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What Explains Equity Home Bias?
Theory and Evidence at the Sector Level

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Abstract

This paper examines the well-known equity home bias puzzle in international finance by exploiting the cross-sector variation. Combining unique financial datasets, I introduce a novel sectoral home bias index that covers 27 industries in 43 countries, which enables empirical and theoretical analysis of the puzzle in unprecedented detail. I uncover two stylized facts (1) sectoral home bias is stronger for nontradable sectors and in countries with a higher degree of capital restrictions, and (2) investors tilt portfolios more towards domestic assets for the sectors in which their countries reveal a comparative advantage. Motivated by these findings, I build a multi-sector model that incorporates transaction costs, information asymmetry, and risk-hedging motives in investors' portfolio choice. Moreover, I quantify the effects of these frictions on both sector- and country-level home bias in a calibrated DSGE model. This framework sheds light on the patterns and determinants of international financial investment.

KEYWORDS: Home bias in open economy macro models, Portfolio choice in DSGE frameworks, Macro aspects of finance and trade

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1 Introduction

Investors exhibit strong bias in favor of domestic equities, despite the current integration of global financial markets. This phenomenon of "equity home bias", which contradicts the traditional theory of portfolio diversification, continues to be a famous puzzle in international macroeconomics. Existing literature on the subject has examined home bias at the country level, but little is known at the sector level about investors' preference between domestic and foreign assets. This paper not only empirically and theoretically analyzes the sector-level home bias, but also evaluates competing explanations for the country-level home bias by exploiting the cross-sector variation.

In the literature there are two broad classes of explanations for equity home bias: financial frictions in global markets and risk-hedging by investors.[1] The first explanation focuses on institutional transaction barriers and information frictions in global financial markets that may tilt portfolios toward domestic securities. The second explanation studies the relevance of correlation between asset returns and nontraded factors, including labor income and real exchange rate, for investors' asset positions. Nevertheless, there is no unified theoretical framework or detailed sub-country data that allow economists to distinguish between the two explanations and disentangle their effects on portfolio non-diversification. This paper fills the gap in the literature by utilizing the variation across sectors, which enables examination of the patterns and determinants of equity home bias in unprecedented detail.

In the empirical section, I first describe the data and methodology employing which I construct the sectoral home bias index. Using Factset/Lionshare, a dataset on institutional investors' equity holdings, complemented by information on market capitalization from Datastream, I compute the sectoral home bias of 27 industries in 43 countries over the sample period from 1998 to 2014. The summary statistics of the index suggest that the share of foreign equities in investors' portfolios is about 60 percent of what it should be based on the international CAPM averaged across countries and sectors. In the next step, I document empirical regularities of sectoral home bias by evaluating country, sector, and time effects respectively. I find that sectoral home bias is weaker in countries where finan-

[1]See Coeurdacier and Rey (2013) for a comprehensive survey on the topic. Papers that examine risk-hedging motives include Baxter and Jermann (1997), Cole and Obstfeld (1991), Obstfeld and Rogoff (2000), and Heathcote and Perri (2013). Meanwhile, Lewis (1999) and Brennan and Cao (1997) among others investigate the impact of institutional and information frictions on home bias. Investors' behavioral biases driven by these market frictions can also be counted in this category (see, for example, French and Poterba (1991)).

cial openness, measured by the Chinn-Ito index, is greater. This finding, complementing the national evidence found by Lewis (1999) and Lane and Milesi-Ferretti (2003), indicates that institutional frictions constrain international diversification. Moreover, I find that investors show stronger home bias in nontradable sectors than in tradable sectors.[2] This novel evidence supports the theoretical arguments made by Stockman and Dellas (1989) and Obstfeld and Rogoff (2000) that nontradable sectors can potentially induce home bias, since risk-averse investors may prefer to hold domestic assets, particularly domestic nontradable sector assets, to stabilize purchasing power under the fluctuation of real exchange rates. Lastly, I find that sectoral home bias declined over time during the sample period, consistent with the empirical pattern documented by Coeurdacier and Rey (2013) at the country level.

In addition to these factors proposed by the existing literature, I hypothesize and then confirm that relative sectoral productivity measured by comparative advantage is a crucial determinant of sectoral home bias. Sectors with different productivity levels potentially expose investors to risks of different magnitudes, which lead investors to exhibit distinct preference for domestic versus foreign assets across sectors. Moreover, investors are subject to information frictions of varying degrees across sectors depending on which sectors their country relatively excel in. These two factors can jointly decide how comparative advantage shapes the pattern of sectoral home bias. In the empirical analysis, I find that sectoral home bias positively comoves with the measure of revealed comparative advantage, which suggests that investors tilt portfolios more towards domestic assets for the sectors in which their countries reveal a comparative advantage.

Motivated by these empirical findings, I develop a symmetric two-country two-sector DSGE model in the theory section to elucidate the effects of various frictions on sectoral home bias. In particular, the model incorporates sectoral productivity differences, asset transaction costs, and information frictions. Asset transaction costs are assumed to be an iceberg cost on foreign asset returns, similar to the specification in Heathcote and Perri (2004) and Tille and Van Wincoop (2010). Information frictions are modeled as a higher perceived variance of foreign assets following the literature including Brennan and Cao (1997) and Okawa and Van Wincoop (2012). To obtain the solution to the portfolio choice problem, I follow the perturbation method developed by Devereux and Sutherland (2011), who combine a second-order approximation of Euler equations with a first-order approximation of the other equations of the model in order to determine a steady-state

[2] In the sample, tradable sectors include manufacturing and transportation, while nontradable sectors include services, construction, and utilities.

portfolio. The methodological contribution I make is to modify the original method in order to accommodate the two types of financial frictions and examine how they affect investors' asset positions.

The theoretical predictions from the model confirm that institutional and informational frictions are important contributors to home bias. Moreover, I also find that sectoral home bias is stronger in comparative disadvantage sectors in the absence of those financial frictions. This result is driven by investors' incentives to avoid domestic productive sectors for risk hedging. However, if there exist asset transaction costs or information frictions, investors are more likely to show stronger home bias in comparative advantage sectors. This finding implies that these two market frictions dominate investors' risk-hedging motives in driving portfolio choice. This theoretical result can potentially explain the empirical finding on the positive comovement between revealed comparative advantage and sectoral home bias.

To quantify the magnitude of each friction in the real world, I conduct a quantitative assessment of an extended model that covers a large group of countries and sectors. In this extended model, I employ Eaton and Kortum (2002)'s trade framework, which embodies the Ricardian theory of comparative advantage. In terms of the computation strategy, the real side of the economy, including sectoral productivity and trade costs in the goods market, is calibrated to match a country's trade flows with the rest of the world. The financial side of the economy, including asset transaction costs and information frictions, is calibrated to match a country's national as well as sectoral home bias. After estimating these variables, I conduct a series of counterfactual analyses in which I exclude one friction at a time and examine how home bias changes. These counterfactual exercises allow me to disentangle the contribution of each friction to equity home bias. Based on the numerical results, asset transaction costs are more critical than information frictions in explaining sectoral home bias. Furthermore, investors' risk-hedging motives remain to be important drivers for national home bias.

This paper contributes to the asset home bias literature by providing novel empirical and theoretical results at the sector level. By exploiting the cross-sector variation, it enables examination of the puzzle in detail with a unified framework that encompasses various explanations for the home bias puzzle. As is surveyed by Coeurdacier and Rey (2013), economists have proposed market frictions such as transaction barriers (for example, French and Poterba (1991) and Lewis (1999)) and information frictions (Brennan and Cao (1997), Portes et al. (2001) , Ahearne et al. (2004), Massa and Simonov (2006), Van Nieuwerburgh and Veldkamp (2009), Okawa and Van Wincoop (2012) among others) as determinants for investors' portfolio choice among global assets. Others have examined the risk-hedging motives that cause deviation of investors' asset positions from perfect diversification. This strand of literature can be further divided into papers that focus on labor income risk (Baxter and Jermann (1997), Baxter et al. (1998), and Heathcote and Perri (2013)) and those on real exchange rate risk (Stockman and Dellas (1989), Kollmann (2006), Matsumoto (2007), and Coeurdacier (2009)). These theoretical papers study one potential explanation mainly due to the scarcity of data even at the country level that allow economists to discriminate and disentangle multiple factors. In addition, most of these papers see a country as a whole and therefore ignore sectoral heterogeneity. Hu (2020) argues that, 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). Therefore, acknowledging sectoral heterogeneity by developing a multi-sector framework enriches our understanding of investors' risk-hedging pattern and portfolio choice. Compared to Hu (2020) which analyzes country-level home bias, this paper constructs a sectoral home bias measure which enables a detailed theoretical and empirical diagnosis of the puzzle. Moreover, this paper considers multiple financial frictions (transaction costs and information frictions) besides the risk-hedging motives. The modeling strategies of incorporating these frictions, and the computation strategies of quantifying them separately in the general equilibrium, expand the toolbox in the existing literature. For these reasons, this paper makes new important contributions to the home bias literature.

Besides this paper, Schumacher (2018) also uses asset holding data to examine institutional investors' portfolio choices at the sector level. This empirical paper focuses on investors' preference among foreign securities, while I attack the home bias puzzle by studying the determinants of investors' choice between domestic and foreign assets. Lastly, this paper is related to the literature on the interaction of risk-sharing and industrial specialization led by Helpman and Razin (1978), Kalemli-Ozcan et al. (2003), and Koren (2003). The framework from this paper examines how trade specialization shaped by comparative advantage influences portfolio diversification. These works on the interplay of capital and commodity flows are essential for understanding globalization.

The remainder of the paper proceeds as follows: Section 2 describes the data and method used to compute sectoral home bias and presents its empirical regularities. Section 3 develops a two-country two-sector model to illustrate the economic intuition and solution techniques of the home bias problem. Section 4 quantifies the magnitude and impact of the frictions in a calibrated quantitative framework. Section 5 concludes.

2 Empirical Analysis

In this section, I first describe the method and data used to construct the sectoral home bias index. Then I explore the country-, sector-, and time-specific factors that explain its variation. Moreover, I establish its relation with sectoral productivity measured by revealed comparative advantage. These novel empirical findings at the sectoral level enable me to examine the detailed patterns and determinants of equity home bias.

2.1 Constructing Sectoral Home Bias Index

To construct the home bias index, I follow Coeurdacier and Rey (2013) by using the difference between the holdings of equities and the share of market capitalization in the global equity market. This difference reflects the deviation of data from the international CAPM, which predicts that a representative investor should hold a world market portfolio in which the share of his financial wealth invested in local equities equals the share of local equities in the world market. I adapt the method to sector-level analysis, which suggests that home bias in country i sector s at time t is defined as

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

The numerator of this formula is the share of foreign equities in countries i's holding of sector s equities at time t, whose data are from Factset/Lionshare. The denominator is the share of foreign equities in the world market portfolio for sector s, whose market values are from Datastream.

Factset/Lionshare provides comprehensive data on the equity holdings of institutional investors from a large group of countries since 1998. Most institutional investors covered by Factset/Lionshare are mutual funds, while the dataset also includes other types of investors including retirement or pension funds, hedge funds, banks, insurance companies, and sovereign wealth funds. The Factset/Lionshare data originate from public filings by institutional investors (such as 13-F filings with the Securities and Exchange Commission in the U.S.), regulatory agencies worldwide, and company annual reports.

I use institutional investors' holdings as a proxy for the whole country's portfolio choice for the following reasons. First, information on household portfolio is scarce, leaving institutional investors as the only subject whose portfolio distribution across sectors and countries can be studied. Second, the country-level home bias index constructed with the Factset/Lionshar data lines up well with the index constructed by Coeurdacier and Rey (2013), who use IMF's IFS data encompassing countries' aggregate equity positions (see A.2). This consistency shows that the under-representation problem caused by considering institutional investors only will not bias the results significantly. Third, institutional investors have replaced households as the main player in equity markets worldwide. Figure A.3 shows how the household share of equity ownership in the U.S. has significantly declined over time. Robert Shiller calls this phenomenon the "migration of capital from Main Street to Wall Street". The dominance of institutional over retail investors is also commonly observed in other countries.[3] Therefore, the investment strategies of financial institutions are crucial for understanding global financial flows.

However, two limitations of using the Factset/Lionshare data to compute home bias are worth noting. In particular, institutional investors may not only represent the households of their origin. This is especially the case for the countries with low tax rates which attract foreign households. Moreover, securities of foreign multinationals cannot be distinguished directly from domestic securities in the Factset/Lionshare dataset. As is argued by Rowland and Tesar (2004), holding multinationals' securities in the domestic market is similar to holding securities in the foreign market for diversification purposes. These two data limitations can be addressed by including dummies for tax havens and major financial hubs hosting multinationals, but the coding of the two dummies can be subjective. Alternatively, I control for country fixed effects in the regressions to confirm the robustness of the empirical findings despite the data limitations.

Given the Factset/Lionshare data, I group securities by their location and sector, and I group institutions by nationality. For instance, figure A.1 shows the funds allocation by U.S. institutional investors in January 2015. The U.S. invests 83.1 percent of its equities domestically. Given that the U.S. market accounts for around 40 percent of the world market portfolio, this allocation indicates strong national home bias. Additionally, U.S. investments are highly diversified sectorally, with finance, health, and electronics being the most popular industries. Calculating sectoral home bias also requires information on market capitalization. Thomson Reuters Datastream offers global country- and sector-level financial data, including market values. Factset/Lionshare and Datastream,

[3]For instance, institutions accounted for 88 percent of the ownership of EU corporate equities in 2012, according to the INSEAD OEE Data Services. There overall lacks an authoritative data source that reports the fraction of institutional investors in total equity holdings across countries, probably because it is difficult to compile households' asset positions from different countries in a systematic way.

unfortunately, do not categorize industries in the same way, so I construct a concordance of the two classification systems (see table A.1).

Combining all the data, I compile the annual sectoral home bias index using formula 1. The index covers 27 sectors in 43 countries over the sample period from 1998 to 2014 (see table A.2 for a list of countries and sectors in the sample). Figure 1 shows the histogram of sectoral home bias averaged over time. Let $\bar{HB}_{i,s}$ denote the time-averaged home bias of country i sector s. $\bar{HB}_{i,s} = 1$ indicates complete home bias for sector s in country i, since it does not hold any foreign equities in the sector. $\bar{HB}_{i,s} = 0$ indicates that country i is fully diversified for that sector. In theory, $\bar{HB}_{i,s}$ can take any value equal to or smaller than 1 (including negative values). When the value is negative, it means that the country over-invests in foreign equities relative to market shares of the sector. There are 834 observations in the histogram,[4] with mean and standard deviation equal to 0.42 and 0.36, respectively. The index ranges from -0.18 to 1, with many observations clustered around 0 and 1, representing the case with no home bias and complete home bias respectively. The median value of 0.36 suggests that the share of foreign equities in investors' portfolios is about 64 percent of what it should be according to the international CAPM. Besides the overall distribution, figures A.4 and A.5 list the average sectoral home bias by country and by sector respectively. Figure A.6 reports the U.K. sectoral home bias as an example, whose mean value is 0.28 and standard deviation is 0.17. Publishing and hospitality show the strongest home bias, while the iron and steel industry shows the weakest.

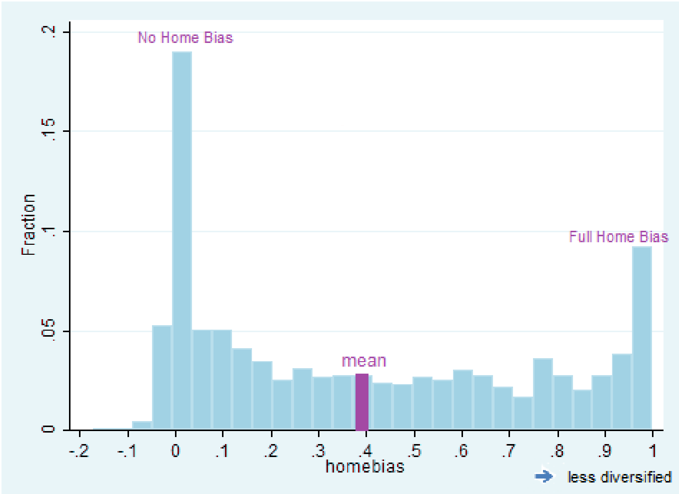
Both figures 1 and A.6 suggest a significant variation in the degree to which investors prefer domestic equities across sectors and countries. In the next step, I investigate various determinants of sectoral home bias to explore the factors influencing investors' portfolio choices in the global financial market.

2.2 Determinants of Sectoral Home Bias

In this section, I explore the country-, sector-, time-specific factors that potentially influence portfolios according to the existing literature on country-level home bias. The comprehensive sector-level data in my sample allows me to examine the impact of these factors in detail.

[4] I exclude the sectors whose holding data are missing from Factset/Lionshare, hence not every country has entries for all the 27 industries. It is difficult to identify the causes for these missing observations in the dataset. Potential causes include institutions' zero holding in some industries, Factset/Lionshare's inability to compile the information for all the industries, or a mix of both reasons.

Figure 1: Distribution of Sectoral Home Bias



Note: This chart is a histogram of the time-averaged sectoral home bias index. The data used to construct this index are from Factset/Lionshare and Datastream.

At the country level, one of the most notable contributors to national home bias is asset transaction costs in global financial markets (see French and Poterba (1991) and Coeurdacier and Rey (2013)). Such costs, including capital controls and differences in trading costs or tax treatments between domestic and foreign assets, lower investors' ability and motivation to hold foreign assets. These country-level barriers that impair global financial mobility should also help explain home bias at the sector level. Therefore, I use the Chinn-Ito index as a proxy for financial openness when exploring the determinants of sectoral home bias. Chinn and Ito (2006) use the IMF's categorical enumeration reported in the Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) to code the index. This de-jure measure of capital account openness is widely used in the international finance literature.

At the sector level, economists including Stockman and Dellas (1989) and Tesar (1993) contend that since households are exposed to fluctuations in the relative price of nontradable sectors, they may skew their portfolio towards domestic assets, especially domestic nontradable sectors' assets to hedge risks. In particular, Obstfeld and Rogoff (2000) discuss a case where tradable and nontradable consumption are log-separable in utility. They reason that households will have few incentives to hold foreign nontradable sectors' assets, as linking the allocation of tradables consumption with asset returns in nontradable sectors does not facilitate risk sharing. Therefore, households should hold globally diversified assets of tradable sectors and only domestic assets of nontradable

Table 1: Determinants of Sectoral Home Bias

Dep. Var: Sectoral HB	(1)	(2)	(3)	(4)	(5)	(6)
Chinn-Ito	-0.688 ***	-0.238 ***				-0.260 ***
	(0.013)	(0.036)				(0.072)
	[-0.444]	[-0.153]				[-0.175]
Tradable dummy			-0.050 ***	-0.065 ***		-0.062 ***
			(0.007)	(0.005)		(0.006)
			[-0.127]	[-0.166]		[-0.160]
Year					-0.006 ***	-0.006 ***
					(0.001)	(0.001)
					[-0.016]	[-0.016]
Country FE	N	Y	N	Y	Y	Y
Sector FE	N	Y	N	N	Y	N
Year FE	N	Y	N	Y	N	N
Observations	11,795	11,795	11,795	11,795	11,795	11,795
R^2	0.197	0.531	0.004	0.509	0.542	0.515

Robust standard errors in parentheses, standardized coefficients in brackets. ***significant at 1%. The dependent variable is sectoral home bias, independent variables include the Chinn-Ito index for financial openness, a dummy for tradable sectors, the year for the data, and country, sector, time fixed effects.

sectors. While theoretical work is abundant, empirical work examining whether investors show more substantial home bias in nontradable sectors is missing. This paper addresses this gap by analyzing home bias at the sector level. When categorizing industries into tradable and nontradable sectors, I follow the benchmark used by Mano and Castillo (2015), who classify industries' tradability based on the trade data. More specifically, manufacturing and transportation (industries coded 1-15 and 20-22 in table A.2) are tradable sectors. Services, construction, and utilities (industries coded 16-19 and 23-27 in table A.2) are nontradable sectors. In addition to the dummy variable, I construct a continuous measure of sectoral tradability based on the World Input-Output Database to verify the robustness of the findings (see table C.1).

In terms of time-series variation, country-level home bias has declined over the past several decades, as is documented by Coeurdacier and Rey (2013). A combination of factors such as reductions in asset transaction costs and informational asymmetries, as well as advanced trading technology in the financial industry, can potentially explain this downward trend. With the available comprehensive panel data, I can examine whether the phenomenon of home bias is indeed disappearing across countries and sectors.

Table 1 presents the findings on the determinants of sectoral home bias discussed above. Columns (1) and (2) show that countries with a higher degree of financial openness, as measured by the Chinn-Ito index, exhibit weaker sectoral home bias. In particular, Column (2) suggests that when country, sector, and time fixed effects are controlled for, a one standard deviation increase in financial openness is associated with a .153 standard deviations decrease in sectoral home bias. This result that investors from economies with greater financial openness hold a larger share of foreign assets at the sector level is consistent with the country-level observations documented by French and Poterba (1991).

Columns (3) and (4) in table 1 report the comovement between sectoral home bias and a tradable dummy whose value equals 1 for tradable sectors and 0 for nontradable sectors. Based on the standardized coefficient in column (4), home bias in tradable sectors is 0.166 standard deviations lower than in nontradable sectors, when country and time fixed effects are controlled for. Table C.1 confirms that the result is robust under a continuous measure of tradability. This novel empirical result that home bias is stronger in the nontradable sector resonates with the theoretical arguments made by Stockman and Dellas (1989), Tesar (1993), and Obstfeld and Rogoff (2000). While these papers discuss hedging real exchange rate risks, there may exist other potential explanations for the difference in home bias between tradables and nontradables. For instance, households face higher information frictions in nontradables since they acquire more knowledge about tradables through imports. I will distinguish between risk-hedging motives and information frictions as drivers of variation in sectoral home bias in the quantitative model.

Lastly, columns (5) and (6) document that sectoral home bias has declined over time. During the sample period, sectoral home bias decreases by .016 standard deviations annually. This declining pattern is consistent with that for national home bias found by Lane and Milesi-Ferretti (2003) and Coeurdacier and Rey (2013). Furthermore, I verify that this downward time trend does not explain the relationship between sectoral home bias and the factors analyzed earlier. Specifically, I regress the change in home bias over time on the Chinn-Ito index and the tradable dummy, after which I report the results in table C.2. Based on the finding that the change in sectoral home bias is not significantly correlated with the two variables, I confirm that financial openness and sectoral tradability remain robust determinants of sectoral home bias.

To sum up, sectoral home bias is weaker in countries with greater capital account openness, for tradable sectors, and more so in the recent past. These findings complement existing theoretical and empirical papers on national home bias.

2.3 Sectoral Home Bias and Comparative Advantage

In addition to the contributors to home bias identified by the existing literature, the interaction of country, sector, and time factors also influence investors' portfolio choice. Among these factors, I hypothesize that relative sectoral productivity measured as comparative advantage is a crucial determinant of sectoral home bias.

The economic reasoning behind this hypothesis is that domestic sectors with different productivity levels potentially expose investors to risks of heterogenous magnitudes, which lead investors to exhibit distinct preference for domestic assets across sectors. As is surveyed by Coeurdacier and Rey (2013), the literature summarizes two sources of risks that may skew households' portfolios under their risk-hedging incentives. First, 'labor income risk' arises from the fluctuation in human capital income (see, for example, Baxter and Jermann (1997) and Heathcote and Perri (2013)). Second, 'real exchange rate risk' refers to the fluctuation in households' purchasing power due to the changes in goods' prices (see Matsumoto (2007) and Coeurdacier (2009) among others). These two factors cannot be traded in financial markets, which induce households to consider their comovements with available financial assets when constructing portfolios.

In a multi-sector framework, a sector with greater comparative advantage is potentially associated with higher labor income risk because the returns to that sector are more highly correlated with the country's labor income than is the case for the returns to a less productive sector. This is driven by the fact that more productive sectors tend to have a larger influence on the aggregate economy since they export more goods and create more jobs. When these sectors fail, the whole country suffers drastic labor income losses. If households hold many home assets in these sectors, their labor income and financial income may plummet simultaneously. Therefore, to hedge against labor income fluctuations, it is optimal for households to hold fewer home assets in comparative advantage sectors and hence show weaker sectoral home bias.

Similarly, a comparative advantage sector can also be associated with greater real exchange rate risk since its returns negatively correlate with the domestic price level. Consider the sector experiences a negative productivity shock, and hence its financial returns fall. Meanwhile, its output price increases to clear the goods market, which — given its greater weight in the price level under comparative advantage — can lead to the appreciation of the real exchange rate. Therefore, holding home assets in such a sector is not optimal for risk-hedging purposes, given the negative correlation between the financial return and real exchange rate. Instead, if households hold financial assets whose returns increase when domestic price levels rise, they do not need to significantly compromise consumption when local goods become more expensive, since the shortfall in purchasing power can be partially offset by their increased financial income.

To empirically test these risk-hedging hypotheses, I examine whether investors exhibit weaker home bias in comparative advantage sectors. Following the trade literature, I employ Balassa (1965)'s method to construct a measure of revealed comparative advantage (RCA hereafter). The measure is based on the Ricardian trade theory: a country reveals a comparative advantage if it is a competitive exporter of that sector relative to the world. RCA is hence defined as

$$RCA_{i,s,t} = \frac{\frac{X_{i,s,t}}{\sum_{s=1}^{S} X_{i,s,t}}}{\frac{X_{w,s,t}}{\sum_{s=1}^{S} X_{w,s,t}}}, \tag{2}$$

where $X_{i,s,t}(X_{w,s,t})$ denotes country i's (world's) exports of sector s at time t. To compute RCA, I use the UN Comtrade dataset at the 3- and 4-digit ISIC levels corresponding to the sectors that appear in Factset/Lionshare and Datastream (table A.3). Contrary to the expectation, the results reported in table 2 suggest that home bias increases in RCA, which implies that investors reveal a stronger home bias in comparative advantage sectors. As column (4) in table 2 suggests, when RCA increases by 1 standard deviation, sectoral home bias increases by 0.083 standard deviations.[5] Moreover, I consider the determinants examined in table 1 and combine them here in the regression. Financial openness measured by the Chinn-Ito index still lowers home bias, while sectoral tradability drops out because of collinearity due to the lack of trade data to compute the RCA measure for nontradables. Instead, I control for sector fixed effects in the regression, and find the positive comovement between sectoral home bias and RCA to be robust.

This analysis, by exploiting the sectoral variation in risk exposure and home bias, casts doubt on the importance of risk-hedging motives in explaining investors' portfolio choice. Even at the country level, economists find the empirical evidence supporting the theory to be mixed. For example, Van Wincoop and Warnock (2008) and Massa and Simonov (2006) find the correlation between asset returns and nontraded factors (labor income and exchange rate) to be too low to rationalize home bias by risk-hedging incentives. This sector-level analysis complements these papers by using detailed data.

One potential explanation to address the discrepancy between the theoretical hypothesis and the empirical finding is that there exists another friction, which works against and eventually dominates risk-hedging incentives by skewing portfolios towards riskier assets representing domestic comparative advantage sectors. Information friction, which

[5] Although the coefficients are statistically significant, their magnitude is relatively small. It could be driven by the fact that risk-hedging motives, whether by themselves or in conjunction with (potentially counteracted by) other frictions, are not as important as proposed in the literature in explaining the variation in home bias. The theoretical model in this paper is useful to explore such possibilities.

Table 2: Sectoral home bias and revealed comparative advantage

Dep. Var: Sectoral HB	(1)	(2)	(3)	(4)
RCA	0.015 ***	0.017 ***	0.021 ***	0.021 ***
	(0.003)	(0.003)	(0.003)	(0.003)
	[0.061]	[0.071]	[0.085]	[0.083]
Chinn-Ito		-0.760 ***		-0.194 ***
		(0.018)		(0.056)
		[-0.484]		[-0.123]
Country FE	N	N	Y	Y
Sector FE	N	N	Y	Y
Year FE	N	N	Y	Y
Observations	6,064	6,064	6,064	6,064
R^2	0.004	0.237	0.564	0.566

Robust standard errors in parentheses, standardized coefficients in brackets.***significant at 1%. The dependent variable is sectoral home bias. The independent variables include sectoral revealed comparative advantage $RC\bar{A}_{i,s,t}$, Chinn-Ito index, and country, sector, time fixed effects.

has been well established in the home bias literature, can potentially be such a friction.[6,7] If information asymmetry between domestic and foreign assets is exacerbated in comparative advantage sectors, investors are more likely to exhibit stronger home bias for these sectors. For example, Korea has a comparative advantage in the electronics industry; therefore, Korean households are knowledgeable about domestic companies like Samsung and LG. Nevertheless, the strength in the industry may dampen Koreans' motivation to inquire into foreign companies such as Apple. It also reduces opportunities for Korean households to acquire knowledge about foreign companies through imports. Through this lens, a comparative advantage sector is subject to greater information frictions. This reasoning can potentially explain why investors would show stronger home bias for comparative advantage sectors even though these sectors expose them to greater risks. However, whether the information friction is relevant for sectoral home bias is hard to test empirically due to the lack of proxies for information frictions at the sector level.[8] Therefore, I propose a theoretical DSGE model using which we can disentangle

[6]Empirical evidence found by Ahearne et al. (2004)) and Bae et al. (2008) among others suggests the existence of the information barriers investors face when buying foreign assets. On the theoretical front, Brennan and Cao (1997) and Okawa and Van Wincoop (2012) model the friction as an exogenous information set with investors' higher perceived variance for foreign assets, while Van Nieuwerburgh and Veldkamp (2009) endogenize the information acquisition decision to examine the home bias puzzle.

[7]Behavioral biases driven by asymmetric beliefs (French and Poterba (1991) and Dumas et al. (2009)) work similarly. Empirically it is challenging to disentangle them from information frictions though.

[8]At the country level, economists have used geographic distance (Portes et al. (2001)) or cross-listing companies' market share (Ahearne et al. (2004)) as an indicator for information frictions. But there lacks comprehensive cross-country measure at the sector level which approximates information frictions

the frictions and quantify their relevance based on model-consistent estimates of frictions in the general equilibrium.

3 Theory

Motivated by the empirical findings, I build a two-country two-sector DSGE model to elucidate the influences of risk hedging and asset market frictions on equity home bias. This framework extends Coeurdacier and Rey (2013)'s analysis by featuring imperfect sectoral specialization and embedding financial frictions when solving for portfolio choice in incomplete markets.

3.1 Setup

Two symmetric countries ($i \in \{H, F\}$) both produce two types of tradable consumption goods ($s \in \{a, b\}$). Production in country i sector s combines labor $l_{i,s,t}$ and capital $k_{i,s,t}$ endowments in a Cobb-Douglas function[9]

$$y_{i,s,t} = T_{i,s,t} k_{i,s,t}^{\alpha} l_{i,s,t}^{1-\alpha}, \tag{3}$$

where productivity $T_{i,s,t}$ follows an AR(1) process over time with a long-term mean $\bar{T}_{i,s}$ and an autoregressive coefficient $\rho_{i,s}$:[10]

$$T_{i,s,t} = \rho_{i,s} T_{i,s,t-1} + (1 - \rho_{i,s}) \bar{T}_{i,s} + \epsilon_{i,s,t}. \tag{4}$$

Productivity innovations are assumed to be i.i.d. shocks $\epsilon_{i,s,t} \sim N(0, \sigma_\epsilon^2)$ in the baseline case. In the quantitative model, their covariance matrix Σ incorporating within- and cross-country correlations will be estimated from the data.

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 long-term average produc-

but does not covary with risk-hedging factors such as trade volume.

[9]Factor intensity is assumed to be the same across sectors in this baseline model, to focus on sectoral productivity (Ricardian) instead of Heckscher-Ohlin type comparative advantage. In section 4, factor intensity will be different and calibrated to sectoral output data. α as the capital share in a production function influences portfolio choice since it determines the ratio of capital income to nontraded factors including labor income. Therefore, the parameter is important for risk-hedging asset positions.

[10]The AR(1) assumption for productivity is standard in DSGE frameworks. The persistence of productivity shocks is relevant for inter-temporal decisions of rational households. Therefore, it influences the expected next-period consumption that appears in the Euler equation for portfolio choice.

tivity satisfies

$$\frac{\bar{T}_{H,a}}{\bar{T}_{H,b}} = \frac{\bar{T}_{F,b}}{\bar{T}_{F,a}} \equiv T > 1, \tag{5}$$

where T denotes the difference between more productive and less productive sectors, which also reflects the degree of comparative advantage.[11]

There is a stock market where firms sell their shares to both domestic and foreign households.[12] Stocks are grouped into four types, each representing sector s in country i. 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 claims to capital income:

$$d_{i,s,t} = \alpha p_{i,s,t} y_{i,s,t}, \tag{6}$$

where $p_{i,s,t}$ denotes the price of output in country i sector s. In this baseline model both labor and capital are factor endowments which are fixed at the country level.[13]

A representative household in country i has a constant-relative-risk-aversion (CRRA) preference. It chooses optimal consumption and asset holdings to maximize his expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_{i,t}^{1-\sigma}}{1-\sigma}. \tag{7}$$

Consumption is a constant-elasticity-of-substitution (CES) bundle of a and b goods:

$$C_{i,t} = (\psi_i^{\frac{1}{\phi}} C_{i,a,t}^{\frac{\phi-1}{\phi}} + (1-\psi_i)^{\frac{1}{\phi}} C_{i,b,t}^{\frac{\phi-1}{\phi}})^{\frac{\phi}{\phi-1}}, \tag{8}$$

where ψ_i is country i's expenditure share on sector a and ϕ is the elasticity of substitution between sectors. Therefore, the price level in country i is

$$P_{i,t} = (\psi_i P_{i,a,t}^{1-\phi} + (1-\psi_i) P_{i,b,t}^{1-\phi})^{\frac{1}{1-\phi}}, \tag{9}$$

[11]Under symmetry, macro variables are the same across countries in the steady state. The realization of $T_{i,s,t}$ will be subject to stochastic shocks $\epsilon_{i,s,t}$ which characterize the risks of the economy. Under these shocks, second-moment (covariance) instead of first-moment (level) variables, especially the covariance between macro variables and sectoral capital income, will determine portfolio choice for risk hedging.

[12]This model focuses on equities for which there are comprehensive data for empirical evaluation. There exist many other forms of financial assets including bonds, bank loans, derivatives, and reserves. While it is beyond the scope of this paper to model all these assets, Appendix C.2 considers bonds and confirms the robustness of theoretical predictions about equity home bias.

[13]I relax this assumption in Appendix C.2 when discussing the robustness of the model predictions, which shows that introducing endogenous labor supply and capital accumulation does not change the qualitative predictions of the baseline model.

whose cross-country ratio defines the real exchange rate

$$e_t = \frac{P_{H,t}}{P_{F,t}}. \tag{10}$$

Within each sector s, consumption is another CES bundle of goods produced at home and abroad, with its quantity and price given by:

$$C_{i,s,t} = (\mu_i^{\frac{1}{\eta}} C_{ii,s,t}^{\frac{\eta-1}{\eta}} + (1-\mu_i)^{\frac{1}{\eta}} C_{ji,s,t}^{\frac{\eta-1}{\eta}})^{\frac{\eta}{\eta-1}}, \tag{11}$$

$$P_{i,s,t} = (\mu_i p_{i,s,t}^{1-\eta} + (1-\mu_i) p_{j,s,t}^{1-\eta})^{\frac{1}{1-\eta}}, \tag{12}$$

where $C_{ii,s,t}$ ($C_{ji,s,t}$) is the consumption of domestic (imported) goods and η denotes the elasticity of substitution within sectors. The goods market clearing condition satisfies

$$y_{i,s,t} = C_{ii,s,t} + C_{ij,s,t}. \tag{13}$$

If domestic goods account for more than half of the consumption ($\mu_i > \frac{1}{2}$), countries exhibit consumption home bias. Consumption preference is symmetric in the baseline case such that $\psi_H = 1 - \psi_F$, $\mu_H = \mu_F$.

In the factor market, wage $w_{i,t}$ and capital rental fee $r_{i,t}$ are determined by the market clearing conditions for factor endowments:

$$l_{i,a,t} + l_{i,b,t} = \bar{L}_i, \qquad k_{i,a,t} + k_{i,b,t} = \bar{K}_i, \qquad i \in \{H, F\}. \tag{14}$$

The endowments are mobile within a country but immobile across borders. In the labor market, I assume a household supplies one unit of labor inelastically for simplicity. In the capital market, capital rental fee is also linked to dividends in the stock market through

$$d_{i,s,t} = r_{i,t} k_{i,s,t}. \tag{15}$$

In terms of stock investment, a household purchases equities of country i sector s at time t for price $q_{i,s,t}$.[14] Let $\nu_{i,s,t}$ ($\nu^{\diamond}_{i,s,t}$) denote the number of shares H (F) country's

[14] In this model, portfolio choice in each country is decided by a single representative household with different household members working in different sectors. The ideal data counterpart for this assumption should be households' asset positions. But such data is scarce mainly because it is impossible to compile households' holdings in a systematic way across countries. Alternatively, in the model, we can assume there is a mutual fund which makes investment decisions on behalf of households in each country to maximize their expected lifetime utility. This assumption is more consistent with the empirical section

household holds for sector s from country i at time t, then the budget constraints of households in country H and F, given by equations 16 and 17 respectively, state that the sum of consumption expenditures and changes in asset positions is equal to the sum of labor income and dividend income:

$$\begin{aligned} P_{H,t}C_{H,t} + \sum_{s=\{a,b\}} [q_{H,s,t}(\nu_{H,s,t+1} - \nu_{H,s,t}) + q_{F,s,t}(\nu_{F,s,t+1} - \nu_{F,s,t})] \\ = w_{H,t}\bar{L}_H + \sum_{s=\{a,b\}} (d_{H,s,t}\nu_{H,s,t} + d_{F,s,t}\nu_{F,s,t}), \end{aligned} \tag{16}$$

$$\begin{aligned} P_{F,t}C_{F,t} + \sum_{s=\{a,b\}} [q_{H,s,t}(\nu^{\diamond}_{H,s,t+1} - \nu^{\diamond}_{H,s,t}) + q_{F,s,t}(\nu^{\diamond}_{F,s,t+1} - \nu^{\diamond}_{F,s,t})] \\ = w_{F,t}\bar{L}_F + \sum_{s=\{a,b\}} (d_{H,s,t}\nu^{\diamond}_{H,s,t} + d_{F,s,t}\nu^{\diamond}_{F,s,t}). \end{aligned} \tag{17}$$

I introduce two financial market frictions into the model. The first one is asset transaction costs, modeled as a tax on foreign returns similar to Heathcote and Perri (2004) and Tille and Van Wincoop (2010). Given the iceberg cost denoted as τ_i, when country i's investors earn 1 unit of wealth from investing abroad, they can only collect $e^{-\tau_i}$ units.[15] The transaction costs are assumed to be second-order in magnitude, which implies that they are proportional to the variance of asset returns.[16] Besides, they are assumed to be equal in the symmetric two-country case: $\tau_i = \tau_j = \tau$. The other friction is the information friction, which is modeled as a higher perceived variance of foreign assets following Brennan and Cao (1997), Van Nieuwerburgh and Veldkamp (2009), and Okawa and Van Wincoop (2012) among others. The idea is that investors perceive foreign stocks as riskier and reduce their foreign stock holdings accordingly. In the model I assume information frictions, denoted as $f_{ij,s}$, are added to the variance of sectoral productivity shocks $\sigma^2_{i,s}$, such that from the perspective of households in country j, $\epsilon_{i,s}$ has a mean of 0 and variance $\sigma^2_{i,s} + f_{ij,s}$. In this symmetric case, $f_{ii,s} = f_{jj,s} = 0$, $f_{ij,s} = f_{ji,s} = f_s > 0$. The information friction can be different across sectors, since the knowledge households

where institutional holdings are used to proxy country-level asset positions.

[15]The iceberg cost is assumed to be country-specific and therefore does not vary across sectors within a country. In reality, there could exist within-country variations for asset transaction barriers, particularly for sensitive industries like aerospace and defense. Such sectors, due to limited data coverage for them in Factset/Lionshare and UN Comtrade, are excluded from the empirical and quantitative analysis.

[16]These frictions enter the Euler equation as a second-order friction and do not change the first-order dynamics of the budget constraint. Otherwise the frictions break the certainty equivalence of assets to the first-order approximation, which invalidates the solution method for portfolio choice developed by Devereux and Sutherland (2011) and Tille and Van Wincoop (2010) in a DSGE model.

acquire about foreign productivity may potentially vary with sector-specific factors such as sectoral trade volume.

The financial returns of country i sector s include dividends and capital gains:

$$R_{i,s,t} = \frac{q_{i,s,t} + d_{i,s,t}}{q_{i,s,t-1}}, \tag{18}$$

which influence households' intertemporal decisions that yield Euler equations:

$$\frac{U'(C_{i,t})}{P_{i,t}} = E_t[\beta \frac{U'(C_{i,t+1})}{P_{i,t+1}} \tilde{R}_{i',s,t+1}],\; i, i' \in \{H, F\};\; s \in \{a, b\}, \tag{19}$$

where $\tilde{R}_{i',s,t+1}$ denotes the asset returns $R_{i,s,t+1}$ defined in equation 18 augmented with transaction costs and information frictions depending on whether the asset is domestic: $\tilde{R}_{i',s,t+1} = R_{i',s,t+1}$ if $i = i'$.

To sum up the description of the model setup, the equilibrium of the model consists of a set of prices and quantities such that 1) households choose consumption and construct portfolio to maximize their expected lifetime utility, 2) firms maximize their profits, and 3) factor, commodity, and asset markets clear.

3.2 Portfolio Choice

3.2.1 Methodology and Parametrization

To solve for portfolios in the equilibrium of the economy, I employ Devereux and Sutherland (2011)'s perturbation method. Acknowledging that assets are only distinguishable by their risk characteristics, Devereux and Sutherland (2011) develop a method that combines a second-order approximation of Euler equations with a first-order approximation of the other equations of the model in order to determine a zero-order (i.e. steady-state) portfolio. This method has been widely used in deriving portfolios in open economy macroeconomic models.

The methodological contribution I make is to modify the original method in order to accommodate the financial frictions in this model. When households incur transaction costs τ when repatriating foreign returns, it follows from Euler equations (19) that

$$\begin{aligned} E_t[\tfrac{U'(C_{H,t+1})}{P_{H,t+1}} R_{H,s,t+1}] &= E_t[\tfrac{U'(C_{H,t+1})}{P_{H,t+1}} e^{-\tau} R_{F,s,t+1}], \\ E_t[\tfrac{U'(C_{F,t+1})}{P_{F,t+1}} R_{F,s,t+1}] &= E_t[\tfrac{U'(C_{F,t+1})}{P_{F,t+1}} e^{-\tau} R_{H,s,t+1}], \qquad s \in \{a, b\} \end{aligned} \tag{20}$$

In the two-country two-sector case, let $R_{F,b,t}$ be a numeraire asset and R_x denote the vector of excess returns to the other assets:

$$\hat{R}_x' = [\hat{R}_{H,a} - \hat{R}_{F,b}, \hat{R}_{H,b} - \hat{R}_{F,b}, \hat{R}_{F,a} - \hat{R}_{F,b}], \tag{21}$$

where $\hat{y}$ represents the log-deviation of any variable y from its steady state.

Based on the ordering of the assets in R_x, I introduce the vector of transaction costs defined as

$$\mathcal{T}' = [\tau, \tau, 0], \tag{22}$$

which appears in the second-order Taylor expansion of Euler equations in both countries:

$$\begin{aligned} E_t[\hat{R}_{x,t+1} + \tfrac{1}{2}\hat{R}^2_{x,t+1} + \tfrac{1}{2}\mathcal{T} - (\sigma\hat{C}_{H,t+1} + \hat{P}_{H,t+1})\hat{R}_{x,t+1}] &= \mathcal{O}(\epsilon^3), \\ E_t[\hat{R}_{x,t+1} + \tfrac{1}{2}\hat{R}^2_{x,t+1} - \tfrac{1}{2}\mathcal{T} - (\sigma\hat{C}_{F,t+1} + \hat{P}_{F,t+1})\hat{R}_{x,t+1}] &= \mathcal{O}(\epsilon^3). \end{aligned} \tag{23}$$

Here $\mathcal{O}(\epsilon^3)$ captures all terms of order higher than two, and $\hat{R}^{2\prime}_{x,t+1}$ denotes differences in squared changes of returns

$$\hat{R}^{2\prime}_{x,t+1} = [\hat{R}^2_{H,a,t+1} - \hat{R}^2_{F,b,t+1}, \hat{R}^2_{H,b,t+1} - \hat{R}^2_{F,b,t+1}, \hat{R}^2_{F,a,t+1} - \hat{R}^2_{F,b,t+1}]. \tag{24}$$

Taking the difference between the two equations in 23 yields a portfolio determination condition:

$$E_t[(\hat{C}_{H,t+1} - \hat{C}_{F,t+1} + \frac{\hat{e}_{t+1}}{\sigma})\hat{R}_{x,t+1}] = \frac{\mathcal{T}}{\sigma} + \mathcal{O}(\epsilon^3). \tag{25}$$

On the left hand side of this portfolio determination condition are two components: 1) the cross-country consumption differential adjusted for the real exchange rate and 2) the excess returns to financial assets. In order to solve the portfolio choice problem, one needs to express these two components in terms of the innovations in the model

$$\epsilon_t' = [\epsilon_{H,a,t}, \epsilon_{H,b,t}, \epsilon_{F,a,t}, \epsilon_{F,b,t}], \tag{26}$$

whose coefficients as a function of asset positions, denoted as $\bar{\alpha}' = [\bar{\alpha}_{H,a}, \bar{\alpha}_{H,b}, \bar{\alpha}_{F,a}]$, need to satisfy equation 25. In this process, we need to take into consideration that these components vary with portfolio returns defined as

$$\xi_t = \tilde{\alpha}'\hat{R}_{x,t}, \tag{27}$$

where $\tilde{\alpha}$ is the asset holdings adjusted for a country's steady-state income $\tilde{\alpha} = \frac{\bar{\alpha}}{\beta\bar{Y}}$. Moreover, excess asset returns $R_{x,t}$ and portfolio returns ξ_t are interdependent. To overcome this simultaneity problem, Devereux and Sutherland (2011) suggest a two-step procedure: In the first step, the two components in equation 25 are expressed as functions of ϵ_t and ξ_t. In the second step, ξ_t is expressed as a function of ϵ_t so that the behavior of consumption differential and excess returns can be expressed in terms of ϵ_t only.

Borrowing the notations from Devereux and Sutherland (2011) with minor modifications, I set up the system of equations in the first step as

$$\hat{C}_{H,t+1} + \frac{\hat{P}_{H,t+1}}{\sigma} = D_{H1}\xi_{t+1} + D_{H2}\epsilon_{t+1} + D_{H3}z_{t+1} + \mathcal{O}(\epsilon^2), \tag{28}$$

$$\hat{C}_{F,t+1} + \frac{\hat{P}_{F,t+1}}{\sigma} = D_{F1}\xi_{t+1} + D_{F2}\epsilon_{t+1} + D_{F3}z_{t+1} + \mathcal{O}(\epsilon^2), \tag{29}$$

$$\hat{R}_{x,t+1} = R_1\xi_{t+1} + R_2\epsilon_{t+1} + \mathcal{O}(\epsilon^2), \tag{30}$$

where $R_1, R_2, D_{i1}, D_{i2}, D_{i3}, i \in \{H, F\}$ are the coefficient matrices extracted from the first-order conditions of the model. R_1 and D_{i1} capture the response of the two components (consumption differential and excess asset returns) to excess portfolio returns; R_2 and D_{i2} capture their response to productivity shocks; and D_{i3} are their response to other state variables in the model summarized by z. Next I impose the condition that ξ_{t+1} is related to excess returns via $\xi_{t+1} = \tilde{\alpha}'\hat{R}_{x,t+1}$. Using this and equation 30 allows me to express ξ_{t+1} and $\hat{R}_{x,t+1}$ in terms of ϵ_{t+1}:

$$\xi_{t+1} = \tilde{H}\epsilon_{t+1}, \qquad where \qquad \tilde{H} = \frac{\tilde{\alpha}'R_2}{1 - \tilde{\alpha}'R_1}; \tag{31}$$

$$\hat{R}_{x,t+1} = \tilde{R}\epsilon_{t+1} + \mathcal{O}(\epsilon^2), \qquad where \qquad \tilde{R} = R_1\tilde{H} + R_2. \tag{32}$$

Moreover, substituting for ξ_{t+1} in equation 28 and 29 using 31 gives

$$\begin{cases} \hat{C}_{H,t+1} + \frac{\hat{P}_{H,t+1}}{\sigma} &= \tilde{D}_H\epsilon_{t+1} + D_{H3}z_{t+1} + \mathcal{O}(\epsilon^2), \qquad where \qquad \tilde{D}_H = D_{H1}\tilde{H} + D_{H2}. \\ \hat{C}_{F,t+1} + \frac{\hat{P}_{F,t+1}}{\sigma} &= \tilde{D}_F\epsilon_{t+1} + D_{F3}z_{t+1} + \mathcal{O}(\epsilon^2), \qquad where \qquad \tilde{D}_F = D_{F1}\tilde{H} + D_{F2}. \end{cases} \tag{33}$$

Now that we have examined the two components separately as functions of innovations ϵ_{t+1}, we can multiply them to evaluate the portfolio determination condition (equation 25). In this process, elements representing information frictions will be loaded on the diagonal of the variance-covariance matrix of sectoral productivity shocks Σ. Let f_s be the information frictions in sector s, then the perceived variance-covariance matrices from country H's and F's perspective are respectively given by

$$\Sigma_H = \Sigma + \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & f_a & 0 \\ 0 & 0 & 0 & f_b \end{bmatrix}, \quad \Sigma_F = \Sigma + \begin{bmatrix} f_a & 0 & 0 & 0 \\ 0 & f_b & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{34}$$

Since the ordering of asset returns follows $R_{H,a}, R_{H,b}, R_{F,a}, R_{F,b}$, households in country H (F) incur information frictions for the 3rd and 4th (1st and 2nd) assets, which correspond to the lower right (upper left) corner the variance-covariance matrix.

With all the ingredients put together, the portfolio determination condition (equation 25) can be re-written as

$$E_t[(\hat{C}_{H,t+1} - \hat{C}_{F,t+1} + \frac{\hat{e}_{t+1}}{\sigma})\hat{R}_{x,t+1}] = \tilde{R}\Sigma_H\tilde{D}'_H - \tilde{R}\Sigma_F\tilde{D}'_F = \frac{\mathcal{T}}{\sigma} + \mathcal{O}(\epsilon^3). \tag{35}$$

Different from the case in Devereux and Sutherland (2011), a closed-form solution to the portfolio choice problem cannot be derived in this framework. Instead, I use equation 35 to obtain the numerical solution to households' asset holdings under various frictions.

The baseline numerical results are solved under the parametric assumptions summarized in table 3. I adopt the following standard assumptions from macroeconomics literature: (i) the annual discount factor is .95, and (ii) the coefficient of risk aversion is 2. In terms of consumption preference, I assume the elasticity of substitution between tradable sectors is 2 following Levchenko and Zhang (2016). Within a sector, economists including Baier and Bergstrand (2001) and Imbs and Mejean (2015) estimate the elasticity to be much greater according to sectoral trade data. Based on their estimates, I set the elasticity of substitution within a sector to be 5. Moreover, households are assumed to spend more on domestic goods ($\mu > 0.5$) and on comparative advantage sectors ($\psi_H > 0.5$). These assumptions skew aggregate price levels toward the prices of domestic comparative advantage sectors. Alternatively, one can introduce trade costs in the goods market instead of consumption home bias to generate the same comovement.

The other parameters, including the amount of endowments and the specification of productivity processes, are set arbitrarily since they will not change the qualitative prediction of this illustrative model. In the quantitative exercise, these parameters will be calibrated to match the data.

Table 3: Baseline Parametrization

Parameter	Description	Value
β	Discount factor	0.95
σ	Coefficient of relative risk aversion	2
ϕ	Elasticity of substitution between sectors	2
η	Elasticity of substitution within sectors	5
μ	Weight of domestic goods in within a sector	0.6
ψ_H	Expenditure shares on comparative advantage sectors	0.6
α	Capital share in production	0.35
$\bar{L}$	Labor endowment	1
$\bar{K}$	Capital endowment	1
ρ	Autoregressive coefficient of productivity	0.9
σ_ϵ	Std. dev. of productivity shocks	0.25

3.2.2 Results from Comparative Statics Analysis

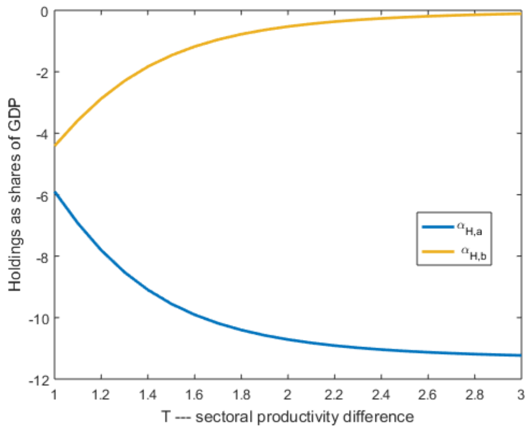
In this section, I examine the variation in sectoral home bias driven by sectoral productivity differences, transaction costs, and information frictions. Specifically, I analyze the comparative statics to illustrate the impact of these factors on country H's portfolio choice. To preview the results, risk-hedging considerations generate investors' stronger home bias in comparative disadvantage sectors. However, financial frictions in the form of transaction costs or information frictions can reverse this prediction.

In order to isolate the influence of comparative advantage on sectoral home bias, I first assume there is no transaction cost or information friction when depicting the change of domestic asset holdings with sectoral productivity differences in figure 2.[17] Three findings are notable from the figure: First, households short-sell domestic assets in both sectors for risk hedging, reflected by the negative asset positions. To understand this result, recall in this framework, both labor income risk and real exchange rate risk induce households to buy foreign assets in order to hedge risks, which is consistent with the arguments made by Baxter and Jermann (1997) and Coeurdacier (2009), among others.[18] Second, households hold fewer domestic assets of comparative advantage sectors as $\alpha_{H,a} < \alpha_{H,b}$. This is because the domestic comparative advantage sector (sector a in country H, denoted as Ha hereafter for brevity) exposes households to greater risks because its asset returns are more

[17]Portfolio weights in the figure ($\alpha_{i,s}$) are the values of asset holdings $\nu_{i,s}$ in the budget constraint (equation 16) scaled by the country's aggregate income in the steady state of the economy.

[18]The prediction can be different under alternative modeling assumptions. For example, Coeurdacier and Rey (2013) contend that parametric assumptions, in particular about the elasticity of substitution between goods and the share of domestic goods in consumption bundles, will determinate whether the real exchange rate risk causes home or foreign bias. See Appendix C.2 for detailed discussions.

Figure 2: Sectoral Home Bias and Comparative Advantage



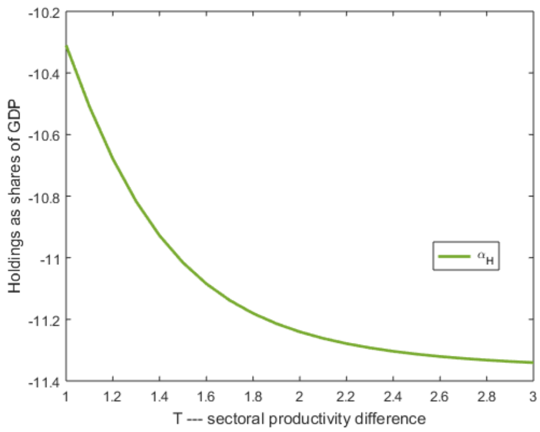
highly correlated with domestic labor income and decrease more closely with real exchange rate (RER).[19] A country has a single wage rate and exchange rate influenced jointly by the two sectors. But with the larger influence of the comparative advantage sector (through its sectoral size in employment and exports) on the economy of the country, any change to that sector influences labor income and RER by a greater magnitude. Therefore, households exhibit weaker home bias (or, more precisely, stronger negative home bias) for risk hedging in the comparative advantage sector which shows stronger correlations with these two macro variables. Third, the disparity between (the negative degrees of) sectoral home bias rises when T — the sectoral productivity difference, which also measures comparative advantage — increases in both countries. To interpret this result, the greater the value of T, the more risks are associated with the comparative advantage sector Ha for households in country H. Hence, households gradually switch from Ha to Hb assets, which are less risky. This explains the growing gap between the two asset positions when T rises in figure 2.

Another interesting finding is that when T increases, households not only raise their holdings of Hb assets for intra-national risk hedging but also raise their holdings of foreign assets for inter-national risk hedging. As figure 3 suggests, aggregate domestic holdings $\alpha_H = \alpha_{H,a} + \alpha_{H,b}$ decrease with T. Hu (2020) analyzes the economic intuition behind this finding: Although the comparative disadvantage sector (Hb) can partially offset the real exchange rate risk, the degree of this intra-national risk hedging is rather limited

[19]This happens even if there is no sectoral productivity difference as the two lines do not intersect at $T = 1$, because the assumption about the consumption weight ($\mu > 0.5$) means that sector Ha is associated with greater real exchange rate risk even though the two home sectors are otherwise the same. See figures C.1-C.2 in Appendix C.2 which disentangles labor income and real exchange rate risks.

in countries with high degrees of industrial specialization (captured by a higher value of T). Therefore, households from these countries tilt their portfolios more towards foreign assets for inter-national risk hedging.

Figure 3: National Home Bias and Comparative Advantage

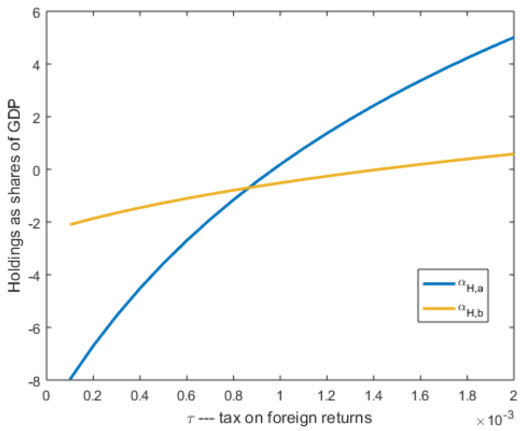


I now proceed to analyze the impact of asset transaction costs on sectoral home bias. Since the effect of sectoral productivity difference on portfolio choice is analyzed earlier, I will fix the value of T as 3 from now on.[20] As figure 4 suggests, both asset curves are upward sloping, which indicates that households increase their holdings of domestic assets in both sectors when asset transaction costs τ rise. This result could be explained by the fact that transaction costs reduce the appeal of foreign assets as risk-hedging instruments, which prompts households to increase the weight of domestic assets in their portfolios. Between the two domestic assets, the holdings of Ha assets are more sensitive to the changes in the transaction cost τ, as the slope of its curve is greater in figure 4. This is because in the case with no transaction costs, sector Fa offers more risk-hedging benefits than Fb for households in country H. To understand this, recall sector Fb is country F's comparative advantage sector. Hence country H imports more in that sector, which increases the comovement of the returns to that sector with H's macro fundamentals. Therefore, Fb assets are not as good hedging instruments as Fa assets from country H's perspective: $\alpha_{F,a} > \alpha_{F,b}$. Nevertheless, when asset transaction costs increase to dominate risk-hedging incentives by lowering foreign returns, households substitute domestic for

[20]In Appendix C.2, I conduct robustness checks under alternative sectoral productivity and confirm that numerical results are qualitatively similar. In this stylized model, I do not take a strong stand on the values of productivity or frictions, depending on which sectoral home bias covaries with RCA in a non-monotonic way. In section 4, I calibrate all these parameters to sectoral data so that we can evaluate the relative importance of these frictions when confronting the model with empirical observations.

foreign assets in their sectoral holdings (Ha for Fa, Hb for Fb) such that $\alpha_{H,a} > \alpha_{H,b}$. This substitution explains the catch-up of sector a's home bias, as is shown in figure 4.

Figure 4: Sectoral Home Bias and Transaction Costs



Last but not least, I examine sectoral home bias under information frictions. For this examination, I first set transactions costs as a constant (1e-4) and assume sectoral information frictions are the same ($f_a = f_b = f$). Figure 5 presents the results of sectoral home bias, which share several similarities with figure 4. First, households raise their holdings of domestic assets in the presence of information frictions. Second, the increase in domestic holdings is more pronounced for the comparative advantage sector Ha. These similarities imply that much of the analysis on transaction costs can also be applied here to information frictions: If households perceive foreign assets as riskier under information asymmetry, they will replace foreign assets — especially in comparative advantage sectors — with domestic assets, even though foreign assets provide more hedging benefits. As figure 5 suggests, if information frictions are large enough, they will dominate the risk-hedging channel by tilting portfolios towards the domestic comparative advantage sector such that $\alpha_{H,a} > \alpha_{H,b}$. Therefore, households exhibit stronger home bias in comparative advantage sectors, even if there is no difference in sectoral information frictions.

As is discussed earlier, information asymmetry between domestic and foreign assets can be exacerbated in comparative advantage sectors because households have less knowledge about foreign assets in the sectors where their country is competitive. To explore this possibility, I show sectoral home bias under heterogenous information frictions. In particular, I assume the information friction in sector a is twice that in sector b ($f_a = 2f_b = 2f$). Figure 6 illustrates the result, which suggests that the greater information frictions in sector a raise H's holdings of Ha assets even further when the households perceive Fa as-

Sectoral Home Bias and Information frictions

Figure 5: Homogeneous Information Frictions

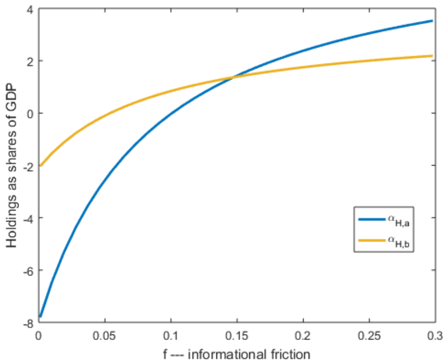
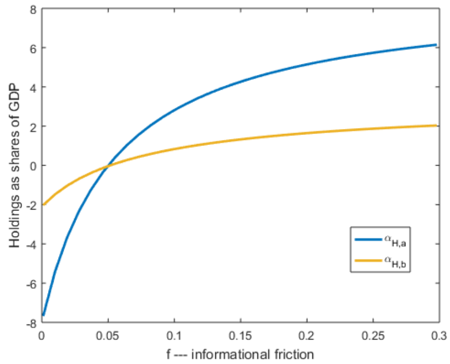


Figure 6: Heterogenous Information Frictions



sets as riskier. Therefore, the gap widens between sectoral home bias under heterogenous information frictions across sectors. This finding confirms my hypothesis that households may favor domestic assets in comparative advantage sectors to a greater extent when information asymmetry worsens in those sectors.

To summarize the model predictions, households hold fewer domestic assets in comparative advantage sectors for risk hedging. Appendix C.2 further shows that this finding is robust in an environment with endogenous capital accumulation and with bond as an additional financial asset. However, if market frictions in the form of transaction costs and information asymmetry are sufficiently large, households will exhibit stronger home bias in comparative advantage sectors. The empirical findings in the previous section suggest that market frictions potentially dominate risk-hedging motives in driving the variation of sectoral home bias. Nevertheless, the empirical analysis cannot quantify the magnitude of the frictions or the contribution of each friction to home bias. To answer such questions, quantitative analyses based on an extended model calibrated to the data are needed. Before conducting the quantitative analyses, I tackle two issues worthy of attention when the above two-country two-sector framework is extended to a richer quantitative model: First, how does the introduction of nontradable sectors change the prediction of the model. Second, how do we separately identify asset transaction costs and information frictions despite the fact that they alter sectoral home bias in a qualitatively similar manner. To answer the first question, I adapt the baseline model to the case discussed by Obstfeld and Rogoff (2000) in which consumption combines tradables and nontradables with a Cobb-Douglas function

$$C_{i,t} = C_{i,a,t}^{\psi_i} C_{i,b,t}^{1-\psi_i}, \tag{36}$$

Nontradable Sector's Home Bias

Figure 7: Under transaction costs τ

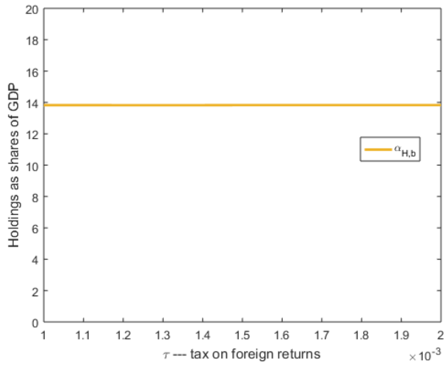
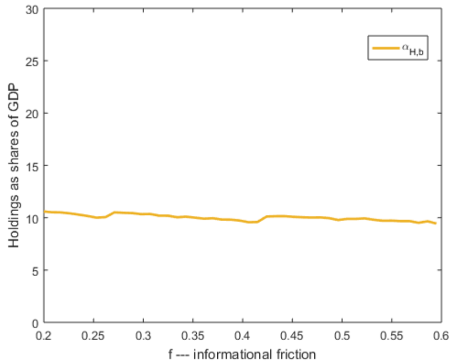


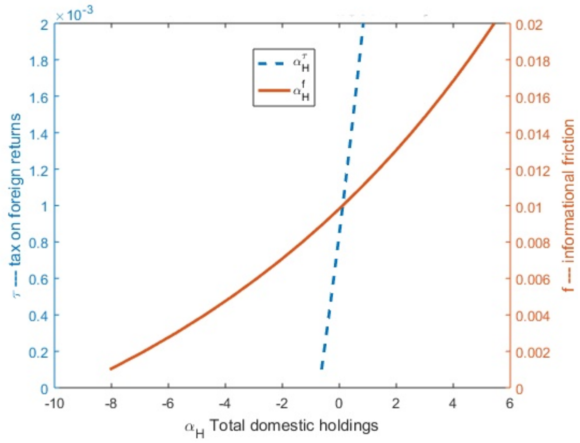
Figure 8: Under information frictions f



where $C_{i,a,t}$ and $C_{i,b,t}$ denote the consumption of tradable and nontradable goods respectively. The Cobb-Douglas specification implies that the elasticity of substitution between tradable and nontradable sectors is 1, which falls within the normal range estimated in the macro literature (see Ostry and Reinhart (1992) and Tesar and Werner (1995) among others). Under the new assumption, I re-draw figures 4-5 which plot H's holding of domestic nontradable sector's assets ($\alpha_{H,b}$) under varying degrees of financial frictions in figures 7 and 8. The pattern of $\alpha_{H,b}$ is different from the baseline case shown in figures 4-5 along two dimensions. First, H investors exhibit remarkably stronger home bias in b once it becomes a nontradable sector. This finding is consistent with the argument made by Obstfeld and Rogoff (2000) and Collard et al. (2007) that a nontradable sector's assets provide hedging benefits against real exchange rate shocks, which will tilt investors' portfolios towards domestic assets. Second, holdings in Hb barely change with transaction costs or information frictions, which implies that risk-hedging motives dominate financial frictions in driving home bias in the nontradable sector. This is because households have few incentives to hold the nontradable sector's foreign assets since those assets are not as good hedging instruments as domestic assets when the country's purchasing power fluctuates. Therefore, adding frictions to make the holding of those foreign assets more costly does not alter investors' portfolio choice in a significant way.

I now proceed to discuss the strategy of quantifying asset transaction costs and information frictions separately when they coexist in a calibrated model. Even though figures 4-6 illustrate that the two types of frictions exert qualitatively similar effects on sectoral home bias, the two frictions' quantitative effects (reflected as the slopes of the curves) are different. This property makes it possible to disentangle the two frictions in a calibrated model, if the number of frictions to be estimated from the data equals the

Figure 9: National Home Bias and Two Frictions



number of target moments. In the two-sector case above, the target moments will be two sectoral home biases and one national home bias. The unknown parameters will be two sector-level information frictions and one country-level transaction cost. In addition, I plot national home bias in figure 9 given varying values of frictions under the same assumptions as those for figures 4-5. The fact that there is a unique intersection of home bias under the two frictions alleviates the concern about the possibility of multiple solutions. Therefore, the system of equations with unknown frictions to be solved is exactly identified, which allows me to determine the values of the two frictions separately in the quantitative model.

In conclusion, this section develops a two-country two-sector framework to explain the economic mechanism and introduce the computation techniques for home bias at the sector level. In the next section, I will combine the home bias index from the empirical analysis and the theoretical framework in this section, to conduct a quantitative assessment of a calibrated model, in order to quantify the effects of various frictions.

4 Quantitative Assessment

In this section, I conduct numerical analysis with a calibrated model to quantify the frictions and explore their effects on sectoral home bias. First, I extend the symmetric two-country two-sector framework to a model with a large group of countries and sectors. After that, I calibrate the model to fit international trade and financial data. Finally, I run a set of counterfactual exercises to disentangle the impacts of frictions.

4.1 Extended Model

The setup of the extended model is modified from Hu (2020) where I examine the influence of industrial specialization on country-level home bias. I modify that model by adding financial frictions so as to match both the real side and the financial side of the economy. In the extended quantitative model, I employ the trade framework developed by Eaton and Kortum (2002) (EK hereafter). The main benefits of using the trade framework are twofold. First, the EK model introduces intra-sectoral trade with minimal parameter restrictions on households' consumption preference. More importantly, sectoral productivity which shapes comparative advantage can be calibrated with the trade data based on the EK model. Following an extensive literature that uses the model to examine the macro implications of trade patterns such as Levchenko and Zhang (2016), Caliendo and Parro (2015), and Uy et al. (2013), I extend the original EK model by incorporating both tradable and nontradable sectors.

There are I countries and $S+1$ industries in the extended model. The consumption of a representative household in country $i \in \{1, 2, ..., I\}$ is a Cobb-Douglas composite of S tradable sectors and one nontradable sector denoted as N:

$$C_{i,t} = C_{i,T,t}^{\mu_i} C_{i,N,t}^{1-\mu_i} = (\sum_{s=1}^{S} \psi_s^{\frac{1}{\phi}} C_{i,s,t}^{\frac{\phi-1}{\phi}})^{\frac{\phi}{\phi-1}\mu_i} C_{i,N,t}^{1-\mu_i}, \tag{37}$$

where μ_i stands for the weight of the tradable bundle $C_{i,T}$ in country i's consumption. Consumption of the tradable bundle is a CES composite of consumption in different tradable sectors $s \in \{1, 2, ..., S\}$. ψ_s denotes the expenditure share on sector s and ϕ denotes the elasticity of substitution between sectors within the tradable bundle.

Following the EK model, I assume there is a continuum of varieties $z \in [0, 1]$ in each sector. Households' consumption of sector s is a CES aggregate of different varieties with elasticity of substitution ϵ:

$$C_{i,s,t} = [\int_0^1 C_{i,s,t}(z)^{\frac{\epsilon-1}{\epsilon}} dz]^{\frac{\epsilon}{\epsilon-1}}. \tag{38}$$

A variety can be produced either at home or abroad and then traded across borders. At time t, country i can produce variety z in sector s with efficiency $A_{i,s,t}(z)$, which is drawn from the Fréchet distribution:

$$F_{i,s,t}(A) = \exp(-T_{i,s,t} A^{-\theta}). \tag{39}$$

$T_{i,s,t}$ captures the central tendency of sectoral productivity: the higher the $T_{i,s,t}$, the more productive country i is in sector s at time t. I add dynamics to the EK model by assuming that $T_{i,s,t}$ follows an AR(1) process subject to shocks around its steady state:[21]

$$T_{i,s,t} = \rho T_{i,s,t-1} + (1-\rho)\bar{T}_{i,s} + \epsilon_{i,s,t}. \tag{40}$$

For the tradable sectors, country i incurs iceberg trade costs $t_{i,t}$ when exporting to the rest of the world.[22] Given the trade costs, the price of variety z in sector s exported from country i to the rest of the world becomes

$$p_{i,s,t}(z) = \frac{t_{i,t}c_{i,s,t}}{A_{i,s,t}(z)}, \tag{41}$$

where production cost $c_{i,s,t}$ combines wage $w_{i,t}$ and capital rental fee $r_{i,t}$ with sectoral capital intensity α_s

$$c_{i,s,t} = r_{i,t}^{\alpha_s} w_{i,t}^{1-\alpha_s}. \tag{42}$$

As in the baseline model, labor and capital are endowments that are mobile across sectors but immobile across countries. Factor prices $r_{i,t}$ and $w_{i,t}$ are pinned down by the market-clearing conditions:

$$\sum_{k\in\{1,2,\ldots,S,N\}} l_{i,k,t} = L_{i,t}, \qquad \sum_{k\in\{1,2,\ldots,S,N\}} k_{i,k,t} = K_{i,t}. \tag{43}$$

Under the assumption of balanced trade, the aggregate consumption expenditure in country i equals the sum of endowment income:[23]

$$X_{i,t} = w_{i,t}L_{i,t} + r_{i,t}K_{i,t}. \tag{44}$$

[21]This is similar to the specification of productivity shocks in a standard DSGE model. To get the numerical solution to steady-state portfolios, I need to analyze the first-order dynamics of the economy around a deterministic steady state. The AR(1) specification makes this analysis tractable. $\bar{T}_{i,s}$ will be calculated as the average of $T_{i,s,t}$ over the sample period.

[22]Trade costs are introduced to match countries' trade patterns, without which sectoral productivity would be mis-estimated from trade data. On the theoretical front, Obstfeld and Rogoff (2000) and Coeurdacier (2009) discuss the implications of trade costs, which tilt a country's consumption bundle toward domestic goods, for asset home bias. This model provides additional determinants of trade patterns, including Ricardian productivity and factor intensity at the sector level, to examine the influence of international trade on financial allocations.

[23]The balanced-trade assumption is commonly used in the quantitative trade literature. Here it isolates the implications of risk-hedging for foreign investment which can also be driven by trade imbalances. I relax the assumption in Appendix C.3 and confirm the robustness of the quantitative results.

Aggregating the varieties in equation 41 gives sectoral price levels and trade flows based on the EK model. In particular, the share of country i's exports in the world market for sector s equals

$$\pi_{i,s} = \frac{T_{i,s}(t_i c_{i,s})^{-\theta}}{\Phi_s} \qquad where \qquad \Phi_s = \sum_i^I T_{i,s}(t_i c_{i,s})^{-\theta}. \tag{45}$$

Appendix B.1 provides the detailed derivation for all the endogenous variables on the real side of the economy.

In the equity market, there are $I \times (S+1)$ types of stocks, each representing sector $k \in \{1, 2, ..., S, N\}$ from country $i \in \{1, 2, ..., I\}$. Dividends of the assets, defined as the claims to capital income as in the theory section, will be proportional to the sectoral income earned in domestic and foreign markets denoted as $Y_{i,k,t}$

$$d_{i,k,t} = \alpha_k Y_{i,k,t}. \tag{46}$$

Ideally, a household in country i should construct a portfolio consisting of all these available stocks. However, solving the portfolio choice problem with such a large number of countries and sectors is computationally challenging.[24] For this reason, when I analyze country i's home bias, I do not distinguish specific destinations of foreign investment but group the rest of the world as a whole, so households in country i choose among $2 \times (S+1)$ assets. In other words, the model collapses to a two-country framework from each country's perspective: country i sees itself as home and the rest of the world as foreign. Given this specification, the remaining financial side of the extended model is set up in a similar manner to the two-country model in the theory section. Appendix B.1 provides the details about the modeling assumptions and solution techniques in the extended model.

The calibration strategy for the real side of the economy is similar to that used in Hu (2020) and outlined in Appendix B.2. In particular, sector-level productivity and country-level trade costs in country i are estimated to match (1) the country's share of all the countries' exports in sector s and (2) the country's overall export-to-output ratio. On the financial side of the economy, I calibrate information frictions and transaction costs to match the data for both sector- and country-level home bias of the countries whose

[24]Given the sparsity of bilateral trade data at the sector level, the large matrix that covers the bilateral ties for all the countries and sectors is badly scaled. Using this matrix to derive countries' portfolio choice with the perturbation method yields inaccurate results.

financial data are available in the Factset/Lionshare database. The financial frictions are exactly identified since the number of targets equals the number of unknowns.[25] Based on this calibration strategy, it seems that financial frictions are hard-wired to explain home bias. However, risk-hedging motives are also endogenously embedded in the portfolio choice problem when the real side of the economy is calibrated to match countries' industrial structure including the size of nontradable sectors and comparative advantage of tradable sectors. Therefore, the estimated financial frictions only account for the part of home bias that remains unexplained by investors' incentives to hedge risks. If the incentives are strong and sufficient enough to explain the data, financial frictions are expected to play a limited role in contributing to home bias.

In addition to this baseline model, I consider two extensions by incorporating 1) global trade imbalances and 2) intermediate inputs and input-output linkages. In particular, I re-calibrate and solve the model to 1) match the trade surplus/deficit data from the World Bank and 2) reflect sectoral input-output linkages based on the parametrization from Di Giovanni et al. (2014). Appendix C.3 reports the quantitative results, which are consistent with those in the baseline model.

Besides the model description presented in this section, Appendix B provides more details of the quantitative model: Section B.1 discusses the determination of endogenous variables and equilibrium conditions in the model. Section B.2 outlines the calibration and algorithm used to obtain numerical solutions.

4.2 Numerical Results

In this section, I present numerical results from the extended model. First, I assess the performance of the model by comparing its predictions to the empirical findings. In the next step, I evaluate and discuss the degree of financial frictions implied by the model. After that, I conduct a set of counterfactual analyses to quantify the effects of each friction on home bias.

To test the fit of the model, I examine whether the quantitative framework replicates the comovement between home bias and factors relevant for risk hedging (including

[25]For each country i, the unknown parameters include 1) $S+1$ information frictions (for S tradable and one nontradable sector) and 2) one country-level asset transaction cost. The targets include $S+1$ sectoral home bias and one national home bias. Note when matching the nontradable sector's home bias, I group the nontradable industries in table A.2 into one nontradable sector, whose sectoral home bias is the weighted average home bias for the country's nontradable industries observed in the data. The two-country two-sector example at the end of the theory section discusses how the two types of frictions are separately identified to match the targets.

sectoral tradability and revealed comparative advantage (RCA)) from the empirical section. Since these risk-hedging factors are not target moments of financial frictions, the relationship between these two factors and home bias predicted by the model serves as a benchmark to evaluate model performance. As the quantitative model examines portfolio choice in the steady state of the economy, I obtain its empirical counterpart by calculating time-averaged home bias and then explore its relation with a dummy for tradable sectors and sectoral RCA. Table 4 presents and compares the findings. Based on the data, tradable sectors show .078 (0.212 standard deviations) lower home bias than nontradable sectors,[26] which is close to the result from the quantitative model that tradables sectors' home bias is 0.082 (0.221 standard deviations) weaker. Moreover, the data and model yield similar predictions about the influence of RCA: A one-standard-deviation increase in RCA is associated with about a 0.08-standard-deviation increase in sectoral home bias. Therefore, the model fits the data well by replicating these key empirical findings. The result that home bias increases with RCA implies that the magnitude of the estimated frictions is sufficiently large, so that financial frictions dominate risk hedging to generate stronger home bias in comparative advantage sectors. This is consistent with the theoretical prediction from figures 4-6 when financial frictions fall in a high range.

Table 4: Test of Model Fit

	HB and Tradability		HB and RCA	
	Data	Model	Data	Model
Dep. Var: Sectoral HB	(1)	(2)	(3)	(4)
Tradable dummy	-0.078 ***	-0.082 ***		
	(0.021)	(0.022)		
	[-0.212]	[-0.221]		
RCA			0.019 **	0.011 ***
			(0.008)	(0.005)
			[0.082]	[0.078]
Country FE	Y	Y	Y	Y
Sector FE	N	N	Y	Y
Observations	462	462	419	419
R^2	0.654	0.652	0.676	0.675

This table compares the relationship between sectoral home bias and factors relevant for risk hedging in the data and quantitative model. Robust standard errors in parentheses, standardized coefficients in brackets.***significant at 1% and ** significant at 5%. The dependent variable is sectoral home bias. The independent variables include a dummy for tradable sectors and revealed comparative advantage (RCA).

After confirming the model fit, I proceed to discuss model-implied financial frictions.

[26]The nontradable industries in table A.2 are grouped into one nontradable sector for comparison here, therefore the estimates are different from those in the empirical section.

Histogram of Estimated Frictions

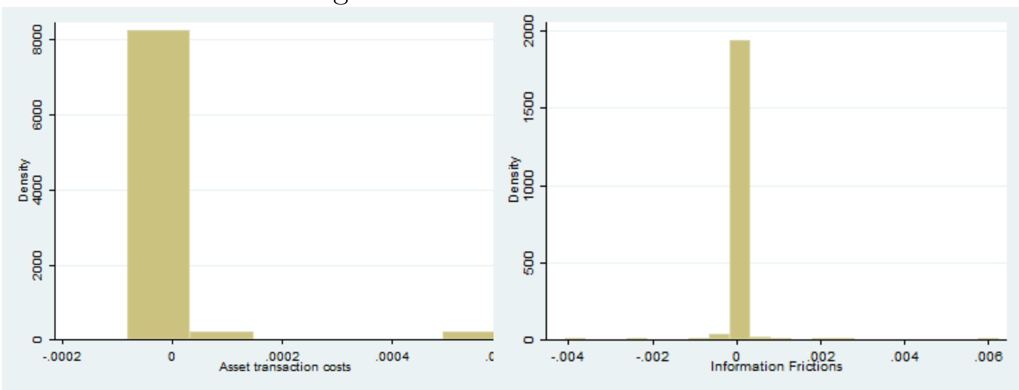


Figure 10: Asset transaction costs $\hat{\tau}_i$ Figure 11: Information frictions $\hat{f}_{i,s}$

For each country i, its households face transaction costs τ_i and sectoral information frictions $f_{i,s}$ when investing abroad, whose values are estimated to match the country's sectoral as well as national home bias. Table 5 presents the summary statistics of these financial frictions estimated from the calibrated model and figures 10-11 show the distribution of the frictions.[27] Due to the perturbation method used to derive portfolios, a small change in the frictions can shift asset positions drastically. Therefore, the magnitude of the estimates is small. Moreover, I don't impose restrictions on the sign of the frictions when conducting the estimation. A positive (negative) estimate implies that the friction under examination tilts portfolios towards home (foreign) assets.

Table 5: Summary statistics of the estimated financial frictions

	Mean	Std. Dev.	Min	Max
$\hat{\tau}_i$	8.2e-6	9.8e-5	-8.2e-5	6.1e-4
$\hat{f}_{i,s}$	1.3e-5	4.3e-4	-4.1e-3	6.3e-3

$\hat{\tau}_i$ is estimated country-level transaction costs modeled as taxes on foreign returns. $\hat{f}_{i,s}$ denotes estimated information frictions modeled as higher perceived variances for foreign sectoral productivity shocks.

To verify that the estimated frictions are reasonable, I examine whether asset transaction costs predicted by the model line up with empirical observations. As is reported in table 5, the estimated asset transaction costs have a mean of 8.2e-6 and standard deviation of 9.8e-5. Table A.4 lists the costs by country, which shows that the value ranges from -8.2e-5 (Belgium) to 6.1e-4 (Russia) in the sample. Most OECD countries' values

[27]The estimation of information frictions requires the variance-covariance matrix of sectoral productivity shocks. See step 6 of the computation algorithm in section B.2 for its estimation strategies.

are at the low end of the spectrum, while countries including Russia, China, South Africa, Malaysia, and Romania are among the countries whose transaction costs are the highest. When I explore the bivariate relationship between the estimated transaction costs with the Chinn-Ito index averaged over the sample period

$$\text{Chinn-Ito}_i = \alpha_0 + \alpha_1 \hat{\tau}_i + \epsilon_i, \tag{47}$$

I find that a 1 standard-deviation increase in transaction costs is associated with a 0.3 standard-deviation decrease in financial account openness measured by the Chinn-Ito index. The negative correlation between the two variables is significant at the 1% level. This finding suggests that the model performs well in predicting that investors from countries with a lower degree of financial account openness face greater transaction barriers when holding foreign assets. Another angle to evaluate the estimated frictions is to see whether they predict asset market incompleteness in the data. When there is no financial friction, asset markets are locally complete since the number of shocks equals the number of assets in the model, so that the spanning and rank conditions are satisfied (Coeurdacier and Gourinchas (2016)). Therefore, consumption allocation should satisfy the Backus-Smith condition:

$$(\frac{C_{i,t}}{C^*_{i,t}})^{-\sigma} = \lambda_i (\text{RER}_{i,t})^{-1}. \tag{48}$$

Real exchange rate (RER) is the product of nominal exchange rate (NER) and price ratio

$$\text{RER}_{i,t} = \text{NER}_{i,t} \frac{P^*_{i,t}}{P_{i,t}}. \tag{49}$$

λ_i in equation 48 is constant when markets are complete. Under this condition, the correlation between the growth rate of relative consumption growth

$$\Delta \log C = (\log C_{i,t+1} - \log C^*_{i,t+1}) - (\log C_{i,t} - \log C^*_{i,t}). \tag{50}$$

and the growth rate of RER should equal 1. Therefore, the deviation of the correlation, denoted as $\rho(\Delta \log C, \Delta \log \text{RER})$, from 1 reflects asset market incompleteness. I regress this deviation from complete markets, using the consumption and RER data from the Penn World Table, on the estimated asset transaction costs

$$\text{Deviation from Backus-Smith}_i = \alpha_0 + \alpha_1 \hat{\tau}_i + \epsilon_i, \tag{51}$$

and find that a 1 standard-deviation increase in transaction costs is associated with a 0.5 standard-deviation increase in asset market incompleteness. This finding provides validity for the estimated frictions as barriers to international risk sharing.

In terms of sectoral information frictions, the summary statistics from table 5 suggest that the mean value of the estimates in the sample is 1.3e-5 and the standard deviation is 4.3e-4. The estimates range from -4.1e-3 (representing the oil and coal industry of Ireland) to 6.3e-3 (representing the pharmaceutical industry of the U.A.E.). When comparing sectoral estimates averaged across countries (table A.4), I find that information frictions are the lowest in the oil and coal industry, and the highest in the pharmaceutical industry. This finding is consistent with the general expectation about the availability of information from these industries: commodities are largely homogeneous across countries and therefore not subject to substantial information asymmetry, while the pharmaceutical industry protects intellectual property which makes information less accessible for foreign investors. This cross-sector comparison is useful to examine whether the estimated information frictions are reasonable.

In the next step I test a hypothesis proposed in the empirical section: greater information frictions exist in sectors where countries exhibit stronger comparative advantage. This sectoral variation in information frictions further strengthens home bias in comparative advantage sectors relative to in comparative disadvantage sectors, which matters for the covariance between sectoral home bias and RCA. To test this hypothesis, I regress the estimated information frictions ($\hat{f_{i,s}}$) on revealed comparative advantage predicted by the model when controlling for country and sector fixed effects:

$$\hat{f_{i,s}} = \beta_0 + \beta_1 \log(RCA_{i,s}) + \beta_{2i} X_i + \beta_{3s} X_s + \epsilon_{i,s}. \tag{52}$$

The coefficient estimates reported in table 6 suggest that when RCA increases by 1%, information frictions increase by 0.03 standard deviations. The positive comovement is significant at the 10 percent level. This finding confirms the hypothesis that investors are subject to greater information frictions when holding foreign assets in the sectors where their countries reveal a comparative advantage. Therefore, information frictions can potentially explain the finding in the empirical section that sectoral home bias is stronger in comparative advantage sectors.

After discussing the magnitude of financial frictions, I proceed to quantify their impacts on investors' portfolio choice. In order to disentangle the contribution of financial frictions to sectoral home bias, I conduct a series of counterfactual analyses in which I set

Table 6: Predictions about Information Frictions

Dep. Var : $\hat{f}_{i,s}$	(1)	(2)
log(RCA)	1.29E-05 *	1.32E-05 *
	(7.68E-06)	(7.70E-06)
	[3.00E-02]	[3.00E-02]
Country FE	Yes	Yes
Sector FE	No	Yes
Observations	419	419
R^2	2.81E-01	3.02E-01

Robust standard errors in parentheses, standardized coefficients in brackets. * significant at 10%.

one friction to zero sequentially and examine how sectoral home bias responds.[28] Table 7 presents the median sectoral home bias across countries and sectors predicted by the quantitative model under various circumstances. Among the tradable sectors ($HB_{i,s}$), column (1) reports that the original sectoral home bias calibrated to the data has a median value of 0.267. In column (2) where I set asset transaction costs to zero, the median home bias decreases to 0.064. Based on these values, asset transaction costs account for $\frac{0.267-0.064}{0.267} = 76\%$ sectoral home bias. Similarly, in column (3) where I shut down information frictions, sectoral home bias declines to 0.237. Therefore, $\frac{0.267-0.237}{0.267} = 11.2\%$ sectoral home bias can potentially be explained by information asymmetry. From this perspective, asset transaction costs are nearly as seven times important as information frictions in explaining investors' portfolio choice in tradable sectors. For the non-tradable sector ($HB_{i,N}$), its median home bias does not change when there is no financial friction, consistent with figures 7 and 8 from the theory section. Home bias in the nontradable sector is driven by risk-hedging motives, thus eliminating financial frictions will not alter asset positions significantly.

Table 7 also reports the country-level home bias predicted by the quantitative model. In columns (2) and (3) where I turn off the two frictions, the median national home bias drops from 0.438 in the original case to 0.418 and 0.419 respectively. This finding suggests that the effects of the two frictions on country-level portfolio diversification are comparable in magnitude, with each friction explaining 5% national home bias. Nevertheless, these changes in national home bias are significantly smaller than those in sectoral home bias in the tradable sector when frictions are shut down. This is largely due to the great

[28] In particular, I focus on the cases without financial frictions. It is very challenging to completely shut down risk-hedging factors shaped by countries' industrial structure, which should involve turning all the nontradable into tradable sectors, and assuming the same sectoral productivity (either within a country or across countries). The resulting outcome will deviate too significantly from the calibrated model, making the counterfactual results difficult to interpret.

Table 7: Predicted Home Bias in Counterfactual Analysis

	Original home bias (1)	No transaction costs (2)	No information frictions (3)
$H\bar{B}_{i,s}$	0.267	0.064	0.237
$H\bar{B}_{i,N}$	0.442	0.442	0.442
$H\bar{B}_i$	0.438	0.418	0.419

This table reports the median sectoral home bias across tradable sectors $H\bar{B}_{i,s}$, nontradable sectors $H\bar{B}_{i,N}$, and median national home bias $H\bar{B}_i$ across countries predicted by the quantitative model. Column (1) reports the original home bias calibrated to the data. Column (2)-(3) report the home bias in counterfactual situations where financial frictions are set to zero.

weight of nontradable sectors' assets in portfolios (51%) averaged across countries in the sample, and the fact that home bias in the nontradable sector does not vary with financial frictions. This finding that nontradable sectors contribute to portfolio non-diversification corroborates the theory proposed by Stockman and Dellas (1989) and Obstfeld and Rogoff (2000) that investors may skew their portfolio towards domestic assets, especially domestic nontradable sectors' assets, to hedge against the fluctuation in real exchange rates. Therefore, risk-hedging motives remain a major explanation for home bias at the country level.

5 Conclusion

This paper contributes to the literature on the well-known home bias puzzle in international finance by adding a sectoral dimension. First, I compile the sector-level home bias of a large group of countries and sectors using financial datasets. This novel index provides detailed information for studying the patterns and determinants of home bias. Second, I develop a two-country two-sector model to explain the impact of multiple frictions on equity home bias. This theoretical model, different from most existing papers on the topic that abstract from sectoral heterogeneity, extends and deepens our understanding of investors' portfolio choice. Lastly, I take the theory to the data by conducting a quantitative assessment of a calibrated multi-sector DSGE model. The numerical exercise quantifies the magnitude of frictions and disentangles their contribution to the home bias puzzle.

The framework in this paper can be extended in several directions for future research. First, we can introduce corporate debt into the model to investigate the complementarity as well as substitutability between debt and equity. Coeurdacier and Gourinchas (2016) discuss the differences between debt and equity for risk-hedging purposes at the country level, but there is little research at the sector level with corporate instead of government debt. Second, this paper considers comparative advantage in a Ricardian framework, and conducts numerical exercises to quantify the importance of sectoral productivity. Nevertheless, there exist alternative sources of comparative advantage including factor endowment (à la Heckscher-Ohlin), firms' entry and exit (à la Melitz), and macroeconomic policy (see Bergin and Corsetti (2020)). Therefore, it is important to consider these additional sources and examine their relevance in future research. Third, this paper focuses on the effect of industrial structure on portfolio choice, while it is also meaningful to examine the impact of asset allocations on the real side of the economy. When there exist financial constraints such as those introduced by Manova (2013), sectors less subject to market frictions are better positioned to accumulate growth. Therefore, the pattern of home bias has a feedback effect on countries' long-run industrial structure. Current data are not sufficient to conduct the analysis yet since studying this channel requires long-term portfolio data given that industrial restructuring is a gradual and prolonged process, so I defer it to future research. By including these extensions, such papers will provide us with a better understanding of the determinants and impacts of global financial allocation.

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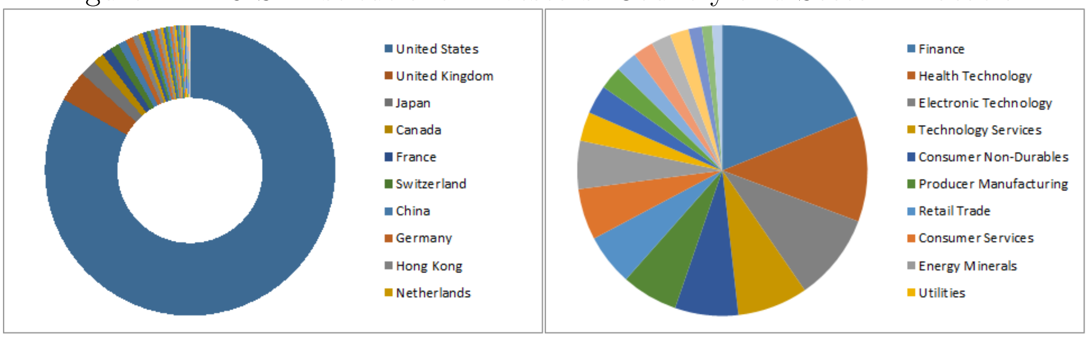
Appendices

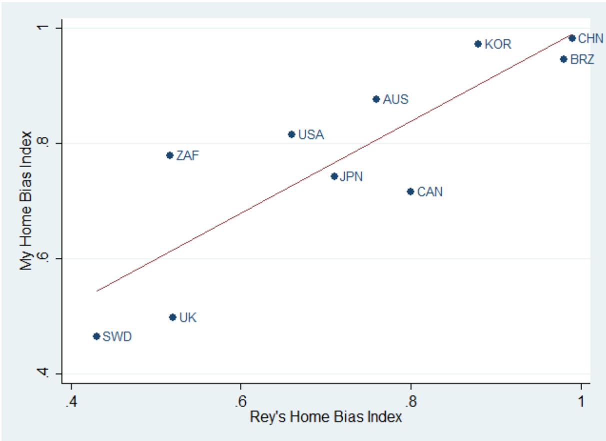
A Tables and Figures

Figure A.1: U.S. Institutional Investors' Country and Sector Allocation



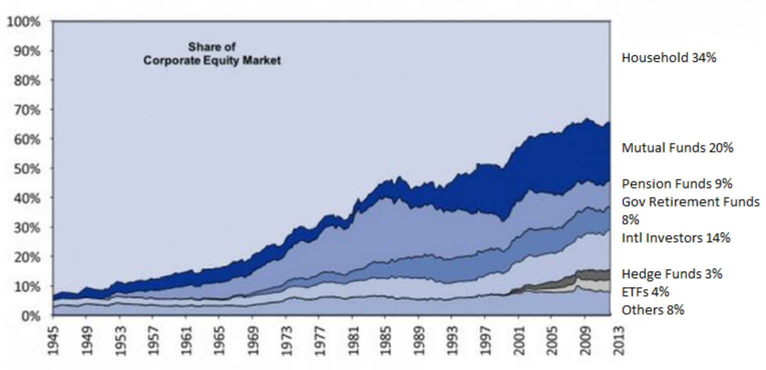
Note: This figure shows U.S. institutional investors' equity portfolio on Jan. 5, 2015. The source is the ownership data from Factset/Lionshare. The left chart is the allocation across countries, and the right chart is the allocation across sectors.

Figure A.2: Comparison of Home Bias Constructed with Factset/Lionshare and IFS Data



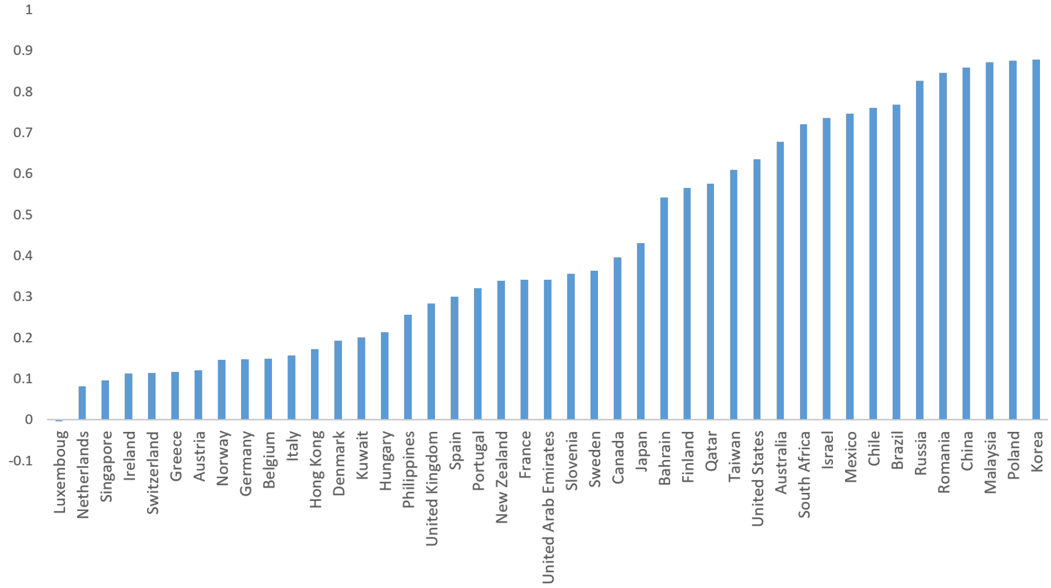
Note: This figure plots the country-level home bias constructed with the Factset/Lionshare data against Coeurdacier and Rey (2013)'s constructed with the IFS and FIBV data (both as of 2008). They only have 10 countries in the sample due to limited coverage of the macro datasets. My using of financial datasets is able to expand the sample size considerably. Among the overlapping countries in our samples, the two indices are consistent since most of the points lie on or close to the 45-degree line.

Figure A.3: Ownership in the U.S. Corporate Equity Market



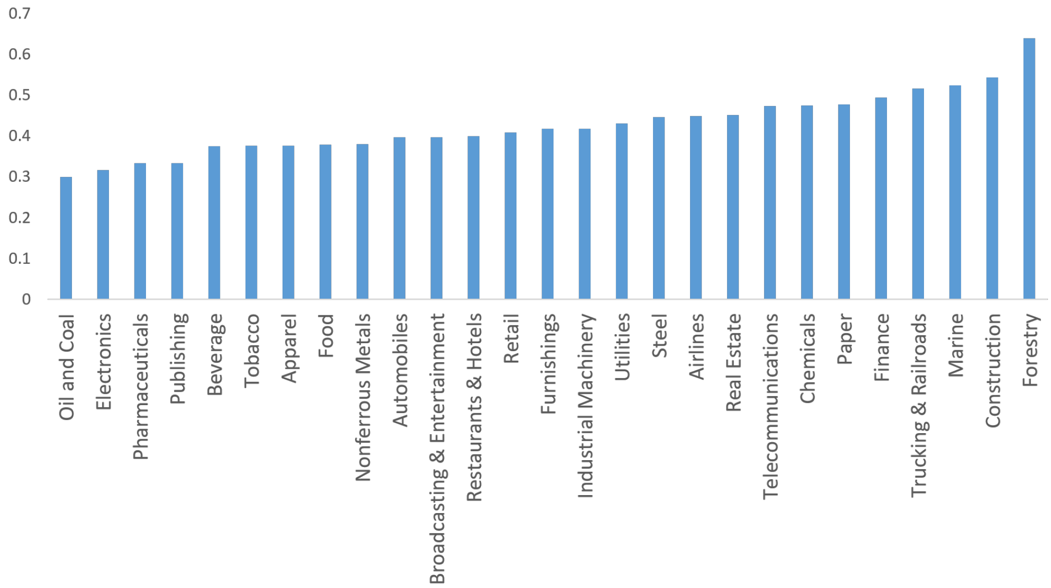
Note: This figure shows the historical trend for ownership in the US equity market since WWII. The data source is Federal Reserve Board St. Louis. The figure shows that institutional investors have replaced households as the largest owners of U.S. equities.

Figure A.4: Average Sectoral Home Bias by Country



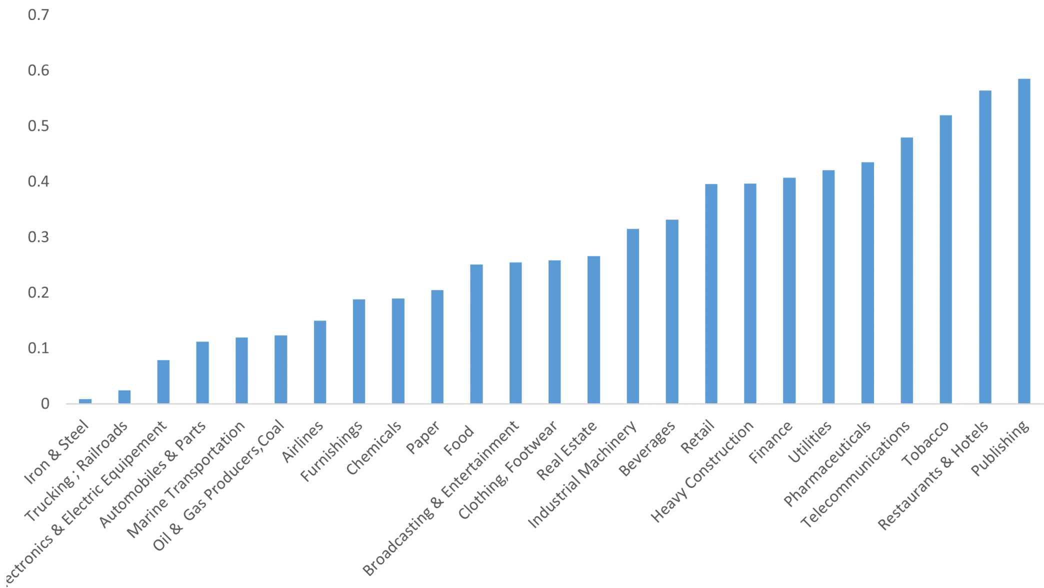
Note: This chart lists the time-averaged sectoral home bias index by country averaged across sectors.

Figure A.5: Average Sectoral Home Bias by Sector



Note: This chart lists the time-averaged sectoral home bias index by sector averaged across countries.

Figure A.6: U.K. Home Bias by Sector



Note: This chart lists the U.K. sectoral home bias index averaged over time.

Table A.1: 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, which is adopted by Datastream. FactSet reports its own industry and sector classifications.

Table A.2: Country and Sector Codes

Country/Region	Code	Country/Region	Code	Sector	Code
Australia	AU	Norway	NW	Food Producers	1
Austria	OE	Philippines	PH	Beverages	2
Bahrain	BA	Poland	PO	Tobacco	3
Belgium	BG	Portugal	PT	Clothing & Accessories, Footwear	4
Brazil	BR	Qatar	QA	Forestry	5
Canada	CN	Romania	RM	Paper	6
Chile	CL	Russia	RS	Oil & Gas Producers,Coal	7
China	CA	Singapore	SG	Chemicals	8
Czech Republic	CZ	South Africa	SA	Pharmaceuticals	9
Denmark	DK	Slovenia	SL	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
New Zealand	NZ			Finance	27

Note: This table lists the name and code of countries and sectors in the sample.

Table A.3: Correspondence between the Sector Code and ISIC 4

Industry Name	Sector 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 & Electrical Equipment	12	3110, 3190, 3210
Industrial Machinery	13	291, 292
Automobiles & Parts	14	3410, 3420, 3430
Furnishings	15	3610

Note: The sector code is based on the industries that appear in the financial datasets (see A.2). ISIC Rev.4. stands for International Standard Industrial Classification of All Economic Activities, Rev.4. I list all the ISIC sectors that correspond to the industries in the financial datasets.

Table A.4: Estimated Frictions by Country and Sector

Country	$\hat{\tau}_i$	Country	$\hat{\tau}_i$	Sector	$\bar{f_{i,s}}$
Australia	3.07E-05	Malaysia	1.05E-05	1	1.02E-04
Austria	-8.66E-06	Mexico	-6.78E-07	2	2.20E-05
Bahrain	3.24E-06	Netherlands	-3.93E-06	3	-1.74E-05
Belgium	-8.20E-05	New Zealand	8.11E-06	4	-1.89E-05
Brazil	2.25E-05	Norway	-9.89E-06	5	1.00E-07
Canada	-8.06E-06	Philippines	4.49E-06	6	-4.26E-06
Chile	5.86E-08	Poland	1.03E-05	7	-1.25E-04
China	8.00E-06	Portugal	-2.01E-05	8	-5.44E-05
Hong Kong	-1.08E-05	Korea	3.64E-06	9	1.73E-04
Czech	-1.16E-05	Romania	5.19E-05	10	-1.36E-05
Denmark	-8.16E-06	Russia	6.10E-04	11	1.33E-04
Finland	-5.71E-06	Singapore	-2.35E-05	12	-2.12E-05
France	3.90E-06	Slovenia	7.78E-06	13	-1.22E-05
Germany	-5.30E-06	South Africa	9.73E-06	14	4.68E-06
Greece	1.88E-07	Spain	-1.59E-05	15	-1.23E-06
Hungary	-2.23E-05	Sweden	-3.94E-05		
Ireland	-3.21E-05	Switzerland	-1.80E-05		
Israel	-9.99E-07	United States	9.52E-06		
Japan	-3.67E-06	U.A.E.	1.69E-06		
Kuwait	-7.30E-05	United Kingdom	-1.94E-05		
Luxemboug	-2.74E-05				

Note: This table lists the estimated financial frictions in the quantitative analysis by country and sector. $\hat{\tau}_i$ denotes country-level asset transaction costs, and $\bar{f_{i,s}}$ denotes sectoral information frictions averaged across countries in the sample. See table A.2 for the code of sectors.

B Details on the Quantitative Model

In this part, I provide more details of the quantitative model: Section B.1 outlines how the equilibrium values of the endogenous variables are computed. Section B.2 discusses the calibration strategies and algorithm used to obtain numerical solutions to the model.

B.1 Model

I first describe the real side of the model. In this part, since the trade framework is relatively 'static' by nature, I omit the time subscript of the variables for brevity. A nice feature of the EK model is that prices and quantities in the goods market are endogenously determined by productivity and trade costs analytically. Given the price in equation 41, the share of country i's exports in the world market for sector s equals the probability that the price of i's goods is the lowest:

$$\pi_{i,s} = \frac{T_{i,s}(t_i c_{i,s})^{-\theta}}{\Phi_s} \quad where \quad \Phi_s = \sum_i^I T_{i,s}(t_i c_{i,s})^{-\theta}. \tag{B.1}$$

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

$$P_{i,s} = [\Gamma(\frac{\theta+1-\epsilon}{\theta})]^{\frac{1}{1-\epsilon}} \Phi_{i,s}^{-\frac{1}{\theta}} \quad where \quad \Phi_{i,s} = \Phi_s - T_{i,s}(t_i^{-\theta} - 1)c_{i,s}^{-\theta}. \tag{B.2}$$

The price of the nontradable sector $P_{i,N}$ is obtained in a similar way when trade costs are assumed to be sufficiently large

$$P_{i,N} = \Gamma(\frac{\theta+1-\epsilon}{\theta})]^{\frac{1}{1-\epsilon}} T_{i,N}^{-\frac{1}{\theta}} c_{i,N} \tag{B.3}$$

Let X_i denote country i's aggregate consumption expenditure, then its expenditure in the nontradable sector becomes

$$X_{i,N} = (1-\mu_i)X_i = (1-\mu_i)(w_i L_i + r_i K_i). \tag{B.4}$$

Similarly, sectoral expenditure in the tradable sectors are determined by consumers' optimality conditions

$$X_{i,s} = \mu_i \psi_s (\frac{P_{i,s}}{P_i})^{1-\phi} X_i, \tag{B.5}$$

where the price of the tradable bundle and aggregate price level in country i are

$$P_{i,T}^{1-\phi} = \sum_{s=1}^{S} \psi_s P_{i,s}^{1-\phi}, \qquad P_i = \mu_i^{-\mu_i}(1-\mu_i)^{\mu_i - 1} P_{i,T}^{\mu_i} P_{i,N}^{1-\mu_i}. \tag{B.6}$$

Sectoral income $Y_{i,s}$ is therefore determined by the goods market clearing conditions:

$$Y_{i,s} = \frac{T_{i,s}(c_{i,s})^{-\theta}}{\Phi_{i,s}} X_{i,s} + \pi_{i,s} \sum_{j \neq i}^{I} X_{j,s}, \qquad Y_{i,N} = X_{i,N}. \tag{B.7}$$

Therefore, the country-level export-to-output ratio is given by

$$E2Y_i = \frac{\sum_{s=1}^{S} (\pi_{i,s} \sum_{j \neq i}^{I} X_{j,s})}{Y_{i,N} + \sum_{s=1}^{S} Y_{i,s}}. \tag{B.8}$$

Based on sectoral factor intensity, sectoral factor allocations should satisfy

$$l_{i,s} = (1-\alpha_s)\frac{Y_{i,s}}{w_i}, \qquad k_{i,s} = \alpha_s \frac{Y_{i,s}}{r_i}, \tag{B.9}$$

$$l_{i,N} = (1-\alpha_N)\frac{Y_{i,N}}{w_i}, \qquad k_{i,N} = \alpha_N \frac{Y_{i,N}}{r_i}, \tag{B.10}$$

which in the equilibrium should clear the factor markets:

$$\sum_{k \in \{1,2,...,S,N\}} l_{i,k} = L_i, \qquad \sum_{k \in \{1,2,...,S,N\}} k_{i,k} = K_i. \tag{B.11}$$

Besides these 'domestic' variables of country i, 'foreign' variables (marked with asterisks below) that represent the rest of the world from i's perspective also need to determined. The foreign cost of production in sector $k \in \{1, 2, ..., S, N\}$

$$c_{i,k}^{*} = r_i^{*\alpha_k} w_i^{*1-\alpha_k} \tag{B.12}$$

is determined by foreign factor prices approximated as

$$r_i^{*} = \frac{\sum_{j \neq i}^{I} r_j K_j}{\sum_{j \neq i}^{I} K_j}, \qquad w_i^{*} = \frac{\sum_{j \neq i}^{I} w_j L_j}{\sum_{j \neq i}^{I} L_j}. \tag{B.13}$$

This approximation ensures that the total factor income added across countries matches the data.

Given the production cost, foreign sectoral productivity in a tradable sector s is calibrated to match country i's trade flows with the rest of the world solved earlier. Therefore, it is recovered from

$$\Phi_{i,s} = T_{i,s} c_{i,s}^{-\theta} + T_{i,s}^* c_{i,s}^{*-\theta}. \tag{B.14}$$

This productivity $T_{i,s}^*$ is then used to calculate the foreign sectoral income

$$Y_{i,s}^* = c_{i,s}^{*-\theta} T_{i,s}^* \sum_{j \neq i}^{I} \frac{X_{j,s}}{\Phi_{j,s}}, \tag{B.15}$$

which determines sectoral factor allocations

$$l_{i,s}^* = (1-\alpha_s)\frac{Y_{i,s}^*}{w_i^*}, \qquad k_{i,s}^* = \alpha_s \frac{Y_{i,s}^*}{r_i^*}. \tag{B.16}$$

Moreover, sectoral productivity also helps to pin down the price at the sector level

$$P_{i,s}^* = [\Gamma(\frac{\theta+1-\epsilon}{\theta})]^{\frac{1}{1-\epsilon}} (T_{i,s}(t_i c_{i,s})^{-\theta} + T_{i,s}^* c_{i,s}^{*-\theta})^{-\frac{1}{\theta}}, \tag{B.17}$$

which in turn determines the price of the tradable bundle:

$$P_{i,T}^{*1-\phi} = \sum_{s=1}^{S} \psi_s P_{i,s}^{*1-\phi}. \tag{B.18}$$

Similarly, the quantity of consumption in the tradable bundle is given by

$$C_{i,T}^{*\frac{\phi-1}{\phi}} = \sum_{s=1}^{S} \psi_s^{\frac{1}{\phi}} (C_{i,s}^*)^{\frac{\phi-1}{\phi}} = \sum_{s=1}^{S} \psi_s^{\frac{1}{\phi}} (\frac{\sum_{j\neq i}^{I} X_{j,s}}{P_{i,s}^*})^{\frac{\phi-1}{\phi}}. \tag{B.19}$$

Next I assume the foreign consumption weight on tradables is calculated with the total consumption from all the other countries

$$\mu_i^* = \frac{\sum_{j\neq i}^{I}(\mu_j X_j)}{\sum_{j\neq i}^{I} X_j}. \tag{B.20}$$

This assumption ensures that the world share of expenditure on tradable sectors matches the data. Under this assumption, the aggregate foreign expenditure is given by

$$X_i^* = \frac{1}{\mu_i^*} P_{i,T}^* C_{i,T}^*, \tag{B.21}$$

which yields the foreign expenditure on nontradables:

$$X_{i,N}^* = (1 - \mu_i^*) X_i^*. \tag{B.22}$$

This in turn pins down the foreign factor employments in the production of the nontradable sector

$$l_{i,N}^* = (1 - \alpha_N) \frac{X_{i,N}^*}{w_i^*}, \qquad k_{i,N}^* = \alpha_N \frac{X_{i,N}^*}{r_i^*}. \tag{B.23}$$

Given the Cobb-Douglas production function, foreign productivity in the nontradable sector is

$$T_{i,N}^* = \alpha_N^{-\alpha_N} (1 - \alpha_N)^{\alpha_N - 1} \frac{X_{i,N}^*}{k_{i,N}^{*\alpha_N} l_{i,N}^{*1-\alpha_N}}. \tag{B.24}$$

based on which sectoral productivity can be solved

$$P_{i,N}^* = \Gamma(\frac{\theta + 1 - \epsilon}{\theta})]^{\frac{1}{1-\epsilon}} T_{i,N}^{*-\frac{1}{\theta}} c_{i,N}^*. \tag{B.25}$$

This price and the price of tradables jointly determine the foreign aggregate price level

$$P_i^* = \mu_i^{*-\mu_i^*} (1 - \mu_i^*)^{\mu_i^* - 1} P_{i,T}^{*\mu_i^*} P_{i,N}^{*1-\mu_i^*}. \tag{B.26}$$

Last but not least, the market clearing conditions determine the foreign factor endowments as

$$\sum_{k \in \{1,2,\ldots,S,N\}} l_{i,k}^* = L_i^*, \qquad \sum_{k \in \{1,2,\ldots,S,N\}} k_{i,k}^* = K_i^*. \tag{B.27}$$

So far, I have described how domestic and foreign variables on the real side of the economy are endogenously determined in the model. When I collapse the original multi-country to a two-country model, I impose mild assumptions to make sure that the foreign variables will be calibrated to keep country i's trade flows with the world consistent with the data. Moreover, the world aggregate factor income and expenditure patterns will also match what we observe in the real world.

On the financial side of the economy, the model setup and solution strategy are similar to those in the theory section. Here I assume there are two countries from each country i's perspective, either home or foreign which represents the rest of the world (whose variables are asterisked). Given this two-country specification, households in country i construct the optimal portfolio to maximize their expected lifetime utility subject to the budget constraint

$$\begin{aligned} X_{i,t} &+ \sum_{k \in \{1,2,\ldots,S,N\}} [q_{i,k,t}(\nu_{i,k,t+1} - \nu_{i,k,t}) + q^*_{i,k,t}(\nu^*_{i,k,t+1} - \nu^*_{i,k,t})] \\ &= w_{i,t}L_{i,t} + \sum_{k \in \{1,2,\ldots,S,N\}} (d_{i,k,t}\nu_{i,k,t} + d^*_{i,k,t}\nu^*_{i,k,t}). \end{aligned} \tag{B.28}$$

$X_{i,t}$ is the total consumption expenditure in country i. $\nu_{i,k,t}$ ($\nu^*_{i,k,t}$) denotes the number of domestic (foreign) shares country i holds of sector k at time t. $q_{i,k,t}$ ($q^*_{i,k,t}$) represents domestic (foreign) asset prices. Together with domestic (foreign) dividends $d_{i,k,t}$ ($d^*_{i,k,t}$), they define the sectoral financial return

$$R_{i,k,t} = \frac{q_{i,k,t} + d_{i,k,t}}{q_{i,k,t-1}}, \qquad R^*_{i,k,t} = \frac{q^*_{i,k,t} + d^*_{i,k,t}}{q^*_{i,k,t-1}}. \tag{B.29}$$

As in the theory section, there are two financial frictions in the form of transaction costs (denoted as τ_i) and information asymmetry (denoted as $f_{i,k}$). Therefore, households in country i collect $e^{-\tau_i} R^*_{i,k,t+1}$ from foreign investment, and form the perceived variance-covariance matrix of foreign sectoral productivity shocks as the sum of the matrix of the shocks itself Σ_i and a diagonal matrix containing the information frictions

$$\tilde{\Sigma}_i = \Sigma_i + \begin{bmatrix} 0 & \cdots & & & & \cdots & 0 \\ \vdots & \ddots & & & & & \vdots \\ & & & & & & \\ & & f_{i,1} & 0 & & \cdots & 0 \\ & & 0 & f_{i,2} & & & \\ & & \vdots & & \ddots & & \vdots \\ \vdots & & & & & f_{i,S} & 0 \\ 0 & \cdots & 0 & \cdots & & 0 & f_{i,N} \end{bmatrix}. \tag{B.30}$$

where the ordering of sectoral asset returns is $R_{i,1}, ..., R_{i,S}, R_{i,N}, R^*_{i,1}, ..., R^*_{i,S}, R^*_{i,N}$. If the foreign nontradable sector's asset is used as a numeraire, the vector of first- and second-order excess returns can be written as

$$\begin{aligned} R'_{xi,t} = [\quad & \hat{R}_{i,1,t} - \hat{R}^*_{i,N,t}, \hat{R}_{i,2,t} - \hat{R}^*_{i,N,t}, ..., \hat{R}_{i,S,t} - \hat{R}^*_{i,N,t}, \hat{R}_{i,N,t} - \hat{R}^*_{i,N,t}, ... \\ & \hat{R}^*_{i,1,t} - \hat{R}^*_{i,N,t}, \hat{R}^*_{i,2,t} - \hat{R}^*_{i,N,t}, ..., \hat{R}^*_{i,S,t} - \hat{R}^*_{i,N,t} \ ]. \\ R^{2\prime}_{xi,t} = [\quad & \hat{R}^2_{i,1,t} - \hat{R}^{*2}_{i,N,t}, \hat{R}^2_{i,2,t} - \hat{R}^{*2}_{i,N,t}, ..., \hat{R}^2_{i,S,t} - \hat{R}^{*2}_{i,N,t}, \hat{R}^2_{i,N,t} - \hat{R}^{*2}_{i,N,t}, ... \\ & \hat{R}^{*2}_{i,1,t} - \hat{R}^{*2}_{i,N,t}, \hat{R}^{*2}_{i,2,t} - \hat{R}^{*2}_{i,N,t}, ..., \hat{R}^{*2}_{i,S,t} - \hat{R}^{*2}_{i,N,t} \ ]. \end{aligned} \tag{B.31}$$

They show up in the second-order approximation of the Euler equations:

$$\begin{aligned} E_t[\hat{R}_{xi,t+1} + \tfrac{1}{2}\hat{R}^2_{xi,t+1} + \tfrac{1}{2}\mathcal{T} - (\sigma \hat{C}_{i,t+1} + \hat{P}_{i,t+1})\hat{R}_{xi,t+1}] &= \mathcal{O}(\epsilon^3), \\ E_t[\hat{R}_{xi,t+1} + \tfrac{1}{2}\hat{R}^2_{xi,t+1} - \tfrac{1}{2}\mathcal{T} - (\sigma \hat{C}^*_{i,t+1} + \hat{P}^*_{i,t+1})\hat{R}_{xi,t+1}] &= \mathcal{O}(\epsilon^3). \end{aligned} \tag{B.32}$$

where $\mathcal{T}$ denotes the vector of transaction costs $\mathcal{T} = [\underbrace{\tau_i, ...\tau_i}_{S+1}, \underbrace{0, ..., 0}_{S}]$. Taking the difference of the two equations in B.32 yields the portfolio determination equation

$$E_t[(\hat{C}_{i,t+1} - \hat{C}^*_{i,t+1} + \frac{\hat{e}_{i,t+1}}{\sigma})\hat{R}_{xi,t+1}] = \tilde{R}_i \tilde{\Sigma}_i \tilde{D}'_i - \tilde{R}_i \Sigma_i \tilde{D}^{*\prime}_i = \frac{\mathcal{T}}{\sigma} + \mathcal{O}(\epsilon^3), \tag{B.33}$$

where $\tilde{R}_i$ is the response of excess returns to sectoral productivity shocks; $\tilde{D}_i$ ($\tilde{D}^*_i$) captures how the inflation-adjusted domestic (foreign) consumption reacts to the shocks. Evaluating this equation derives households' asset positions under various frictions.

B.2 Computation

The quantitative exercise covers 15 ISIC tradable sectors (the same sectors as in the empirical section) from about 60 countries, which account for more than 90 percent of world trade volume, over the sample period 2001-2014 (the same time frame as in the empirical section for most countries in the sample). On the real side of the model, four categories of parameters need to be calibrated: (1) standard parameters taken from the macro/trade literature, (2) sector-specific factors including capital intensity and consumption weights, (3) country-specific factors including endowments, trade costs, expenditure shares on the nontradable sector, and (4) country-sector-specific productivity. On the financial side are two frictions, including country-specific asset transaction costs and country-sector-specific information frictions.

Table B.1 summarizes the values of these variables in the quantitative exercise. Most of the parameters on the real side of the economy are discussed in detail by Hu (2020). Many country- and sector-specific parameters are readily available in the literature or data. However, sector-level productivity and country-level trade costs need to be calibrated to match (1) the country's share of all the countries' exports in sector s and (2) the country's overall export-to-output ratio. The calibrated sectoral productivity is also used to compute the variance-covariance matrix of productivity shocks, including within- and cross-country correlations across sectors. On the financial side of the economy, information frictions and transaction costs are calibrated to minimize the distance between the data and numerical results for both sector- and country-level home bias.

Table B.1: Parametrization

Parameter	Description	Value	Source
β	Annual discount factor	0.95	Macro literature
σ	Coefficient of relative risk aversion	2	Macro literature
ϕ	Elasticity of substitution between sectors	2	Levchenko and Zhang (2016)
η	Dispersion of productivity efficiency	8.28	Eaton and Kortum (2002)
ρ	Persistence of sectoral productivity	0.95	U.S. BLS
ψ_s	Consumption weights within tradables		U.S. BEA
α_s	Sectoral capital intensity		U.S. I-O matrix
μ_i	Country i's expenditure shares on nontradables		STAN and a fitted regression
$L_{i,t}$	Labor endowment		Number of employees from PWT
$K_{i,t}$	Capital endowment		Capital stock from PWT
t_i	Trade costs		Calibrated to match observed trade flows
$\bar{T}_{i,s}$	Sectoral productivity		Calibrated to match observed trade flows
$f_{i,s}$	Information frictions		Calibrated to match observed home bias
τ_i	Asset transaction costs		Calibrated to match observed home bias

The following paragraphs outline the computation procedure to solve the model. Step 1-5 describe how the steady-state values of the real variables are determined. Step 6-8 discuss how the financial variables are calibrated when solving for portfolios.

Step 1. Calculate steady-state factor endowments, GDP, and exports

Obtain the data of country-level factor endowments and GDP (whose dynamic values are both taken from the Penn World Table (PWT)), and of sector- and country- level exports (from UN Comtrade). The mean values over the sample period will be used as the steady-state values of these variables in the calibrated model.

Step 2. Form initial guess for factor prices

Use the information in step 1 and country-level capital share α_i available from PWT to guess factor prices under the Cobb-Douglas assumption:

$$r_i = \alpha_i \frac{Y_i}{K_i}, \qquad w_i = (1-\alpha_i)\frac{Y_i}{L_i}, \tag{B.34}$$

Step 3. Calibrate productivity and trade costs to match trade flows

Use the factor prices in Step 2 and solve for sectoral productivity $T_{i,s}$ and trade cost t_i to match (1) country i's share of all the countries' exports in sector s ($\pi_{i,s}$), and (2) the country's overall export-to-output ratio ($E2Y_i$). This involves plugging w_i, r_i, $T_{i,s}$ and t_i in equations B.1 through B.8 until the two target variables match the data.

Step 4. Update factor prices to clear the factor market

Plug the estimated productivity and trade costs from Step 3, follow equations B.9 through B.11 to check whether the country-level factor endowments predicted by the model match those in the data. If not, repeat Steps 3 and 4 until the updated factor prices satisfy the factor market clearing conditions.

Step 5. Solve all the domestic and foreign real variables

Given the equilibrium factor prices obtained in Step 4, repeat Step 3 and then follow equations B.1 through B.27 to calculate the steady-state values of all the domestic and foreign variables on the real side of the economy.

Step 6. Estimate the covariance matrix of productivity shocks

Use the steady-state trade costs computed earlier to solve for time-varying sectoral productivity ($T_{i,s,t}$) that matches the dynamic sectoral trade shares ($\pi_{i,s,t}$) and endowments observed in the data. After that, follow equation B.14 to calculate the corresponding $T^*_{i,s,t}$ every period. The dynamic domestic and foreign sectoral productivity can then be used compute the variance-covariance matrix of productivity shocks (Σ_i) based on the AR(1) process specified in equation 40.

Step 7. Extract the coefficient matrices from first order conditions

Examine the first-order dynamics of the model to extract the coefficient matrices in equation B.33. These matrices, capturing the responses of consumption and asset returns to productivity shocks, will be used to determine asset positions.

Step 8. Solve for financial frictions to match observed home bias

Plug the coefficient matrices obtained in Step 7 and solve for information frictions and transaction costs to minimize the distance between the data and numerical results for both sector- and country-level home bias. This involves plugging the two unknown frictions and coefficient matrices in the portfolio determination equation (B.33) until the inferred asset holdings match home bias observed in the data. Specific steps include:

1) Form initial guesses for asset holdings under no financial frictions using equation B.33:

$$\alpha_0 = [\alpha_{0H,1} \ldots \alpha_{0H,S+1}, \alpha_{0F,1} \ldots \alpha_{0F,S+1}]. \tag{B.35}$$

2) Calculate transaction costs τ_0 under no information frictions to match national home bias. This involves solving for portfolios over a grid of different τ values using equation B.33 with the initial guess α_0, and calculating the resulting home bias until it matches the data under a specific value denoted as τ_0. After that, get the corresponding asset position α_1 under τ_0 using equation B.33 again.

3) Compile the initial guesses, including τ_0 for transaction costs, α_1 for asset positions, and a vector of zeros for information frictions. Loop over a combination of frictions τ and f_s until the corresponding asset positions determined by equation B.33 predict the sectoral and national home bias that converge to the data. Consistent with the definition in the empirical section (equation 1), sectoral home bias and national home bias are

$$HB_{i,s} = 1 - \frac{\frac{\alpha_{F,s}}{\alpha_{H,s}+\alpha_{F,s}+MV^d_{i,s}}}{1 - MV^w_{i,s}}, \tag{B.36}$$

$$HB_i = 1 - \frac{\frac{\sum_s^{S+1} \alpha_{F,s}}{\sum_s^{S+1}(\alpha_{H,s}+\alpha_{F,s}+MV^d_{i,s})}}{1 - MV^w_i}, \tag{B.37}$$

where $MV^d_{i,s}$ and $MV^w_{i,s}$ represent the share of country i sector s market values ($MV_{i,s}$) in total domestic assets ($\sum_s^{S+1} MV_{i,s}$) and total sectoral assets ($\sum_i^I MV_{i,s}$) respectively, while $MV_i^w = \frac{MV_i}{\sum_i^I MV_i}$ represents the share of country i market values in the global market.

In addition to this baseline strategy, I have tried different initial guesses for financial frictions and greater weights for national than for sectoral home bias when calibrating the frictions to match the data. The quantitative results barely change and therefore remain robust under these alternative computation strategies.

C Robustness

C.1 Empirical Analysis

Table C.1: Robustness check for sectoral tradability and sectoral HB

Dep. Var: Sectoral HB	Export-based tradability		Import-based tradability	
	(1)	(2)	(3)	(4)
Tradabilility	-0.181 ***	-0.194 ***	-0.306 ***	-0.328 ***
	(0.029)	(0.021)	(0.033)	(0.023)
	[-0.056]	[-0.060]	[-0.083]	[-0.089]
Country FE	N	Y	N	Y
Time FE	N	Y	N	Y
Observations	11,795	11,795	11,795	11,795
R^2	0.003	0.506	0.007	0.510

Robust standard errors in parentheses, standardized coefficient in brackets. ***significant at 1%. The dependent variable is sectoral home bias, the independent variables include tradability based on the sectoral data from the WIOD and country, time fixed effects.

Table C.1 presents the robustness check for the relationship between sectoral tradability and sectoral equity home bias. This continuous measure of tradability is based on the sectoral data reported in ISIC Rev. 4 in the International Supply and Use Tables (Int SUTs) from the World Input-Output Database (WIOD). WIOD has a comprehensive coverage of tradable and nontradable industries which line up well with those from the financial datasets (listed in table A.2). I consider both an export-based measure calculated as the ratio of sectoral exports to total sectoral use (EXP/USE bas) and an import-based measure calculated as the ratio of sectoral imports to total sectoral supply (IMP/SUP bas). I calculate the world aggregate exports (imports) as shares of use (supply) added across countries averaged over the sample period 2001-2014 when measuring sectoral tradability. Both measures suggest that sectoral home bias decreases with sectoral tradability, consistent with the baseline finding that home bias is stronger in nontradable sectors.

Table C.2: Robustness check for sectoral HB and time trend

Dep. Var: Δ HB	(1)	(2)	(3)	(4)
Chinn-Ito	1.67E-03		-1.27E-03	2.21E-02
	(4.00E-03)		(2.30E-03)	(1.42E-02)
Tradable dummy		-5.33E-05	5.20E-03	7.79E-03
		(2.29E-03)	(4.36E-03)	(8.00E-03)
Country FE	N	Y	N	Y
Sector FE	Y	N	N	Y
Year FE	Y	Y	N	Y
Observations	10,926	10,926	10,926	10,926
R^2	1.83E-02	3.04E-02	1.00E-04	3.27E-02

Robust standard errors in parentheses.

Table C.2 explores the potential influence of the time trend on the determinants of home bias. The dependent variable is the change in home bias over time, and independent variables include the Chinn-Ito index and tradable dummy. As these two variables do not show strong correlations with the trend, financial openness and sectoral tradability remain determinants of sectoral home bias.

Table C.3: Robustness check for Sectoral home bias and RCA

Dep. Var: Sectoral HB	(1)	(2)	(3)	(4)
RCA	0.017 ***	-0.061 ***	0.021 ***	-0.053 ***
	(0.003)	(0.015)	(0.003)	(0.012)
	[0.071]	[-0.247]	[0.083]	[-0.213]
Chinn-Ito	-0.76 ***	-0.864 ***	-0.194 ***	-0.310 ***
	(0.018)	(0.025)	(0.056)	(0.047)
	[-0.484]	[-0.549]	[-0.123]	[-0.197]
RCA × Chinn		0.089 ***		0.084 ***
		(0.016)		(0.014)
		[0.335]		[0.314]
Country FE	N	N	Y	Y
Sector FE	N	N	Y	Y
Year FE	N	N	Y	Y
Observations	6,064	6,064	6,064	6,064
R^2	0.237	0.243	0.566	0.570

Robust standard errors in parentheses, standardized coefficients in brackets.***significant at 1%. The dependent variable is sectoral home bias. The independent variables include sectoral revealed comparative advantage $RC\bar{A}_{i,s,t}$, Chinn-Ito index, their interactions, and country, sector, time fixed effects.

Table C.3 explores the joint influences of risk hedging and financial frictions on sectoral home bias. The interaction term of reveal comparative advantage (RCA) and the Chinn-Ito index has a positive coefficient estimate. This result suggests that when asset transaction costs are controlled for, sectoral home bias is weaker in comparative advantage sectors. Therefore, the positive covariance between sectoral home bias and RCA reported in table 2, which contradicts the theoretical prediction from risk-hedging mechanisms, can potentially be explained by financial frictions. This result provides empirical support for the theoretical prediction of figure 4 in section 3.2.2.

C.2 Theoretical Analysis

In this section, I explore possible extensions of the baseline model and their implications for model predictions. First, I discuss the effects of parametric assumptions on asset positions under households' hedging motives against labor income risk and real exchange risk separately. Second, I introduce endogenous capital accumulation and bond assets to examine portfolio choice in a more general setup.

One common challenge in the theoretical home bias literature lies in the fact that model predictions are sensitive to parametric assumptions (as summarized by Coeurdacier and Rey (2013)). Specifically, for the hedging against real exchange rate fluctuations, the assumptions about households' preference regarding the elasticity between domestic and foreign goods, as well as the degree of consumption home bias, determine whether the model predicts equity home or foreign bias. For the hedging against labor income shocks, the assumptions that govern the correlation between labor income and financial income decide whether home bias arises. Under the baseline parametrization listed in table 3, both labor income risk and real exchange rate risk would lead households to exhibit weaker home bias in the comparative advantage sector because 1) elasticities of substitution are greater than one and the consumption bundle tilts toward the domestic comparative advantage sector, which makes real exchange rate more negatively correlated with the returns to that sector, and 2) labor income and financial income show perfect comovement under the Cobb-Douglas production function, which makes labor income more positively correlated with the returns to the comparative advantage sector when the sector affects the fluctuations in the country's macroeconomic performance in a more substantial way. To analyze the hedging positions driven by the two risks separately under these assumptions, I decompose figure 2 into figures C.1 and C.2.[29] The figures confirm that home bias in the comparative advantage sector is weaker under both risks.

[29] To do the decomposition, I assume the consumption weight $\mu = 0.5$ to shut down the hedging position against real exchange rate risk in order to isolate the hedging position against labor income risk.

Disentangling the Hedging against Labor Income and Exchange Rate Risks

Figure C.1: Under Labor Income Risk

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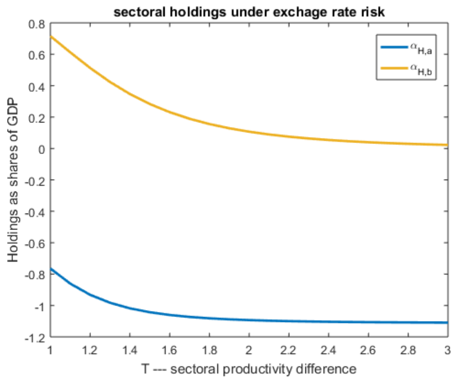

Figure C.2: Under Exchange Rate Risk

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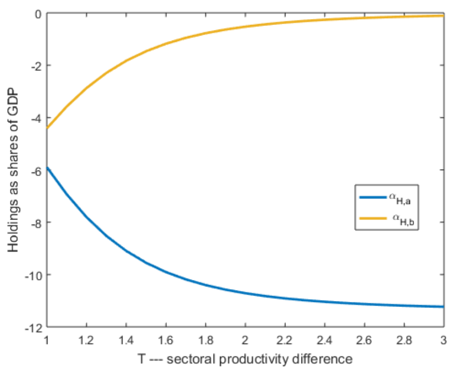


Figure C.3: Under Both Risks (same as figure 2)

To alleviate the heavy reliance of model predictions on parametric assumptions, I extend the model by considering ingredients from the recent home bias literature. In particular, Heathcote and Perri (2013) introduce endogenous capital accumulation to break the positive comovement of labor and financial income, and therefore generate home bias under the hedging motive against labor income risk. Meanwhile, Coeurdacier and Gourinchas (2016) introduce bonds which share the roles of hedging exchange rate risk played by equities, and hence raise equity home bias. I hereby discuss the implications of these two features in the two-country two-sector framework, whose one-sector version without financial friction is also exemplified by Coeurdacier and Rey (2013).

In the extended model, I relax the assumption that capital and labor are fixed in supply. Households face the tradeoff between consumption and leisure with utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{i,t}^{1-\sigma}}{1-\sigma} - \zeta_{i,t} \frac{N_{i,t}^{1+\eta}}{1+\eta}\right), \tag{C.1}$$

where the consumption bundle $C_{i,t}$ remains the same as in the baseline model, and the second term captures households' disutility from labor hours $N_{i,t}$ subject to an exogenous preference shock $\zeta_{i,t}$.[30]

Meanwhile on the production side, capital is no longer a fixed endowment. Its law of motion in country i sector s follows

$$k_{i,s,t} = (1-\delta)k_{i,s,t-1} + IV_{i,s,t}, \qquad s \in \{a, b\} \tag{C.2}$$

where $IV_{i,s,t}$ denotes capital investment and δ denotes depreciation. Country i's aggregate physical investment and investment Euler equation can therefore be written as

$$IV_{i,t} = IV_{i,a,t} + IV_{i,b,t}, \tag{C.3}$$

$$\frac{U'(C_{i,t})}{P_{i,t}} = \beta E_t\left[\frac{U'(C_{i,t+1})}{P_{i,t+1}}\left(\frac{\alpha p_{i,s,t+1} y_{i,s,t+1}}{k_{i,s,t+1}} + 1 - \delta\right)\right]. \tag{C.4}$$

To focus on the main idea without introducing too many parameters that complicate the analysis, I assume investment and consumption have the same input composition in

[30] $\zeta_{i,t}$ is introduced to ensure the number of shocks in the model equals the increased number of assets (bonds plus equities) so that a unique solution to the portfolio choice problem can be determined. See Coeurdacier and Rey (2013) and Coeurdacier and Gourinchas (2016) for a detailed discussion on alternative forms of the shocks which do not change the prediction for portfolio choice.

terms of weights and elasticities (as in equations 8 and 11)

$$IV_{i,t} = (\psi_i^{\frac{1}{\phi}} I_{i,a,t}^{\frac{\phi-1}{\phi}} + (1-\psi_i)^{\frac{1}{\phi}} I_{i,b,t}^{\frac{\phi-1}{\phi}})^{\frac{\phi}{\phi-1}}, \qquad I_{i,s,t} = (\mu_i^{\frac{1}{\eta}} I_{ii,s,t}^{\frac{\eta-1}{\eta}} + (1-\mu_i)^{\frac{1}{\eta}} I_{ji,s,t}^{\frac{\eta-1}{\eta}})^{\frac{\eta}{\eta-1}}, \tag{C.5}$$

so that the price of investment goods in country i is also $P_{i,t}$. Therefore, by holding the equity of sector s from country i, households receive its dividends as capital income less investment expenditure given by

$$d_{i,s,t} = \alpha p_{i,s,t} y_{i,s,t} - P_{i,t} IV_{i,s,t}. \tag{C.6}$$

Moreover, households can also purchase real bonds that yield one unit of a country's goods in the following period. Under the new assumptions, wealth constraints become

$$\begin{aligned} P_{H,t}C_{H,t} &+ \sum_{s=\{a,b\}} [q_{H,s,t}(\nu_{H,s,t+1} - \nu_{H,s,t}) + q_{F,s,t}(\nu_{F,s,t+1} - \nu_{F,s,t})] \\ &+ \sum_{i=\{H,F\}} [q^B_{H,t}(\nu^B_{H,t+1} - \nu^B_{H,t}) + q^B_{F,s,t}(\nu^B_{F,t+1} - \nu^B_{F,t})] \\ &= w_{H,t}N_{H,t} + \sum_{s=\{a,b\}} (d_{H,s,t}\nu_{H,s,t} + d_{F,s,t}\nu_{F,s,t}) + P_{H,t}\nu^B_{H,t} + P_{F,t}\nu^B_{F,t}, \end{aligned} \tag{C.7}$$

$$\begin{aligned} P_{F,t}C_{F,t} &+ \sum_{s=\{a,b\}} [q_{H,s,t}(\nu^\diamond_{H,s,t+1} - \nu^\diamond_{H,s,t}) + q_{F,s,t}(\nu^\diamond_{F,s,t+1} - \nu^\diamond_{F,s,t})] \\ &+ \sum_{i=\{H,F\}} [q^B_{H,t}(\nu^{\diamond B}_{H,t+1} - \nu^{\diamond B}_{H,t}) + q^B_{F,s,t}(\nu^{\diamond B}_{F,t+1} - \nu^{\diamond B}_{F,t})] \\ &= w_{F,t}N_{F,t} + \sum_{s=\{a,b\}} (d_{H,s,t}\nu^\diamond_{H,s,t} + d_{F,s,t}\nu^\diamond_{F,s,t}) + P_{H,t}\nu^{\diamond B}_{H,t} + P_{F,t}\nu^{\diamond B}_{F,t}. \end{aligned} \tag{C.8}$$

The bonds are in zero net supply, while the demand for them is determined by households' Euler equation

$$\frac{U'(C_{i,t})}{P_{i,t}} = E_t[\beta \frac{U'(C_{i,t+1})}{P_{i,t+1}} R^B_{i',t+1}], \; i, i' \in \{H, F\}, \tag{C.9}$$

where $R^B_{i,s,t+1}$ denotes the bond returns defined as[31]

$$R^B_{i,t+1} = \frac{P_{i,t+1} + q^B_{i,t+1}}{q^B_{i,t}}. \tag{C.10}$$

Table C.4 presents the numerical results of the robustness check with capital investment and bonds. The results are computed under the same parametric assumptions as in the baseline model listed in table 3 and when relative productivity $T = 1.5$. The table reports the correlation between financial returns and macroeconomic variables to examine the risk-hedging benefits offered by domestic assets as well as the resulting domestic households' holding of these assets. There are three notable findings. First, due to the strong comvement of bond returns and real exchange rate ($\rho(R^B_H, e)$), households can hedge real exchange rate risk mainly through bond positions. Conditional on bond holdings, households no longer short-sell domestic equities and instead take positive asset positions for both Ha and Hb. This result echoes the argument made by Coeurdacier and Gourinchas (2016), who rationalize equity home bias in the presence of bonds which share risk-hedging functions. Second, equity returns negatively covary with domestic investment as $\rho(R_{H,s}, IV_H) < 0, s \in \{a, b\}$ when investment expenditure is considered in the calculation of dividends (equation C.6), the same prediction as from Heathcote and Perri (2013). What is different is that the modeling and parametric assumptions here induce positive comovement between domestic equity returns and labor income ($\rho(R_{H,s}, W) > 0$), whereas in their paper the comovement is negative. Nonetheless, based on the previous point, the negative comovement between domestic equity returns and labor income is no longer necessary to generate equity home bias conditional on the existence of bonds. Third, domestic households still exhibit stronger home bias in the comparative disadvantage sector (Hb) than in the comparative advantage sector (Ha) for risk hedging as $\alpha_{H,a} < \alpha_{H,b}$. This is mostly driven by the fact that Ha exposes households to greater labor income risk since $\rho(R_{H,a}, W) > \rho(R_{H,b}, W)$. Meanwhile, the result that $\rho(R_{H,a}, e) < \rho(R_{H,b}, e)$ also means sector Ha is associated with greater real exchange rate risk, but this does not matter much since bonds are the dominant hedging instrument against the risk. That said, the hedging against labor income risk alone is sufficient to generate weaker home bias in the comparative advantage sector. Through this analysis, the prediction about the variation in sectoral home bias shaped by risk-

[31] This exercise compares the risk-hedging benefits of bonds versus equities, and therefore does not consider asset transaction costs or information frictions. If needed, these two frictions can be introduced in a similar way as in the baseline model with equities only.

Table C.4: Risk Hedging and Portfolio Choice

Assets	$\rho(R, IV_H)$	$\rho(R, e)$	$\rho(R, W)$	α
Ha	-0.1398	-0.7099	0.2278	0.0069
Hb	-0.1667	-0.7030	0.2081	0.0108
H^B	0.2579	0.6723	-0.1166	-0.0106

This table reports the correlation (denoted as ρ) between home assets' returns (R) and macroeconomic variables including aggregate home investment (IV_H), real exchange rate ($e = \frac{P_H}{P_F}$), and relative labor income across countries ($W = \frac{w_H N_H}{w_F N_F}$). Assets include domestic equities of comparative advantage (disadvantage) sectors Ha (Hb) and domestic bonds (H^B), whose holdings as shares of GDP (α) are also reported in the table.

hedging incentives from the baseline model remains robust, after both capital investment and bond positions are controlled for. Moreover, the magnitude of the model-predicted sectoral home bias in table C.4 is too small even in this two-sector framework compared to that in the data, which implies that financial frictions are still necessary to explain empirical observations.

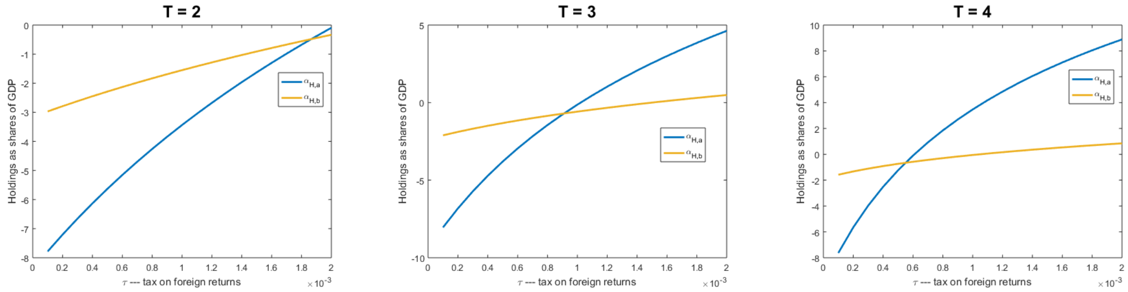
Figure C.4 below re-produces figure 4 in the baseline model under alternative $T = 2, 3, 4$, which shows that qualitative predictions are similar but the slopes of the curves vary with Ts. In particular, a higher T increases the slope of $\alpha_{H,a}$ with the change in asset transaction costs. This pattern is consistent with the discussion for figure 4: The higher the degree of industrial specialization (captured by a higher T), the more appealing Fa is relative to Fb as a hedging instrument for country H's households ($\alpha_{F,a} > \alpha_{F,b}$). Under asset transaction costs, households substitute domestic for foreign assets in their sectoral holdings (Ha for Fa). Therefore, the catch-up for sector a's home bias is more pronounced, reflected as a greater slope of $\alpha_{H,a}$, when the relative productivity is higher. Numerical results in the stylized model are sensitive to parametric assumptions for sectoral productivity T and market frictions τ, f. Therefore, we build a quantitative model, which is carefully calibrated in section 4, to evaluate the magnitude and impact of these frictions when the model confronts the data.

C.3 Quantitative Analysis

This section extends the baseline model by adding two important features of globalization: trade imbalances and input-output linkages.

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

Figure C.4: Sectoral Home Bias and Transaction Costs under Alternative Productivity



country i satisfies

$$X_{i,t} = w_{i,t}L_{i,t} + r_{i,t}K_{i,t} - D_{i,t}. \tag{C.11}$$

The value of $D_{i,t}$ is taken from the World Bank, which reports a country's external balance on goods and services as shares of GDP. When re-calibrating the model, I follow the steps in B.2, while I replace the balanced-trade condition with equation C.11. The trade surplus/deficit data will be matched by the net asset positions in the solution to the portfolio choice problem. As is predicted by the balance of payments identity, the increase in a country's holding of net foreign assets equals its trade surplus.

Moreover, I follow the quantitative trade literature including Di Giovanni et al. (2014) and Caliendo and Parro (2015) by adding intermediate inputs and input-output (I-O) linkages to the model. Given intermediate goods from sector $n \in \{1, 2, ...S, N\}$, the new production cost in sector k is

$$c_{i,k} = (r_i^{\alpha_k} w_i^{1-\alpha_k})^{\nu_k} (\Pi_n (P_{i,n})^{\gamma_{kn}})^{1-\nu_k}, \tag{C.12}$$

where γ_{kn} is the share of input n used for k's production and $1 - \nu_k$ is the weight of intermediate inputs in sector k. I calibrate their values following Di Giovanni et al. (2014), who estimate the parameters using the UNIDO Industrial Statistics Database and the Direct Requirements Table of the U.S.

Table C.5 reports the numerical results under these two extensions. In the scenarios with global imbalances and input-output linkages, asset transaction costs are predicted to play a more significant role in driving home bias. For example, based on the results in columns (4) and (6), sectoral home bias drops to 0.05 and 0.07, which are slightly lower than 0.10 in the baseline model. The difference is more pronounced for national home bias: Extended models predict that home bias drops from 0.46 to about 0.34. Based on this result, asset transaction costs account for approximately a quarter of national home bias. In contrast, the impact of information frictions on both national and sectoral home bias is quantitatively small and similar across different models. Based on the estimates, information frictions explain about 10% and 20% sectoral home bias under trade imbalances and I-O linkages, respectively. These frictions account for between 2% and 10% national home bias, consistent with the result in the baseline case. The similarity of these quantitative findings across different specifications validates the robustness of the numerical results.

Table C.5: Robustness Check for Quantitative Analysis

	Observed home bias	Counterfactual home bias					
		Baseline		Imbalances		I-O linkages	
Friction excluded		τ	f	τ	f	τ	f
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$H\bar{B}_{i,s}$	0.29	0.10	0.26	0.05	0.26	0.07	0.23
$H\bar{B}_{i}$	0.46	0.42	0.42	0.34	0.45	0.33	0.41

Note: $H\bar{B}_{i,s}$ denotes the median sector-level home bias, and $H\bar{B}_{i}$ denotes the median country-level home bias. Column (1) reports home bias observed in the data. Columns (2)-(7) list the counterfactual home bias in the baseline quantitative model, in the model incorporating trade imblances, and in the model featuring input-output linkages, respectively, under the circumstances where transaction costs (τ) and information frictions (f) are turned off.