# Can nontradables generate substantial home bias?*

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**Abstract**

The past decade has witnessed an increase in the fraction of equity portfolios invested abroad, as barriers to international asset trade have significantly declined. What are the long-run implications of this process? In this paper we investigate to what extent nontradables (consumption and leisure) can affect the portfolio allocation decision in otherwise integrated capital markets. We find that hedging against nontradables shocks can account for only a small portfolio bias towards domestic assets. These results suggest that in the near future we can expect to observe sizable additional international diversification.

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# 1 Introduction

A number of recent studies have documented a significant, yet slowly falling 'home bias' in international financial portfolios among industrialized countries.[1] The most recent evidence, from Tesar and Werner (1998), shows that by the end of 1996 the fraction of stock-market wealth invested in foreign assets was 10% for the US, 11% for Canada, 18% for Germany, and 22% for the UK. These numbers have increased from a decade ago. In 1987 US residents invested 4% abroad, Canadian investors 6%, and British investors 17%.

It is likely that the demand for diversification will increase in the near future, as the development of cheaper and more efficient information and communication technologies reduce information asymmetries.[2] The diffusion of a core set of international accounting standards and a more liberal regulatory environment worldwide are likely to contribute to this process as well.[3]

A key question is where the process of increasing portfolio diversification will eventually settle down. In other words, what is the long-term 'benchmark portfolio' in the absence of regulatory obstacles, capital controls, information asymmetries, or any other type of constraint on investors' activity. The standard theoretical baseline assumes symmetry across agents and countries, and predicts that agents worldwide hold the same portfolio. The fraction invested at home is therefore equal to the value of the domestic stock market relative to the value of the world stock market.

Figure 1 shows this benchmark allocation relative to current aggregate portfolio shares, thus providing a visual representation of the 'long way to go' to bridge the gap between observed and predicted portfolios. For example, British residents currently invest 78% at home, but would invest 10% domestically under the benchmark. Similarly, US residents invest 90% at home, but would invest 42% in domestic securities under the benchmark.

There are several reasons though why the symmetric portfolio based on market capitalization may not be the correct long-term benchmark. Traded securities such as equity and corporate bonds are effectively claims on some component of corporate profits. But corporate profits make up only about 10% of national income. Depending on the correlation between the return on traded and non-traded assets, residents in different countries will generally hold different portfolios. A number of studies have recently investigated the role of non-traded human capital for portfolio choice, in particular Bottazzi, Pesenti and van Wincoop (1996) and Baxter and Jermann (1997).[4]

About half of a consumer's budget is spent on items that can be qualified as nontradable. Moreover, leisure can be considered a nontraded good as well. Fluctuations in nontradables can affect the optimal portfolio choice through their impact on the marginal utility from tradables consumption.

Consider for example the case where leisure and consumption are substitutes. Intuitively, one can interpret leisure as non-market production (staying at home to take care of the baby) that can be substituted for market production (hiring a baby-sitter). When non-market production is low (*i.e.*, a cyclical upturn), the need to finance a larger amount of market consumption is strong. Investing in domestic assets makes it on average easier to finance such additional consumption since the payoff on domestic assets is likely to be high relatively to foreign assets during a boom. In other words, it is optimal to invest at home because there is a negative correlation between domestic asset returns and leisure. With regards to nontradables consumption, on the other hand, one might expect a positive correlation between asset returns and nontradables. In that case it becomes attractive to invest at home when tradables and nontradables consumption are complements.

The aim of this paper is to quantify to what extent the presence of nontradables raises the fraction of stock-market wealth invested at home *vis-à-vis* the symmetric baseline of Figure 1. Does the discrepancy between observed and predicted portfolios significantly shrink when the appropriate theoretical benchmark is taken into account?

The recent literature has emphasized several reasons why we may expect nontradables to play an important role in portfolio choice. For instance, Lewis (1996) finds that perfect risksharing cannot be rejected among a set of countries with unrestricted capital flows, as long as one allows for nonseparability in preferences between tradables and nontradables (consumption or leisure). In the context of the complete-markets Lewis (1996) model, the observed home bias can only be explained as the result of an optimum *hedge* against nontradables uncertainty.

Extensive evidence on imperfect portfolio diversification *within* the U.S. also suggests that nontradables may play an important role in explaining the observed home bias.[5] In fact, to the extent that nontradables are not traded within countries as well as among countries, explanations based on nontradables provide a general interpretive framework to rationalize the existence of both *intra* and *inter*national home bias in investors' portfolios.

Most of the literature on the role played by nontradables in the 'home bias puzzle' is theoretical.[6] Although the importance of nontradables is frequently raised as a potential explanation for the home bias puzzle,[7] the empirical literature remains quite limited. Tesar (1995) focuses on the role of nontraded goods and provides preliminary evidence on empirical measures of portfolio weights in the context of a static two-country setup where the only traded assets are claims on tradables output. Jermann (1998) considers the role of fluctuations in leisure in the context of a model with productivity shocks.

In this paper our aim is to provide a systematic analysis of the effects of nontradables uncertainty on international asset allocation, obtaining empirical measures of the portfolio home bias when both nontraded leisure and consumption are considered. We cast our empirical analysis in the context of a simple continuous-time, infinite horizon model with state-dependent utility of tradables consumption, where the state variable represents the stochastic endowment of nontradables. In the empirical application asset returns are either equity returns or approximations of 'fundamental returns' associated with claims on one period's profits or claims on the present discounted value of firms' profits.

The paper is organized as follows. In Section 2 we derive closed-form expressions for optimal international portfolio shares and portfolio home bias. Next, we parameterize preferences in terms of the CES class of utility functions to obtain an explicit expression of the propensity to hedge as a function of preference parameters. Section 3 applies the model to a set of fourteen OECD countries, using three alternative measures of national asset returns. We estimate with GMM the preference parameters that determine the propensity to hedge and obtain estimates of the home bias. The main conclusions are summarized in section 4.

# 2 A model of international portfolio choice with nontradables

## 2.1 The setup

In our theoretical framework, by *nontradables* or *nontradables consumption* we refer indifferently to consumption of nontraded goods (services), or leisure. Domestic residents receive an endowment stream of nontradables $S(t)$, whose stochastic rate of growth is given by

$$\frac{dS(t)}{S(t)} = \mu dt + \sigma_X d\xi(t) \tag{1}$$

where $\mu$ and $\sigma_X$ are constant parameters and $\xi$ is a standard Wiener process.[8] National securities are internationally traded without restrictions. The instantaneously stochastic returns on domestic and foreign assets are:

$$\begin{aligned} dR(t) &= \eta dt + \sigma_R d\omega(t) && (2) \\ dR^*(t) &= \eta dt + \sigma_{R^*} d\omega^*(t) && (3) \end{aligned}$$

Here $R$ is the cumulative return on the domestic asset and $R^*$ the cumulative return on the foreign asset. The parameters $\sigma_R^2$ and $\sigma_{R^*}^2$ denote the instantaneous conditional variances, while $\eta$ denotes the expected return per unit time, assumed to be equal across countries and constant over time.[9] The instantaneous correlation between the returns is denoted $\rho \equiv [E(d\omega d\omega^*)]/dt$. The correlations between the growth rate of nontradables consumption and the two asset returns are denoted $\rho_{RX} \equiv [E(d\omega d\xi)]/dt$ and $\rho_{R^*X} \equiv [E(d\omega^* d\xi)]/dt$.

The stochastic process for domestic wealth $W$ (measured in terms of traded goods) is

$$\begin{aligned} dW(t) &= [n(t)\,dR(t) + (1 - n(t))\,dR^*(t)]\,W(t) \\ &\quad + p(t)\,S(t)\,dt - C(t)\,dt - p(t)\,X(t)\,dt \end{aligned} \tag{4}$$

where $C(t)$ is domestic consumption of tradables, $X(t)$ consumption of nontradables, $n(t)$ is the fraction of wealth invested at home and $p(t)$ is the relative price of nontradables.

Domestic residents determine optimal consumption and portfolio plans by maximizing the expected present discounted value of their utility stream, $U[C, X]$. Preferences are assumed to be symmetric across investors worldwide. The value function $V[W, X]$ is defined as:

$$V[W(t), X(t)] \equiv \max_{C(t),n(t)} E_t \int_t^{\infty} e^{-\delta(s-t)} U[C(s), X(s)] ds \tag{5}$$

where $\delta$ is the rate of time preference. In equilibrium we have $S(t) = X(t)$, and the relative price of nontradables $p(t)$ is equal to the ratio of the marginal utilities $U_X/U_C$. Optimal consumption/portfolio choice $C(t)$ and $n(t)$ solves the Bellman equation:

$$\delta V[W(t), X(t)] = \max_{C(t),n(t)} U[C(t), X(t)] + (E_t dV[W(t), X(t)])/dt \quad (6)$$

subject to (1)-(4) and the appropriate boundary conditions.

In the specification above, technical complexities are deliberately downplayed to help focus on hedging against nontradables uncertainty. Yet, it is worth emphasizing that the basic framework can be generalized to encompass asset return features such as mean reversion or stochastic volatility, without substantially altering our analysis of the portfolio bias.[10]

## 2.2 The 'bias' formula

Applying standard techniques of stochastic dynamic programming,[11] the first order condition for a maximum with respect to consumption yields the envelope expression:

$$U_C = V_W \quad (7)$$

and the first order condition with respect to $n$ determines the optimal portfolio shares:

$$n = \frac{\sigma_{R^*}^2 - \rho\sigma_{R^*}\sigma_R}{\sigma_R^2 + \sigma_{R^*}^2 - 2\rho\sigma_R\sigma_{R^*}} + bias \quad (8)$$

where the term *bias* can be written as:

$$bias \equiv H\sigma_X \left( \frac{\sigma_R\rho_{RX} - \sigma_{R^*}\rho_{R^*X}}{\sigma_R^2 + \sigma_{R^*}^2 - 2\rho\sigma_R\sigma_{R^*}} \right) \quad (9)$$

In eq.(9), the expression $H$ denotes the 'propensity to hedge' against unanticipated fluctuations in nontradables consumption, and is defined as

$$H \equiv -\frac{V_{WX}}{V_{WW}}\frac{X}{W}, \quad (10)$$

a function of preferences and the ratio of nontradables consumption to wealth.

The first term on the right hand side of (8) is the minimum-variance portfolio share. One could think of this expression as the benchmark of Figure 1, since the minimum-variance portfolio must be identical worldwide.[12] The second term, denoted *bias* and defined in eq.(9), measures the degree of skewness towards domestic (if positive) or foreign (if negative) securities as a result of hedging against nontradables fluctuations. In other words, *bias* measures the extent to which the correct long-term benchmark is different from that in Figure 1. For instance, if *bias* were equal to 20%, the benchmark long term investment portfolio for U.S. residents would involve an investment of 62% at home, as opposed to the 42% reported in Figure 1.

In eq.(9), for a given propensity to hedge the term *bias* depends on the second moments of the processes for asset returns and nontradables consumption. The economic role played by these moments is intuitive. In absolute value the term *bias* is an increasing function of the volatility of nontradables consumption growth $\sigma_X$ — a measure of potential scope for hedging. Assuming that $H$ is positive, investors will hold a larger fraction of domestic assets to the extent that domestic nontradables consumption growth is more correlated with domestic than foreign returns. The opposite holds if $H$ is negative. Notice that, if returns are less volatile abroad than at home (*i.e.*, if $\sigma_{R^*} < \sigma_R$),[13] the usefulness of the 'foreign' asset as a hedge lessens.

## 2.3 The propensity to hedge under CES preferences

At the level of generality of the previous section, very little can be said about the order of magnitude of the propensity to hedge. We can only observe that 1 is the upper limit for $H$ if the instantaneous utility function $U[C, X]$ is homogeneous of degree $1-\gamma$ (where $\gamma$ represents any non-negative number) in $C$ and $X$, so that the value function is homogeneous of the same degree in $W$ and $X$. Using the homogeneity property, it is straightforward to show that[14]

$$H = 1 + \gamma \left( \frac{V_W}{V_{WW} W} \right) \leq 1 \qquad (11)$$

We can illustrate in more detail the characteristics of the propensity to hedge for a constant elasticity of substitution (CES) utility function. Suppose that the instantaneous utility function takes the form[15]

$$U[C, X] = \frac{1}{1-\gamma} [\alpha X^{1-1/\epsilon} + (1-\alpha) C^{1-1/\epsilon}]^{\frac{\epsilon}{\epsilon-1}(1-\gamma)} \qquad 0 < \alpha < 1 \quad (12)$$

where $\epsilon$ is the elasticity of substitution between tradables and nontradables, and $\gamma$ is the rate of relative risk aversion. The sign of $U_{CX}$ is the same as that of $1-\gamma\epsilon$. Tradables and nontradables are complementary in preferences when $\gamma\epsilon < 1$, while they are substitutes when $\gamma\epsilon > 1$.

Taking into account the properties of homogeneous functions,[16] it is useful to transform the problem in terms of a unique state variable. Posing $z \equiv X/W$, $V \equiv \varphi(z)X^{1-\gamma}$ and $C \equiv \tau(z)W$ without loss of generality, it can be shown that the propensity to hedge $H$ can be written as a function of the state variable $z$:[17]

$$H(z) = 1 - \frac{\gamma\epsilon\,(1+m)}{(1+\gamma\epsilon m)\left(1 - \dfrac{\tau' z}{\tau}\right)} \tag{13}$$

where $m(z) \equiv C/pX$ is the ratio of tradables to nontradables consumption.

There are special cases, and parameter configurations, for which the propensity to hedge is *not* state-dependent. For instance, if $\gamma = 0$ (infinite elasticity of intertemporal substitution) it is immediate from eq.(13) that the propensity to hedge is always equal to 1, its maximum value. By the same token, the propensity to hedge is 1 when $\epsilon = 0$, the case of extreme intratemporal complementarity under Leontief preferences. If $1 - \gamma\epsilon = 0$, the utility function is additively separable in the two consumption goods (as in Stockman and Dellas (1989)). In this case, changes in $X$ do not affect the marginal utility of tradables consumption, there is no scope for hedging ($H = 0$), and agents fully diversify their portfolios of claims on tradable goods.[18] If $\epsilon = 1$, it is easy to verify that the value function takes the form $V = [X^{\alpha}(\tau W)^{1-\alpha}]^{(1-\gamma)}/[\tau(1-\gamma)]$ for some constant $\tau$. Under these conditions, consumption of tradables is equal to $\tau W$, hence independent of $X$, and the propensity to hedge is a constant equal to $(1-\gamma)\,/\,[1+\gamma(1-\alpha)\alpha^{-1}]$.

If none of the (restrictive) conditions outlined above hold, the propensity to hedge will not be constant over time. However, there is another case — an empirically relevant one, as we discuss later — in which the propensity to hedge will be approximately constant. For 'small' levels of risk and sufficiently similar rates of consumption growth in the two sectors (thus constant $p$ and $m$), the propensity to hedge is approximately equal to

$$H = \frac{1-\gamma\epsilon}{1+m\epsilon\gamma}, \tag{14}$$

a function of the consumption ratio $m$ only.

To obtain the above formula, observe that in the absence of uncertainty the two consumption goods would grow at the same rate if and only if $\eta = \delta + \gamma\mu$. In this case, $m$ and $\tau$ would both be constant over time, and $\tau'$ would be zero. If we 'perturbed' this balanced-growth economy by adding a marginal amount of uncertainty, the characteristics of consumption behavior would not be sensitively affected:[19] the propensity to consume out of wealth would remain substantially unchanged, $\tau'$ would still be negligible, and eq.(14) would represent a good local approximation.

In the data discussed in the next section the share spent on nontradables consumption has actually increased during our sample period. In the absence of balanced growth $\tau'$ would no longer be zero, even within a deterministic framework. It can be shown that, when both goods are complements in preferences, the sign of $\tau'$ is the opposite of that of the growth rate of the fraction spent on nontradables.[20] The implications for the formula *bias* are intuitive: if $\tau'$ were negative, the anticipated higher relevance of nontradables in future consumption would shift upward the current propensity to hedge, thus enhancing the current portfolio bias.

However, in Appendix A we show that the observed increase in the share spent on nontradables is not large enough to significantly affect the estimate of the propensity to hedge and home bias. Specifically, in Appendix A we discuss how to obtain a numerical solution to $\tau(z)$, and therefore $H(z)$, using the Chebyshev interpolant method described in Judd (1992). It is shown in Appendix A that under the balanced growth assumption $\eta = \delta + \gamma\mu$, the solution to $H(z)$ is approximately identical to (14). In the next section we will therefore adopt the balanced growth parameterization and use (14) as a close approximation of the propensity to hedge.

# 3 Nontradables and home bias in the OECD countries

In what follows, we apply our model to a sample of fourteen OECD countries.[21] To implement empirically the home bias formula (9), we need estimates of the relevant moments based on measures of the return on capital and nontradables growth. We first discuss the different measures of the returns, relegating details about the data to Appendix B. Next we estimate the parameters needed to compute the propensity to hedge. The final subsection discusses the home bias results.

### 3.1 Measures of the return to capital and nontradables

Any choice of a 'comprehensive' measure of the nation-wide return on capital entails, almost by definition, a high degree of arbitrariness. In this paper we consider three alternative approaches, two of which are 'fundamentals' based while the third uses financial returns. The first measure of capital return, referred to as $\Delta R_1$, is given by the profit rate in the tradables sector, defined as operating surplus divided by the capital stock.[22] As default, we identify the tradables sector with the manufacturing industry; however, in our sensitivity analysis we consider a broader definition which also includes mining and agriculture. Annual data for the period 1970-1993 are obtained from the OECD International Sectoral Data Base.

Hypothetically, $\Delta R_1$ would represent the correct measure of capital return in a world in which international investors were allowed to allocate their funds among a set of national 'workshops', converting capital into consumption goods at zero cost. The main drawback of $\Delta R_1$ as a measure of the return to capital is its inability to take into account capital gains.[23]

Our second measure of capital return, indexed by $\Delta R_2$, emphasizes the role of adjustment costs and the associated capital gains and losses. It is based on a valuation procedure similar to what Brainard, Shoven and Weiss (1980) call the 'constant-capital' intrinsic value of the firm, here generalized to allow for a (constant) growth rate of net investment. The innovation in the return to capital is written as the innovation to the present discounted value of expected profit rates.[24] The discount rate is $\eta - g$, where $\eta$ is the (constant) expected return and $g$ is the growth rate of capital (and investment). In our application, we set $g$ equal to $\mu$, the average rate of growth of nontradables, so that

$$\Delta R_{2,t+1} \equiv \eta + (E_{t+1} - E_t) \sum_{s=0}^{\infty} \frac{\Delta R_{1,t+s+1}}{(1+\eta-\mu)^s} \tag{15}$$

The computation of the innovation to the expected present discounted value of profits is based on an estimated first-order autoregressive process for the profit rate $\Delta R_1$; an AR(2) is considered in sensitivity analysis.

The profit rate, on which both $\Delta R_1$ and $\Delta R_2$ are based, exhibits a strong trend in virtually all countries in our sample. In several countries, the profit rate is downward trending in the 1970s and upward trending in the 1980s, while in others it is downward or upward trending throughout the entire sample. While such movements are possibly transitory phases of long cycles around stable means, our sample is too short to allow for an analysis of the low-frequency features of these series. Thus, to extract the transitory components of the series we filter out a second-order polynomial trend. However, in the sensitivity analysis we also consider results obtained when extracting a Hodrick-Prescott trend, or no trend at all.

Our first two measures of asset returns are indirect. The third measure focuses on stock market data directly.[25] It is defined as

$$\Delta R_3 \equiv \Delta R_{STOCK}, \tag{16}$$

where $\Delta R_{STOCK}$ is the average annual return on stock, computed from Morgan Stanley index data (see Appendix B for details).

The return is hedged for exchange rate risk, using one-year forward premium data. Since the forward premium is generally not equal to the inflation differential across two different countries, the real return of investing in a particular country differs across investors located in different countries. As a result, for each country we obtain a separate matrix of returns on investment in all other countries. These data are available for nine countries[26] over the period 1973-1993.

For all three measures of capital return, $\Delta R^*$ is computed by taking a weighted average of capital returns in foreign countries. For the first two return measures the weights are based on average GDP shares over 1985-1989, while for the stock returns the weights are based on average stock market capitalization shares over 1985-1989.

We use two alternative measures of the nontradables growth rate $dX/X$: nontradables consumption and leisure. Although both may affect investors' portfolio choice, we consider only one at a time for the purposes of expositional simplicity and consistency with the model. Thus, when using nontradables consumption as a measure of $X$, we assume that leisure enters utility in an additively separable way, so that it does not affect portfolio decisions. Both nontradables consumption and leisure measures are divided by population and converted into per capita terms.

Nontradables consumption data are taken from the United Nations National Accounts Statistics. Nontradables categories are gross rent, fuel and power; medical care and health expenses; public transportation and communication; recreation, entertainment, education and cultural services; personal care; expenditure in restaurants, cafes, hotels; other goods and services. We define the remaining categories — food; clothing and footwear; furniture, household equipment and operation; and personal transportation — as tradables consumption. All consumption categories defined above refer to private expenditure. Given the well-known conceptual and statistical difficulties in distinguishing appropriately between tradables and nontradables consumption, in sensitivity analysis we discuss the implications of such measurement problems for the home bias estimates, and also consider some alternative measures of nontradables consumption.[27]

We compute leisure as total hours per week available for both work and leisure, minus total hours worked. We set total hours available for work and leisure equal to the number of people in the labor force times twelve hours per day (84 hours per week). In the sensitivity analysis we also consider 16 hours per day available for both work and leisure. Actual hours worked is computed as total employment times hours worked per week per employee. Data on hours worked per week per employee are obtained from the Yearbook of Labour Statistics. Data are not available for all countries on hours worked in non-agricultural activities. We therefore use hours worked per week in manufacturing, which is available for all countries, and is highly correlated with hours in non-agricultural activities in countries for which both are available. Once again, in sensitivity analysis we discuss the effects of measurement error for the home bias estimates.

## 3.2 How large is the propensity to hedge?

As shown in eq.(14), we need estimates of $m$, $\epsilon$ and $\gamma$ to compute the propensity to hedge. The average share spent on nontradables is equal to $1/(1+m)$, which we set equal to the average in the sample (across time and countries).

We obtain estimates for $\epsilon$ and $\gamma$ as follows. Let $N$ be the number of countries in the sample. For any country $j$ at time $t$, define the vector $\mathbf{h}_j(\epsilon, \gamma)$ as

$$\mathbf{h}_j = \begin{pmatrix} ln\frac{X_{t+1}}{X_t} - ln\frac{C_{t+1}}{C_t} + \epsilon \, ln\frac{p_{t+1}}{p_t} \\ U_{C,t}(\Delta R_t - \Delta R_t^W) \end{pmatrix}, \tag{17}$$

where $U_C = (1-\alpha)(C/U)^{-1/\epsilon}$ and $U$ is defined in equation (12). The model of Section 2 implies that $E\ \mathbf{h}_j = \mathbf{0}$. Theoretically, the first equation holds even without the expectations operator, as it follows from the first-order condition representing the trade-off between tradables and nontradables consumption: $U_X/U_C = p$. The second equation, $E\ U_C(\Delta R - \Delta R^W) = 0$, is a discrete time version of the trade-off between investing in domestic assets and a world portfolio. The latter is a weighted average of the return of investing in all countries. Defining the matrix

$$H(\epsilon, \gamma) = \begin{pmatrix} \mathbf{h}_1 \\ \cdot \\ \mathbf{h}_N \end{pmatrix}, \tag{18}$$

it follows that $E\ H(\epsilon, \gamma) = 0$, which can be used to estimate $\epsilon$ and $\gamma$ jointly by using the generalized methods of moments (GMM).[28]

We measure the relative price $p$ as the ratio of either the nontradables consumption price index to the tradables consumption price index or the ratio of the hourly wage rate to the tradables consumption price index. The hourly wage rate is measured as total employee compensation (OECD National Accounts Statistics) divided by the numbers of hours worked (employment times hours). As a caveat, it is worth emphasizing that some measure of marginal wage rate would be more appropriate in our context. Overtime hours are generally paid at a different rate, although this is only a concern when the ratio of marginal to average wages is volatile. Yet, because of practical difficulties in constructing a marginal wage rate dataset for a large number of countries, in our exercise we only consider the average wage rate, following a common practice in estimating labor supply equations.[29]

Another problem we face is that when $X$ is defined as nontradables consumption, in all but one country both $X/C$ and $p$ rise during the sample. For positive $\epsilon$ this is inconsistent with the first of the two first order conditions. A possible explanation, which has recently received considerable attention, is that inflation may be overstated as a result of imperfect measurement of quality improvements. This would be particularly relevant for traded goods, where most quality improvements have taken place.[30]

Accounting for the latter effect, we introduce a parameter $a$ that captures the growth rate of tradables consumption as a result of unmeasured quality improvements and posit:

$$C = e^{at} C^{data}, \tag{19}$$

where $C^{data}$ is observed consumption and $C$ is quality-adjusted consumption.

Because this measurement problem does not apply to total nominal spending on tradables, it is appropriate to assume that the quality-adjusted relative price of tradables consumption is $p_T = e^{-at} p_T^{data}$, with self-explanatory notation. We then estimate $a$ jointly with $\epsilon$ and $\gamma$. Ultimately, the identification of $\epsilon$ is based not on the *average* relative growth rates of $X/C$ and $p$, but on the *comparison* across time and countries of the growth rates of $X/C$ and $p$.

A final parameter that enters the first-order conditions is the preference weight $\alpha$ (through the expression for $U_C$). We calibrate it, as opposed to estimating it with GMM, both because it is easily observed directly from the data and because we do not want to impose any restriction on its variability across countries. For each country we therefore set $\alpha$ equal to the average fraction spent on non-tradables in 1980.

Since it is the trade-off between risk and expected returns that allows us to estimate the rate of risk-aversion $\gamma$, we perform the GMM estimation only for the subset of countries for which we have equity return data. The second fundamentals return measure, which is available for all countries, cannot be used to estimate the parameters as it only provides a measure of return innovations, not of average return. $\Delta R^W$ is computed as the weighted average of stock returns of all nine countries, again using average stock market capitalization shares over the period 1985-1989 as weights.

The results are shown in Table 1. We report our estimates of $\epsilon$, $\gamma$, as well as $\epsilon\gamma$. Standard errors are in brackets. The last two columns show corresponding estimates of the propensity to hedge. $H_{estimate}$ corresponds to the point estimates of $\epsilon$ and $\gamma$, while $H_{max}$ is the size of the propensity to hedge that leads to the largest possible home bias, conditional on keeping $\epsilon\gamma$ within two standard deviations of the point estimate. It will be used below to provide an upper bound on the size of the home bias that we can rationalize as the result of hedging against nontradables uncertainty.

While $\epsilon$ is quite precisely estimated to be about 0.4 for both nontradables consumption and leisure, the estimates of $\gamma$ exhibit large standard errors. When $X$ is nontradables consumption, the estimates suggest that tradables and non-tradables are complements.[31] The implied hedging propensity is 0.98, close to the upper bound of 1, although the imprecision of $\gamma$ allows for lower values of the true hedging propensity. As we show below, the upper bound of the hedging propensity $H = 1$ leads to the largest possible home bias, due to the positive correlation between the return on capital and nontradables consumption growth.

When $X$ is leisure, the estimated $\epsilon\gamma$ is 0.52 and $H = 0.40$. Even though the point estimate suggests that consumption and leisure are complements, the large standard error associated with $\gamma$ allows for the possibility that consumption and leisure are substitutes, with the lowest admissible hedging propensity of -1.32 (raising $\epsilon\gamma$ by two standard errors). As we show below, the return on capital and the growth rate of leisure are negatively correlated in the data, so that a *negative* hedging propensity generates a positive home bias. A hedging propensity of -1.32 therefore leads to the largest possible home bias consistent with the data.

## 3.3 How large is the predicted portfolio bias?

For a given propensity to hedge, we can use the formula (9) to compute the home bias as a result of an optimal hedge against nontradables uncertainty. Tables 2, 3 and 4 report the statistical moments that enter the home bias formula, for all three measures of return on capital. Each table reports the moments for both measures of nontradables, nontradables consumption (referred to as $c_N$) and leisure ($\ell$).

On average nontradables consumption growth is positively correlated with the return on domestic capital for all three measures of return, while the growth rate of leisure is negatively correlated with the return on domestic capital. The correlations are higher (in absolute value) for the fundamentals returns than the equity returns, although the numbers are similar when $X$ is leisure. While the estimated moments vary significantly across countries, the sign of the correlation with the domestic return is the same in most countries.

This pattern of correlations leads to home bias when tradables and nontradables consumption are complementary ($H > 0$) or tradables consumption and leisure are substitutes ($H < 0$). While the correlation between nontradables growth and foreign return generally has the same sign as the correlation between nontradables growth and domestic return, it is somewhat smaller on average (in absolute terms) and receives less weight in the bias formula (9). This is because on average the return on a well-diversified portfolio of foreign claims is less volatile than the domestic return.

Table 5 reports the corresponding home bias for all three measures of return. For each country the first row reports the home bias based on the point estimate of the propensity to hedge, while the second row (in italics) reports the home bias when assuming $H = 1$ for $X = c_N$ and $H = -1.32$ for $X = \ell$. As discussed above, the latter calibration yields the largest average home bias consistent with the data. The two bottom rows provide different measures of average home bias. The first one is a simple unweighted average of the home bias estimated for the individual countries. The second one reports the bias for a representative country, for which we assume that the moments that enter the home bias formula (9) are equal to an unweighted average across countries. The latter may provide a better statistic, as the unweighted average of $bias$ over individual countries can be very sensitive to extreme outliers.

The overall conclusion that can be drawn from Table 4 is that only a small portfolio home bias can be attributed to optimal hedging against nontradables. When $X = c_N$ the maximum home bias for a representative country is 0.26, 0.07 and 0.00, respectively, for the three measures. When $X = \ell$ the upper bound for home bias in a representative country is 0.17, 0.09, and 0.01, respectively, for the three asset return measures.[32] These figures are substantially smaller than the home bias seen in the data. Even if we shift up the benchmark in Figure 1 by 26 percentage points, the average fraction invested domestically remains 45% above the benchmark. Moreover, Table 5 shows that the bias often has the wrong sign for individual countries.

We have performed substantial sensitivity analysis for both measures of fundamentals return.[33] We have considered the sensitivity of results with respect to the method of detrending the profit rate, the sectors included in the measure of the profit rate, and the measure of nontradables consumption and leisure. As alternatives to extracting a second-order polynomial trend from the profits rate we have considered not extracting a trend at all, or extracting a Hodrick-Prescott filter. We have considered a broader measure of the tradables sector to compute the profit rate, including also agriculture and mining. In computing the second measure of the return on capital we have considered a second-order autoregression in the profit rate (as opposed to the first-order autoregression in the benchmark).

While our measure of nontradables consumption only includes private consumption, we have considered adding government consumption. We have also experimented with narrower measures of nontradables consumption, subtracting (one at a time or all together) from the previous definition the categories 'public transportation and communication', 'recreation, entertainment, education and cultural services', and 'expenditures in restaurants, hotels and cafes'. We have finally considered computing leisure under the assumption that the total supply of time for leisure plus work is 16 (instead of 12) hours per day. None of these changes alter the conclusion that the extent of home bias that can be attributed to an optimal hedge against nontradables falls far short of the observed home bias. The largest home bias we found for the representative country is 0.27 (for the largest propensity to hedge consistent with the data).

While we have carried out sensitivity analysis with regards to the measure of nontradables consumption, there always remain doubts concerning measurement error. All consumption categories have components of both tradables and nontradables consumption. Each tradable good goes through a local distribution network before it reaches the consumer. Similarly, items typically referred to as nontraded goods, such as medical services, are provided with traded inputs like medical equipment and medication. The grey area between tradables and nontradables likely — and unavoidably — affects the measures of the profit rates and consumption growth.

To some extent, however, measurement problems strengthen our conclusions, in the sense that they are likely to cause an *over*estimation of home bias. To the extent tradables and nontradables consumption are less complementary than the sub-categories within them, by 'mixing' the sub-categories we are likely to impart an upward bias to the estimated degree of complementarity between tradables and nontradables consumption. Similarly, by 'mixing' the consumption sub-categories we can overestimate the extent of substitutability between tradables consumption and leisure. This is because leisure and nontradables consumption are likely to be closer substitutes than leisure and tradables consumption, particularly when leisure is interpreted as non-market production. Measurement error can therefore lead to an estimate of $\epsilon$ that is downward biased when $X$ measures nontradables consumption and upward biased when $X$ measures leisure. In both cases, measurement errors make the estimate of the propensity to hedge excessively large in absolute value. Thus, it is implausible that our measures of home bias would be larger with more accurate measures of tradables and nontradables.

# 4 Conclusions

Interpretations and explanations of the home bias puzzle in international finance have frequently focused on optimal insurance strategies against fluctuations in nontradables. Whether, and to what degree, hedging against fluctuations in nontradables can significantly affect the international allocation of financial wealth in the absence of barriers to international asset trade is ultimately an empirical question. This paper has investigated to what extent the long-term international portfolio benchmark is affected by the presence of nontradables, in the form of both leisure and nontradables consumption.

Our findings indicate that the explanatory power of this approach is, from any reasonable vantage point, very limited. We find that accounting for nontradables leads to only a small bias towards domestic assets. The bias is no larger than 27%, and probably much smaller than that. Current data, in contrast, show that the average bias towards domestic assets is close to 70% of the total portfolio. These results suggest that with regards to portfolio strategies we are still witnessing a relatively early stage of globalization. In parallel with the intensification of the process of international capital markets integration, in the near future we can expect to observe a sizable additional shift in demand for worldwide diversification.

# Appendix A: Numerical solution

The purpose of this Appendix is threefold. First, we describe how the Bellman equation can be solved numerically through the Chebyshev interpolant method. Second, through an example we illustrate that the numerical solution to the propensity to hedge is practically identical to that based on (14). Third, we illustrate that a realistic deviation from the balanced growth assumption does not change much the estimate of the propensity to hedge.

Posing $z \equiv X/W$, $V \equiv \varphi(z)X^{1-\gamma}$ and $C \equiv \tau(z)W$, after substituting the optimal domestic ownership share $n$ (eqn.(8)) into (6), the Bellman equation becomes:

$$\begin{aligned} \theta_0\, \varphi &= (1-\gamma)^{-1}\left[\alpha + (1-\alpha)\,(\tau/z)^{1-1/\epsilon}\right]^{\frac{\epsilon}{\epsilon-1}(1-\gamma)} \\ &\quad + \varphi' z\,(\tau - \theta_1 + 2\theta_2) + \varphi'' z^2 \theta_2 - \frac{\gamma^2\,(\varphi')^2\, zb}{\varphi'' z + 2\varphi'} \end{aligned} \tag{A.1}$$

and the envelope condition ($V_W = U_C$) becomes

$$\varphi' = -[\alpha + (1-\alpha)(\tau/z)^{1-1/\epsilon}]^{\frac{1-\gamma\epsilon}{\epsilon-1}}(1-\alpha)(\tau/z)^{-1/\epsilon}z^{-2} \tag{A.2}$$

The parameters $\theta$ are defined as follows:

$$\begin{aligned} \theta_0 &\equiv \delta - (1-\gamma)\mu + \gamma(1-\gamma)\sigma_X^2/2 \\ \theta_1 &\equiv \eta - \mu + \gamma\sigma_X^2 - \gamma c - 2\gamma b \\ \theta_2 &\equiv \sigma_X^2/2 + a - b - c \\ a &\equiv 1/\left(2\mathbf{i}'\boldsymbol{\Sigma}^{-1}\mathbf{i}\right) \\ b &\equiv \mathbf{s}'\boldsymbol{\Sigma}^{-1}\left(\mathbf{s} - c\mathbf{i}\right)/2 \\ c &\equiv \left(\mathbf{i}'\boldsymbol{\Sigma}^{-1}\mathbf{s}\right)/\left(\mathbf{i}'\boldsymbol{\Sigma}^{-1}\mathbf{i}\right) \end{aligned} \tag{A.3}$$

where $\boldsymbol{\Sigma}$ is the variance-covariance matrix of asset returns, i.e.

$$\Sigma \equiv \begin{pmatrix} \sigma_R^2 & \rho\sigma_R\sigma_{R^*} \\ \rho\sigma_R\sigma_{R^*} & \sigma_{R^*}^2 \end{pmatrix} \tag{A.4}$$

and $\mathbf{s} \equiv \sigma_X \left(\sigma_R\rho_{RX} \;\; \sigma_{R^*}\rho_{R^*X}\right)'$ is the covariance between nontradables consumption growth and the asset return vector. Differentiating the envelope condition and rearranging, we obtain the formula for the propensity to hedge $H$ as a function of the state variable $z$ (13) in the main text.[34]

The envelope condition (A.2) expresses $\varphi'$ as a function of $\tau$ and $z$, say $\varphi' = f_1(\tau, z)$. Differentiating the Bellman equation (A.1) with respect to $z$, and considering the envelope condition and its derivative, we obtain another expression $\varphi' = f_2(\tau,\ \tau',\ \tau'',\ z)$. Thus, we have $f_1(\tau, z) = f_2(\tau,\ \tau',\ \tau'',\ z)$, which implicitly defines a second-order differential equation for $\tau$ as a function of $z$. To solve numerically this equation, we implement the Chebyshev interpolant method as reviewed in Judd (1992).

We can briefly summarize the strategy of solution as follows. First, having set arbitrarily two upper and lower thresholds $z_m$ and $z_M$, we consider an approximation for $\tau$, denoted $\hat{\tau}$ and defined over the domain $z_m \leq z \leq z_M$ as

$$\hat{\tau}(z, \mathbf{w}) \equiv \sum_{i=1}^{I} w_i \psi_i(z). \tag{A.5}$$

Here $\psi_i(z)$ are Chebyshev polynomials,[35] $\mathbf{w} = (w_1\ w_2\ ...\ w_I)$ is the vector of parameters to be computed numerically, and $I$ the degree of approximation. Properties of Chebyshev polynomials guarantee that a relatively low number of terms is required to get a good approximation. Second, we define the 'residual function' as $R(z, \mathbf{w}) \equiv f_1(\hat{\tau}, z) - f_2(\hat{\tau}, \hat{\tau}', \hat{\tau}'', z)$. Third, we consider $I$ values of $z$, denoted by $z_i$, $i = 1, ..., I$, and we choose the vector $\mathbf{w}$ so that $R(z_i, \mathbf{w}) = 0$ for each $i$. Although it is possible to compute the vector $\mathbf{w}$ for any collection of $z_i$, the best choice for the values of $z_i$, as discussed by Judd (1992), is given by the $I$ zeroes of $\psi_{I+1}$, namely $z_i = z_m + 0.5\,(z_M - z_m)\left\{1 + \cos\left[(2i-1)\,\pi\,(2I)^{-1}\right]\right\}$.

The solution for $\tau(z)$ and $\tau'(z)$ can be substituted in the expression (13) in order to compute the home bias as a function of $z$. To illustrate that the approximate expression for the home bias in (14) yields very accurate results, assume that $\epsilon = 0.39$ and $\gamma = 11.08$. These parameters correspond to the largest value of $\epsilon\gamma$ consistent with the data when $X$ is leisure, which leads to the largest home bias for leisure reported in Table 5. We evaluate the propensity to hedge of $z$ for which $1/(1 + m(z)) = 0.74$, which is the average share spent on $X$ when $X$ is leisure. We also set $\mu = 0.03$ and $\delta = 0.02$. In that case the estimate of the propensity to hedge is -1.3219 based on the approximate formula (14). Using the numerical approximation method, we find that the propensity to hedge is -1.3283 when using average moments based on the second fundamentals return, and -1.2331 when using average stock return moments. Both are quite close to the result based on the approximate formula (14).

Using the numerical solution method above we can also solve for the propensity to hedge in the presence of deviations from balanced growth. According to our data the share spent on leisure has gradually increased over time: on average, in our sample $1/m = pX/C$ grew by 2.29% per year. Assuming the same parameters for $\epsilon$ and $\gamma$ as above, an increase in $\eta$ by 6.985% relative to the balanced growth path leads to a 2.29% expected growth rate for $1/m$. We find that the numerical solution for the propensity to hedge (based on the second fundamentals return) then drops only slightly, from -1.3283 to -1.3753. The share spent on nontradables consumption also rose during the sample, on average an annual 2.58% increase, but the reported home bias results when $X$ is nontradables consumption are already based on a hedging propensity close to 1, which generates the largest possible bias in that case.

# Appendix B: Data sources

**Profit rate** The profit rate in the tradables sector is defined as operating surplus in the tradables sector, divided by the capital stock of the previous year. Data are annual and are from the OECD International Sectoral Data Base, available from 1970 to 1993 for 14 countries. Since the capital stock is only available at constant prices, operating surplus is divided by nominal GDP and then multiplied by the ratio of GDP at constant prices to the capital stock at constant prices. The tradables sector is defined as either manufacturing only, or the sum of manufacturing, agriculture and mining (in sensitivity analysis only).

**Leisure** Leisure is computed as $HOURS{*}LABF - HW{*}EMPL$, where $HOURS$ is the total number of hours per week available for both leisure and work, $HW$ is the number of hours per week allocated to work, $LABF$ is the labor force, and $EMPL$ is total employment. Both $LABF$ and $EMPL$ are obtained from the OECD Annual Labour Force statistics. $HOURS$ is set at 84 (12 hours per day). In sensitivity analysis we consider 16 hours per day. $HW$ is approximated as the number of hours worked per week in the manufacturing sector, from the Yearbook of Labour Statistics. For countries for which hours per week in all non-agricultural sectors is available, this is highly correlated with hours per week in manufacturing.

**Nontradables consumption** Annual data on various consumption categories at constant prices are available from the OECD National Accounts, Volume II. For some countries data are missing early in the sample for some consumption categories. These data are obtained from the United Nations National Accounts Statistics. Aggregate nontradables consumption is computed as the sum over the categories listed in the text. We divide by population and then use the growth rate of per capita nontradables consumption as our empirical measure for $dX/X$ in the model.

**Tradables consumption** A measure of tradables consumption is needed for the GMM estimation of $\epsilon$ and $\gamma$. Tradables consumption is defined as the sum of food; clothing and footwear; furniture; household equipment; personal transportation. Before aggregating, for the last three categories, which refer to durable goods, we follow van Wincoop (1994) in computing a stock index from the flow data, assuming depreciation rates of respectively 0.5, 0.4 and 0.3. For each durables consumption category the stock of durables at time zero is computed as $D(0) = (e+v)^{-1} T^{-1} \sum_{t=1}^{T} E(t)/(e+v)^t$, where $v$ is the rate of depreciation, $E$ is real purchases and $e$ the mean growth rate of the flow variable $E$ over the sample. Subsequently the stock of durables evolves according to $D(t+1) = (1-v)D(t) + E(t+1)$. We assume that the flow of services from durables is proportional to the stock. For each tradables consumption category we index the level (of either the flow of durables services or nondurables consumption) equal to 1 in 1980. We then aggregate all categories into a Cobb-Douglas index, using 1980 nominal spending weights.

**Relative price of nontradables** The relative price of nontradables to tradables consumption is also needed for the GMM estimation of $\epsilon$ and $\gamma$. For nontradables consumption the price index is computed as the ratio nontradables consumption at nominal and constant prices, using data from the United Nations National Accounts Statistics on the sum over all categories. When leisure is the nontraded good, the price is defined as the hourly wage rate, computed as total employee compensation (OECD National Accounts Statistics) divided by the numbers of hours worked ($HW * EMPL$). The tradables consumption price index is computed as a Cobb-Douglas index of the prices of tradables consumption categories, using 1980 spending weights and computing the price of each category from the United Nations National Accounts Statistics consumption data at constant and nominal prices.

**Stock return** We use the $NL$ stock index from Morgan Stanley. This is a local currency index, with dividend reinvestment net of withholding taxes. Data are monthly. To obtain annual return data, we compute the average annual hedged return on stock as follows:

$$\Delta R_{STOCK} = \sum_{t=1}^{12} \frac{1}{12} \left[ \frac{NL_{t+12} - NL_t}{NL_t} - FD_{t,12} \right] - \Pi_T$$

Here $NL$ is the stock index, $FD_{12}$ the 12-month forward discount, and $\Pi_T$ the tradables consumption inflation rate. The summation is over the 12 annual returns from one month to the same month next year. Forward discount data are obtained from the Harris Bank weekly review. We would like to thank Chris Telmer for providing us access to this database. The tradables consumption inflation rate is computed based on the annual tradables consumption price index discussed above.

**Notes**

[1] See, among others, Cooper and Kaplanis (1986, 1994), French and Poterba (1990, 1991), Golub (1990), Kang and Stulz (1997), Tesar and Werner (1994, 1995, 1998), and the surveys by Solnik (1991), Lewis (1995) and Obstfeld (1995). The 'home bias' puzzle is particularly striking in light of the large potential gains from international risksharing, as estimated *e.g.* by van Wincoop (1994, 1996, 1999) and Athanasoulis and van Wincoop (1999a).

[2] See Brennan and Cao (1997), Coval (1996), and Gehrig (1993) for information-based interpretations of the obstacles to diversification.

[3] For instance, the fraction that pension funds are allowed to invest abroad has risen from 10% to 30% in Japan in 1986, and from 10% to 20% in Canada during 1990-1995. Within the new euro zone, currency-matching rules that applied to pension funds and insurance companies in several European countries are no longer binding.

[4] The two papers do not come to the same conclusion. Bottazzi, Pesenti and van Wincoop (1996) find a small home bias in optimal portfolios, while Baxter and Jermann (1997) report a large *foreign* bias. The main difference between the two papers is that Baxter and Jermann (1997) assume a stochastic trend in both wages and profits that differs across countries, while Bottazzi, Pesenti and van Wincoop (1996) assume a common trend among countries that does not affect international portfolio choice. For a theoretical survey of international portfolio models with nontraded labor incomes see Ghosh and Pesenti (1994).

[5] Huberman (1997) documents a substantial home bias in claims held by U.S. investors on Regional Bell Operating Companies. Schultz (1996) reports, based on a 1996 survey of 246 companies, that 43% of money invested in defined contribution plans is held in employer stock. Coval and Moscovitz (1997) find that U.S. investment managers exhibit a strong preference for locally-headquartered firms. Finally, Athanasoulis and van Wincoop (1999b) find that the standard deviation of dividend income of state residents is only slightly lower than the standard deviation of state profits. For a review of this literature see Huberman (2000).

[6] See *e.g.* Eldor, Pines and Schwartz (1988), Stockman and Dellas (1989), Serrat (1996) and Baxter, Jermann and King (1998). See also the discussion in Obstfeld and Rogoff (1996), pp. 326-328.

[7] See for example Tesar (1993), Obstfeld (1995) and Lewis (1995).

[8] The exogeneity of the stochastic process for nontradables may ap-

pear peculiar, particularly when $S(t)$ is interpreted as leisure. However, since we are only interested in the implications of our model for home bias, without loss of generality one can think of the process for S as the result of optimal labor/leisure decisions and our partial-equilibrium analysis of optimal portfolios as conditional on such decisions.

[9] In a technical appendix available on request we show that the model can be generalized to account for time-varying expected returns. For instance, expected returns $\eta$ and $\eta^*$ can be modeled as mean-reverting processes, say

$$\begin{aligned} d\eta(t) &= -k(\eta(t) - \bar{\eta})\,dt + \phi d\omega(t) \\ d\eta^*(t) &= -k(\eta^*(t) - \bar{\eta})\,dt + \phi^* d\omega^*(t) \end{aligned}$$

with $\bar{\eta}$, $\phi$ and $\phi^*$constant positive parameters. Under this specification a shock $d\omega$ raises both the current return *and* the future expected return on domestic assets. If the expected return $\eta$ is currently above its long-run average $\bar{\eta}$, it is expected to decline.

[10] In a more general setup, investors hedge against all sources of uncertainty, not only nontradables fluctuations. However, uncertainty in state variables different from country-specific nontradables affects investors' choices symmetrically across countries. As all investors worldwide adjust their portfolios to hedge against these additional global sources of uncertainty, no systematic *home* bias can arise as a result of such global hedges. Similarly, differences in expected returns $\eta$ and $\eta^*$ (see previous footnote) lead investors of *all* countries to shift their portfolio allocations toward the country with the highest expected return, and do not lead to a systematic difference in portfolio shares across investors in different countries.

[11] See *e.g.* Merton (1990), Ingersoll (1987), ch.13, and Duffie (1996), ch.9.

[12] Since equilibrium asset prices are market clearing and in the absence of home bias all agents hold the same portfolio, the fraction invested at home corresponds to the value of the domestic equity market relative to the world equity market. This is why the baseline portfolio of Figure 1 does not depend on the characteristics of asset returns.

[13] Interpreting the foreign country as the rest of the world, this is indeed the general case in our empirical application below.

[14] Homogeneity implies that $(1-\gamma)V = V_W W + V_X X$. Differentiating with respect to $W$ and substituting the result in (10) yields (11).

[15] Such preferences can be somewhat problematic when $X$ denotes leisure. Unless $\epsilon = 1$, the first order condition $U_X/U_C = p$ is inconsistent with equal steady-state growth rates of real wages and consumption combined with constant steady-state leisure. Although theoretically this is a concern, from an empirical vantage point it is worth noticing that during our sample there has been a trend increase in leisure. Thus, for the sake of symmetry we have chosen to adopt the same preferences both when $X$ denotes leisure and nontradables consumption. Jermann (1998) adopts a similar specification of consumption/leisure preferences.

[16] Since both instantaneous utility and the value function are homogeneous of the same degree $(1-\gamma)$ in their respective arguments, the partial derivatives $U_C$ and $V_W$ are homogeneous of degree $-\gamma$ in their arguments. Also, optimal consumption of tradables is homogeneous of degree 1 in $X$ and $W$: for $\lambda > 0$ we have $U_C[\lambda C, \lambda X] = \lambda^{-\gamma} U_C[C, X]$ and $V_W[\lambda W, \lambda X] = \lambda^{-\gamma} V_W[W, X]$; choosing $\lambda = 1/W$ and recalling the envelope condition $U_C = V_W$ we can write $U_C[C/W, X/W] = V_W[1, X/W]$, which implicitly defines $C/W$ as a function of $X/W$.

[17] See Appendix A. The expression (13) can be derived by substituting $V \equiv \varphi(z)X^{1-\gamma}$ into (10), and using the result from differentiating (A.2) in the Appendix.

[18] This can also be seen from (13), realizing that in this case $\tau$ will be a constant and thus $\tau' = 0$.

[19] Formally, it can be shown that an infinitesimal increase in $\sigma_X$, holding $\sigma_X/\sigma_R$ and $\sigma_X/\sigma_{R^*}$ constant, has a second order effect on the propensity to consume out of wealth $\tau$ and its derivative $\tau'$.

[20] Both this proof and the one mentioned in the previous footnote are included in a technical appendix available on request.

[21] Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, United Kingdom, and United States.

[22] In the fundamental measures we only consider claims on the traded goods sector, making easier the comparison of our results with the findings by Tesar (1993, 1995).

[23] On the empirical advantages and drawbacks of $\Delta R_1$, see for instance Christiano (1990).

[24] See Bottazzi, Pesenti and van Wincoop (1996) for details.

[25] On the negative side, because of the emphasis on a particular class

of financial securities, this measure is less comprehensive than the first two.

[26] The countries are listed in the footnote above, excluding Australia and the Scandinavian countries.

[27] Some of the sectors described as nontradables above arguably have substantial tradables components. We prefer to err on the side of a broad measure of nontradables in the benchmark in order to give the nontradables explanation for home bias as much chance as possible. In sensitivity analysis we consider various narrower measures of nontradables.

[28] Note that the first element of $\mathbf{h}_j$ can only be non-zero due to measurement error, while the second element can be non-zero as the combination of both measurement and expectational errors. In computing the spectral density matrix we assume that $H$ is serially uncorrelated (this is theoretically the case for the expectational error) and that for any pair of countries $(i, j)$, the vectors $\mathbf{h}_i$ and $\mathbf{h}_j$ are uncorrelated. This is appropriate for the second equation because the deviation of the national return from the global return is on average uncorrelated across countries, provided that the number of countries in the sample is sufficiently large. Also, there is no apparent reason why measurement errors should be correlated across countries. We let the variance of $\mathbf{h}_j$ be country-specific.

[29] See Mankiw, Rotemberg, and Summers (1985), Eichenbaum, Hansen, and Singleton (1988) and Pencavel (1986).

[30] See for example Boskin *et.al.* (1996), who report the largest bias in appliances and consumer electronics.

[31] Lewis (1996) also finds that tradables and nontradables consumption are complements.

[32] It may be argued that the bias based on the stock return is too small because the stock market is only a small fraction of total financial capital, leading us to overstate the volatility of the return on domestic and foreign capital. But we find that when we use the standard deviation of domestic and foreign returns from the second fundamentals return measure, as well as their correlation, combined with the correlations between nontradables growth and stock returns, the maximum home bias for the representative country remains 0.01 for leisure and marginally rises to 0.02 for nontradables consumption.

[33] Tables with the results from the sensitivity analysis are available on request.

[34] The relative price $p$ is equal to $U_X/U_C = \alpha(1-\alpha)^{-1}(z/\tau)^{-1/\epsilon}$.

Multiplying by $X/C = z/\tau$ and taking the reciprocal yields $m(z) \equiv C/pX = (1-\alpha)\,\alpha^{-1}\left[\tau\left(z\right)/z\right]^{(1-1/\epsilon)}$.

[35] The definition of Chebyshev polynomial for $i = 1, 2...I$ is

$$\psi_i(z) \equiv \cos\left\{(i-1)\arccos\left[2\left(z - z_m\right)\left(z_M - z_m\right)^{-1} - 1\right]\right\}$$

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