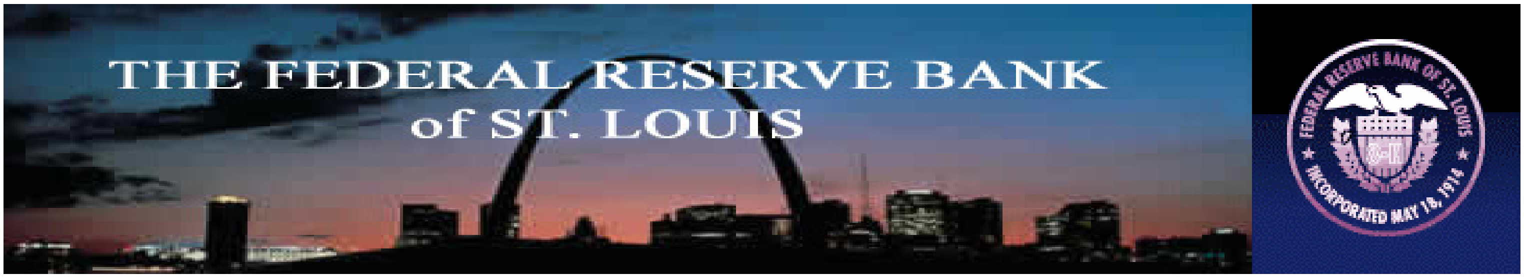

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Home Bias and High Turnover in an Overlapping Generations Model with Learning.*

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Abstract

This paper develops a two-country OLG model under the assumption that investors are on a Bayesian learning path. While investors from both countries receive identical information flows, domestic investors start off with less precise prior beliefs concerning foreign fundamentals. On a learning path, differences in beliefs and estimation risk generate portfolio biases similar to those observed empirically: home bias in equity portfolios and trend-chasing in international flows. In addition, due to the higher volatility of the estimates of foreign state variables, our model produces excessive turnover in foreign securities as reported by Tesar and Werner (1995). We use real GDP data for the US and Europe to calibrate the model and produce simulations that show that under the assumption of a financial liberalization during the 1970s, substantial home bias and excess turnover should have been observed in the subsequent years.

1. **Introduction**

Despite the liberalization of world capital markets in the 1980s, there is overwhelming evidence of a home country bias in asset portfolios: investors prefer securities issued in their country of origin over foreign securities (Tesar and Werner (1992, 1995)). Thus their strategies strongly depart from the investment in the World market portfolio predicted by standard ICAPM models and the unexploited gains from international diversification seem substantial. Another puzzle is related to the high turnover of foreign asset holdings (Tesar and Werner (1992, 1995)). Although on average investors tend to bias their choices against foreign stocks, they also turn over their holdings of foreign securities rather frequently. These empirical regularities represent troubling evidence against standard asset pricing models.

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Institutional and regulatory barriers and transaction costs were the first factors invoked to rationalize the home country bias (Black (1974), Stulz (1981)). If transaction costs are responsible for the bias, then the turnover of the foreign component of equity portfolios should be lower than the domestic one. Ahearne et al. (2001), Domowitz et al. (2000), and Warnock (2001) have recently confirmed that measurable transaction costs do not help explain the observed home bias. Another explanation is that investors might find it optimal to bias their portfolios towards domestic stocks to hedge against deviations from purchasing power parity (PPP). Cooper and Kaplanis (1994) estimate the transaction costs implied by portfolio choice data, and find them to be implausibly high. Also, the PPP-deviations story does not account for the high turnover in foreign asset holdings. It has also been noticed that return correlations tend to increase in bear markets, when it would be most important to diversify risks (cf. Lin et al. (1994)). Thus, the potential benefits of international diversification could be lower than what is commonly thought. However the econometric evidence on the subject remains at best indecisive, and the conclusions strongly depend on specific assumptions concerning the stochastic process of returns. Finally, since in the presence of country-specific non-tradeable goods different bundles are consumed in different countries, some papers have examined the hypothesis that the desire of investors to hedge against the country-specific risk generated by non-tradeables might generate home bias (cf. Stockman and Dellas (1990), and Serrat (2001)). However the strength of the resulting bias turns out to depend on some technical assumptions, such as the separability of a representative agent's utility function with respect to tradeable vs. non-tradeable.

Recently, some studies have focused on the role of information asymmetries between domestic and foreign investors and on the possibility that agents from different countries might hold different beliefs concerning the stochastic process of the risk factors. French and Poterba (1991) use a simple mean-variance framework to back out investors' returns expectations from observed portfolio weights, assuming the variance-covariance matrix is constant over time and known. They conclude that investors must expect returns in their domestic equity market to be several hundred basis points higher than abroad. Coval (1999) develops an infinite horizon equilibrium model in which agents can only obtain noisy observations on fundamentals abroad. When calibrated on the U.S. economy, (one of) the resulting rational expectations equilibria is characterized by home equity preference and by some degree of excess turnover, although the effects are small and strongly depend on parameters hard to calibrate, such as the degree of information asymmetry. It is clear that the home bias and the excessive turnover in foreign stocks still represent genuine puzzles.

Our paper builds on a different argument also based on asymmetric information. We study two related questions: First, can a model with symmetric information flows (identical precision of the signals received by domestic and foreign agents) *but asymmetric initial information endowments* generate portfolio choices consistent with the stylized facts? Second, are the resulting biases in portfolio weights and in their dynamics (i.e. portfolio turnover and trend chasing) persistent enough to fit the empirical evidence? We propose a simple dynamic equilibrium model in which foreign and domestic investors are on a learning path. The combination of learning effects and asymmetric information endowments creates differences in estimation risk across securities and leads to biases in portfolio stocks and flows.

We start by showing that in a standard, full-information, rational expectations equilibrium model heterogeneous beliefs on the means and the covariance matrix of fundamentals cannot arise. As such, no portfolio biases obtain. Therefore we relax the assumption of full information, introducing (Bayesian) learning. The fact that agents are on a learning path makes asymmetries in the cumulative stock of informational endowments relevant. On a sequence of temporary equilibria, the model is able to generate portfolio choices and flows that reproduce the stylized facts. Both the presence of differential estimation risk and of recursive updating of beliefs contribute to these findings. Next the model is simulated to evaluate the size and persistence of the biases. Here the results are twofold. Our model seems capable of generating high and durable excess turnover in foreign stocks. Our simulations also cast doubts on the statistical significance of the home country bias, in the sense that it appears that biases such as those observed are compatible with optimizing behavior and symmetric information flows, at least in the aftermath of a financial liberalization. Finally, we use data on real GDP for the US and Europe to show that under the assumption of a financial liberalization during the 1970s, substantial home bias and excess turnover ought to be observed in the following years.

A growing empirical literature has concluded that asymmetric information is an important explanation of the home country bias. Ahearne et al. (2001) study US equity holdings in a number of countries. Indirectly, they find strong evidence of causality from information asymmetries to the home bias: when companies based in a foreign country have issued debt or equity in the US, the US investor's bias against their stocks is comparatively smaller. Coval and Moskowitz (1999) measure the degree of preference for geographically proximate stocks exhibited by US mutual fund managers in their holdings of US-headquartered companies. They find that the average US fund manager invests in companies that are between 160 to 184 kilometers (or 9 to 11%) closer than the average firm in the market portfolio. Grinblatt and Keloharju (2001) cannot reject the hypothesis that investors exhibit a preference for familiar companies on a unique data set on holdings, purchases, and sales of Finnish stocks by Finnish investors. Portes et al. (2001) show that a gravity model for international financial transactions gives an excellent fit. They interpret distance as a proxy for information asymmetries and notice that the significance of geographical variables increases as the complexity of the securities under study increases.

In a recursive Bayesian learning framework, it may not come as a complete surprise the result that investors prefer on average securities with the longest history on the underlying fundamentals. A few papers have already hinted at the fact that in general investors will prefer securities for which they have relatively long histories of past realized *returns*, and this implies reduced estimation risk (cf. Barry and Brown (1985), Balduzzi and Liu (2000), and Stambaugh (1997)). However, we stress that in our paper home country bias is generated in a fully characterized dynamic equilibrium framework that allows us to track the evolution of the induced home equity bias as investors recursively learn the (joint) process followed by fundamentals. Moreover, there are at least two further implications that come as 'overidentifying' restrictions that help us to gauge of the plausibility of the model. First, a considerable degree of excessive turnover in foreign equities is generated, consistently with a part of the empirical findings in the literature. Second, portfolio flows to foreign securities exhibit trend-following patters, i.e. the tendency to be positively associated with positive returns on foreign markets. To the best of our knowledge, ours is the first paper to provide a *quantitative* evaluation of the size and persistence of *equilibrium* asset allocation distortions implied by differential estimation risk.

A related paper is Balduzzi and Liu (2000), who move some steps towards an explanation of the home bias based on Bayesian learning. However, their study is limited to the investigation of the partial equilibrium problem of an agent who learns the mean return vector. Epstein and Miao (2001) characterize the equilibrium of a complete market economy when agents have recursive multiple-priors utility in a set-up that affords the Knightian distinction between risk and ambiguity. Under the assumption that foreign securities are exogenously perceived as more ambiguous than domestic ones, they obtain home bias, excessive turnover, and high correlations between country-specific consumption and output growth. We depart from such an approach by endogenously linking differentials in risk perceptions to information asymmetries, and deriving their dynamics as a part of a recursive learning process.

An obvious benchmark is Brennan and Cao (1997, BC), who assume that initially domestic and foreign investors have *symmetric information*. The information asymmetry builds up over time as a consequence of *small differentials in the precision of information signals*. One implication is that the correlation between foreign market returns and holdings of foreign stocks should be positive when foreign investors are less well informed than local investors. Furthermore, excess turnover in foreign equities results. Our paper differs from theirs in three ways. First, although of a very simple type, our model is of a general equilibrium nature and features dynamic learning, i.e. agents recursively update their perception of the predictive density of fundamentals by observing dividend realizations over time to solve for their optimal portfolio weights. On the opposite BC write a noisy rational expectations equilibrium model in which signals concern returns and no dynamic learning occurs. Second, while BC assume the existence of asymmetries in the quality of the information flows, we assume symmetry of information flows but asymmetries in the initial stock of information. Third, although BC give conditions under which their theoretical framework would produce home bias and excess turnover in equity holdings, we further proceed to quantify the size of such biases by conducting simulations.

Section 2 documents the stylized facts our model intends to reproduce. Section 3 presents the model. Section 4 solves the model under full information rational expectations and shows that no biases arise in portfolio choices. Section 5 is devoted to the case of recursive Bayesian learning and differential estimation risk. The model is solved numerically and its ability to generate home bias and excess turnover in foreign stocks is discussed. Section 6 evaluates the model by simulation. Section 7 performs a path-calibration using U.S. and European real GDP data. Section 8 concludes.

2. Home Bias, Trend Chasing Patterns, and High Turnover in International Portfolio Choices

The seminal papers by Tesar and Werner (1995) and Bohn and Tesar (1996) brought to the attention of researchers in international finance the existence of three stylized facts. First, there exists home bias in international equity and bond portfolios, i.e. foreign securities represent an abnormally small portion of investors' holdings. Table I reports a few illustrative data from previous studies. Panel A shows the percentage shares invested in foreign equities for five developed countries and (in parenthesis) the complement to 100 of the weight of each country in the world equity market portfolio. While the international version of the classical capital asset pricing model (ICAPM) predicts that investors from country j should hold the (equity) world market portfolio − therefore stocks from all foreign countries in a proportion equal to 100 minus the weight of country j in the world equity market portfolio[1] − the table stresses that observed behavior is markedly different. At the end of the 1990s, the U.K., the most well-diversified country, was investing in foreign stocks only about one quarter of what the standard ICAPM predicts (24% vs. 88%). On the other hand, as shown by Ahearne et al. (2001, Fig. 1) and Tesar and Werner (1998, p. 298), there is no doubt that the size of the home bias has been slowly but steadily declining over the past two decades, as the weight of foreign securities have increased, both in absolute value and relative to the optimal weight implied by the ICAPM. Panel B of Table I shows that the home country bias hardly depends either on the inclusion in official statistics of relatively small and unsophisticated investors (households) or on the focus on relatively sophisticated and risky securities (equities). As documented by Lewis (1999), even looking at the portfolio holdings of large institutional investors (mutual and pension funds) a sizeable home bias emerges.

Second, Bohn and Tesar (1996, henceforth BT) and Brennan and Cao (1997) present evidence that monthly U.S. portfolio *flows* to foreign securities are positively related to the contemporaneous returns in foreign markets, i.e. there is evidence of a trend-following behavior. Although competing explanations exist (e.g. price pressure on foreign markets), this stylized fact is normally interpreted as an indication of strong information asymmetries between locals and foreign investors. BT report that (when scaled by their foreign holdings) *net* purchases of foreign equities by U.S. citizens,

$$NP_t^* \equiv x_{j,t}^* W_t - (1 + g_t^*) x_{j,t-1}^* W_{t-1}, \tag{1}$$

($x_{j,t}^*$ is the weight of the foreign asset, W_t is nominal wealth, and g_t^* is the net capital gain return) are significantly correlated with predictions of foreign (excess) returns. Table II (panel A) reports the estimation results for six countries that accounted for roughly 80% of U.S. foreign security holdings as of 1994. BT also reject the hypothesis that rebalancing flows might explain portfolio flows. BC find that U.S. *gross* purchases of equities in foreign markets (i.e. $x_{j,t}^* W_t - x_{j,t-1}^* W_{t-1}$, using the notation in (1)) tend to be positively correlated with concurrent and lagged returns in those markets. Table II (panel B) shows the results of some of the regressions estimated by BC using data on U.S. portfolio flows. Although omitted here, their findings for U.S. trend-chasing in emerging markets are similar.

Third, Tesar and Werner (1995, TW) showed that foreign portfolios tend to be turned over at a higher rate than domestic equity portfolios. For instance, in 1989 Canadians would have turned their foreign equities over seven times faster than domestic holdings; the corresponding figure for US investors was two. Table III shows turnover rates for the US and Canada calculated by TW with reference to 1989. Unfortunately, accurate calculations for other countries have never been performed, although TW (1998, p. 306) report that in 1996 the turnover of foreign investors in U.S. stocks was 119% compared to a domestic turnover for U.S. stocks of 93%. However, the finding of excess turnover in foreign positions vs. domestic holdings of securities has been recently questioned by Warnock (2001). He points out that the initial results were based on hardly reliable data on U.S. and Canadian capital flows published before the collection of survey-based cross-border security holdings data was started in

[1] This prediction is obtained under a few assumptions, such as that the PPP holds and that positions in foreign currencies may be perfectly hedged. On the other hand, Lewis (1999) reports results that confirm that the finding of home bias in equity portfolios is hardly sensible to such assumptions.

the 1990s.[2] Table III shows Warnock's estimates compared to the original TW's findings: Although for 1989 the use of benchmark surveys data drastically reduces the foreign turnover index, unfortunately comparable estimates for the domestic turnover are unavailable. When the calculations are performed with reference to 1997, the turnover in foreign security is of the same order of magnitude as in 1989, and systematically higher (a factor between 2 and 4) than the turnover in domestic securities. Therefore it seems that Warnock's estimates have certainly reduced the entity of the puzzle first raised by Tesar and Werner, but not completely solved it.[3] Although we recognize the existence of some uncertainty as to the extent of the comparative turnover in foreign vs. domestic securities, in the following we also take the finding of a tendency of investors not to buy and sell foreign securities at a rate *inferior* to domestic securities as a further stylized fact that an accurate international asset pricing model ought to replicate.

3. A Dynamic Equilibrium Model

Suppose the World economy consists of two countries, labeled 1 and 2. Three assets are traded. In each country a long-lived stock index is issued. In period t the index j is traded at an ex-dividend price of S_t^j, after paying off a dividend of D_t^j $(j = 1, 2)$. For simplicity, suppose the exogenous supply of stocks is equal to 1 and is constant in both countries. The third asset is a riskless one-period bond that pays in both countries an exogenous and constant (real) interest rate of r units of account.[4] The price of the bond constitutes the numéraire for the economy and thus this short-term endogenous asset is always issued at a real price of 1 and pays a coupon (plus the principal) at expiration. Exchange rates are fixed and there is no exchange rate risk.

We focus on a process for fundamentals that gives stark predictions on equilibrium prices and portfolio choice under alternative assumptions concerning the mechanism by which beliefs are updated. In period t the two national stock markets pay out exogenous, stochastic dividends following the random walk process

$$\mathbf{D}_t = \boldsymbol{\alpha} + \mathbf{D}_{t-1} + \boldsymbol{\delta}_t \tag{2}$$

where $\mathbf{D}_t \equiv [D_t^1 \; D_t^2]'$, $\boldsymbol{\alpha} \equiv [\alpha^1 \; \alpha^2]'$ is a vector of drift parameters, and $\boldsymbol{\delta}_t \equiv [\delta_t^1 \; \delta_t^2]'$ is a random vector of fundamental shocks normally distributed with zero means, zero cross correlations at all leads and lags, zero autocorrelations at all lags, and constant variance-covariance matrix Σ:

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{bmatrix}$$

[2] Traditionally (e.g. in Tesar and Werner (1995)), the approach taken by researchers to estimating U.S. portfolio investment in foreign securities involved making a guess of the initial stock (normally based on the 1943 survey), which was then updated using subsequent flow data, perhaps price-adjusting along the way.

[3] Quoting Warnock (2001, pp. 6-7): "(...) Investors may well turn over their foreign portfolios slightly faster than their domestic portfolios, but [the table] also highlights that turnover rates vary greatly across stock exchanges.". Tesar and Werner (1998, p. 306) draw similar conclusions.

[4] These bonds are loans across countries and within the same (young) generation. The old generation is not allowed to borrow from its counterparts as it would never pay back its debts, and has no incentives to make loans as it would not survive long enough to be paid back. Hence the only possible loans are between youngsters in different countries. Since exchange rates are irrevocably fixed and the goods markets are perfectly integrated, there cannot exist any interest rate differentials between countries. Coval (1999) and Spiegel (1998) assume a constant and exogenous risk-free rate.

Hence $\boldsymbol{\delta}_t$ is i.i.d. $N(\mathbf{0}, \Sigma)$ and $\mathbf{D}_t$ follows a random walk with drift. This assumption is consistent with the evidence reported in Cogley (1990) for nine countries. The fact that Σ is not necessarily diagonal implies that the fundamentals in the two countries may have non-zero correlations, mimicking comovements of output (international business cycles). Furthermore, the structure of the multivariate process (its parameters) is time-invariant, i.e. there are no structural breaks.[5]

We model the two economies by means of an overlapping generations structure. Agents live for two periods and are modeled as an atomless continuum of investors with stable unit mass. The existence of a continuum of agents implies that they can be thought of as price takers. Across countries 1 and 2, agents have *homogenous* constant absolute risk aversion (CARA) preferences over consumption of the agents' final wealth, with risk-aversion parameter θ:

$$U(W^j_{t,t+1}) = -e^{-\theta W^j_{t,t+1}} \quad j = 1, 2 \tag{3}$$

where $W^j_{t,t+1}$ denotes final wealth (at time $t+1$) of agents born in period t. Since preferences are homogeneous, we are ruling out explanations of asset allocation biases based on trivial preference differences across countries. (3) implies that consumption is not possible in the first period. In practice, our agents behave like portfolio managers with a short-term horizon.

An agent born in period t can buy and sell securities when young (in period t). Each young agent comes to life endowed with a certain quantity of consumption goods. To avoid complications and since they do not affect the equilibrium (cf. Spiegel (1998)), suppose the initial endowments are equally spread among the newly born population.[6] Call $W^j_{t,t}$ the market value of the initial endowment of generation t from country j. After trade ends in period t, the economy moves to period $t+1$. At this time three things happen. First, old agents of generation (born in) t receive their period $t+1$ payoffs from the securities they hold: stocks pay out dividends D_{t+1} and the one-period bond pays $(1+r)$ per unit invested. Second, a new generation indexed time $t+1$ comes to life with an endowment valued $W^j_{t+1,t+1}$ units. Next, the elders from generation t sell off all of their portfolios at current market prices to the youngsters who are getting rid of their endowments and making their portfolio decisions. It follows that:

$$W^1_{t+1,t+1} + W^2_{t+1,t+1} = S^1_{t+1} + S^2_{t+1},$$

the aggregate value of the long-lived assets in the World. The elders consume the proceeds of the sale of their financial wealth plus the other real payoffs received (dividends and interests), and then die.

Let $\mathbf{x}^j_t = [x^j_{1t} \; x^j_{2t}]'$ (j=1, 2) be the portfolio investment in the two national stock markets by generation-t agents living in country j, and B^j_t the net loans made or received at the risk-free rate r to/from other (foreign) youngsters of the same generation. Therefore each generation in each country faces the following budget constraint when young:

$$W^j_{t,t} = (\mathbf{x}^j_t)'\mathbf{S}_t + B^j_t \quad j = 1, 2 \tag{4}$$

[5]This specification for the dividends process and the fact that the Gaussian random variables δ^j_t have the entire real line as their support implies a positive probability for dividends to become negative. However notice that $\Pr\{D^j_t < 0\} = \Pr\{\sum_{i=0}^{t-1} \delta^j_i < -D^j_0 - \alpha^j t\}$ can be made arbitrarily small by increasing D^j_0 and/or α^j enough. Also, notice that for $\alpha^j > 0$, as $t \to \infty$ this probability converges to zero. Cf. also Coval (1999, p. 7, f. 18)).

[6]The goods market is always in equilibrium. Thus we are free to focus on the equilibrium in financial markets.

where $\mathbf{S}_t \equiv [S_t^1 \ S_t^2]'$. Since consumption when young is ruled out by (3), the entire (real) endowment must be invested in existing assets at current market prices. Suppose that short sales of stocks are prohibited, so that $x_{it}^j \in [0,1]$, $i,j = 1,2$.[7] At the beginning of period $t+1$ all members of generation t in each country receive the payoffs from the securities in their portfolios and then sell their entire financial wealth to finance final consumption:

$$W_{t,t+1}^j = (\mathbf{x}_t^j)'[\mathbf{S}_{t+1} + \mathbf{D}_{t+1}] + (1+r)B_t^j \quad j = 1,2. \tag{5}$$

Notice that $W_{t,t+1}^j$ in (5) can be expressed as a function of the initial endowments by using the fact that $B_t^j = W_{t,t}^j - (\mathbf{x}_t^j)'\mathbf{S}_t$:

$$W_{t,t+1}^j = (\mathbf{x}_t^j)'[\mathbf{S}_{t+1} - \mathbf{S}_t + \mathbf{D}_{t+1} - r\mathbf{S}_t] + (1+r)W_{t,t}^j \quad j = 1,2. \tag{6}$$

Thus each agent in generation t seeks to maximize the expected utility of final wealth $W_{t,t+1}^j$ given by (6) by choosing the optimal portfolio composition given by $\mathbf{x}_t^j$.

4. The Full Information Rational Expectations Equilibrium

Following standard practice in the literature (cf. Spiegel (1998, p. 425)), we focus on a particular class of stationary, *full-information rational expectations* (FI for short) equilibria. We define a FI equilibrium as a collection of policy functions describing the utility-maximizing portfolio choices by agents, and of market-clearing price functions derived under the assumption that traders *know the exogenous data-generating process* followed by the state variables, dividends. This does not imply that agents are able to perfectly foresee future dividends, and simply rules out that they may systematically be mistaken. Forecast errors may result from the random shocks $\boldsymbol{\delta}_t$. An equilibrium is *stationary* when the policy and price functions mapping state variables into optimal decisions and market-clearing prices are characterized by time-invariant parameters.

We conjecture a linear form for the price functions and then verify that if all agents believe in the postulated form, it will in fact hold, defining an equilibrium. In our model, at time t the newly born generation in each country observes two state variables, D_t^1 and D_t^2. This list reflects the choice of not imposing any restrictions on cross-country information flows concerning fundamentals. Investors in country 1 freely observe and fully understand the information concerning dividends in country 2, and vice-versa. Thus we are focusing on a World of *symmetric information flows.* We conjecture that in a linear, stationary FI equilibrium

$$\mathbf{S}_t^{FI} = \mathbf{K} + Q\mathbf{D}_t \quad \forall t \geq 1 \tag{7}$$

where $\mathbf{K}$ is a 2×1 vector of constants to be determined in equilibrium, and Q is a 2×2 matrix mapping the state variables $\mathbf{D}_t$ into market-clearing asset prices. Under FI agents in both countries are assumed to know the multivariate, zero-means normal density of the fundamental shocks, the random walk with drift process of $\mathbf{D}_t$, as well as the drift parameter vector $\boldsymbol{\alpha}$ and the covariance matrix Σ. Substituting

[7] In an representative agent framework it is difficult to believe that investors in country j might be capable in the aggregate to sell short the national stock market of country $-j$.

the conjectured price function (7) into (6), straightforward algebra gives:

$$W^j_{t,t+1} = (\mathbf{x}^j_t)'[Q\boldsymbol{\alpha} + Q\boldsymbol{\delta}_{t+1} + \boldsymbol{\alpha} + \mathbf{D}_t + \boldsymbol{\delta}_{t+1} - r\mathbf{K} - rQ\mathbf{D}_t] + (1+r)W^j_{t,t}.$$

With normally distributed shocks, expected utility maximization is equivalent to the maximization of

$$E_t[W^j_{t,t+1}] - \frac{1}{2}\theta Var_t[W^j_{t,t+1}].$$

Appendix A shows that the long-lived assets' demand functions are:

$$\hat{\mathbf{x}}^j_t = \theta^{-1}\left[(I+Q)\Sigma(I+Q)'\right]^{-1}\left[(I+Q)\boldsymbol{\alpha} + (I-rQ)\mathbf{D}_t - r\mathbf{K}\right]. \tag{8}$$

It is also proven that in equilibrium:

$$\mathbf{S}^{FI}_t = \frac{1+r}{r^2}\boldsymbol{\alpha} - \frac{1}{2}\frac{(1+r)^2}{r^3}\theta\Sigma\boldsymbol{\iota} + \frac{1}{r}\mathbf{D}_t = \frac{1}{r}\begin{bmatrix} \frac{1+r}{r}\alpha^1 - \frac{1}{2}\frac{(1+r)^2}{r^2}\theta\left(\sigma^2_1 + \sigma_{12}\right) + D^1_t \\ \frac{1+r}{r}\alpha^2 - \frac{1}{2}\frac{(1+r)^2}{r^2}\theta\left(\sigma^2_2 + \sigma_{12}\right) + D^2_t \end{bmatrix} \tag{9}$$

where $\sigma_{12} = Cov(D^1_t, D^2_t)$. As intuition suggests, the FI equilibrium price of a stock is an increasing function of the dividend drift, and a decreasing function of risk aversion, the volatility of fundamentals, and the covariance between dividends paid by the two stocks.

As for international portfolio choices, observe that given our assumption of homogeneous preferences, in (8) no country-specific parameters or variables appear on the right-hand side. Therefore:

$$\hat{\mathbf{x}}_t = \hat{\mathbf{x}}^1_t + \hat{\mathbf{x}}^2_t = 2\hat{\mathbf{x}}^1_t = \boldsymbol{\iota}_2 \Longrightarrow \hat{\mathbf{x}}^1_t = \hat{\mathbf{x}}^2_t = \frac{1}{2}\boldsymbol{\iota}_2 \Longleftrightarrow (\hat{\mathbf{x}}^1_t)'\mathbf{S}_t = (\hat{\mathbf{x}}^2_t)'\mathbf{S}_t = \frac{1}{2}\boldsymbol{\iota}'\mathbf{S}_t$$

Hence: (i) investors in different countries should have the same, optimal equity portfolio composition; (ii) in particular, investors in each country should hold a portfolio in which all stock indices enter with a weight exactly equal to their weight in the World equity market capitalization, *the international market portfolio*; (iii) the risk-free asset has a country j net aggregate demand of

$$\hat{B}^j_t = W^j_{t,t} - (\hat{\mathbf{x}}^j_t)'\mathbf{S}_t = W^j_{t,t} - \frac{1}{2}\boldsymbol{\iota}'\mathbf{S}_t \quad (j = 1, 2).$$

Although the simple two-period OLG structure of the model prevents us from pursuing the effects of intertemporal consumption smoothing decisions on prices and asset allocation decisions, at least cross-country consumption smoothing forces may is possible:[8] since in equilibrium

$$\hat{B}^1_t + \hat{B}^2_t = 0 = W^1_{t,t} + W^2_{t,t} - S^1_t - S^2_t = (W^1_{t,t} - S^1_t) + (W^2_{t,t} - S^2_t),$$

the country whose initial wealth exceeds the value of its national stock market lends to the less endowed country to allow the achievement of perfect risk-sharing. Under FI and with identical risk preferences, we obtain the pooling equity portfolio allocation studied by Lucas (1982). This class of FI equilibria does not generate any home country bias in equity portfolios. Since $\hat{\mathbf{x}}^j_t = \frac{1}{2}\boldsymbol{\iota}\ \forall t \geq 1$, $\Delta\hat{\mathbf{x}}^j_t = 0\ \forall t \geq 2$ implies that there cannot be any excess turnover in foreign stocks. At all times, agents purely hold half of the supply of each national stock market. No stocks are traded *internationally* (between agents born

[8]In an infinite horizon model, Michelides (2001) shows that the benifits of international portfolio diversification might be overestimated because consumption fluctuations can be smoothed with a small amount of buffer stock savings.

in different countries). Moreover, these highly restrictive implications for optimal portfolio choices imply international portfolio flows with counterfactual properties: on one hand, net flows (in the sense of (1)) are zero at all times by construction; on the other, gross flows consist entirely of portfolio-rebalancing flows, i.e. the weight of the foreign stock increases as long as its price does, given that $\hat{x}_t^j = \frac{1}{2}\iota \; \forall t \geq 1$. Clearly, both the static and the dynamic international portfolio choice implications of full-information rational expectations are at odds with the empirical evidence.[9]

5. **Recursive Bayesian Learning**

5.1. *Learning Dynamics*

We relax the assumption of full information rational expectations: traders in both countries are on a *recursive learning path* concerning the stochastic properties of the state variables. We make the following assumptions concerning the learning scheme:

(i) Traders from both countries know that the shocks $\boldsymbol{\delta}_t = [\delta_t^1 \; \delta_t^2]'$ are multivariate $N(\mathbf{0}, \Sigma)$ with zero serial correlation and no cross-correlations at all leads and lags, and that dividends follow a random walk with drift. However, we assume that traders do not know both the drift parameters ($\boldsymbol{\alpha} = [\alpha^1 \; \alpha^2]'$) and the variance-covariance matrix Σ.

(ii) Traders recursively estimate the five unknown parameters (two means, two standard deviations, and one covariance term), recognizing that changes in dividends follow a stationary process and that the estimated parameters are recursively updated over time. In particular, agents born in both countries are *Bayesian econometricians* engaged in the estimation of the moments of a bivariate Gaussian random walk. Also suppose that at $t = 1$ agents in both countries have an uninformative prior density on α and Σ:[10]

$$p^j(\alpha, \Sigma) \propto |\Sigma|^{-\frac{3}{2}} \quad j = 1, 2. \tag{10}$$

(iii) Traders in generation k from both countries use information previously available to all past generations born in $t = 1, 2, ...k-1$ *in the same country*. As Bayesian econometricians they recursively update their priors in the light of the data to obtain a country-specific posterior density of the unknown parameters. Because of the OLG structure, learning is intergenerational, i.e. each generation progresses in the learning process starting from where the previous generation had left. Also assume that agents can observe in each period the latest realization of D_t when young, before making their portfolio choices.

(iv) As in Brennan and Cao (1997), there exists a cumulative information advantage of domestic investors over foreign investors. However, we depart from their setup by assuming that the asymmetry is caused by *a differential of experience*: traders born in the country in which a security is issued have a superior information endowment, in the form of a longer history of past realizations. At time $t \geq 1$, investors from country 1 will have $t + b_1$ observations on stock 1, but only t observations on stock 2. Symmetrically,

[9] Although our OLG framework derives prices in equilibrium, by discounting expected future dividend payments, under full-information the model implications for prices and portfolio choices also have a static CAPM flavor. Agents in the two countries can be thought of as borrowing and lending at the international rikless rate to achieve optimal positioning on a common capital market line in the mean-variance space. I owe this insight to an anonymous referee.

[10] This prior is standard in the Bayesian literature, cf. Zellner (1971, p. 225).

investors from country 2 possess $t + b_2$ observations on stock 2, but a shorter history of t observations on stock 1. b_1 and b_2 represent the additional length of the cumulated histories on domestically issued stocks. b_1 and b_2 are known and deterministic.[11] Because of assumption (iii), the information asymmetry is transmitted from one generation to the next, i.e. the domestic cumulative advantage b_j ($j = 1, 2$) characterizes all generations.
(v) Suppose either that investors are boundedly rational and do not realize that there exist asymmetries in the cumulative information stocks of traders in different countries, or that the initial stock of knowledge that gives better information on domestic fundamentals cannot be transferred. In the former case agents do not realize they are at an informational disadvantage relative to foreign investors on securities issued abroad. Therefore they do not attempt to infer the information possessed by foreigners from realized prices and portfolio choices.[12] In the latter case, our model becomes a stylized description of a world in which past information concerning the fundamentals is so complex to foreigners that it cannot simply be recovered from observed market outcomes.

Assumption (iv) deserves comment. Consider two countries that are financially integrated. There are no barriers or controls on capital flows. Investors from both countries have incentives to collect all kinds of information that are helpful in allocating their wealth, including news on securities issued abroad. Suppose that traders have no impediments to receiving information on foreign assets. Therefore there are no important asymmetries in the *quality* of current flows of information concerning international investment opportunities. The recursive learning process is thus based on homogenous informational *flows*. While this description of the physical environment would be exhaustive in a model in which all economies had always been fully financially integrated, in a more realistic setting that takes into account that the degree of financial integration may have changed over time, other aspects of the distribution of the information across countries matter. When in the past a *financial liberalization* occurred, important *asymmetries in the cumulated stock of information* concerning fundamentals are likely to affect equilibrium outcomes. Though incentives to collect information on foreign securities are at work, it is unrealistic to believe that all traders will be immediately able to cumulate the same quantity of past information on securities issued abroad as their foreign counterparts have already. In general, equity investments in foreign companies require a great deal of understanding of foreign accounting practices and corporate relationships, not to mention the legal environment (see Porter et al. (2001)). While this is difficult already with reference to the current institutional environment, the task is even harder when applied to practices and institutions enforced before a financial liberalization occurred. The assumption that in a learning environment traders have a longer history of data concerning the state variables affecting assets issued at home than foreign traders do is a shortcut to modeling these differentials of cumulated experience.

In practice portfolio problems are much more complicated than the ones recursively solved by our Bayesian learners, implying difficult evaluations of the future perspectives of companies and entire na-

[11] This assumption could be relaxed by assuming that b_j — conditional on the dividend innovations δ_j — does not depend on α and Σ and as such does not convey any information on the bivariate process for dividend news.

[12] The model could be enriched with further assumptions preventing agents from *perfectly* inferring foreign prior information from realized equibrium prices and portfolio weights. For instance, the assumption that the foreign supply of stocks as well as foreign portfolio holdings of the stock issued abroad (X_{-jt}^{-j}) are unobservable would do.

tional economies. Moreover, the proximity of an investor to an investment opportunity gives advantages that are unlikely to disappear altogether after a financial liberalization. Although they are hard to measure, some of these advantages manifest themselves even within country borders (Coval and Moskowitz (1999)) and probably cumulate over time. In this sense our simulation exercises should be read as providing a lower bound for the size of the portfolio biases resulting from realistic information asymmetries and an upper bound for the speed with which such biases decline over time.

5.2. *Bayesian Inference*

Proposition 1 in Appendix B provides details on the Bayesian predictive density $g^j(\Delta\mathbf{D}_{t+1}|\Im_t^j; b_j)$ for the vector of dividend changes between t and $t+1$, given the non-informative prior beliefs in (10) and the asymmetric-length past histories, $\Im_t^j \equiv \{\mathbf{y}_{1,t}^j, \mathbf{y}_{b_j,t}^{-j}\}$. In practice the notation just stresses that while agent j ($j = 1, 2$) has available $t + b_j$ observations on fundamentals in country j, on the other hand, she can count on only t observations on fundamentals in country $-j$. It turns out that such a predictive density has a non-standard, possibly non-elliptical shape.[13] Such a density may be conveniently decomposed as a product of two Student t densities, a t-Student with $t + b_j - 1$ degrees of freedom and (conditional on ΔD_{t+1}^j) a t-Student with $t - 1$ degrees of freedom.

What is remarkable of Proposition 1 is that the first two moments of $g^j(\Delta\mathbf{D}_{t+1}|\Im_t^j; b_j)$ behave in very different ways. While the drift $E_t^j[\Delta D_{t+1}^j|\Im_t^j; b_j]$ characterizing the home country fundamentals is the sample mean of past dividend changes, the perceived drift of foreign fundamentals $E_t^j[\Delta D_{t+1}^{-j}|\Im_t^j; b_j]$ does not simply truncate the sample to the most recent t periods but is instead

$$E_t^j\left[\Delta D_{t+1}^{-j}|\Im_t^j; b_j\right] = \hat{\gamma} + \hat{\beta}\hat{\alpha}^j,$$

where $\hat{\gamma}$ corresponds to the mean of foreign dividend changes observed by the investor. On the contrary, a term $\hat{\beta}\hat{\alpha}^j$ brings into the estimation also information collected in periods 1, 2, ..., $b_j - 1$. Indeed the OLS coefficient β is used to extrapolate likely information on the behavior of foreign fundamentals over the period for which data are not available. On the other hand, even with reference to the period for which data on foreign fundamentals are available, these information is filtered with respect to the contemporaneous evidence on domestic fundamentals. A sample mean of foreign fundamentals too low given what is predicted by the contemporaneous realization of home fundamentals implies a downward revision of the perceived drift $E_t^j[\Delta D_{t+1}^{-j}|\Im_t^j; b_j]$. Second, the presence of estimation risk directly affects the perceived covariance matrix for the predictive density of future changes in dividends. In general, all the elements exceed their OLS counterparts that ignore estimation risk. For instance,

$$Var_t^j[\Delta D_{t+1}^j|\Im_t^j; b_j] = \frac{t + b_j + 1}{t + b_j - 3}\hat{\sigma}_j^2 > \hat{\sigma}_j^2$$

The increase in the perceived risk of foreign fundamentals is particularly relevant when t is small.

The presence of learning is necessary for differential experience to matter in portfolio choices. Under FI there cannot be any learning process and as such only current information matters. Only asymmetries in the quality of information flows are important as agents simply need to know the most recent values

[13] An appendix that proves Proposition 1 is available at www.virginia.edu/economics/guidolin.htm.

assumed by the state variables in order to allocate their portfolios. When there is learning the quantity of information — parameterized by b_1 and b_2 in our setup — is also crucial, by influencing the covariance matrix of the estimates in a Bayesian framework.

5.3. *Solution*

In a linear equilibrium:[14]

$$\mathbf{S}_t^{BL} = \mathbf{K}_t^{BL} + Q_t^{BL}\mathbf{D}_t \quad \forall t \geq 1 \tag{11}$$

where the matrices $\mathbf{K}_t^{BL}$ and Q_t^{BL} are now a function of the Bayesian predictive densities estimated by the current generations, and may therefore change over time as they are recursively re-estimated. As a result, the equilibrium is non-stationary. Using (11) to substitute in equation (6), we obtain:

$$W_{t,t+1}^j = (\mathbf{x}_t^j)'[Q_t^{BL}\Delta\mathbf{D}_{t+1} + \mathbf{D}_t + \Delta\mathbf{D}_{t+1} - r\mathbf{K}_t^{BL} - rQ_t^{BL}\mathbf{D}_t] + (1+r)W_{t,t}^j \tag{12}$$

Agents from both countries solve the unconstrained optimization:

$$\begin{aligned}\max_{\mathbf{x}_t^j} E_{\boldsymbol{\phi}}\left\{E_t\left[U(W_{t,t+1}^j)|\boldsymbol{\phi}\right]\right\} &= \max_{\mathbf{x}_t^j} \int_{\boldsymbol{\phi}}\int_{\Delta\mathbf{D}_{t+1}} -e^{-\theta W_{t,t+1}^j} f_t^j(\Delta\mathbf{D}_{t+1}|\boldsymbol{\phi}; b_j) f_t^j(\boldsymbol{\phi}|\Delta\mathbf{D}_{t+1}; b_j) d\Delta\mathbf{D}_{t+1} d\boldsymbol{\phi} \\ &= \max_{\mathbf{x}_t^j} \int_{\Delta\mathbf{D}_{t+1}} -e^{-\theta W_{t,t+1}^j} g_t^j(\Delta\mathbf{D}_{t+1}; b_j) d\Delta\mathbf{D}_{t+1} \qquad (j = 1, 2)\end{aligned} \tag{13}$$

where $\boldsymbol{\phi} \equiv [\boldsymbol{\alpha}\ vech(\Sigma)]'$, and $g_t^j(\Delta\mathbf{D}_{t+1}; b_j) \equiv \int_{\boldsymbol{\phi}} f_t^j(\Delta\mathbf{D}_{t+1}|\boldsymbol{\phi}; b_j) f_t^j(\boldsymbol{\phi}|\Delta\mathbf{D}_{t+1}; b_j) d\boldsymbol{\phi}$ is the *predictive density* of the stationary dividend shocks $\Delta\mathbf{D}_{t+1}$, obtained by integrating the density parameterized by $\boldsymbol{\phi}$ with respect to the Bayesian posterior $f_t^j(\boldsymbol{\phi}|\Delta\mathbf{D}_{t+1}; b_j)$. Klein and Bawa (1976) name this solution to the one-period ahead portfolio choice problem *the unconditional solution*. When the economy is on a learning path with respect to some of the parameters of the state variables process, there are strong arguments for using the Bayesian approach to portfolio choice. For instance, for an investor to choose her portfolio shares according to (13) is consistent with the von Neumann-Morgenstern axioms.

Since on a Bayesian learning path the multivariate predictive density for $\Delta\mathbf{D}_{t+1}$ is a non-standard, possibly non-elliptical density, the investor's portfolio choice problem can only be solved numerically. Appendix C provides further details.

5.4. *Intuition for the case of known covariance matrices*

Since the model can be solved for equilibrium prices and international portfolio choices only numerically, we are short of precious economic intuition. However, there is a case in which closed-form solutions can be obtained even in the presence of Bayesian learning: known covariance matrices. For the purposes of this subsection only, assume that (i) - (v) above apply , with the only difference that investors just do not

[14]Disregarding the effects of the no-short sales constraints, the generic existence of a linear equilibrium follows from results in Hart (1974) that have straightforward adaptation to our OLG set-up in which agents trade when young only. Since agents' probability beliefs on time $t+1$ securities' payoffs are independent of current, equilibrium security prices, theorem 3.2 in Hart (1974, p. 302) is both necessary and sufficient for existence. In practice, this result imposes bounds on the amount of "disagreement" characterizig the beliefs of strictly risk-averse agents, plus some technical conditions.

know the drift parameters of the process of dividends, $\boldsymbol{\alpha}$. On the contrary, Σ is known. Although this is of course unrealistic given the great emphasis portfolio managers place on the methods through which to estimate covariance matrices, the advantage is that Proposition 1 now simplifies to the following:[15]

Corollary 1. Given the non-informative prior in (10), when $\boldsymbol{\alpha}$ is unknown but Σ is known, the predictive density for $\Delta\mathbf{D}_{t+1}$ perceived at time t by investors from country j ($j = 1, 2$) corresponds to the bivariate normal density $N\left(\hat{\mathbf{m}}_t^j, V_t^j\right)$where

$$\hat{m}_{1,t}^j = (t+b_j)^{-1}\sum_{i=1}^{t+b_j}\Delta D_i^j, \quad \hat{m}_{2,t}^j = \hat{\gamma} + \hat{\beta}\hat{\alpha}^j, \quad Var_t^j\left[\Delta D_{t+1}^j|\Im_t^j; b_j\right] = \left(\frac{1}{t+b_j}+1\right)\sigma_j^2$$

$$Var_t^j\left[\Delta D_{t+1}^{-j}|\Im_t^j; b_j\right] = \left[\frac{(1-\rho^2)(t+b_j)+\rho^2 t}{(t+b_j)t}+1\right]\sigma_{-j}^2$$

$$Cov_t^j\left[\Delta D_{t+1}^j, \Delta D_{t+1}^{-j}|\Im_t^j; b_j\right] = \left(\frac{1}{t+b_j}+1\right)\rho\sigma_1\sigma_2$$

and $\hat{\boldsymbol{\xi}} = \left[\widehat{\gamma}\ \widehat{\beta}\right]' = \left[(X_{b_j,t}^j)'X_{b_j,t}^j\right]^{-1}(X_{b_j,t}^j)'\mathbf{y}_{b_j,t}^j$.

Given the bivariate normality of the predictive density it is straightforward to show that since in equilibrium asset prices must set demand equal to supply, the following system of equations

$$\sum_{j=1}^{2}\theta^{-1}\left\{\left[(I+Q_t^{BL})V_t^j(I+Q_t^{BL})'\right]^{-1}\left[(I+Q_t^{BL})\hat{\mathbf{m}}_t^j+(I-rQ_t^{BL})\mathbf{D}_t - r\mathbf{K}_t^{BL}\right]\right\} = \boldsymbol{\iota}_2$$

characterizes stock prices. Solving for the unknown matrices in the price function, gives $Q^{BL} = \frac{1}{r}I_2$ and

$$\mathbf{K}_t^{BL} = \frac{1+r}{r^2}\left[(V_t^1)^{-1}+(V_t^2)^{-1}\right]^{-1}\left[(V_t^1)^{-1}\hat{\mathbf{m}}_t^1+(V_t^2)^{-1}\hat{\mathbf{m}}_t^2\right] - \theta\frac{(1+r)^2}{r^3}\left[(V_t^1)^{-1}+(V_t^2)^{-1}\right]^{-1}\boldsymbol{\iota}_2$$

The first restriction corresponds to the one derived in Section 4: despite learning effects and differential estimation risk, there exists a proportional, time-invariant relationship between current dividends and the equilibrium stock price. Also the second restriction is very similar to the FI expression, as $\mathbf{K}_t^{BL}$ is now function of averages of the means of the predictive densities of dividend changes as perceived by agents in 1 and 2 ($\hat{\mathbf{m}}_t^1$ and $\hat{\mathbf{m}}_t^2$) with weighting matrices provided by the inverses of the perceived covariance matrices under their predictive densities ($(V_t^1)^{-1}$ and $(V_t^2)^{-1}$). The last, negative term employs a harmonic mean of the variance-covariance matrices perceived by the agents instead of the simple matrix Σ in the expression for $\mathbf{K}^{FI}$ of Section 4.

Putting the above findings together and plugging them back into conjecture (11), we derive the following equilibrium price functions:[16]

$$\tilde{\mathbf{S}}_t^{BL} = \frac{1+r}{r^2}\left[(V_t^1)^{-1}+(V_t^2)^{-1}\right]^{-1}\left[(V_t^1)^{-1}\hat{\mathbf{m}}_t^1+(V_t^2)^{-1}\hat{\mathbf{m}}_t^2\right] - \theta\frac{(1+r)^2}{r^3}\left[(V_t^1)^{-1}+(V_t^2)^{-1}\right]^{-1}\boldsymbol{\iota}_2+\frac{1}{r}\mathbf{D}_t \quad (14)$$

[15] This is the case on which Balduzzi and Liu (2000) focus, although in a partial equilibrium setting.

[16] We are aware of the invertibility of $\tilde{\mathbf{S}}_t^{BL}$ to find $\hat{\mathbf{m}}_t^{-j}$ given $\hat{\mathbf{m}}_t^j$ ($j = 1, 2$), i.e. of the fact that in the known covariance matrix case, there are two observable market outcomes (prices) and two sufficient statistics for past dividend realizations (the means), so that each agent could in principle fill in the information gap on foreign fundamentals after observing one set of prices only. However, this subsection has the only purpose of conveying some intuition for the general case in which asset pricing relationships cannot be trivially inverted to recover the information of better informed agents.

Analogously, plugging in the previous expression for $\mathbf{K}_t^{BL}$ and Q^{BL} into (8) we obtain a vector of country-specific stock demand functions

$$\hat{\mathbf{x}}_t^j = \theta^{-1}\left(\frac{r}{1+r}\right)(V_t^j)^{-1}\Big\{\hat{\mathbf{m}}_t^j - \left[(V_t^1)^{-1} + (V_t^2)^{-1}\right]^{-1} \times$$
$$\times \left[(V_t^1)^{-1}\hat{\mathbf{m}}_t^1 + (V_t^2)^{-1}\hat{\mathbf{m}}_t^2\right] + \theta\frac{(1+r)}{r}\left[(V_t^1)^{-1} + (V_t^2)^{-1}\right]^{-1}\boldsymbol{\iota}_2\Big\}$$

Comparing $\tilde{\mathbf{S}}_t^{BL}$ with (9), the model with Bayesian learning *no longer generates stationary equilibria.* The pricing function changes over time, as the vector $\mathbf{K}_t^{BL}$ depends on time through $(V_t^1)^{-1}$, $(V_t^2)^{-1}$, $\hat{\mathbf{m}}_t^1$, and $\hat{\mathbf{m}}_t^1$. Since $\mathbf{K}_t^{BL}$ is a function of time, stock prices no longer follow a random walk with drift. On the contrary, their process displays a complex time dependence through the revisions of the traders' beliefs concerning the means and the covariance matrix of the predictive density.

As for international portfolio choices, the expression of $\hat{\mathbf{x}}_t^j$ reveals that it is likely that investors based in different countries will hold different portfolios. Indeed country-specific variables appear on the right-hand side of the expression, both time-varying estimates of the two unknown drift vectors and time-varying perceived covariance matrices. Investors will no longer hold the same international market portfolio and some home-country bias is likely to appear in equilibrium. We can distinguish between two sources of bias. First, on a dynamic learning path agents from both countries may believe that the fundamentals of their own national stocks are superior to those of securities issued abroad. When $\sum_{i=1}^{b_j-1}\Delta D_i^j$ is high relative to $\sum_{i=b_j}^{t}\Delta D_i^j$ for j =1, 2, agents from country 1 might rationally decide to tilt their equity holdings towards stock 1, and agents from 2 to do the same for stock 2. Of course other outcomes — at the extreme, investors in both countries believing that foreign stocks are 'better' than domestic securities — are possible. Notice however that under FI none of this was possible. Second, there is a contribution of differential estimation risk to home bias. When there exist asymmetries in the cumulative, initial knowledge of the history of fundamentals and agents are on a learning path, they will end up perceiving foreign stocks as intrinsically riskier than stocks issued at home. Therefore they will bias their portfolios towards their own national stock market.

To understand the source of the last type of bias, consider what happens to the demand from country j for domestic vs. foreign ($-j$) stocks. By construction $V_t^j \equiv \Omega_t^j + \Sigma$, where

$$\mathbf{e}_j'\Omega_t^j = (t+b_j)^{-1}\boldsymbol{\iota}' \qquad \mathbf{e}_{-j}'\Omega_t^j = \begin{bmatrix}(t+b_j)^{-1} & \dfrac{(1-\rho^2)(t+b_j)+\rho^2 t}{(t+b_j)t}\end{bmatrix}$$

($\mathbf{e}_1 \equiv [1\ 0]'$ etc.). Since after a financial liberalization t is small, $\mathbf{e}_{-j}'V_t^j \simeq [\rho\sigma_1\sigma_2 \quad 2\sigma_{-j}^2] \geq [\rho\sigma_1\sigma_2 \quad \sigma_{-j}^2]$, while $\mathbf{e}_j'V_t^j \simeq [\sigma_j^2 \quad \rho\sigma_1\sigma_2]$ provided that b_j is large enough. Therefore, since $(V_t^j)^{-1}$ enters the expression for $\hat{\mathbf{x}}_t^j$, investors from country j should reduce portfolio holdings of stocks issued in other countries relative to the FI portfolio choice in which $V_t^j = \Sigma$. This intuition is even stronger for the unknown Σ case: the resulting predictive density for future changes in fundamentals is now non-Gaussian and is likely to be characterized by the fat tails typical of t-Student distributions. This is especially true with reference to foreign fundamentals, for which the number of degrees of freedom is limited (as $v_{-j} = t-1$). This has intuitive appeal: since the fundamentals underlying foreign stocks are likely to be perceived as riskier than domestic fundamentals, on average investors will tilt their portfolios away from investments abroad. However, this bias might be partially compensated by the fact that in equilibrium assets in low demand should command a lower price and therefore higher excess returns. Overall, how much bias can emerge in equilibrium is however a quantitative issue examined in Section 6.

The implications for international portfolio flows are very complicated even when Σ is known. On one hand, it is now clear that time variation in the perceived moment matrices V_t^j and $\hat{m}_t^j$ induces time variation in $\hat{x}_t^j$ $(j = 1, 2)$ so that non-zero net portfolio flows become possible. This is an important difference vs. the FI case, in which no trend-chasing behavior by net flows is obtainable, contrary to Bohn and Tesar's results, while gross flows are entirely dominated by rebalancing. On the other hand, any comparative statics exercise is made difficult by the fact that the model is of a general equilibrium nature, so that changes in agents' perceptions of V_t^j and/or $\hat{m}_t^j$ map in complex ways into changes of stock prices and changes in portfolio holdings. For instance, while an increase in $\hat{m}_{2,t}^1$ $-$ the mean dividend drift in country 2 perceived by investors in country 1 $-$ is very likely to increase $\hat{S}_t^2$ (hence foreign stock returns, as long as $\pi \equiv \frac{\partial}{\partial \hat{m}_{1,t}^2}\{\mathbf{e}_2' \, [(V_t^1)^{-1} + (V_t^2)^{-1}]^{-1}[\mathbf{e}_1' V_t^1 \mathbf{e}_1 \; \mathbf{e}_1' V_t^1 \mathbf{e}_2]'\} > 0$), the net effect on $\hat{x}_{2,t}^1$ is uncertain and depends on a different condition, $\pi < 1$. The intuition is that following the perception of good news on the fundamentals by foreigners, the price of a stock might increase so quickly to actually discourage demand from foreign investors, causing net outflows from the equity market. In practice, such comparative statics exercises have even less value, as in a dynamic equilibrium price and portfolio choices will jointly depend on V_t^j, $\hat{m}_t^j$, and D_t. Also in this case, the properties of capital flows under BL become a quantitative issue to be examined by simulating from the model.

Finally, since the available history of foreign fundamentals is shorter than the one for domestic fundamentals, at least for small t, the drift vector estimates $\hat{\mathbf{m}}_t^j$ will be much more volatile in their $-jth$ component than in their jth component. Therefore investors should be more inclined to drastically change the portfolio weight of foreign stocks from one period to the other. Hence the equity portfolio turnover in stocks issued abroad should be higher than for stocks issued in the country of origin. On average it is likely that some excess turnover in foreign securities would emerge. The intuition fully extends to the unknown Σ case: revisions in the perceptions of the second moments will be stronger for foreign fundamentals than for domestic ones, thus adding to the creation of excess turnover. Section 6 undertakes the task of evaluating the strength and persistence of this effect through simulations.

6. **Simulations**

Section 5 left us with some unanswered questions. First, what is the strength of the home equity preference generated solely by the existence of differentials in the cumulated experience on a learning path? How persistent are such portfolio biases? Second, does learning induce any trend-chasing behavior? Third, is there any tendency to sustain a higher turnover rate on foreign equity holdings than on domestic ones? To tackle these issues, we simulate the model using the following parameters:

$$r = 0.02, \;\; \theta = 1, \;\; D_0 = [2 \; 2]' = 2\iota, \; \alpha = \begin{bmatrix} 0.02 \\ 0.02 \end{bmatrix}, \text{ and } \Sigma = \begin{bmatrix} 0.0009 & 0.00063 \\ 0.00063 & 0.0009 \end{bmatrix}$$

The two countries are symmetric: they have the same (unit) size, the same process for fundamentals (as identified by the marginal density of dividend changes), and identical preferences. Our specification for

Σ implies a low-volatility dividend process. Shocks to fundamentals are mildly linearly correlated with $Corr(\Delta D_t^1,\, \Delta D_t^2) = 0.7$. This positive correlation means that an international business cycle exists. Notice that α implies a time 0 expected rate of growth of about 0.5% per period ($100 \times \frac{0.02}{D_0} = 0.5$), while σ_j^2 implies a time 0 standard deviation of the dividend growth rate equal to 0.75%. Although these parameter values do not intend to be representative of any pair of countries in particular, notice that 2% is a plausible level for the real risk-free rate; the quarterly real growth of the US GDP has been about 0.6% in the last 30 years; the quarterly volatility of the rate of growth of the US real GDP over the same period has been about 0.85%; a correlation of 0.70 exactly matches the value reported in Backus et al. (1992) for the correlation between US and European real GDP growth.[17] Therefore the parameters employed in the simulation exercise represent a rough calibration on sensible values.

We simulate a two-country World economy for 60 periods when agents are on a Bayesian learning path with differential cumulative experience. Therefore, taking the quarter as our unit of time, we monitor the properties of equilibrium choices and market outcomes for 15 years. Dividends paid by both stocks are 'pre-simulated' for 60 periods to accommodate for the maximum cumulative knowledge investors could have built on each endowment process before they are granted the possibility to diversify internationally. Therefore $b_1 = b_2 = 60$. At time $t \geq 1$ investors from country j have $60 + t$ observations on home fundamentals and only t on foreign $(-j)$ fundamentals.[18] We repeat 1,500 times this process of generating time series for dividends, equilibrium prices and portfolio allocations for both countries. Problems with negative dividends never arose, which sidesteps the issue of assessing the effects of discarding simulations. In the following we use the simulated distribution of a few summary statistics calculated on the previous list of state variables and equilibrium market outcomes.

6.1. *Home Country Bias on a Bayesian Learning Path*

Figure 1 reports the histograms of the values assumed by the indicator

$$HCB_N^j \equiv \frac{1}{N}\sum_{t=1}^{N}\left[\left(\frac{X_{jt}^j \tilde{S}_t^j}{X_{1t}^j \tilde{S}_t^1 + X_{2t}^j \tilde{S}_t^2}\right) - \left(\frac{\tilde{S}_t^j}{\tilde{S}_t^1 + \tilde{S}_t^2}\right)\right]$$

for a few values of N ($N = 5$, 20, 40, and 60) and j=1, 2. A similar set of histograms were generated for country 2 and are not reported to save space. HCB_N^j measures the average percentage deviation over a period of length N of the percentage equity holdings of investors in country j from the FI benchmark of $X_{jt}^j = \frac{1}{2}\ \forall t \geq 1$. Notice that substituting $X_{jt}^j = \frac{1}{2}$ in $\frac{X_{jt}^j S_t^j}{X_{jt}^j S_t^j + X_{-jt}^j S_t^{-j}}$ gives $\frac{S_t^j}{S_t^j + S_t^{-j}}$, the weight of stock market j on the World market portfolio. In each histogram, the median indicator of home bias as well as a 90 percent 'confidence interval' (the difference between the 95-th and the 5-th percentiles of the distributions of the simulated outcomes) are reported. HCB_5^j measures the effects of learning and differential estimation risk in the immediate aftermath of a financial liberalization. As N gets bigger,

[17] According to OECD statistics for a European aggregate during the period 1970-2000, the annual mean and standard deviation for real GDP growth are roughly the same as the US values, 0.62% and 0.58%.

[18] Such an assumption might be excessive with reference to major North American and European markets. However also for those countries doubts remain. Tesar and Werner (1998) stress that "(...) informational barriers as well as explicit controls significantly impeded the free flow of capital across countries even in the mid-1980s. (...) Industrialized countries including Canada and France, still maintained restrictions on domestic holdings of foreign securities (...)" (p. 286).

we expect the portfolio biases to get smaller and smaller as this corresponds to the case of $t \to \infty$ when both estimation risk and the cross-country differential in estimation risk disappear. When applied to the distributions of simulated market outcomes, standard location measures — such as the median — give an indication of the strength of the pure estimation risk effect, since over a high number of simulations the effects of heterogeneity in perceived drifts are likely to wash out.

Figure 1 shows that learning effects surely make the appearance of sizeable biases in equity portfolios possible. In the case of HCB_5^j (j =1,2) 90% of the frequency mass is between the values +10% and +51%, an interval that includes the empirically observed distortions in international equity portfolios and that illustrates how some strong domestic bias in equity portfolios ought to be expected after a financial liberalization. Even in the case of HCB_{60}^j, i.e. after 60 time periods (say from 5 to 60 years depending on the frequency to which the model applies) these pseudo-confidence interval remains as wide as -9% and +26%, the latter value being still close to observed patterns in portfolio weights. Unsurprisingly, the effects of learning on portfolio choices disappear over time. The medians of HCB_N^j as a function of N reveal that the pure effect of differential estimation risk is initially strong but then dies out. For instance, HCB_5^1 has a median of 40% that fully explains the portfolio biases normally reported in the empirical literature. However the median declines to 19% after 20 periods, and is down to 9% for the full 60 period interval. Although these values are far from being irrelevant in the light of literature on the home country bias, the full-period figures are still too small to claim that differential estimation risk induced by asymmetric information stocks can explain the phenomenon.

In summary, even a simple model with learning as ours is able to explain the home country bias by generating wide confidence intervals in which the portfolio outcomes of a general equilibrium model of international financial markets fall. However the impact of learning effects declines over time, as the world economy learns the true value of the unknown parameters (i.e. their Bayesian posteriors degenerate to a unit mass on the true values) and thus converges to the FI equilibrium. Therefore the real puzzle, if any, is: Why do we still observe strong biases in equity portfolio choices despite the accelerating process of financial liberalization and integration of the last two decades?[19]

6.2. *Trend Chasing in International Portfolio Flows*

Table IV summarizes results concerning the properties of gross and net portfolio flows. For both FI and BL, we report results on two 'statistics'. First, we study the correlation between normalized *net* purchases of foreign stocks − (1) divided by the value of initial investment − and *lagged* foreign stock returns (including dividends). In other words, for each of the 1,500 simulations we calculate a full-sample (60 periods long) correlation coefficient as in Bohn and Tesar (1996). Foreign returns are lagged because they should represent variables helping in the prediction of subsequent stock returns. Although not directly comparable with BT's regressions (based on a richer set of prediction variables), under BL we obtain a median correlation of 0.65 while 90% of the simulations fall in the interval [0.16, 0.88].[20]

[19] Ahearne et al. (2000) formally test for the 'catching up hypothesis' — that a high bias in 1994 is associated with a declining bias in the following years — and are not able to reject at 5 or even 1%. However, there is not yet enough evidence to conclude that the home bias has been declining at a speed comparable to the one exhibited by our model.

[20] Under FI net flows are always zero and no trend-chasing pattern may emerge. Under FI portfolio flows derive entirely from rebalancing: the median correlation between rebalancing flows and stock returns is 0.99 (less than one because returns

Second, as in BC (1997), we regress the normalized (i.e. divided by the sum of the gross flows over the previous four periods) *gross* flows on a constant and on contemporaneous, foreign stock returns

$$\left[\frac{\hat{x}_{jt}^{-j}\hat{S}_{t}^{-j}-\hat{x}_{jt-1}^{-j}\hat{S}_{t-1}^{-j}}{\sum_{i=1}^{4}(\hat{x}_{jt-i}^{-j}\hat{S}_{t-1}^{-j}-\hat{x}_{jt-i-1}^{-j}\hat{S}_{t-i-1}^{-j})}\right]=a_j+b_j\left(\frac{\hat{S}_{t}^{-j}+D_{t}^{-j}}{\hat{S}_{t-1}^{-j}}-1\right)+\varepsilon_t^j \quad j=1,2.$$

We repeat the estimation for each of the simulations and countries, and report in Table IV summary statistics on the OLS estimates $\hat{a}_j$ and $\hat{b}_j$, and the corresponding t-ratios. On U.S. data, Brennan and Cao find that $\hat{a}_j$ is positive and statistically significant, while $\hat{b}_j$ is also positive (between 1.5 and 7.2) and significant for three out of four countries. When the model is simulated under FI, we find too strong an evidence of a trend-chasing pattern: the median $\hat{a}_j$ has to wrong sign (-1.45) and tends to be significant (the median t-ratio is -3.3), while a 90% confidence band even fails to include positive values, $[-8.4, -0.4]$; more important, the median $\hat{b}_j$ is indeed positive (48.3) and significant (3.9), but it also appears way too large (furthermore, the fifth percentile is already in excess of 20). Results are somewhat closer to the empirical evidence when the model is simulated under BL: although the median displays the incorrect sign (-0.3), it stops being significant (the median t-ratio is now -1.2), while a 90% confidence band now includes the typical values found by BC in their empirical work, $[-5.6, 1.3]$; although high, the median $\hat{b}_j$ is positive (14), significant (the median t-ratio is 2.2) and closer to the values suggested by the data. Interestingly, a 90% confidence band now includes the estimates reported in Table II, panel B. Therefore recursive learning produces asset prices and portfolio choices that more closely track the trend-chasing properties of international flows.

6.3. *Domestic vs. Foreign Turnover*

Finally, we turn to a discussion of the presence of excess turnover on foreign stocks. Figure 2 shows the histograms of the values assumed by the indicator

$$EXT_N^j \equiv 100\times\frac{\frac{1}{N}\sum_{t=1}^{N}\frac{|X_{-jt}^j-X_{-jt-1}^j|S_t^{-j}}{|X_{-jt}^jS_t^{-j}|+|X_{-jt-1}^jS_{t-1}^{-j}|}}{\frac{1}{N}\sum_{t=1}^{N}\frac{|X_{jt}^j-X_{jt-1}^j|S_t^j}{|X_{jt}^jS_t^j|+|X_{jt-1}^jS_{t-1}^j|}}$$

The numerator measures the sub-period N average ratio between the value of the change in portfolio holdings of the foreign stock and the average value of the portfolio holdings of the same asset between time $t-1$ and time t. The denominator does the same thing for the domestic stock. EXT_N^j takes the percentage ratio between the turnover indices at the numerator and the denominator. If $EXT_N^j > 100$ there is excess turnover in foreign stocks with respect to domestic stocks. So we expect $EXT_N^j > 100$ and also that EXT_N^j be decreasing with respect to the time window N.

Our results for the excess turnover puzzle are stronger than those achieved for the home country bias. For agents in country 1, Figure 2 shows that learning can generate much more trading in foreign stocks than in stocks issued at home. The intuition is that in the presence of learning, agents are likely to revise the optimal portfolio weights for foreign assets more frequently and radically than they do with

include dividends while portfolio rebalancing in our model follows only from changes in stock prices).

national securities. EXT_5^1 has a median of 886%,[21] while 87% of the simulations display excess turnover (84% have a turnover in foreign stocks which is the double than the turnover in domestic stocks). Even after 60 periods, EXT_{60}^1 still has a median of 297%, with 94% of the simulations displaying excess turnover (74% still show $EXT_{60}^1 > 200$). In this respect, the alleged higher turnover on foreign stocks is no puzzle: the distribution of the possible (average) equilibrium outcomes from our simulations is so wide that the values observed in the empirical literature — even as high as 300% (cf. Tesar and Werner (1992)) — pose no real challenge in terms of statistical significance at standard confidence levels. Of course, as $N(t) \to \infty$, means and medians decline towards 100% and the width of the confidence interval shrinks towards zero, the FI asymptote. However, it is likely than even for very large values of N, excessive turnover effects of some empirical relevance (for instance, consistent with the moderate values found by Warnock (2001)) would persist.

6.4. *Robustness*

There are two residual issues. First, since the model was evaluated by simulation, there is the issue of the choice of the deep parameters. Although at the beginning of this Section we have made an effort to provide justification for our choices, it is interesting to study the effect of changes in the parameters on the results we have claimed. Therefore we perform a few additional sets of simulations using a range of values for θ — 0.2, 0.5, 2, 3, 4, and 5 — and ρ — 0.3, 0.5, 0.8 —, besides the pair {1, 0.7}. To save computational time, the simulations are performed for 40 periods only and in much smaller sets of 500 only. We examine results for both HCB_N^1 and EXT_N^1, when $N = 5$ or 40. While sampling errors dominate the plots when $N = 5$, for $N = 40$ our results are possibly underestimated. Even for a ρ smaller than 0.7, increases in θ bring the average home bias well above the median of 11% calculated in Section 6.1, between 15 and 20%. On the other hand, the behavior of the median of HCB_{40}^1 shows that the home bias that the model can generate is an increasing function of the strength of the international comovements in output. As far as excessive turnover is concerned, the important point is that independently of N, ρ, or θ, EXT_N^1 is always abundantly in excess of 100%.

Second, we might be worried that 1,500 simulations be in fact not enough to provide an accurate evaluation of the average home bias and excess turnover over N periods. We analyze plots (not reported) of the median of HCB_{60}^1 and EXT_{60}^1 as a function of the number of simulation trials performed, S. When $S \geq 1,000$ the residual variability in the statistics is very small: HCB_{60}^1 oscillates in the narrow range 8.5%-8.7% while the turnover in foreign securities is always between 297% and 299% of the turnover in domestic securities. The absence of any discernible trend for large S is reassuring.

7. **Empirical Results**

Finally, we confront our stylized model with the data and ask whether — in the presence of a financial liberalization occurring between the mid and late '70s — time series on economic fundamentals for two aggregate regions of the world — Europe and the US — support a structure of international portfolio weights and relative turnover rates in foreign vs. domestic equities similar to those observed during the

[21] EXT_N^2 statistics are not reported as they are not sensibly different from EXT_N^1.

past 20 years. Of course, given the stylized structure of our model, we are not able to take into account the effects of exchange rate dynamics and of switching between alternative exchange rate regimes (since European countries belonging to the ERM are involved). The assumption is that all equity positions are hedged so that exchange rates do not influence stock returns in the domestic currency and consumption opportunities. Also, our model is of a two-country type. Therefore we are going to consider Europe and the US in isolation, as if the rest of the world did not exist, which is a drastic simplification.

We use OECD Historical Statistics to build a quarterly series of real GDP changes for 1960:02 - 2000:02, 161 quarters. Since it is virtually impossible to come up with an estimate of stock market liberalization dates for *aggregates* of countries, the experiment is repeated for several dates, the first quarter of each year between 1974 and 1979.[22] Call this date t_0. We calculate equilibrium international portfolio choices for a US and a European representative investor based on our model under the following assumption: each investor has available a quarterly history spanning the interval 1960:01 - t on domestic (real) fundamentals, while the available data on foreign fundamentals cover the shorter period $[t_0, t]$, with $t \geq t_0$. In terms of our notation, the interval 1960:02 - t_0 has a length b (between 56 and 80 quarters). For simplicity, b is the same for the two regions. First, we investigate the dynamics of the estimated drift and volatility of changes in fundamentals in the two 'regions' by US and European investors, respectively. For instance, while US investors use at each point $t \geq t_0$ a number of observations equal to $t + b$ to form their beliefs on the moments of their domestic fundamentals, European investors only use t observations. It turns out that according to our model, investors should have been consistently more optimistic about their own domestic economy than about foreign economies, in the sense that for both US and European investors the belief on the domestic mean rate of change of real GDP is higher than the belief of foreigners, while the belief on domestic fundamental volatility is lower than the corresponding estimated formed by foreigners. A priori, these findings are consistent with home bias.

Under the assumption that $\theta = 1$ and $r = 2\%$, Figure 3 plots the dynamics of the optimal portfolio structure of US and European investors. Each line represents a different experiment, in the sense that the timing of the original financial liberalization varies from 1974:01 to 1979:01. In particular, the two top plots show the percentage structure of the equity portfolio in the two countries, while the bottom plots show the overall composition, including investments in the international risk-free asset. The plot for the US equity portfolio structure shows that the presence of some degree of home equity preference is no big surprise. With some minor exceptions, US investors should have invested at least 60% of their equity portfolio in US stocks, and the average value of this figure is rather 70-80% for the 1970s and 1980s. The bold, solid line shows the optimal allocation under FI (using the full-sample values for $\boldsymbol{\alpha}$ and Σ) and stresses the entity of the bias induced by learning and differential estimation risk. Indeed the average bias over the period up to 2000:02 is between 9.2% (for a liberalization in 1979:01) and 18.2% (for a liberalization in 1975:01). The case of Europe is different: if some degree of home equity preference can be generated during the 1970s (mainly because of differential estimation risk), the bias disappears very soon and on the contrary a European investors should have held European stocks for a

[22] In some European countries the barriers to internation investments were not entirely preventing outflows well before the '70s (for instance, the UK). However, in the aggregate, it is plausible that most of the tax and legislative barriers have been lifted during the 1970s. For instance, Bekaert and Harvey (2000, p. 568) list 1987:12 and 1986:07 as official liberalization dates for Greece and Portugal, respectively. Both countries belong to the OECD aggregate we are using.

bit less than 50% of the value of her portfolio. The average bias over the period up to 2000:02 is between -6.2% (1978:01) and 7% (1974:01) only. Although the observation that the bias in European portfolios is much weaker than for US investors corresponds to common wisdom, our results occasionally show foreign-equity preference, which is problematic. On the contrary, our path-simulation has no problem generating simultaneous excess turnover in foreign stocks for both US and European investors: for instance, over the period up to 1989 US portfolio managers should have turned over their European equity holdings at a rate which is between 139% (1979:01) and 218% (1975:01) of the domestic rate. The analogous figures for European investors are 108% (1979:01) and 471% (1978:01). In general all the average excess turnover indicators are well above 100%.

8. **Conclusion**

This paper explores a new way in which information asymmetries between domestic and foreign investors may generate optimal portfolio choices that are consistent with three well-known stylized facts: a strong home bias in equity portfolios, trend-following in international portfolio flows, and turnover in foreign stocks in excess of domestic stocks. While Brennan and Cao (1997) assume that the asymmetry concerns the quality (precision) of information flows and that these asymmetries do cumulate over time, we use a simple dynamic OLG model with Bayesian learning to study the effects of asymmetries in the initial informational endowment of investors located in different countries. When agents undertake a recursive learning process, asymmetries in initial informational endowments generate differentials in estimation risk. Home bias, trend-chasing, and excessive turnover emerge in equilibrium.

Our simulations generate strong and persistent excess turnover in foreign equities, although the sizeable home country bias generated in the aftermath of a financial liberalization (35-40%) rapidly dies off reaching levels of about 10% after 60 periods. However, simulations cast doubts on the extent to which the measured home bias represents a 'puzzle' in a statistical sense, i.e. an outcome far out in the tails of the simulated distribution. Even over long samples, the 90% confidence interval of our bias indicator includes a range of values characterized by levels of home bias of 25%, which is consistent with the empirical evidence. The path simulation performed in Section 7 generates a sizeable and persistent bias for the US. Unfortunately, this finding is hard to obtain for European portfolios. On the other hand, both the simulations in Section 6 and the calibration exercise in Section 7 leave no doubt as to the possibility that learning might cause strong and persistent excess turnover in foreign securities.

Our paper makes it evident that in a quantitative sense the type of information asymmetry we focus on can hardly explain by itself the entire home country bias. It would be interesting to study a dynamic equilibrium model in which there is learning and differential estimation risk but in which the asymmetries also involve the quality of the information flows, as in Coval (1999). It is our suspicion that while deficiencies in the information stocks might have caused the exceptionally strong biases observed during the 1980s, imperfections in the information flows might have contributed later on to support the persistence of some (although weaker) bias. Finally, our model has stark implications for equilibrium asset returns on a dynamic learning path. It would be interesting to pursue a quantitative assessment of its ability to reproduce well-known stylized facts − excess volatility, time-varying volatility (ARCH) and correlations, high and variable equity premia, etc. − in the presence of portfolio biases.

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Appendix A: Derivation of Equilibrium Prices and Portfolio Choice Under FI

Under FI, agents from both countries will solve the unconstrained optimization:

$$\max_{\mathbf{x}_t^j}(\mathbf{x}_t^j)'E_t\left[(I+Q)\boldsymbol{\alpha}+(I+Q)\boldsymbol{\delta}_{t+1}+(I-rQ)\mathbf{D}_t-r\mathbf{K}\right]+(1+r)W_{t,t}^j-\frac{1}{2}\theta(\mathbf{x}_t^j)'Var_t\left[(I+Q)\boldsymbol{\delta}_{t+1}\right]\mathbf{x}_t^j$$

(j=1, 2). Necessary and sufficient first-order conditions are:

$$[(I+Q)\boldsymbol{\alpha}+(I-rQ)\mathbf{D}_t-r\mathbf{K}]-\theta(I+Q)\Sigma(I+Q)'\hat{\mathbf{x}}_t^j=0$$

so that the long-lived assets' demand functions are:

$$\hat{\mathbf{x}}_t^j = \theta^{-1}\left[(I+Q)\Sigma(I+Q)'\right]^{-1}\left[(I+Q)\boldsymbol{\alpha} + (I-rQ)\mathbf{D}_t - r\mathbf{K}\right].$$

Since in each country generation t agents have unit mass, $\hat{\mathbf{x}}_t^j$ equals the vector of aggregate demands for stock indices in country j (j=1, 2). Therefore $\hat{\mathbf{x}}_t^1 + \hat{\mathbf{x}}_t^2$ equals the aggregate, international demand for stocks. In equilibrium, asset prices must clear asset markets. Noting that the country index j does not enter (**??**), $\hat{\mathbf{x}}_t^1 + \hat{\mathbf{x}}_t^2 = 2\hat{\mathbf{x}}_t^1$. Therefore the market-clearing conditions are

$$2\hat{\mathbf{x}}_t^1 = 2\theta^{-1}\left[(I+Q)\Sigma(I+Q)'\right]^{-1}\left[(I+Q)\boldsymbol{\alpha} + (I-rQ)\mathbf{D}_t - r\mathbf{K}\right] = \boldsymbol{\iota}_2$$

with $\boldsymbol{\iota}_2 = [1\ 1]'$. Setting the matrix of coefficients in the price function to match the terms on the left- and right-hand sides, gives the following restrictions:

1. $(I-rQ)\mathbf{D}_t = 0 \quad \forall \mathbf{D}_t \Longrightarrow Q = \frac{1}{r}I$
2. $2\theta^{-1}\frac{r^2}{(1+r)^2}\Sigma^{-1}\left[\frac{1+r}{r}\boldsymbol{\alpha} - r\mathbf{K}\right] = \boldsymbol{\iota} \Longrightarrow \mathbf{K} = \frac{1+r}{r^2}\alpha - \frac{1}{2}\frac{(1+r)^2}{r^3}\theta\Sigma\boldsymbol{\iota}$

The presence of a drift term $\mathbf{K}$ in the pricing function reflects the presence of a drift in the process for dividends. Putting 1.-2. together and plugging them back into the conjectured solution (**??**), we derive the following price function:

$$\mathbf{S}_t^{FI} = \frac{1+r}{r^2}\boldsymbol{\alpha} - \frac{1}{2}\frac{(1+r)^2}{r^3}\theta\Sigma\boldsymbol{\iota} + \frac{1}{r}\mathbf{D}_t = \frac{1}{r}\begin{bmatrix} \frac{1+r}{r}\alpha^1 - \frac{1}{2}\frac{(1+r)^2}{r^2}\theta\left(\sigma_1^2 + \sigma_{12}\right) + D_t^1 \\ \frac{1+r}{r}\alpha^2 - \frac{1}{2}\frac{(1+r)^2}{r^2}\theta\left(\sigma_2^2 + \sigma_{12}\right) + D_t^2 \end{bmatrix}$$

where $\sigma_{12} = Cov(D_t^1, D_t^2)$. As intuition suggests, the FI equilibrium price of a stock is an increasing function of the dividend drift, and a decreasing function of risk aversion, the volatility of fundamentals, and the covariance between dividends paid by the two stocks.
We check that market clearing for long-lived assets implies market-clearing for infra-generational risk-free loans:

$$\begin{aligned} B_t^1 + B_t^2 &= W_{t,t}^1 + W_{t,t}^2 - (\mathbf{x}_t^1)'\mathbf{S}_t - (\mathbf{x}_t^2)'\mathbf{S}_t \\ &= \mathbf{S}_t^1 + \mathbf{S}_t^2 - (\mathbf{x}_t^1)'\mathbf{S}_t - (\mathbf{x}_t^2)'\mathbf{S}_t \\ &= [\boldsymbol{\iota}_2 - \mathbf{x}_t^1 - \mathbf{x}_t^2]'\mathbf{S}_t = 0 \end{aligned}$$

where $\boldsymbol{\iota}_2$ is a 2×1 vector of ones corresponding to the supply of the national stock indices in the two countries. The first equality derives from the budget constraint re-written in compact form ($B_t^j = W_{t,t}^j - (\mathbf{x}_t^j)'\mathbf{S}_t$), the second equality from the equilibrium in the goods markets, and the last equality from the assumed equilibrium in the two stock markets. Of course, this is just an application of Walras' law.
Notice that since $\mathbf{S}_{t-1}^{FI} = \frac{1+r}{r^2}\boldsymbol{\alpha} - \frac{1}{2}\frac{(1+r)^2}{r^3}\theta\Sigma\boldsymbol{\iota} + \frac{1}{r}\mathbf{D}_{t-1}$,

$$\mathbf{S}_t^{FI} = \mathbf{S}_{t-1}^{FI} + \frac{1}{r}(\mathbf{D}_t - \mathbf{D}_{t-1}) = \mathbf{S}_{t-1}^{FI} + \frac{1}{r}\boldsymbol{\alpha} + \frac{1}{r}\boldsymbol{\delta}_t,$$

i.e. stock prices follow a random walk with drift. Price shocks are a zero mean i.i.d. normal vector, with zero serial correlation and (conditional) variance-covariance matrix:

$$Cov_{t-1}[\mathbf{S}_t^{FI}] = \Sigma_{S,t} = \frac{1}{r^2}\Sigma. \tag{1}$$

As prices are random walks, changes in prices $\mathbf{S}_t^{FI} - \mathbf{S}_{t-1}^{FI}$ have variance-covariance matrix given by (**??**), while prices themselves can be written as

$$\mathbf{S}_t^{FI} = \mathbf{S}_0 + \frac{1}{r}\boldsymbol{\alpha}t + \frac{1}{r}\sum_{k=1}^{t}\boldsymbol{\delta}_k$$

implying that the unconditional variance-covariance matrix is

$$Cov[\mathbf{S}_t^{FI}] = \Sigma_S = \frac{1}{r^2} t\Sigma.$$

One implication of the fact that $\Delta\mathbf{S}_t^{FI}$ has covariance matrix (**??**) is that the correlation between changes of the equilibrium prices of the two national stock markets is

$$Corr(\Delta S_t^1, \Delta S_t^2) = \frac{\frac{1}{r^2}\rho\sigma_1\sigma_2}{\left(\frac{1}{r}\sigma_1\right)\left(\frac{1}{r}\sigma_2\right)} = \rho.$$

Appendix B: Details on the Bayesian Predictive Density

Denote as $-j$ the complement of $\{j\}$ in $\{1, 2\}$. Define as $Y_{b_j,t}$ the $t \times 2$ matrix

$$\begin{bmatrix} \Delta D^1_{b_j} & \Delta D^2_{b_j} \\ \Delta D^1_{b_j+1} & \Delta D^2_{b_j+1} \\ \vdots & \vdots \\ \Delta D^1_{b_j+t} & \Delta D^2_{b_j+t} \end{bmatrix}$$

collecting the equal length histories of dividend changes between b_j and b_j+t, and the $(t+b_j)\times 1$ vector $\mathbf{y}^j_{1,t} = [\Delta D^j_1 \ \Delta D^j_2 \ ... \ \Delta D^j_{b_j} \ ... \ \Delta D^j_{b_j+t}]'$ collecting the longer available series on domestic fundamentals. By the same notation, $\mathbf{y}^{-j}_{b_j,t} = [\Delta D^{-j}_{b_j} \ \Delta D^{-j}_{b_j+1} \ ... \ \Delta D^{-j}_{b_j+t}]'$ is simply the -jth column of $Y_{b_j,t}$. Given the previous list of assumptions and definitions, the following result shows how an agent should perform inference using data on fundamentals that include series of different length:

Proposition 1. Given the noninformative prior beliefs in (10), the predictive density for $\Delta\mathbf{D}_{t+1}$ perceived at time t by investors from country j ($j = 1, 2$) corresponds to the nonstandard (possibly non-elliptical) density:

$$\begin{aligned} g^j(\Delta\mathbf{D}_{t+1}|\mathbf{y}^j_{1,t}, \mathbf{y}^{-j}_{b_j,t}; b_j) &= p^j(\Delta D^j_{t+1}|\mathbf{y}^j_{1,t}, \mathbf{y}^{-j}_{b_j,t}; b_j) \times p^j(\Delta D^{-j}_{t+1}|\Delta D^j_{t+1}, \mathbf{y}^j_{1,t}, \mathbf{y}^{-j}_{b_j,t}; b_j) \\ &\propto \left\{ v_j + \frac{v_j}{\hat{\sigma}^2_j(t+b_j)}\left(1 - \frac{1}{t+b_j+1}\right)\left(\Delta D^j_{t+1} - \hat{\alpha}^j\right)^2 \right\}^{-\frac{v_j+1}{2}} \times \\ &\quad \times \left\{ v_{-j} + \left[\Delta D^{-j}_{t+1} - X^j_{t+1}\hat{\boldsymbol{\xi}}\right]' \frac{Z\widehat{\psi}^{-1}}{(t/v_{-j})} \left[\Delta D^{-j}_{t+1} - X^j_{t+1}\hat{\boldsymbol{\xi}}\right] \right\}^{-\frac{v_{-j}+1}{2}} \end{aligned}$$

where $v_j = t + b_j - 1$, $v_{-j} = t - 1$, and

$$\begin{aligned} \hat{\alpha}^j &= (t+b_j)^{-1}\sum_{i=1}^{t+b_j}\Delta D^j_i \qquad \hat{\sigma}^2_j = (t+b_j)^{-1}\sum_{i=1}^{t+b_j}(\Delta D^j_i - \hat{\alpha}^j)^2 \\ \hat{\Psi} &= t^{-1}\left(Y^{-j}_{b_j,t} - X^j_{b_j,t}\hat{\boldsymbol{\xi}}\right)'\left(Y^{-j}_{b_j,t} - X^j_{b_j,t}\hat{\boldsymbol{\xi}}\right) \\ \hat{\boldsymbol{\xi}} &= \left[\widehat{\gamma}\ \widehat{\beta}\right]' = \left[(X^j_{b_j,t})'X^j_{b_j,t}\right]^{-1}(X^j_{b_j,t})'\mathbf{y}^j_{b_j,t} \\ Z &= 1 - X^j_{t+1}\left[(X^j_{b_j,t})'X^j_{b_j,t} + (X^j_{t+1})'X^j_{t+1}\right]^{-1}(X^j_{t+1})' \end{aligned}$$

and $X^j_{b_j,t} \equiv [\iota_t \ Y^j_{b_j,t}]$ while $X^j_{t+1} \equiv [1 \ \Delta D^j_{i+1}]$. The first and second moments are:

$$E_t^j\left[\Delta D_{t+1}^j|\mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j\right] = \hat{\alpha}^j \qquad E_t^j\left[\Delta D_{t+1}^{-j}|\mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j\right] = \hat{\gamma}+\hat{\beta}\hat{\alpha}^j$$

$$Var_t^j\left[\Delta D_{t+1}^j|\mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j\right] = \frac{v_j}{v_j-2}\frac{t+b_j+1}{t+b_j-1}\hat{\sigma}_j^2$$

$$Var_t^j\left[\Delta D_{t+1}^{-j}|\mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j\right] = \frac{t}{v_{-j}-2}Z^{-1}\widehat{\psi}+\hat{\beta}^2\frac{v_j}{v_j-2}\frac{t+b_j+1}{t+b_j-1}\hat{\sigma}_j^2$$

$$Cov_t^j\left[\Delta D_{t+1}^j,\Delta D_{t+1}^{-j}|\mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j\right] = \hat{\beta}\frac{v_j}{v_j-2}\frac{t+b_j+1}{t+b_j-1}\hat{\sigma}_j^2.$$

Appendix C: Details on the Approximation of Equilibrium Prices and Portfolio Allocations in a 2×2 Economy with Bayesian Learners.

$g^j(\Delta\mathbf{D}_{t+1}|\mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j)$ is a product of two Student t densities: $p^j(\Delta D_{t+1}^j|\mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j)$ is a t-Student with $t+b_j-1$ degrees of freedom, while $p^j(\Delta D_{t+1}^{-j}|\Delta D_{t+1}^j,\ \mathbf{y}_{1,t}^j,\mathbf{y}_{b_j,t}^{-j};b_j)$ is (conditional on ΔD_{t+1}^j) t-Student with $t-1$ degrees of freedom. In practice, two separate tasks are solved using numerical methods:[1]

- For each country and generic time t, the portfolio weights $\hat{\mathbf{x}}_t^j$ maximizing the expectation of a nonlinear function of future dividends $\mathbf{\Delta D}_{t+1}$ under the predictive density have to be determined. Specifically, we calculate the multiple integrals defining expected utility from $t+1$ wealth using a Monte Carlo approach, and maximize expected utility by searching over a fine grid over the values of the elements of $\mathbf{x}_t^j$, a subset of R^2. Notice that in virtue of (**??**) $\hat{\mathbf{x}}_t^j$ is then a function of a postulated vector of current asset prices $\mathbf{S}_t^{BL}$, $\hat{\mathbf{x}}_t^j=\hat{\mathbf{x}}_t^j(\mathbf{S}_t^{BL})$.
- Given the excess demand vector $\mathbf{z}(\mathbf{S}_t^{BL})\equiv\iota_2-\hat{\mathbf{x}}_t^1(\mathbf{S}_t^{BL})-\hat{\mathbf{x}}_t^2(\mathbf{S}_t^{BL})$, we adopt a simple but efficient recursive grid search algorithm to find approximations to equilibrium stock prices $\tilde{\mathbf{S}}_t^{BL}$ such that $\mathbf{z}(\tilde{\mathbf{S}}_t^{BL})\cong\mathbf{0}$. Since searching for $\tilde{\mathbf{S}}_t^{BL}$ and searching for $\tilde{\mathbf{K}}_t^{BL}$ given $Q_t^{BL}=Q^{FI}=\frac{1}{r}I$ are equivalent, we adopt the latter search scheme.

In cases in which our algorithm fails to reduce the excess demand below a given threshold in a finite (acceptable) time, the simulation trial is rejected and the algorithm restarted. Since the existence of a (temporary) equilibrium is not guaranteed under either substantial heterogeneity of beliefs or no-short sales constraints (see footnote *??*), it is possible that the failure of the code to have $\mathbf{z}(\tilde{\mathbf{S}}_t^{BL})$ converging to zero might derive from the non-existence of the equilibrium. When drawing simulations from random sample paths of fundamentals, this procedure poses some issues concerning the rejection-induced biases in the final results. Section 6.5 discusses the robustness of our findings to the occurrence of rejections.

Since we have admitted that our grid search algorithm solving for equilibrium prices and financial decisions may sometimes fail to locate an (approximate) equilibrium in a finite (efficient) time. In these situations, the entire simulation trial is discarded. In the face of the advantage of getting rid of difficult cases in which our procedure cannot find the equilibrium, the disadvantage is that this arbitrary choice may severely bias our results. Indeed the fact that a given algorithm fails to efficiently locate an equilibrium in our model may not imply that such an equilibrium does not exist. For this reason we store and analyze the partial results — i.e. results up to time t_f-1, where t_f is defined as the simulated time at which the code fails — on portfolio stocks and flows for those simulations that are rejected with $t_f\geq 5$. The number of such rejected simulations is quite modest, 61, a further indication of efficiency of the algorithm employed. We analyze plots (not reported) comparing the medians of HCB_N^1 and EXT_N^1 for N up to 40 (in steps of 5) for the 1,500 simulations used in the paper with the analogous median for the 61 rejected simulations. The graphs are quite reassuring of the fact that our rejection procedure is not biasing the results on international portfolio choices in any direction.

[1] An additional, technical appendix that describes how expected utility is approximated and efficient recursive grid search algorithms to find equilibrium stock prices is available from the Author either upon request or at www.virginia.edu/economics/guidolin.htm.

Table I

Home Country Bias in Equity Portfolio Holdings for Five Countries.

Panel A reports estimates of aggregate percentage holdings in foreign equities compared (in parenthesis) to the complement to 100% of the weight of the rest of world (excluded the country under investigation) in the world equity market portfolio. The data for 1975 - 1990 are from Tesar and Werner (1995), while those for 1996-1997 are from Ahearne, Griever, and Warnock (2001) and Tesar and Werner (1998). Panel B reports similar statistics for institutional investors (average of mutual and pension funds) holdings of foreign equities from Lewis (1999).

	Panel A - % portfolio holdings in foreign equities				
	1975	**1980**	**1985**	**1990**	**1996-1997**
U.S.	2.3[*] (36.0)	1.5 (38.8)	2.0 (44.4)	3.3 (60.0)	10.1 (51.7)[♣]
Canada	4.0[*] (95.6)	6.0 (93.6)	6.5 (95.8)	6.6 (96.8)	11.0 (95.9)
Germany	2.4[*,**] (88.9)	2.7[*,**] (87.9)	5.8[*,**] (90.7)	10.2[*,**] (90.4)	18.0 (NA)
Japan	1.3[*] (86.5)	2.0[*] (80.0)	6.9[*] (77.9)	10.7[*] (68.9)	5.0 (NA)
United Kingdom	8.6[*] (93.1)	16.9 (90.1)	24.8 (90.7)	23.5 (88.4)	23.0 (NA)
	Panel B - % portfolio holdings in foreign securities - institutional investors				
	1980	**1988**	**1990**	**1991**	**1993**
U.S.	0.7[♣♣]	2.7[♣♣]	4.2[♣♣]	5.4	7.9
Canada	12.0	11.9	11.6	12.4	13.7
Germany	NA	3.8[♣♣]	30.4	29.0	25.4
Japan	0.5[♣♣]	7.7	7.6	10.7	9.0[♣♣]
United Kingdom	10.1[♣♣]	16.5[♣♣]	26.6	31.0	25.9

*Overall portfolio investments (equities and bonds). ** Excludes assets held by the banking sector.

♣ Data from Ahearne, Griever, and Warnock (2001). ♣♣ Pension funds only.

Table II

Trend-Chasing Behavior of US Investors in International Portfolio Choices.

Panel A reports OLS estimates of a model regressing (scaled) *net* purchases by U.S. investors on predicted excess returns on the foreign market from Bohm and Tesar (1996). The sample period is 1981:01 - 1994:11 (monthly data). Panel B reports SUR estimates of Model II from Brennan and Cao (1997), a linear system in which normalized (*gross*) equity portfolio flows of US investors are explained by the (USD-denominated) returns on the foreign market. The sample period is 1982:II - 1994:IV (quarterly data). Values of t-ratios are in parenthesis.

	Panel A - Bohm and Tesar (1996) net foreign equity purchases regressions						
US portfolio flows to:	Constant	Canadian returns	German returns	Japanese returns	UK returns	French returns	Dutch returns
Canada	NA	2.75 (1.9)					
Germany	NA		1.76 (3.1)				
Japan	NA			20.59 (5.8)			
UK	NA				6.35 (2.3)		
France	NA					1.60 (2.4)	
The Netherlands	NA						1.78 (3.3)

	Panel B - Brennan and Cao (1997) gross equity portfolio flow regressions				
US portfolio flows to:	Constant	Canadian equity returns	German equity returns	Japanese equity returns	UK equity returns	R^2
Canada	0.69 (2.57)	7.19 (2.51)				0.05
Germany	0.60 (2.20)		6.83 (3.00)			0.15
Japan	0.61 (1.41)			4.79 (2.08)		0.09
UK	1.30 (4.02)				1.53 (0.59)	0.01

Table III

Turnover Rates in Domestic vs. International Equities - U.S. and Canada.

Domestic turnover is the ratio of annual transactions on a market to its capitalization. The turnover in foreign securities is the ratio of annual transactions in foreign securities to total investment position in foreign equities.

Year and Source	U.S.		Canada	
	Domestic	Foreign securities	Domestic	Foreign securities
1989 - from Tesar and Werner (1995)	1.07	2.5	0.61	7.7
1989 - from Warnock (2001)	NA	1.18*	NA	0.83
1997 - from Warnock (2001)	0.65**	1.29	0.54	2.13

* Estimates obtained by carrying back positions resulting from March 1994 surveys (see details in Warnock (2001)). ** Based on NYSE transaction data.

Table IV

Trend-Chasing Behavior in International Equity Portfolios – Simulation Results.

The graphs plot the distribution over a set of 1,500 simulations of an indicator of home bias in equity portfolios of country 1. The simulations are based on the following parameter choices:

$$\theta = 1;\ r = 2;\ \boldsymbol{\alpha} = [.02\ .02]',\ \Sigma = \begin{bmatrix} 0.0009 & 0.00063 \\ 0.00063 & 0.0009 \end{bmatrix};\ D_0 = [2\ 2]'.$$

At time t, investors have 60 + t observations on domestic fundamentals and only t on foreign fundamentals.

Statistic/Coefficient		**Median**	**Mean**	**St. Dev.**	**5th percentile**	**95th percentile**
		Results under Bayesian Learning				
		Correlation btw. normalized net flows and lagged foreign returns				
$\rho(NNP^{-j}_t, R^{-j}_{t-1})$	Country 1	0.650	0.604	0.221	0.159	0.881
	Country 2	0.642	0.597	0.229	0.186	0.880
		OLS regression of normalized gross portfolio flows into foreign stocks on returns on foreign stocks, $NGP^{-j}_t = a_j + b_j R^{-j}_t + \varepsilon^j_t$				
$\hat{a}_j$	Country 1	-0.351	-0.691	1.091	-6.649	0.581
	Country 2	-0.290	-0.561	0.962	-4.681	1.950
$\hat{a}_j$ t-ratio	Country 1	-1.195	-1.213	1.307	-3.256	0.649
	Country 2	-1.028	-1.006	1.021	-3.415	0.804
$\hat{b}_j$	Country 1	14.151	21.126	19.917	1.263	115.28
	Country 2	14.002	20.853	19.707	1.143	102.59
$\hat{b}_j$ t-ratio	Country 1	2.262	2.649	1.794	0.427	5.627
	Country 2	2.139	2.537	1.701	0.141	5.584
		Results under Full Information				
		Correlation btw. normalized net flows and lagged foreign returns				
$\rho(NNP^{-j}_t, R^{-j}_{t-1})$	Country 1-2	NA	NA	NA	NA	NA
		OLS regression of normalized gross portfolio flows into foreign stocks on returns on foreign stocks, $NGP^{-j}_t = a_j + b_j R^{-j}_t + \varepsilon^j_t$				
$\hat{a}_j$	Country 1	-1.454	-4.550	34.018	-8.363	-0.377
	Country 2	-1.473	-4.180	25.714	-9.366	-0.440
$\hat{a}_j$ t-ratio	Country 1	-3.348	-3.521	1.988	-6.924	-0.407
	Country 2	-3.337	-3.539	1.968	-7.104	-0.707
$\hat{b}_j$	Country 1	48.317	130.52	882.87	20.840	231.85
	Country 2	47.671	118.27	596.17	21.768	261.42
$\hat{b}_j$ t-ratio	Country 1	3.941	4.417	2.631	0.863	9.430
	Country 2	3.933	4.420	2.622	1.120	9.851

Figure 1

Distribution of the Percentage Home Country Bias in Equity Portfolios of Investors from Country 1

The graphs plot the distribution over a set of 1,500 simulations of an indicator of home bias in equity portfolios of country 1. The simulations are based on the following parameter choices:

$$\theta = 1;\ r = 2;\ \boldsymbol{\alpha} = [.02\ .02]',\ \Sigma = \begin{bmatrix} 0.0009 & 0.00063 \\ 0.00063 & 0.0009 \end{bmatrix};\ D_0 = [2\ 2]'.$$

At time t, investors have 60 + t observations on domestic fundamentals and only t on foreign fundamentals. The following indicator measures the average, percentage home bias:

$$HBN_N^1 = \frac{1}{N}\sum_{t=1}^{N}\left[\left(\frac{x_{1t}^1 \tilde{S}_t^1}{x_{1t}^1 \tilde{S}_t^1 + x_{2t}^1 \tilde{S}_t^2}\right) - \left(\frac{\tilde{S}_t^1}{\tilde{S}_t^1 + \tilde{S}_t^2}\right)\right]$$

where N takes the values 5, 20, 40, and 60. The 5% percentile and the 95% percentile are reported in brackets in each histogram.

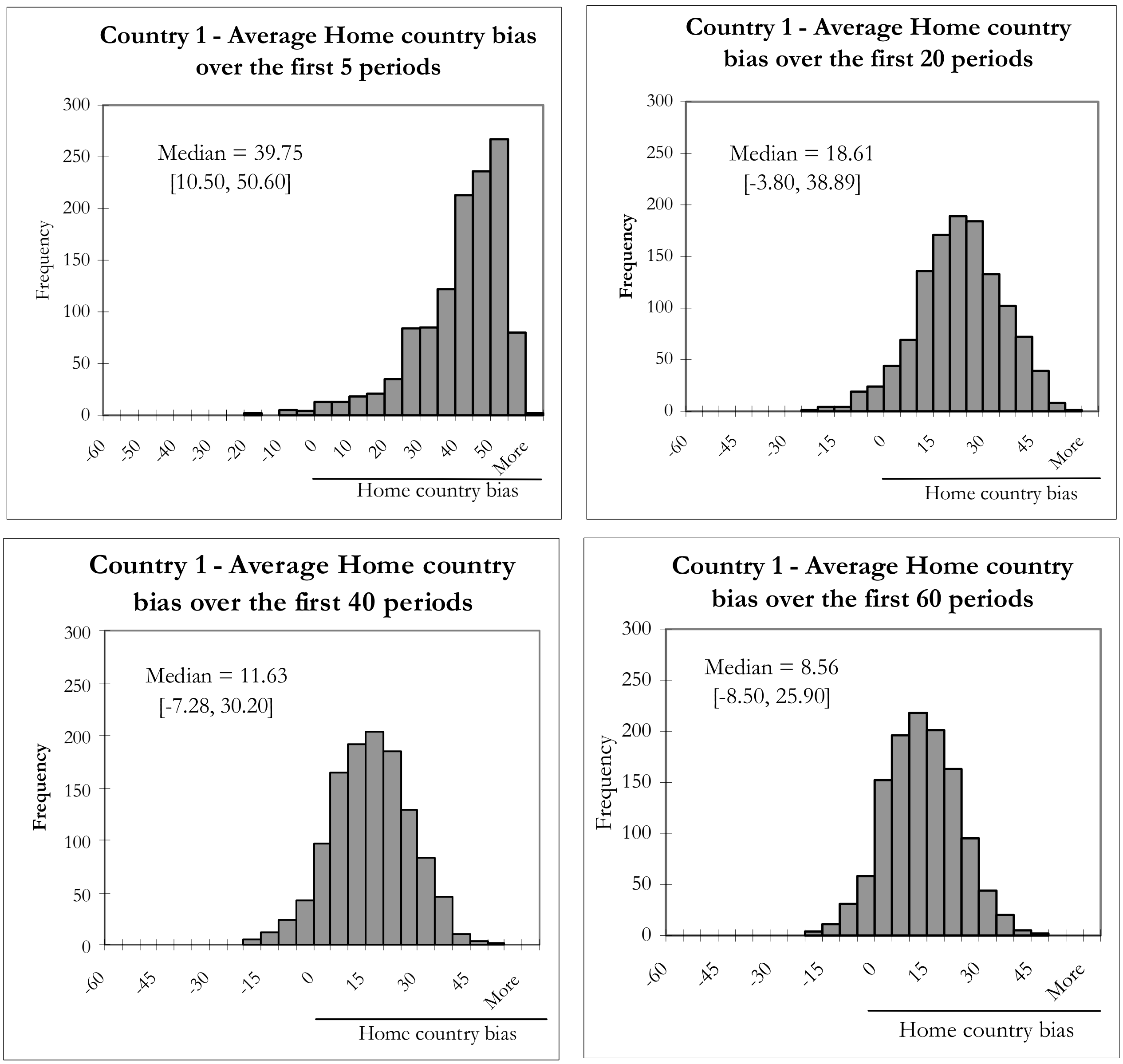

Figure 2

Distribution of an Indicator of Excess Turnover in Foreign Stocks for Country 1

The indicator is derived as the percentage ratio between the equity portfolio turnover in foreign stocks and the turnover in the national stock index for agents in country 1:

$$EXT_N^1 = 100 \times \frac{\dfrac{1}{N}\displaystyle\sum_{t=1}^{N} \frac{|x_{2,t}^1 - x_{2,t-1}^1|\,\widetilde{S}_t^2}{|x_{2,t}^1 \widetilde{S}_t^2| + |x_{2,t-1}^1 \widetilde{S}_{t-1}^2|}}{\dfrac{1}{N}\displaystyle\sum_{t=1}^{N} \frac{|x_{1,t}^1 - x_{1,t-1}^1|\,\widetilde{S}_t^1}{|x_{1,t}^1 \widetilde{S}_t^1| + |x_{1,t-1}^1 \widetilde{S}_{t-1}^1|}}$$

where N takes the values 5, 20, 40, and 60. The histograms report the distribution of the sub-period averages over a set of 1,500 random simulations. The 5% percentile and the 95% percentile are reported in brackets in each histogram.

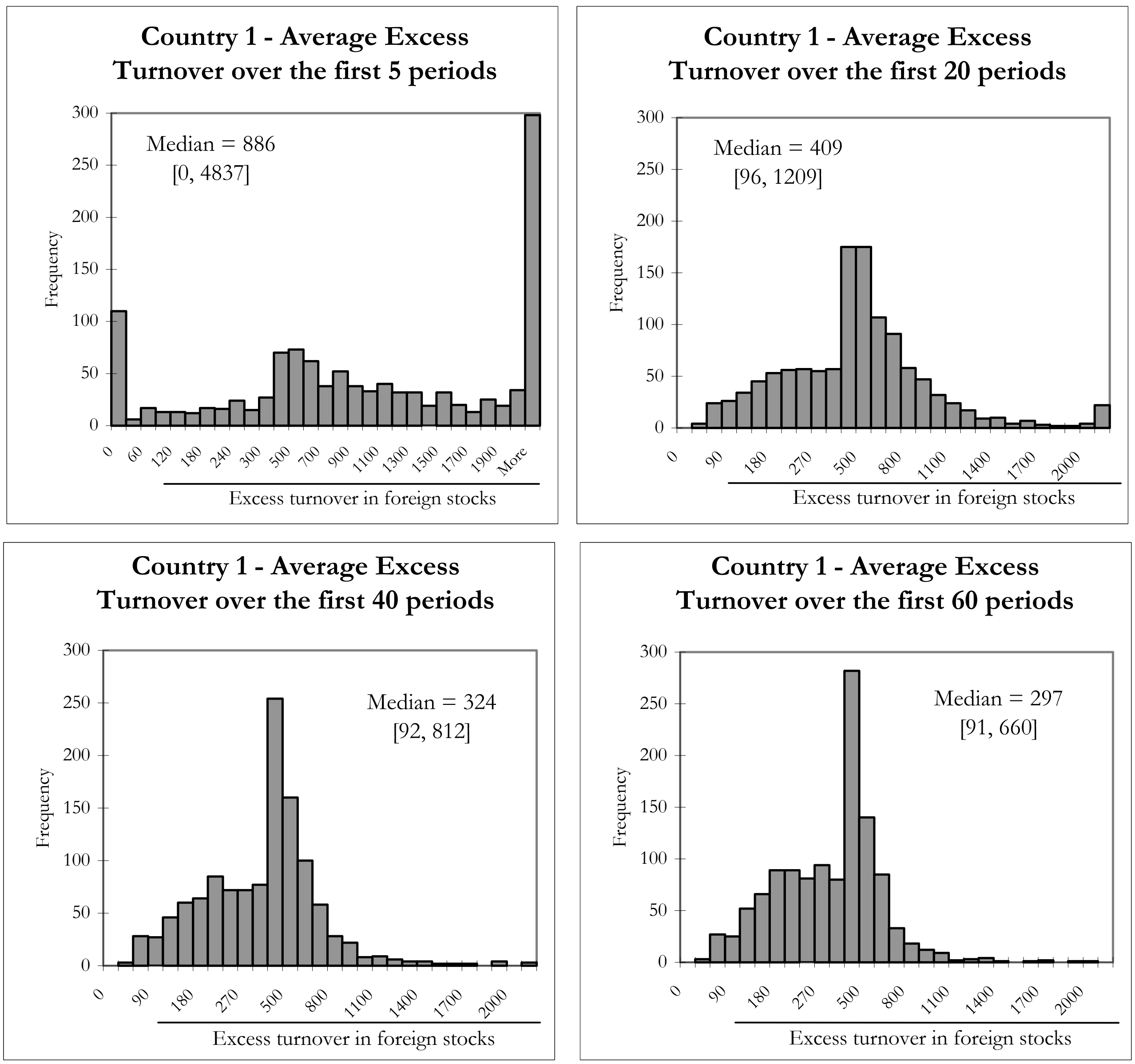

Figure 3

Portfolio Choices for US and European Investors Under Alternative Assumptions on the Initial Liberalization of Capital Market Flows

The first row of plots show the percentage structure of equilibrium equity portfolios for US and European investors predicted by our model when the fundamentals are identified with real GDP. The different lines illustrating the predicted evolution on portfolio weights over time correspond to alternative assumptions on the date of an initial financial liberalization between US and Europe. The second row of plots shows instead the overall structure of portfolio weights (also including risk-free bonds) for US and European investors predicted by our model. For clarity, only the lines corresponding to the liberalization dates 1974:01, and 1979:01 are plotted. The data on real GDP are from OECD, Historical Statistics. The following parameter choices were employed: $r = 2$, $\theta = 1$, and $D_0 = [1\ 1]'$ (as of 1960:01). At time t, investors have 54 + $(t - t_0)$ quarterly observations on domestic fundamentals and only $(t - t_0)$ on foreign fundamentals, where 54 corresponds to the interval 1960:01 — 1973:04.