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ABSTRACT

Obstfeld and Rogoff (2000) have reinvigorated an old literature on the link between home bias in the goods market and home bias in the asset market by arguing that trade costs in the goods market can account for the observed portfolio home bias. The key link between home bias in the two markets is the real exchange rate. Home bias in consumption implies a different expenditure allocation across countries, which leads to different inflation rates when measured in the same currency. This leads investors from different countries to choose different portfolios to hedge against inflation uncertainty. An older partial equilibrium literature argued that such hedge portfolios are not large enough to produce substantial home bias. We link the general equilibrium and partial equilibrium literatures and show that in both the resulting home bias in the equity market depends on a covariance-variance ratio: the covariance between the real exchange rate and the excess return on home relative to foreign equity, divided by the variance of the excess return. Empirical evidence shows that this ratio and the implied home bias are close to zero, casting significant doubt on a meaningful link between home bias in the goods and asset markets. General equilibrium models that conclude otherwise imply a covariance-variance ratio that is at odds with the data.

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1 Introduction

A literature dating back to the late 1970s and early 1980s suggests that the optimal international portfolio allocation is related to the allocation of consumption expenditure across countries.[1] In the most extreme and well-known case, when agents are infinitely risk-averse and local-currency output prices are constant, optimal portfolio shares are identical to expenditure shares because such portfolio shares provide the best inflation hedge. This literature therefore suggests that home bias in the goods market may be related to home bias in the asset market. The link is the real exchange rate: a different expenditure allocation leads to different inflation rates (when measured in the same currency) which leads to different hedge portfolios.

The literature that has followed has restated the issue in general equilibrium (GE) terms. A substantial number of papers have analyzed the optimal home bias in the context of two-country GE models with traded and non-traded goods.[2] A well-known result is that when utility is separable in traded and non-traded goods a country should be perfectly diversified in equity issued by the traded-goods sector but hold the entire equity supply of the domestic non-traded goods sector.

Recently fresh wind was blown into the argument linking portfolio shares and expenditure shares by the provocative contribution of Obstfeld and Rogoff (2000). They argue that costs to international trade in goods, which lead to home bias in trade, can explain many puzzles in open economy macroeconomics, including the portfolio home bias puzzle. This has lead to renewed theoretical interest in the topic. Recent contributions by Coeurdacier (2005), Heathcote and Perri (2005) and Kollmann (2006b) study the home bias issue in the context of two-country GE models with trade costs or home bias in preferences.[3] Different authors reach

[1]See Adler and Dumas (1983), Braga de Macedo (1983), Braga de Macedo, Goldstein and Meerschwam (1984), Branson and Henderson (1985), Kouri (1976), Kouri and Braga de Macedo (1978), and Stulz (1981). See Karolyi and Stulz (2003) and Lewis (1995) for recent surveys of the literature on international portfolio allocation.

[2]See for example Baxter, Jermann and King (1998), Dellas and Stockman (1989), Eldor, Pines and Schwartz (1988), Hnatkovska (2005), Kollmann (2006a), Pesenti and van Wincoop (2002) and Serrat (2002).

[3]Milesi-Ferretti and Lane (2004) generalize the Obstfeld and Rogoff (2000) model to a multi-country setup, leading to a gravity equation relating cross-border asset holdings and trade costs. See also the comments on Obstfeld and Rogoff (2000) in Engel (2000). Also closely related is Fitzgerald (2006), who uses a general equilibrium framework to study the impact of trade costs

different conclusions, though, depending on details of the model and parameter assumptions.

There is a small empirical literature that has investigated the impact of inflation uncertainty on optimal international portfolios in the context of partial equilibrium models with trade in equity and bonds. Adler and Dumas (1983) show that the component of the optimal portfolio that depends on inflation risk (the hedge portfolio) is close to zero and therefore does not differ significantly across countries. Cooper and Kaplanis (1994) develop a more formal test of inflation risk as an explanation for home bias and strongly reject it. These studies have not received any attention in the general equilibrium home bias literature with trade costs or non-traded goods. There are at least two reasons for that. First, the models in the empirical papers are quite different from the more recent models in that they are partial equilibrium and adopt N-country, $2N$-asset frameworks (bonds and equity). Second, home bias in the GE models can be computed without considering the asset pricing implications of the model. The covariance between asset returns and inflation risk, which is a key relationship in the partial equilibrium papers, receives no attention in the GE literature.

The main goal of this paper is to develop a link between the burgeoning GE literature and the much smaller empirical partial equilibrium literature. To develop this link we first frame the question of portfolio home bias with real exchange rate uncertainty in the context of a two-country partial equilibrium portfolio choice model. As a starting point we only consider trade in equity (as in most of the GE literature). We show that portfolio home bias depends on a covariance-variance ratio: the covariance between the real exchange rate and the excess return on home relative to foreign equity, divided by the variance of the excess return. When also introducing a forward market or trade in nominal bonds, we show that the home bias expression still depends on the covariance-variance ratio, although with different conditioning variables to compute the moments.

By adopting a partial equilibrium setting in which the stochastic processes of asset returns and the real exchange rate are exogenous, the link between portfolio home bias and the covariance-variance ratio develops naturally. The same link must apply in two-country GE models, but the GE literature does not discuss it.

Any explanation for portfolio home bias in the context of GE models only makes

on the extent of risk sharing across countries. Uppal (1993) is an earlier paper that investigates the impact of trade costs on portfolio home bias in a two-country general equilibrium setup.

sense if the resulting covariance-variance ratio is consistent with the data. In an application of the two-country setup to the United States versus the rest of the world (21 other industrialized countries) we find that the covariance-variance ratio is close to zero. This implies that very little portfolio home bias can be explained through home bias in trade. We then illustrate that conclusions of large portfolio home bias (or foreign bias) in the context of GE models are based on specifications in which the implied covariance-variance ratio is grossly at odds with the data. Any GE model that matches this feature of the data will come to the conclusion that there is no link between home bias in goods markets and home bias in financial markets.

The remainder of the paper is organized as follows. In section 2 we discuss the partial equilibrium portfolio maximization problem for a two-country setup under different asset market structures. Section 3 provides empirical results on the covariance-variance ratio and the implied home bias. Section 4 develops a link with the GE literature and section 5 concludes.

2 Home Bias Measures

In this section we derive home bias measures under three asset market structures: (i) trade in equity only, (ii) trade in equity plus a forward market, (iii) trade in equity and nominal bonds. We adopt a static (1-period) framework.[4] Without loss of generality, denote all asset returns, prices and inflation rates in terms of the currency of country 1.

Trade in Equity

First consider a setup in which the only assets are equity issued by both countries. The gross nominal return of country j equity is R_j. Country n investors face the following portfolio maximization problem. The initial wealth is $\bar{W}(n)$, of which a fraction $\alpha_j(n)$ is invested in country j equity. The inflation rate is $e^{\pi(n)}$, so that the real portfolio return is

$$R^p(n) = (\alpha_1(n)R_1 + (1 - \alpha_1(n))R_2)\, e^{-\pi(n)} \tag{1}$$

[4]In a multi-period setup a hedge against changes in future expected returns can be another source of home bias, but Tille and van Wincoop (2006) find that the home bias from this source is small and we will abstract from it.

Country n investors consume end of period wealth $W(n) = R^p(n)\bar{W}(n)$. Expected utility from end of period wealth is

$$EW(n)^{1-\gamma}/(1-\gamma) \tag{2}$$

The first order condition for optimal portfolio choice is

$$E\left(R^p(n)\right)^{-\gamma}(R_1 - R_2)e^{-\pi(n)} = 0 \tag{3}$$

Indicating log returns with lower case letters, the first order condition becomes

$$Ee^{-\gamma r^p(n)+r_1-\pi(n)} = Ee^{-\gamma r^p(n)+r_2-\pi(n)} \tag{4}$$

Now adopt a first order log-linearization of the real portfolio return[5]

$$r^p(n) = \alpha_1(n)r_1 + (1-\alpha_1(n))r_2 - \pi(n) \tag{5}$$

After substituting in (4) and assuming normality of log returns and inflation, some basic algebra yields the following optimal portfolio:

$$\alpha_1(n) = \lambda + \frac{\gamma-1}{\gamma}\frac{cov(r_1-r_2,\pi(n))}{var(r_1-r_2)} \tag{6}$$

When γ is one, investors have logarithmic preferences and the optimal portfolio (the so-called logarithmic portfolio) is given by λ, which depends on first and second moments of asset returns but is the same for investors in both countries:

$$\lambda = \frac{E(r_1-r_2) + 0.5(var(r_1) - var(r_2)) + \gamma cov(r_2-r_1, r_2)}{var(r_1-r_2)}$$

We adopt a standard definition of home bias: the fraction invested by country n investors in country n equity ($\alpha_n(n)$) minus the share of country n's equity in the world equity supply (β_n). Under perfect diversification this measure of home bias equals zero. The *average* home bias across the two countries is

$$home\ bias = \frac{1}{2}(\alpha_1(1) - \beta_1) + \frac{1}{2}(\alpha_2(2) - \beta_2) \tag{7}$$

[5] Engel and Matsumoto (2006) use the same approach to solve optimal portfolios. An alternative, which gives the same solution, is to take a second order approximation of the log portfolio return and then derive the first order condition and optimal portfolio. See, for example, Bacchetta and van Wincoop (2006).

Let $\Delta q = \pi(1) - \pi(2)$ be the change in the real exchange rate. A rise in Δq represents a country 1 real appreciation; that is, an increase in prices in country 1 relative to country 2 (when expressed in a common currency). Let $er = r_1 - r_2$ be the excess return. Using (6) and noting that $\beta_1 + \beta_2 = 1$ and $\alpha_2(2) = 1 - \alpha_1(2)$, the average home bias can be written as

$$home\ bias = 0.5 \frac{\gamma - 1}{\gamma} \frac{cov(er, \Delta q)}{var(er)} \tag{8}$$

This is a very simple and powerful equation. With log preferences ($\gamma = 1$) there is no home bias. More generally, (8) shows that that the average home bias depends on a covariance-variance ratio: the covariance of the excess return and the real exchange rate divided by the variance of the excess return.

While derived from a simple partial equilibrium portfolio maximization problem, the home bias expression (8) will hold in any two-country GE model with constant relative risk-aversion and trade limited to equity. It is therefore key that GE models match the moment

$$\frac{cov(er, \Delta q)}{var(er)}$$

in the data.

Adding a Forward Market

Now consider adding a forward market to cover against nominal exchange rate fluctuations. Let next period's nominal exchange rate be S and the current spot and forward exchange rates be $\bar{S}$ and F (currency 1 per unit of currency 2). When country n investors purchase forward $m(n)\bar{W}(n)/\bar{S}$ units of currency 2 in exchange for currency 1, the real portfolio return becomes

$$R^p(n) = \left(\alpha_1(n) R_1 + (1 - \alpha_1(n)) R_2 + m(n) \frac{S - F}{\bar{S}} \right) e^{-\pi(n)} \tag{9}$$

Using math similar to that above (see Appendix A for details) and letting Δs be the change in the log exchange rate, the optimal fraction invested in country 1 equity is

$$\alpha_1(n) = \mu + \frac{\gamma - 1}{\gamma} \frac{cov_{\Delta s}(r_1 - r_2, \pi(n))}{var_{\Delta s}(r_1 - r_2)} \tag{10}$$

Here the second moments $cov_{\Delta s}$ and $var_{\Delta s}$ refer to the covariance and variance based on the components of returns and inflation that are orthogonal to Δs. Only the parts of asset returns and inflation that are orthogonal to changes in the nominal exchange rate matter for the equity portfolio choice since nominal exchange rate risk can be separately hedged through the forward market. The parameter μ measures the logarithmic portfolio that depends on first and second moments of returns and exchange rates, but is the same for both countries' investors.

Applying the same home bias formula for the equity market as before, we get

$$home\ bias = 0.5\frac{\gamma-1}{\gamma}\frac{cov_{\Delta s}(er,\Delta q)}{var_{\Delta s}(er)} \tag{11}$$

The only difference is that now the home bias formula is based on the components of the excess return and real exchange rate that are orthogonal to the nominal exchange rate. Introducing a forward market is important because in the data nominal and real exchange rates are highly correlated. When changes in the nominal exchange rate can be hedged through a forward market, only the component of real exchange rate fluctuations that is orthogonal to nominal exchange rate fluctuations matters for home bias.

Equity and Nominal Bonds

Finally, consider a setup in which each country's equity and nominal bonds are traded. This is equivalent to trade in equity, plus a forward market, plus a nominal bond from either country. The nominal interest rate in country n is i_n. Let $b(n)$ be the fraction invested in country 2 nominal bonds by investors from country n. Then the portfolio return is

$$R^p(n) = (1+i_1)e^{-\pi(n)} + \tag{12}$$
$$\left(\alpha_1(n)(R_1-(1+i_1)) + \alpha_2(n)(R_2-(1+i_1)) + b(n)\left((1+i_2)\frac{S}{\bar{S}} - (1+i_1)\right)\right)e^{-\pi(n)}$$

Leaving details of the algebra to the Appendix, the optimal fraction invested in country 1 and 2 equity is

$$\alpha_1(n) = \kappa_1 + \frac{\gamma-1}{\gamma}\frac{cov_{\Delta s,r_2}(er,\pi(n))}{var_{\Delta s,r_2}(er)} \tag{13}$$

$$\alpha_2(n) = \kappa_2 - \frac{\gamma-1}{\gamma}\frac{cov_{\Delta s,r_1}(er,\pi(n))}{var_{\Delta s,r_1}(er)} \tag{14}$$

Here $cov_{\Delta s,r_j}(x,y)$ denotes the covariance between the components of x and y that are orthogonal to both Δs and r_j. These orthogonal components can be obtained from the error term of a regression of x and y on both Δs and r_j. The log portfolios (κ_1 and κ_2) depend on first and second moments of asset returns and exchange rates and are the same for both countries' investors.

The home bias measure (7) used so far can be written as the average fraction invested in domestic equity, $0.5(\alpha_1(1)+\alpha_2(2))$, minus the average share of domestic equity supply, $0.5(\beta_1 + \beta_2) = 0.5$. With trade in nominal bonds portfolio shares are now a fraction of total financial wealth, which is larger than equity wealth. We therefore define home bias as

$$home\ bias = \omega \frac{\alpha_1(1) + \alpha_2(2)}{2} - 0.5 \tag{15}$$

where ω is the ratio of world wealth to the world equity market. This is consistent with the measure of home bias without trade in bonds, where $\omega = 1$.

Define w_1 as the share of country 1 in world wealth. Using the equity market clearing conditions $\alpha_i(1)w_1 + \alpha_i(2)(1 - w_1) = \beta_i/\omega$ for $i = 1, 2$, implementing this home bias definition yields (see Appendix B)

$$home\ bias = 0.5\omega\frac{\gamma - 1}{\gamma}\left(w_1\frac{cov_{\Delta s,r_1}(er, \Delta q)}{var_{\Delta s,r_1}(er)} + (1 - w_1)\frac{cov_{\Delta s,r_2}(er, \Delta q)}{var_{\Delta s,r_2}(er)}\right) \tag{16}$$

There are two changes relative to home bias measures (8) and (11). First, the home bias is scaled upwards because $\omega > 1$. Second, the moment

$$\frac{cov(er, \Delta q)}{var(er)}$$

is now replaced by a weighted average of the same moment based on two different orthogonal components of the real exchange rate and excess return, the first with respect to Δs and r_2 and the second with respect to Δs and r_1.

3 Empirics

Data Description

We compute the covariance-variance ratios in (8), (11), and (16) using monthly data for the period 1988-2005. The two-country framework in the previous section is interpreted as a model of the United States and the rest of the world (ROW). For our purposes, ROW will be composed of an equity-market-capitalization-weighted combination of twenty-one industrialized countries that have complete data.[6]

The calculation of the home bias expressions require data for U.S. inflation, U.S. equity returns, as well as three ROW market-capitalization-weighted indexes: a nominal dollar index, an index of foreign equity returns, and a foreign inflation index. Inflation (both U.S. and foreign) and equity returns are expressed in dollars. We use identical weighting schemes to compute the ROW indexes; weights are given by the relative weight of each foreign country in total ROW equity market capitalization.[7] Equity indexes, which include both capital gains and dividends and are converted into dollars, are as of month end from MSCI Barra. The excess return is computed as the log first difference between the U.S. and ROW equity indexes: $er = r^{US} - r^{ROW}$. Nominal exchange rates are month-end data from Board of Governors of the Federal Reserve System's G.5 Report (as compiled by Haver Analytics). Consumer price indexes are from the IMF's International Financial Statistics database. The ROW dollar price index is computed by first multiplying the local currency price indexes of each country with the nominal exchange rate to convert to dollars and then applying the equity market capitalization weights. The change in the real exchange rate Δq is equal to the difference between U.S. and ROW inflation rates, both expressed in dollars.

Covariance-Variance Calculations

Calculations of the covariance-variance ratio in the first home bias expression (8) are given in column (1) of Table 1. The ratio is 0.32. This implies that the maximum home bias (for infinite risk-aversion) is one-half of that, or 0.16. For a rate of risk-aversion of 5, the bias would be 0.13. While not negligible, the bias is substantially below existing estimates of home bias.[8] More importantly, this bias is almost entirely the result of nominal exchange rate fluctuations that identically

[6]The countries included in ROW are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, and United Kingdom.

[7]The weights are based on closing values as of December 31 of the previous year. Annual updating of weights is in line with the methodology used by the Federal Reserve Board in forming its monthly trade-weighted dollar indexes. See Loretan (2005).

[8]U.S. home bias has ranged between 0.4 and 0.5 over the past decade. See Ahearne, Griever and Warnock (2004) and Kho, Stulz and Warnock (2006).

affect the real exchange rate and the excess return. Once we introduce a forward market, this disappears.

In column (2) we implement the home bias formula (11) in the presence of a forward market, using the components of the real exchange rate and excess return that are orthogonal to the nominal exchange rate. Now the covariance-variance ratio falls to near zero (0.0052). A similar result applies when introducing both Home and Foreign nominal bonds in addition to trade in equity of both countries. The covariance-variance ratios embedded in home bias formula (16), shown in columns (3) and (4), are very small. Even after scaling these numbers up by any reasonable estimate of total financial wealth to equity wealth (represented by ω in the home bias formula), the result remains close to zero. We can conclude that portfolio home bias associated with hedging real exchange rate risk is essentially zero.

The data underlying Table 1 are 216 monthly observations. One could argue that timing issues put undue burden on data of a relatively high frequency. In Table 2 we recomputed the covariance-variance ratios using data sets with overlapping 12-month cumulative returns, quarterly data, and annual data. The story remains the same: the relationship between relative equity returns and the real exchange rate is too weak to generate substantial home bias. The evidence is clearly not supportive of a link between home bias in assets and home bias in goods.

4 Link to the General Equilibrium Literature

In the preceding sections we have analyzed the home bias based on partial equilibrium solutions to portfolio choice. But it nonetheless closely connects to the GE literature on home bias in the presence of trade costs, non-traded goods or home bias in preferences. We have adopted a two-country model, as is standard in the GE literature. The assumed constant relative risk-aversion utility function is also standard in the GE literature. While we have taken the stochastic process of asset returns and the real exchange rate as exogenously given, the resulting home bias expression is exactly the same when asset returns and the real exchange rate are endogenously determined in GE models. Finally, most of the GE literature assumes that trade is limited to equity. Therefore the home bias equation (8) connects closely to the GE literature. However, none of the GE home bias papers mentioned in the introduction draws the link between home bias and the covariance-variance ratio, nor does any compare the implied covariance-variance ratio to the data.

The conclusions in GE models about the magnitude of home bias in the presence of trade costs or home bias in preferences range from large home bias (e.g. Heathcote and Perri (2004), Kollmann (2006) and Obstfeld and Rogoff (2000)) to substantial foreign bias (Coeurdacier (2005)). The question then is how these findings can be reconciled with our conclusion that home bias based on hedging real exchange rate uncertainty is close to zero. The reconciliation consists of two steps. First, the GE models do not introduce a forward market or trade in nominal bonds denominated in the currencies of the countries.[9] We showed that introducing such assets reduces the implied home bias to essentially zero. Second, by ignoring the covariance-variance ratio, GE models can derive home bias results that are not at all constrained by data on these moments.

To make this second point a bit more precise, consider for example the GE model in Coeurdacier (2005), which nests the case studied by Obstfeld and Rogoff (2000) as a particular example. The model in Coeurdacier (2005) is a static two-country GE model with the same constant rate of relative risk-aversion preferences as assumed in section 2. Each country produces a different good with one fixed factor, so that it is essentially an endowment economy. Productivity shocks in both countries determine the level of output. The two countries trade claims on the output of both goods. The consumption index in the Home country is

$$C = \left[\alpha^{1-\rho} C_H^{\rho} + (1-\alpha)^{1-\rho} C_F^{\rho}\right]^{1/\rho} \tag{17}$$

where C_H and C_F are respectively consumption of Home and Foreign goods, $\alpha \geq 0.5$ is a parameter of bias in preferences toward the Home good and $1/(1-\rho)$ is the elasticity of substitution between Home and Foreign goods.[10] In addition, there is a trade cost τ that is of the iceberg type, such that 1 good arrives if $1+\tau$ goods are shipped. The model in Obstfeld and Rogoff (2000) is the same, but adopts the additional restrictions $\alpha = 0.5$ (no home bias in preferences) and $\gamma = 1-\rho$ (overall utility is separable in both goods).

[9] Nominal exchange rate risk is often absent from GE models because they usually do not introduce money or nominal rigidities.

[10] Coeurdacier (2005) allows for a continuum of goods produced in each country, with a constant elasticity of substitution between them. But that feature plays no role in the subsequent analysis, so we omit it.

While Coeurdacier (2005) does not draw a link between home bias and the covariance-variance ratio, the portfolio home bias in this model is exactly that in (8) with the covariance-variance ratio equal to

$$\frac{cov(er, \Delta q)}{var(er)} = \frac{-\theta_\rho}{\frac{\rho}{1-\rho} + \theta_\rho^2 \left(\frac{1}{\gamma} - \frac{1}{1-\rho}\right)} \tag{18}$$

where

$$\theta_\rho = \frac{1-\xi}{1+\xi}$$

and

$$\xi = \frac{1-\alpha}{\alpha} \left(\frac{1}{1+\tau}\right)^{\frac{\rho}{\rho-1}}$$

Here we followed the notation of Coeurdacier (2005). The home bias in preferences and trade costs are jointly captured by $\xi < 1$.

First consider the preferred parameterization by Obstfeld and Rogoff (2000): $\tau = 0.25$, $\alpha = 0.5$, $1/(1-\rho) = 6$ and $\gamma = 1-\rho$. This leads to a covariance-variance ratio of about -0.10. This is clearly inconsistent with the data, where we found a positive covariance-variance ratio of 0.32 with trade limited to equity. Obstfeld and Rogoff (2000) generated a positive home bias with a negative covariance-variance ratio because their assumption $\gamma = 1-\rho$ implies a rate of relative risk-aversion of less than 1 ($\gamma = 1/6$). This near-zero rate of relative risk-aversion is at odds with a substantial body of empirical evidence, but together with the negative covariance-variance ratio of -0.1 implies a home bias of 0.25.[11]

The preferred parameterization in Coeurdacier (2005) is $\alpha = 0.7$, $1/(1-\rho) = 5$, $\gamma = 2$ and $\tau = 0.35$. This generates of negative home bias of about 0.15, or a foreign bias of 0.15. In this case the covariance-variance ratio is -0.58, also significantly different from that in the data. In fact, even if we vary τ from 0 to 1, γ from 1 to 10 and $1/(1-\rho)$ from 1 to 10, the model is not able to come anywhere near the observed 0.32 covariance-variance ratio.[12]

Conclusions about home or foreign bias from GE models with trade costs or home bias in preferences should therefore be considered as suspect as they are not firmly grounded in data on the covariance-variance ratio that is the ultimate source

[11] Obstfeld and Rogoff (2000) report a home bias of 0.31 in this case. The small discrepancy is the result of the first order approximation of the model in Coeurdacier (2005), on which (18) is based.

[12] Positive numbers can be attained, but they are always much greater than one.

of the home bias. If GE models are parameterized to match this key feature of the data, and are rich enough to allow for a forward market or trade in nominal bonds, then one must conclude that home bias in the goods market cannot account for home bias in financial markets.

5 Conclusion

We conclude that the answer to the question in the title of the paper is "highly unlikely". Home bias in the goods market is linked to home bias in the asset market through the real exchange rate. When the expenditure allocation differs across countries in the presence of a bias towards domestically produced goods, the real exchange rate fluctuates and inflation rates (when measured in the same currency) differ across countries. This leads investors from different countries to hold different hedge portfolios to protect against inflation uncertainty. We have shown under various asset market structures that the resulting home bias depends on a covariance-variance ratio: the covariance between the real exchange rate and the excess return divided by the variance of the excess return. Empirical evidence shows that this ratio is close to zero, casting significant doubt on trade costs as an explanation for portfolio home bias. GE models are subject to the same covariance-variance ratio; those that produce substantial home bias do so through an implied covariance-variance ratio that is at odds with the data.

Appendix

A Home Bias with a Forward Market and Equity Markets

In this Appendix we derive the home bias formula (11) in the presence of a forward market. There are now two first order conditions, with respect to $\alpha_1(n)$ and $m(n)$, which in the log-return notation are

$$Ee^{-\gamma r^p(n)+r_1-\pi(n)} = Ee^{-\gamma r^p(n)+r_2-\pi(n)} \tag{19}$$

$$Ee^{-\gamma r^p(n)+\Delta s-\pi(n)} = Ee^{-\gamma r^p(n)+(f-\bar{s})-\pi(n)} \tag{20}$$

where Δs is the change in the log exchange rate. The linearized log-portfolio return is now

$$r^p(n) = \alpha_1(n)r_1 + (1-\alpha_1(n))r_2 + m(n)(\Delta s - (f-\bar{s})) - \pi(n) \tag{21}$$

To solve for the optimal portfolio allocation $\alpha_1(n)$ and $m(n)$, first substitute the log portfolio return into the first order conditions to get

$$\lambda_1 - \gamma\alpha_1(n)var(r_1-r_2) - (1-\gamma)cov(r_1-r_2,\pi(n)) - \gamma m(n)cov(r_1-r_2,\Delta s) = 0$$
$$\lambda_2 - \gamma\alpha_1(n)cov(r_1-r_2,\Delta s) - (1-\gamma)cov(\Delta s,\pi(n)) - \gamma m(n)var(\Delta s) = 0$$

where

$$\lambda_1 = E(r_1-r_2) + 0.5(var(r_1)-var(r_2)) + \gamma cov(r_2-r_1,r_2)$$
$$\lambda_2 = E(\Delta s - f + \bar{s}) + 0.5var(\Delta s) - \gamma cov(r_2,\Delta s)$$

The parameters λ_1 and λ_2 are the same for investors from both countries.

Solving for $m(n)$ from the second first order condition and substituting into the first one yields

$$\eta - \gamma\alpha_1(n)var(r_1-r_2) - (1-\gamma)cov(r_1-r_2,\pi(n)) \tag{22}$$
$$+\gamma\alpha_1(n)\frac{cov(r_1-r_2,\Delta s)^2}{var(\Delta s)} + (1-\gamma)\frac{cov(\pi(n),\Delta s)cov(r_1-r_2,\Delta s)}{var(\Delta s)} = 0$$

where

$$\eta = \lambda_1 - \lambda_2 \frac{cov(\Delta s, r_1 - r_2)}{var(\Delta s)}$$

For any variable x, define $\hat{x}$ as the residual of a regression of x on Δs. Therefore

$$x = \frac{cov(x, \Delta s)}{var(\Delta s)} \Delta s + \hat{x} \tag{23}$$

Applying this to $x = r_1 - r_2$ and $x = \pi(n)$, (22) becomes

$$\eta - \gamma \alpha_1(n) var(\hat{r}_1 - \hat{r}_2) - (1 - \gamma) cov(\hat{r}_1 - \hat{r}_2, \hat{\pi}(n)) = 0 \tag{24}$$

This implies (10) with

$$\mu = \frac{\eta}{\gamma var(\hat{r}_1 - \hat{r}_2)}$$

Using (7), which can be rewritten as average $bias = \frac{1}{2}(\alpha_1(1) - \alpha_1(2))$, then yields (11).

B Home Bias with Bond and Equity Markets

In this Appendix we derive the home bias formula (16) in the presence of both bond and equity markets.

In log-return notation, the first order conditions for $\alpha_1(n)$, $\alpha_2(n)$ and $b(n)$ are

$$E_t e^{-\gamma r^p(n) + r_1 - \pi(n)} = E_t e^{-\gamma r^p(n) + ln(1+i) - \pi(n)} \tag{25}$$

$$E_t e^{-\gamma r^p(n) + r_2 - \pi(n)} = E_t e^{-\gamma r^p(n) + ln(1+i) - \pi(n)} \tag{26}$$

$$E_t e^{-\gamma r^p(n) + ln(1+i^*) + \Delta s - \pi(n)} = E_t e^{-\gamma r^p(n) + ln(1+i) - \pi(n)} \tag{27}$$

and the log-linearized portfolio return is

$$r^p(n) = i_1 + \alpha_1(n)(r_1 - i_1) + \alpha_2(n)(r_2 - i_1) + b(n)(i_2 + \Delta s - i_1) - \pi(n) \tag{28}$$

Substituting (28) into the first order conditions (25)-(27), we get

$$\lambda_1 - \gamma \alpha_1(n) var(r_1) - \gamma \alpha_2(n) cov(r_1, r_2) - \gamma b(n) cov(r_1, \Delta s) - (1 - \gamma) cov(r_1, \pi(n)) = 0$$

$$\lambda_2 - \gamma \alpha_1(n) cov(r_1, r_2) - \gamma \alpha_2(n) var(r_2) - \gamma b(n) cov(r_2, \Delta s) - (1 - \gamma) cov(r_2, \pi(n)) = 0$$

$$\lambda_3 - \gamma \alpha_1(n) cov(r_1, \Delta s) - \gamma \alpha_2(n) cov(r_2, \Delta s) - \gamma b(n) var(\Delta s) - (1 - \gamma) cov(\Delta s, \pi(n)) = 0$$

where

$$\lambda_1 = Er_1 - ln(1+i_1) + 0.5var(r_1)$$
$$\lambda_2 = Er_2 - ln(1+i_1) + 0.5var(r_2)$$
$$\lambda_3 = E\Delta s + ln(1+i_2) - ln(1+i_1) + 0.5var(\Delta s)$$

The first step towards solving the home bias formula is the same as with a forward market. Again define $\hat{x}$ as the component of x orthogonal to Δs, as in (23). Applying this to returns and inflation rates after substituting the solution for $b(n)$ from the last first order condition into the first two first order conditions, we get

$$\eta_1 - \gamma\alpha_1(n)var(\hat{r}_1) - \gamma\alpha_2(n)cov(\hat{r}_1,\hat{r}_2) + (\gamma-1)cov(\hat{r}_1,\hat{\pi}(n)) = 0 \quad (29)$$
$$\eta_2 - \gamma\alpha_1(n)cov(\hat{r}_1,\hat{r}_2) - \gamma\alpha_2(n)var(\hat{r}_2) + (\gamma-1)cov(\hat{r}_2,\hat{\pi}(n)) = 0 \quad (30)$$

where η_1 and η_2 depend on first and second moments that are the same from the perspective of investors of both countries.

Substituting (30) into (29) gives

$$\mu_1 - \gamma\alpha_1(n)var(\hat{r}_1) + \gamma\alpha_1(n)\frac{cov(\hat{r}_1,\hat{r}_2)^2}{var(\hat{r}_2)}$$
$$+(\gamma-1)cov(\hat{r}_1,\hat{\pi}(n)) - (\gamma-1)\frac{cov(\hat{r}_2,\hat{\pi}(n))cov(\hat{r}_1,\hat{r}_2)}{var(\hat{r}_2)} = 0 \quad (31)$$

where μ_1 is the same for investors of both countries.

Now define $\tilde{r}_1$ and $\tilde{\pi}(n)$ as the components of $\hat{r}_1$ and $\hat{\pi}(n)$ that are orthogonal to $\hat{r}_2$. Again applying (23), (31) becomes

$$\mu_1 - \gamma\alpha_1(n)var(\tilde{r}_1) + (\gamma-1)cov(\tilde{r}_1,\tilde{\pi}(n)) = 0 \quad (32)$$

Since $\tilde{r}_1$ and $\tilde{\pi}(n)$ are the same as the residuals of regressions of respectively r_1 and $\pi(n)$ on both Δs and r_2, (13) follows. Equation (14) follows by symmetry.

Using the equity market clearing conditions

$$\alpha_i(1)w_1 + \alpha_i(2)(1-w_1) = \beta_i/\omega \quad (33)$$

for $i = 1, 2$, (**??**) becomes

$$home\ bias = 0.5\omega\left[(\alpha_1(1) - \alpha_1(2))(1-\omega_1) + (\alpha_2(2) - \alpha_2(1))\omega_1\right] \quad (34)$$

Substituting (13) and (14) yields (16).

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Table 1. Covariance-Variance Ratios: Monthly Data, 1988-2005

	(1) $\frac{\text{cov}(er,\Delta q)}{\text{var}(er)}$	(2) $\frac{\text{cov}_{\Delta s}(er,\Delta q)}{\text{var}_{\Delta s}(er)}$	(3) $\frac{\text{cov}_{\Delta s,r_2}(er,\Delta q)}{\text{var}_{\Delta s,r_2}(er)}$	(4) $\frac{\text{cov}_{\Delta s,r_1}(er,\Delta q)}{\text{var}_{\Delta s,r_1}(er)}$
cov(*er*,*q*)	1.7084	0.0193	-0.0023	0.0263
var(*er*)	5.3863	3.7224	2.5832	3.4661
Ratio	0.3172	0.0052	-0.0009	0.0076

Notes. The covariance-variance ratios correspond to those in equations (8), (11), and (16). Specifically, in column (1), corresponding to the expression below equation (8), straight excess returns and real exchange rate changes are used; in column (2), corresponding to the expression in equation (11), *er* and Δq are orthogonal to changes in the nominal exchange rate; in column (3), corresponding to the first term in equation (16), *er* and Δq are orthogonal to changes in the nominal exchange rate and r^{ROW}; and in column (4), corresponding to the second term in equation (16), *er* and Δq are orthogonal to changes in the nominal exchange rate and r^{US}. There are 216 monthly observations underlying each calculation.

Table 2. Covariance-Variance Ratios: Different Frequencies

	(1) $\frac{\text{cov}(er,\Delta q)}{\text{var}(er)}$	(2) $\frac{\text{cov}_{\Delta s}(er,\Delta q)}{\text{var}_{\Delta s}(er)}$	(3) $\frac{\text{cov}_{\Delta s,r_2}(er,\Delta q)}{\text{var}_{\Delta s,r_2}(er)}$	(4) $\frac{\text{cov}_{\Delta s,r_1}(er,\Delta q)}{\text{var}_{\Delta s,r_1}(er)}$
12-month cumulative returns	0.1266	-0.0119	-0.0143	0.0063
Quarterly data	0.3187	-0.0024	-0.0266	-0.0018
Annual data	0.1109	-0.0106	-0.0166	-0.0084

Notes. The covariance-variance ratios correspond to those in equations (8), (11), and (16); see Table 1 for details. The number of observations in the three rows are 205, 72, and 18, respectively.