Hedging Against the Government: A Solution to the Home Asset Bias Puzzle*

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Abstract

This paper explains two puzzling facts: international nominal bonds and equity portfolios are biased domestically. In our two-country model, holding domestic nominal debt provides a hedge against price-level shocks and the impact on taxes they induce. For this result, only two features are essential: some nominal risk and taxes falling only on domestic agents. A third feature explains why agents choose to hold primarily domestic equity: government spending falls on domestic goods. Then, an increase in government spending raises the returns on domestic equity, providing a hedge against the subsequent increase in taxes. These conclusions are robust to the presence of inflation-indexed government debt, some tax revenues from foreign agents, and some government spending on foreign goods. Moreover, they are robust to a wide range of preference parameter values and the incompleteness of financial markets. A calibrated version of the model predicts asset holdings that quantitatively match the data.

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1 Introduction

While international trade in bonds and equity has increased greatly in the last two decades, country portfolios still show a sizeable bias towards domestic assets. For example, Burger and Warnock (2003) find that foreign bonds comprised about 6% of U.S. investors' bond portfolios in 1997 and 4% in 2001 and Kyrychenko (2005) finds that around 95% of U.S. bond holders choose to hold only domestic bonds. Moreover, Nechio (2009) shows that in the U.S., only around 2 % of government bond holders hold any kind of foreign bonds, including indirect holdings through mutual funds.[1] Such evidence points towards significant domestic bias in international government bond portfolios. Similarly, table 1, reproduced from Coeurdacier et al (2007), shows that international equity portfolios are heavily biased domestically as countries hold a significantly higher fraction of their portfolios in domestic equity as compared to the world market capitalization share of their stock markets.

From the perspective of standard international macroeconomic models, the degree of home asset bias observed in the data is a long-standing puzzle, as it implies a lack of international risk sharing among countries. For equity holdings, Lucas (1982) showed in a two-country economy with trade in claims to domestic and foreign endowments that perfect risk sharing against endowment shocks can be supported by each agent owning half the claims to the home endowment and half to the foreign endowment.[2] For debt holdings, if there are idiosyncratic risk to returns on bonds, one would similarly expect agents to diversify their holdings.

In our baseline model, we add to a standard two country, two good endowment economy model with trade in equities, a government that issues one-period nominal debt and taxes domestic agents to finance its expenditure on domestic goods. In this frictionless set-up with complete markets, we show that equilibrium portfolio holdings are biased completely towards domestic debt and equity. To our knowledge, this is the first paper to generate joint home bias in both nominal government debt and equity in a standard frictionless international macroeconomic model.

What drives our results? Holding domestic bonds offers insurance against price level risk due to policy shocks. For bonds with nominal returns known one period in advance, the risk that agents face is in the form of the price level next period. If the price level is higher than expected at home, then agents will realize lower real return on domestic bonds. With a higher price level at home however, the expected value of future taxes on domestic

[1] Burger and Warnock (2003) use the 1997 and 2001 benchmark surveys of U.S. Holdings of Foreign Securities while Kyrychenko (2005) and Nechio (2009) use the Survey of Consumer Finances.

[2] In fact, in a production economy model, Baxter and Jermann (1997) show that optimal portfolio holdings involve shorting domestic assets. This implies that the data is highly at odds with the theory.

agents is lower since the real value of debt outstanding has decreased and the intertemporal government budget constraint has to be satisfied. Therefore, real return on domestic bonds and taxes co-move positively and, since the government taxes only domestic agents, holding only domestic bonds achieves optimal risk-sharing.

Holding only domestic equity is an optimal portfolio decision because government spending falls on domestic goods.[3] Then, a positive domestic government spending shock will increase the relative price of the domestic good and imply an improvement in the terms of trade for the domestic economy. This means that the relative return of claims on the domestic good is higher compared to the claims on the foreign good. Since government spending has increased, in order to fulfill the intertemporal government budget constraint, domestic taxes have to increase. Therefore, to hedge against this risk, agents will want to hold an asset that offers a relatively higher return. Domestic equity is precisely such an asset.

These basic mechanisms that lead to home asset bias are fully operative when we progressively relax the assumptions of our baseline model. In particular, the home nominal bond bias result is robust to the presence of inflation indexed government debt and some taxation on the foreign agent. The only requirements for home bias in nominal government debt is the presence of some nominal risk that can be hedged through nominal bonds and taxes falling relatively more on the domestic agent. We view these features as a realistic description of the behavior of the governments of at least the industrialized countries. Moreover, our result also holds if government spending adjusts, rather than taxes, when a nominal shock hits. It is also robust to multiple kinds of distortionary taxes, for example, labor income taxes under elastic labor supply.[4]

Since our model posits that government debt provides a hedge against nominal risk, a prediction is that the formation of a monetary union should lower home debt bias. The evidence from the European Union is in support of this prediction: Schoenmaker and Bosch (2008) and De Santis and Gerard (2009) show that the introduction of the Euro has decreased the bond bias in Europe and that this decline is strongest for EMU countries.

Similarly, the home equity bias result is robust to some government spending on foreign goods as long as government spending shocks fall relatively more on domestic goods compared to foreign goods. It is also robust to some part of government spending adjusting endogenously to debt changes. A general result of our paper is that to generate equity home bias, a sufficient condition is for the government's consumption to be roughly more biased than the consumer's towards domestic goods. What is the empirical support for this

[3] We are following a long standing tradition in international macroeconomic models that assumes that government spending falls relatively more on domestic (or non-traded) goods.

[4] Therefore, while our basic mechanism behind debt bias is reminiscent of the Ricardian equivalence result in Barro (1974), our results hold under a more general environment.

requirement? Corsetti and Muller (2006) provide the most direct evidence where they show that for many OECD countries, government spending has the lowest import content when compared to private consumption and investment.

In addition, how realistic is the mechanism of our model for explaining equity bias: the positive correlation between government spending shocks and relative equity returns? We are not aware of any direct empirical evidence, either in support or to the contrary. Regarding the channel that creates this correlation in our model, government spending shocks improving the terms of trade, there is empirical support. For example, Monacelli and Perotti (2008), Muller (2008), and Corsetti and Muller (2006) find that for the United States, the terms of trade appreciates in response to a government spending shock.[5]

While in our baseline model, we consider complete markets to derive analytical solutions and isolate the basic mechanisms at work, we relax this assumption and show that our results are still valid under imperfect risk-sharing. Finally, we present a fully dynamic version of the two country model with production, numerically solve for portfolio choice under the realistic assumption of incomplete markets and multiple kinds of distortionary taxes, and show that a calibrated model is able to quantitatively match the portfolio holdings observed in the data.

Related literature:

Home bias in nominal government debt has been neglected in the literature, while home bias in equity has been extensively addressed. Since this literature is quite voluminous, here we discuss a set of approaches that are directly relevant for comparison with our set-up. One approach, exemplified by Kollmann (2006) and Obstfeld (2006), relies on assuming a preference bias of agents towards domestic goods. This bias is motivated by the empirical observation that the majority of consumption falls on domestic goods. Then, with only country specific endowment shocks, these models generate domestic bias in equity if the elasticity of substitution between domestic and foreign goods is less than one.

The intuition for this result is the following. When a positive endowment shock hits the domestic economy, the terms of trade deteriorates and the real exchange rate depreciates. Since the domestic agent is biased towards consuming domestic goods and that good has become cheaper, risk-sharing involves holding an asset whose returns are relatively lower. With an elasticity of substitution lower than one, the deterioration in terms of trade is so strong that the return on domestic equity is in fact lower than that on foreign equity. Therefore, agents are biased towards holding domestic equity. In these models, equity positions are

[5] There is some evidence, such as in Monacelli and Perrotti (2006), that a government spending shock depreciates the real exchange rate. They do not directly identify the effect on the terms of trade, however. With preference bias in consumption, our model would predict the real exchange rate appreciating in response to a government spending shock. Even then, Beetsma et al. (2008), Froot and Rogoff (1991), and Frankel and Razin (1992) find that government spending appreciates the real exchange rate.

used to hedge against real exchange rate risk and they imply a high and positive correlation between the real exchange rate and relative equity returns. As van Wincoop and Warnock (2006) point out however, the empirical evidence for this mechanism is weak since the data shows a very low correlation.

Compared to this literature, our results hold even when we do not assume any preference bias in consumption, that is, when there is no real exchange rate movement. This leads to a zero correlation between the real exchange rate and relative equity returns. Therefore in our mechanism, equity positions are not used to hedge against real exchange rate risk. Even for the empirically realistic case of consumption home bias and hence real exchange rate movement, since our incomplete markets model is driven by both supply and government spending shocks, the correlation between the real exchange rate and equity returns is not pinned down to be high and positive. Moreover, our results are robust to a wide range of values for the elasticity of substitution between domestic and foreign goods, including whether it is greater than or less than one.

A second approach, for example in Heathcote and Perri (2007), explains the observed equity bias by a negative correlation between relative domestic equity returns and relative non-diversifiable labor income. In their model with production and capital, which again assumes preference bias in consumption, domestic equity bias is an optimal way to risk share against country specific productivity shocks. Given a positive productivity shock, labor income is higher and therefore agents will hold primarily domestic equity if the return on it is lower than foreign equity. In their set-up, equity is a claim to the capital stock and the relative price of capital is equal to the relative price of consumption. A positive productivity shock depreciates the real exchange rate and thereby, leads to a devaluation of the domestic capital stock. Under a range of parameter values, this devaluation is so strong that the return on domestic equity is lower than foreign equity.

Their baseline results hold for log utility and unit elasticity of substitution between domestic and foreign goods. As pointed out by Coeurdacier et al (2008), however, the results are very sensitive to preference parameters: whenever both these parameter values are even slightly greater than one, the model predicts a foreign equity bias. Given the uncertainty in the empirical literature about these parameter values, we view the robustness of our results to both the risk aversion and the elasticity parameters as a significant strength of our model.[6]

In another approach, Coeurdacier et al (2007) generate home bias in equities without

[6] Moreover, when preferences are not restricted to log utility, the model of Heathcote and Perri (2007) also predicts a high and positive correlation between the real exchange rate and relative equity returns, which as we pointed out earlier, is low in the data.

requiring equity positions to hedge against real exchange rate risk. In their endowment economy model, a new set of shocks, called redistributive shocks, redistribute income randomly between equity and non-diversifiable income. These break the perfect correlation between the real exchange rate and relative equity returns while creating an incentive to hold domestic equity. In the presence of such shocks, to hedge against them, agents want to hold domestic equity since in states of the world where due to a positive redistribution shock, domestic equity income is lower, non-diversifiable income will be higher.[7] In contrast, in our paper, the shocks that we use, government expenditure shocks, have been extensively used in the literature, for example in Obstfeld (1989) and Backus, Kehoe and Kydland (1994).[8]

Plan of the paper:

In section 2 we impose some restrictions on preference parameters and present exact analytical solutions for portfolio choice in a two period, two good, two country endowment economy model with complete markets. In section 3 we show that our results on government nominal debt and equity bias are robust to relaxing all of our restrictions on the preference parameters. Moreover, the mechanisms are fully operative in extensions of the model such as presence of some inflation-indexed debt, taxes falling also on foreign agents, government spending adjusting rather than taxes, some non-stochastic component of government spending, and government spending on foreign goods. We also consider incomplete markets and show the generality of our results. In section 4 we present our production model and the quantitative exercise. In section 5 we conclude.

2 Simple Model

We start with a simple model for two reasons. First, it enables us to derive exact analytical solutions that provide intuition for the mechanism behind our results. In particular, we restrict the agent's preferences in assumption 1 below.

Assumption 1: *The agents have log utility, no preference bias for domestic goods, and unit elasticity of substitution between domestic and foreign goods.*

Second, this set-up makes clear which assumptions are essential to generate our asset allocation results. For this purpose, we consider complete markets and model the government as taxing only domestic agents and spending only on domestic goods. We will relax all of our assumptions on preferences, asset structure, and the set-up of taxation and government spending later in the paper to show the robustness of our results.

[7] There is an empirical debate on the existence and relevance of such a shock. See for example, Julliard (2006).

[8] In independent ongoing work, Coeurdacier and Gourinchas (2008) mention government spending shock as an alternative to redistribtive shock. In this paper, we explore the role of government spending thoroughly.

2.1 Setup

We consider a two-period ($t = 0, 1$) two symmetric countries (home (H), foreign (F)) model. Two goods, Y^H and Y^F, are endowed to the respective countries in period 1. The representative household in each country starts with initial wealth and makes portfolio decisions in period 0 and consumes only in period 1. We allow for trade in government nominal bonds and claims on the realization of endowments, which we interpret as equity trading.

Each country has a government that can only tax the representative consumer in its country, spends only on domestic goods, and is subject to a budget constraint. The government issues nominal debt in period 0 and taxes and retires all debt in period 1. It consumes in period 1 and its expenditure can be stochastic.

2.1.1 Consumers

The domestic representative agent maximizes the following expected utility (analogous for the foreign agent)

$$E_0 \left[\log C_1^H \right] \tag{1}$$

where C_1^H is the composite consumption good and is subject to the following budget constraints in period 0 and 1, respectively

$$W_0^H = B_0^{Hh} + B_0^{Hf} + q_0^H E_0^{Hh} + q_0^F E_0^{Hf} \text{ and} \tag{2}$$

$$C_1^H + \tau_1^H = \frac{Y_1^H P_1^{Hh}}{P_1^H} + \frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf} Q_1}{P_1^F} + \frac{Y_1^H E_0^{Hh} P_1^{Hh}}{P_1^H} + \frac{Y_1^F E_0^{Hf} Q_1 P_1^{Ff}}{P_1^F} \tag{3}$$

where E_0^{Hj} is the home agent's holding of claims of endowment $j \epsilon \{h, f\}$ in time 0, B_0^{Hj} is the home agent's holding of nominal bonds in j currency, q_0^j is the price of a claim on endowment j, and R_0^j is the nominal interest rate on public debt of country j.[9] Similarly, P_1^j are the price indices for the respective consumption bundles, P_1^{ij} is the price of good j in country $i \epsilon \{h, f\}$, Q_1 is the real exchange rate defined as $Q_1 = \frac{S_1 P_1^F}{P_1^H}$, and τ_1^H are taxes. Since this is a two-period model, a no-Ponzi condition implies that the total bond holdings of the consumer in period 1, $B_1^{Hh} + B_1^{Hf}$, should be greater or equal to zero. In writing eqn.(3), we have already imposed the optimality condition, $B_1^{Hh} + B_1^{Hf} = 0$.

As eqn.(2) makes clear, there is no consumption at $t = 0$, but at this date agents are allowed to trade assets. The agent starts with initial wealth, W_0^H, which is equal to his asset

[9] Note that in eqn.(2), we normalize the price level in both countries and the nominal exchange rate to 1 in period 0.

holdings in period 0. No consumption or storage technology in period 0 implies that the sum of the wealth of the two agents should be equal to the sum of government debts. We add an additional restriction that W_0^H is equal to B_0^H, the amount of nominal debt outstanding of his own government. This is a simplifying normalization assumption that does not affect the results and implies that the initial net foreign asset position of the country is zero.[10]

In period 1, after the endowment and price level uncertainty are realized, households consume using their resulting financial income less taxes, as captured by eqn.(3). The composite consumption good is a Cobb-Douglas aggregate of domestic and foreign final goods

$$C_1^H = \left(C_1^{Hh}\right)^{0.5}\left(C_1^{Hf}\right)^{0.5} \tag{4}$$

where C_1^{Hh} and C_1^{Hf} are home consumption of the domestic and foreign goods.[11]

As is well known, expenditure minimization by the agent will imply the following utility-based aggregate price index at home $P_1^H = 2\left(P_1^{Hh}\right)^{0.5}\left(P_1^{Hf}\right)^{0.5}$. The law of one price holds for the two traded goods, implying $P_1^{Hh} = S_1 P_1^{Fh}$, $P_1^{Hf} = S_1 P_1^{Ff}$, and $Q_1 = \frac{S_1 P_1^F}{P_1^H} = 1$. The terms of trade, the ratio of price of exports to imports, facing the domestic economy is defined as $\frac{P_1^{Hh}}{P_1^{Hf}}$ or as $\frac{P_1^{Fh}}{P_1^{Ff}}$.

The optimality conditions of the consumer are

$$E_0\left[\frac{R_0^H}{C_1^H P_1^H}\right] = E_0\left[\frac{R_0^F}{C_1^H P_1^F} Q_1\right] = E_0\left[\frac{Y_1^H P_1^{Hh}}{C_1^H P_1^H}\right] = E_0\left[\frac{Y_1^F Q_1 P_1^{Ff}}{C_1^H P_1^F}\right] \tag{5}$$

$$\frac{C_1^{Hh}}{C_1^{Hf}} = \frac{P_1^{Hf}}{P_1^{Hh}}. \tag{6}$$

The first set of equations show the standard non-arbitrage conditions for the four assets available while the second equation governs the relative demand of the home good with respect to the foreign good.

2.1.2 Government

Each government starts in period 0 with a stock of nominal debt (home (B_0^H), foreign (B_0^F)) and collects tax on its agent in period 1 (home (τ_1^H), foreign (τ_1^F)). In period 1, the government consumes only domestic goods and is subject to the budget constraint

$$\frac{B_1^H}{P_1^H} = \frac{R_0^H B_0^H}{P_1^H} - \tau_1^H + G_1^{Hh}\left(\frac{P_1^{Hh}}{P_1^H}\right). \tag{7}$$

[10] Note that this choice of the initial value is analogous to the set-up in dynamic international macro models where the equations are log-linearized around a zero steady-state net foreign asset position.

[11] Note the unitary elasticity of substituion between the two goods and no preference bias in consumption.

By combining the transversality conditions of the two agents, $B_1^{Hh} + B_1^{Hf} = 0$ and $B_1^{Ff} + B_1^{Fh} = 0,$ it follows that $\frac{B_1^H}{P_1^H} + \frac{B_1^F}{P_1^F} = 0$, that is, the total debt of the two governments in period 1 is equal to zero. Here, we add the assumption that each government pays any outstanding debt in period 1, that is, $\frac{B_1^H}{P_1^H} = \frac{B_1^F}{P_1^F} = 0$. We think that this is a reasonable additional restriction since other possibilities such as allowing $\frac{B_1^H}{P_1^H}$ to be negative and $\frac{B_1^F}{P_1^F}$ to be positive would imply that country H would be subsidizing country F government 's consumption. This restriction, along with the optimality conditions of the agents, implies, $B_1^{Hh} = B_1^{Hf} = B_1^{Fh} = B_1^{Ff} = 0$.

The government issues only nominal bonds in its currency and taxes only its citizen. Most advanced country governments issue primarily fiat debt in their currency and tax revenue is predominantly collected from domestic agents. We relax this assumption in section 3.1.2 and 3.1.4. In section 3.1.3 we let government spending rather than taxes adjust to fulfill the budget constraint. For government purchases, here we follow most international macro models, for example Corsetti and Pesenti (2001), which assume that all of government spending falls on domestic goods. We relax this assumption in section 3.2.2.

2.1.3 Market Clearing

For goods, market clearing conditions are

$$C_1^{Hh} + C_1^{Fh} + G_1^{Hh} = Y_1^H \qquad C_1^{Hf} + C_1^{Ff} + G_1^{Ff} = Y_1^F. \tag{8}$$

In the market for assets notice that the claims on endowments are inside assets while there is an outside supply of nominal bonds by the government. Market-clearing conditions are

$$E_0^{Hh} + E_0^{Fh} = 0 \qquad E_0^{Hf} + E_0^{Ff} = 0 \tag{9}$$

$$B_0^{Hh} + B_0^{Fh} = B_0^H \qquad B_0^{Hf} + B_0^{Ff} = B_0^F. \tag{10}$$

2.1.4 Uncertainty and Market Completeness

We allow for three different types of shocks. First, we assume that the monetary authority controls the price level in period 1, which is a known value in period 0 plus an error in period 1. That is, $P_1^H = \bar{P}^H + \varepsilon_1^H$ and $P_1^F = \bar{P}^F + \varepsilon_1^F$. We motivate this shock as a policy-maker choosing the price level with an error. In section 4, these policy shocks come from monetary policy through a Taylor rule or fiscal policy through tax responses to real public debt.

Second, we allow for endowment shocks $Y_1^H = \bar{Y}^H + \varepsilon_1^{Yh}$, $Y_1^F = \bar{Y}^f + \varepsilon_1^{Yf}$ and third, we take government i's expenditure to be an exogenous process, $G_1^{Hh} = \varepsilon_1^{Gh}$ and $G_1^{Ff} = \varepsilon_1^{Gf}$. All ε_i^j are independent with mean 0 and standard deviation σ_j. We normalize the standard deviation of all the shocks to 1 in the analytical sections of the paper and relax this simplification in section 4.

Given our asset structure of trading in domestic and foreign nominal debt and equity, the presence of all shocks described above would lead to market incompleteness. Any combination of nominal shocks with either endowment or government expenditure shocks would make the asset market effectively complete.[12]

2.1.5 Competitive Equilibrium

An equilibrium is a set of endogenous variables Φ_N that satisfies the consumer's maximization problem, government behavior and market-clearing conditions, given initial conditions Φ_I and exogenous processes Φ_X.

The endogenous variable set Φ_N comprises of all consumption allocations, asset allocations, prices, exchange rates, and taxes of both countries. In section 2 it is $\Phi_N^{SM} = \{C_1^{Hh},\ C_1^{Hf},\ C_1^{Ff},\ C_1^{Ff},\ E_0^{Hh},\ E_0^{Hf},\ B_0^{Hh},\ B_0^{Hf},\ E_0^{Ff},\ E_0^{Fh},\ B_0^{Ff},\ B_0^{Fh},\ P_1^{Hh},\ P_1^{Hf},\ P_1^{Ff},\ P_1^{Ff},\ Q_1,\ S_1,\ q_0,\ \tau_1^H,\ \tau_1^F\}$. Other form of taxes (section 3.1.2) and real bonds and their returns (section 3.1.4) are added to this set in the model extensions.

The initial conditions set Φ_I is given by the initial amount of government outstanding nominal bonds, pre-determined interests on these bonds, and the initial wealth of each agent. In section 2 it is $\Phi_I^{SM} = \left\{B_0^H, B_0^F,\ W_0^H, W_0^F,\ R_0^H,\ R_0^F\right\}$. Initial amount of outstanding real debt of each government (section 3.1.4) should be added to this set when the real bond case is considered.

The exogenous variable set Φ_X encompasses the shocks of the economy. In different versions of the model, we show our results for different combination of the shocks. In section 2 it is $\Phi_X^{SM} = \{Y_1^H,\ Y_1^F,\ G_1^{Hh},\ G_1^{Ff},\ P_1^H,\ P_1^F\}$. When we allow government consumption to fall on the foreign good (sections 3.2.2, 3.3 , and 3.4), the exogenous process for this, G^{Hf} and G^{Fh}, should be added.

2.2 Home Bond Bias

In this section, we show that the uncertainty with respect to the price level, as well as the fact that the government taxes *only* her citizen leads to a complete home bias in the holdings of nominal bonds. In order to isolate the basic mechanisms that drive our results, we turn off the endowment shocks and the government expenditure shocks, $Y_1^H = Y_1^F = \bar{Y}$ and

[12] This is true only up-to a first order under general preferences.

$G_1^{Hh} = G_1^{Ff} = 0$. Moreover, without shocks on the relative availability of the goods, the agents become indifferent between the two claims on endowment and we focus only on the bond allocation decision.

Given that we are assuming G_1^i is zero, using $\frac{B_1^H}{P_1^H} = 0$, eqn.(7) implies

$$\frac{R_0^H B_0^H}{P_1^H} = \tau_1^H. \tag{11}$$

This equation shows a clear negative relationship between the price level and the taxes at home in period 1, as total taxes depend on the real value of outstanding government debt. This implies a positive correlation between returns on domestic bonds and domestic taxation.

Since we are abstracting from trade in equities here, eqn.(3) is given by

$$C_1^H + \tau_1^H = \frac{\bar{Y} P_1^{Hh}}{P_1^H} + \frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F}. \tag{12}$$

Thus, by holding primarily domestic government bonds, the agent will be able to hedge against the movement in taxation that results from a shock to the price level and not be exposed to foreign price level shocks. Holding foreign nominal bonds will lead to exposure to foreign price shocks without being compensated by the resulting tax movement. Proposition 1 formalizes this intuition:

Proposition 1 (Home Bond Bias) *Given assumption 1, (i) in the presence of nominal shocks, if (ii) the government taxes only the domestic agent, then the agent holds only the nominal bonds of her own government.*

Proof. *Combining eqns.(11) and (12) we get*

$$C_1^H = \frac{\bar{Y} P_1^{Hh}}{P_1^H} + \frac{R_0^H \left(B_0^{Hh} - B_0^H\right)}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F}. \tag{13}$$

Using market completeness leads to

$$\frac{C_1^H}{C_1^F} = Q_1 = 1 \tag{14}$$

or

$$C_1^H = C_1^F. \tag{15}$$

This condition along with no consumption bias and eqn.(8) implies that

$$C_1^{Hh} = C_1^{Fh} = C_1^{Hf} = C_1^{Ff} = \frac{\bar{Y}}{2}. \tag{16}$$

Eqn.(6) then implies $\frac{P_1^{Hh}}{P_1^{Hf}} = \frac{P_1^{Ff}}{P_1^{Fh}} = 1$ *and using the price aggregate definition, we have* $\frac{P_1^{Hh}}{P_1^{H}} = \frac{1}{2}$*. By eqns.(16) and (4), we have* $C_1^H = \frac{\bar{Y}}{2}$*. Plugging these into eqn.(13) yields*

$$\frac{\bar{Y}}{2} = \frac{\bar{Y}}{2} + \frac{R_0^H \left(B_0^{Hh} - B_0^H\right)}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F}.$$

The market completeness condition is then satisfied only if we can find B_0^{Hh} *and* B_0^{Hf} *that satisfy the above equation for all realizations of shocks and is not contingent on them. The unique asset allocation that fulfills this requirement is* $B_0^{Hh} = B_0^H$ *and* $B_0^{Hf} = 0$*.* ■

As we make clear in section 3, we want to emphasize that for there to be domestic bias in nominal bonds, only two features of the model described above are essential. First, there has to be some price level uncertainty in the bond returns. Second, the government has to tax relatively more domestic agents than foreign agents. The result is also robust to allowing government spending rather than taxes adjust to fulfill the government budget constraint.

2.3 Home Equity Bias

Now we consider the case where there is trade in both government nominal bonds and equities. As shown in Cole and Obstfeld (1991), with assumption 1, equity allocation with endowments shocks is indeterminate, as all possible combinations of equity allocations achieve perfect risk sharing. This is because the terms of trade movement perfectly pools all risk arising from endowment shocks, regardless of equity holdings.

We introduce government expenditure shocks instead of endowment shocks, and show that this result can be overturned, and that there is a specific allocation for equity which achieves the complete market allocation. In fact when government spending falls only on domestic goods, it leads to a complete home bias in equity holdings, as shown in the proposition below:

Proposition 2 (Home Asset Bias) *Given assumption 1, (i) in the presence of nominal and government expenditure shocks, if (ii) the government taxes only the domestic agent and (iii) all government expenditure falls on domestic goods, then the agent holds a) only the nominal bonds of her own government and b) only domestic equity.*

Proof. *Eqns.(14) and (15) still hold, given the agent's preferences and complete markets. Using eqns.(6), (8), and (14) we get*

$$C_1^{Hh} = C_1^{Fh} = \frac{1}{2}(\bar{Y} - G_1^{Hh}); \quad C_1^{Ff} = C_1^{Hf} = \frac{1}{2}(\bar{Y} - G_1^{Ff}).$$

Plugging this back to eqn.(4) yields

$$C_1^H = \frac{1}{2}(\bar{Y} - G_1^{Hh})^{\frac{1}{2}}(\bar{Y} - G_1^{Ff})^{\frac{1}{2}} \tag{17}$$

and to eqn.(6) yields

$$\frac{P_1^{Hh}}{P_1^{Hf}} = \frac{\bar{Y} - G_1^{Ff}}{\bar{Y} - G_1^{Hh}}; \; \frac{P_1^{Hh}}{P_1^H} = \frac{1}{2}\left(\frac{\bar{Y} - G_1^{Ff}}{\bar{Y} - G_1^{Hh}}\right)^{\frac{1}{2}} \text{ and } \frac{P_1^{Ff}}{P_1^F} = \frac{1}{2}\left(\frac{\bar{Y} - G_1^{Hh}}{\bar{Y} - G_1^{Ff}}\right)^{\frac{1}{2}}. \tag{18}$$

Combining eqns.(3) and (7) leads us to

$$C_1^H + \frac{R_0^H B_0^H}{P_1^H} + G_1^{Hh}\frac{P_1^{Hh}}{P_1^H} = \frac{\bar{Y} P^{Hh}}{P_1^H} + \frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F} + E_0^{Hh}\frac{\bar{Y} P_1^{Hh}}{P_1^H} + E_0^{Hf}\frac{\bar{Y} P_1^{Ff}}{P_1^F}. \tag{19}$$

Using eqns.(17) and (18) in (19) we get

$$\frac{1}{2}(\bar{Y} - G_1^{Hh})^{\frac{1}{2}}(\bar{Y} - G_1^{Ff})^{\frac{1}{2}} + \frac{R_0^H B_0^H}{P_1^H} + G_1^{Hh}\frac{1}{2}\left(\frac{\bar{Y} - G_1^{Ff}}{\bar{Y} - G_1^{Hh}}\right)^{\frac{1}{2}} = \bar{Y}\frac{1}{2}\left(\frac{\bar{Y} - G_1^{Ff}}{\bar{Y} - G_1^{Hh}}\right)^{\frac{1}{2}}$$
$$+\frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F} + E_0^{Hh}\bar{Y}\frac{1}{2}\left(\frac{\bar{Y} - G_1^{Ff}}{\bar{Y} - G_1^{Hh}}\right)^{\frac{1}{2}} + E_0^{Hf}\bar{Y}\frac{1}{2}\left(\frac{\bar{Y} - G_1^{Hh}}{\bar{Y} - G_1^{Ff}}\right)^{\frac{1}{2}}.$$

The market completeness condition is then satisfied only if we can find E_0^{Hh}, E_0^{Hf}, B_0^{Hh} and B_0^{Hf} that satisfy the above equation for all realizations of shocks and is not contingent on them. The unique asset allocation that fulfills this requirement is $B_0^{Hh} = B_0^H$, $B_0^{Hf} = 0$, and $E_0^{Hh} = E_0^{Hf} = 0$. ■

The home bias for nominal bonds follows exactly the same logic as in the previous section, where it is used as insurance against the nominal shocks and the resulting movement in taxes. What is the intuition for the home equity bias result? When a domestic government spending shock hits, domestic taxes have to increase to fulfill the budget constraint. Given this increase in taxes and the subsequent negative wealth effect, the agents would like to hold more of an asset that has a higher rate of return. When government spending falls only on domestic good, it increases the relative price of the domestic good compared to the foreign good, that is, it improves the terms of trade facing the domestic economy. This can be seen clearly from the expression $\frac{P_1^{Hh}}{P_1^{Hf}} = \frac{\bar{Y} - G_1^{Ff}}{\bar{Y} - G_1^{Hh}}$. This implies that the relative rates of return on domestic equity are higher, since the difference in returns between domestic and foreign equity is given by $\frac{\bar{Y}}{P_1^H}\left[P_1^{Hh} - P_1^{Hf}\right]$. Hence optimal portfolios are biased domestically as it provides a hedge against taxation resulting from government expenditure shocks.

As we make clear in section 3, we want to emphasize that for there to be domestic bias in equity, what is essential is that government spending fall relatively more on the domestic good. In particular, the result is robust to the introduction of endowment shocks and some non-stochastic component to government spending.

3 Robustness

Here we allow for general preferences and progressively relax other assumptions of section 2. The representative consumer now maximizes

$$E_0 \left[\frac{\left(C_1^H\right)^{1-\sigma}}{1-\sigma} \right] \quad \sigma > 0$$

where C_1^H is a CES aggregator of domestic and foreign final goods defined as

$$C_1^H = \left[a^{\frac{1}{\eta}} \left(C_1^{Hh}\right)^{\frac{\eta-1}{\eta}} + (1-a)^{\frac{1}{\eta}} \left(C_1^{Hf}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \quad \eta > 0 \tag{20}$$

where C_1^{Hh} and C_1^{Hf} are home consumption of the domestic and foreign goods and η is the elasticity of substitution between home and foreign goods. Here a denotes the relative preference of domestic over foreign goods, with $a > 0.5$ implying home consumption bias in preferences. Expenditure minimization by the agent will imply the following utility-based aggregate price index at home $P_1^H = \left[a \left(P_1^{Hh}\right)^{1-\eta} + (1-a) \left(P_1^{Hf}\right)^{1-\eta} \right]^{\frac{1}{1-\eta}}$.

3.1 Home Bond Bias Revisited

Here we revisit the result on home bias in nominal bonds in this general preferences set up. We also progressively relax the assumptions we made on no taxes on the foreign agent, only taxes adjusting, and no real government bonds.

3.1.1 General Preferences

The result of home bias in nominal bonds is valid in this general setup on preferences. With only nominal shocks and taxes only on the domestic agent, we show in proposition 3 in the appendix that the agent holds only the nominal bonds of her own government. The reason is that since the complete market allocation can be supported by using only nominal bonds even with general preferences, nominal shocks do not have an effect on relative prices. Therefore, the only uncertainty over the price level and the resulting movement in taxes can still be completely hedged by a complete bias in nominal bonds.

3.1.2 Tax on Foreign Agent

Here we allow governments to tax both the domestic and the foreign agents and assume that tax on the domestic agent is k times the tax on the foreign agent. That is, $\tau_1^{Hh} = k\tau_1^{Hf}$, where τ^{Hh} and τ^{Hf} are lump-sum taxes of the domestic government on the domestic and the foreign agent respectively. Using this rule, the government budget constraint, and the symmetry between the two countries, we can write the consumer budget constraint as

$$C_1^H + \frac{k}{(1+k)}\frac{R_0^H B_0^H}{P_1^H} + \frac{1}{(1+k)}\frac{R_0^F B_0^F}{P_1^F} = \frac{\bar{Y} P_1^{Hh}}{P_1^H} + \frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F} Q_1. \tag{21}$$

With only nominal shocks, in proposition 4 in the appendix we show that $k > 1$ implies home bias in nominal bond holdings. The interpretation of this result is very similar to that of proposition 1. Now price level shocks in the two countries affect the total taxes paid by the agent and the agent then will want to hedge against them through a combination of nominal bonds that has returns perfectly correlated with the total tax movements. A portfolio with domestic to foreign bonds ratio of k does precisely this job. Therefore, there will be home bias in nominal bonds as long as $k > 1$, that is, the domestic government's tax revenue is generated mostly by taxes on the domestic agent.[13]

3.1.3 Adjusting Government Expenditure

Here we make government spending adjust rather than taxes to fulfill the government budget constraint. This implies that $\frac{R_0^H B_0^H}{P_1^H} = -G_1^{Hh}\frac{P_1^{Hh}}{P_1^H}$. In proposition 5 in the appendix we show that up to a first-order, domestic bond holdings are given by $\frac{B_0^H\left(\sigma - \sigma B_0^H - a\sigma + 2a^2 + \sigma a\eta - a\right)}{1+\sigma\eta+4a(a-1)-\sigma B_0^H}$.[14] In Table 2, we show that this implies home debt bias for any reasonable parameters values. Our debt home bias result is therefore robust to this change.

What is the intuition for this result? When a positive price level shock hits, the returns on domestic bonds are lower compared to the foreign bond. Since real debt outstanding has gone down, government expenditure, which falls on domestic goods, increases. Then terms of trade improves, which increases the value of the domestic endowment. For optimal risk

[13]We also tried other taxation schemes, such as taxes on exports: $\tau^H = (1+\bar{\tau})\frac{C_1^{Hf}P_1^{Hf}}{P_1^H}$ and $\tau^F = (1+\bar{\tau})\frac{C_1^{Fh}P_1^{Fh}}{P_1^f}$. Our result is robust to these specifications.

[14]General preferences, nominal shocks, and government expenditure adjustment lead to market incompleteness in the non-linear model. This is due to the non-linear non-separability of the effect of the shocks. However, in a first-order approximation of the model, each shock's effect over returns and allocations can be analyzed separately and market completeness can be supported. Given that these higher-order effects of the shocks are not driving our results, we decided to proceed with the approximate model, which yields an analytical solution.

sharing, the domestic agent wants to hold an asset that has a relatively low return. Domestic government bond is precisely such an asset.

Table 2 shows that as η increases, domestic bond holdings decreases. This is because the effects of the price level shock on the terms of trade decreases, while the effect on the relative bond returns remains the same. When $\eta- > \infty$, there is complete diversification as the bond returns contain fully idiosyncratic risk.

3.1.4 Real Government Bonds

So far, we have assumed that the government only issues nominal debt. One might wonder if this restriction plays a crucial role in our results and whether they might be overturned if we allowed the government to issue some inflation-indexed debt in addition to nominal debt. Intuitively, this should not be the case, as long as there is some nominal risk. This is because an asset such as inflation-indexed debt will be useful to hedge against terms of trade or real exchange movements and not price level risk, which will be hedged using a nominal asset. Therefore, as long as there is some uncertainty in the price level and taxes fall mostly on the domestic agent, there should be domestic nominal debt bias, regardless of what real bond allocation is needed to hedge against real exchange rate risk.

We show in the appendix that this intuition goes through mathematically in an extension of our model where the government issues both nominal and CPI-indexed debt. Notice that if we just have nominal shocks and trade in nominal and real bonds, then since all of the nominal risk can be hedged using the nominal bond and markets are complete, nominal shocks do not have an effect on relative prices. Therefore, $\frac{P_1^{Hh}}{P_1^{Hf}} = 1$ and hence $Q_1 = 1$. Then, real bonds will be completely redundant and will have no role to play in insurance against any shocks. To establish a meaningful role for real bonds, we need to introduce another shock in the model and therefore, now we allow for both nominal and government spending shocks.

In proposition 6 in the appendix we show that upto a first order, the agent holds only the nominal bonds of her government while foreign real bond holdings are given by $\frac{(a-1)\{1-\sigma-2a(1-\sigma\eta)\}}{\sigma(2a-1)}$. The intuition for the complete home nominal bond bias is the same as in the rest of the paper. Next, notice with $\sigma = 1$ and $\eta = 1$ it is optimal for the agents also to hold no foreign bond real bonds because as is well known, with these parameter values, the terms of trade movement automatically pool risk due to government spending shocks.[15] Hence the agents do not hold any position in foreign real bonds in order to not get exposed to unwarranted terms of trade risk.

[15] In fact, with these preferences, the result holds exactly and not just upto a first-order approximation.

With more general preference parameters agents do take some non-zero position on foreign real bonds to hedge against terms of trade risk. Real bonds in this way act as a substitute for a similar role primarily of equity, and not of nominal bond.[16] Moreover, whether the position is positive or negative depends on the parameter values. Therefore, this example makes clear that the presence of indexed-debt will not interfere with the price uncertainty hedging property of the nominal bond and our result of home nominal bond bias is robust to this extension. For the rest of the paper, we therefore, do not consider real bonds.

3.2 Home Equity Bias Revisited

Now we consider general preferences with trade in both government nominal bonds and equities. We also progressively relax our assumptions on taking government spending as a completely exogenous process and it falling only on domestic goods.

3.2.1 Endogenous Government Spending

For the equity bias result in section 2.3, we assumed that all of government spending is an exogenous process. Here we show that our results are robust even if we allow government spending to be endogenous to the real value of outstanding debt, as long as some portion of government spending is exogenous. We consider the following

$$G_1^{Hh}\left(\frac{P_1^{Hh}}{P_1^H}\right) = \omega\varepsilon_1^{Gh} + (1-\omega)\,\frac{R_0^H B_0^H}{P_1^H} \tag{22}$$

where $\omega > 1$ is the weight on the exogenous component of government spending. In proposition 7 in the appendix we show that upto a first order, the agent holds only the nominal bonds of her own government and equity holdings are biased domestically.

The intuition for this result is that if there is some exogenous stochastic component in government expenditure, this shock would again affect both taxes and the equity returns in the same way as before. Then, domestic equity provides a hedge against this shock. In addition, as long as there is some adjustment of taxes to nominal shocks, then holding domestic bond is a good hedge against nominal risk. In fact the asset holdings in this specification are identical to the ones obtained if all of government spending was exogenous and only taxes adjust to fulfill the government budget constraint.

[16] This similarity between the roles of real bonds and equity is emphasized for example, in Couerdacier and Gourinchas (2008).

3.2.2 Government Spending on Foreign Goods

Here we specify that the government spends a constant fraction of its total consumption on domestic goods as given by $G_1^{Hh} = xG_1^{Hf}$ and $G_1^{Ff} = xG_1^{Fh}$ where $x > 0$. This means that if $x > 1$, the government consumption is biased towards domestic goods. The exogenous processes for government expenditures are now

$$G_1^H = G_1^{Hh}\left(\frac{P_1^{Hh}}{P_1^H}\right) + G_1^{Hf}\left(\frac{P_1^{Hf}}{P_1^H}\right) = \varepsilon_1^{Gh} \text{ and } G_1^F = G_1^{Fh}\left(\frac{P_1^{Fh}}{P_1^F}\right) + G_1^{Ff}\left(\frac{P_1^{Ff}}{P_1^F}\right) = \varepsilon_1^{Gf}.$$

As shown extensively in the literature starting with Lucas (1982), in an environment with idiosyncratic shocks to endowment and no consumption bias in preferences, the agent's optimal allocation for claims on the realization of these endowments would seek complete diversification of his country-specific risk. In this section we show that this result can be overturned, and substantial home equity bias can be generated as an optimal portfolio decision, when stochastic government expenditure is biased towards domestic goods.

In the appendix we show that domestic holdings of home equity, denoted here for simplicity by θ, are given upto a first-order by

$$\theta = -\frac{1}{2} + \frac{1}{2}(2a-1)\left[\frac{1+x}{x-1}\left(\frac{2a-1}{\sigma} - \frac{4\eta a(a-1)}{2a-1}\right) + 1 - \frac{1}{\sigma}\right]. \tag{23}$$

Notice that for $a = 0.5$, this expression reduces to

$$\theta = \frac{1}{2}\left(\frac{\eta(1+x)}{x-1} - 1\right). \tag{24}$$

In this case, we also show in proposition 8 that the agent holds only domestic nominal bonds. Eqn.(24) implies home equity bias whenever $x > 1$ even without any preference bias on consumption of domestic agents. For a general value of a using eqn.(23), we find numerically that once we assume $\sigma > 0.2$,[17] $x > 1$ is still a sufficient condition for home bias in equity, regardless of the value of η.

What is the intuition for this result? As before, when a domestic government spending shock hits, domestic taxes have to increase to fulfill the budget constraint. Given this increase in taxes and the subsequent negative wealth effect, the agents would like to hold more of an asset that has a higher rate of return. When government spending falls relatively more on the domestic good, since it is effectively a positive demand shock, it increases the relative price of the domestic good compared to the foreign good, $\hat{P}_1^{Hh} - \hat{P}_1^{Hf}$. That is, it improves

[17] Notice that the literature usually assumes either log-utility or $\sigma > 1$, as Coeurdacier et al (2007).

the terms of trade facing the domestic economy. Since the relative rate of return on domestic equity is given by $\left(\hat{Y}_1^H + \hat{P}_1^{Hh} - \hat{P}_1^H\right) - (\hat{Y}_1^F + \hat{P}_1^{Hf} - \hat{P}_1^H) = \hat{P}_1^{Hh} - \hat{P}_1^{Hf}$, it is now higher. Hence, optimal portfolios are biased domestically as it provides a hedge against taxation resulting from government expenditure shocks.

Notice that θ is a *decreasing* function of x, if $x > 1$. The intuition is clear: in response to a government expenditure shock, x slightly above 1 would make the relative returns on domestic equity only slightly higher and so a huge asset position is needed to hedge against the taxation movement, which is invariant to the composition of government expenditure.

Finally, by comparing eqn.(24) with eqn.(23), we see that there is greater home bias in equity holdings when $a > 0.5$ compared to $a = 0.5$, whenever η is lower than 1. The intuition for this result is the following. With $a > 0.5$, there is an additional channel for government spending to affect equity holdings since given a government spending shock, the real exchange rate appreciates leading to a higher price for the domestic good. Now because the domestic agent is more biased towards the domestic good, which has become more expensive relative to the foreign good, and she has relatively inelastic demand as $\eta < 1$, she needs to hold more of the asset with higher returns. With government spending falling relatively more on domestic good, for the same reasons described before, domestic equity is precisely such an asset.

3.3 Market Incompleteness

We have used market completeness so far to help us show our mechanisms clearly. A necessary robustness check of our results however, is market incompleteness since empirical evidence suggests that there is imperfect risk sharing in the international financial markets.[18] We take up this task by allowing for nominal, government spending, and endowment shocks with trade in nominal bonds and equities. This will imply that markets are incomplete, even up to first order. Moreover, there is a clear trade-off in the problem of equity allocation: while endowment shocks call for full diversification, the home-biased government expenditure shock leads to home bias in equity.

In the appendix, we show using recently developed techniques, that for $a = 0.5$, the equity allocation, θ, is given by

$$\theta = -\frac{1}{2} + \frac{1}{2}\frac{\eta\left(x^2 - 1\right)}{(\eta - 1)^2(1 + x)^2 + 2(1 - x)^2}. \tag{25}$$

[18] See for example, Corsetti et al (2008). Complete market models predict perfect comovement between the real exchange rate and relative consumption between countries, which is rejected empirically. This is also known as the Backus-Smith puzzle in the literature.

The optimal nominal bonds allocation is $B_0^{Hh} = B_0^H$, that is, full home bias once again. The first term in eqn.(25), which leads to $\theta = -\frac{1}{2}$, reflects the hedging motive against idiosyncratic endowment shocks. The second term reflects hedging against government spending shocks. When $x = 1$, government spending shock does not affect the terms of trade, and hence this term is zero and optimal equity holdings are fully diversified. In this situation, we have a generalized version of the Lucas (1982) model with government shocks.

When $x > 1$ however, the second term is positive, leading to a home bias in equity holdings. The expression makes it clear that this result does not depend on the value of η. In fig.1, we plot the value of θ for different values of η. Notice that as x increases above 1, there is a trade off between the shocks: while government expenditures shocks push the allocations to start high and to decrease monotonically, endowment shocks push for diversification. The sum of these effects leads to an initial increase and subsequent decrease of home bias in equity allocation, as x increases.

In the case of incomplete markets and any value for σ and $a > 0.5$, we show the system of equations to be solved in the appendix. The final analytical solution for the portfolio holdings turns out to be cumbersome and we resort to numerical solutions to find the condition for home bias in equity. We are particularly interested on how these allocations depend on x, the fraction of government consumption on domestic goods and the degree of consumers' home bias, $\frac{a}{1-a}$. A robust result is that for reasonable values of σ, x roughly greater than $\frac{a}{1-a}$ again generates home equity bias, regardless of the value of η. In the appendix, in fig. 2 we plot the results for for $\sigma = 1.5$ and for different values of a and η. It is clear that for all $x > \frac{a}{1-a}$, the home bias on equity is high. This approximate bound $x > \frac{a}{1-a}$ can be made exact in the case of log-utility, as shown in proposition 9 in the appendix.

We see that here the change from the case with complete markets, or incomplete markets but with $a = 0.5$, is that the necessary and sufficient condition to generate home bias in equity is now $x > \frac{a}{1-a}$ as opposed to $x > 1$. In other words, now we need the government to be more biased than the consumer in order to generate home bias in equity, but the result is still independent of the value of η. Why does the case with incomplete markets and $a > 0.5$ require more bias in government spending compared to the cases we have analyzed before? The fundamental reason is that with incomplete markets and $a > 0.5$, the real exchange rate moves in response to the shocks, and hence there arises a hedging motive against this real exchange rate movement. In essence, since $\frac{a}{1-a}$ determines the extent of agent's bias in consumption and the resulting role for real exchange rate hedging, $x > \frac{a}{1-a}$ is needed to ensure that the terms of trade movement due to government shocks counteracts the real exchange rate movement.

Another important result in this case is that due to market incompleteness, monetary policy affects the terms of trade and has real effects even with log utility. As a result, we show in the appendix that while there is still substantial home bias in bonds, the agent does not hold only domestic bonds as it can improve insurance by holding some foreign bonds.

3.4 Comparison With the Literature

We are not aware of any other paper that has shown equilibrium government debt portfolios to be predominantly domestic. Devereux and Sutherland (2006) have an endowment economy model with nominal bonds, but the bonds are inside assets in net zero supply. In their model, where they consider exogenous nominal demand, a positive domestic endowment shock has a negative effect only on the domestic price level. Therefore, domestic bond returns are high precisely when output is high. In order to hedge against the endowment shock, agents therefore, take a short position in domestic nominal bonds. In our model, in contrast, a domestic endowment shock affects both the domestic and foreign price levels by the same amount. Thus, government debt positions cannot be used to hedge against output risk. In fact, with only endowment shocks, domestic and foreign government bonds are perfect substitutes. Nominal bonds are therefore used to hedge against idiosyncratic country specific price level shocks, which as we have explained before, create a positive correlation between taxes and returns on domestic bonds.

What is the value-added of our mechanism for generating home equity bias in relation to the previous literature with endowment economies? First, as explained in detail in Obstfeld (2006) and Coeurdacier et al (2007), the previous literature in a set-up similar to ours can generate home bias in equity only by starting with the assumption that $a > 0.5$. In this paper, we generate equity home bias even when $a = 0.5$. Second, even after assuming $a > 0.5,$ for reasonable degree of risk aversion, the mechanism requires that $\eta,$ the elasticity of substitution between domestic and foreign goods, be (approximately) less than 1.[19] There is a great deal of uncertainty in the empirical literature regarding the value of $\eta,$ and most estimates put it above 1.[20] Given this, we view the fact that our result is independent of the value of η to be a significant strength of our proposed mechanism.

Third, the previous literature's mechanism which generates home equity bias in response to endowment shocks by relying on $a > 0.5$ and η (approximately) less than 1, implies a strong positive correlation between the real exchange rates and equity returns. This is because equity positions are used to hedge against real exchange rate risk. As van Wincoop

[19] In fact, in our set-up with nominal and endowment shocks, which replicates the previous literature, bond holdings will be completely domestic, while equity holdings will be given by $-\frac{1}{2}\left[1+\frac{(2a-1)(\rho-1)}{-\rho+4\eta\rho(1-a)+(2a-1)^2}\right]$. Notice that equity holdings are fully diversified if $a = 0.5$ or if $\rho = 1$.

[20] See Coeurdacier et al (2007) and citations therein.

and Warnock (2006) find however, this correlation is close to 0 in the data. In our set up, when $a = 0.5,$ the real exchange rate upto first order is zero, there is no correlation between the real exchange rate and relative equity returns. We view this as another strength of our mechanism since it clearly shows that equity bias is not a result of hedging against real exchange rate risk. Even when there is home consumption bias in preferences, and hence real exchange rate movement, since we have both government spending shocks and endowment shocks, the correlation between real exchange rates and equity returns is not pinned down to be high and positive. For example, when we compute Cov_0(relative equity returns$_1, \hat{Q}_1)/Var_0$(relative equity returns$_1$) for $\eta = 1.2$ and $x = 4,$ it is 0.0855 and for $\eta = 1.5$ and $x = 4,$ it is -0.0450.

To drive home the difference from the previous literature, table 3 compares results for equity holdings only with endowment shocks, with those in our model with government spending shocks and endowment shocks and $a > 0.5$, that is, section 3.3. The results are for $\sigma = 1.5$. The table makes clear that the introduction of a government spending shock that is biased towards domestic good leads to home bias in equity, even when $\eta > 1$. The previous literature, on the other hand, relies on $\eta < 1$, which is outside the range of most empirical estimates.

In conclusion, therefore, we have shown that in a variety of settings, complete or incomplete markets, log utility or general CRRA utility, home consumption bias or not, a sufficient condition for home bias in equity is that the government spending is more biased towards domestic goods as compared to the consumer. We have also shown that the result of home bias in bonds is valid when we allow for trade in equities and the aforementioned extensions. Most importantly, we generate home equity bias without depending on the value of $\eta,$ the elasticity of substitution between domestic and foreign goods.

4 Dynamic model with production

4.1 Setup

In this section we present a fully dynamic infinite-horizon model with production so that we can undertake a realistic quantitative exercise. In this model, there are two symmetric production economies, each populated by a representative agent with symmetric preferences. Each country specializes in the production of one tradable final good. Within each country, the agent consumes a domestically produced good and an imported good.

Both of the tradable goods are produced in differentiated brands by a continuum of monopolistically competitive firms of measure 1. A brand of a given good is an imperfect substitute for all other brands of that good. Firms use only labor, that is supplied competitively and is immobile between countries, in their production process. For simplicity, there are no intermediate and non-tradable goods in the model. Furthermore, prices are fully flexible.

In each country, there is also a government that supplies one period non state-contingent nominal bonds and taxes the labor income of the representative agent and profits of the firm. The government conducts monetary policy using a interest rate rule and fiscal policy using a rule for taxes.

Agents in each country can trade claims to aggregate profits of the firms and hold domestic and foreign bonds with returns denominated in the respective currencies. Since there are three sources of aggregate uncertainty in the model: productivity shocks, monetary shocks, and government spending shocks, and asset trade is limited to only equities and nominal bonds, markets are incomplete and therefore, risk-sharing of the country-specific shocks is imperfect.

We want to emphasize here that a infinite horizon version of the endowment economy with lump sum taxes model of section 2 would imply the same portfolio holdings as the two period set-up. Therefore, the main difference in results of the more realistic model of this section come from the tax structure and production and not from the dynamic setup.

4.1.1 Consumer

A representative agent at home maximizes the expected present discounted value of utility

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_t^H\right)^{1-\sigma}}{1-\sigma} - \lambda \frac{\left(L_t^H\right)^{1+\nu}}{1+\nu} \right] \quad \beta > 1,\ \sigma > 0,\ \nu > 0,\ \lambda > 0 \tag{26}$$

where C_t^H is the composite domestic consumption good and L_t^H is domestic labor supply. The agent is subject to the period budget constraint

$$C_t^H + \frac{B_t^{Hh}}{P_t^H} + \frac{B_t^{Hf}}{P_t^F} Q_t + q_t^H \ E_t^{Hh} + q_t^F \ E_t^{Hf} Q_t = (1-\tau_t^L) w_t^H L_t^H \tag{27}$$

$$+\Pi_t^H + \frac{R_{t-1}^H B_{t-1}^{Hh}}{P_t^H} + \frac{R_{t-1}^F B_{t-1}^{Hf}}{P_t^F} Q_t + \left(q_t^H \ + \Pi_t^H\right) E_{t-1}^{Hh} + \left(q_t^F \ + \Pi_t^F\right) Q_t E_{t-1}^{Hf}$$

where $B_{t-1}^{Hh},\ B_{t-1}^{Hf},\ E_{t-1}^{Hh}$, and E_{t-1}^{Hf} are holdings of domestic nominal bonds, foreign nominal bonds, claims to aggregate after-tax profits of domestic firms, and claims to aggregate after-tax profits of foreign firms purchased in period $t-1$ to be brought into period t. We assume that the domestic agent owns the domestic firms and sells claims to them.

Moreover, P_t^H is the aggregate domestic price level, P_t^F is the aggregate foreign price level, Q_t is the real exchange rate, q_t^H is the (real) price of one unit of claim to domestic profits, q_t^F is the (real) price of one unit of claim to foreign endowment, Π_t^H is after-tax aggregate real profits of domestic firms, Π_t^F is after-tax aggregate real profits of foreign firms, R_{t-1}^H is the nominal interest rate on domestic bonds accruing to bond holdings in period t (but known in period $t-1$), R_{t-1}^F is the nominal interest rate on foreign bonds accruing to bond holdings in period t (but known in period $t-1$), τ_t^L is the rate of labor income tax, and w_t^H is the real wage at home. For future purposes, define real wealth of the home agent W_t^H as

$$W_t^H = \frac{B_t^{Hh}}{P_t^H} + \frac{B_t^{Hf}}{P_t^F} Q_t + q_t^H \ E_t^{Hh} + q_t^F \ E_t^{Hf} Q_t.$$

The composite consumption good C_t^H is a CES aggregate of domestic C_t^{Hh} and foreign C_t^{Hf} final goods as defined in section 3. The home consumption good C_t^{Hh} is produced in differentiated brands c_t^{Hh} by a continuum of monopolistically competitive home firms indexed j and of measure 1, and is defined as

$$C_t^{Hh} = \left[\int_0^1 c_t^{Hh}(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \quad \theta > 1 \tag{28}$$

where the elasticity of substitution among the brands is given by θ. Similarly, the foreign consumption good C_t^{Hf} is produced in differentiated brands c_t^{Hf} by a continuum of monopolistically competitive foreign firms indexed f and of measure 1, and is defined as

$$C_t^{Hf} = \left[\int_0^1 c_t^{Hf}(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}} \tag{29}$$

where the elasticity of substitution among the brands is given by θ.

As is well known, expenditure minimization by the agent will imply a utility-based aggregate price index at home, P_t^H, exactly as in section 3. Expenditure minimization will also imply the following domestic price level of the home consumption good $P_t^{Hh} = \left[\int_0^1 p_t^{Hh}(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}}$, where $p_t^{Hh}(j)$ is the domestic price level of brand j of the domestic good, and the following domestic price level of the foreign consumption good $P_t^{Hf} = \left[\int_0^1 p_t^{Hf}(f)^{1-\theta} df \right]^{\frac{1}{1-\theta}}$, where $p_t^{Hf}(f)$ is the domestic price level of brand f of the foreign good.

Similarly, given the definition of the consumption goods and the price levels, manipulation of the demand curves at the brand level gives

$$\frac{c_t^{Hh}(j)}{C_t^{Hh}} = \left(\frac{p_t^{Hh}(j)}{P_t^{Hh}}\right)^{-\theta} \qquad \frac{c_t^{Hf}(j)}{C_t^{Hf}} = \left(\frac{p_t^{Hf}(j)}{P_t^{Hf}}\right)^{-\theta}. \tag{30}$$

The law of one price holds among the tradable brands and hence we have

$$p_t^{Hh}(j) = S_t\ p_t^{Fh}(j) \quad p_t^{Hf}(f) = S_t\ p_t^{Ff}(f) \tag{31}$$

where $p_t^{Fh}(j)$ and $p_t^{Ff}(f)$ are the foreign price level of price of the brand j of the domestic good and brand f of the foreign good.

Given the definition of the consumption indices and the price indices resulting from expenditure minimization, the optimization problem of the consumer, that is maximizing eqn.(26) with respect to C_t^H, B_t^{Hh}, B_t^{Hf}, E_t^{Hh}, E_t^{Hf}, and L_t^H, subject to eqn.(27), results in

$$\frac{1}{\left(C_t^H\right)^{\sigma}} = E_t\left[\frac{\beta\ P_t^H R_t^H}{\left(C_{t+1}^H\right)^{\sigma} P_{t+1}^H}\right] = E_t\left[\frac{\beta P_t^F R_t^F Q_{t+1}}{\left(C_{t+1}^H\right)^{\sigma} P_{t+1}^F Q_t}\right], \tag{32}$$

$$\frac{1}{\left(C_t^H\right)^{\sigma}} = E_t\left[\frac{\beta\ \left(q_{t+1}^H + \Pi_{t+1}^H\right)}{\left(C_{t+1}^H\right)^{\sigma} q_t^H}\right] = E_t\left[\frac{\beta\left(q_{t+1}^F + \Pi_{t+1}^F\right) Q_{t+1}}{\left(C_{t+1}^H\right)^{\sigma} q_t^F Q_t}\right] \tag{33}$$

$$\lambda\left(L_t^H\right)^{\nu} = \left(C_t^H\right)^{-\sigma}(1-\tau_t^L)w_t^H. \tag{34}$$

Eqns.(32)-(33) are the familiar euler equations with respect to the four assets that are available while eqn.(34) determines labor supply decisions of the agent by equating the marginal rate of substitution between leisure and consumption with after tax real wage.

The budget constraint and the optimization problem of the foreign representative agent is entirely analogous and is not presented here to conserve space. For our purposes, the most important equations with respect to the foreign agent are the euler equations, which we present below

$$\frac{1}{\left(C_t^F\right)^{\sigma}} = E_t\left[\frac{\beta\ P_t^H R_t^H Q_t}{\left(C_{t+1}^F\right)^{\sigma} P_{t+1}^H Q_{t+1}}\right] = E_t\left[\frac{\beta P_t^F R_t^F}{\left(C_{t+1}^F\right)^{\sigma} P_{t+1}^F}\right], \tag{35}$$

$$\frac{1}{\left(C_t^F\right)^{\sigma}} = E_t\left[\frac{\beta\ \left(q_{t+1}^H + \Pi_{t+1}^H\right) Q_t}{\left(C_{t+1}^F\right)^{\sigma} q_t^H Q_{t+1}}\right] = E_t\left[\frac{\beta\left(q_{t+1}^F + \Pi_{t+1}^F\right)}{\left(C_{t+1}^F\right)^{\sigma} q_t^F}\right]. \tag{36}$$

4.1.2 Firms

Each brand j of the domestic good is produced by a single home firm j using the following linear production function

$$y_t^H(j) = A_t^H l_t^H(j) \tag{37}$$

where $y_t^H(j)$ is the domestic output of brand j, A_t^H is the country-specific productivity shock that follows an exogenous process, and $l_t^H(j)$ is the labor demand by firm j. Firms hire labor in a competitive market taking the wage as given and the labor used is homogenous across all firms j. The firms are identical except for the fact that they produce differentiated brands for the same good. The process for productivity is given by $\log A_t^H = \rho_A \ \log A_{t-1}^H + \epsilon_{a,t}$.

Firm j maximizes real profits, that is revenue less labor costs, given by

$$\frac{p_t^{Hh}(j)\ y_t^H(j)}{P_t^H} - w_t^H l_t^H(j) \tag{38}$$

subject to eqn.(37) and eqn.(30), leading to the familiar pricing equation

$$p_t^{Hh}(j) \ = \frac{\theta}{\theta-1} P_t^H \left(\frac{w_t^H}{A_t^H}\right) \tag{39}$$

where monopolistically competitive firms charge a price that is a mark-up times the nominal marginal cost.

The aggregate after tax real profits of the firms in the domestic economy can be written as

$$\Pi_t^H = (1-\tau_t^\pi)(P_t^{Hh} - \frac{w_t^H}{A_t^H} P_t^H)\frac{Y_t^H}{P_t^H} \tag{40}$$

and the optimization decision of the individual domestic firms gives

$$\frac{P_t^{Hh}}{P_t^H} = \frac{\theta}{\theta-1}\frac{w_t^H}{A_t^H}. \tag{41}$$

The optimization problem of the foreign firms is entirely analogous and is not presented here to conserve space.

4.1.3 Government

The home government faces the following period budget constraint

$$\frac{B_t^H}{P_t^H} = \frac{R_{t-1}^H B_{t-1}^H}{P_t^H} - \tau_t^L w_t^H L_t^H - \tau_t^\pi (P_t^{Hh} - \frac{w_t^H}{A_t^H} P_t^H) \frac{Y_t^H}{P_t^H} + G_t^{Hh} \left(\frac{P_t^{Hh}}{P_t^H} \right) + G_t^{Hf} \left(\frac{P_t^{Hf}}{P_t^H} \right) \quad (42)$$

where B_t^H is total nominal debt issued by the home government in period t and G_t^{Hh} and G_t^{Hf} respectively are the home government's spending on domestic and foreign good.[21] The ratio of labor tax revenue vs. profit tax revenue is for simplicity, constant

$$\tau_t^L w_t^H L_t^H = y \left[\tau_t^\pi (P_t^{Hh} - \frac{w_t^H}{A_t^H} P_t^H) \frac{Y_t^H}{P_t^H} \right] \quad (43)$$

where y is a parameter of our model.

We assume here that government spending over the differentiated brands of the domestic and foreign goods is defined in the same way as for the consumer with the same elasticity of substitution over the brands. That is,

$$G_t^{Hh} = \left[\int_0^1 g_t^{Hh}(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \qquad G_t^{Hf} = \left[\int_0^1 g_t^{Hf}(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}}. \quad (44)$$

The ratio of government spending over domestic vs. foreign good is for simplicity, constant

$$G_t^{Hh} = x G_t^{Hf} \quad (45)$$

where x is a parameter of our model. Government spending follows an exogenous process

$$G_t^H = G_t^{Fh} \left(\frac{P_t^{Fh}}{P_t^F Q_t} \right) + G_t^{Ff} \left(\frac{P_t^{Ff}}{P_t^F} \right) = \rho_G \; G_{t-1}^{Hh} + \epsilon_{g,t}. \quad (46)$$

In this paper, we do not consider explicit optimal government policy and use simple rules as descriptions of government policy. The government conducts monetary policy using a interest rate rule given by

$$R_t^H = \gamma_0 \left(P_t^H / P_{t-1}^H \right)^\gamma \exp(\epsilon_{r,t}^H) \quad (47)$$

where the interest rate shock follows the exogenous process $\log \epsilon_{r,t}^H = \rho_R \; \log \epsilon_{r,t-1}^H + e_{r,t}$ and fiscal policy using a rule for total tax revenue responding to real value of debt

[21] Notice we have no lump-sum taxes and allow the government to tax both the labor income of the home agent and the profits of home firms so that the model can be taken to the data realistically.

$$\tau_t^L w_t^H L_t^H + \tau_t^\pi (P_t^{Hh} - \frac{w_t^H}{A_t^H} P_t^H) \frac{Y_t^H}{P_t^H} = \phi_0 \left(\frac{B_t}{P_t^H} \right)^\phi . \tag{48}$$

Again, the foreign government's description is completely analogous and symmetric.

4.1.4 Market Clearing

Market clearing for goods implies

$$c_t^{Hh}(j)+c_t^{Fh}(j)+g_t^{Hh}(j)+g_t^{Fh}(j) = A_t^H l_t^H(j) \quad c_t^{Ff}(f)+c_t^{Hf}(f)+g_t^{Hf}(f)+g_t^{Ff}(f) = A_t^F l_t^F(j). \tag{49}$$

Similarly, market clearing for assets implies

$$\begin{aligned} E_t^{Hh} + E_t^{Fh} &= 0 \quad E_t^{Hf} + E_t^{Ff} = 0 \\ B_t^{Hh} + B_t^{Fh} &= B_t \quad B_t^{Hf} + B_t^{Ff} = B_t^F \end{aligned} \tag{50}$$

and total labor demand by firms equaling labor supply implies

$$\int_0^1 l_t^H(j) dj = L_t^H. \tag{51}$$

4.1.5 Competitive Equilibrium

An equilibrium is a set of quantities, $c_t^{Hh}(j)$, $c_t^{Hf}(j)$, $c_t^{Fh}(j)$, $c_t^{Ff}(j)$, $l_t^H(j)$, $l_t^F(j)$, E_t^{Hh}, E_t^{Hf}, B_t^{Hh}, B_t^{Hf}, B_t, E_t^{Ff}, E_t^{Fh}, B_t^{Ff}, B_t^{Fh}, B_t^F, τ_t^L, τ_t^π prices, $p_t^{Hh}(j)$, $p_t^{Hf}(j)$, $p_t^{Ff}(j)$, $p_t^{Ff}(j)$, Q_t, S_t, q_t^H, q_t^F, w_t^H, w_t^F, R_t^H, R_t^F, and exogenous processes $A_t^H(j)$, $A_t^F(j)$, G_t^H, G_t^F, $\epsilon_{r,t}$, $\epsilon_{r,t}$ for all $t \geqslant 0$, that satisfy eqns.(27)-(51).

4.2 Quantitative analysis

Here we conduct a quantitative analysis of our production model to investigate whether the asset holdings that our model predicts match the ones observed in the data. We solve the model using approximation methods around a non-stochastic symmetric steady state. The approximated equations are provided in the appendix. Since markets are incomplete, we compute steady state asset holdings using the same methodology detailed in the appendix for section 3.3.

4.2.1 Calibration

Next, we describe in detail how we calibrate the various parameters in our model.

Preference parameters: We set β, the discount rate, as 0.99, so that the quarterly real interest rate is 4%, and following the literature that has estimated σ, the risk aversion parameter, for example, Smets and Wouters (2008), as 1.5. We choose υ, the inverse of the Frish elasticity of labor supply, to be 4 following the norm in the literature. In accordance with many papers in international macroeconomics, such as Chari et al (2002), we pick a, the parameter governing home bias in consumption, as 0.76. There is no empirical consensus in the literature on the value of η, the elasticity of substitution between domestic and foreign goods, so we consider a range of values from $0.95 - 4$. This range encompasses values used in the literature such as Coeurdacier et al (2007) and Chari et al (2002). We set θ as 11 , which implies a before-tax profit share in the economy of 9%. This again is a widely used value in the literature.

Policy parameters: For the parameters governing monetary and tax policy rules, γ and ϕ, respectively, to ensure the existence and uniqueness of the price level, we need either γ, $\phi > 1$ (in which case monetary policy will be active and fiscal policy passive) or γ, $\phi < 1$ (in which case monetary policy will be passive and fiscal policy active). We pick γ, $\phi = 1.5$ in the baseline calibration, which implies active monetary policy and passive fiscal policy. Our results are robust to the particular values that we pick for these parameters, as long as an unique equilibrium exists. We set y to be 4 , which implies that 80% of total tax revenue is through labor taxes and 20% through profit taxes. We choose $\bar{B}$ as 1.26, which implies a steady state debt-to-GDP ratio of 126%. Our results are also robust to the exact number that we pick for the parameter. We view these calibrations as a plausible benchmark for advanced economies.

The parameter x, which governs the portion of government spending that falls on domestic goods vs. foreign goods, is important for our analysis. We could use Corsetti and Muller (2006) to calibrate this parameter. Their estimate would suggest a value of x around 9 for advanced economies. Here, we take a more conservative approach and use a wide range of values of x, from 1.5 to 8, to check the robustness of our results. We then discuss the range of values for x that is needed to generate home bias in equities that is observed in the data.

Exogenous processes: To estimate these parameters, we use quarterly US data from 1972:1 - 2008:4 and impose symmetry for the two countries. Using the production function, we can measure the aggregate productivity shocks exactly as $\log(A_t^i) = \log(Y_t^i) - \log(L_t^i)$, $i = H, F$. Using real GDP and total non-farm hours, we estimate $\rho_A = 0.98$ and $\sigma_A^2 = 0.0036\%$. These values are in the range used in the literature. Since we set $\gamma = 1.5$, we then use eqn.(47) to measure nominal shocks. Using the Fed funds rate and CPI inflation, we estimate

$\rho_R = 0.45$ and $\sigma_R^2 = 0.0083\%$. Finally, for government expenditure shocks, we use real Federal consumption expenditure and estimate $\rho_G = 0.966$ and $\sigma_G^2 = 0.0077\%$.

These parameters are important for our analysis since they define the risk that portfolio decisions respond to. For this reason, we conduct several robustness checks on the calibration of these parameters, as detailed in the robustness section below. None of the alternate calibrations change the quantitative conclusions of the paper.

4.2.2 Results

Table 5 reports the steady state asset holdings of our model using the parameter values listed in table 4. The results of our calibrated model, with consistently higher than 70% of asset holdings in domestic assets, match quantitatively the empirical findings for a wide range of parameter values for the elasticity of substitution and the relative proportion of government spending falling on domestic goods vs. foreign goods. Given the difficulty in the literature in generating empirically valid portfolio bias for reasonable parameter values, we view these results as a contribution of our paper.

The intuition for home bond bias is the same as in section 2. In the model, for bonds with nominal returns known one period in advance, the risk that agents face is in the form of the price level next period. If the price level is higher than expected at home due to positive interest rate shocks, for example, then agents will realize lower real return on domestic bonds. With a higher price level at home however, since the real value of debt outstanding has decreased and the intertemporal government budget constraint has to be satisfied, expected value of future taxes on domestic agents will be lower. Therefore, real return on domestic bonds and taxes co-move positively in our model and since the government taxes only domestic agents, agents hold predominantly domestic bonds to achieve optimal risk-sharing. The reason why there is some holdings of foreign bonds is because now monetary shocks at home have spillovers on foreign price level and relative price levels under incomplete markets, like in section 3.3.

In this model, there are two reasons for home equity bias. First, a positive domestic government spending shock that falls relatively more on domestic goods will increase the relative price of the domestic good and imply an improvement in the terms of trade for the domestic economy. This means that the relative return of claims on the domestic good is higher compared to the claims on the foreign good. Since government spending has increased, in order to fulfill the intertemporal government budget constraint, domestic taxes have to increase. Therefore, in order to hedge against this risk, agents will want to hold an asset that offers a relatively higher return. With government spending falling relatively more on domestic goods, domestic equity is precisely such an asset. So, just the presence of government spending shocks that fall asymmetrically on domestic vs. foreign goods is sufficient to generate home bias in equity, just like in the model in section 3.2.2

Second, in this production model, the presence of profit taxes create an additional hedging motive to hold domestic equity independently of the distribution of government spending on domestic vs. foreign goods. When a government spending shock hits, regardless of how it falls relatively on domestic goods vs. foreign goods, it leads to higher taxes, both on profits and labor. With part of those taxes falling on profits of domestic firms, this implies that returns on domestic equity will be lower. On the other hand, as is standard in this kind of models, higher government spending which leads to negative wealth effects due to higher taxes, leads to greater labor income as agents work more. While taxes on labor income increase as well, with our calibration, the negative wealth effect channel dominates and labor income net of taxes are higher.[22] Thus, labor income and equity income will be negatively correlated if agents hold more of an asset with lower returns. Domestic equity is precisely such an asset. This is why here the value of x at which there is significant bias in equity holdings is lower than $\frac{a}{1-a}$.

To clearly see the crucial role played by government expenditure shocks in our results for equity holdings, we report the asset holdings for the model with the same calibration for the other shocks, but after shutting down government expenditure shocks. The home equity bias result disappears, unless $\eta < 1$, as shown in table 6. Productivity shocks by themselves therefore, do not generate home bias in equity unless we restrict η.

4.2.3 Robustness

For the baseline calibration we have used parameter values that imply an active monetary and passive fiscal policy. Our results however, are robust even if we specify an active fiscal and passive monetary policy, which is another possible combination that would lead to an existence and uniqueness of the price level.

In that case, the shock that would change the price level would be a tax shock in the tax rule, eqn.(48). A positive tax shock, by definition, would increase taxes. Then, the equilibrium price level would be determined via the intertemporal government budget constraint using the standard fiscal theory of the price level (FTPL) reasoning: with higher taxes, the price level would decrease to increase the real value of debt outstanding and satisfy the budget constraint. Lower price level would imply a higher real return on domestic bonds. Therefore, since there exists a positive correlation between taxes and real return on domestic bonds, agents will be biased towards holding domestic bonds.

[22] Numerically, we find that this holds unless θ, which determines steady-state profits, is very low.

Moreover, when a government spending shock hits, since primary surplus has decreased, using the standard FTPL reasoning, it will lead to an increase in the equilibrium price level at home to fulfill the intertemporal government budget constraint. An increase in the price level at home however, will lead to lower returns on domestic bonds. Given that the agents are biased towards holding domestic bonds, as described above, this implies that they suffer a negative wealth hit. To counteract this negative wealth effect, they want to hold more of the asset that has a relatively higher return. With government spending falling relatively more on domestic goods, domestic equity is exactly such an asset, for reasons discussed extensively in the rest of the paper.

The results in the paper are also robust if we introduce demand shocks into the model, as in some international macroeconomic models such as Coeurdacier et al (2007). Finally, we conduct exhaustive robustness checks on the calibration of the parameters governing the shocks. First, we allow for decreasing returns on labour, which affects the estimation of the productivity shocks, and also some of the model equations. Table 9 in the appendix shows the calibration and table 10 shows the asset holdings for this case. Second, we experiment with the estimated values for the shocks in Justiniano et al (2008). Table 7 in the appendix shows the calibration and table 8 shows the asset holdings for this case. Third, we also allow for $\gamma = 2$, 2.5, and 3, which affects the estimation of the nominal shocks. Fourth, we re-calibrate the shocks in different time periods (i) 1954:1 - 2008:4, (ii)1979:1 - 2008:4, and (iii) 1972:1 - 2000:4. None of these alternative calibrations change significantly the quantitative conclusions of the paper.

5 Conclusion

In this paper, in a standard frictionless international macroeconomic model with trade in equity and a government that issues nominal bonds, we showed that equilibrium portfolios are biased towards domestic equity and debt. In the model, holding domestic nominal debt offers insurance against price level risk due to policy shocks and the resulting movement in taxes while holding domestic equity offers optimal hedging against government expenditure shocks that fall relatively more on domestic goods.

For there to be domestic bias in nominal bonds, only two features of the model are essential. First, there has to be some price level uncertainty in the bond returns. Second, the government has to tax relatively more domestic agents than foreign agents. The result is robust to a wide range of preference parameter values and a variety of extensions such as incomplete markets, infinite horizon, government spending adjusting rather than taxes, production economy, distortionary taxation, and different policy regimes.

We also showed that in a variety of settings, complete or incomplete markets, log utility or general CRRA utility, home consumption bias or not, a sufficient condition for home bias in equity is that the government spending is more biased towards domestic goods as compared to the consumer. Most importantly, we generate home equity bias without depending on the value of η, the elasticity of substitution between domestic and foreign goods.

Finally, a calibrated dynamic production economy version of the model generates asset holdings that quantitatively matches empirical findings.

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6 Appendix - Not for Publication

6.1 Proofs of Propositions in the exact model

Proposition 3: (i) In the presence of nominal shocks, if (ii) the representative agent has CRRA utility, preference bias in consumption for domestic goods, and CES over domestic and foreign goods and (iii) the government taxes only domestic agents, then the agent holds only the nominal bonds of her own government.

Proof: Our strategy is to guess a consumption allocation consistent with complete markets and then verify that complete home bias in nominal bonds is the only asset allocation that can support this consumption allocation. Guess

$$C_1^{Hh} = C_1^{Ff} = a\bar{Y} \text{ and } C_1^{Hf} = C_1^{Fh} = (1-a)\bar{Y}. \tag{52}$$

Plugging this back to consumer's optimality condition

$$\frac{C_1^{Hh}}{C_1^{Hf}} = \frac{a}{1-a}\left(\frac{P_1^{Hh}}{P_1^{Hf}}\right)^{-\eta}. \tag{53}$$

we have $\frac{P_1^{Hh}}{P_1^{Hf}} = \frac{P_1^{Ff}}{P_1^{Fh}} = 1$, implying $Q_1 = 1$. Note that in this general case, our market completeness condition is

$$\left(\frac{C_1^H}{C_1^F}\right)^{\sigma} = Q_1$$

which implies $C_1^H = C_1^F$, once again. Eqns.(52) and (20) imply that $C_1^H = C_1^F = \bar{Y}$. Using this relations back to the consumer's budget constraint yields

$$\bar{Y} = \bar{Y} + \frac{R_0^H(B_0^{Hh} - B_0^H)}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F}.$$

The only asset allocation that is consistent with the equation above and is not contingent on the realization of shocks is $B_0^{Hh} = B_0^H$ and $B_0^{Hf} = 0$, that is, full home bias in nominal bonds.

Proposition 4 : (i) In the presence of nominal shocks, if (ii) the representative agent has CRRA utility, preference bias in consumption for domestic goods, and CES over domestic and foreign goods and (ii) the government taxes domestic and foreign agents using the rule $\tau^{Hh} = k\tau^{Hf}$, then $k > 1$ implies home bias in nominal bond holdings.

Proof: The budget constraint of the domestic government is in this case:

$$0 = \frac{B_1^H}{P_1^H} = \frac{R_0^H B_0^H}{P_1^H} - \tau_1^{Hh} - \tau_1^{Hf} \tag{54}$$

where τ^{Hh} and τ^{Hf} are lump-sum taxes of the domestic government on the domestic and the foreign agent respectively. We assume that tax on the domestic agent is k times the tax on the foreign agent as follows

$$\tau_1^{Hh} = k\tau_1^{Hf}. \tag{55}$$

Eqn.(55) allows us to re-write eqn.(54) as

$$\tau_1^{Hf} = \frac{1}{(1+k)} \frac{R_0^H B_0^H}{P_1^H} \text{ or } \tau_1^{Hh} = \frac{k}{(1+k)} \frac{R_0^H B_0^H}{P_1^H}. \tag{56}$$

The budget constraint of the domestic consumer then becomes

$$C_1^H + \tau_1^{Hh} + \tau_1^{fH} = \frac{\bar{Y} P_1^{Hh}}{P_1^H} + \frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F} Q_1. \tag{57}$$

Plugging in eqn.(56) and using symmetry gives

$$C_1^H + \frac{k}{(1+k)} \frac{R_0^H B_0^H}{P_1^H} + \frac{1}{(1+k)} \frac{R_0^F B_0^F}{P_1^F} = \frac{\bar{Y} P_1^{Hh}}{P_1^H} + \frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf}}{P_1^F} Q_1. \tag{58}$$

Since the markets are complete, guess the allocation

$$C_1^{Hh} = C_1^{Ff} = a\bar{Y} \text{ and } C_1^{Hf} = C_1^{Fh} = (1-a)\bar{Y}.$$

This implies from eqn.(20) that $C_1^H = \bar{Y}$ .Moreover, plugging this back to eqn.(53) we have $\frac{P_1^{Hh}}{P_1^{Hf}} = \frac{P_1^{Ff}}{P_1^{Fh}} = 1$, implying $Q_1 = 1$. Next, replacing this in the budget constraint, eqn.(58), gives

$$\left[\frac{kB_0^H}{(1+k)} - B_0^{Hh}\right] \frac{R_0^H}{P_1^H} + \left[\frac{B_0^F}{(1+k)} - B_0^{Hf}\right] \frac{R_0^F}{P_1^F} = 0.$$

The market completeness condition is then satisfied only if we can find B_0^{Hh} and B_0^{Hf} that satisfy the above equation for all realizations of shocks and is not contingent on them. The unique asset allocation that fulfills this requirement is

$$B_0^{Hh} = \frac{kB_0^H}{(1+k)} \quad ; \quad B_0^{Hf} = \frac{B_0^F}{(1+k)}.$$

Therefore, given the symmetry of the two countries, which implies $B_0^H = B_0^F$, the ratio of the agent's holding of domestic nominal bonds over foreign nominal bonds will be k.

6.2 Log-linearized Model (CRRA+CES+Consumption Bias)

Here we describe the log-linearized version of the model where all the shocks are present. We log-linearize around the symmetric non-stochastic values of the variables in period 1.[23] We present the equations for the domestic agent only and the foreign agent's equations are analogous.

The domestic agent's optimality conditions for goods of the two agents a:

$$\hat{C}_1^{Hf} - \hat{C}_1^{Hh} = \eta(\hat{P}_1^{Hh} - \hat{P}_1^{Hf}) \qquad \hat{C}_1^{Fh} - \hat{C}_1^{Ff} = \eta(\hat{P}_1^{Ff} - \hat{P}_1^{Fh}). \tag{59}$$

The definition of the consumption indices log-linearized give

$$\hat{C}_1^H = a\hat{C}_1^{Hh} + (1-a)\hat{C}_1^{Hf} \qquad \hat{C}_1^F = \ a\hat{C}_1^{Ff} + (1-a)\hat{C}_1^{Fh} \tag{60}$$

and the corresponding welfare based price indices are

$$\hat{P}_1^H = a\hat{P}_1^{Hh} + (1-a)\hat{P}_1^{Hf} \qquad \hat{P}_1^F = a\hat{P}_1^{Ff} + (1-a)\hat{P}_1^{Fh}. \tag{61}$$

Next, the law of one price log-linearized gives us

$$\hat{P}_1^{Hh} = \hat{S}_1 + \hat{P}_1^{Fh} \quad \hat{P}_1^{Hf} = \hat{S}_1 + \hat{P}_1^{Ff}. \tag{62}$$

Because we allow for consumption bias and the shocks lead to movements in relative prices, the shocks will also affect the real exchange rate in our model. The real exchange rate follows as

$$\hat{Q}_1 = (2a-1)(\hat{P}_1^{Hf} - \hat{P}_1^{Hh}). \tag{63}$$

The goods market clearing relations are given by

$$a\hat{C}_1^{Hh} + (1-a)\hat{C}_1^{Fh} + G_1^{Hh} + G_1^{Fh} = \hat{Y}_1^H \qquad a\hat{C}_1^{Ff} + (1-a)\hat{C}_1^{Hf} + G_1^{Hf} + G_1^{Ff} = \hat{Y}_1^F. \tag{64}$$

Finally, in the case where markets are complete, we have that

[23] $\hat{k}$ for log- deviations of k, and $\bar{k}$ for the value of the k in absence of shocks.

$$\sigma(\hat{C}_1^H - \hat{C}_1^F) = \hat{Q}_1. \tag{65}$$

6.3 Proofs of Propositions

Proposition 5 : Upto a first-order, (i) in the presence of nominal shocks, if (ii) the representative agent has CRRA utility, preference bias in consumption for domestic goods, and CES over domestic and foreign goods and (iii) taxes are constant while government expenditure, which only falls on domestic goods, adjust to fulfill the budget constraint, then nominal bond holdings are given by $\frac{B_0\left(\sigma-\sigma B_0-a\sigma+2a^2+\sigma a\eta-a\right)}{1+\sigma\eta+4a(a-1)-\sigma B_0}$.

Proof: Since we only have nominal shocks, (64) reduces to:

$$a\hat{C}_1^{Hh} + (1-a)\hat{C}_1^{Fh} - \bar{G}_1^{Hh}\hat{P}_1^{Hh} = 0, \quad a\hat{C}_1^{Ff} + (1-a)\hat{C}_1^{Hf} - \bar{G}_1^{Ff}\hat{P}_1^{Ff} = 0 \tag{66}$$

Moreover, the log-linearized domestic agent budget constraint is given by:

$$a\hat{C}_1^{Hh} + (1-a)\hat{C}_1^{Hf} = \bar{Y}\left(\hat{P}_1^{Hh} - \hat{P}_1^H\right) + R_0^H B_0^{Hh}\left(-\hat{P}_1^H\right) + R_0^F B_0^{Hf}\left(-\hat{P}_1^F\right) + R_0^F B_0^{Hf}\left(\hat{Q}_1\right) \tag{67}$$

Combining eqns.(60), (61), (66), (67) and (63), we can solve for $\hat{C}_1^{jk}$ and $\hat{P}_1^{ik}$, $j = H, F$ and $k = f, h$, as function of bond holdings and nominal shocks, $\hat{P}_1^j$, $j = H, F$. The only bond holdings consistent with eqn.(65) is $\frac{B_0\left(\sigma-\sigma B_0-a\sigma+2a^2+\sigma a\eta-a\right)}{1+\sigma\eta+4a(a-1)-\sigma B_0}$.

Table 2 presents the domestic agent's domestic debt holding as a fraction of total government debt, for the case where $\sigma = 1.5$, $\bar{Y}^H = \bar{Y}^F = 1$ and $B_0^H = B_0^F = 0.25$. Holdings above 50% imply nominal bond bias.

Proposition 6: Upto a first-order, (i) in the presence of nominal and government expenditure shocks, if (ii) the representative agent has CRRA utility, preference bias in consumption for domestic goods, and CES over domestic and foreign goods, (iii) the government taxes only the domestic agent, and (iv) the government spends only on domestic goods, then the agent holds (a) only the nominal bonds of only her government and (b) foreign real bond holdings are given by $\frac{(a-1)\{1-\sigma-2a(1-\sigma\eta)\}}{\sigma(2a-1)}$.

Proof: Denoting b_1^H and b_0^{Hf} respectively domestic holdings of foreign and domestic real bonds, the consumer budget constraint is given by:

$$C_1^H + \tau_1^H = \frac{\bar{Y}^H P^{Hh}}{P_1^H} + \frac{R_0^H B_0^{Hh}}{P_1^H} + \frac{R_0^F B_0^{Hf} Q_1}{P_1^F} + r_0^H b_0^{Hh} + r_0^F b_0^{Hf} Q_1. \tag{68}$$

Using eqn.(10) and assuming symmetry between the two governments' debt, i.e. $B_0^H =$

B_0^F, we have that $B_0^{Hh} = B_0^{Ff} = z$ and $B_0^{Hf} = B_0^{Fh} = B - z$, where z and $B = B_0^H = B_0^F$ are simplified notation. Log-linearizing eqn.(68), gives

$$\hat{C}_1^H + \bar{\tau}\hat{\tau}_1^H = (\hat{P}_1^{Hh} - \hat{P}_1^H) - R_0^H z \hat{P}_1^H - R_0^F (B - z)(\hat{P}_1^F - \hat{Q}_1) + r_0^F b(\hat{P}_1^F - \hat{Q}_1) \tag{69}$$

where b is the domestic holdings of foreign real bonds.

The domestic government budget constraint is now re-written as

$$0 = b_1^H + \frac{B_1^H}{P_1^H} = r_0^H b_0^H + \frac{R_0^H B_0^H}{P_1^H} - \tau_1^H + G_1^{Hh}\left(\frac{P_1^{Hh}}{P_1^H}\right) \tag{70}$$

which log-linearized gives

$$\bar{\tau}\hat{\tau}_1^H = G_1^{Hh} - R_0^H B \hat{P}_1^H \tag{71}$$

Combining these two, along with eqns.(60), (64), and (65) gives

$$\begin{aligned} G_1^{Hh} - G_1^{Ff} &= \left(\left(\frac{2a-1}{\sigma}\right) + 2(1-a) - 2\,(2a-1)\, r_0^F b\right)\left(\hat{P}_1^{Hh} - \hat{P}_1^{Hf}\right) \\ &\quad + 2R_0(B - z)\left(\hat{P}_1^H - \hat{P}_1^F\right) + 2R_0(B - z)\hat{Q}_1 \end{aligned} \tag{72}$$

Using eqns.(59), (60), (64), and (65), we get

$$G_1^{Hh} - G_1^{Ff} = (2a-1)\left(\frac{2a-1}{\sigma} + \frac{(1-a)\eta}{a(2a-1)} + \eta\left(\frac{1}{a} - 2a + 1\right)\right)\left(\hat{P}_1^{Hh} - \hat{P}_1^{Hf}\right). \tag{73}$$

Eqns.(72) and (73) determine the stochastic process for $\hat{P}_1^{Hh} - \hat{P}_1^{Hf}$. Once we realize that $\left(\hat{P}_1^H - \hat{P}_1^F\right)$ is an exogenous stochastic process independent of all the government expenditure processes, the only way the two equations are consistent is when $z = B$. For the foreign agent, the proof is the same. This shows that each agent only hold their own government bond.

Then using $z = B$ in the above equations, we get

$$G_1^{Hh} - G_1^{Ff} = \left(\left(\frac{2a-1}{\sigma}\right) + 2(1-a) - 2\,(2a-1)\, r_0^F b\right)\left(\hat{P}_1^{Hh} - \hat{P}_1^{Hf}\right)$$

$$G_1^{Hh} - G_1^{Ff} = (2a-1)\left(\frac{2a-1}{\sigma} + \frac{(1-a)\eta}{a(2a-1)} + \eta\left(\frac{1}{a} - 2a + 1\right)\right)\left(\hat{P}_1^{Hh} - \hat{P}_1^{Hf}\right)$$

Since these two equations must hold for all realization of shocks and b cannot be contingent on the shocks, after normalizing $r_0^F = 1,$ we get

$$b = \frac{(a-1)\{1-\sigma-2a(1-\sigma\eta)\}}{\sigma(2a-1)}.$$

Proposition 7: Upto a first-order, (i) in the presence of nominal and government expenditure shocks, if (ii) the representative agent has CRRA utility, preference bias in consumption for domestic goods, and CES over domestic and foreign goods, (iii) the government taxes only domestic agents, and (iv) all government expenditure, part of which is endogenous, falls on domestic goods, then the agent holds a) only the nominal bonds of her own government and b) equity holdings are biased domestically.

Proof: Let's start by deriving the log-linear budget constraint. By the symmetry in the two countries and marketing clearing, we know that $E_0^{Hh} = -E_0^{Hf} = E_0^{Ff} = -E_0^{Fh} = \theta$. We denote this holding as θ to simplify notation and to make clear that it does not depend on the realization of the shocks in $t = 1$. Analogously, using the bond holdings' market clearing and assuming symmetry between the two governments' debt, i.e. $B_0^H = B_0^F$, we have that $B_0^{Hh} = B_0^{Ff} = z$ and $B_0^{Hf} = B_0^{Fh} = B - z$, where z and $B = B_0^H = B_0^F$ are simplified notation. These relations simplify the consumer budget constraint as

$$\hat{C}_1^H + \bar{\tau}\hat{\tau}_1^H = (1+\theta)(\hat{P}_1^{Hh} - \hat{P}_1^H + \hat{Y}_1^H) - \theta(\hat{P}_1^{Hf} - \hat{P}_1^H + \hat{Y}_1^F) - R_0^H z \hat{P}_1^H - R_0^F (B-z)(\hat{P}_1^F - \hat{Q}_1). \tag{74}$$

The government budget constraint is, up to a first order approximation

$$\bar{\tau}\hat{\tau}_1^H = G_1^{Hh} + G_1^{Hf} - R_0^H B \hat{P}_1^H. \tag{75}$$

Using eqns.(75), (60), (64), and (65), we can write eqn.(75) as

$$\begin{aligned} G_1^{Hh} - G_1^{Ff} &= \left(2(1-\theta-a) + \frac{2a-1}{\sigma}\right)\left(\hat{P}_1^{Hh} - \hat{P}_1^{Hf}\right) \\ &\quad + R_0(B-z)\left(\hat{P}_1^H - \hat{P}_1^F\right) + R_0(B-z)\hat{Q}_1. \end{aligned} \tag{76}$$

Then, using eqns.(59), (60), (64), and (65), we get

$$G_1^{Hh} - G_1^{Ff} = (2a-1)\left(\frac{2a-1}{\sigma} + \frac{(1-a)\eta}{a(2a-1)} + \eta\left(\frac{1}{a} - 2a + 1\right)\right)\left(\hat{P}_1^{Hh} - \hat{P}_1^{Hf}\right). \tag{77}$$

From eqn.(22), we re-write eqns.(76) and (77), as:

$$\begin{aligned}\omega(\varepsilon_1^G-\varepsilon_1^{G*}) &= \left(2(1-\theta-a)+\frac{2a-1}{\sigma}\right)\left(\hat{P}_1^{Hh}-\hat{P}_1^{Hf}\right) \\ &\quad +R_0(B+z-(1-\omega)B)\left(\hat{P}_1^H-\hat{P}_1^F\right)+R_0(B-z)\hat{Q}_1.\end{aligned} \tag{78}$$

$$\begin{aligned}\omega(\varepsilon_1^G-\varepsilon_1^{G*}) &= (2a-1)\left(\frac{2a-1}{\sigma}+\frac{(1-a)\eta}{a(2a-1)}+\eta\left(\frac{1}{a}-2a+1\right)\right)\left(\hat{P}_1^{Hh}-\hat{P}_1^{Hf}\right) \\ &\quad +(1-\omega)BR_0\left(\hat{P}_1^H-\hat{P}_1^F\right)\end{aligned} \tag{79}$$

Since eqns.(78) and (79) must hold for all realization of shocks and θ or z cannot be contingent on the shocks, we find that $z=B$ and

$$\theta=-\frac{1}{2}+\frac{1}{2}\left[\left(\frac{(2a-1)^2}{\sigma}-4a\eta(a-1)\right)+(2a-1)\left(1-\frac{1}{\sigma}\right)\right] \tag{80}$$

which implies domestic bias for any usual parameter values.

Proposition 8: Upto a first-order, (i) in the presence of nominal and government expenditure shocks, if (ii) the representative agent has CRRA utility, no preference bias in consumption, and CES over domestic and foreign goods, (iii) the government taxes only domestic agents, and (iv) government expenditure ratio between domestic goods and foreign goods is x , then (a) the agent holds only the bonds of her government (b) $x>1$ implies home equity bias.

Proof: Eqn.(74) becomes:

$$\hat{C}_1^H+\bar{\tau}\hat{\tau}_1^H=(1+\theta)(\hat{P}_1^{Hh}-\hat{P}_1^H+\hat{Y}_1^H)-\theta(\hat{P}_1^{Hf}-\hat{P}_1^H+\hat{Y}_1^F)-R_0^H z\hat{P}_1^H-R_0^F(B-z)(\hat{P}_1^F-\hat{Q}_1). \tag{81}$$

Here, we derive the portfolio allocation with general level of agents' consumption bias a and σ, and in the end we relate to the specific case of the proposition where $a=0.5$. Using eqns.(75), (60), (64), and (65), we can write eqn.(81) as

$$G_1^{Hh}+G_1^{Hf}-G_1^{Fh}-G_1^{Ff} = \left(2(1-\theta-a)+\frac{2a-1}{\sigma}\right)\left(\hat{P}_1^{Hh}-\hat{P}_1^{Hf}\right) \tag{82}$$

$$+R_0(B-z)\left(\hat{P}_1^H-\hat{P}_1^F\right)+R_0(B-z)\hat{Q}_1. \tag{83}$$

Then, using eqns.(59), (60), (64), and (65), we get

$$G_1^{Hh}-G_1^{Hf}+G_1^{Fh}-G_1^{Ff}=(2a-1)\left(\frac{2a-1}{\sigma}+\frac{(1-a)\eta}{a(2a-1)}+\eta\left(\frac{1}{a}-2a+1\right)\right)\left(\hat{P}_1^{Hh}-\hat{P}_1^{Hf}\right). \tag{84}$$

Eqns.(84) and (82) determine the stochastic process for $\hat{P}_1^{Hh}-\hat{P}_1^{Hf}$. Once we realize that $\left(\hat{P}_1^{H}-\hat{P}_1^{F}\right)$ is an exogenous stochastic process independent of all the government expenditure processes, the only way the two equations are consistent is when $z=B$. For the foreign agent, the proof is the same. This shows that each agent only hold their own government bond.

From eqn.(84) and using $z=B$, we have

$$G_1^{Hh}-G_1^{Fh}-G_1^{Hf}-G_1^{Ff}=\left[2(1+\theta-a)(\frac{2a-1}{\sigma})\right](\hat{P}_1^{Hh}-\hat{P}_1^{Hf}).$$

Using that $G^{Hh}=xG^{Hf}$ and $G^{Ff}=xG^{Fh}$, we can re-write eqn.(84) as

$$(x-1)(G_1^{Hf}-G_1^{Fh})=(2a-1)\left[\frac{2a-1}{\sigma}+\frac{(1-a)\eta}{a(2a-1)}+\eta(\frac{1}{a}-2a+1)\right](\hat{P}_1^{Hh}-\hat{P}_1^{Hf}) \tag{85}$$

and eqn.(82) as

$$(1+x)(G_1^{Hf}-G_1^{Fh})=\left[2(1+\theta-a)+(\frac{2a-1}{\sigma})\right](\hat{P}_1^{Hh}-\hat{P}_1^{Hf}). \tag{86}$$

Since eqns.(85) and (86) must hold for all realization of shocks and θ cannot be contingent on the shocks, we find that

$$\theta=-\frac{1}{2}+\frac{1}{2}(2a-1)\left[\frac{1+x}{x-1}\left(\frac{2a-1}{\sigma}-\frac{4a\eta(a-1)}{2a-1}\right)+1-\frac{1}{\sigma}\right] \tag{87}$$

which gives us eqn.(23).

With $a=0.5$, $\eta=1$ and $\sigma=1$, the equivalent of eqn.(87) is $\theta=\frac{1}{x-1}$. With $a=0.5$ and general η and σ, eqn.(87) is $\theta=\frac{1}{2}\left(\frac{\eta(1+x)}{x-1}-1\right)$, and it follows trivially that $x>1$ implies $\theta>-0.5$, that is, home bias in equity. This gives us the proof of proposition 7.

The case of incomplete markets (with endowment shocks) Because markets are incomplete, we follow Devereux and Sutherland (2006) in order to compute equilibrium portfolios. This consists in satisfying a second order accurate approximation of the household

Euler equation, which in our case has the form:

$$E_0\left[\left(\hat{C}_1^H - \hat{C}_1^F - \frac{\hat{Q}_1}{\sigma}\right) r_{x,1}^i\right] = 0 \tag{88}$$

where $r_{x,1}^i$, $i = 1, 2$ and 3, is the excess returns of all assets with respect to a reference asset, in our case the returns of foreign equity. Formally, the definitions are

$$\hat{r}_x^1 = \hat{Y}_1^H + \hat{P}_1^{Hh} - \hat{Y}_1^F - \hat{P}_1^{Hf}$$

$$\hat{r}_x^2 = -R_0^H \hat{P}_1^H - \hat{Y}_1^F - \hat{P}_1^{Hf} - \hat{P}_1^H$$

$$\hat{r}_x^3 = -R_0^F \hat{P}_1^F + \hat{Q}_1 - \hat{Y}_1^F - \hat{P}_1^{Hf} - \hat{P}_1^H$$

In other words, using the equilibrium conditions, we can write $\hat{C}_1^H - \hat{C}_1^F - \frac{\hat{Q}_1}{\sigma} = \Xi_a(\theta, z) * \zeta_1'$ and $\hat{r}_{x,1} = \Xi_b(\theta, z) * \zeta_1'$, where $\zeta_1 = \left[\begin{array}{cccccc} \hat{Y}_1^H & \hat{Y}_1^F & G_1^{Hf} & G_1^{Fh} & \hat{P}_1^H & \hat{P}_1^F \end{array}\right]$ and $\hat{r}_{x,1} = \left[\begin{array}{ccc} \hat{r}_x^1 & \hat{r}_x^2 & \hat{r}_x^3 \end{array}\right]$. Then the solution for θ and z is given by the following system of equations.

$$\Xi_a(\theta, z)\Sigma\Xi_b(\theta, z)' = 0 \tag{89}$$

where $\Sigma = E_0\left[\zeta_1'\zeta_1\right]$. Again here we consider $\Sigma = I$.

In the case where there is no consumption bias of the agent, that is $a = 0.5$, it implies that $\hat{Q}_1 = 0$. Using demand and market-clearing conditions as well as the budget and resource constraints, we get:

$$\hat{C}_1^H - \hat{C}_1^F = \begin{pmatrix} (1+2\theta)(1-\frac{1}{\eta}) \\ -(1+2\theta)(1-\frac{1}{\eta}) \\ -(1+2(\theta+\frac{1}{2})\frac{1}{\eta}\frac{1-x}{1+x}) \\ (1+2(\theta+\frac{1}{2})\frac{1}{\eta}\frac{1-x}{(1+x)}) \\ 2R_0(B-z) \\ -2R_0(B-z) \end{pmatrix}' \begin{pmatrix} \hat{Y}_1^H \\ \hat{Y}_1^F \\ G_1^{Hf} \\ G_1^{Fh} \\ \hat{P}_1^H \\ \hat{P}_1^F \end{pmatrix}$$

And $\hat{r}_x = \begin{pmatrix} \hat{r}_x^1 \\ \hat{r}_x^2 \end{pmatrix}$ is given by:

$$\hat{r}_{x,1} = \begin{pmatrix} 1-\frac{1}{\eta} & \frac{1}{\eta}-1 & \frac{1}{\eta}\frac{x-1}{1+x} & -\frac{1}{\eta}\frac{x-1}{1+x} & 0 & 0 \\ -\frac{1}{2\eta} & \frac{1}{2\eta}-1 & \frac{1}{2\eta}\frac{x-1}{1+x} & -\frac{1}{2\eta}\frac{x-1}{1+x} & -R_0 & 0 \end{pmatrix} \begin{pmatrix} \hat{Y}_1^H \\ \hat{Y}_1^F \\ G_1^{Hf} \\ G_1^{Fh} \\ \hat{P}_1^H \\ \hat{P}_1^F \end{pmatrix}$$

Then using the methodology above (Eqns.(89)), we have a system of two equations and two variables and we can get the following allocations:

$$\theta = -\frac{1}{2} + \frac{1}{2}\frac{\eta\left(x^2-1\right)}{(\eta-1)^2(1+x)^2 + 2(1-x)^2}$$

$$z = B$$

Proposition 9: Upto a first-order, (i) in the presence of nominal, endowment, and government expenditure shocks, if (ii) the representative agent has log-utility, preference bias in consumption for domestic goods, and CES over domestic and foreign goods, (iii) the government taxes only domestic agents, and (iv) government expenditure ratio between domestic goods and foreign goods is x , then (a) there is home nominal bond bias (b) $x > \frac{a}{1-a}$ implies home equity bias.

Proof: The set of equations to be solved is given below. We can re-write the system as:

$$\begin{pmatrix} -1 & 1 & 1 & -1 \\ a + \frac{(\theta+1-a)}{\eta} & 1-a-\frac{(\theta+1-a)}{\eta} & 0 & 0 \\ a & 0 & 1-a & 0 \\ 0 & 1-a & 0 & a \end{pmatrix} \begin{pmatrix} \hat{C}_1^{Hh} \\ \hat{C}_1^{Hf} \\ \hat{C}_1^{Fh} \\ \hat{C}_1^{Ff} \end{pmatrix} =$$

$$= \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ \theta+1 & -\theta & -x-1 & 0 & R_0(B-z) & -R_0(B-z) \\ 1 & 0 & -x & -1 & 0 & 0 \\ 0 & 1 & -1 & x & 0 & 0 \end{pmatrix} \begin{pmatrix} \hat{Y}^H \\ \hat{Y}^F \\ G^{Hf} \\ G^{Fh} \\ \hat{P}^H \\ \hat{P}^F \end{pmatrix}$$

We can solve for the consumption levels in terms of the shocks. Using also that $\hat{Q}_t = (2a-1)(\hat{P}^{Hf} - \hat{P}^{Hh})$ we can re-write the excess returns as :

$$r_{x,t} = \begin{pmatrix} 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & -R_0 & 0 \end{pmatrix} \begin{pmatrix} \hat{Y}^H \\ \hat{Y}^F \\ G^{Hf} \\ G^{Fh} \\ \hat{P}^H \\ \hat{P}^F \end{pmatrix} + \begin{pmatrix} 1 \\ a \end{pmatrix} \frac{(\hat{C}^{Hh} - \hat{C}^{Hf})}{\eta}$$

We can use eqn.(89) for θ and z, using $\sigma = 1$. The resulting expressions for θ and z, while closed-form, are very cumbersome to put in text. We have shown using a symbolic package that $x > \frac{a}{1-a}$ is there sufficient condition to generate home bias in equity. Here for illustrative purposes, we show in Figure 2 for different values of a and η that it is indeed the case.

6.4 Production Economy

6.4.1 First-order approximation

To solve the model, we use an approximation around a symmetric non-stochastic steady state where the net foreign assets of the countries, wealth of the consumer less government debt, is equal to zero. In addition, steady state aggregate consumption, aggregate price levels, and aggregate output is equal to one while government spending is equal to zero. Next, we present the system of log-linearized equations that are relevant for determining portfolio holding where percentage deviation of variable x from its steady state value is represented by $\hat{x}$ while the steady state of a variable x is represented by $\bar{x}$.

Consumer The FOCs of the home agent log-linearized give

$$-\sigma \hat{C}_t^H = E_t \left[-\sigma \hat{C}_{t+1}^H + \hat{P}_t^H + \hat{R}_t^H - \hat{P}_{t+1}^H \right] \tag{90}$$

$$-\sigma \hat{C}_t^H = E_t \left[-\sigma \hat{C}_{t+1}^H + \hat{P}_t^F + \hat{R}_t^F - \hat{P}_{t+1}^F + \hat{Q}_{t+1} - \hat{Q}_t \right] \tag{91}$$

$$-\sigma \hat{C}_t^H = E_t \left[-\sigma \hat{C}_{t+1}^H + \beta \hat{q}_{t+1}^H - \hat{q}_t^H + (1-\beta)\Pi_{t+1}^H \right] \tag{92}$$

$$-\sigma \hat{C}_t^H = E_t \left[-\sigma \hat{C}_{t+1}^H + \beta \hat{q}_{t+1}^F - \hat{q}_t^F + (1-\beta)\Pi_{t+1}^F + \hat{Q}_{t+1} - \hat{Q}_t \right] \tag{93}$$

$$\nu \hat{L}_t^H = -\sigma \hat{C}_t^H + \hat{w}_t^H - \left(\frac{\bar{\tau}^L}{1-\bar{\tau}^L} \right) \hat{\tau}_t^L \tag{94}$$

The FOCs of the foreign agent log-linearized and combined with FOCs of the domestic agent gives

$$-\sigma\left[\hat{C}_t^H-\hat{C}_t^F\right]+\hat{Q}_t= \ -\sigma E_t\left[\hat{C}_{t+1}^H-\hat{C}_{t+1}^F\right]+E_t\left[\hat{Q}_{t+1}\right] \tag{95}$$

Similarly the definition of the various aggregate indices and the demand curve can be written as

$$\hat{C}_t^H=a\hat{C}_t^{Hh}+(1-a)\hat{C}_t^{Hf} \qquad \hat{P}_t^H=a\hat{P}_t^{Hh}+(1-a)\hat{P}_t^{Hf} \tag{96}$$

$$\hat{C}_t^{Hh}-\hat{C}_t^{Hf}=\eta(\hat{P}_t^{Hf}-\hat{P}_t^{Hh}) \tag{97}$$

The real exchange rate can be expressed as

$$\hat{Q}_t=\hat{S}_t+\hat{P}_t^F-\hat{P}_t^H \tag{98}$$

and the law of one price in aggregate terms as

$$\hat{P}_t^{Hh}=\hat{S}_t+\hat{P}_t^{Fh} \qquad \hat{P}_t^{Hf}=\hat{S}_t+\hat{P}_t^{Ff} \tag{99}$$

Finally, the consumer's budget constraint can be written as

$$\begin{aligned}\hat{C}_t^H+\bar{B}\hat{W}_t^H \;=\;& \frac{1}{\beta}\bar{B}(\hat{W}_{t-1}^H+\hat{r}_t^1)+\frac{(1-\bar{\tau}^\Pi)}{\theta}\hat{\Pi}_t^H-\left(\bar{\tau}^L\bar{w}\right)\hat{\tau}_t^L+ \\ & \left(1-\bar{\tau}^L\right)\bar{w}(\hat{w}_t^H+\hat{L}_t^H)+\frac{\bar{B}^{Hf}}{\beta}\hat{r}_{x,t}^1+\frac{\bar{q}^H\bar{A}^{Hh}}{\beta}\hat{r}_{x,t}^2+\frac{\bar{q}^F\bar{A}^{Hf}}{\beta}\hat{r}_{x,t}^3\end{aligned} \tag{100}$$

where

$$\hat{r}_t^1=\hat{P}_{t-1}^H+\hat{R}_{t-1}^H-\hat{P}_t^H \tag{101}$$

is the real return on domestic nominal bonds and

$$\hat{r}_{x,t}^1=\left(\hat{P}_{t-1}^F+\hat{R}_{t-1}^F-\hat{P}_t^F+\hat{Q}_t-\hat{Q}_{t-1}\right)-\hat{r}_t^1 \tag{102}$$

$$\hat{r}_{x,t}^2=\left(\beta\hat{q}_t^H-\hat{q}_{t-1}^H+(1-\beta)\Pi_t^H\right)-\hat{r}_t^1 \tag{103}$$

$$\hat{r}_{x,t}^3=\left(\beta\hat{q}_t^F-\hat{q}_{t-1}^F+(1-\beta)\Pi_t^F+\hat{Q}_t-\hat{Q}_{t-1}\right)-\hat{r}_t^1 \tag{104}$$

are the excess returns of foreign nominal bonds, domestic equity, and foreign equity over domestic nominal bonds.

Firms The aggregate production technology log-linearized yields

$$\hat{Y}_t^H = \hat{A}_t^H + \hat{L}_t^H \tag{105}$$

while profits and the pricing rule are given by

$$\hat{\Pi}_t^H = \theta \left[-\bar{w} \left(\hat{w}_t^H + \hat{Y}_t^H - \hat{A}_t^H \right) + \left(\hat{P}_t^{Hh} - \hat{P}_t^H + \hat{Y}_t^H \right) \right] - \left(\frac{\bar{\tau}^{\Pi}}{1 - \bar{\tau}^{\Pi}} \right) \hat{\tau}_t^{\pi}$$

$$\hat{P}_t^{Hh} - \hat{P}_t^H = \hat{w}_t^H - \hat{A}_t^H \tag{106}$$

Government The government budget constraint can be expressed as

$$\bar{B} \left(\hat{B}_t - \hat{P}_t^H \right) = \beta^{-1} \bar{B} \left(\hat{R}_{t-1}^H + \hat{B}_{t-1} - \hat{P}_t^H \right) - \left(1 + \frac{1}{y} \right) \bar{\tau}^L \bar{w} \left(\hat{\tau}_t^L + \hat{w}_t^H + \hat{L}_t^H \right) + G_t^{Hh} + G_t^{Hf} \tag{107}$$

The monetary policy rule as

$$\hat{R}_t^H = \gamma \left(\hat{P}_t^H - \hat{P}_{t-1}^H \right) + \epsilon_{r,t}$$

and the fiscal policy rule as

$$\hat{\tau}_t^L + \hat{w}_t^H + \hat{L}_t^H = \phi \left(\hat{B}_t - \hat{P}_t^H \right)$$

The relationship between government spending on domestic and foreign goods, and the tax revenues through labor and profits can be written as

$$G_t^{Hh} = x G_t^{Hf} \tag{108}$$

$$\hat{\tau}_t^L + \hat{w}_t^H + \hat{L}_t^H = \hat{\tau}_t^{\pi} + \hat{Y}_t^H - \theta \left(\hat{P}_t^H - \hat{P}_t^{Hh} \right) - (\theta - 1) \left(\hat{w}_t^H - \hat{A}_t^H \right) \tag{109}$$

Market clearing The market clearing condition for goods at the aggregate level can be expressed as

$$a\hat{C}_t^{Hh} + (1-a)\hat{C}_t^{Fh} + G_t^{Hh} + G_t^{Fh} = \hat{Y}_t^H \qquad \hat{C}_t^{Ff} + \hat{C}_t^{Hf} + G_t^{Hf} + G_t^{Ff} = \hat{Y}_t^F \tag{110}$$

while the asset market clearing condition in terms of steady state values are given by

$$\bar{E}^{Hh} + \bar{E}^{Fh} = 0 \qquad \bar{E}^{Hf} + \bar{E}^{Ff} = 0 \tag{111}$$

$$\bar{B}^{Hh} + \bar{B}^{Fh} = \bar{B} \qquad \bar{B}^{Hf} + \bar{B}^{Ff} = \bar{B}^{F} \tag{112}$$

6.4.2 Solution for steady-state portfolio

The technique used to determine steady state portfolio holdings under incomplete markets is the same as described in section 2. That is, we take second order approximations of the domestic and foreign consumer's euler equations and combine them to get

$$E_t\left[\left(\hat{C}^H_{t+1} - \hat{C}^F_{t+1} - \frac{\hat{Q}_{t+1}}{\sigma}\right)\hat{r}^i_{x,t+1}\right] = 0; \quad i = 1:3 \tag{113}$$

Then, we solve the system of equations up to first order approximation for given values of $\bar{B}^{Hf}$, $\bar{A}^{Hh}$, and $\bar{A}^{Hf}$. Then, we check if the resulting dynamics of variables satisfy the euler equations upto second order accuracy. We iterate until a fixed-point for the asset holdings is found.

6.4.3 Alternative Calibrations

A. Here we use Justiniano et al (2008)'s estimation of the exogenous processes to calibrate our model. Thus, we have the table 7 of parameters:

Table 8 shows that our results are robust to this alternative calibration.

B. Decreasing returns In this case, each brand j of the domestic good is produced by a single home firm j using the following decreasing returns on labor production function

$$y^H_t(j) = A^H_t\left(l^H_t(j)\right)^{\alpha} \tag{114}$$

Firm j is subject to eqn.(114) and eqn(30), leading to the pricing equation

$$p^{Hh}_t(j) = \frac{\theta}{\theta-1}P^H_t\left(\frac{w^H_t}{\alpha A^H_t}l^H(j)^{1-\alpha}\right)^{\frac{\alpha}{-\theta\alpha+\theta+\alpha}}. \tag{115}$$

The aggregate after tax real profits of the firms in the domestic economy can be written as

$$\Pi^H_t = (1-\tau^{\pi}_t)(P^{Hh}_t - \frac{w^H_t}{A^H_t}P^H_t)\frac{Y^H_t}{P^H_t} \tag{116}$$

and the optimization decision of the individual domestic firms gives

$$\frac{P_t^{Hh}}{P_t^H} = \frac{\theta}{\theta - 1} \left(\frac{w_t^H}{\alpha A_t^H} \left(L_t^H \right)^{1-\alpha} \right)^{\frac{\alpha}{-\theta\alpha+\theta+\alpha}} \tag{117}$$

We took $\alpha = 2/3$ as the parameter for decreasing returns. For the calibration for the technology shock, following the same procedure described in section 4.2.2 we have the following parameters in Table 9. Table 10 shows that home asset bias is still present if we consider decreasing returns to scale:

Country	World mkt. share	Dom. stock share	Home bias - log(column 3/column 2)
AUS	1.2	71.7	4.09
CAN	2.4	84	3.55
FRA	4.3	79.8	2.92
GER	4	61.3	2.72
ITA	2.2	67.3	3.42
JPN	11.3	89.5	2.06
NLD	2	43.6	3.03
ESP	1.4	86	4.11
CHE	2.2	45.6	3.03
GBR	8.1	77	2.25
USA	47.8	88.7	0.62

Table 1: Domestic equity bias. Source: Coeurdacier et al (2007). [24]

[24] World mkt share measures the share of domestic stocks in countries portfolios in 2001 for the biggest market capitalization (CPIS data). Dom. stock share measures the share of domestic stocks in a representative sample of mutual funds, averaged over the period 1999-2000 (Chan et al. (2005)).

Bond Holdings Endogenous G					
	$\eta = 0.95$	$\eta = 1.2$	$\eta = 1.5$	$\eta = 2$	$\eta = 4$
$a = 0.5$	104%	89%	80%	71%	60%
$a = 0.6$	110%	97%	89%	80%	70%
$a = 0.7$	112%	102%	95%	88%	79%
$a = 0.8$	110%	103%	99%	94%	87%

Table 2: Domestic bond holdings: endogenous govt expenditure

		Equity Holdings			
		$\eta = 0.95$	$\eta = 1.2$	$\eta = 1.5$	$\eta = 2$
$a = 0.5$	no G_t	50%	50%	50%	50%
	$x = \frac{2a}{1-a}$	192%	223%	230%	200%
$a = 0.6$	no G_t	104%	31%	43%	46%
	$x = \frac{2a}{1-a}$	147%	169%	185%	192%
$a = 0.7$	no G_t	120%	-8%	32%	42%
	$x = \frac{2a}{1-a}$	127%	140%	154%	171%
$a = 0.8$	no G_t	116%	-1200%	0%	31%
	$x = \frac{2a}{1-a}$	114%	122%	131%	144%

Table 3: Equity allocations without govt. exp. shocks vs. equity allocations with govt. exp. shocks and $x = \frac{2a}{1-a}$, for different levels of consumption bias and elasticity of substitution.

Parameters	Values	Parameters	Values
β	0.99	y	4
σ	1.5	$\overline{B}$	1.26
ν	4	ρ_A	0.98
a	0.76	ρ_g	0.966
η	$0.95-4$	ρ_R	0.45
θ	11	σ_a^2	0.0036%
γ	1.5	σ_g^2	0.0077%
ϕ	1.5	σ_R^2	0.0083%
x	$1.5-8$		

Table 4: Parameter values used in the quantitative analysis of the model.

Domestic Holdings					
		$x = 1.5$	$x = 2$	$x = 4$	$x = 8$
$\eta = 0.95$	Bonds	88%	93%	98%	104%
	Equity	80%	83%	86%	91%
$\eta = 1.2$	Bonds	108%	108%	112%	118%
	Equity	81%	81%	84%	86%
$\eta = 1.5$	Bonds	110%	110%	113%	115%
	Equity	79%	79%	81%	83%
$\eta = 2$	Bonds	105%	105%	105%	103%
	Equity	77%	77%	78%	80%
$\eta = 4$	Bonds	84%	81%	78%	78%
	Equity	74%	74%	74%	74%

Table 5: Domestic asset holdings - quantitative model

Domestic Holdings: No Government Expenditure Shocks	
	Equity
$\eta = 0.95$	118%
$\eta = 1.2$	-100%
$\eta = 1.5$	20%
$\eta = 2$	40%
$\eta = 4$	48%

Table 6: Equity holdings with no government expenditure shocks

Parameters	Values	Parameters	Values
β	0.99	y	4
σ	1.5	$\overline{B}$	1.26
ν	4	ρ_A	0.22
a	0.76	ρ_g	0.99
η	$0.95 - 4$	ρ_R	0.16
θ	11	σ_a^2	0.0089%
γ	1.5	σ_g^2	0.0035%
ϕ	1.5	σ_R^2	0.0022%
x	$1.5 - 8$		

Table 7: Alternate calibration A

		Domestic Holdings			
		$x = 1.5$	$x = 2$	$x = 4$	$x = 8$
$\eta = 0.95$	Bonds	88%	93%	98%	104%
	Equity	80%	83%	86%	91%
$\eta = 1.2$	Bonds	108%	108%	112%	118%
	Equity	81%	81%	84%	86%
$\eta = 1.5$	Bonds	110%	110%	113%	115%
	Equity	79%	79%	81%	83%
$\eta = 2$	Bonds	105%	105%	105%	103%
	Equity	77%	77%	78%	80%
$\eta = 4$	Bonds	84%	81%	78%	78%
	Equity	74%	74%	74%	74%

Table 8: Asset holdings alternate calibration A

Parameters	Values	Parameters	Values
β	0.99	x	$1.5-8$
σ	1.5	y	4
α	2/3	$\overline{B}$	1.26
ν	4	ρ_A	0.959
a	0.76	ρ_g	0.966
η	$0.95-2$	ρ_R	0.45
θ	11	σ_a^2	0.003%
γ	1.5	σ_g^2	0.0077%
ϕ	1.5	σ_R^2	0.0083%

Table 9: Alternate calibration B

Domestic Holdings					
		$x = 1.5$	$x = 2$	$x = 4$	$x = 8$
$\eta = 0.95$	Bonds	336%	138%	103%	96%
	Equity	134%	99.5%	96%	97%
$\eta = 1.2$	Bonds	230%	120%	100%	95%
	Equity	120%	96%	93%	94%
$\eta = 1.5$	Bonds	167%	108%	96%	94%
	Equity	109%	92%	90%	91%
$\eta = 2$	Bonds	120%	96%	91%	91%
	Equity	97.5%	87%	86%	87%
$\eta = 4$	Bonds	76%	80%	82%	85%
	Equity	76%	73%	74%	75%

Table 10: Asset holdings alternate calibration B

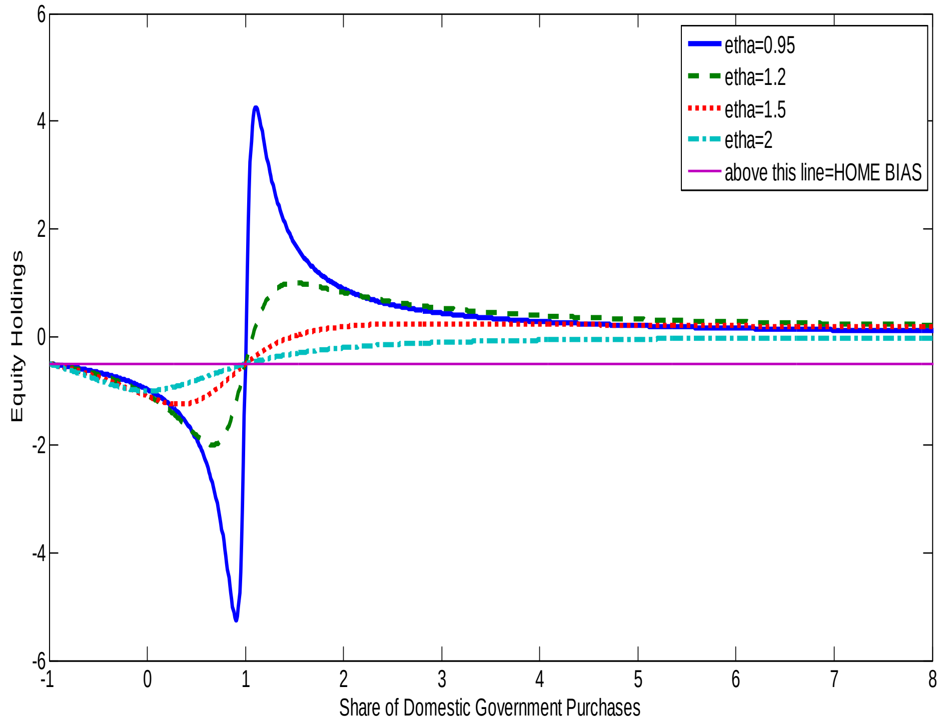

Figure 1: Equity allocations as a function of the share of domestic government expenditure - no consumption bias

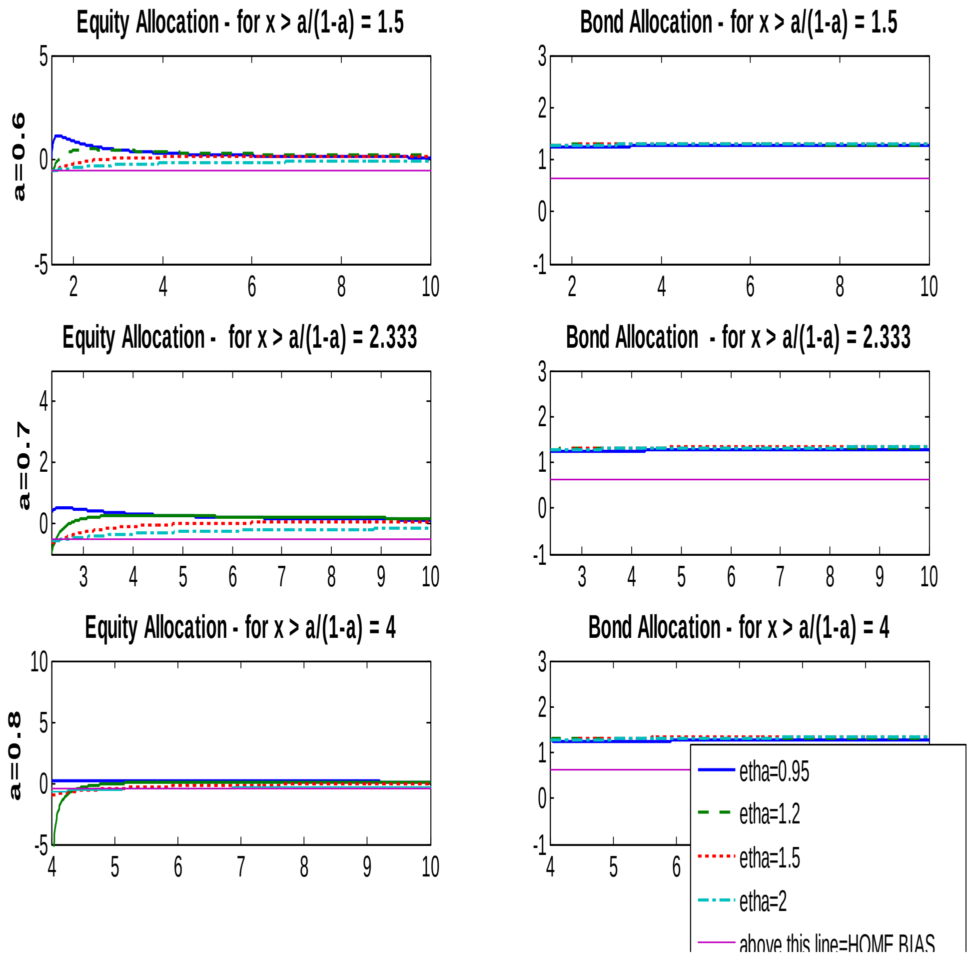

Figure 2: Asset allocations as a function of the share of domestic government expenditure and home consumption bias - incomplete markets