Industrial Specialization Matters:
A New Angle on Equity Home Bias

Chenyue Hu

University of California, Santa Cruz

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Abstract

This paper theoretically and empirically examines how industrial structure affects equity home bias. I embed portfolio choice in a multi-country, multi-sector model in order to explore how sectoral productivity differences affect a country's risk exposure and hence influence home bias. The model predicts that investors from highly specialized economies who want to hedge their risk have a strong incentive to avoid domestic assets. I confirm the prediction with the data by finding that home bias is negatively correlated with a country's degree of industrial specialization. This finding unveils the interaction between intranational risk hedging across sectors and international risk hedging across countries.

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

JEL CLASSIFICATION CODES: F36, F41, G11, G15

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 perplexing puzzle in international economics.

Various attempts have been made to examine home bias. Besides informational and institutional frictions that prohibit capital flows, investors' desire to hedge their risk has been proposed as an explanation for why it is optimal to deviate from portfolio diversification.[1] However, most of these studies abstract from industrial structure and as a consequence ignore productivity differences across sectors. In this paper I contend that heterogeneity in sectoral productivity significantly influences the pattern of risk hedging by investors and their portfolio choices. I identify and explain the novel fact that home bias is stronger in countries with more diversified industrial structures.

In order to better understand why industrial specialization may drive the variation in home bias across countries, I build a model in a multi-country, multi-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 volumes, which in turn influence a country's risk exposure. To obtain an analytical solution to the portfolio choice problem in the baseline two-country, two-sector model, I follow the approach developed by Coeurdacier (2009), who derives investors' optimal asset holdings by analyzing the covariances between asset returns and macroeconomic variables. In solving for equity holdings in an extended quantitative framework, I employ the method of Devereux and Sutherland (2011), who use a higher degree of approximation of investors' objective function to capture portfolio behavior.

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[1]This strand of literature may not necessarily solve the home bias puzzle. For instance, Baxter and Jermann (1997) argue that the puzzle becomes even more difficult once non-diversifiable risks are taken into consideration. See Coeurdacier and Rey (2013) for a detailed discussion.

The solution to the model enriches our understanding of investors' risk-hedging pattern and hence their portfolio choices. In this multi-sectoral setting, investors are able to hedge their risk 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 of sectors and the choice of countries.

The interaction predicts that industrial specialization has a negative effect on home bias. More industrially-diversified countries exhibit higher degrees of intranational 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 because they have few productive sectors. In those countries there is limited intranational risk hedging since, once the key industries are in peril, other domestic sectors are also susceptible to financial losses. Thus, to hedge their risk, 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 equity home bias and countries' industrial specialization proxied by the Herfindahl-Hirschman Index (HHI). The home bias index I construct uses proprietary financial datasets, while HHI uses the UNIDO sectoral data. After constructing the two indices, I document a robust negative correlation between them: when institutional features and GDPs are controlled for, a 1 standard deviation increase in HHI is associated with a 0.25 standard deviation decrease in home bias. The result is robust when factor endowment is used as instrumental variables.

In the numerical part of this paper, I extend the baseline model to a quantitative framework that covers a large set of countries and industries. I estimate sectoral productivity and trade cost consistent with the model and trade data. After that, I solve for investors' portfolio choices given the industrial structure. The model performs well in predicting trade volumes, factor prices, and financial frictions. Furthermore, it replicates the negative correlation between home bias and industrial specialization observed in the data. After evaluating model performance, I simulate a counterfactual sce-

nario absent sectoral productivity differences and find the resulting home bias to be notably higher than in the original case. This result, reflecting the benefit of intranational risk hedging arising from industrial diversification, reinforces the importance of incorporating rich industrial structures in studying equity home bias.

This paper extends the literature that relates investors' risk-hedging motives to equity home bias by adding the sectoral productivity dimension. Coeurdacier and Rey (2013) provide a comprehensive survey of the literature. Baxter and Jermann (1997) argue that home bias is more puzzling when labor income risk — due to the positive correlation between domestic labor and capital income — is taken into account. Cole and Obstfeld (1991), Coeurdacier (2009), and Kollmann (2006) introduce real exchange rate risk by including one tradable good from each country. Unlike 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) and Collard et al. (2007), who have one tradable and one nontradable sector in each country. I introduce trade costs in the quantitative framework to incorporate nontradable sectors. Moreover, this paper is related to the work of Heathcote and Perri (2013) and Steinberg (2017), who link portfolio diversification to trade openness. Unlike their models with taste preference as the main driver of trade, I provide more micro-foundations using a Ricardian multi-sectoral framework. This approach is in line with recent research that examines the macroeconomic implications of trade structure, such as Eaton et al. (2016).

The analysis in this paper also complements the literature on the interaction of risk sharing and industrial specialization. This strand of literature can be traced back to Helpman and Razin (1978), who argue that the increased benefits of specialization can be achieved by trade in assets to insure against production risk. More recently, Kalemli-Ozcan et al. (2003) and Koren (2003) find empirical support for the positive impact of financial integration on trade specialization. Here I focus on the influence of industrial structure on asset positions by studying how trade specialization affects portfolio diversification. All of these works, which examine the

interplay between international goods and capital flows, are particularly important for understanding the patterns of globalization.

The remainder of the paper proceeds as follows: Section 2 describes and solves the baseline model. Section 3 presents the empirical findings. Section 4 conducts the quantitative analysis of an extended framework. Section 5 concludes.

2 Model

In this section I build a two-country, two-sector model in which I solve for optimal portfolios. There are two sectors of different productivity levels in each country. Sectoral sizes and trade patterns are determined by sectoral productivity based on Eaton and Kortum (2002)'s framework. Firms in each country and sector use labor and capital to produce goods. Capital income is distributed to shareholders as a dividend. Households choose portfolios that will maximize their expected lifetime utility. The solution to the portfolio choice problem sheds light on the risk-hedging patterns across sectors and countries.

2.1 Setup

2.1.1 Firms

Two countries ($i = \{H, F\}$) both produce two types of consumption goods ($s = \{a, b\}$). In country i sector 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:

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

At time t, firms producing variety z in i sector s draw its technology $A_{i,s,t}(z)$ from the Frechet distribution, as in Eaton and Kortum (2002):[2]

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

$T_{i,s,t}$ captures the central tendency of sector s in country i at time t: the higher the $T_{i,s,t}$, the higher the average productivity of the industry. Over time, I assume that $T_{i,s,t}$ is subject to shocks around a steady state $\bar{T}_{i,s}$.[3] Meanwhile, θ reflects the dispersion of the industry; it takes on a greater value when the sectoral variance is low.

Relative productivity across sectors can be 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. In the symmetric case, the steady state productivity satisfies

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

where T captures the productivity disparity between more productive and less productive sectors.

Firms use labor and capital to produce goods with a Cobb-Douglas technology. Production factors are mobile within a country but immobile across borders. Given capital share α, production cost $c_{i,t}$ is a function of capital rental fee $r_{i,t}$ and wage rate $w_{i,t}$: $c_{i,t} = r_{i,t}^{\alpha}w_{i,t}^{1-\alpha}$.[4] The price of one

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[2]I use Eaton and Kortum (2002)'s framework (EK hereafter) in this paper for three reasons. First, the EK model introduces intra-sectoral trade with minimal parameter restrictions on agents' preference. Second, parameters in the numerical exercise including sectoral productivity can be calibrated with the trade data based on the EK framework. Lastly, the EK model has been widely used by economists to examine the macro implications of trade patterns and industrial structures, fitting the purpose of this paper very well. Recent examples in this strand of literature include Eaton et al. (2016) and Alvarez (2017).

[3]This works similar to productivity shocks in a standard DSGE model. In order to solve for countries' portfolio holdings, I employ the perturbation method that uses higher-order Taylor approximations around a deterministic steady state. In the quantitative exercise, the steady-state productivity will be recovered by the time-averaged trade and production data.

[4]In the baseline case, I assume factor intensity is the same across sectors. This assumption is relaxed in the extended model.

unit of variety z produced in country i sector s is

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

Exports from country j to country i are subject to iceberg trade costs τ_{ij}. In the baseline case, $\tau_{ij} = \tau_{ji} = \tau > 1$ for $i \neq j$ and $\tau_{ii} = \tau_{jj} = 1$. In this two-country world, consumers choose cheaper goods after comparing domestic and foreign prices. Aggregating the prices across varieties yields sectoral prices under the Frechet distribution:

$$P_{i,s,t} = [\Gamma(\frac{\theta + 1 - \epsilon}{\theta})]^{\frac{1}{1-\epsilon}} \Phi_{i,s,t}^{-\frac{1}{\theta}} \equiv \gamma \Phi_{i,s,t}^{-\frac{1}{\theta}} \quad where \quad \Phi_{i,s,t} = \sum_{j \in \{H,F\}} T_{j,s,t}(\tau_{ij}c_{j,t})^{-\theta}.$$

Consequently, $\pi_{ij,s,t}$ — the trade share of country j's products in sector s country i at time t — is equal to the probability that the price of country j's goods is lower. Its expression,

$$\pi_{ij,s,t} = \frac{T_{j,s,t}(\tau_{ij}c_{j,t})^{-\theta}}{\Phi_{i,s,t}},$$

shows that trade share increases in productivity $T_{j,s,t}$ but decreases in production cost $c_{j,t}$ and trade cost τ_{ij}.

There is an equity market where firms sell their stocks to both domestic and foreign households. Given the Cobb-Douglas production technology, firms use $1 - \alpha$ of their revenues to cover labor costs, and pay α as a dividend to stock owners. In other words, dividends are claims to capital income. Equities are then grouped into four types, each representing an industry of country i sector s. The dividends in sector s country i are a constant share of sectoral output:

$$d_{i,s,t} = \int_0^1 d_{i,s,t}(z)dz = \int_0^1 \alpha p_{i,s,t}(z)y_{i,s,t}(z)dz = \alpha P_{i,s,t}Y_{i,s,t}.$$

Firms hire labor and rent capital for production. In the labor market, a representative household supplies one unit of labor inelastically. Both labor and capital endowments are assumed to be fixed in each country, thus we

have market clearing conditions:

$$L_{i,a,t} + L_{i,b,t} = L_i, \qquad K_{i,a,t} + K_{i,b,t} = K_i.$$

In the symmetric case, endowments are equal across countries: $L_H = L_F, K_H = K_F$. Another assumption I make in the baseline model is $K_i = \frac{\alpha}{1-\alpha}L_i$. Under this assumption, factor prices are equal to production costs: $r_{i,t} = w_{i,t} = c_{i,t}$. This specification not only simplifies the solution but also makes it comparable to that in other studies of home bias.[5] The solution remains qualitatively the same under alternative assumptions for factor ratios.

2.1.2   Households

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

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

The household's consumption is a CES bundle of a and b goods. Consumption and aggregate price at home and abroad are given by

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

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 that a domestic household holds at time t, and $\nu_{i,s,t}^*$ denote the asset holdings of a foreign household. Households' 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:

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[5]For instance, see Coeurdacier and Rey (2013) and Baxter and Jermann (1997).

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

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

In this budget constraint, f_i is introduced to capture the financial friction country i incurs when investing in foreign assets. The friction can be driven by capital account restrictions, transaction costs, and capital taxes. As is surveyed by Coeurdacier and Rey (2013), these factors also explain why investors tilt towards domestic assets. If $f_i = 1$, households do not incur financial frictions when investing abroad. If $f_i > 1$, households pay additional costs when buying and selling foreign equities. I assume $f_H = f_F = f$ in the baseline case.

2.2 Portfolio Choice

In order to solve for the portfolio choices in the model, I apply and extend Coeurdacier and Rey (2013)'s analysis to a case with multiple sectors in a country. To do so, I log-linearize the model around the steady state and derive the portfolio that maximizes households' utility regardless of the types of productivity shocks realized in the economy (see Appendix E for details).

I 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. When I derive the results in the partial equilibrium, I assume there are no financial frictions. This assumption makes the results comparable to those in the existing literature and therefore highlights my mechanism. In the general equilibrium, I introduce financial frictions and examine how they influence home bias together with other factors.

There are four types of equities in a domestic household portfolios 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 $\nu_{H,a}, \nu_{H,b}, \nu_{F,a}$, and $\nu_{F,b}$ are $\mu S_a, \mu(1 - S_a), (1 - \mu)S_b$, and $(1 - \mu)(1 - S_b)$ respectively. Given 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 investors' portfolio weights). Plugging this result in the static budget constraints of the two countries yields

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

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

Let $x_t = \frac{x_{H,t}}{x_{F,t}}$ be the ratio of home to foreign variables, and $\hat{x}$ be its deviation from the steady state. I also denote the sum of the covariances of variable $\hat{x}$ with domestic relative to foreign sectoral dividends as

$$\rho(\hat{x}) = cov(\hat{x}, \hat{d}_{H,a} - \hat{d}_{F,a}) + cov(\hat{x}, \hat{d}_{H,b} - \hat{d}_{F,b}).$$

A country's home bias can be examined by adding up the two budget constraints (equation 3 and 4).

Proposition 1. *If there are no financial frictions, the share of domestic assets in the portfolio is*

$$D \equiv \mu S_a + (1 - \mu)S_b = \frac{1}{2} + \zeta[\frac{\sigma - 1}{2\sigma\alpha}\rho(\hat{e}) - \frac{1 - \alpha}{2\alpha}\rho(\hat{wL}) - \frac{2\mu - 1}{2}\rho(\hat{d}_H)]. \tag{5}$$

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

Proof. See Appendix E. $\qquad\qquad\square$

In equation 5, aggregate domestic share D consists of four terms: $\frac{1}{2}$, $\rho(\hat{e})$, $\rho(\hat{wL})$ and $\rho(\hat{d}_H)$. $\frac{1}{2}$ represents households' diversification motives across countries. If there is no covariance between asset returns and macro

variables, a household splits its portfolio evenly across the two countries' assets (as in Lucas (1982)). The other three terms capture households' asset positions driven by risk-hedging incentives. With $\zeta > 0$ (shown in Appendix E), aggregate domestic share D increases in $\rho(\hat{e})$ 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 a greater need to smooth consumption across time. In order to stabilize their purchasing power, they prefer to hold assets whose returns are high when local goods are expensive. As a result, they hold domestic assets since there is a positive correlation between domestic returns and local prices. Besides, D also decreases in $\rho(\hat{wL})$, indicating that households hold foreign assets to hedge against domestic labor income risk. This result stems 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 analysis is the term capturing the covariance between domestic returns across sectors $\rho(\hat{d}_H)$. Its sign determines the relationship between the choice of sectors and the choice of countries.

Proposition 2. *Sectoral share μ and national share D are substitutes as long as $\rho(\hat{d}_H) > 0$.*

The reasoning is as follows. $\hat{d}_H$ is the increase of $d_{H,a}$ relative to $d_{H,b}$. When $\rho(\hat{d}_H)$ is positive, domestic relative to foreign returns is increasing in sectoral returns of the more productive sector relative to the less unproductive sector. Algebraically,

$$\begin{aligned}
\rho(\hat{d}_H) &= cov(\hat{d}_H, \hat{d}_a) + cov(\hat{d}_H, \hat{d}_b) \\
&= cov(\hat{d}_{H,a} - \hat{d}_{H,b}, \hat{d}_{H,a} - \hat{d}_{F,a}) + cov(\hat{d}_{H,a} - \hat{d}_{H,b}, \hat{d}_{H,b} - \hat{d}_{F,b}) > 0.
\end{aligned} \tag{6}$$

When the intranational gap $(\hat{d}_{H,a} - \hat{d}_{H,b})$ widens, so does the international gap $(\hat{d}_{H,s} - \hat{d}_{F,s}, s = a, b)$. In this situation, '$Ha'$ the productive sector at home is associated with great risks, so aggregate domestic holdings D decrease in aggregate productive sectors' holdings μ; Households skew their choice toward foreign assets to globally diversify the risks associated with

favoring the productive sector. In the other case where $\rho(\hat{d}_H) < 0$, intra-national risk and international risk partially cancel out. For example, the improved performance of the productive sector at home lowers 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 $D(= \nu_{H,a} + \nu_{H,b})$ increase with sectoral holdings of the productive sector $\mu(= \nu_{H,a} + \nu_{F,b})$. Nonetheless, this case would require implausible parametric assumptions; nor can I find such a scenario in the data.

Adding this interplay between sector and country choices points to a new explanation for why home bias in some countries is strong. In an economy with $\rho(\hat{d}_H) > 0$, D takes a higher value when μ is low. Intuitively, in order to shield themselves from the excessive risks associated with domestic productive sectors, investors hold either domestic assets in unproductive sectors or foreign assets. The former is intranational risk hedging across sectors and the latter is international risk hedging across countries. If investors hold many unproductive sectors' assets, intranational risk hedging across sectors replaces the need for international risk hedging across countries. Therefore the country exhibits strong home bias.

Next I analyze the general equilibrium of the model. Households choose portfolio weights 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 of productivity shocks.

Proposition 3. *Asset holdings in the general equilibrium features*

$$\Omega_1 \equiv \mu S_a - (1-\mu)(1-S_b)f = -\frac{T}{T+1}\frac{1-\alpha}{\alpha} + \frac{T}{T+1}\frac{1}{\alpha}(1-\frac{1}{\sigma})\lambda, \quad (7)$$

$$\Omega_2 \equiv (1-\mu)S_b - \mu(1-S_a)f = \underbrace{-\frac{1}{T+1}\frac{1-\alpha}{\alpha}}_{Labor\ Income\ Risk} \underbrace{-\frac{T}{T+1}\frac{1}{\alpha}(1-\frac{1}{\sigma})\lambda}_{Exchange\ Rate\ Risk}, \quad (8)$$

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

Proof. See Appendix E. □

In the expressions above, Ω_1 reflects the difference in investors' holdings of domestic and foreign productive sectors, while Ω_2 reflects the dif-

ference in investors' holdings of domestic and foreign unproductive sectors. The term $-\frac{1-\alpha}{\alpha}$ captures households' hedging against labor income risk. When we add the coefficients before the term across Ω_1 and Ω_2, we have $\frac{T}{T+1} + \frac{1}{T+1} = 1$. This result, that the sum is a fixed number, indicates that, if investors hold many domestic productive sectors' assets ('Ha' in the example), fewer domestic unproductive sectors' assets 'Hb' are needed to hedge labor income risk. Similarly, $\frac{1}{\alpha}(1 - \frac{1}{\sigma})\lambda$ captures the hedging against real exchange rate risk. When we take the difference between the coefficients before the term across Ω_1 and Ω_2, we have $\frac{T}{T+1} - (-\frac{1}{T+1}) = 1$. This suggests that, if investors hold many domestic productive sectors' assets 'Ha', they also need to hold more domestic unproductive sectors' assets 'Hb' to hedge exchange rate risk. According to this analysis, the two sectors within a country achieve intranational risk hedging by (1) alleviating the positive correlation between labor income and the performance of the other sector and (2) stabilizing the real exchange rate such that the country's purchasing power is not excessively subject to price fluctuations in the other sector. This analysis of the interaction between sectors within a country provides a more robust understanding of countries' risk-hedging patterns than the one-sector case discussed in previous literature.

Adding up equations 7 and 8 yields aggregate domestic shares

$$D = \frac{f}{f+1} + \frac{1}{f+1}[-\frac{1-\alpha}{\alpha} + \frac{1}{\alpha}\frac{T-1}{T+1}(1 - \frac{1}{\sigma})\lambda]. \qquad (9)$$

λ is negative as long as the elasticity of substitution between tradable sectors ϕ is above unity.[6] In this case, we draw the following conclusion:

Proposition 4. *Home bias decreases in T, the productivity difference between sectors: $\frac{\partial HB}{\partial T} < 0$ from*

$$HB = 1 - \frac{1-D}{1/2} = \frac{f-1}{f+1} + \frac{2}{f+1}[-\frac{1-\alpha}{\alpha} + \frac{1}{\alpha}\frac{T-1}{T+1}(1 - \frac{1}{\sigma})\lambda]. \quad (10)$$

In the expression of home bias (equation 10), financial frictions f not only affect the level of portfolio diversification, but also appear as the risk-hedging coefficients. When households face great financial frictions for

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[6]The trade literature, including Broda and Weinstein (2006), Levchenko and Zhang (2014) and Caselli et al. (2015), estimates the parameter to be 2.

foreign investment (f is high), they show weak incentives to diversify and hedge their risks across countries. In the extreme case where $f = \infty$, households only hold domestic assets and exhibit full home bias.

If there are no financial frictions ($f = 1$), equation 10 becomes

$$HB = 1 - \frac{1-D}{1/2} = -\frac{1-\alpha}{\alpha} + \frac{1}{\alpha}\frac{T-1}{T+1}(1 - \frac{1}{\sigma})\lambda.$$

This result is comparable to the theoretical results in several previous papers on the topic. When $T = 1$, we are back to Baxter and Jermann (1997)'s case in the absence of real exchange rate risk, where sectors' influence on exchange rates is ignored. When $T = \infty$, as in Coeurdacier and Rey (2013)'s case, there is full specialization and no intra-sectoral trade. Between these two extreme cases, home bias decreases in the productivity difference T.

This proposition can be understood by considering the intra- versus inter-national risk-hedging mechanism discussed earlier. When there is greater productivity disparity between sectors, world production and trade are more specialized. In this scenario, domestic unproductive sectors' assets are highly correlated with productive sectors' given the equalization of factor prices. When domestic asset returns are highly correlated across sectors, there is limited intranational risk hedging, which in turn induces households to hold more foreign assets for international risk-hedging. Meanwhile, the existence of trade costs biases the domestic price index towards the more productive sector's price at home. Therefore, specialization strengthens households' incentives to hold more foreign assets in order to hedge against real exchange risk.

To sum up, the model shows that industrial concentration driven by heterogeneity in sectoral productivity influences countries' risk exposure and portfolio choice. It follows that countries with diversified industrial structures show stronger home bias than countries with few major industries. I confront this theory with data in the next section.

3 Empirical Analysis

In this section, I empirically examine the relationship between industrial specialization and portfolio diversification. I start by describing the data sources for the home bias index.

3.1 Data

Coeurdacier and Rey (2013) define home bias as the difference between the actual country-level holdings of equities and the share of market capitalization in the global equity market to measure home bias. Home bias in country i at time t equals

$$HB_{i,t} = 1 - \frac{\text{Share of Foreign Equities in Country i Equity Holdings at Time t}}{\text{Share of Foreign Equities in the World Market Portfolio at Time t}}. \tag{11}$$

$HB_{i,t} = 1$ indicates that country i is fully home biased since it does not hold any foreign equities. $HB_{i,t} = 0$ indicates that country i is fully diversified between domestic and foreign equities. In theory, $HB_{i,t}$ can take any value below 1 (including a negative value).[7]

To construct the home bias index, I use proprietary financial datasets including Factset/Lionshare and Datastream. The existing literature on home bias mainly relies on macro datasets such as the International Financial Statistics (IFS), which cover a small number of countries. I expand the coverage considerably by using financial datasets. Plus, I compare the home bias index constructed using financial datasets with that using the IFS data, and find that the two data sources give consistent results (shown in Figure A.1).

The numerator of the expression for home bias (equation 11) uses data from Factset/Lionshare. This dataset provides comprehensive information on the equity holdings of institutional investors from a large number of countries or regions since 1998. The denominator uses data from Datas-

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[7]Home bias is negative when investors outweigh foreign assets relative to market capitalization. Home bias is smaller than 1 since all the equity holdings are positive in the data. In a model without short-sale constraints, equity holdings can be negative and home bias is no longer bound by 1.

tream. Thomson Reuters Datastream offers global financial data including market values, with which I obtain countries' weights in the world equity market.

Table A.1 lists the constructed home bias index averaged over time. The mean is 0.56 and the standard deviation is 0.31. Small open economies like Norway and the Netherlands show the weakest preference for domestic equities, close to the full diversification scenario with zero home bias. In contrast, Romania, China, and Russia show almost full home bias, due to either stringent capital controls or, my focus, hedging motives. I control for the former while exploring the latter in regression analyses.

In terms of the explanatory variable for home bias, I use the Herfindahl-Hirschman index (HHI) as a proxy for countries' degree of industrial specialization. HHI in country i at time t is defined as the sum of squared shares of each sector (s) in the country's total output:

$$HHI_{i,t} = \sum_{s=1}^{S} b_{i,s,t}^2.$$

Its value is bound between 0 and 1. The greater the HHI value, the more concentrated the country's production. I use the ISIC Rev.4 sectoral value-added data from UNIDO to calculate countries' HHI. Industries are aggregated to two-digit ISIC levels, such as food, clothing, and automobiles. Most of the industries UNIDO cover are tradable, including the 15 manufacturing sectors listed in Table A.4.

Besides industrial specialization measured by HHI, I also consider other variables that potentially influence home bias. To control for the size of economies, I use real GDP data from the World Bank. Moreover, transaction barriers such as capital controls also affect investors' international diversification. To this end, I add the Chinn-Ito index as a control variable to my analysis to see whether economies with fewer institutional frictions depict weaker home bias. Chinn and Ito (2006) use the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) to compile this de jure measure of capital account openness, which has become widely used in the international finance literature. Higher values imply greater financial openness.

I check all the data carefully for quality, dropping outliers and unreliable observations. In particular, Factset/Lionshare has relatively poor coverage in the early years and UNIDO's data after 2009 were scarce when this paper was written. After I clean the data, there are 332 country-year observations in the sample, mainly falling between 2001 and 2008. I conduct panel regressions using time fixed effects to identify the relationship between home bias and HHI.[8]

3.2 Findings

Table 1: Home Bias and Industrial Specialization

Dep. Var: Home Bias	(1)	(2)	(3)	(4)
HHI	-2.072 ***	-2.380 ***	-2.407 ***	-2.866 ***
	(0.373)	(0.276)	(0.308)	(0.472)
	[-0.234]	[-0.268]	[-0.271]	
Chinn-Ito		-0.781 ***	-0.778 ***	-0.779 ***
		(0.052)	(0.052)	(0.054)
		[-0.607]	[-0.605]	
log(GDP)			-0.004	-0.007
			(0.013)	(0.012)
			[-0.015]	
IV	No	No	No	Yes
Observations	332	332	332	330
R^2	0.080	0.438	0.438	0.434

Note: Robust standard errors in parentheses and standardized coefficients in brackets. ***significant at 1%. Regressions include time fixed effects. The dependent variable is home bias. The independent variables include Herfindahl-Hirschman Index (HHI), Chinn-Index, and real GDP in natural logs. Column 4 uses land area (in sq. km, natural logs), total population (in thousands, natural logs), and total natural resources as shares of GDP as instrumental variables for HHI.

The regression results are summarized in Table 1. In column (1), when a country's HHI increases by 1 standard deviation, home bias decreases by 0.234 standard deviation. This result confirms the hypothesis that home bias is weaker for countries with greater industrial specialization. In column (2), I add the Chinn-Ito index, taking into account the fact that institutional features of financial markets also drive the variation in home bias. Not

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[8]I do not add country fixed effects since most of the variation is across countries rather than within countries. Within-country variations are largely driven by temporary fluctuations or data noise. This is due to the fact that the panel data cover a short period, while it takes a long time for countries' industrial structures and portfolio holdings to be adjusted.

surprisingly, countries with greater financial openness show weaker home bias: when the Chinn-Ito index value increases by 1 standard deviation, equity home bias decreases by 0.607 standard deviation. After adding this measure of financial openness, the coefficient of HHI increases in absolute value, which indicates that industrial structure becomes more important in explaining the variation in home bias. In column (3) where I add the size of the economies (proxied by GDP) as another control variable, the result is similar. The coefficient of HHI is negative at the 1 percent level of significance in both cases. Plus, GDP is not significantly related to home bias, similar to the finding in Heathcote and Perri (2013).

Furthermore, I add instrumental variables (IV) into the regressions in order to guard against potential endogeneity and reverse causality. I consider factor endowments as IV, since they are closely related to industrial specialization based on the Heckscher-Ohlin model but are likely to be exogenous for portfolio diversification. To this end, I collect the data on land area, total population, and natural resources rents as shares of GDP from the World Bank. In column (4) of Table 1, the coefficient of HHI even increases in absolute value after these instrumental variables are included in the regression, which reinforces the hypothesis that industrial structure influences portfolio holdings.

In additional to these baseline results, I add interactions terms to the original regressions (shown in Table A.2). The coefficient of HHI × Chinn-Ito is negative, suggesting that the influence of industrial specialization on equity home bias is more pronounced for countries with greater financial openness. This can be understood from the fact that it is easier for economies with fewer capital account restrictions to hold foreign assets for optimal risk hedging. In column (3), the coefficient of GDP itself is negative, which suggests that smaller economies tend to show weaker home bias. Nevertheless, these smaller economies are more specialized and thus have greater incentives to hedge their investments abroad.[9] This explains the positive coefficient of HHI × GDP, which indicates that the effect of specialization on home bias is stronger for smaller economies. Eventually

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[9]Imbs and Wacziarg (2003) show that countries follow a U-shaped industrial specialization pattern at different stages of development. Many small countries in my sample are advanced economies that are late in the development process, so their degree of specialization is high.

the two coefficients cancel each other out and leave the overall effect of GDP on home bias ambiguous (as shown in column (3) and (4) of Table 1).

Besides panel analysis, I also run cross-country regressions with time-averaged home bias and industrial specialization. The estimated coefficient will serve as a benchmark for my numerical solution in the quantitative exercise. Table A.3 reports the findings. In column (1), when a country's HHI increases by 1 standard deviation, home bias decreases by 0.313 standard deviation. The results are robust in column (2) where I add the Chinn-Ito index and in column (3) where I control for GDP. In column (4), I exclude the three commodity-dependent countries in the sample — Kuwait, Norway, and Qatar — because portfolio strategies specific to these oil exporters may bias the result. The coefficient of HHI is still significantly negative and becomes larger in value, indicating that industrial structure plays an important role in explaining the variation in home bias among non-oil-exporters.

To sum up this section, I use proprietary financial datasets to compute home bias and find that it has a negative relationship with industrial specialization. This novel empirical finding, which is not explained in the existing literature, underscores the importance of a multi-sectoral framework for studying home bias. In the next section, I implement a quantitative assessment of an extended model.

4 Quantitative Assessment

In this section I conduct a numerical analysis of the model in order to further examine the influence of industrial structure on portfolio diversification. I first extend the symmetric two-country, two-sector framework built in Section 2 to a case with a large group of countries and industries. I then calibrate the model to fit international trade and macro data. After that, I solve for investors' optimal asset holdings given countries' industrial structures. Finally, I run a counterfactual exercise to compute home bias in the case when sectoral productivity differences are absent.

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4.1 Extended Model

The extended model features I countries and $S + 1$ industries. Consumption in country $i \in \{1, 2, ..., I\}$ is a Cobb-Douglas bundle of S tradable sectors and one nontradable sector denoted as N:

$$C_i = C_{i,T}^{\mu_i} C_{i,N}^{1-\mu_i} = (\sum_{s=1}^{S} \psi_s^{\frac{1}{\phi}} C_{i,s}^{\frac{\phi-1}{\phi}})^{\frac{\phi}{\phi-1}\mu_i} C_{i,N}^{1-\mu_i}.$$

μ_i denotes the weight of the tradable bundle $(C_{i,T})$ in country i's consumption. The implied elasticity of substitution between the tradables and nontradables is 1, which falls within the normal range in previous studies.[10] The tradable bundle is a CES composite of consumption in different sectors $(C_{i,s})$, with ψ_s being the weight assigned to sector $s \in \{1, 2, ..., S\}$ and ϕ being the elasticity of substitution between sectors within the tradable bundle.

For tradable sectors, iceberg costs τ_i are introduced to reflect tariffs and other forms of trade barriers when country i exports to and imports from the rest of the world. Given the trade cost τ_i, the price of variety z in sector s exported from country i to the rest of the world becomes

$$p_{i,s}(z) = \frac{\tau_i c_{i,s}}{A_{i,s}(z)}.$$

Aggregating the varieties gives the share of country i's exports in the world market for sector s as

$$\pi_{i,s} = \frac{T_{i,s}(\tau_i c_{i,s})^{-\theta}}{\Phi_s} \quad where \quad \Phi_s = \sum_i^I T_{i,s}(\tau_i c_{i,s})^{-\theta}.$$

Meanwhile, the price level of sector s in country i is given by

$$P_{i,s} = [\Gamma(\frac{\theta + 1 - \epsilon}{\theta})]^{\frac{1}{1-\epsilon}} \Phi_{i,s}^{-\frac{1}{\theta}} \quad where \quad \Phi_{i,s} = \Phi_s - T_{i,s}(\tau_i^{-\theta} - 1)c_{i,s}^{-\theta}.$$

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[10]The values for the elasticity of substitution between tradable and non-tradable goods range from 0.4 in Tesar and Stockman (1995) to 1.6 in Ostry and Reinhart (1992).

The price of the nontradable sector $P_{i,N}$ is obtained in a similar way when foreign competitors' trade cost is assumed to go to infinity:

$$P_{i,N} = \Gamma(\frac{\theta + 1 - \epsilon}{\theta})]^{\frac{1}{1-\epsilon}} T_{i,N}^{-\frac{1}{\theta}} c_{i,N}.$$

Production cost in each sector ($c_{i,k}, k \in \{1, 2, ..., S, N\}$) is jointly determined by sector-specific factor intensity α_k and country-specific factor prices including wage and capital rental fee: $c_{i,k} = r_i^{\alpha_k} w_i^{1-\alpha_k}$. As in the baseline model, labor and capital are mobile across sectors but immobile across countries. Factor prices are pinned down by the market-clearing conditions:

$$\sum_{k \in \{1,2,...,S,N\}} L_{i,k,t} = L_{i,t}, \qquad \sum_{k \in \{1,2,...,S,N\}} K_{i,k,t} = K_{i,t}.$$

In the equity market, there are $I \times (S + 1)$ types of stocks, each representing $f_{i,k}, \ k \in \{1, 2, ..., S, N\}, i \in \{1, 2, ..., I\}$. When I analyze country i, I do not distinguish specific destinations of foreign investment but group the rest of the world as country F. After all, home bias focuses only on investment decisions related to domestic and foreign equities. Moreover, solving bilateral financial investment with such a great number of countries and industries is computationally challenging.[11] Therefore, I examine aggregate foreign investment instead of bilateral asset positions.

Households in country i choose the optimal portfolio to maximize their expected lifetime utility subject to the budget constraint

$$
\begin{aligned}
P_{i,t} C_{i,t} + &\sum_{k \in \{1,2,...,S,N\}} [q_{i,k,t}(\nu^i_{i,k,t} - \nu^i_{i,k,t-1}) + q_{j,k,t} f_i (\nu^i_{j,k,t} - \nu^i_{j,k,t-1})] \\
= w_{i,t} L_{i,t} + &\sum_{k \in \{1,2,...,S,N\}} (d_{i,k,t} \nu^i_{i,k,t} + d_{j,k,t} f_i \nu^i_{j,k,t}).
\end{aligned}
\tag{12}
$$

$\nu^i_{i,k,t}$ ($\nu^i_{j,k,t}$) denotes the number of domestic (foreign) shares country i holds of sector k at time t. $q_{m,k,t}$ and $d_{m,k,t}, \ m \in \{i, j\}$ are asset prices and dividends respectively. As in the baseline model, dividends are claims to capital

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[11] Since I use the perturbation method to derive countries' optimal portfolio choice, the accuracy of the results falls when the large matrix is badly scaled given the sparsity of trade data.

income: $d_{m,k,t} = \alpha_k p_{m,k,t} y_{m,k,t}$. f_i is the financial friction country i incurs when buying and selling foreign assets. Lastly, the aggregate expenditure in country i satisfies

$$P_{i,t} C_{i,t} = w_{i,t} L_{i,t} + r_{i,t} K_{i,t}. \tag{13}$$

under the assumption of balanced trade for each country. This assumption ensures that the foreign asset holdings are driven by risk-hedging motives instead of global imbalances. Since the sum of a country's current account and capital account is always zero, any trade surplus must be matched by a deficit in the capital account. This channel is important for capital flows but is not the focus of this paper; I therefore assume balanced trade to isolate the implications of industrial composition for foreign investment. In robustness checks, I relax the balanced trade assumption and confirm the consistency of the quantitative results. Another extension I consider is including the input-output matrix to reflect the current interdependent production structures around the world. Appendix D shows that the results are robust under these two extensions.

4.2 Computation

The quantitative exercise covers 15 two-digit ISIC tradable sectors in 58 countries, which account for more than 90 percent of world trade volume. To numerically implement the model, I need to calibrate four categories of model parameters including (1) common parameters taken from the literature such as the coefficient of risk aversion, productivity dispersion parameter, and elasticity of substitution between sectors, (2) sector-specific factors including capital intensity and consumption weights in the tradable bundle, (3) country-specific factors including aggregate labor and capital endowments, trade costs, expenditure shares on the nontradable sector, and (4) country-sector-specific productivity. Some of these parameters can be taken from data; others need to be estimated by imposing the model structure. I discuss them in turn.

First I obtain common parameters from previous macro and trade literature. For instance, Eaton and Kortum (2002) estimate θ, which captures dispersion of productivity, to be 8.28. Levchenko and Zhang (2014) and

Caselli et al. (2015) set the elasticity of substitution between tradable sectors equal to 2. Lastly, the coefficient of risk aversion is assumed to be 2 and the annual discount factor is 0.95, both of which are common values found in the literature.

Regarding sector-specific parameters, I follow Di Giovanni et al. (2014) in choosing the values for factor intensity and consumption weights. They use the U.S. Input-Output Matrix to obtain capital intensity α_s, and use the U.S. consumption data to compute taste parameters ψ_s in the consumption bundle. Table A.4 lists the sector-specific parameters for the 15 tradable sectors in the sample.

For country-level parameters, data on capital stock and labor force are taken directly from the Penn World Table. The shares of expenditure on traded goods (μ) are obtained from the STAN Database for OECD countries. For countries not covered by STAN, I calculate μ as the value predicted by a linear regression that captures the relationship between μ, consumption as shares of GDP, and GDP per capita. Table A.5 lists the shares of expenditure on tradable goods for the countries in the sample. Lastly, country-level trade costs are computed to fit a country's overall export-to-output ratio when sectoral productivity is estimated.[12]

The procedure I use to estimate sectoral productivity is modified from Shikher (2011) and Di Giovanni et al. (2014). Compared to these two papers that focus on country-to-country trade flows, I impose fewer constraints in order to keep the estimation simple and the following portfolio choice problem computationally tractable. Sectoral productivity and trade costs are estimated to match (1) country i's share of all the countries' exports in sector s, and (2) the country's overall export-to-output ratio. Data on sectoral trade are taken from the UN Comtrade Database, and export-to-output ratios are from the Penn World Table. The algorithm used to estimate model parameters and solve the model is outlined in Appendix B.

The last step is to derive countries' optimal portfolio choices using De-

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[12]In the trade literature, iceberg trade costs are normally estimated in a gravity model with geographic distance, free-trade zone, and common borders, among other factors, as the determinants of bilateral trade flows. This approach is not applicable here since I focus on a country's overall trade ties with the rest of the world instead of with a single trade partner. Meanwhile, as is argued by Bernard et al. (2003) and many other papers, overall trade matrix is a sufficient statistic for trade costs in simulating a model. This is the rationale I use to estimate a country's trade costs from its exports-to-GDP ratio.

vereux and Sutherland (2011)'s method. This method combines a second-order approximation of the portfolio Euler equation with a first-order approximation of all the other equations in the model to calculate households' optimal portfolio. The solution captures the correlation between asset returns and macro fundamentals and hence reflects households' optimal portfolios driven by their risk-hedging motives.

The dynamic side of the model is modeled in a similar way as a DSGE framework, since I use the perturbation method to solve for the portfolio choice around a deterministic steady state. In this spirit, I assume that productivity $T_{i,s}$ follows a mean-reverting AR(1) process with autoregressive coefficients ξ and i.i.d. shocks $\epsilon_{i,s,t} \sim N(0, \sigma_\epsilon^2)$, similar to the productivity shocks in a standard DSGE model:

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

Based on the AR(1) process, the persistence parameter ξ is calibrated to be 0.95, the average autocorrelation coefficient across 3-digit NAICS manufacturing industries based on the US sectoral TFP data from the Bureau of Labor Statistics. The covariance matrix of the shocks does not matter for the steady-state portfolio, which can be pinned down by first-order macro dynamics alone at the level of approximation. To compute the steady state productivity $\bar{T}_{i,s}$, all the time-variant variables are averaged over time between 2001 and 2007 for the estimation. This period, which witnessed a steady growth in world trade, is chosen to match the data coverage in the empirical analysis. I exclude 2008 since the financial crisis caused abrupt changes to trade patterns during the global recession.

The model incorporates key elements that are relevant for industrial structure, including heterogeneous sectoral productivity and factor intensity, national factor endowment and prices, nontradable sectors, and trade costs. By embedding these ingredients, the model fits real-world observations. I evaluate the model's fit by (1) comparing sectoral trade flows predicted by the model to trade data, and (2) comparing the model-implied wage rate with the data in the Penn World Table. In Appendix C, I show that the model performs well in matching these two targets.

4.3 Numerical Results

In this section, I confront the numerical solution to the model with data. I find that (1) the model successfully predicts the negative correlation between home bias and industrial specialization, and (2) the model-implied financial friction lines up with the prediction of the Chinn-Ito index.

After I estimate and solve the model following the algorithm outlined in Appendix B, I derive optimal portfolios on the financial side as well as the values of all the sectoral and national variables on the real side of the economy. This allows me to compute home bias and industrial specialization implied by the model in absence of financial frictions.

Table 2 compares the model and data in terms of the bivariate relationship between home bias and industrial specialization. In the numerical solution to the model, when HHI increases by 1, home bias decreases by 2.849. It is slightly greater in magnitude than 2.134 in the data, which can be attributed to the fact that institutional and informational frictions also contribute to home bias in the real world, dwarfing the influence of industrial structure. This explains why the constant term's coefficient is significant in the data but insignificant in the model. Based on the fact that the standardized coefficients and R-squared are comparable in value, the model does a good job of predicting the influence of industrial specialization on home bias.

Figure 1 establishes the negative correlation between home bias and

Table 2: Model vs Data

Dep. Var: Home Bias	Model	Data
HHI	-2.849 ***	-2.134 **
	(1.028)	(0.867)
	[-0.311]	[-0.313]
Constant	-0.452	0.650 ***
	(0.488)	(0.082)
Observations	58	36
R^2	0.097	0.098

Note: Robust standard errors in parentheses and standardized coefficients in brackets. **significant at 5%, and *** significant at 1%. The table reports the correlation between home bias and HHI in the model absent financial frictions and compares that with data.

Figure 1: Model-predicted Home Bias and HHI
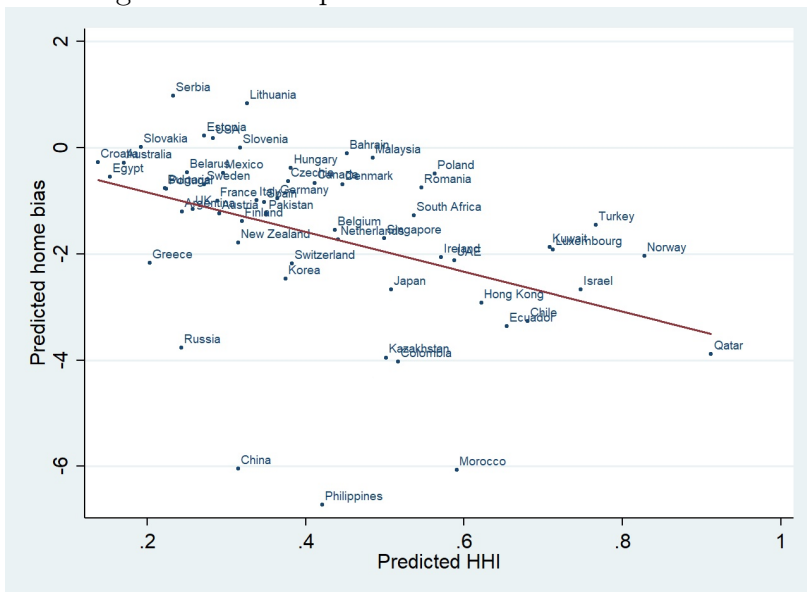
Note: This figure plots the home bias and specialization indices (HHI) as predicted by the model absent financial frictions.

industrial specialization graphically. From the scatter plot, the model successfully predicts that highly specialized oil exporters, including Qatar and Norway, exhibit weaker home bias. Because these economies rely heavily on natural resources, other sectors in these countries cannot provide a buffer when the oil industries fluctuate. Hence the limited domestic options prompt their investors to invest abroad for international risk hedging. In contrast, countries such as Australia and the United States have diversified industrial structures, so they can benefit from a high degree of intranational risk hedging, which replaces the need for investors to hedge their risk by holding foreign assets. As a result, home bias in these economies is relatively strong.

Another angle from which to evaluate the model performance is to examine whether the model-implied financial friction lines up with alternative measures of capital restriction. As Figure 1 shows, most countries exhibit negative home bias in absence of financial frictions, which indicates that investors rely heavily on international risk hedging given the world industrial structure. Nevertheless, capital restrictions dampen investors' incentives to hold foreign assets for risk hedging and diversification (see Proposition

in the baseline model).

Let $\widehat{HB}_i$ denote country i's home bias implied by the model absent financial frictions, HB_i denote the actual home bias in the data. Based on equation 10, the model-implied financial friction f_i can be recovered from

$$HB_i = \frac{f_i - 1}{f_i + 1} + \frac{2}{f_i + 1}\widehat{HB}_i.$$

Therefore I compare this model-consistent measure of financial friction with the Chinn-Ito index, a de jure measure of capital account openness. By running the bivariate linear regression

$$f_i = \alpha + \beta Chinn_i + \epsilon_i,$$

I find that, when the Chinn-Ito index value increases by 1 standard deviation (which implies greater financial openness), the financial friction f_i decreases by 0.60 standard deviation. The estimated coefficient is significantly negative at 5%. Therefore the model-implied financial friction is consistent with the prediction of the Chinn-Ito index. In Figure 1, countries such as China, Russia, and the Philippines are subject to great capital account restrictions, which prohibit investors from holding foreign assets. This explains the divergence between their high home bias in the data and their low home bias in the model.

To sum up, the model in the numerical exercise performs well in replicating the negative correlation between home bias and industrial specialization described in the empirical section. Based on the framework, I conduct a counterfactual analysis to isolate the effect of sectoral productivity.

4.4 Counterfactual Analysis

This paper focuses on sectoral productivity differences as a determinant of industrial specialization in the spirit of the Ricardian framework, but a country's industrial structure can potentially be influenced by many factors.[13] Therefore I simulate the model in a counterfactual scenario with no productivity difference across sectors within a country, and study how home

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[13]For example, the Heckscher-Ohlin model argues that country-level factor endowment and industry-level factor intensity are important for industrial and trade patterns.

bias responds. Since I keep everything else constant in this counterfactual exercise, it allows me to disentangle the influence of sectoral productivity heterogeneity on industrial specialization and portfolio diversification.

To implement the exercise numerically, I assume sectoral productivity is the national average productivity across industries. Table A.6 presents the model-implied home bias and industrial specialization in the original model and the counterfactual exercise, both under the assumption that there are no financial frictions. Under homogeneous sectoral productivity, there are notable drops in nearly all the countries' industrial specialization proxied by HHI. The mean reduction is 0.24 (or 55.8 percent) and the median is 0.19 (or 50 percent). Meanwhile, most of the countries have remarkably higher home bias in the counterfactual scenario. The mean increase is 2.04 (126 percent) and the median is 1.90 (154 percent). These results suggest that sectoral productivity differences are important determinants of industrial specialization and portfolio diversification.

If I run the bivariate regression in the counterfactual case, the correlation between HHI and home bias is no longer significantly negative, unlike in the original case or in the data (Table 2). This finding supports the argument of the paper that the influence of industrial specialization on portfolio positions is mainly driven by sectoral productivity differences.

In order to further compare the original model and counterfactual scenario, I regress each country's change in home bias (ΔHB_i) on its change in specialization (ΔHHI_i) between the two cases,

$$\Delta HB_i = \alpha + \beta \Delta HHI_i + \epsilon_i.$$

The regression results show that, when a country's industrial specialization index decreases by 1 standard deviation, its predicted home bias increases by .304 standard deviation. The coefficient is significantly negative at the 5 percent level.

This counterfactual analysis reinforces that industrial specialization influences home bias. When an economy becomes more industrially diversified, both the influence of major industries on the overall economy and the correlation among domestic industries fall significantly. Consequently, investors switch from international to intranational risk hedging, thanks to

the growing hedging benefits of holding domestic assets. As a result, home bias is much higher than in the original model.

An interesting implication of the numerical exercise is that, if countries become more specialized as global production grows increasingly integrated, equity home bias will decline even further. This mechanism, together with reductions in transaction barriers in international financial markets, can lead to greater decreases in home bias. Therefore, the home bias phenomenon will be even less puzzling in the future.

5 Conclusion

This paper examines the well-known home bias phenomenon from a new perspective by linking portfolio diversification and industrial specialization. I embed portfolio choice in a multi-country, multi-sector Eaton-Kortum trade framework to study how differences in sectoral productivity drive the variation in home bias across countries.

First I build a two-country, two-sector symmetric model to illustrate the interesting interaction between intranational risk hedging across sectors and international risk hedging across countries. Second, to empirically test the model's prediction that home bias decreases as industrial specialization rises, I use unique financial datasets to construct the home bias (HB) and Herfindahl-Hirschman indices (HHI). After confirming the hypothesis, I conduct a numerical assessment of an extended model. The quantitative framework successfully replicates the negative correlation between HB and HHI. Furthermore, a counterfactual exercise based on the model shows that home bias will be significantly higher in a case without sectoral productivity differences within countries.

This paper, together with Hu (2017), contributes to the literature on home bias by adding the sectoral dimension. In these two papers, I do not distinguish between specific destinations but group the rest of the world as a whole. Incorporating richer geographic features and examining bilateral equity holdings would be interesting but beyond the scope of this paper. Future research can employ a similar framework to study the influence of bilateral trade ties on bilateral financial flows. Another topic to explore is the impact of investment on portfolio choice. Heathcote and Perri (2013) argue that introducing investment may change the covariance between equity returns and labor income, and increase the appeal of domestic assets for investors. My paper abstracts from investment mainly owing to the scarcity of reliable sectoral data for developing economies, without which it is challenging to calibrate investment patterns across industries. When such data become available, the model can be extended to examine the implications of the investment channel for industrial structure and portfolio investment. By including these extensions, future research will deepen our understanding of the interplay between trade and financial globalization.

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Appendices

A   Tables and Figures

Table A.1: Home Bias

Australia	0.797	France	0.424	Kuwait	0.376	Russia	0.955
Austria	0.099	Germany	0.210	Malaysia	0.983	Singapore	0.123
Bahrain	0.889	Greece	0.354	Mexico	0.939	Slovenia	0.809
Belgium	0.138	Hong Kong	0.184	Netherlands	0.097	South Africa	0.761
Brazil	0.836	Hungary	0.418	Norway	0.087	Spain	0.410
Canada	0.539	Ireland	0.238	Philippines	0.571	Sweden	0.463
China	0.953	Israel	0.891	Poland	0.939	Taiwan	0.773
Denmark	0.144	Italy	0.273	Portugal	0.747	U.A.E	0.836
Finland	0.599	Japan	0.488	Qatar	0.458	U.K.	0.393
		Korea	0.939	Romania	0.998	U.S.	0.666

Note: This table lists the home bias index averaged over time. The formula for constructing 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 A.1: Comparison of Home Bias Constructed with Factset/Lionshare and IFS
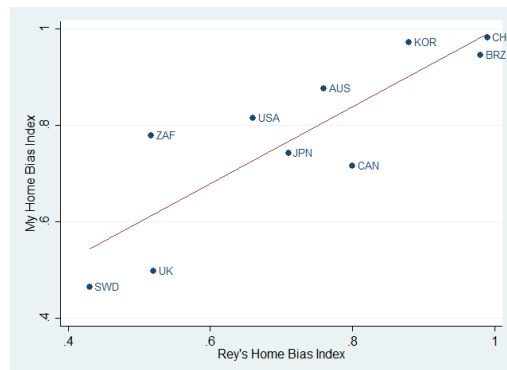
Note: This figure plots my home bias index against Coeurdacier and Rey (2013)'s (both as of 2008). I use the Factset/Lionshare data to construct the index, while they use the IFS data. The two indices are consistent since most of the points lie on or close to the 45 degree line.

Table A.2: Robustness Check with Interaction Terms

Dep. Var: Home Bias	(1)	(2)	(3)
HHI	3.371 ***	-71.953 ***	-34.187 ***
	(1.253)	(13.816)	(12.423)
Chinn-Ito	-0.410 ***		-0.385 ***
	0.103		0.121
GDP		-0.167 ***	-0.084 ***
		(0.031)	(0.029)
HHI × Chinn-Ito	-7.175 ***		-7.022 ***
	1.608		2.039
HHI × GDP		2.713 ***	1.455 ***
		(0.538)	(0.501)
Observations	332	332	332
R^2	0.457	0.141	0.472

Note: Robust standard errors in parentheses. ***significant at 1%. The dependent variable is home bias. The independent variables include the Herfindahl-Hirschman Index (HHI), the Chinn-Ito index, real GDP, and their interactions terms.

Table A.3: Cross-country Regressions

Dep. Var: Home Bias	(1)	(2)	(3)	(4)
				Excluding oil exporters
HHI	-2.134 **	-2.073 ***	-1.993 ***	-4.065 **
	(0.867)	(0.561)	(0.737)	(1.960)
	[-0.313]	[-0.304]	[-0.402]	[-0.262]
Chinn-Ito		-0.808 ***	-0.809 ***	-0.772 ***
		(0.156)	(0.156)	(0.160)
		[-0.633]	[-0.634]	[-0.636]
log(GDP)			0.009	0.004
			(0.039)	(0.038)
			[0.035]	[0.016]
Observations	36	36	36	33
R^2	0.098	0.498	0.499	0.477

Note: Robust standard errors in parentheses and standardized coefficients in brackets. **significant at 5%, and ***significant at 1%. The dependent variable is home bias. The independent variables include time-averaged Herfindahl-Hirschman Index (HHI), the Chinn-Ito index, and real GDP in natural logs.

Table A.4: Sector-specific Parameters

Sector Name	Expenditure Shares within Tradables (ψ_s)	Capital Intensity (α_s)
Food	0.165	0.329
Beverages	0.054	0.272
Tobacco	0.010	0.264
Clothing & Accessories, Footwear	0.134	0.491
Forestry	0.009	0.452
Paper	0.013	0.366
Oil & Gas Producers,Coal	0.096	0.244
Chemicals	0.008	0.308
Pharmeceutical	0.036	0.319
Iron & Steel	0.015	0.381
Nonferrous Metals	0.074	0.407
Electronics & Electric Equipement	0.060	0.405
Machinery	0.073	0.473
Automobiles & Parts	0.183	0.464
Furnishings	0.068	0.460

Note: ψ_s and α_s are estimated and compiled by Di Giovanni et al. (2014). Most of their sectors line up with mine, and I make modifications for the sectors that do not. For instance, I disaggregate their SIC 15 industry into "food" and "beverage" based on consumption shares using the data from BEA Table 2.3.5.U. I also normalize all the weights so that they add up to 1.

Table A.5: Expenditure Shares on Tradable Sectors

Argentina	0.507	Ecuador	0.543	Luxembourg	0.521	Russia	0.578
Australia	0.615	Egypt	0.458	Malaysia	0.568	Serbia	0.488
Austria	0.413	Estonia	0.602	Mexico	0.55	Singapore	0.526
Bahrain	0.587	Finland	0.474	Morocco	0.567	Slovakia	0.594
Belarus	0.573	France	0.468	Netherlands	0.475	Slovenia	0.579
Belgium	0.497	Germany	0.484	New Zealand	0.472	South Africa	0.552
Bulgaria	0.537	Greece	0.444	Norway	0.526	Spain	0.507
Canada	0.461	Hungary	0.563	Pakistan	0.475	Sweden	0.484
Chile	0.503	Ireland	0.492	Peru	0.528	Switzerland	0.375
China	0.648	Israel	0.436	Philippines	0.498	Turkey	0.536
Hong Kong	0.424	Italy	0.496	Poland	0.608	U.S.	0.379
Colombia	0.472	Japan	0.404	Portugal	0.501	U.A.E.	0.475
Croatia	0.542	Kazakhstan	0.555	Qatar	0.558	U.K.	0.437
Czech	0.541	Kuwait	0.572	Korea	0.425		
Denmark	0.466	Lithuania	0.722	Romania	0.535		

Note: This table lists countries' expenditure shares of tradables (ν_i). ν_i is mainly taken from the OECD data on household consumption expenditures. For some countries that are missing in the dataset, I compute μ as the value predicted by a linear regression that captures the relationship between μ, consumption as shares of GDP, and GDP per capita.

Table A.6: Model Results

Country	Original Model (1) Home Bias	HHI	Counterfactual Exercise (2) Home Bias	HHI	Difference (3) Δ Home Bias	Δ HHI
Argentina	-1.22	0.24	-1.24	0.16	-0.02	-0.09
Australia	-0.29	0.17	1.01	0.22	1.30	0.05
Austria	-1.24	0.29	0.83	0.21	2.07	-0.08
Bahrain	-0.11	0.45	-4.90	0.23	-4.79	-0.22
Belarus	-0.47	0.25	-0.18	0.14	0.29	-0.12
Belgium	-1.55	0.44	0.46	0.22	2.01	-0.22
Bulgaria	-0.76	0.22	-5.83	0.11	-5.07	-0.11
Canada	-0.67	0.41	0.92	0.21	1.59	-0.20
Chile	-3.27	0.68	-1.16	0.16	2.10	-0.52
China	-7.64	0.32	1.17	0.18	8.81	-0.14
Hong Kong	-2.92	0.62	0.84	0.22	3.76	-0.40
Colombia	-4.03	0.52	-0.97	0.16	3.06	-0.36
Croatia	-0.31	0.14	-0.77	0.18	-0.46	0.05
Czechia	-0.64	0.38	1.70	0.21	2.33	-0.17
Denmark	-0.70	0.45	0.62	0.21	1.31	-0.24
Ecuador	-3.36	0.65	-5.76	0.16	-2.40	-0.49
Egypt	-0.55	0.15	-1.03	0.11	-0.48	-0.04
Estonia	0.23	0.27	-0.80	0.16	-1.02	-0.11
Finland	-1.38	0.32	0.53	0.22	1.91	-0.10
France	-1.00	0.29	0.94	0.21	1.95	-0.08
Germany	-0.96	0.36	0.93	0.21	1.89	-0.15
Greece	-2.31	0.20	0.69	0.21	3.00	0.01
Hungary	-0.39	0.38	1.43	0.17	1.82	-0.21
Ireland	-2.06	0.57	0.35	0.21	2.41	-0.36
Israel	-2.67	0.75	0.66	0.20	3.32	-0.55
Italy	-0.99	0.34	0.89	0.22	1.88	-0.12
Japan	-2.67	0.51	0.99	0.21	3.65	-0.30
Kazakhstan	-3.95	0.50	4.56	0.17	8.51	-0.33
Kuwait	-1.87	0.71	1.53	0.22	3.39	-0.49
Lithuania	0.84	0.33	1.13	0.16	0.29	-0.17
Luxembourg	-1.91	0.71	-0.64	0.22	1.27	-0.49
Malaysia	-0.20	0.48	0.05	0.16	0.24	-0.33
Mexico	-0.48	0.30	0.94	0.15	1.42	-0.15
Morocco	-6.07	0.59	2.93	0.16	9.00	-0.43
Netherlands	-1.73	0.44	0.84	0.21	2.57	-0.23
New Zealand	-1.82	0.31	-0.68	0.18	1.14	-0.13
Norway	-2.04	0.83	1.27	0.22	3.31	-0.61
Oman	-0.02	0.89	0.53	0.20	0.56	-0.69
Pakistan	-1.26	0.35	-0.93	0.12	0.33	-0.23
Philippines	-6.80	0.42	-0.13	0.17	6.67	-0.25
Poland	-0.51	0.56	1.15	0.16	1.66	-0.40
Portugal	-0.77	0.22	-0.37	0.20	0.40	-0.02
Qatar	-3.88	0.91	7.06	0.22	10.95	-0.69
Korea	-2.46	0.37	0.94	0.20	3.41	-0.17
Romania	-0.77	0.55	-1.68	0.15	-0.91	-0.39
Russia	-4.11	0.24	1.16	0.16	5.27	-0.09
Serbia	0.97	0.23	-0.54	0.17	-1.51	-0.07
Singapore	-1.71	0.50	0.93	0.23	2.64	-0.27
Slovakia	0.01	0.19	1.52	0.17	1.52	-0.02
Slovenia	-0.01	0.32	3.50	0.21	3.51	-0.11
South Africa	-1.28	0.54	1.56	0.14	2.84	-0.40
Spain	-1.02	0.35	-0.10	0.20	0.92	-0.14
Sweden	-0.69	0.27	0.61	0.21	1.31	-0.07
Switzerland	-2.19	0.38	0.87	0.21	3.05	-0.18
Turkey	-1.45	0.77	1.38	0.14	2.83	-0.62
USA	0.18	0.28	0.98	0.22	0.80	-0.06
U.A.E.	-2.13	0.59	0.64	0.25	2.77	-0.34
UK	-1.15	0.26	0.96	0.21	2.11	-0.05
Min	-7.64	0.14	-5.83	0.11	-5.07	-0.69
Max	0.97	0.91	7.06	0.25	10.95	0.05
Mean	-1.62	0.43	0.42	0.19	2.04	-0.24
Median	-1.23	0.38	0.83	0.20	1.90	-0.19

Note: This table presents the home bias and the industrial specialization indices (H-HI) as predicted by the model. Column (1) lists the results from the original model, while column (2) lists those from the counterfactual exercise absent sectoral productivity differences. Column (3) shows the difference between the two.

B Algorithm

In this part I outline the algorithm to compute and solve the model.

Step 1. Guess factor prices under the Cobb-Douglas assumption using output and endowment data :

$$r_i = \alpha_i \frac{Y_i}{K_i}, \qquad w_i = (1 - \alpha_i) \frac{Y_i}{L_i},$$

where α_i is country-specific capital share, which is also available in the Penn World Table.

Step 2. Estimate sectoral productivity $T_{i,k}$ and trade cost τ_i to match (1) country i's share of all the countries' exports in sector s (denoted as $\pi_{i,s}$), and (2) the country's overall export-to-output ratio (denoted as $x2y_i$). It involves the following steps:

Step 2.1. Compute the cost and price of tradable sectors using the following equations:

$$c_{i,s} = r_i^{\alpha_s} w_i^{1-\alpha_s}$$

$$\Phi_s = \sum_i^I T_{i,s} (\tau_i c_{i,s})^{-\theta}$$

$$\Phi_{i,s} = \Phi_s - T_{i,s}(\tau_i^{-\theta} - 1)c_{i,s}^{-\theta}$$

$$P_{i,s} = [\Gamma(\frac{\theta + 1 - \epsilon}{\theta})]^{\frac{1}{1-\epsilon}} \Phi_{i,s}^{-\frac{1}{\theta}}$$

$$P_{i,T}^{1-\phi} = \sum_{s=1}^S \psi_s P_{i,s}^{1-\phi}$$

Step 2.2. Based on prices, calculate consumers' aggregate expenditures and their demand for specific goods.

$$P_i C_i = w_i L_i + r_i K_i$$

$$y_{i,s} = \mu_i P_i C_i \psi_s (\frac{P_{i,s}}{P_{i,T}})^{1-\phi}$$

Step 2.3. Calculate the cost, demand, productivity, and price of the nontradable sector.

$$c_{i,N} = r_i^{\alpha_N} w_i^{1-\alpha_N}$$

$$y_{i,N} = (1 - \mu_i) P_i C_i$$

$$T_{i,N} = \frac{y_{i,N}}{A K_{i,N}^{\alpha_N} L_{i,N}^{1-\alpha_N}} \quad where \quad A = \alpha_N^{-\alpha_N}(1 - \alpha_N)^{\alpha_N - 1}$$

$$P_{i,N} = \Gamma(\frac{\theta + 1 - \epsilon}{\theta})]^{\frac{1}{1-\epsilon}} T_{i,N}^{-\frac{1}{\theta}} c_{i,N}$$

Step 2.4. Given demand, compute productivity and trade costs to match $\pi_{i,s}$ and $x2y_i$.

$$\pi_{i,s} = \frac{T_{i,s}(\tau_i c_{i,s})^{-\theta}}{\Phi_s}$$

$$x2y_i = \frac{\sum_{s=1}^{S} \pi_{i,s} \sum_{j\neq i}^{I} y_{j,s}}{y_{i,N} + \sum_{s=1}^{S} y_{i,s} T_{i,s} c_{i,s}^{-\theta}/\Phi_{i,s}}$$

After estimating trade costs and productivity, I numerically solve the equilibrium of the model by following the steps below.

Step 3. Plug the estimated $T_{i,s}$ and τ_i in the equations from Step 2.1 to Step 2.3. Determine factor allocations based on the Cobb-Douglas production.

$$L_{i,s} = (1 - \alpha_s)\frac{\sum_{s=1}^{S} \pi_{i,s} \sum_{j\neq i} y_{j,s} + T_{i,s} c_{i,s}^{-\theta}/\Phi_{i,s} y_{i,s}}{w_i}$$

$$K_{i,s} = \alpha_s \frac{\sum_{s=1}^{S} \pi_{i,s} \sum_{j\neq i} y_{j,s} + T_{i,s} c_{i,s}^{-\theta}/\Phi_{i,s} y_{i,s}}{r_i}$$

$$L_{i,N} = (1 - \alpha_N)\frac{y_{i,N}}{w_i}$$

$$K_{i,N} = \alpha_N \frac{y_{i,N}}{r_i}$$

Step 4. Update factor prices w_i, r_i, repeat Step 2 and 3, until the prices satisfy the market-clearing conditions:

$$\sum_{k\in\{1,2,...,S,N\}} L_{i,k} = L_i, \qquad \sum_{k\in\{1,2,...,S,N\}} K_{i,k} = K_i.$$

Step 5. Solve the portfolio choice problem using Devereux and Sutherland (2011)'s method.

C   Model Fit

In this section I evaluate the performance of the model in predicting wages and sectoral trade flows.

Figure C.1 plots the relationship between the wages predicted by the model and those calculated with the data in the Penn World Table.[14] As can be seen in the figure, the model does a good job of matching real-world observations since most of the countries lie on the 45-degree line. However, the model over predicts the wages in some countries, particularly oil exporters such as Norway, Qatar, and Kuwait. This happens because the gravity model over-estimates the labor hired by the lucrative oil industry. Therefore, the predicted national wage is higher than that in data averaged across industries. Apart from this, the model performs well, as the correlation between the actual and predicted wages exceeds 0.8.
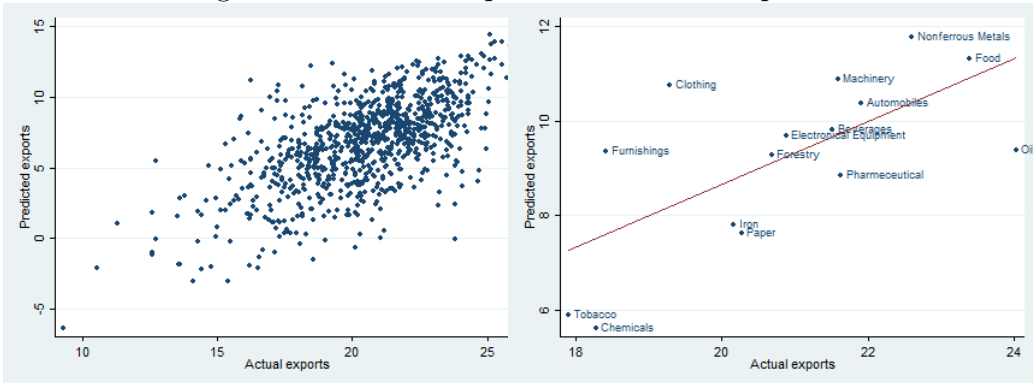
Figure C.1: Model-implied and Actual Wages
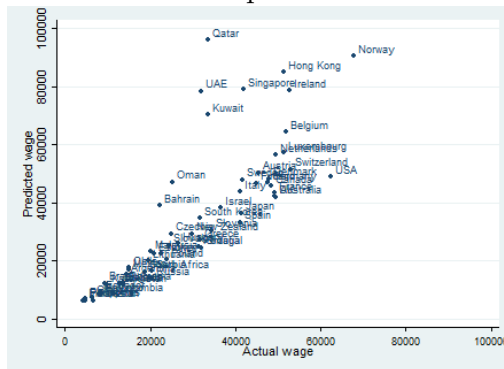
Note: This figure plots the relationship between model-implied and actual wages. Predicted wages are on the horizontal axis, and actual wages are on the vertical axis.

Figure C.2 (left) plots the predicted and actual sectoral exports of a country to the rest of the world as another way to examine model fit. The model does modestly well in predicting the pattern: the correlation between the predicted and actual trade flows is 0.63. Figure C.2 (right) shows Australia as an example. The relative ranking of sectoral exports is mostly predicted by the model. Australia exports the least tobacco and chemicals and exports the most metals and food.

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[14]The wage is calculated as Rgdpe(Expenditure-side real GDP at chained PPPs) $\times$ labsh(Share of labour compensation in GDP)/emp(Number of persons engaged)

Figure C.2: Model-implied and Actual Exports

Note: This figure plots the relationship between model-implied and actual sectoral exports in logs. Actual exports are on the horizontal axis, and predicted exports are on the vertical axis.

D Computation Robustness

This section examines two additional features of globalization — trade imbalances and input-output linkages — that could influence industrial specialization and portfolio diversification.

Trade and financial imbalances are predominant features of globalization. In particular, several emerging markets have run enormous current account surpluses as well as capital account deficits against advanced economies in recent decades. Even if the paper focuses more on industrial composition as a driver for asset positions, it is helpful to incorporate these imbalances as a robustness check.

Let $D_{i,t}$ be the trade surplus of country i in year t. The aggregate expenditure in country i satisfies

$$P_{i,t}C_{i,t} = w_{i,t}L_{i,t} + r_{i,t}K_{i,t} - D_{i,t}. \tag{14}$$

Based on the balance of payments identity, a country's trade surplus $D_{i,t}$ is equal to its increase in net foreign assets $\Delta(\nu_{j,t}^i - \nu_{i,t}^j)$, $i \neq j$.

I solve the model following the steps in B, while I replace Equation (13) with (14). The data for trade surplus/deficit are from the World Bank. These data will be matched by the net asset positions in the model solution.

Moreover, intermediate inputs and input-output (I-O) matrixes have received much attention in the trade literature, since they are important factors for structural changes and welfare gains from trade (see, e.g. Uy et al. (2013) and Caliendo and Parro (2015)). I therefore incorporate them

in the production structure of the model.

Given intermediate goods from sector $n \in \{1, 2, ...S, N\}$, the new production cost in sector k is given by

$$c_{i,k} = (r_i^{\alpha_k} w_i^{1-\alpha_k})^{\nu_k} (\Pi_n (P_{i,n})^{\gamma_{kn}})^{1-\nu_k},$$

where γ_{kn} is the share of input n used for k's production and its price in country i is denoted as $P_{i,n}$. The weight of intermediate inputs in sector k is denoted as $1 - \nu_k$. The parametrization of the production weights — γ_{kn} and ν_k — follows Di Giovanni et al. (2014). Lastly, the goods market clearing condition under the new production structure becomes

$$Y_{i,n} = C_{i,n} + \sum_k (1 - \nu_k) \gamma_{kn} \pi_{i,n} \frac{P_{i,k} Y_{i,k}}{P_{i,n}}.$$

Table D.1 reports the numerical results for the robustness checks. Under global imbalances and input-output linkages, a country's industrial specialization is still an important determinant of equity home bias. Columns (2) and (3) show that more specialized economies exhibit greater portfolio diversification, the same prediction as in the baseline model (column (1)) and data (column (4)). The coefficients of HHI in the robustness checks become a little lower, which resembles the data slightly better. Overall, the similarity of the numerical results across different specifications validates the robustness of the findings.

Table D.1: Robustness Check

Dep. Var:	Baseline	Model Imbalanced Trade	I-O Matrix	Data
Home Bias	(1)	(2)	(3)	(4)
HHI	-2.849 ***	-2.141 **	-2.213 **	-2.134 **
	(1.028)	(0.889)	(1.064)	(0.867)
Constant	-0.452	-1.064	0.484	0.650
	(0.488)	(0.415)	(0.514)	(0.082)
R^2	0.097	0.059	0.037	0.098

Note: Robust standard errors. *significant at 10%, **significant at 5%, and *** significant at 1%. In columns (1) through (3), I compare the relationship between home bias and HHI in the model with that in the data (column (4)).

E Proofs

In this section I derive the theoretical results in the baseline two-country two-sector model.

E.1 Model Log-linearization

First I log-linearize the model around its steady state and evaluate the effect of sectoral productivity shocks on the relative wage and exchange rate. The answer helps us understand the roles that different assets play in risk hedging and how investors choose their optimal equity portfolio.

In the baseline case, I assume the two countries are symmetric for simplification purposes. They have the same amount of labor, and their within-country relative productivity and preference of goods are also symmetric. These 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

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

Absent trade costs, the price of sector a goods relative to sector b goods follows

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

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

$$\hat{e} = (\frac{1 - \tau^{1-\phi}}{1 + \tau^{1-\phi}})\hat{s}.$$

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),[15] the changes in the relative marginal utility across countries are proportional to the changes in the consumption-based real exchange rate as

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

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[15]This condition is not essential for the results. Coeurdacier and Gourinchas (2016) shows that the portfolio characterization remains unchanged when markets are incomplete.

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

$$\hat{PC} = \hat{P} + \hat{C} = (1 - \frac{1}{\sigma})\hat{e} = (\frac{1 - \tau^{1-\phi}}{1 + \tau^{1-\phi}})(1 - \frac{1}{\sigma})\hat{s}.$$

Now let us focus on 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 (2009) show that a "static" budget constraint condition is equivalent to a dynamic budget constraint condition 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

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

From the expressions, we find that the covariances between dividends depend not only on productivity shocks 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

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

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 given

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

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

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

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

where $\eta \equiv 1+\theta-\phi+(\frac{1-\tau^{1-\phi}}{1+\tau^{1-\phi}})^2(\phi-\frac{1}{\sigma})$.[16]

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 $-\eta\frac{T(T-1)}{\theta}$ (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.

E.2   Proof of Proposition 2

When there are no financial frictions, 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. I also denote the sum of the covariances of variable $\hat{x}$ with $\hat{d}_a, \hat{d}_a$ as $\rho(\hat{x})$. When we take the covariance between $\hat{d}_s$ and all the other variables, we find

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

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[16]Since the elasticity of substitution between tradable goods is above unity (the literature, including Levchenko and Zhang (2014) and Caselli et al. (2015), sets it equal to 2), $\eta < \theta$ always holds.

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

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

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

When I plug them back in and rearrange the equation, I obtain the aggregate domestic share as

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

Next, I determine the sign of $\zeta \equiv [\chi^2(\hat{d}) + \chi(\hat{d}_a, \hat{d}_b)]^{-1}$:

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

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

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

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

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

Let $\Omega_1 = \mu S_a - (1 - \mu)(1 - S_b)f$ and $\Omega_2 = (1 - \mu)S_b - \mu(1 - S_a)f$. Plug this into the original budget constraint, and we will get an equation with

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$(\hat{s}, \hat{w})$ only:

$$(1 - \frac{1}{\sigma})(\frac{1 - \tau^{1-\phi}}{1 + \tau^{1-\phi}}))\hat{s} = (1 - \alpha)\hat{w} + \alpha\Omega_1(\eta\hat{s} + \hat{T}_1 - \theta\hat{w}) + \alpha\Omega_2(-\eta\hat{s} + \hat{T}_2 - \theta\hat{w})$$

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

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

$$\Omega_1 \equiv \mu S_a - (1 - \mu)(1 - S_b)f = -\frac{T}{T + 1}\frac{1 - \alpha}{\alpha} + \frac{T}{T + 1}\frac{1}{\alpha}(1 - \frac{1}{\sigma})\lambda, \quad (15)$$

$$\Omega_2 \equiv (1 - \mu)S_b - \mu(1 - S_a)f = -\frac{1}{T + 1}\frac{1 - \alpha}{\alpha} - \frac{T}{T + 1}\frac{1}{\alpha}(1 - \frac{1}{\sigma})\lambda, \quad (16)$$

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