index proxied by the Herfindahl-Hirschman Index (HHI). I find a negative correlation which supports the prediction of the model: More specialized countries have lower national home bias.

This paper extends the literature that studies investors' risk-hedging motives as a reason for equity home bias by adding the sectoral productivity dimension. Coeurdacier and Rey (2013) provide a comprehensive survey of this strand of literature. Other examples include Baxter and Jermann (1997) and Heathcote and Perri (2013) which focus on the hedging of labor income risk with different assumptions regarding the covariance between physical capital and human capital. Cole and Obstfeld (1991), Coeurdacier (2009) and Kollmann (2006) introduce real exchange rate risk by including one tradable good from each country. Compared to previous work, my model allows for multiple sectors of production within countries and intra-sectoral trade across countries. Investors not only choose assets based on the country of issue but also the sector, and thus have more ways to hedge against the two risks. My model is also a more general case of Tesar (1993), Matsumoto (2007) and Collard et al. (2007) who have one tradable and one nontradable sector in each country. I introduce sector-specific trade costs in Eaton and Kortum (2002)'s framework to capture the nontradability of some industries.

The paper is also related to the literature on the interaction of risk sharing and industrial specialization. The strand of literature can be traced back to Helpman and Razin (1978) who argue that the benefits of specialization can be achieved by trade in assets to insure against production risk. Recently, Kalemli-Ozcan et al. (2003) and Koren (2003) find empirical support for the positive impact of financial integration on trade specialization. This paper focuses on the feedback of industrial structure on asset positions by examining how trade specialization affects portfolio diversification.

The remainder of the paper proceeds as follows: Section 2 presents the empirical findings about sectoral and national home bias. Section 3 describes and solves the model. Section 4 elaborates on the application of the model. Section 5 concludes.

2 Empirical Analysis

In this section, I empirically examine two hypotheses about equity home bias. First, at the sectoral level, investors exhibit stronger home bias in less productive sectors than in more productive sectors. Second, at the national level, counties with a higher degree of industrial specialization show weaker aggregate home bias. The analysis will support the model prediction that sectoral productivity differences affect portfolio choices between domestic and foreign assets.

2.1 Data Description

Equity Holdings

Factset/Lionshare provides comprehensive data on the equity holdings of institutional investors from over 100 countries or regions since 1998. Typical institutional investors include banks, insurance companies, retirement or pension funds, hedge funds and sovereign wealth funds. Table A1 lists the top twenty U.S. institutional investors by assets as of 2014Q3.

Institutional investors have played an increasing role in equity markets worldwide. Figure A1 shows how the US household share of equity ownership has fallen over time. Robert Shiller calls this phenomenon 'migration of capital from Main Street to Wall Street'. The dominance of institutional investors over household investors is also commonly observed in other countries.[1]

Factset/Lionshare data originate from public filings by investors (such as 13-F filings with the Securities and Exchange Commission in the U.S.), regulatory agencies around the world and company annual reports. Using the dataset, we can group securities by their location and sector, as well as group holders by their nationality.[2]

Figure 1 shows the funds allocation for the US on Jan 5, 2015. The U.S. invests 83.1% of its equities domestically.[3] The U.S. is highly diversified in terms of sectors, with finance, health and electronics being the most popular ones.

Stock Market Values

Thomson Reuters Datastream offers global country- and sector-level financial data including market values. Factset/Lionshare and Datastream unfortunately do not categorize industries in the same way. Table A2 lists the concordance of the two classification system.

Productivity Measures

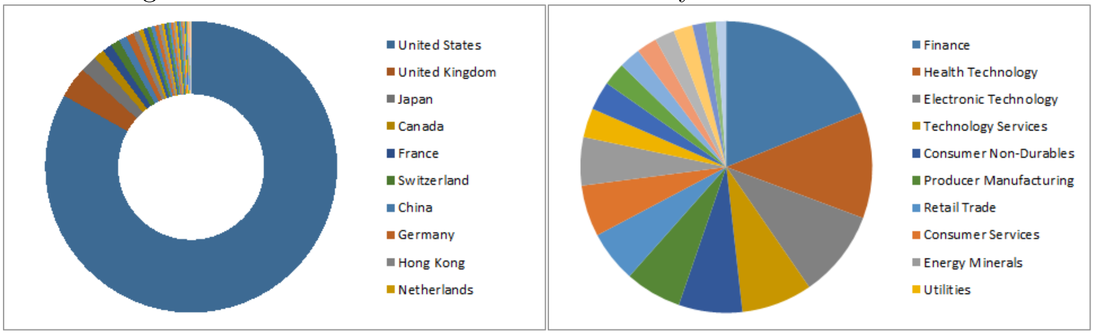
I use the UNIDO Industrial Statistics Database to calculate sectoral productivity. It reports data at the 4-digit level of ISIC Rev.4 on value-added, employment, wages and fixed capital for-

[1] According to INSEAD OEE Data Services, households only accounted for 12% ownership of the EU corporate equities in 2012.

[2] Data limitations only allow me to aggregate the top 50 institutional investors in each of the 100+ countries. Since the top institutional are the most comprehensive and unbiased investors (like those listed in Table A1), their portfolio choices are representative of the national equity preference to a great extent.

[3] It is partly due to the gigantic size of its stock market relative to other markets. The US accounts for around 40% of the world market portfolio.

Figure 1: US Institutional Investors' Country and Sector Allocation



Note: This figure shows the US institutional investors' equity portfolio on Jan 5, 2015. The source is the ownership data from Factset/Lionshare. The left chart is the allocation across countries, and the right chart is the allocation across sectors.

mation by sector. I consider two measures of productivity: labor productivity and total factor productivity. The former is more comprehensive since investment data are scarce for developing countries. I divide value-added of a sector by its employment to get sectoral labor productivity.

I calculate sectoral total factor productivity (TFP) using the method documented by Inklaar and Timmer (2013)) when they construct the Penn World Table. Capital stocks are estimated using the perpetual inventory method (PIM) based on $K_{t+1} = (1-\delta)K_t + I_t$, where K_t is capital stock and I_t is investment or fixed capital formation. δ represents capital depreciation which is assumed to be 10% annually. To apply PIM, I need to compute the initial capital stock K_0 of a sector. Inklaar and Timmer (2013) argue that assuming an initial capital/output ratio k in $K_0 = Y_0 \times k$ leads to superior results. I compute the value of k by dividing the country's capital stock by its GDP (both of the initial period) in the Penn World Table. Initial capital stock K_0 will be the product of initial net output V_0 and k. After computing K_0, I use $K_{t+1} = (1-\delta)K_t + I_t$ to trace the dynamic capital stock K_t. I also calculate the sectoral factor intensity $1-\alpha$ by averaging the share of wages in value-added of a sector over time. Given all this information, sectoral total factor productivity is computed as $TFP_t = \frac{Y_t}{K_t^{\alpha} L_t^{1-\alpha}}$. Estimates are averaged across time between 1998 and 2014 to be used in the cross-sectoral regression.

2.2 Sectoral Home Bias

Following Ahearne et al. (2004) and Coeurdacier and Rey (2013), I use the difference between the actual country-level holdings of equities and the share of market capitalization in the global equity market to measure national home bias. Home bias in country i sector s is equal to

$$HB_{i,s} = 1 - \frac{\text{Share of Sector s Foreign Equities in Country i Equity Holdings}}{\text{Share of Sector s Foreign Equities the World Market Portfolio}}$$

$HB_{i,s} = 1$ indicates that country i is fully home biased in sector s since it does not hold any foreign equities. $HB_{i,s} = 0$ indicates that country i is fully diversified across countries. In theory, $HB_{i,s}$ can take any value below 1 (including negative values). The numerator in the expression for $HB_{i,s}$ uses the data from Factset/Lionshare directly, while the denominator uses market values from Datastream to get a country's equity share in industry s.

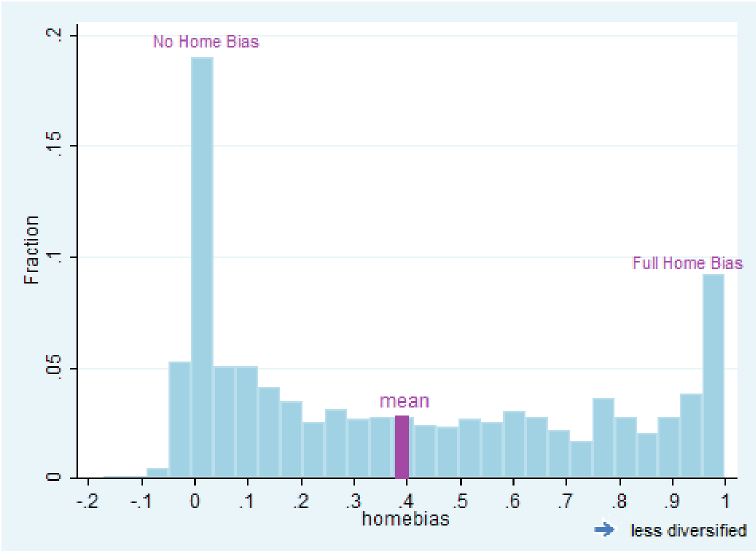
The comprehensive sectoral home bias indices are shown in Table A4, complemented by an abbreviation list of countries and sectors (Table A5).[4] Figure 2 shows the histogram of sectoral home bias. The index ranges from -.2 to 1, with many observations clustered around 0 and 1. Figure 3 plots US sectoral home bias. Furnishings, apparel and utilities show the strongest home bias, while publishing, automobiles and telecommunications show the weakest.

Using the data on sectoral home bias, I explore the the impact of productivity on sectoral home bias. As productive sectors hire more labor , the returns to productive sectors should be more correlated with domestic labor income than is the case for the returns to unproductive sectors. Hence, productive sectors are exposed to greater labor income risk. Consequently, investors respond by showing weaker home bias in productive sectors. In this spirit, I test whether the correlations between sectoral productivity and sectoral home bias are negative by running the following regression

$$HB_{i,s} = \alpha_0 + \alpha_1 X_{i,s} + Z + \epsilon_{i,s}$$

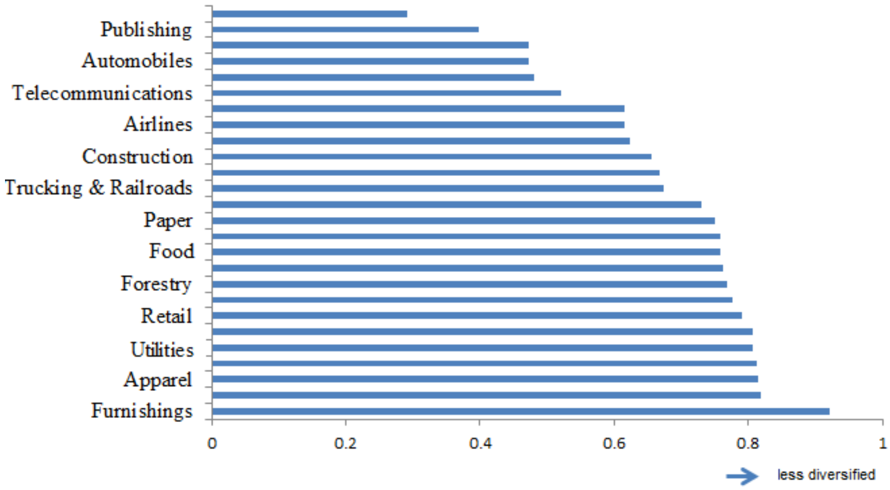
[4] I exclude the countries whose institutional investors hold only domestic assets. Their investment pattern is driven by factors other than risk-hedging motives. These countries include Columbia, Cyprus, Bulgaria, Egypt, India, Indonesia, Sri Lanka, Thailand, Peru, Oman and Turkey. Most of these countries' governments impose strict capital controls on foreign portfolio investment.

Figure 2: Distribution of Sectoral Home Bias



Note: This chart displays the histogram of the sectoral home bias index. The formula of the index is $HB_{i,s}$=1-Share of Sector s Foreign Equities in Country i Equity Holdings/Share of sector s Foreign Equities the World Market Portfolio. The data are from Factset/Lionshare and Datastream. The index covers 26 sectors from 43 countries. There are 834 observations in total, with mean 0.39 and std. dev. 0.36. Detailed information is provided in Table A4.

Figure 3: Ranking of U.S. Sectoral Home Bias



Note: This chart lists the US sectoral home bias from highest to lowest. The horizontal axis labels the home bias index.

The dependent variable $HB_{i,s}$ is sectoral home bias of country i sector s. The independent variable is sectoral productivity $X_{i,s}$. Besides, Z denotes various configurations of fixed effects including country fixed effects (denoted Z_i) and sector fixed effects (denoted Z_s). Country fixed effects enable us to evaluate the role of relative productivity instead of absolute productivity, since in this case country level productivity is controlled for and we can focus on the within-country variation in sectoral productivity. On the other hand, sector fixed effects capture many industry-specific characteristics including factor intensity and nontradability.

The regression results are summarized in Table 1. Overall, sectoral home bias is significantly negatively correlated with sectoral productivity. The results are robust to various specifications of fixed effects. In the OLS case, when labor productivity increases by 1 standard deviation, sectoral home bias decreases by .303 standard deviation; When TFP increases by 1 standard deviation, sectoral home bias decreases by .208 standard deviation. The negative correlation between sectoral home bias and sectoral productivity is robust when the standard errors are clustered at country and sector levels (see Appendix B.1 for more information). Hence, the empirical analysis on sectoral home bias confirms the hypothesis that home bias is weaker in productive sectors than in unproductive sectors. The United Kingdom is a typical example. The UK investors show the weakest home bias in their more productive sectors like automobiles and iron, and show the strongest home bias in their less productive sectors like pharmaceuticals and beverages. Overall, there is a negative correlation between sectoral home bias and sectoral productivity (see Appendix A6 for more information).

In addition to the baseline specification, I do robustness checks by including intermediate imports and outbound foreign direct investment (FDI) as independent variables (see Appendix B.2 for more information). This exercise is to address the concern that trade patterns can also potentially influence equity home bias: given the integration of world production, investors may choose to invest abroad because production takes place in other countries. Table A8 shows that the negative correlation between sectoral productivity and sectoral home bias still holds when we control for intermediate imports and outbound FDI. Meanwhile, these two new variables do not show significant association with home bias.

Based on the variation in sectoral home bias, I further hypothesize that productivity differences across sectors within a country affect a country's overall risk exposure and hence

Table 1: Sectoral Home Bias and Sectoral Productivity

Dep. Var: Sectoral HB	(1)	(2)	(3)
labor productivity	-0.113 ***	-.113 ***	-0.112 ***
	(0.0167)	(0.0167)	(0.0167)
	[-0.303]	[-0.304]	[-0.302]
constant	1.626 ***	1.621 ***	1.612 ***
	(0.185)	(0.186)	(0.189)
Country FE	No	Yes	No
Sector FE	No	No	Yes
Observations	454	454	454
Adj R^2	0.0899	0.088	0.0882
Dep. Var: Sectoral HB	(1)	(2)	(3)
TFP	-0.038 ***	-0.037 ***	-0.045 ***
	(0.010)	(0.010)	(0.010)
	[-0.208]	[-0.207]	[-0.247]
constant	0.472 ***	0.405 ***	0.438 ***
	(0.048)	(0.057)	(0.050)
Country FE	No	Yes	No
Sector FE	No	No	Yes
Observations	350	350	350
Adj R^2	0.0431	0.0550	0.0562

Note: Robust standard errors in parentheses and standardized coefficients in brackets.***significant at 1%. The dependent variable is sectoral home bias. The independent variables are productivity in natural logs. The table reports coefficients in the ordinary least squares (OLS), country fixed effect, sector fixed effect and country-sector fixed effect models.

influences its national home bias. I explore this relationship further in the following section.

2.3 National Home Bias

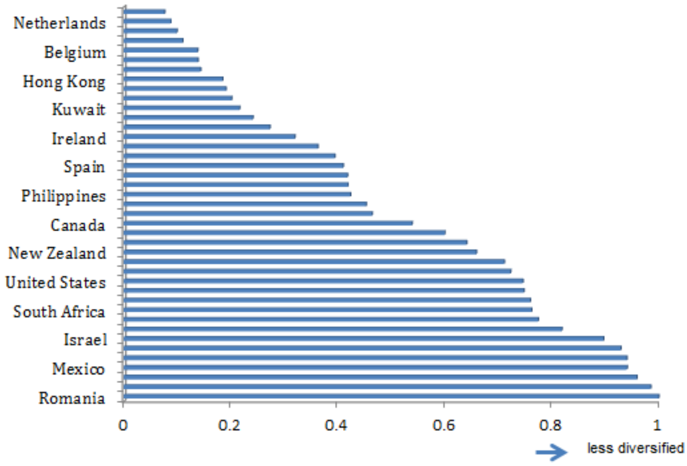
Using the same dataset and method, I calculate home bias at the national level by adding up equities by country

$$HB_i = 1 - \frac{\text{Share of Foreign Equities in Country i Equity Holdings}}{\text{Share of Foreign Equities the World Market Portfolio}}$$

Figure 4 and Table A6 show this constructed national home bias index.[5] Ireland, Luxembourg, Singapore, Belgium and the Netherlands are among the countries that show the weakest home bias. They share some common features like being small open economies. Romania, Malaysia, Korea and China show the greatest home bias. This can be due either to their stringent capital control regime or to their hedging motives. I will explore the latter in the theoretical part of the paper.

[5] My national home bias index is the most comprehensive so far by covering the most countries, meanwhile it is consistent with those in existing literature (shown in Figure A6).

Figure 4: Ranking of National Home Bias



Note: This chart displays the national home bias index. The formula of the index is HB_i=1-Share of Foreign Equities in Country i Equity Holdings/Share of Foreign Equities the World Market Portfolio. The data are from Factset/Lionshare and Datastream.

The home bias index allows me to empirically test my hypothesis that national level home bias is negatively correlated with countries' degree of industrial specialization. The reasoning behind the hypothesis is that, to shield themselves from the excessive risks associated with the productive sectors, investors either hold domestic assets in unproductive sectors or foreign assets. The former is intra-national risk-hedging across sectors and the latter is inter-national risk-hedging across countries. However, when productive sectors account for a predominant share in a country, intra-national risk-hedging is limited: if the key industries fail, the whole economy plummets and the domestic unproductive assets are not immune to the loss of returns. Hence, investors should avoid holding home assets in such a concentrated economy, which leads to low national home bias. Based on this reasoning, I hypothesize that national home bias is stronger in countries with diversified industrial structure than in countries with specialized structure.

I use the Hirschman-Herfindahl index (HHI) to measure industrial specialization. HHI in country i is defined as the sum of squared shares of each sector (s) in the country's total output.

$$HHI_i = \sum_{s=1}^{S} b_{i,s}^2$$

Table 2: National Home Bias and Countries' Industrial Specialization

Dep. Var: National HB	(1)	(2)	(3)	(4)
HHI	-5.900 ***	-5.682 ***	-6.278***	-5.002 **
	(1.645)	(1.843)	(2.210)	(2.364)
	[-0.37]	[-0.35]	[-0.39]	[-0.31]
log(GDP)		0.003	0.012	0.006
		(0.035)	(0.034)	(0.036)
OECD dummy			-0.211 **	
			(0.090)	
tax haven dummy				-0.087
				(0.166)
constant	0.704***	0.622	0.552	0.524
	(0.069)	(0.976)	(0.920)	(0.991)
# observations	40	40	40	40
R^2	0.1364	0.1247	0.2172	0.1349

Note: Robust standard errors in parentheses and standardized coefficients in brackets. **significant at 5%,***significant at 1%. The dependent variable is national home bias. The independent variables include Herfindahl-Hirschman Index (HHI) and GDP in natural logs. In addition, OECD dummy equals one if a country is a member of the Organisation for Economic Cooperation and Development (OECD). Tax haven dummy takes the value of one for countries with zero percent capital gains tax rates.

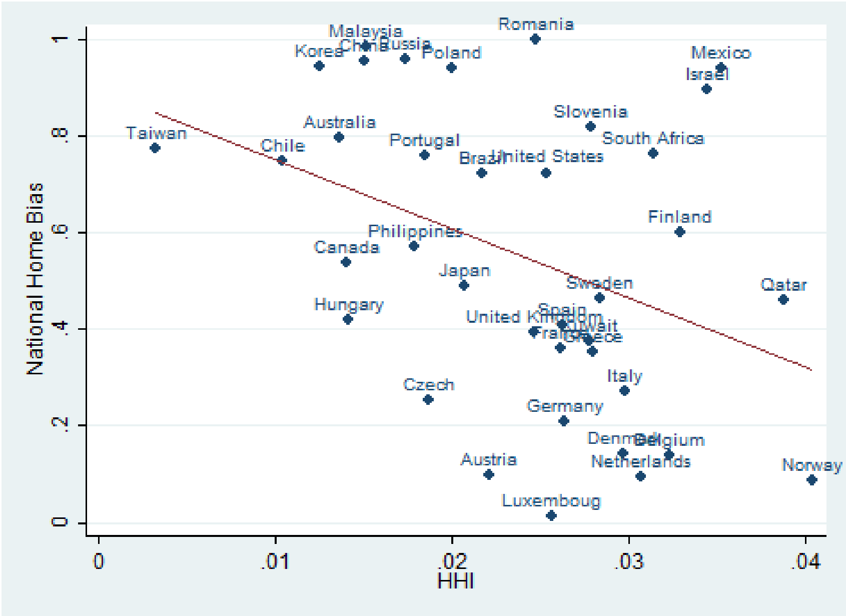
The higher the index value, the more concentrated is the country's production. I use the three-digit ISIC Rev.4 sectoral data from UNIDO averaged from 1998 to calculate countries' HHI. The regression results are summarized in Table 2.

In column 1 of Table 2, when a country's HHI increases by 1 standard deviation, its national home bias decreases by .37 standard deviation. In column 2 where I add the size of the economy (proxied with GDP) as another control variable, the result is similar. The coefficients of HHI are negative at 1% level of significance.

In column 3 of Table 2, I add a dummy for OECD countries to control for the fact that the institutional features of financial markets are different between developing and developed countries. The coefficient of the OECD dummy turns out to be significantly negative at 5%, indicating that OECD countries show weaker national home bias. After controlling for this dummy, the coefficient of HHI increases in the absolute value, which indicates that specialization is more important in explaining the variation in national home bias.

In column 4 of Table 2, I add a dummy for tax havens to correct for potential bias arising from Factset's data limitation that institutional investors in some countries may not only represent the citizens of their own countries, which is especially the case for tax havens which attract many foreign households. I set the dummy equal to one for countries with no capital gains tax.

Figure 5: National Home Bias and Industrial Specialization



Note: This figure plots the relationship between national home bias and countries' specialization index. Herfindahl-Hirschman Index (HHI) is on the horizontal axis and national home bias is on the vertical axis.

The coefficient of HHI is still negative at 5% level of significance in this case.

Figure 5 plots country i's national home bias H_i against the industrial specialization index (HHI_i). Countries like Qatar and Norway, which are heavily dependent on their oil industry as the main source of income, have high HHI_i. As a consequence of their dependence on the oil sector, other sectors in the two countries cannot buffer the economy when there are significant fluctuations in the oil industry. Thus, the investors in the two countries would rather hold foreign assets and exhibit weak national home bias. In contrast, the U.S. and China have highly diversified industrial structures, so they can enjoy a relatively high level of intra-country inter-industry risk hedging. As a result, home bias in these two economies is relatively high.

To sum up the section, I compute sectoral home bias and find its negative correlation with productivity. I also find that national home bias decreases in countries' degree of industrial specialization. In the next section, I build a model to account for these empirical findings.

3 Model

I set up a model in which I derive countries' optimal portfolio in a two-country two-sector framework. The solution sheds light on the risk-hedging patterns across sectors and across countries. The model also explains the empirical findings about sectoral and national home bias in the previous section and elicits implications in the next section about world financial flows.

3.1 Setup

3.1.1 Producers

Two countries ($i = \{H, F\}$) both produce two types of consumption goods ($s = \{a, b\}$). In every country-sector-pair-specific industry (denoted as $f_{i,s}$), there is a continuum of varieties $z \in [0, 1]$. The composite good in an industry is a CES aggregate of different varieties with elasticity of substitution ϵ:

$$Y_{i,s} = [\int_0^1 y_{i,s}(z)^{\frac{\epsilon-1}{\epsilon}} dz]^{\frac{\epsilon}{\epsilon-1}}$$

A firm in country i sector s producing variety z draws its technology $A_{i,s}(z)$ from the Frechet Distribution, as in Eaton and Kortum (2002):

$$F_{i,s}(A) = exp(-T_{i,s}A^{-\theta})$$

$T_{i,s}$ captures the central tendency of sector s in country i: the higher the $T_{i,s}$, the higher average productivity of the industry. Meanwhile, θ reflects the dispersion of the industry; it takes on a great value when the sectoral variance is low. Over time, $T_{i,s}$ follows an AR(1) process with autoregressive coefficients $\rho_{i,s}$ and i.i.d. shocks $\epsilon_{i,s,t} \sim N(0, \sigma_\epsilon^2)$:

$$T_{i,s,t} = \rho_{i,s}T_{i,s,t-1} + (1 - \rho_{i,s})\bar{T}_{i,s} + \epsilon_{i,s,t}$$

Firms hire labor to produce goods. Labor is mobile within a country but immobile across countries. Thus, the production cost is local wage rate w_i. Under perfect competition, the price of one unit of variety z in country i sector s is

$$p_{i,s}(z) = \frac{w_i}{A_{i,s}(z)}$$

In this two-country world, consumers shop globally for the best deal. The actual price of z they pay is the lower of the domestic price and the foreign price. In the benchmark case without trade costs,

$$p_{i,s}(z) = \min\{p_{H,s}(z), p_{F,s}(z)\}$$

Aggregating the prices across varieties, I get sectoral prices under the Frechet distribution:

$$P_s = [\Gamma(\frac{\theta + 1 - \epsilon}{\theta})]^{\frac{1}{1-\epsilon}} \Phi_s^{-\frac{1}{\theta}} \equiv \gamma \Phi_s^{-\frac{1}{\theta}} \qquad where \qquad \Phi_s = \sum_{i \in \{H,F\}} T_{i,s} w_i^{-\theta}$$

Consequently, $\pi_{ij,s}$ — the trade share of country j's products in sector s country i — is equal to the probability that the price of country j's goods is lower. From its expression below, trade share increases in productivity $T_{j,s}$ but decreases in w_j the labor cost of the country.

$$\pi_{ij,s} = \frac{T_{j,s} w_j^{-\theta}}{\Phi_s}$$

Relative productivity across sectors is different across countries. Without loss of generality, I assume country H is more productive in sector a and country F is more productive in b:

$$\frac{\bar{T}_{H,a}}{\bar{T}_{H,b}} > \frac{\bar{T}_{F,a}}{\bar{T}_{F,b}}$$

There is an equity market where firms sell their stocks to both domestic and foreign households. The firms use $1 - \alpha$ of their revenues to cover labor costs, and pay α as dividends to their stock owners. In other words, dividends are a constant share (α) of claims to firms' output.[6]

$$d_{i,s}(z) = p_{i,s}(z) y_{i,s}(z) - w_{i,s}(z) l_{i,s}(z) = \alpha p_{i,s}(z) y_{i,s}(z)$$

In the model, households do not choose firm-level equities but country-sector-specific equities. In total, there are four types of equities, each representing an industry $f_{i,s}$, $(i \in H, F, s \in a, b)$.

[6] It is isomorphic to the case where production is Cobb-Douglas and dividends are claims to capital income.

The dividends in sector s country i are a constant share of the sectoral output:

$$d_{i,s} = \int_0^1 d_{i,s}(z)dz = \alpha Y_{i,s}$$

3.1.2 Households

A representative agent in country i has constant-relative-risk-aversion (CRRA) preference in consumption. His objective is to maximize the expected lifetime utility defined as

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_{i,t}^{1-\sigma}}{1-\sigma}$$

His consumption bundle consists of his expenditure on the two goods: a and b.[7] In the symmetric case, I assume the weight of the more productive goods in consumption is the same across countries[8]. Consumption and aggregate price at home and abroad are given by

$$C_i = (\psi_i^{\frac{1}{\phi}} C_{i,a}^{\frac{\phi-1}{\phi}} + (1-\psi_i)^{\frac{1}{\phi}} C_{i,b}^{\frac{\phi-1}{\phi}})^{\frac{\phi}{\phi-1}}, \qquad P_i = (\psi_i P_{i,a}^{1-\phi} + (1-\psi_i) P_{i,b}^{1-\phi})^{\frac{1}{1-\phi}}$$

where $\psi_H = 1 - \psi_F = \psi$. Given the CES preference, the expenditure share of country s in sector i is dependent on sectoral prices: $\Lambda_{i,s,t} = \psi_{i,s}(\frac{P_{i,s,t}}{P_{i,t}})^{1-\phi}$ with $\psi_{H,a} = \psi_{F,b} = \psi$ and $\psi_{H,b} = \psi_{F,a} = 1 - \psi$.

In the stock market, a household purchases the equities in country i sector s at time t for price $q_{i,s,t}$. Let $\nu_{i,s,t}$ denote the number of shares in country i sector s a domestic household holds at time t, and $\nu^*_{i,s,t}$ denote the asset holdings of the foreign household. Their budget constraints are

$$P_{H,t}C_{H,t} + \sum_{s=\{a,b\}} [q_{H,s,t}(\nu_{H,s,t} - \nu_{H,s,t-1}) + q_{F,s,t}(\nu_{F,s,t} - \nu_{F,s,t-1})] = w_{H,t}L_{H,t} + \sum_{s=\{a,b\}} (d_{H,s,t}\nu_{H,s,t} + d_{F,s,t}\nu_{F,s,t}) \quad (1)$$

[7] The CES functional form is similar to many international macroeconomics models on the topic but the context is different. In one strand, Coeurdacier (2009) and Kollmann (2006) have a consumption composite of aggregate domestic and aggregate foreign goods. In another strand with multi-sectoral analysis, Tesar and Stockman (1995) and Matsumoto (2007) have a composite of tradables and nontradables. In my story, the two goods can be a pair of any two sectors, whether tradable or not. If there is need to introduce non-tradable features of some particular sectors, I can introduce sector-specific trade costs $\tau \to \infty$.

[8] The symmetry of preference over sectors simplifies the derivation of a closed-form solution. If we assume $\psi > \frac{1}{2}$, it means a household consumes more goods in a sector his country is good at producing. With the greater size of the productive sector, we arrive at the usual assumption of consumption home bias commonly seen on the topic. See, for instance, Kollmann (2006) and Heathcote and Perri (2013).

$$P_{F,t}C_{F,t}+\sum_{s=\{a,b\}}[q_{H,s,t}(\nu^*_{H,s,t}-\nu^*_{H,s,t-1})+q_{F,s,t}(\nu^*_{F,s,t}-\nu^*_{F,s,t-1})] = w_{F,t}L_{F,t}+\sum_{s=\{a,b\}}(d_{H,s,t}\nu^*_{H,i,t}+d_{F,s,t}\nu^*_{F,s,t}) \quad (2)$$

The budget constraints state that the sum of consumption expenditures and changes in equity positions is equal to the sum of labor income and dividend income.

In the labor market, a representative household supplies one unit of labor inelastically. The amount of labor is fixed in each country, thus we have the market-clearing condition:

$$L_{i,a,t} + L_{i,b,t} = L_i$$

In the benchmark case, $L_H = L_F = 1$. Due to the mobility of labor across sectors, wage within a country is identical: $w_{i,a,t} = w_{i,b,t} = w_{i,t}$. Without loss of generality, I normalize $w_{F,t}$ to one and denote $w_{H,t}$ as w_t.

3.1.3 Optimal Allocation

In this two-country context, the complete market features perfect risk-sharing across countries such that an individual country's consumption is not subject only to its own income constraint. According to Backus and Smith (1993), the optimal consumption allocation in the complete market satisfies the condition that the relative marginal utility across countries equals the consumption-based real exchange rate:

$$\frac{U'(C_{H,t})}{U'(C_{F,t})} = \frac{P_{H,t}}{P_{F,t}} = e_t$$

The solution to the portfolio choice problem will support this optimal allocation.

3.1.4 Equilibrium

The equilibrium of the model consists of a sequence of prices such as goods prices $P_{i,s,t}, P_{i,t}, P_{s,t}$, wages $w_{H,t}, w_{F,t}, w_t$, asset prices $q_{i,s,t}$, dividends $d_{i,s,t}$ and the real exchange rate e_t, as well as a vector of quantities including output $Y_{i,s,t}$, consumption $C_{i,s,t}, C_{i,t}$, labor $L_{i,s,t}$, and asset holdings $\nu_{i,s,t}$ such that:

(a) Firms choose prices and quantities to maximize their profits;

(b) Households choose consumption and equity holdings to maximize expected lifetime utility;

(c) Goods market clears: $\sum_{i=\{H,F\}} Y_{i,s,t} = \sum_{i=\{H,F\}} C_{i,s,t}$;

(d) Factor market clears: $\sum_{s=\{a,b\}} L_{i,s,t} = L_i$;

(e) Equity market clears: $\nu_{i,s,t} + \nu^*_{i,s,t} = 1$ for $i \in \{H, F\}, s \in \{a, b\}$.

(f) Portfolio holdings support the optimal consumption allocations in the complete market.

3.2 Portfolio Choice

I apply and extend Coeurdacier and Rey (2013)'s analysis to a case with multiple sectors in a country, in order to solve for the portfolio choices in the model. To do so, I log-linearize the model around the steady state (see Appendix C.1) and solve for the portfolio that supports the optimal consumption allocation regardless of the types of productivity shocks to be realized in the economy. I will start with the partial equilibrium where I relate portfolio choices to variables' covariances and then proceed to the general equilibrium where the portfolio is expressed in terms of parameters in the model.

There are four types of country-sector-pair-specific equities in the domestic households' portfolio and three unknown weights: the weight of sector a in the portfolio μ and the weights of domestic assets within each sector S_a, S_b. Thus, the weights of the four assets $f_{H,a}, f_{H,b}, f_{F,a}$ and $f_{F,b}$ are $\mu S_a, \mu(1 - S_a), (1 - \mu)S_b$ and $(1 - \mu)(1 - S_b)$ respectively. With the symmetry across countries, foreign asset holdings should be the mirror image of domestic asset holdings: $S_a = S^*_b, S_b = S^*_a, \mu^* = 1 - \mu$ (asterisk is shorthand for foreign choices). Plugging the result in the static budget constraints of the two countries yields

$$P_H C_H = w_H L_H + \mu S_a d_{H,a} + \mu(1 - S_a)d_{F,a} + (1 - \mu)S_b d_{H,b} + (1 - \mu)(1 - S_b)d_{F,b} \quad (3)$$

$$P_F C_F = w_F L_F + \mu S_a d_{F,b} + \mu(1 - S_a)d_{H,b} + (1 - \mu)S_b d_{F,a} + (1 - \mu)(1 - S_b)d_{H,a} \quad (4)$$

I examine the country's national home bias by adding up the two budget constraints (Equation 3 and 4). Let $\chi(x_1, x_2)$ be the covariance between variable x_1 and variable x_2 and $\chi^2(x)$ be the variance of variable x. I also denote the sum of the covariances of variable $\hat{x}$ with $\hat{d}_a, \hat{d}_a$ as $\sum \chi(\hat{x})$ and the variance of sectoral relative returns as $\chi^2 = \chi^2(\hat{d}_a) = \chi^2(\hat{d}_b)$.

Proposition 1. *The share of domestic assets in the portfolio is*

$$\mu S_a+(1-\mu)S_b = \frac{1}{2}+[\frac{\sigma-1}{2\sigma\alpha}\sum\chi(\hat{e})-\frac{1-\alpha}{2\alpha}\sum\chi(\hat{wL})-\frac{2\mu-1}{2}\sum\chi(\hat{d}_H)][\chi^2+\chi(\hat{d}_a,\hat{d}_b)]^{-1} \quad (5)$$

When the households are risk averse, they increase their aggregate domestic holdings to hedge against real exchange rate risk. Meanwhile, they increase their aggregate foreign holdings to hedge against labor income risk.

Proof. See Appendix B. □

In Equation 5, aggregate domestic share (denoted as D hereafter) consists of four terms: $\frac{1}{2}$, $\sum\chi(\hat{e})$, $\sum\chi(\hat{wL})$ and $\sum\chi(\hat{d}_H)$. $\frac{1}{2}$ represents households' diversification motives across countries. The other three terms capture households' asset positions driven by risk-hedging incentives. With $\chi^2+\chi(\hat{d}_a,\hat{d}_b) > 0$, D increases in $\sum\chi(\hat{e})$ when $\sigma > 1$, meaning that risk-averse households buy domestic assets to hedge against real exchange rate risk. The intuition is that when households are risk averse, they have stronger needs to smooth consumption across time. When local goods are expensive, they do not postpone consumption but purchase assets with high returns to stabilize their purchasing power. As a result, they hold domestic assets as there is a positive correlation between domestic returns and local prices. Besides, D also decreases in $\sum\chi(\hat{wL})$, indicating that households hold foreign assets to hedge against domestic labor income risk. This result arises from the positive correlation between domestic labor income and domestic asset returns. So far, the conclusions resonate with those in prior works summarized in a generic form by Coeurdacier and Rey (2013).

What is new in my paper is the term capturing the covariance between domestic returns across sectors $\sum\chi(\hat{d}_H)$. Its sign determines the relationship between the choice over sectors and the choice over countries.

Proposition 2. *Sectoral share μ and national share D are substitutes as long as $\sum\chi(\hat{d}_H) > 0$. If $\sum\chi(\hat{d}_H) < 0$, μ and D are complements.*

The reasoning is as follows. $\hat{d}_H$ is the increase of $d_{H,a}$ relative to that of $d_{H,b}$. When $\sum\chi(\hat{d}_H)$ is positive, it means the sum of domestic sectoral returns relative to foreign ones is increasing in the relative performance of domestic productive sector relative to that of the domestic unproductive sector. Algebraically,

$$\sum \chi(\hat{d}_H) = \chi(\hat{d}_H, \hat{d}_a) + \chi(\hat{d}_H, \hat{d}_b) = \chi(\hat{d}_{H,a} - \hat{d}_{H,b}, \hat{d}_{H,a} - \hat{d}_{F,a}) + \chi(\hat{d}_{H,a} - \hat{d}_{H,b}, \hat{d}_{H,b} - \hat{d}_{F,b}) > 0$$

When intra-national gap $(\hat{d}_{H,a} - \hat{d}_{H,b})$ is widening, so is inter-national gap $(\hat{d}_{H,s} - \hat{d}_{F,s}, s = a, b)$. The internal condition and the external condition work in the same direction on the relative performance of sector $f_{H,a}$. $f_{H,a}$ the productive sector at home is associated with great risks, so aggregate domestic holdings D decrease in aggregate productive sectors' holding μ; Households skew their choice towards foreign assets to globally diversify the risks arising from favoring the productive sector. In the other case where $\sum \chi(\hat{d}_H) < 0$, intranational risk and international risk partially cancel out. For instance, the improved performance of the productive sector at home deteriorates the relative performance of the home country as a whole. The negative correlation makes domestic assets a good hedge against the risks associated with the productive sector. Therefore, aggregate domestic holdings D increase in aggregate sectoral holdings of the productive sector μ.

By adding this interplay between sector choice and country choice, I point to a new explanation of why national home bias in some countries is high. In an economy with $\sum \chi(\hat{d}_H) > 0$, home bias can be high because the country holds many unproductive sectors' assets so that risk-hedging across sectors replaces the need for risk-hedging across countries.

Next I analyze the general equilibrium of the model. Households choose the optimal values of μ, S_a and S_b regardless of the type of shocks to be realized in the economy. Thus, I solve the portfolio problem by matching the corresponding coefficients after log-linearizing the model.

Proposition 3. *In this complete market, sectoral home bias in the general equilibrium features*

$$\Omega_1 \equiv \mu S_a - (1-\mu)(1-S_b) = -\frac{T}{T+1}\frac{1-\alpha}{\alpha} + \frac{T}{T+1}\frac{1}{\alpha}\frac{(1-\frac{1}{\sigma})}{\lambda-\theta} \tag{6}$$

$$\Omega_2 \equiv (1-\mu)S_b - \mu(1-S_a) = \underbrace{-\frac{1}{T+1}\frac{1-\alpha}{\alpha}}_{\textit{Labor Income Risk}} \underbrace{-\frac{1}{T+1}\frac{1}{\alpha}\frac{(1-\frac{1}{\sigma})}{\lambda-\theta}}_{\textit{Exchange Rate Risk}} \tag{7}$$

where $\lambda \equiv 1 + \theta - \phi + (2\psi - 1)^2(\phi - \frac{1}{\sigma})$

Proof. See Appendix B. □

In the expressions above, Ω_1 reflects households' preference for the domestic productive sector relative to the foreign productive sector, while Ω_2 reflects households' relative preference for the domestic unproductive sector over the foreign unproductive sector. The term $-\frac{1-\alpha}{\alpha}$ captures households' hedging against labor income risk in holding equities. When we add the coefficients before the term across Ω_1 and Ω_2, we have $\frac{T}{T+1} + \frac{1}{T+1} = 1$. On the other hand, $\frac{1}{\alpha}\frac{(1-\frac{1}{\sigma})}{\lambda-\theta}$ captures the real exchange rate risk. When we take the difference between the coefficients before the term across Ω_1 and Ω_2, we have $\frac{T}{T+1} - (-\frac{1}{T+1}) = 1$.

From this analysis, the two sectors within a country achieve intra-national risk-hedging by (1) alleviating the positive correlation between labor income and financial returns to the other sector and (2) stabilizing the real exchange rate such that the country's purchasing power is not subject to the price fluctuation of the other sector. Therefore, the interaction between the sectors within a country enriches countries' risk-hedging patterns.

When we add up Equation 6 and 7, we find the share of aggregate domestic equities is

$$D = \frac{1}{2} - \frac{1}{2}\frac{1-\alpha}{\alpha} + \frac{1}{2}\frac{1}{\alpha}\frac{T-1}{T+1}\frac{1-\frac{1}{\sigma}}{\lambda-\theta} \tag{8}$$

Equation 8 in the general equilibrium is the counterpart to Equation 5 in the partial equilibrium. The first term $\frac{1}{2}$ is the diversification term, the second terms captures the hedging of labor income risk and the third term reflects the hedging of real exchange rate risk[9]. The result is comparable to that in Coeurdacier and Rey (2013), only when we abstract from the multi-sectoral setting by assuming T goes into infinity.

Therefore, the national home bias of country H follows

$$H_H = 1 - \frac{1-D}{1/2} = -\frac{1-\alpha}{\alpha} + \frac{1}{\alpha}\frac{T-1}{T+1}\frac{1-\frac{1}{\sigma}}{\lambda-\theta}$$

From the expression, we draw the following conclusion:

Proposition 4. *National home bias decreases in T the productivity disparity.*

When there is much productivity disparity between the productive sector and unproductive sector, the world production and trade are more specialized. Under this circumstance, intra-

[9]When the elasticity of substitution between tradable sectors is above unity (Literature including Levchenko and Zhang (2011) set it equal to 2.), $\lambda < \theta$ always holds.

national risk-hedging against real exchange rate risk weakens when T gets bigger, which in turn induces households to hold more foreign assets for inter-national risk-hedging. In the extreme case when $T = 1$, we are back to the Baxter and Jermann (1997)'s case in the absence of real exchange rate risk. In this case, we ignore sectors' different ability to influence the exchange rate; Households hold foreign assets only to deal with labor income risk.

The result predicts that countries with diversified industrial structures have stronger national home bias than countries with few major industries (which is supported by empirical evidence in Section 2.3). Countries like the US have higher national home bias because they can benefit much from intra-national risk-hedging which dampens their incentives to hold foreign assets. But this option is not possible for some oil exporters because their production is overly concentrated in natural resources. The limited domestic options prompt them to invest abroad.

Productivity is not only related to the choice over countries but also to the choice over sectors. When we take the difference between Equation 6 and 7, we find

$$\mu = \frac{1}{2} - \frac{1}{2}\frac{T-1}{T+1}\frac{1-\alpha}{\alpha} + \frac{1}{2}\frac{1}{\alpha}\frac{1-\frac{1}{\sigma}}{\lambda-\theta} \tag{9}$$

Proposition 5. *The share of the more productive sector decreases in T the productivity disparity.*

The greater T, the greater labor income risk is associated with the productive sector. Households respond by favoring the assets in the unproductive sector. In the extreme case where $T = 1$, we are back to Coeurdacier (2009)'s case in the absence of labor income risk. In this case, we ignore sectors' different ability to influence labor income; Households choose assets in the unproductive sector only to hedge against real exchange rate risk.

This result indicates that countries with concentrated industrial structures should avoid assets of their major industries. Otherwise price fluctuations in productive sectors will cause drastic shifts in the households' labor income. For instance, Qatar and Norway should diversify their investment among different industries besides oil. In contrast, countries with diversified industrial structures have more income stabilizers at home, so their preference for productive sectors in the portfolio will not cause fatal problems. An example is that Germany and the US do not need to avoid investing in the auto industry to hedge risks.

So far, I have extended Coeurdacier and Rey (2013)'s analysis to a case with multiple sectors.

In the next section, I will use Devereux and Sutherland (2007)'s method to solve for sectoral home bias and examine how it varies with productivity disparity T.

3.3 Sectoral Home Bias

Devereux and Sutherland (2007, 2011) combine a second-order approximation of the portfolio Euler equation with a first-order approximation of other equations in the model to calculate the static portfolio. Around the steady state of this economy, the approach offers a unique solution where a country's holdings of a sector's assets at home and abroad add up to zero.

Since the analytical results are not illustrative enough, I analyze comparative statics graphically to examine the effect of productivity on sectoral home bias. I get the values for most of the parameters from previous literature in trade and macroeconomics. For instance, Eaton and Kortum (2002) measure technology dispersion θ to be 8.28. Levchenko and Zhang (2011) set the elasticity of substitution between broad sectors ϕ equal to 2. Assumptions about discount factor and technology process are standard. I also assume the coefficient of relative risk aversion is 2 and the weight of productive sectors in consumption is 0.6.[10] In sum, parameter values are listed in Table 3.

Figure 6 plots domestic households' holdings of domestic assets, where the black line is

Table 3: Parametrization in the Benchmark Case

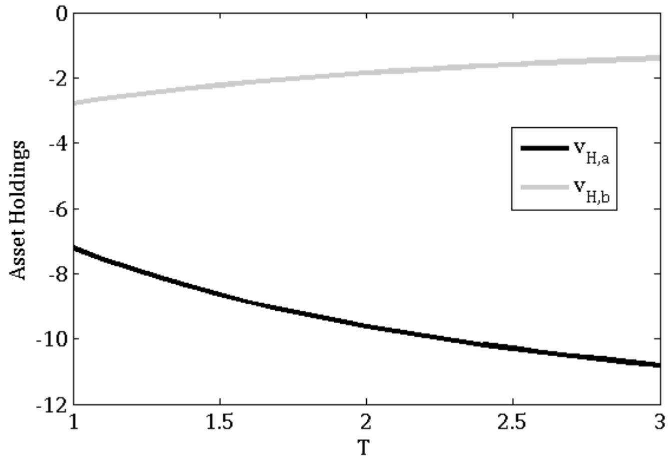
Parameter	Description	Value
β	discount factor	0.95
σ	coefficient of relative risk aversion	2
θ	technological dispersion in the EK model	8.28
ρ	coefficient of autocorrelation in technology	0.9
σ_a	standard deviation of productivity shocks	.025
ψ	weight of the productive sectors' goods in consumption	0.6
ρ	elasticity of substitution between sectors	2

the position of the domestic productive sector and the grey line is the position of the domestic unproductive sector. The holdings of foreign assets are the mirror image of the holdings of domestic assets in the same sector. The unit on the y-axis is the share of the asset in the steady state home income $\bar{Y}_H$. $T = \frac{\bar{T}_{H,a}}{\bar{T}_{H,b}}$ measures the strength of relative productivity.

[10] Appendix D shows that the results of sectoral home bias basically stay the same qualitatively under different parametrization of these two variables.

When I increase the value of T from 1 to 3, $\nu_{H,a}$ decreases and $\nu_{H,b}$ increases, while $\nu_{H,a}$

Figure 6: Sectoral Home Bias and Relative Productivity T



is consistently below $\nu_{H,b}$. With the increase in T, countries are more specialized in production and trade. Thus, the productive sector $f_{H,a}$ is even more exposed to risks. In response, domestic households sell more assets in sector $f_{H,a}$ and increase their holdings of $f_{H,b}$.

In order to further explain the mechanism, Table 4 lists the correlations between asset returns ($r_{i,s}, i \in \{H, F\}, s \in \{a, b\}$) and labor income ($wL$) as well as exchange rate (e) when $T = 3$. From the two rows of the table, $r_{H,a}$ has the greatest correlations, followed by $r_{F,b}$ and then $r_{H,b}$, while $r_{F,a}$ has the least correlations with w and e. The risk-hedging motives prompt households to hold the assets that have the least correlations while avoiding those with the greatest correlations with labor income. Consequently, households prefer $f_{H,b}$ and $f_{F,a}$ to $f_{F,b}$ and $f_{H,a}$. This accounts for the greater home bias in sector b than in sector a.

Table 4: Asset Returns' Correlations with Labor Income and Real Exchange Rate

	$r_{H,a}$	$r_{H,b}$	$r_{F,a}$	$r_{F,b}$
$\rho(wL, r_{i,s})$	0.1896	0.1393	-0.0359	0.1405
$\rho(e, r_{i,s})$	0.2142	0.1613	-0.0202	0.2292

Note: This table lists the correlation between the sectoral financial returns of country i sector s and the real exchange rate e as well as the domestic labor income wL.

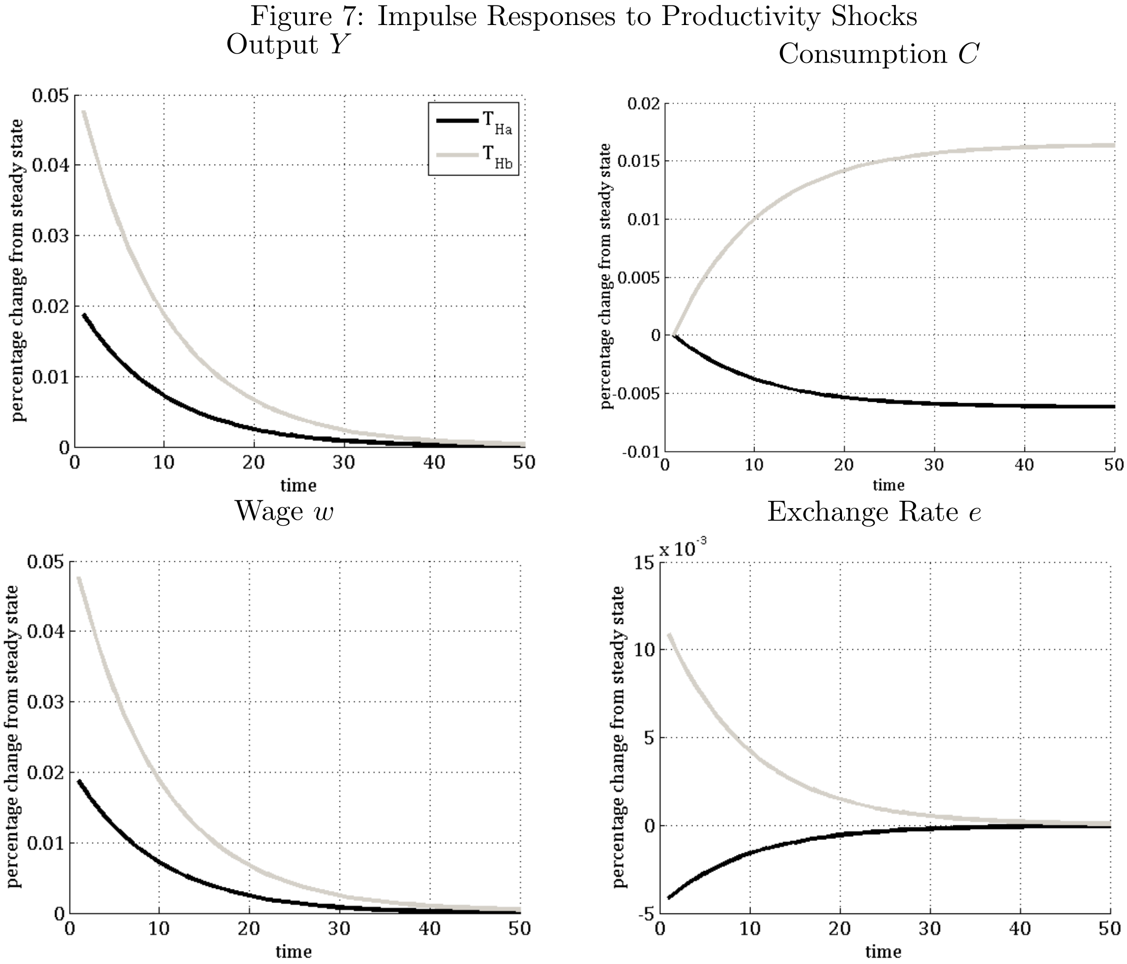
To sum up, sectoral home bias is stronger in unproductive sectors than in productive sectors. Households sell short more of domestic productive sectors' assets for hedging purposes. The difference in sectoral home bias between a and b increases in the relative productivity T.

3.4 Dynamic Analysis

In this section, I study the dynamics of the economy in response to sectoral productivity shocks. I start with macroeconomic variables and then proceed to asset positions.

Figure 7 compares the influence of a one-standard deviation sectoral productivity shock at home on relative output, consumption, wage earnings and exchange rate across countries.

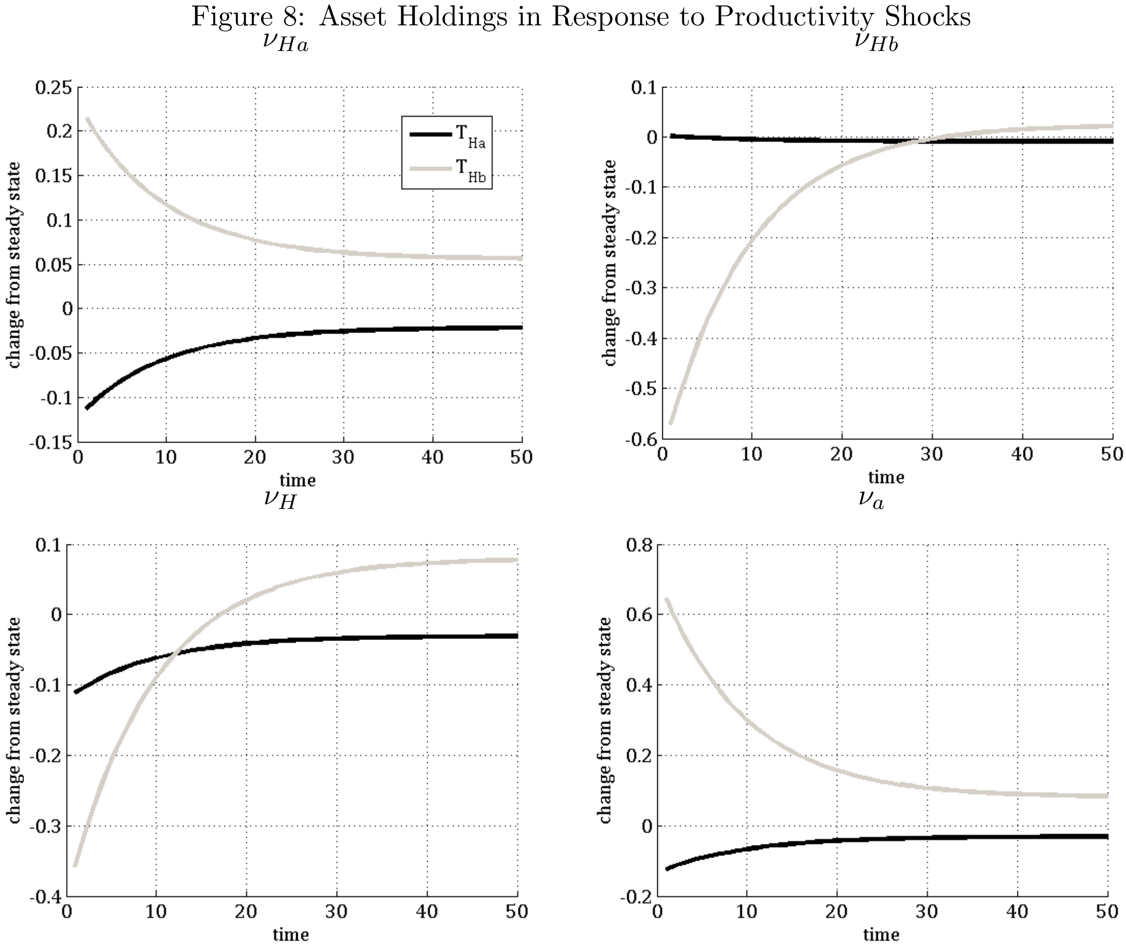
Figure 7: Impulse Responses to Productivity Shocks



The aggregate domestic output relative to foreign output rises in response to the sectoral productivity shocks at home. Adjusted for different standard deviations across sectors, the effect of a 1% increase in the productivity of the productive sector ($T_{H,a}$) will be greater than that of the unproductive sector ($T_{H,b}$). Since labor income constitutes a constant proportion of aggregate output, we observe a similar trend in the impulse response of the relative wage.

Shifts in $T_{H,a}$ and $T_{H,b}$ affect the relative consumption at home as well as the real exchange rate in the opposite direction. A positive productivity shock in the productive sector depresses the domestic consumption and depreciates the home purchasing power. This is due to the fact that the productivity boost in the productive sector worsens the weighted terms-of-trade of the home country, impacting its ability to consume and to purchase. Whereas a productivity enhancement in the unproductive sector improves terms-of-trade and boosts consumption.

Figure 8: Asset Holdings in Response to Productivity Shocks



We can also use the method in Devereux and Sutherland (2011) to analyze dynamic portfolio choices [11]. Figure 8 depicts the dynamics of country H's holdings of sectoral domestic assets

[11]The mechanism of the method can be traced back to Samuelson (1970) who states that an $N+2$ degree of

($\nu_{H,s}, s \in \{a, b\}$), aggregate domestic assets (ν_H) and aggregate productive sectors' assets at home and abroad (ν_a).

In the first two subplots where there is productivity improvement in either domestic sector $f_{H,s}, s \in \{a, b\}$, households lower their holdings of that particular sector on impact. Whether the other sector at home can absorb some of the outflow depends on its relative productivity. In the graph, $\nu_{H,b}$ is almost unchanged by a $T_{H,a}$ shock, while $\nu_{H,a}$ goes up significantly and permanently when $T_{H,b}$ changes. In the former case, $\nu_{H,b}$ in the steady state already carries much responsibility in risk hedging. Thus, a productivity shock to the domestic productive sector $f_{H,a}$ is anticipated and accounted for by the optimal setting of $\nu_{H,b}$ in the first place. In the latter case, $\nu_{H,a}$ does not play as important a role in risk hedging as $\nu_{H,b}$ does. Hence, when a shock happens to $f_{H,b}$, $\nu_{H,a}$ has to increase significantly to offset the decrease in $\nu_{H,b}$, in which process it takes over the responsibility of stabilizing the real exchange rate and labor income. Another way to illustrate the point is that there is less productivity disparity across sectors at home with the boost of $T_{H,b}$, so sector $f_{H,a}$ becomes less risky and attracts more investment.

The aggregate domestic holdings ν_H (shown in subplot 3) give us a sense of portfolio adjustment across countries. Domestic shares decrease on impact with any positive productivity shock at home, due to the fact that the home country suffers a surprise initial loss of wealth due to their negative holdings of domestic assets. After 30 periods, holdings gradually converge to a new steady state. Whether it is higher than the original one depends on the productivity of the sector that experiences the shock. If what changes is $T_{H,a}$, domestic households want to cut their aggregate domestic holdings further as domestic risks are strengthened with the productive sector's rising productivity. If $T_{H,b}$ changes, domestic holdings increase since the improvement of the unproductive sector eliminates some of the risks because now the two sectors are more even and more intra-country risk hedging becomes possible.

The last subplot in Figure 8 shows the change in ν_a (the sum of $\nu_{H,a}$ and $\nu_{F,a}$). ν_a increases when there is a positive shock to $T_{H,b}$. The strengthening of the unproductive sector at home alleviates the positive covariance between labor income and financial returns to sector a's assets.

approximation of an investors' objective function can capture the N^{th} order of portfolio behaviour. In solving the steady state (zero-order) portfolio problem, we combine the second-order approximation of the portfolio choice equation with the first-order approximation of the equations describing the economy. In solving the dynamic (first-order) portfolio problem, we combine the third-order approximation of portfolio choice equation and the second-order approximation of other equations in the model.

Consequently, households increase the holdings of sector a which is exposed to less risks than before. The last two subplots reaffirm the validity of Proposition 4 and Proposition 5.

3.5 Model Extension

In this section, I extend the baseline model by incorporating nontradability. To do so, I impose sector-specific trade costs ($\tau \to \infty$) on b and turn the model into an economy with a tradable sector (a) and a nontradable sector (b). Meanwhile I also relax the assumption of symmetric preferences across countries. Table 5 compares the results in the baseline case and the case with nontradables.

Table 5: Asset Holdings with and without Nontradables

		Baseline Model	Model with Nontradables
Macro Correlations	$\rho(Y_H, Y_F)$	0.38	0.36
	$\rho(C_H, C_F)$	0.81	0.39
Asset Holdings	$\nu_{H,a}$	-10.81	-10.15
	$\nu_{H,b}$	-1.40	13.67

From the table, we find the cross-country correlations of consumption $\rho(C_H, C_F)$ and output $\rho(Y_H, Y_F)$ are lower with the introduction of nontradables, since nontradables are consumed and produced locally.

Regarding asset holdings, while domestic holdings are negative in the baseline model, they turn positive for the nontradable sector in the extended model. International risk sharing has been greatly impaired, thus households do not circumvent domestic assets as before. Of the two domestic assets, investors prefer $f_{H,b}$ the nontradable sector. Investors have little incentive to hold foreign assets in nontradable sectors because they do not benefit much from linking consumption to returns in nontradable sectors. The result is consistent with those in other papers on the topic such as Matsumoto (2007) and Collard et al. (2007)[12].

[12] My model is a more general representation of previous work, encompassing both tradables of different productivity and nontrable sectors.

4 Conclusion

In this paper, I illustrate whether sectoral productivity drives a country's portfolio choice and explain why. I show empirically and theoretically that industrial structure affects equity home bias both at the industry level and at the country level. The framework I build in this model has wide applications in international economics.

In future research, I will modify the method I use to solve for the optimal portfolio. Devereux and Sutherland (2007, 2011) introduce a powerful tool in capturing the relative patterns of asset holdings, but the method has the following short-comings that prevent it from capturing the absolute moments. First, there is no short-sale constraint in the baseline setup so that agents may hold negative assets in the model. This assumption is not valid in many real situations, so it is necessary to extend the technique by embedding a non-negative constraint. Second, the method solves for the optimal asset holdings around the steady state of the model, which makes it hard to apply it to a case with multiple equilibria or no equilibrium. Coeurdacier et al. (2011) among others also discuss the problem.

The model itself can be extended in the following directions to better capture the reality of international capital flows. First, I will build and solve a full-fledged multi-country multi-sector model with a carefully calibrated numerical exercise to do both cross-sectional and time series analyses of home bias. Second, we can introduce corporate debt into the model to investigate the complementarity as well as the substitutability between debt and equity. Coeurdacier and Gourinchas (2011) discuss the difference between debt and equity at the national level, but the picture will be different at the industry level with corporate instead of government debt. Third, we can incorporate institutional and information frictions in the portfolio choice problem. Despite the fact that these two factors mainly work at the national level, there exists cross-industry variation as is pointed out by Schumacher (2012). Fourth, my model abstracts from physical capital. We can introduce capital goods and dynamic investment to match the characteristics of a production economy better. A good example in this direction is Heathcote and Perri (2013) who argue that the correlation between labor income and capital income affects the hedging ability of financial assets and hence changes investors' equity positions. By including these extensions, future research will provide us with a better understanding of the interplay between industrial structure and home bias.

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Appendices

A Tables and Charts

Table A1: Top Twenty U.S. Institutional Investors by Assets

Name	Equity Assets ($)	Location
The Vanguard Group, Inc.	1,607,502,939,834	PA
BlackRock Fund Advisors	1,216,454,636,413	CA
SSgA Funds Management, Inc.	1,000,113,734,436	MA
Fidelity Management & Research Co.	818,423,292,122	MA
T. Rowe Price Associates, Inc.	505,493,540,323	MD
Capital Research & Management Co.	458,524,984,616	CA
Wellington Management Co. LLP	410,550,019,151	MA
Capital Research & Management Co.	405,170,640,206	CA
Northern Trust Investments, Inc.	343,990,576,944	IL
Massachusetts Financial Services Co.	267,025,899,324	MA
JPMorgan Investment Management, Inc.	247,083,106,467	NY
Dimensional Fund Advisors LP	234,054,032,158	TX
BlackRock Advisors LLC	193,125,056,156	NY
Mellon Capital Management Corp.	191,980,125,222	CA
TIAA-CREF Investment Management LLC	187,726,247,974	NY
Geode Capital Management LLC	173,264,747,809	MA
Invesco Advisers, Inc.	170,566,991,974	GA
Columbia Management Investment Advisers LLC	155,105,284,565	MA
Dodge & Cox	153,491,210,142	CA
OppenheimerFunds, Inc.	147,243,417,222	NY

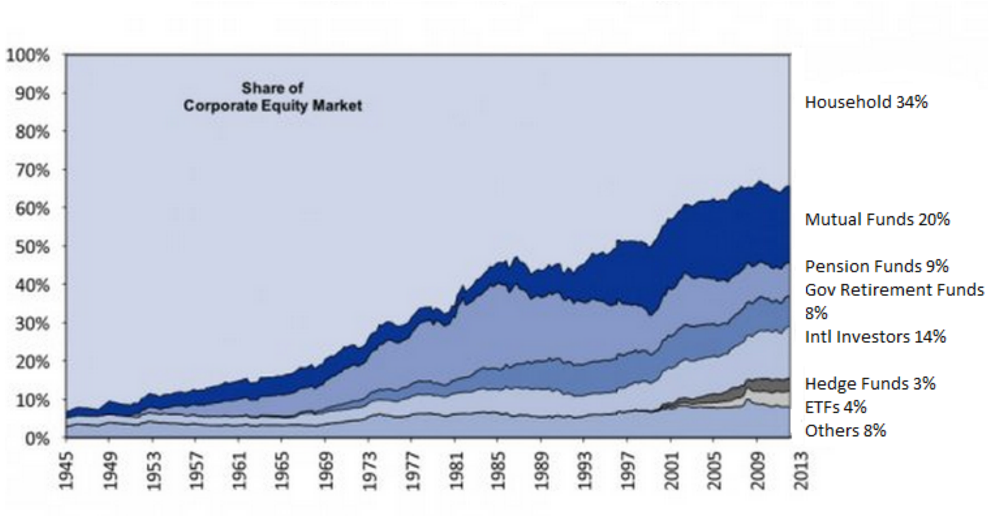
Note: This table lists the name, asset size and location of the top twenty US institutional investors as of 2014Q3. The data source is Factset/Lionshare.

Table A2: Correspondence between Factset and Datastream Industries

Factset Code	Description	ICB	Description
2405 2410	Foods: Major Diversified;	FOODS	Food Producers
2415	Foods: Specialty/Candy; Foods: Meat/Fish/Dairy		
2420 2425	Beverages: Non-Alcoholic; Beverages: Alcoholic	BEVES	Beverages
2430	Tobacco	TOBAC	Tobacco
2440	Apparel; Footware	CLTHG	Clothing & Accessories, Footwear
1130	Forest Products	FORST	Forestry
2230	Pulp & Paper	FSTPA	Paper
2100	Energy Minerals(gas and oil production, coal)	OILGP, COALM	Oil & Gas Producers
2205 2210	Chemicals: Major Diversified ;	CHMCL	Chemicals
2215	Chemicals: Specialty; Chemicals: Agricultural		
2305 2310	Pharmaceuticals: Major;	PHARM	Pharmaceuticals & Biotechnolog
2315	Pharmaceuticals: Other; Pharmaceuticals: Generic		
1105	Steel	STEEL	Iron & Steel
1115 1120	Aluminum; Precious Metals;	NOFMS	Nonferrous Metals
1125	Other Metals/Minerals		
1300	Electronic Technology	ELTNC	Electronics & Electric Equipement
1210	Industrial Machinery	IMACH	Industrial Machinery
1405	Motor Vehicles	AUTMB	Automobiles & Parts
1420	Home Furnishings	FURNS	Furnishings
4700	Utilities(Electric Utilities, Gas Distributors,	UTILS	Utilities
	Water Utilities, Alternative Power Generation)		
3115	Engineering & Construction	HVYCN	Heavy Construction
3500	Retail Trade	RTAIL	Retail
4615 4620	Trucking ; Railroads	TRUCK RAILS	Trucking ; Railroads
4625	Marine Shipping	MARIN	Marine Transportation
4610	Airlines	AIRLN	Airlines
3435 3440	Restaurants; Hotels/Resorts/Cruiselines	RESTS,HOTEL	Restaurants & Bars; Hotels
3420 3425	Publishing: Newspapers;	PUBLS	Publishing
	Publishing: Books/Magazines		
3405 3410	Broadcasting; Cable/Satellite TV;	BRDEN	Broadcasting & Entertainment
3415	Media Conglomerates		
4900	Telecommunications	TELCM	Telecommunications
4800	Finance	FINAN	Financials
4885	Real Estate Development	RLEST	Real Estate

Note: ICB stands for Dow Jones/FTSE's Industry Classification Benchmark. FactSet reports its own industry and sector classifications.

Figure A1: Ownership of the US Corporate Equity Market



Note: This figure shows the historical trend for the ownership of the US equity market since WWII. The data source is Federal Reserve Board St. Louis. From the figure, institutional investors have replaced households as the main owner of the US equities.

Table A3: Correspondence between My Industry Code and ISIC 4

Industry Name	My Code	ISIC 4
Food Producers	1	151, 153, 1520, 154
Beverages	2	155
Tobacco	3	1600
Clothing & Accessories, Footwear	4	1810, 1820
Forestry	5	202
Paper	6	210
Oil & Gas Producers,Coal	7	2310, 2320
Chemicals	8	241, 242
Pharmaceuticals	9	2423
Iron & Steel	10	2710
Nonferrous Metals	11	2720
Electronics & Electric Equipement	12	3110, 3190, 3210
Industrial Machinery	13	291, 292
Automobiles & Parts	14	3410, 3420, 3430
Furnishings	15	3610
Trucking ; Railroads	20	3520
Marine Transportation	21	351
Publishing	24	221

Note: ISIC Rev.4. stands for International Standard Industrial Classification of All Economic Activities, Rev.4.

Table A4: Sectoral Home Bias

sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
AU	0.46	0.69		0.86	0.31	0.63	0.93	0.59	0.67	0.93	0.92	0.25	0.28	0.31		0.63	0.83	0.88	0.78	0.91	0.69	0.95	0.26	0.93	0.63	0.65
BA	0.00	0.00		0.13			0.00	0.16	0.01	0.56		0.02	0.38	0.07		0.11	0.13		0.31			-0.01	0.01			0.10
BD																	0.28	0.02	0.08				0.99			0.91
BG	0.02	0.33		0.10				0.30	0.10		0.25	0.10	0.00			0.00	0.21	0.24	0.16		0.43		0.00	0.07	0.00	0.13
BR	0.68	0.72	0.98	0.98		1.00	0.55	0.81		0.87		0.79	0.85	0.88		0.76	0.72	0.45	0.61	0.99		0.33			0.15	0.42
CA	0.22	0.09	-0.01	0.40	0.90	0.05	0.82	0.64	0.10	0.04	0.72	0.23		0.58	0.42	0.37	0.60	0.36	0.28	0.87		0.26	0.19	0.23	0.39	0.54
CL	0.53	0.75	0.51	0.96	1.00	-0.06	0.00	0.49	0.95	0.54	0.80					0.73	0.88	0.69	0.90		1.00	0.98				0.77
CN	0.94	0.93	0.00	0.96	1.00	1.00	0.84	0.95	0.96	1.00	0.70	0.99	0.98	0.99	1.00	0.80	0.99	0.89	0.55	1.00	0.65	0.95	0.80	0.64	0.92	0.54
CZ	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00							-0.01	0.00	0.00	0.00		0.00		0.00		0.00	0.00
DK	-0.01	0.31		0.27				0.10	0.30			0.09	-0.03			0.00	0.42	0.00	0.16	0.34	0.50			0.13		0.13
ES	0.39	0.25				0.99	0.00	0.64	0.08	0.77	0.69	0.82	0.77	0.00		0.74	0.91	0.61	0.61		0.78	0.83		0.66		0.25
FN	0.61	0.32		0.63		0.16	0.02	0.31	0.31	-0.03	0.06	0.16	-0.06	0.34		0.35	0.75	0.40	0.70	0.20	-0.03	0.31	0.34	0.27	0.24	0.40
FR	0.03	0.00		0.18	0.04	-0.03	0.00	0.50	0.18	0.11	0.01	-0.01	0.23	0.66	-0.01	0.23	0.26	0.07	0.28	0.00		0.52		0.06	0.04	0.13
GR	0.15	-0.01	0.00	0.00			0.00	0.00	0.00	0.03	0.05		0.32			0.14	0.36	0.29	0.58			0.08	0.06	0.08	0.00	0.13
HK	0.34	0.01		0.19	-0.04	0.11	0.34	0.13	0.07	0.00	0.00	0.10	0.06	0.01	0.24	0.38	0.05	0.48	0.63		0.17	0.11	0.35	0.18	0.11	0.31
HN	0.00	0.61		0.06			0.00	0.58	0.22				0.00	0.00		0.26		0.00	0.16				0.59		0.00	0.36
IR	0.39	0.05					0.07		0.00						0.03		0.00	0.00	0.00			0.48	0.00	0.23		0.00
IS	0.60			0.91			0.81	0.94	0.46			0.82	0.84			0.86	0.98	0.64	0.90			0.72	0.50		0.44	0.57
IT	0.08	0.07		0.40		0.07	-0.03	0.02	0.01	-0.04	0.00	0.02	0.31	0.18	0.47	0.50	0.28	0.01	0.07	0.00	0.20	0.00	0.38	0.46	0.37	0.08
JP	0.53	0.32	0.14	0.45		0.57	0.09	0.60	0.34	0.65	0.20	0.40	0.78	0.77	0.20	0.35	0.87	0.44	0.77	0.69	0.94	0.39	0.23	-0.03	0.33	0.25
KO	-0.01	0.00	-0.02	0.00		0.00	-0.01	-0.02	0.00	-0.09	-0.01	-0.05	-0.04	-0.04	-0.01	-0.01	-0.06	-0.01	0.00		-0.03	-0.02	0.00		0.00	-0.02
KW	0.25						0.10	0.11				0.00					0.07	0.00	0.49			0.00	0.00			0.77
LX	0.00	0.00								-0.02		0.00				0.00		0.00	0.00			0.00			-0.03	0.00
MX		0.99	0.94	0.27	1.00	0.98	0.01	0.98		0.98		0.93	0.76	1.00		1.00	0.98	0.54	0.98		1.00	1.00	0.97	0.93	0.98	0.98
MY		0.98						0.94	0.86	0.45	0.95			-0.03		0.13	1.00	1.00	0.96			0.14	1.00		1.00	0.99
NL	0.18	0.14		0.00		0.03		0.11	0.00	-0.05		0.05	0.05	0.03	0.01		0.20	0.16	0.01		-0.02		0.00	0.61	0.00	0.08
NW	0.52	0.19		0.00	0.87	-0.01	0.19	0.63	0.03	0.31		0.10	0.17	0.00		0.80		0.60	0.66	0.00		0.82	0.51	0.00	0.73	0.82
NZ	0.05					0.31	0.01	0.13	0.00			0.01	-0.01		0.53	0.07	0.13	0.00	0.12		0.45	0.09		0.35		0.11
OE	0.17	-0.01					0.72		0.00		0.44	0.06				0.39		0.14	0.69			0.18	0.00		0.02	0.59
PH	0.95	0.86		0.92		1.00	0.92	0.92	0.62	0.88	0.99	0.55	0.95	0.91		0.73	0.98	0.90	0.82	0.92			0.98	0.95	0.68	0.96
PO	0.00	0.10				0.98	0.00	0.00	0.00	0.00		0.03		0.10		0.76	0.56	0.50	0.00		0.00		0.16	0.76	0.87	0.63
PT																0.00		0.00	1.00		1.00					0.94
QA	1.00	0.87		0.00		1.00	1.00	0.93	1.00	0.91		0.29	0.90	1.00		1.00	0.94	0.55	0.97				1.00			
RM	1.00						0.62	1.00	1.00	0.40	0.13		1.00	1.00		1.00	1.00	1.00	0.10		1.00	1.00				0.90
RS	0.06	-0.01		0.00			0.00	0.00	0.00	0.00	0.00	0.09	0.04		0.12	0.00	0.08	0.02	0.40		0.13	0.49	0.13	0.38	0.00	0.09
SA	0.51	0.74		0.00			0.00	0.75	0.93			0.00	0.00	0.18	0.00		0.12	0.79		0.66			0.57	0.00		0.52
SD	0.97	0.01				0.90	1.00	0.96	0.82	0.98		0.53			1.00	0.00	0.99	0.86	0.51		1.00			0.20	0.83	0.76
SG	0.34	0.32	-0.02	0.16	0.67	0.25	0.03	0.05	0.14	0.65	0.00	0.02	0.11	0.05		0.77	0.82	0.01	0.75			-0.01	0.56	0.08	0.49	0.51
SJ	0.08		0.43			0.47	0.18	0.00	0.08	0.57	0.19	0.54	0.91	0.04	0.60	0.00	0.77	0.69	0.61			0.29	0.11	0.00	0.53	0.45
SW	0.26			-0.17	0.57	0.11	0.00	0.24	0.17	0.02		0.03	0.20	0.05		-0.01	0.02	0.07	0.25		0.30	-0.01	0.00	0.03		0.04
TA	0.55			0.49			0.00	0.66		0.72		0.86	0.57	0.45				0.28	0.22		0.68	0.60				0.74
UAE	0.00	0.05							0.00							0.00	0.43		0.43			0.85	0.45			0.54
UK	0.26	0.34	0.52	0.27		0.21	0.14	0.20	0.46	0.01		0.08	0.32	0.12	0.19	0.44	0.41	0.41	0.28	0.03	0.12	0.17	0.61	0.62	0.28	0.50
US	0.76	0.67	0.76	0.81	0.77	0.75	0.82	0.73	0.62	0.47	0.29	0.81	0.61	0.47	0.92	0.81	0.65	0.79	-0.02	0.67	0.48	0.62	0.78	0.40	0.81	0.52
avg	0.35	0.33	0.32	0.34	0.65	0.44	0.28	0.45	0.31	0.41	0.35	0.29	0.39	0.36	0.36	0.40	0.52	0.38	0.44	0.52	0.48	0.41	0.38	0.34	0.37	0.44

Note: This table lists the sectoral home bias index. The formula of the index is $HB_{i,s}$=1-Share of Sector s Foreign Equities in Country i Equity Holdings/Share of sector s Foreign Equities the World Market Portfolio. The data are from Factset/Lionshare and Datastream. The index covers 26 sectors from 43 countries. There are 834 observations in total, with mean 0.39 and std. dev. 0.36. The histogram is shown in Figure 2.

Table A5: Country and Sector Codes

Country/Region	Code	Country/Region	Code	Sector	Code
Australia	AU	New Zealand	NZ	Food Producers	1
Austria	OE	Norway	NW	Beverages	2
Bahrain	BA	Philippines	PH	Tobacco	3
Belgium	BG	Poland	PO	Clothing & Accessories, Footwear	4
Brazil	BR	Portugal	PT	Forestry	5
Canada	CN	Qatar	QA	Paper	6
Chile	CL	Romania	RM	Oil & Gas Producers,Coal	7
China	CA	Russia	RS	Chemicals	8
Czech Republic	CZ	Singapore	SG	Pharmaceuticals	9
Denmark	DK	South Africa	SA	Iron & Steel	10
Finland	FN	Spain	ES	Nonferrous Metals	11
France	FR	Sweden	SD	Electronics & Electric Equipement	12
Germany	BD	Switzerland	SW	Industrial Machinery	13
Greece	GR	Taiwan	TA	Automobiles & Parts	14
Hong Kong	HK	U.A.E.	AE	Furnishings	15
Hungary	HN	United Kingdom	UK	Utilities	16
Ireland	IR	United States	US	Heavy Construction	17
Israel	IS			Retail	18
Italy	IT			Real Estate	19
Japan	JP			Trucking ; Railroads	20
Korea	KO			Marine Transportation	21
Kuwait	KW			Airlines	22
Luxembourg	LX			Restaurants & Bars; Hotels	23
Malaysia	MY			Publishing	24
Mexico	MX			Broadcasting & Entertainment	25
Netherlands	NL			Telecommunications	26

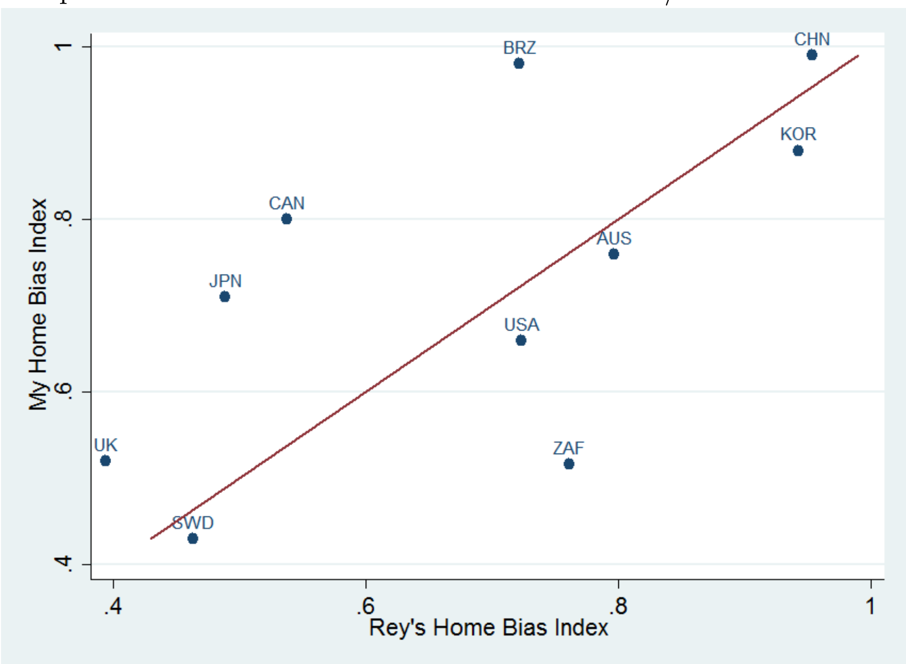
Note: This table defines the abbreviation of countries and sectors listed in Table A4.

Table A6: National Home Bias

Australia	0.797	France	0.362	Malaysia	0.984	Russia	0.958
Austria	0.099	Germany	0.209	Mexico	0.939	Singapore	0.124
Bahrain	0.927	Greece	0.354	Netherlands	0.096	Slovenia	0.818
Belgium	0.138	Hong Kong	0.184	New Zealand	0.658	South Africa	0.761
Brazil	0.722	Hungary	0.418	Norway	0.087	Spain	0.410
Canada	0.538	Ireland	0.319	Philippines	0.570	Sweden	0.463
Chile	0.747	Israel	0.896	Poland	0.939	Switzerland	0.158
China	0.954	Italy	0.272	Portugal	0.758	Taiwan	0.773
Czech	0.254	Japan	0.489	Qatar	0.459	United Arab Emirates	0.836
Denmark	0.144	Korea	0.943	Romania	0.998	United Kingdom	0.394
Finland	0.599	Kuwait	0.377			United States	0.724

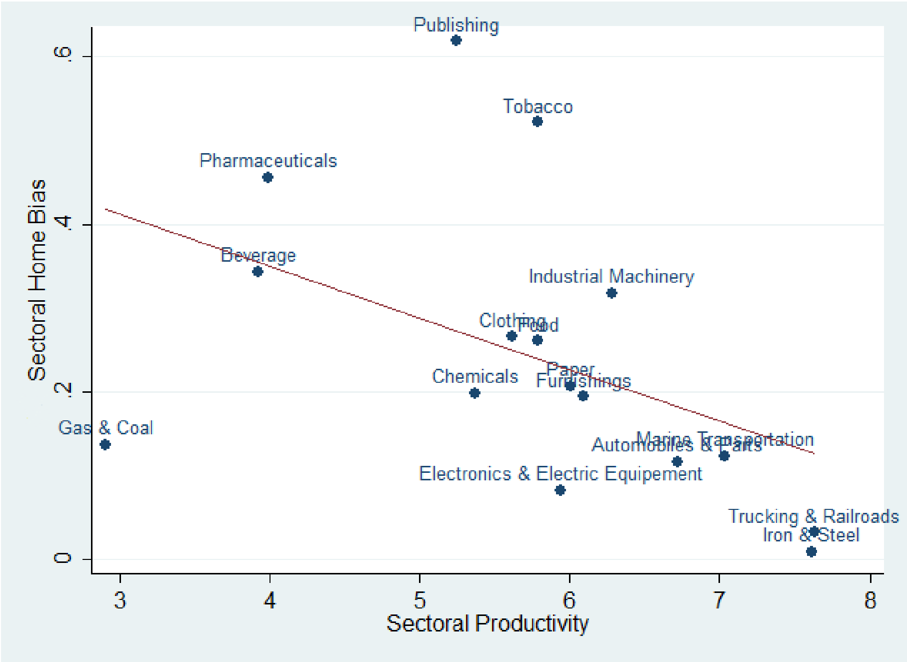
Note: This table lists the national home bias index. The formula of the index is HB_i=1-Share of Foreign Equities in Country i Equity Holdings/Share of Foreign Equities the World Market Portfolio. The data are from Factset/Lionshare and Datastream.

Figure A6: Comparison of Home Bias Constructed with Factset/Lionshare Data and IFS Data



Note: This figure plots my national home bias index against that in Coeurdacier and Rey (2013). I use Factset/Lionshare data to construct the index while they use IFS data. Most of the points are close to the 45 degree line, so the two indices are consistent. Our datasets do cover different time periods, which may account for much of the discrepancy.

Figure A6: UK Sectoral Home Bias and Sectoral Productivity



Note: This figure shows the relationship between the UK sectoral home bias and the UK sectoral TFP in logs. The UK investors show the weakest home bias in their more productive sectors like automobiles and iron, and show the strongest home bias in their less productive sectors like pharmaceuticals and beverages. Overall, there is a negative correlation between sectoral home bias and sectoral productivity.

B Empirical Robustness Checks

B.1 Clustering

In this section, I cluster standard errors at country and sector levels. This exercise is to control for the within-group correlations between observations. In Table A7, we find the negative correlation between sectoral home bias and sectoral productivity still holds.

Table A7: Sectoral Home Bias and Sectoral Productivity

Dependent Variable: Sectoral Home Bias

Clustered at Country Level	(1)	(2)	(3)
TFP	-0.038 **	-0.037 **	-0.045 **
	(0.019)	(0.019)	(0.021)
constant	0.472 ***	0.441 ***	0.438 ***
	(0.115)	(0.111)	(0.107)
Country FE	No	Yes	No
Sector FE	No	No	Yes
Observations	350	350	350
Adj R^2	0.043	0.045	0.056
Clustered at Sector Level	(1)	(2)	(3)
TFP	-0.038 ***	-0.037 ***	-0.045 ***
	(0.008)	(0.009)	(0.009)
constant	0.472 ***	0.441 ***	0.438 ***
	(0.053)	(0.064)	(0.054)
Country FE	No	Yes	No
Sector FE	No	No	Yes
Observations	350	350	350
Adj R^2	0.043	0.045	0.056

Note: Robust standard errors in parentheses and standardized coefficients in brackets.***significant at 1%, **significant at 5%. The dependent variable is sectoral home bias. The independent variables are productivity in natural logs. Standard errors are clustered at country and sector levels.

B.2 Intermediate Imports and Outbound FDI

In this section, I do robustness checks by including intermediate imports and outbound foreign direct investment as independent variables in the regressions which test the relationship between sectoral home bias and sectoral productivity.

The data of sectoral intermediate imports are available in the OECD statistics library. The data of outbound foreign direct investment are available at the International Trade Centre. The regression results are listed in Table A8.

Table A8: Sectoral Home Bias and Sectoral Productivity

Dep. Var: Sectoral HB	(1)	(2)	(3)
TFP	-0.038 ***	-0.038 ***	-0.040 ***
	(0.010)	(0.011)	(0.011)
intermediate imports	-0.004	-0.006	-0.007
	(0.007)	(0.007)	(0.008)
constant	0.521 ***	0.474 ***	0.542 ***
	(0.114)	(0.119)	(0.117)
Country FE	No	Yes	No
Sector FE	No	No	Yes
Observations	308	308	308
R^2	0.045	0.059	0.046
Dep. Var: Sectoral HB	(1)	(2)	(3)
TFP	-0.082 ***	-0.082 ***	-0.084 ***
	(0.021)	(0.020)	(0.022)
outbound FDI	0.003	0.000	0.003
	(0.014)	(0.014)	(0.014)
constant	0.697 ***	0.631 ***	0.684 ***
	(0.183)	(0.182)	(0.183)
Country FE	No	Yes	No
Sector FE	No	No	Yes
Observations	89	89	89
R^2	0.145	0.178	0.148

Note: Robust standard errors in parentheses and standardized coefficients in brackets.***significant at 1%. The dependent variable is sectoral home bias. The independent variables are productivity, imports of intermediate goods and outbound FDI, all in natural logs. The table reports coefficients in the ordinary least squares (OLS), country fixed effect, sector fixed effect and country-sector fixed effect models.

Sectoral home bias is negatively correlated with sectoral TFP in all the specifications. The coefficients of intermediate imports and outbound FDI are not significant, indicating that these two factors are not important drivers for sectoral home bias. My hypothesis that sectoral home bias is weaker in more productive sectors still holds.

C Proofs

C.1 Model Log-linearization

In this section, I log-linearize the model around its steady state and evaluate the effect of sectoral productivity shocks on wages and exchange rates. The answer enables us to determine the equity portfolio by helping us understand the roles that different assets play in risk-hedging.

In the benchmark case, I assume the two countries are symmetric for simplification purposes. Not only do they have the same amount of labor, their within-country relative productivity and preference over goods are also symmetric. The assumptions make it easier to derive analytical solutions and allow us to concentrate on the main mechanism of the model. Many of the assumptions can be relaxed in extended models.

I assume the productivity levels in the steady state are

$$\bar{T}_{H,b} = \bar{T}_{F,a} = 1, \qquad \bar{T}_{H,a} = \bar{T}_{F,b} = T > 1$$

Since there is no trade cost, goods prices are the same across countries with the law of one price (LOOP). The price of sector a goods relative to sector b goods follows

$$s \equiv \frac{P_a}{P_b} = [\frac{T_{H,a}w_H^{-\theta} + T_{F,a}w_F^{-\theta}}{T_{H,b}w_H^{-\theta} + T_{F,b}w_F^{-\theta}}]^{-\frac{1}{\theta}} = [\frac{T_{H,a}w^{-\theta} + T_{F,a}}{T_{H,b}w^{-\theta} + T_{F,b}}]^{-\frac{1}{\theta}}$$

Given the CPI-based real exchange rate $e = \frac{P_H}{P_F}$, we can find the link between the fluctuation in the relative sectoral price s and the variation in the exchange rate e under the CES utility:

$$\hat{e} = (2\psi - 1)\hat{s}$$

where $\hat{x} = log\frac{x_t - \bar{x}}{x}$ is the log-deviation of a variable from its steady state.

Based on Backus and Smith (1993), the changes in the relative marginal utility across countries are proportional to the changes in the consumption-based real exchange rate as

$$-\sigma(\hat{C}_H - \hat{C}_F) = \hat{e}$$

Hence, the relative price-adjusted aggregate consumption $\frac{P_H C_H}{P_F C_F}$ follows

$$\hat{PC} = \hat{P} + \hat{C} = (1 - \frac{1}{\sigma})\hat{e} = (2\psi - 1)(1 - \frac{1}{\sigma})\hat{s}$$

Now let us focus on the the covariance between financial returns. In our model, asset returns of country i sector s at time t are equal to the sum of dividends and changes in the price of equities

$$r_{i,s,t} = \frac{q_{i,s,t} + d_{i,s,t}}{q_{i,s,t-1}}$$

Coeurdacier et al. (2010) and Coeurdacier (2009) show that a 'static' budget constraint condition is equivalent to a dynamic budget constraint condition (Equation1,2) up to a first order approximation. In the static budget constraint with no future variables, the prices of equities q disappear and the covariance between financial returns is solely dependent on the covariance between dividends.

Within a sector, the relative dividend at home versus abroad ($d_s = \frac{d_{H,s}}{d_{F,s}}, s \in \{a, b\}$) is equal to the relative market shares of the two countries in sector s.

$$\hat{d}_s = \hat{T}_s - \theta\hat{w}$$

Within a country, the relative dividend in sector a versus sector b ($d_i = \frac{d_{i,a}}{d_{i,b}}, i \in \{H, F\}$) becomes

$$\hat{d}_i = \hat{T}_i + [\theta - \phi + 1 + (2\psi - 1)^2(\phi - \frac{1}{\sigma})]\hat{s}$$

From the expressions, we find the covariances between dividends not only depend on productivity shifts themselves, but also on their impact on the relative wage and exchange rate.

Denote the difference between the productivity shocks of the two countries' productive sectors as $\hat{T}_1 \equiv \hat{T}_{H,a} - \hat{T}_{F,b}$ and that of the unproductive sectors as $\hat{T}_2 \equiv \hat{T}_{H,b} - \hat{T}_{F,a}$. With the Eaton-Kortum framework which links goods supply to labor cost, a pair of productivity shocks $(\hat{T}_1, \hat{T}_2)$ is uniquely mapped to a pair of wages and prices changes $(\hat{w}, \hat{s})$. The relative wage at home is equal to the relative price-adjusted aggregate production, thus

$$\hat{w} = \frac{1}{1+\theta}\{\frac{T-1}{T+1}[1 + \theta - \phi + (2\psi - 1)^2(\phi - \frac{1}{\sigma})]\hat{s} + \frac{T}{T+1}\hat{T}_1 + \frac{1}{T+1}\hat{T}_2$$

Moreover, the log-linearization of the relative price yields

$$\hat{s} = \frac{T-1}{T+1}\hat{w} + \frac{1}{\theta}\frac{1}{T+1}[-T\hat{T}_1 + \hat{T}_2]$$

Hence, sectoral productivity shocks affect relative labor income and real exchange rate with

$$\hat{s} = \{(T+1)^2(1+\theta) - (T-1)^2\lambda\}^{-1}\{[(T-1)T - \frac{\theta+1}{\theta}(T+1)T]\hat{T}_{H,a} + [T - 1 + \frac{\theta+1}{\theta}(T+1)]\hat{T}_{H,b}$$

$$+[(T-1)(-1) - \frac{\theta+1}{\theta}(T+1)]\hat{T}_{F,a} + [-(T-1)T + \frac{\theta+1}{\theta}(T+1)T]\hat{T}_{F,b}\}$$

$$\hat{w} = \{(T+1)^2(1+\theta) - (T-1)^2\lambda\}^{-1}\{[(T+1)T - \frac{\lambda}{\theta}(T-1)T]\hat{T}_{H,a} + [(T+1) - \frac{\lambda}{\theta}(T-1)(-1)]\hat{T}_{H,b}$$

$$+[(T+1)(-1) - \frac{\lambda}{\theta}(T-1)]\hat{T}_{F,a} + [(T+1)(-T) - \frac{\lambda}{\theta}(T-1)(-T)]\hat{T}_{F,b}\}$$

where $\lambda \equiv 1 + \theta - \phi + (2\psi - 1)^2(\phi - \frac{1}{\sigma})$.[13]

There are two parts in each of the coefficients. The first one denotes the direct effect of sectoral productivity shocks on s or w, and the second denotes the indirect effect induced by demand changes. For instance, the coefficient of $\hat{T}_{H,a}$ in $\hat{w}$ consists of $T(T+1)$ (direct effect) and $-\lambda\frac{T(T-1)}{\theta}$ (indirect effect). With the direct effect, the productivity boost raises the domestic income. With the indirect effect, domestic labor income decreases due to the lower price of exports. The overall influence of the shock depends on which effect dominates.

[13] Since the elasticity of substitution between tradable goods is above unity (Literature including Levchenko and Zhang (2011) set it equal to 2), $\lambda < \theta$ always holds.

C.2 Proof of Proposition 1

The difference between the two countries' budget constraints follows

$$\frac{1}{\alpha}\hat{PC} - \frac{1-\alpha}{\alpha}\hat{wL} = [\mu S_a - (1-\mu)(1-S_b)]\hat{d}_a + [(1-\mu)S_b - \mu(1-S_a)]\hat{d}_b + (2\mu-1)\hat{d}_F$$

$\chi(x_1, x_2)$ is the covariance between x_1 and x_2. $\chi^2(x)$ is the variance of variable x. I also denote the sum of the covariances of variable $\hat{x}$ with $\hat{d}_a, \hat{d}_a$ as $\sum\chi(\hat{x})$. When we take the covariance between $\hat{d}_s$ and all the other variables, we find

$$\begin{aligned}\frac{1}{\alpha}(1-\frac{1}{\sigma})\chi(\hat{e},\hat{d}_a) - \frac{1-\alpha}{\alpha}\chi(\hat{wL},\hat{d}_a) &= [\mu S_a - (1-\mu)(1-S_b)]\chi^2(\hat{d}_a) \\ &+ [(1-\mu)S_b - \mu(1-S_a)]\chi(\hat{d}_b,\hat{d}_a) + (2\mu-1)\chi(\hat{d}_F,\hat{d}_a) \\ \frac{1}{\alpha}(1-\frac{1}{\sigma})\chi(\hat{e},\hat{d}_b) - \frac{1-\alpha}{\alpha}\chi(\hat{wL},\hat{d}_b) &= [\mu S_a - (1-\mu)(1-S_b)]\chi(\hat{d}_a,\hat{d}_b) \\ &+ [(1-\mu)S_b - \mu(1-S_a)]\chi^2(\hat{d}_b) + (2\mu-1)\chi(\hat{d}_F,\hat{d}_b)\end{aligned}$$

$$\Rightarrow \frac{1}{\alpha}(1-\frac{1}{\sigma})\Sigma\chi(\hat{e}) - \frac{1-\alpha}{\alpha}\Sigma\chi(\hat{wL}) = (2\mu-1)\Sigma\chi(\hat{d}_F) + [\mu S_a - (1-\mu)(1-S_b) + (1-\mu)S_b - \mu(1-S_a)](\chi^2 + \chi(\hat{d}_a,\hat{d}_b))$$

Sectoral technological shocks are i.i.d. and countries are symmetric, so the following equations hold

$$\chi^2(\hat{d}_a) = \chi^2(\hat{d}_b) = \chi^2, \qquad \Sigma\chi(\hat{d}_F) = \Sigma\chi(\hat{d}_H)$$

Plug them back and rearrange the equation, I obtain the aggregate domestic share as

$$\mu S_a + (1-\mu)S_b = \frac{1}{2} + [\frac{\sigma-1}{2\sigma\alpha}\sum\chi(\hat{e}) - \frac{1-\alpha}{2\alpha}\sum\chi(\hat{wL}) - \frac{2\mu-1}{2}\sum\chi(\hat{d}_H)][\chi^2 + \chi(\hat{d}_a,\hat{d}_b)]^{-1}$$

Next, I determine the sign of $\chi^2 + \chi(\hat{d}_a, \hat{d}_b)$:

$$\chi^2 + \chi(\hat{d}_a,\hat{d}_b) = [(2\theta T(1 - \frac{\lambda^{\frac{T-1}{T+1}}}{\theta}) - 1]^2 + [2\theta(1 + \frac{\lambda^{\frac{T-1}{T+1}}}{\theta}) - 1]^2 > 0$$

Since it has a positive sign, the coefficient of labor income in Equation 5 is negative and the coefficient of real exchange rate is positive when $\sigma > 1$.

C.3 Proof of Proposition 3

The difference between domestic and foreign budget constraints can be written as

$$\frac{1}{\alpha}\hat{PC} - \frac{1-\alpha}{\alpha}\hat{wL} = [\mu S_a - (1-\mu)(1-S_b)]\hat{d}_1 + [(1-\mu)S_b - \mu(1-S_a)]\hat{d}_2$$

where $\hat{d}_1$ and $\hat{d}_2$ can represent $\hat{d}_1 = \hat{d}_{H,a} - \hat{d}_{F,b} = \lambda s + \hat{T}_1 - \theta\hat{w}, \quad \hat{d}_2 = \hat{d}_{H,b} - \hat{d}_{F,a} = -\lambda\hat{s} + \hat{T}_2 - \theta\hat{w}$. Moreover, a pair of $(\hat{T}_1, \hat{T}_2)$ is uniquely mapped to a pair of $(\hat{s}, \hat{w})$ via

$$\hat{T}_1 = \frac{1}{2T}[(1-T)\lambda - (T+1)\theta]\hat{s} + \frac{1}{2T}[(1+\theta)(T+1) + \theta(T-1)]\hat{w}$$

$$\hat{T}_2 = \frac{1}{2}[(T+1)\theta - \lambda(T-1)]\hat{s} + \frac{1}{2}[(1+\theta)(T+1) - \theta(T-1)]\hat{w}$$

Let $\Omega_1 = \mu S_a - (1-\mu)(1-S_b)$ and $\Omega_2 = (1-\mu)S_b - \mu(1-S_a)$. Plug this in the original budget constraint, and we will get an equation with $(\hat{s}, \hat{w})$ only:

$$(1-\frac{1}{\sigma})(2\psi-1))\hat{s} = (1-\alpha)\hat{w} + \alpha\Omega_1(\lambda\hat{s} + \hat{T}_1 - \theta\hat{w}) + \alpha\Omega_2(-\lambda\hat{s} + \hat{T}_2 - \theta\hat{w})$$

$$\Rightarrow (1-\frac{1}{\sigma})(2\psi-1))\hat{s} = \{1-\alpha-\theta\alpha\Omega_1-\theta\alpha\Omega_2+\frac{\alpha\Omega_1}{2T}[(\theta+1)(T+1)+\theta(T-1)]+\frac{\alpha\Omega_2}{2}[(\theta+1)(T+1)-\theta(T-1)]\}\hat{w}$$

$$+\{\alpha\lambda\Omega_1 - \alpha\lambda\Omega_2 + \frac{\alpha\Omega_1}{2T}[(1-T)\lambda - (T+1)\theta] + \frac{\alpha\Omega_2}{2T}[(1-T)\lambda + (T+1)\theta]\}\hat{s}$$

Optimal portfolio ensues regardless of the w and s shocks to be realized in the economy. By matching the coefficients of $\hat{s}$ and $\hat{w}$, we get the expressions of Ω_1 and Ω_2.

$$\Omega_1 \equiv \mu S_a - (1-\mu)(1-S_b) = \frac{T}{T+1}\frac{\alpha-1}{\alpha} + \frac{T}{T+1}\frac{1}{\alpha}\frac{(1-\frac{1}{\sigma})}{\lambda-\theta}$$

$$\Omega_2 \equiv (1-\mu)S_b - \mu(1-S_a) = \frac{1}{T+1}\frac{\alpha-1}{\alpha} - \frac{1}{T+1}\frac{1}{\alpha}\frac{(1-\frac{1}{\sigma})}{\lambda-\theta}$$

D Comparative Statics with σ and ψ

Home Bias and σ

Domestic households buy the domestic unproductive sector's assets ($\nu_{H,b} > 0$) and sell the domestic productive sector's assets ($\nu_{H,a} < 0$). Home bias in sector a is weaker than that in sector b. With the increase in the coefficient of risk aversion σ, the two asset positions gradually converge. The more risk-averse the households are, the greater tendency they have to smooth consumption by cutting the holdings of risky assets. This explains why the absolute values of the four equity assets all decrease in σ.

Home Bias and ψ

For most values of ψ, $\nu_{H,a}$ lies below $\nu_{H,b}$. Nevertheless, at the right end of ψ, the relationship flips and the holdings of $f_{H,a}$ shoot up. When there is less diversification need in consumption since a domestic agent places dominant weights on a goods, there is limited risk-hedging role for sector b to play. As a result, sectoral home bias is very volatile at the tails of ψ.

Figure A8: σ

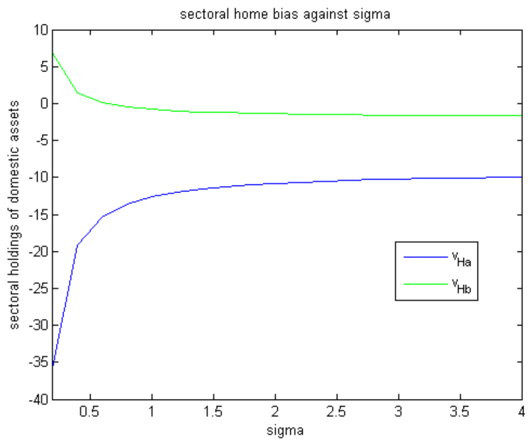
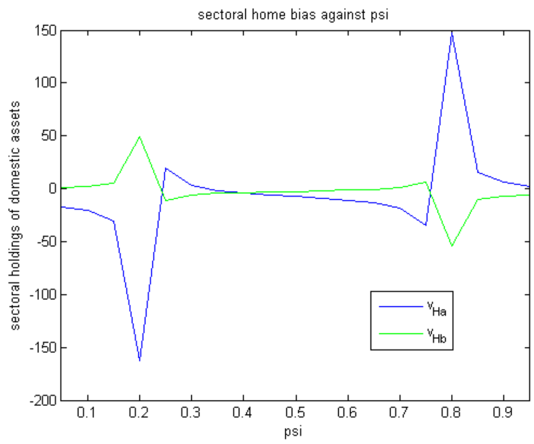


Figure A8: ψ



Note: This figure presents sectoral home bias under different values of coefficient of risk aversion σ and weight of productive sectors' goods in consumption ψ. Parameter values of σ and ψ are on the vertical axes and equity holdings are on the horizontal axes.