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INTERNATIONAL PORTFOLIO CHOICE AND LIQUIDITY CONSTRAINTS: CAN SMALL INFORMATION COSTS EXPLAIN THE HOME EQUITY BIAS PUZZLE?

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International Portfolio Choice and Liquidity Constraints: Can Small Information Costs Explain the Home Equity Bias Puzzle?*

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Abstract

This paper solves for optimal international portfolio choice in the presence of liquidity constraints and undiversifiable labor income risk. Optimal portfolios are internationally diversified while positive correlation between domestic stock market returns and permanent labor income shocks can worsen the home equity bias puzzle. Nevertheless, either small information costs associated with investing abroad or a slightly positive domestic to foreign equity premium differential are sufficient to either deter households from participating in a foreign market or generate a substantial bias for home equities. The benefits of international diversification are limited because consumption fluctuations can be smoothed with a small amount of buffer stock saving while exchange rate risk makes foreign investments less appealing to risk averse investors.

JEL Classification: E2, F39, G11.

Key Words: International Portfolio Choice, Home Equity Bias, Liquidity Constraints, Information Costs.

1 Introduction

International finance theory emphasizes the effectiveness of global diversification in achieving a higher expected return at a lower risk (Levy and Sarnat (1970) were among the earliest papers to point this out).[1] This theoretical prediction contrasts sharply with the available evidence on international portfolio positions that concludes in favor of a widespread lack of diversification across countries. Specifically, French and Poterba (1991) and Tesar and Werner (1995) estimated the percentages of aggregate stock market wealth invested in domestic equities at the beginning of the 1990s to have been well above 90% for the U.S. and Japan and around 80% for the U.K. and Germany.[2] Tesar and Werner (1998) further show that foreign equity participation by U.S. investors has increased in the 1990s, but it still remains at low levels (in 1996 only around ten percent of total U.S. equity holdings was invested abroad). In a related empirical puzzle, Feldstein and Horioka (1980) have argued that domestic investment is highly correlated with domestic savings, a fact which could be interpreted as the manifestation of home bias in the real economy.

What can potentially explain this divergence of economic theory from economic reality? Lewis (1999) offers an extensive survey of potential explanations that have been put forth to date, ranging from the potential for domestic stocks to better hedge home risks than foreign stocks, the presence of non-tradeable consumption goods, diversification costs exceeding the gains, and the effects of uncertainty about the economic environment. Lewis concludes that "overall, equity home bias in portfolio levels remains a puzzle" (p.590).

This paper develops a potential explanation for the home equity bias puzzle that depends on undiversifiable labor income risk and liquidity constraints. Recently, there has been substantial interest in drawing out the implications of this model in a number of areas. Deaton (1991) and Carroll (1992, 1997)[3] have used this model to explain why consumption tracks income while at the same time consumption is smoother than labor income; buffer stock savers can smooth idiosyncratic earnings fluctuations with a small buffer stock of wealth, thereby explaining why consumption tracks income over time (Carroll and Summers, 1991). Constantinides et. al. (1998) and Storeslettern et. al. (1998) argue that borrowing constraints and undiversifiable labor income risk over the life cycle explain a substantial component of the equity premium. Moreover, the evidence adduced by Gourinchas and Parker (1999) from microeconomic data and Ludvigson and Michaelides (forthcoming) from macroeconomic data is supportive of the buffer stock saving model as a plausible alternative to the classic Permanent Income Hypothesis in explaining consumption dynamics.

It is probably important at this point to isolate the differences between the treatment of human capital under this approach and the way non-tradeable human wealth has been used to date in the home equity bias literature. Baxter and Jermann (1997) show that domestic human capital returns are more positively correlated with domestic stock rather than with foreign stock returns, an observation that forces their two country general equilibrium real business cycle model to conclude that “the international diversification puzzle is worse than you think.” Bottazzi, Pesenti and van Wincoop (1996) argue instead that focussing on the correlation between productivity shocks among different countries might be misleading since other shocks that lead to a redistribution of total income between labor and capital might make foreign securities a less attractive hedge against labor income uncertainty. Using OECD data, they argue that redistributive shocks are sufficiently important to generate a bias towards home equities but the model falls short from matching the magnitude of the home equity bias. This paper differs from these studies in a number of important dimensions. First, undiversifiable labor income risk generates an ex post heterogeneous population of consumers/investors. Second, labor income risk is calibrated to be consistent with microeconometric studies rather than being calibrated from macroeconomic data. Finally, liquidity constraints are explicitly imposed and are an integral part of the analysis[4].

This paper begins by analyzing the theoretical predictions of the buffer stock saving model for international portfolio choice; this is the direct generalization of Heaton and Lucas (1997) in an international context[5]. In this setup we analyze how exchange rate risk affects international portfolio choice and assess the magnitude of hedging demands generated by either positive correlation between foreign and domestic stock markets or by a positive correlation between labor income risk and domestic stock market returns. The model predicts, for reasonably calibrated parameters, complete portfolio specialization in stocks, the manifestation of the equity premium puzzle from the portfolio demand side.[6] Moreover, the agent holds a diversified portfolio with positive amounts of both the domestic and foreign equities given the benefits of international diversification. In fact, to the extent that permanent idiosyncratic labor income shocks are positively correlated with domestic stock market returns, the model generates a complete portfolio specialization in foreign stocks prediction, reflecting the Baxter and Jermann (1997) message that "the international portfolio diversification puzzle is worse than you think."

Given these counterfactual predictions, the model is adjusted to include the possibility that domestic investors are better informed about domestic rather than foreign investment opportunities. The idea that domestic residents might be facing a cost in acquiring information about foreign equity markets or simply be better informed about domestic markets is not new; see Gehrig (1993) and Brennan and Cao (1997), for instance. We model this informational asymmetry in two different ways. First, investors perceive that they can earn a slightly higher return by investing domestically rather than abroad. We then ask how high must this perceived mean equity differential between domestic and foreign stocks be to generate home equity bias. For empirically plausible parameter configurations, a mere two percent differential is sufficient to generate a home equity bias. Second, we ask whether small information acquisition costs about the foreign stock market can generate home equity bias, even if the expected return from investing abroad is the same as that from investing domestically. Small costs are shown to be sufficient in generating a bias for home equities.[7]

Why do such small information costs or such small changes in the mean expected return in the foreign market generate such a sharp change in the predictions of the model? The answer lies with the fundamental mechanisms of consumption smoothing in the model. Agents expect high future earnings growth against which they cannot borrow; asset accumulation is costly and they therefore accumulate a small buffer stock of assets that is sufficient to smooth the idiosyncratic labor income shocks they face. Given the small magnitude of this buffer stock of assets and the exchange rate risk associated with foreign investing, small information costs are sufficient to deter foreign investments.

The paper is organized as follows. Section 2 describes the international portfolio choice model. Section 3 discusses the numerical solution method that generalizes in an international context the method proposed by Haliassos and Michaelides (1999) for solving the domestic portfolio choice model. Section 4 discusses the optimal international portfolio choice policy rules under different assumptions about the economic environment and computes the time series moments for consumption, domestic and foreign stock and bond holdings, and the portfolio share of domestic and foreign risky assets. Section 5 asks what information cost is necessary to generate a bias for domestic equities and Section 6 concludes.

2 The Model

We consider the problem of an infinitely-lived household that maximizes expected intertemporal utility faced with a menu of a domestic and foreign risky asset and a riskless domestic investment opportunity. The household solves

$$MAX_{\{B_t,S_t^d,S_t^f\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t), \tag{1}$$

subject to

$$C_t + B_t + S_t^d + S_t^f \leq X_t \tag{2}$$

$$X_{t+1} = S_t^d \widetilde{R^d}_{t+1} + S_t^f \widetilde{R^f}_{t+1} \widetilde{E}_{t+1} + B_t R_f + Y_{t+1} \tag{3}$$

$$B_t \geq 0 \tag{4}$$

$$S_t^d \geq 0 \tag{5}$$

$$S_t^f \geq 0 \tag{6}$$

All variables are in real terms. B_t, S_t^d and S_t^f are real amounts of the riskless asset (bonds), of the risky domestic asset (domestic stocks) and of the risky foreign asset (foreign stocks), respectively, that are held between the beginning of period t and the beginning of period $t+1$. E_t denotes the mathematical expectation operator based on information available up to the beginning of period t, while β is the discount factor that satisfies $0 < \beta < 1$. $U(C_t)$ is the felicity derived from consumption in period t, X_t is cash on hand at the beginning of period t, $\{\widetilde{R}_{t+1}^d = 1 + \mu^d + \varepsilon_{t+1}^d\}$ is the risky gross return on domestic stocks held between the beginning of period t and that of period $t+1$, $\{\widetilde{R}_{t+1}^f = 1 + \mu^f + \varepsilon_{t+1}^f\}$ is the risky gross return on foreign stocks held between the beginning of period t and that of period $t+1$, $\{\widetilde{E}_{t+1} = 1 + \widetilde{e}_{t+1}\}$ is the stochastic exchange rate that will be used to translate foreign investments into domestic cash on hand in period $(t+1)$, $\{R_f = 1+r\}$ is the gross riskless rate which is assumed time-invariant, and Y_t is labor income received at the beginning of period t. All the innovations $\{\varepsilon^d_{t+1}, \varepsilon^f_{t+1}, \widetilde{e}_{t+1}\}$ have mean zero and can have an arbitrary correlation structure between them.

The budget constraint (2) will hold with equality, given the assumption of non-satiation. The period-by-period felicity function is of the constant relative risk aversion (CRRA) form $U(C_t) = \frac{C_t^{1-\rho}-1}{1-\rho}$, $\rho \neq 1$, $\rho > 0$ and $U(C_t) = \ln C_t$ when $\rho = 1$. Constraint (6) is a direct generalization of the no short sales constraints imposed by Heaton and Lucas (1997) in a single, domestic, risky asset model.[8]

2.1 Labor Income

Labor income risk is nondiversifiable because of moral hazard and adverse selection considerations, and it cannot be ignored by households concerned about their consumption paths. Labor income of household i follows:

$$Y_{it} = P_{it} U_{it}, \tag{7}$$

$$P_{it} = G P_{it-1} N_{it} \tag{8}$$

This process, first used in a nearly identical form by Carroll (1992), is decomposed into a "permanent" component, P_{it}, and a transitory component, U_{it}. We assume that $\ln U_{it}$ and $\ln N_{it}$ are each independent and identically (normally) distributed with means $\{-.5 * \sigma^2_u$, $-.5 * \sigma^2_n\}$, and variances σ^2_u and σ^2_n, respectively[9].

The log of P_{it}, evolves as a random walk with a deterministic drift, $\mu_g = \ln G$, assumed to be common to all individuals. Given these assumptions, the growth in individual labor income follows

$$\Delta \ln Y_{it} = \ln G + \ln N_{it} + \ln U_{it} - \ln U_{it-1}, \tag{9}$$

where the unconditional mean growth for individual earnings is $\mu_g - .5 * \sigma^2_n$, and the unconditional variance equals $(\sigma^2_n + 2\sigma^2_u)$. Individual income growth in (9) has a single Wold representation that is equivalent to the MA(1) process for individual earnings growth estimated using household level data (MaCurdy [1981], Abowd and Card [1989], and Pischke [1995]).[10]

2.1.1 Calibration of Parameters

The horizon that the model is calibrated for is one year. We set the rate of time preference, δ, equal to 0.05, and the constant real interest rate, r, equal to 0.02. Carroll (1992) estimates the variances of the idiosyncratic shocks using data from the *Panel Study of Income Dynamics*, and our benchmark simulations use values close to those: 0.1 percent per year for σ_u and 0.08 percent per year for σ_n. We set μ_g equal to 0.03 and the benchmark coefficient of relative risk aversion is set to either 2 or 5. The mean equity premium equals 6 percent and its standard deviation is 18 percent (both for domestic and foreign stocks). That is $\mu^d = \mu^f = .08$ and $\sigma_{\varepsilon^d} = \sigma_{\varepsilon^f} = .18$. The exchange rate innovation $\widetilde{e}$ has mean zero and its variance is set to approximately half of the equity premium variance (its standard deviation is therefore around .13). Comparative statics results from varying the contemporaneous correlation between stock returns, exchange rates and labor income shocks are also undertaken and reported in Section 4. Numerical quadrature is used to take expectations, in the spirit of Tauchen (1986).

3 Solution Method

There is no analytical solution to the model and we therefore proceed with a numerical solution. Analytical first order conditions for bonds and for stocks respectively can be written as follows:

$$U'(C_t) = \frac{1+r}{1+\delta} E_t U'(C_{t+1}) + \lambda_B \tag{10}$$

and

$$U'(C_t) = \frac{1}{1+\delta} E_t \left[U'(C_{t+1})\, \widetilde{R^d}_{t+1} \right] + \lambda_S^d \tag{11}$$

and

$$U'(C_t) = \frac{1}{1+\delta} E_t \left[U'(C_{t+1}) \widetilde{E}_{t+1}\, \widetilde{R^f}_{t+1} \right] + \lambda_S^f \tag{12}$$

where λ_B, λ_S^d and λ_S^f refer to the Lagrange multipliers for the no short sales constraints on bonds, domestic stocks and foreign stocks, respectively. Recalling that the budget constraint in period t is

$$C_t = X_t - B_t - S_t^d - S_t^f \tag{13}$$

where X_t is cash on hand, a binding short sales constraint on bonds, implies that $C_t = X_t - S_t^d - S_t^f$. Similarly, when the constraint preventing short sales of domestic stocks is binding, (13) implies that $C_t = X_t - B_t - S_t^f$, while a binding constraint on foreign stock short selling implies that $C_t = X_t - B_t - S_t^d$.

Given the non-stationary process followed by labor income, we normalize asset holdings and cash on hand by the permanent component of earnings P_{it}, denoting the normalized variables by lower case letters (Carroll, 1992). Defining $Z_{t+1} = \frac{P_{t+1}}{P_t}$ and taking advantage of the homogeneity of degree $(-\rho)$ of marginal utility implied by CRRA preferences, the three Euler equations can be rewritten in the following way:

$$U'(x_t - s_t^d - s_t^f - b_t) = MAX\left[U'(x_t - s_t^d - s_t^f), \frac{1+r}{1+\delta}E_t U'(c_{t+1})Z_{t+1}^{-\rho}\right] \tag{14}$$

and

$$U'(x_t - s_t^d - s_t^f - b_t) = MAX\left[U'(x_t - b_t - s_t^f), \frac{1}{1+\delta}E_t\{\widetilde{R^d}_{t+1}U'(c_{t+1})Z_{t+1}^{-\rho}\}\right]. \tag{15}$$

and

$$U'(x_t - s_t^d - s_t^f - b_t) = MAX\left[U'(x_t - b_t - s_t^d), \frac{1}{1+\delta}E_t\{\widetilde{R^f}_{t+1}\widetilde{E}_{t+1}U'(c_{t+1})Z_{t+1}^{-\rho}\}\right] \tag{16}$$

The normalized state variable x (following Deaton, 1991) evolves according to

$$x_{t+1} = (s_t^d\widetilde{R}_{t+1}^d + s_t^f\widetilde{R}_{t+1}^f\widetilde{E}_{t+1} + b_t R_f)Z_{t+1}^{-1} + U_{t+1} \tag{17}$$

The identity $c_{t+1} = x_{t+1} - b_{t+1} - s_{t+1}^d - s_{t+1}^f$ where $\{b_{t+1}, s_{t+1}^d, s_{t+1}^f\}$ are all functions of x_{t+1} is used to substitute out c_{t+1} on the right hand sides of (14), (15) and (16) (see appendix A for the proposed algorithm).

In order for the algorithm to work, we must make sure that the three functional equations of interest define a contraction mapping. Three sufficient conditions for the individual Euler equations (14), (15) and (16) to define a contraction mapping for $\{b(x), s^d(x), s^f(x)\}$ respectively are the conditions in Theorem 1 of Deaton and Laroque (1992):

$$\frac{1+r}{1+\delta} E_t Z_{t+1}^{-\rho} < 1 \tag{18}$$

and

$$\frac{1}{1+\delta} E_t\{\widetilde{R}_{t+1} Z_{t+1}^{-\rho}\} < 1 \tag{19}$$

and

$$\frac{1}{1+\delta} E_t\{\widetilde{R}_{t+1} \widetilde{E}_{t+1} Z_{t+1}^{-\rho}\} < 1 \tag{20}$$

If these conditions hold simultaneously, there will exist a unique set of optimum policies satisfying the three Euler equations. We next simplify these conditions to gain an intuitive understanding of the problem. Given that $Z_{t+1} = GN_{t+1}$, with $\{N\}$ being log normally distributed, we have $E_t(GN_{t+1})^{-\rho} = \exp(-\rho\mu_g) * \exp(-\rho\mu_n + \frac{\rho^2\sigma_n^2}{2})$. Assuming that all three variables are uncorrelated with each other, we have

$$\begin{aligned} E_t\{\widetilde{R}_{t+1} \widetilde{E}_{t+1} Z_{t+1}^{-\rho}\} &= E_t\{\widetilde{R}_{t+1}\} E_t\{Z_{t+1}^{-\rho}\} E_t\{\widetilde{E}_{t+1}\} \\ &= (1+\mu_f) * \exp(-\rho\mu_g) * \exp(-\rho\mu_n + \frac{\rho^2\sigma_n^2}{2}) * 1 \end{aligned} \tag{21}$$

Taking logs of the two conditions and using the approximation $\log(1+x) \approx x$ for small x, (18) becomes

$$\frac{r-\delta}{\rho} + \frac{\rho}{2}\sigma_n^2 < \mu_g + \mu_n \tag{22}$$

which is the condition derived by Deaton (1991) with $\mu_n = 0$. (19) and (20) are identical because the conditional next period expectation of the exchange rate is one and the domestic and foreign equity premia are equal. The conditions therefore become[11]

$$\frac{\mu^f-\delta}{\rho} + \frac{\rho}{2}\sigma_n^2 < \mu_g + \mu_n \tag{23}$$

Note that the three conditions collapse into one when the stock market investment opportunities have the same return characteristics as the risk free rate.

With a positive equity premium ($\mu^f > r$), satisfaction of (23) guarantees (22). Impatience must now be even higher than in the saving model to prevent the accumulation of infinite stocks, since the condition involving $\mu^f - \delta$ must be satisfied. Two other distinct cases can also guarantee the existence of a solution. First, a high expected earnings growth profile (as measured by μ_g) guarantees that the individual will not want to accumulate an infinite amount of stocks or bonds but would rather borrow now, expecting earnings to increase in the future. Second, if the rate of time preference exceeds the expected stock return, more risk averse (higher ρ) individuals will not satisfy the convergence conditions.

4 Comparative Statics

4.1 Labor Income Uncorrelated to Stock Returns

There is very little empirical evidence on the correlation of individual labor income shocks and stock market returns. Davis and Willen (1999) is one of the first empirical studies trying to determine the degree of correlation between individual domestic stock market returns and idiosyncratic labor income shocks (I am aware of no study that computes the correlation between individual labor income shocks and foreign stock market returns). Their results vary over different groups and over the life cycle but the highest correlation is around 0.3 for some segments of the population, even though a correlation of zero arises for many occupational categories. Given the uncertainty that exists about the magnitude of this correlation, we solve the model for correlations equal to zero and 0.3.

The policy functions for $\{\rho = 2, 5\}$ are given in figures 1-4. We first note that the consumption policy rule has the same shape as in the buffer stock saving literature (figure 1), while complete portfolio specialization in stocks, first derived by Heaton and Lucas (1997) for the domestic portfolio choice problem, persists (figure 4 shows that no savings is allocated in the riskless asset market). Moreover, the total amount of savings is not affected by varying the risk aversion parameter (see figure 1), even though there are substantial changes in the portfolio composition (see figures 2 and 3), conditional on ρ.

The benefits of international diversification can be clearly seen since the portfolio contains both domestic and foreign investments once saving takes place (figures 2 and 3). Figure 2 illustrates that the share of wealth in domestic stocks is a declining function of cash on hand and decreasing in risk aversion. Given that what wealth is left is completely allocated in the foreign stock market, the share of wealth invested in the foreign stock market is an increasing function of cash on hand and increasing in risk aversion. The declining shape of the share of wealth in domestic stocks is a familiar result from both infinite horizon[12] and finite horizon[13] domestic portfolio choice models. In the absence of an international asset, this shape arises because future labor income that cannot be borrowed against is viewed as implicit holdings of a riskless asset. At low levels of financial wealth (where the share of the implicit riskless asset in total wealth is high), the agent allocates total savings in the stock market, making the portfolio more diversified, once the implicit holdings of the riskless asset in the form of future labor income are taken into account. As financial wealth rises (and the labor income component in total financial wealth decreases), however, the riskless asset must be added to the portfolio to make it well diversified. With international portfolio choice, this logic works in the same way except that the role of the riskless asset is taken up by the foreign asset. The foreign asset is riskier than the domestic asset, though, since exchange rate risk is not hedged, and this riskiness generates a bias towards domestic investments (the share of wealth in the domestic market is higher than the share of wealth invested in the foreign market). Higher risk aversion reduces the share of wealth invested in the domestic stock market because the benefits from international diversification are higher for more risk averse agents, generating a higher allocation of stocks in the foreign market.

Table 1 uses the invariant distribution of normalized cash on hand (see Appendix B) to show that mean and median bondholding are zero. Table 1 also illustrates that consumption smoothing is achieved, with individual normalized consumption having half the standard deviation of individual normalized earnings. The table also shows that (for either $\rho = 2$ or $\rho = 5$) there is a bias towards domestic investments with both the mean and median share of wealth invested domestically being around twice as high as the share of wealth invested abroad. Specifically, the mean share of wealth invested domestically is 61 percent for $\rho = 2$

and 59 percent for $\rho = 5$, while the respective numbers for the foreign investment are 27 and 31 percent. The remaining 12 and 10 percent is the time spent with no savings (and therefore no stockholding). Computing medians yields a similar bias towards domestic equities: 68 percent of wealth is invested domestically and 32 percent abroad when $\rho = 2$ and when $\rho = 5$ the share of wealth in domestic stocks falls to 65 percent and the share abroad rises to 35 percent. Even though there is a bias towards domestic investments, however, this is not sufficient to generate the bias observed in the data.

Figures 2 and 3 show that once households begin to save, they hold a diversified portfolio that includes both domestic and foreign stocks, a manifestation of the home equity bias puzzle. The source of this result, and of its robustness to different levels of risk aversion, can be seen with reference to the different shadow values of the two short-sales constraints on domestic and foreign stock holding. Combining (11) and (12) yields

$$\frac{1}{1+\delta}E_t\left[U'(C_{t+1})\left(\widetilde{R}^d_{t+1} - \widetilde{E}_{t+1}\widetilde{R}^f_{t+1}\right)\right] = \lambda^d_S - \lambda^f_S. \tag{24}$$

Under no stockholding, no correlation between earnings and stock returns and no correlation between stock returns and exchange rate risk, equation (24) can be rewritten as

$$\frac{1}{1+\delta}E_t\left[U'(C_{t+1})\right]E_t\left[\widetilde{R}^d_{t+1} - \widetilde{E}_{t+1}\widetilde{R}^f_{t+1}\right] = \lambda^d_S - \lambda^f_S \tag{25}$$

Given the same expected return on the domestic and foreign investment, as assumed up to this point, the left hand side of (25) is zero. Since $\lambda^d_S = \lambda^f_S$ at zero saving, households that start saving would like to invest in both the domestic and foreign stock market since the shadow value of investing is the same in both markets. Thus, there is a second puzzle predicted by this model; even the smallest amount of positive savings is allocated in both stock markets, despite casual empiricism that suggests that investors first enter the domestic market and then move on to other markets.

4.2 Correlation between domestic stock market returns and labor income risk

In this section we investigate the effect of positive correlation between permanent labor income shocks and stock returns on the international portfolio choice decision[14] (see figures 5 to 8 for correlation equal to 0.3). The consumption policy rule shape and the complete portfolio specialization in stocks are not altered from this change in the economic environment. What is clearly illustrated in figures 6 and 7 is the Baxter and Jermann (1998) message that "The international portfolio diversification puzzle is worse than you think". Specifically, the investor first enters the foreign stock market fully when starting to save (figure 7), while the share of wealth invested in foreign stocks remains equal to one for quite a while before some investments are made in the domestic stock market.

The results are even more striking when we look at the time series averages from the invariant distribution (table 2). Not only does complete portfolio specialization in stocks hold (mean and median normalized bond holdings are zero), but we now have complete portfolio specialization in foreign stocks; both the mean and median share of wealth invested domestically is zero. This result has two implications. First, to the extent that positive correlation between earnings shocks and stock returns exists in the data, home equity bias becomes much more difficult to explain. Given the evidence in Heaton and Lucas (2000a) that small business proprietors are more likely to be stock holders and that their business income might be more positively correlated with the domestic stock market, the home equity bias puzzle is worsened. Second, positive correlation between stock returns and labor income shocks could be used to explain the co-existence of bonds and stocks in the portfolio, thereby avoiding the complete portfolio specialization in stocks prediction of the domestic portfolio choice model (see Heaton and Lucas (2000b)). If this route is taken, however, then the home equity bias puzzle becomes more difficult to explain as the extension of the model in the international context generates complete portfolio specialization in foreign stocks.

4.3 Does International Diversification Pay when Stock Markets are Positively Correlated?

The next comparative statics exercise investigates the benefits from international diversification when stock markets are positively correlated (figures 9 to 12). I have used two correlation coefficients: 0.3 and 0.7. The lower number captures representative correlations among developed equity markets, as reported by Lewis (1999, table 2)[15] for the Morgan

Stanley (MSCI) database of developed market stock indices with reinvested dividends. The high correlation (0.7) is the correlation between the US and Canada (this is the highest correlation that Lewis reports in the correlation matrix that includes the U.S., Canada, France, Germany, Italy, Japan and the U.K.).

Figure 9 illustrates once more that the consumption policy rule has the familiar buffer stock saving shape, and that complete portfolio specialization in stocks obtains (figure 12). Varying ρ does not affect significantly the results for this parameter configuration and therefore these comparative statics results are omitted. Increasing the correlation between domestic and foreign stock markets makes the preference for domestic stocks stronger since the benefits of diversification are reduced as this correlation increases (figures 10 and 11). International diversification does pay, however, since for either correlation both domestic and foreign assets are included in the portfolio, once saving is undertaken.

The results in table 3 confirm these conclusions. First, varying the coefficient of relative risk aversion does not affect the time series results. Second, the bias towards the domestic stock market is increasing in the correlation between the domestic and foreign stock market. The mean share of wealth invested in the domestic stock market is 76 percent while that invested abroad is 12 percent when $\rho = 2$ (this ratio rises to 77/12 when $\rho = 5$). The conclusions are even starker when medians are used. If the correlation is 0.3, then the median share of wealth in domestic stocks is 68/69 percent for $\rho = 2$ / $\rho = 5$. When this correlation rises to 0.7, however, the median share of wealth in domestic stocks is 88 percent when $\rho = 2$ and 86 percent when $\rho = 5$. Thus, domestic bias can be generated with such high positive correlations.

Is high domestic to foreign stock market correlation a reasonable explanation of the home equity bias puzzle? The highest correlation between stock markets reported by Lewis (1999) is that between the U.S. and Canada (0.7). The model would therefore predict that a U.S. based investor would have a domestic equity bias against Canada. Is this the case empirically? Bohn and Tesar (1996) argue that, if anything, U.S. investors first invested in Canada and only gradually shifted some of their investments in Europe, Japan and emerging economies, while maintaining the bias towards domestic equities. High correlations between the domestic and foreign stock market make the equity bias puzzle even stronger therefore since, if anything, U.S. investors should not have first invested in Canada.

4.4 How Important is Foreign Exchange Risk in the International Portfolio Choice Decision?

We have seen that even though the foreign asset is always held in positive amounts in the portfolio once saving takes place, there is a bias towards holding a larger proportion of wealth in the domestic asset. This arguably arises from the exchange rate risk that a foreign investment entails for a prudent investor. In order to more closely analyze the effect of foreign exchange rate risk on the optimal international portfolio choice decision, I recomputed the policy functions that would result from two of the previous sections but by reducing the standard deviation of exchange rate changes to 0.01 (from 0.127 in the benchmark model). The results are plotted in figures 13 to 16.

Figures 13 and 14 plot the share of wealth in domestic and foreign stocks respectively when both the correlation between permanent earnings shocks and domestic stock returns and the correlation between domestic and foreign stock returns is zero. It is found that the portfolio allocation is extremely sensitive to exchange rate volatility; the reduction in foreign exchange rate risk reduces the share of wealth allocated in the domestic market as the agent allocates more wealth abroad. In particular, when exchange rate risk is practically eliminated, approximately half of the wealth is allocated in the domestic market and half is allocated abroad[16], regardless of the coefficient of relative risk aversion (see figures 13 and 14).[17]

What happens when positive correlation between permanent labor income shocks and domestic stock returns exists? Figures 15 and 16 plot the shares of wealth invested domestically and abroad respectively. Foreign exchange rate risk is shown to be once again an important determinant of the international portfolio choice decision; lower foreign exchange rate risk increases the share of wealth invested abroad by a substantial rate (see figure 16, for instance).

We conclude by pointing out that since lower foreign exchange rate risk implies an aggressive increase in foreign equities, a currency union that eliminates exchange rate risk should imply a higher rate of cross border investment within the union. The European Monetary Union should therefore provide the catalyst for a substantial increase in cross border investment within the members of the Union. Moreover, if international investors can (cheaply) hedge their foreign exchange risk, then the home equity puzzle becomes even more difficult to explain.

5 Can Small Information Costs Generate Home Bias in Equity Investments?

In the popular press, the idea that investors have better information about nearby firms than distant ones is taken for granted.[18] More recently, a number of academic papers have rigorously tested this hypothesis. Coval and Moskowitz (1999a) find that the distance between fund managers and potential investments is a "key determinant of U.S. investment manager portfolio choice." Coval and Moskowitz (1999b) also find that investors possess significant informational advantages in evaluating nearby investments and also find that active mutual fund managers overweight proximate firms in their portfolios and earn substantial abnormal returns in local holdings. If this argument holds for domestic investments, then it is natural to conjecture that geographical distance might be an important determinant of international portfolio choice. Indeed, Coval and Moskowitz (1999a) extrapolate their findings to the international scale and find that "distance may account for roughly one third of the observed home country bias in U.S. portfolios estimated by French and Poterba (1991)".

In the next two subsections I assess the potential for small information costs to generate a home equity bias puzzle. The first subsection assumes that domestic investors are better informed about domestic investment opportunities than foreign stock markets and therefore can earn a higher expected return on domestic investments; the question that arises then is what level of domestic to foreign equity premium differential is needed to generate the observed home equity bias. The second subsection assumes that there is an explicit cost differential in gathering information about foreign investments relative to the cost of information acquisition about domestic markets. In such an economic environment, we ask whether small information cost differentials can generate home equity bias.

5.1 How low must the foreign equity premium be to generate home equity bias?

In the benchmark model analyzed in previous sections, both the domestic and foreign equity premia were set equal to six percent. Interesting portfolio allocations result from changing the foreign equity premium downwards from six to two percent in the different economic environments under consideration. When both the correlation between domestic stock returns and permanent earnings shocks and between domestic and foreign stock markets are zero and $\rho = 2$, a foreign equity premium between two and five percent generates complete portfolio specialization in domestic stocks. With $\rho = 5$, a foreign equity premium lower than four percent generates a home bias in domestic equities.

These results are quite surprising given the benefits that international diversification can offer and the consistent prediction in the previous section that the agent should hold an internationally diversified portfolio. What is the economic mechanism that can explain these surprising results? Buffer stock savers can smooth idiosyncratic earnings shocks with little wealth accumulation. Table 1 has shown that normalized consumption is half as volatile as normalized earnings (comparing standard deviations) and this is achieved by accumulating a total of 0.15 units of normalized wealth when $\rho = 2$ and 0.16 units of normalized wealth when $\rho = 5$. In turn, this wealth is broken down between 0.1 units in domestic assets and 0.05 and 0.06 units in foreign stocks respectively. The low level of total savings and the bias towards domestic stocks that exchange rate risk generates, are two factors that reduce the attractiveness of foreign equities quite quickly. The even lower foreign equity premium needed to generate a domestic equity bias for higher degrees of prudence (ρ) is consistent with this explanation since the level of wealth invested in the foreign stock market is higher in this case and therefore the gain from international diversification is even stronger.

What is even more surprising is that such conclusions can be generated even for the case when positive correlation between domestic stock returns and permanent labor income shocks exist. In this case, given the magnitude of the home equity bias puzzle illustrated in section 4.2, the foreign equity premium must be perceived to be even lower than in the zero correlation case. For $\rho = 2$ the foreign equity premium must fall to four from five percent to generate complete portfolio specialization in domestic stocks while for $\rho = 5$ it must fall even lower to around three percent.

We conclude this section by pointing out that a domestic to foreign equity premium differential of the range of 2-3 percent can generate the observed bias in domestic equities. How reasonable is such an assumption? This is an empirical question but the evidence adduced by Coval and Moskowitz is consistent with this observation; if investors believe that they have more accurate information about investments close to home, and therefore a higher domestic to foreign return on investment, home equity bias will arise. Equivalently, if familiarity raises domestic expected returns above foreign ones, even by a two to three percent per annum level, then it might breed domestic (rather than foreign) investment.

5.2 Can small information costs generate home equity bias?

We will now consider the potential for small information/trading costs associated with investing abroad to generate home equity bias while keeping the same expected equity premia in the two different countries. The thought experiment is as follows. Suppose that access to foreign stockholding opportunities entails a small cost (it might be the cost of opening a foreign account, the opportunity cost of time monitoring a foreign investment, the higher cost of acquiring information about a foreign market, higher brokerage fees from investing abroad or simply inertia). We are interested in computing the threshold cost that will keep this investor in the domestic market, thereby generating a complete portfolio specialization in domestic stocks.

To compute this threshold entry cost, we solve for the associated value functions. Details of this computation are found in Appendix C. The value function of the international portfolio choice model exceeds that of the domestic portfolio choice model at any level of normalized cash on hand, since households are no worse off when they have the option to invest in foreign stocks. If we denote the value function associated with participating in the foreign stock market by V_s^f and the value function when using domestic capital markets by V_s^d, the normalized threshold entry cost as a function of normalized cash on hand is $k(x)$, such that

$$V_s^f(x - k(x)) = V_s^d(x) \tag{26}$$

Given the monotonicity in cash on hand of the value function, we can use a numerical interpolation procedure to invert the value functions and derive the entry cost as

$$k(x) = x - V_s^{f^{-1}}(V_s^d(x)) \tag{27}$$

Since $k(x)$ varies with the realized cash on hand, we can now make use of the time-invariant distribution of normalized cash on hand[19] to find the maximum level of x that the household will experience. We compute this from the invariant distributions depicted in Figs. 17-18 as the level $\widehat{x}$, such that $\Pr(x \leq \widehat{x}) = 1$. The threshold entry cost is then computed as $k(\widehat{x})$.[20]

The invariant distributions are plotted for completeness in figures 17 and 18; they illustrate that for higher degrees of risk aversion/prudence, higher wealth accumulation takes place and the distribution of cash on hand is skewed to the right. The resulting certainty equivalents are also graphed in figures 19 and 20 and are increasing in the level of liquid wealth. At higher wealth levels the benefit from diversifying internationally is greater and therefore a higher cost is needed to generate foreign market non-participation. Moreover, higher levels of prudence require a higher threshold cost to deter foreign market non-participation since higher risk aversion implies a higher level of precautionary saving balances and therefore a higher benefit from diversifying internationally. Positive correlation between domestic stock market returns and permanent labor income shocks is also associated with higher levels of threshold costs needed to deter foreign market participation since, again, the benefits from diversifying internationally are greater than when this correlation is zero (see figure 19).

Table 4 reports the values of these threshold costs for different specifications of the economic environment as a percentage of mean labor income. The threshold entry costs are highest when the correlation between permanent labor income shocks and domestic stock returns is positive (panel II); this is consistent with the higher need to diversify internationally when the domestic stock market is not a good hedge against earnings fluctuations. The costs of 6.4 percent (for $\rho = 2$) and 15.4 percent (for $\rho = 5$) are substantial implying that in this economic environment, the home equity bias cannot be explained by small information costs. On the other hand, panels I, II and IV show that when $\rho = 2$ very small information costs can generate home equity bias; these costs vary between 0.6 and 1.5 percent of mean labor income.

One may wonder why entry costs tend to be low, given that the household gains access to foreign stocks over an infinite horizon. Three factors are at work. First, access to stocks does not necessarily imply stockholding in every period. Liquidity constraints imply that households are likely to spend a substantial fraction of their time at levels of normalized cash on hand that do not justify any stockholding. Specifically, when $\rho = 2$ and stock returns are uncorrelated with labor income, the household does not save anything around 12 percent of the time. When the coefficient of relative risk aversion rises to 5, on the other hand, the liquidity constraint is binding around 10 percent of the time, enhancing the value of entering the foreign stock market and justifying the higher cost needed to generate stock market non-participation (the cost rises from one to 2.6 percent of mean labor income). With positive correlation between domestic and foreign stock returns and $\rho = 2$, the household does not save anything approximately 12 percent of the time while for $\rho = 5$ this occurs around 11 percent of the time. Second, the amount of total saving is low (see the results in tables 1-3) implying that the benefits from international diversification are limited. Third, the exchange rate risk associated with foreign investing is non-negligible. Given the risk aversion of the agent, compounded by the liquidity constraint, the benefit of international diversification comes with a cost in the form of an additional layer of uncertainty. All three factors detract from the appeal of having access to foreign stocks and tend to lower the threshold entry costs.

The finding that relatively low entry costs can generate foreign stock market non-participation is consistent with the theoretical findings of Haliassos and Michaelides (1999) that low entry costs can generate stock market non-participation in the context of the domestic portfolio choice model. Given the recent empirical findings by Vissing-Jorgensen (1999) and Paiella (2000) that small entry cost can generate stock market non-participation domestically, we conjecture that an empirical study in an international context could yield similar support for international stock market non-participation. Moreover, it is important to note that foreign equity participation by U.S. investors has increased in the 1990s, but at around ten percent of equity holdings being invested abroad, it still remains at low levels (Tesar and Werner, 1998). The increase in foreign stock market participation by U.S. investors would be consistent with a gradual reduction in information costs about foreign investment opportunities in the 1990s either through the proliferation of mutual funds invested in foreign securities or simply through the greater ease of information acquisition that the Internet provides.

6 Concluding Remarks

This paper has extended the Heaton and Lucas (1997) approach to solving domestic portfolio choice models in an international context. We have found that the investor holds an internationally diversified portfolio, even when very small amounts of wealth are being invested. Positive correlation between domestic stock market returns and permanent labor income innovations worsens the home bias puzzle significantly since it predicts complete portfolio specialization in foreign stocks. Positive correlation between domestic and foreign stock markets reduces foreign stock market participation but the portfolio remains internationally balanced. Mitigating exchange rate risk also worsens the home equity bias puzzle.

Given these counterfactual predictions, the model was modified in two different directions that can both be motivated by the presence of differential information costs about domestic versus foreign investment opportunities. Specifically, more accurate information about domestic investments that leads to either higher expected returns domestically or to small foreign investment costs generates a substantial home equity bias. The model departs from the Obstfeld and Rogoff (2000) assumption of using costs of trade in the goods market to explain home bias by assuming that costs of trade arise in asset trading. Nevertheless, it retains the flavor of the argument that small costs might change the predictions of different models significantly and the effects of incorporating small costs/frictions should therefore be more closely scrutinized.

A Appendix A: Numerical Dynamic Programming

The three Euler equations are given by (14), (15) and (16) while normalized cash on hand evolves according to (17). The single state variable (cash on hand, x_t) is discretized into 50 equidistant grid points between (.6 and 3). Given that the three conditions that guarantee that the above system defines a contraction mapping are satisfied, we can solve simultaneously for $\{s^d(x), s^f(x), b(x)\}$. Starting with any initial guess (say $s^d(x) = .1*x$, $s^f(x) = .1*x$, $b(x) = .1*x$), we use the right hand side of the first Euler equation ((14)) to get an update for b and continue doing so until b converges to its time invariant solution b_1^* (see Deaton (1991)). We then use the second Euler equation with b_1^* taken as given, to find the solution for the time invariant optimal s^d, call it s_1^{d*}. We then substitute these two functions in the third Euler equation and iterate on s^f until we find the time invariant solution for this function, call it s_1^{f*}. We know have three updated functions $\{b_1^*, s_1^{d*}, s_1^{f*}\}$; the process can be repeated until these functions converge to their time invariant solutions.

A.0.1 Contemporaneous Correlation

To find the probabilities associated with different state realizations in the presence of contemporaneous correlation, we discretize the joint probability distribution of a bivariate standard normal in the following way. The univariate standard normal distribution is divided into ten equiprobable intervals using eleven points; $\{\pm 10, \pm 1.28155, \pm 0.84162, \pm 0.5244, \pm 0.25334, 0\}$. A discrete approximation of the formula

$$F(y_1 \leq Y \leq y_2, z_1 \leq Z \leq z_2) = F(y_2, z_2) - F(y_2, z_1) - F(y_1, z_2) + F(y_1, z_1)$$

where F is the bivariate standard normal of the two random variables (Y, Z) is then derived using the $CDFBVN$ command in GAUSS.

B Appendix B: Computing the Time- Invariant Distribution

Normalized cash on hand follows a renewal process[21] and therefore has an associated invariant distribution. To find the time invariant distribution of normalized cash on hand, we first compute the optimal policy rules; bond ($b(x)$), domestic stock ($s^d(x)$) and foreign stock ($s^f(x)$) policy functions. Note that the normalized cash on hand evolution equation is

$$\begin{aligned} x_{t+1} &= [b(x_t)R_f + s^d(x_t)\widetilde{R}^d_{t+1} + s^f(x_t)\widetilde{R}^f_{t+1}\widetilde{E}_{t+1}]\frac{P_t}{P_{t+1}} + U_{t+1} \qquad (28) \\ &= w(x_t|\widetilde{R}^d_{t+1}, \widetilde{R}^f_{t+1}, \frac{P_t}{P_{t+1}}, \widetilde{E}_{t+1}) + U_{t+1} \end{aligned}$$

where $w(x)$ is defined by the last equality and is conditional on $\{\widetilde{R}^d_{t+1}, \widetilde{R}^f_{t+1}, \frac{P_t}{P_{t+1}}, \widetilde{E}_{t+1}\}$. Denote the transition matrix of moving from x_j to x_k,[22] as T_{kj}. Let Δ denote the distance between the equally spaced discrete points of cash on hand on the grid. The risky domestic asset return $\widetilde{R}^d$, the risky foreign asset return $\widetilde{R}^f$, the exchange rate next period $\widetilde{E}$ and the permanent shock$\frac{P_t}{P_{t+1}}$ are all discretized using 10 grid points respectively: $R^d = \{R_l\}_{l=1}^{l=10}$, $R^f = \{R_m\}_{m=1}^{m=10}$, $\widetilde{E} = \{E_n\}_{n=1}^{n=10}$, $\frac{P_t}{P_{t+1}} = \{GN_o\}_{o=1}^{o=10}$. $T_{kj} = \Pr(x_{t+1=k}|x_{t=j})$ is found using

$$\begin{aligned} \sum_{l=1}^{l=10}\sum_{m=1}^{m=10}\sum_{n=1}^{n=10}\sum_{o=1}^{o=10} \Pr(x_{t+1}|x_t,\theta) * \Pr(\widetilde{R}^d_{t+1} &= R_l) * \Pr(\widetilde{R}^f_{t+1} = R_m) \qquad (29) \\ * \Pr(\widetilde{E}_{t+1} &= E_n) * \Pr(\frac{P_t}{P_{t+1}} = N_o) \qquad (30) \end{aligned}$$

where $\theta' = [\widetilde{R}^d_{t+1} = R_l,\ \widetilde{R}^f_{t+1} = R_m,\ \widetilde{E}_{t+1} = E_n,\ \frac{P_t}{P_{t+1}} = N_o]$ and the assumption that all four random variables are independent was used. Making use the approximation that for small values of σ_u^2, $U \sim N(\exp(\mu_u + .5 * \sigma_u^2), (\exp(2 * \mu_u + (\sigma_u^2)) * (\exp(\sigma_u^2) - 1)))$, and denoting the mean of U by $\overline{U}$ and its standard deviation by σ, the transition probability conditional on $\{R_l, R_m, E_n, N_o\}$ then equals

$$\begin{aligned} T_{kjlmno} &= \Phi(\frac{x_k + \frac{\Delta}{2} - w(x_t|\theta') - \overline{U}}{\sigma} \geqslant x_{t+1} \geqslant \frac{x_k - \frac{\Delta}{2} - w(x_t|\theta') - \overline{U}}{\sigma} \\ |x_t &= x_j, \theta') \end{aligned}$$

The unconditional probability from x_j to x_k is then given by

$$T_{kj} = \sum_{l=1}^{l=10} \sum_{m=1}^{m=10} \sum_{n=1}^{n=10} \sum_{o=1}^{o=10} T_{kjlmno} \Pr(R_l) \Pr(R_m) \Pr(E_n) \Pr(N_o) \tag{31}$$

The time invariant distribution π is then calculated as the normalized eigenvector of T corresponding to the unit eigenvalue by solving the linear equations

$$\begin{pmatrix} T - I & e \\ e' & 0 \end{pmatrix} \begin{pmatrix} \pi \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \tag{32}$$

where e is a (50 by 1) vector of ones .

Once the limiting distribution of cash on hand is derived, average cash on hand can be computed using $\sum_j \pi_j * x_j$. Similar formulae can be used to compute the mean, median and standard deviations of the variables of interest, as reported in the tables. Correlation between the random variables can be accommodated by calculating the joint probabilities of the variables in (31).

C Appendix C: Value Function Computation

An induction argument is sufficient to show that the value function inherits the properties of the utility function; in particular, the value function is homogeneous of degree $(1 - \rho)$ when the utility function in of the CRRA form. As a result, the equation that determines the value function

$$V(X_t, P_t) = MAX_{B_t, S_t^d, S_t^f} U(C_t) + \beta E_t V(X_{t+1}, P_{t+1}) \tag{33}$$

can be rewritten as

$$V(x_t) = MAX_{b(x_t), s^d(x_t), s^f(x_t)} U(c_t) + \beta E_t[\{\frac{P_{t+1}}{P_t}\}^{1-\rho} V(x_{t+1})] \tag{34}$$

Starting from any initial guess of the value function (say $V(x) = \frac{x^{1-\rho}}{1-\rho}$) and substituting this along with the optimal consumption, bond and stock policy functions on the right hand side of (34), we obtain an update of $V(x)$; this procedure can be repeated until the value function converges at all grid points.

References

[1] Abowd, John and Card, David, "On the Covariance Structure of Earnings and Hours Changes" *Econometrica*, 1989, 57, 411-45.

[2] Baxter, Marianne and Urban J. Jermann. 1997. "The International Diversification Puzzle is Worse Than You Think." *American Economic Review*, 87:1, pp. 170-180.

[3] Block, Sandra. February 28 1997. "Finding Returns By Investing Close to Home." *USA Today*, 8B.

[4] Bohn Henning and Linda Tesar. 1996. "U.S.Equity Investment in Foreign Markets: Portfolio Rebalancing or Return Chasing?" *American Economic Review,* Vol. 86, No. 2, Papers and Proceedings of the Hundredth and Eighth Annual Meeting of the American Economic Association San Francisco, CA, January 5-7, 1996, pp. 77-81.

[5] Bottazzi, Laura, Paolo Pesenti and Eric van Wincoop. 1996. "Wages, Profits and the International Portfolio Puzzle." *European Economic Review*, 40:2, pp. 219-254.

[6] Brennan, Michael and Henry Cao. 1997. "International Portfolio Investment Flows." *Journal of Finance*, 52:5, 1851-80.

[7] Carroll, Christopher and Lawrence Summers. 1991. "Consumption Growth Parallels Income Growth: Some New Evidence." In B. Douglas Bernheim and John B. Shoven (eds) *National Saving and Economic Performance*, Chicago, Chicago University Press for NBER, 305-43.

[8] Carroll, Christopher D., 1992. "The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence." *Brookings Papers on Economic Activity* no. 2: 61-156.

[9] Carroll, Christopher D., 'Buffer Stock Saving and the Life Cycle / Permanent Income Hypothesis' 1997, Quarterly Journal of Economics, CXII, 1, 3-55.

[10] Cocco F. Joao, Fransisco J. Gomes and Pascal Maenhout. 1997. "Consumption and Portfolio Choice over the Life Cycle". Harvard University Working Paper.

[11] Constantinides, George, John Donaldson and Rajnish Mehra. 1998. "Junior Can't Borrow: A New Perspective on the Equity Premium Puzzle." Working paper, University of Chicago.

[12] Cooper, Ian A and Evi Kaplanis. 1986. "Costs of Cross Border Investment and International Equity Market Equilibrium." In *Recent Advances in Corporate Finance*. Jeremy Edwards, ed. Cambridge: Cambridge University Press.

[13] Coval, Joshua and Tobias Moskowitz. 1999a. "The Geography of Investment: Informed Trading and Asset Prices." CRSP Working Paper No. 502.

[14] ———— 1999b. "Home Bias at Home: Local Equity Preference in Domestic Portfolios." *Journal of Finance*, December, 54(6), pp. 2045-2073.

[15] Davis, Steven and Willen, Paul. 1999. "Using Financial Assets to Hedge Labor Income Risks: Estimating the Benefits." University of Chicago Working Paper.

[16] Deaton Angus, 1991: 'Saving and Liquidity Constraints', *Econometrica*, Vol. 59, No.5, (September, 1991), 1221-1248.

[17] ————- and Laroque G., 1992, 'On the Behavior of Commodity Prices' *Review of Economic Studies*, 59, 1-23.

[18] Feldstein Martin and Charles Horioka. "Domestic Savings and International Capital Flows," *Economic Journal*, June 1980, 90 (358), pp 314-329

[19] French, Kenneth R. and James M. Poterba. 1991. "International Diversification and International Equity Markets." *American Economic Review*, 81:2, pp.222-26.

[20] Gehrig, Thomas P. 1993. "An Information Based Explanation of the Domestic Bias in International Equity Investment." *Scandinavian Journal of Economics*, 95:1, pp. 97-109.

[21] Gourinchas P. and Parker J. "Consumption over the Life Cycle" 1999, Princeton University Working Paper.

[22] Haliassos, Michael and Alexander Michaelides. 1999. "Portfolio Choice and Liquidity Constraints." University of Cyprus working paper.

[23] Heaton John, and Deborah Lucas. 1997. "Market Frictions, Savings Behavior, and Portfolio Choice." *Macroeconomic Dynamics* 1: 76-101.

[24] —— 2000a. "Asset Pricing and Portfolio Choice: The Importance of Entrepreneurial Risk." *Journal of Finance*, 55: no 3.

[25] —- 2000b. "Portfolio Choice in the Presence of Background Risk." *The Economic Journal* 110: 1-26.

[26] Levy H., Sarnat, M., 1970. International Diversification of Investment Portfolios. *American Economic Review*, 60, 668-675.

[27] Lewis, Karen. 1999. "Trying to Explain Home Bias in Equities and Consumption." *Journal of Economic Literature*, Vol. XXXVII pp. 571-608.

[28] Ludvigson Sydney and Alexander Michaelides. "Does Buffer Stock Saving Explain the Smoothness and Excess Sensitivity of Consumption?" forthcoming, *American Economic Review.*

[29] MaCurdy, T. E. 1981. "The use of time series processes to model the error structure of earnings in longitudinal data analysis." *Journal of Econometrics*. 18: 83-114.

[30] Obstfeld, Maurice and Kenneth Rogoff. 2000. "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?" Forthcoming in the *NBER Macroeconomics Annual.*

[31] Paiella, Monica. 2000. "Transaction Costs and Limited Stock Market Participation to Reconcile Asset Prices and Consumption Choices", mimeo.

[32] Pischke Jörn-Steffen, 1995, 'Individual Income, Incomplete Information and Aggregate Consumption' *Econometrica*, Vol.63, No.4, 805-840.

[33] Solnik, Bruno. 1974. "An Equilibrium Model of the International Capital Market." *Journal of Economic Theory.* 8:4, pp. 500-524.

[34] Storeslettern, Kjetil, Telmer Chris and Yaron Amir. "Persistent Idiosyncratic Shocks and Incomplete Markets." Working paper, Carnegie Mellon University, 1998.

[35] Tauchen, George. 1986. "Finite State Markov chain approximations to univariate and vector autoregressions." *Economic Letters* 20: 177-81.

[36] Tesar, Linda and Ingrid Werner. 1995. "Home Bias and High Turnover." *Journal of International Money and Finance*, 14:4, pp. 467-92.

[37] ——- 1998. "The Internationalization of Securities Markets since the 1987 Crash." In *Brookings-Wharton papers on Financial Services.* R Litan and A Santomero (eds). Washington: The Brookings Institution.

[38] Viceira, Luis. 2000. "Optimal Portfolio Choice for Long-Horizon Investors with Non-tradable Labor Income." Forthcoming, *Journal of Finance.*

[39] Vissing-Jorgensen, Annette. 1999. "Towards an Explanation of Household Portfolio Choice Heterogeneity: Nonfinancial Income and Participation Cost Structures", Department of Economics, University of Chicago, mimeo.

Notes

[1]Solnik (1974) derives an international Capital Asset Pricing Model that predicts that the share of wealth in the domestic market should be a constant multiple of the share of wealth invested in the foreign market.

[2]Cooper and Kaplanis (1986) argue that home bias seems to characterize smaller countries as well.

[3]Carroll (1992) generates no borrowing behavior endogenously by assuming that the transitory labor income shock can fall to zero in any given period with a small probability (0.5 percent). Deaton (1991), on the other hand, explicitly imposes a no borrowing liquidity constraint.

[4]Viceira (2000) considers the effects of labor income risk on optimal domestic portfolio choice in a model without liquidity constraints.

[5]Heaton and Lucas (1997, 2000b) and Haliassos and Michaelides (1999) have studied the portfolio choice implications of the model for a single domestic risky asset. Heaton and Lucas (1997) find that such a model predicts complete portfolio specialization in stocks, and that this result is robust to habit persistence, transactions costs, risk aversion, and to an equity premium as low as two percent. Nevertheless, Heaton and Lucas (2000b) find that positive correlation between stock returns and shocks to labor income (or income from business ownership, Heaton and Lucas (2000a)) tends to discourage households from putting all of their wealth in stocks. Haliassos and Michaelides (1999) corroborate these findings for a different labor income process but show that small stock market entry costs are sufficient to generate stock market non-participation because buffer stock savers can smooth idiosyncratic labor income shocks with a small buffer stock of assets. Low wealth accumulation implies that stock market entry has limited benefits and therefore a small cost can deter households from entering the stock market. They conclude that to the extent that the median household behaves like a buffer stock saver (see Carroll (1997)), median stock holding in a population could be zero in the presence of small, stock market entry costs.

[6]This is the generalization of the Heaton and Lucas (1997) domestic portfolio model result in an international setting.

[7]Obstfeld and Rogoff (2000) argue that small transportation costs in the goods market can explain home equity bias; the analysis here differs by considering the effects of small costs in assets markets.

[8]See also Haliassos and Michaelides (1999). In turn, the single domestic risky asset model is a direct generalization of the Deaton (1991) model that only allowed for a single riskless asset.

[9]The lognormality of U_{it} and the assumption about the mean of its logarithm imply that $EU_{it} = \exp(-.5 * \sigma_u^2 + .5 * \sigma_u^2) = 1$ and similarly for EN_{it}.

[10]Although these studies generally suggest that individual earnings changes follow an MA(2), the MA(1) is found to be a close approximation.

[11]If the domestic mean return differs from the foreign mean return, then the condition becomes $\frac{MAX[\mu^f, \mu^d] - \delta}{\rho} + \frac{\rho}{2}\sigma_n^2 < \mu_g + \mu_n$.

[12]See Heaton and Lucas (2000b) and Haliassos and Michaelides (1999).

[13]See Cocco, Gomes and Maenhout (1999) for instance.

[14]Both Haliassos and Michaelides (1999) in the domestic portfolio choice model and Viceira (2000) in a domestic portfolio choice model without liquidity constraints have evaluated the hedging demands arising from this correlation. Both have found that a positive correlation between transitory earnings shocks and stock returns do not generate any hedging demands unless the correlation is (counterfactually) high. They therefore focus on analyzing the effects of correlation between permanent earnings shocks and stock returns, something that we do in this paper as well.

[15]Lewis (1999) uses monthly returns to compute the correlations whereas the current theoretical model is calibrated at an annual frequency. Given the low number of non-overlapping observations that would result from estimating the annual correlations for exchange rate changes post 1973, we use the monthly estimates as indicative of what to expect at an annual frequency.

[16]There is still a slight bias towards domestic equities in the graphs as the exchange rate risk is not completely eliminated due to numerical convergence problems arising from the fact that the domestic and foreign asset become indistinguishable assets when exchange rate risk is completely absent, rendering the Euler equations for domestic and foreign asset choice identical.

[17]Note that this is consistent with the Solnik (1974) model where in the presence of two foreign markets with the same equity premia and variances of returns, half of total wealth is allocated domestically and half is allocated abroad.

[18]In "Finding Returns by Investing Close to Home" Sandra Block writes that a number of fund managers believe that they can obtain abnormal returns by investing in "their own back yard" with the belief that geographic proximity offers them a competitive advantage. She quotes Conrad Herrmann, manager of the Franklin California Growth Fund, as stating: "We have a unique advantage over someone investing from over 3000 miles away. We read the local newspapers, socialize with people that work for these companies, and we can get a sense for how the region is doing." (USA Today, February 28, 1997).

[19]See Appendix B for the computation of the time invariant distribution.

[20]We use the invariant distribution associated with the domestic portfolio choice model to compute $\widehat{x}$ since we are assuming that the household is contemplating entry in the foreign stock market for the first time.

[21]The proof for a mathematically equivalent model of commodity prices with non-negative inventories is given by Deaton and Laroque (1992, theorem 2).

[22]The normalized grid is discretized between $(x\min, x\max)$ where $x\min$ denotes the minimum point on the equally spaced grid and $x\max$ the maximum point.

Table 1: Time Series Moments from varying coefficient of relative risk aversion when both the correlation between the domestic and foreign stock market and the correlation between permanent labor income shocks and domestic stock returns are zero

	$\rho = 2$	$\rho = 5$
Mean Normalized Bond Holdings	0.00	0.00
Mean Normalized Domestic Stock Holdings	0.10	0.10
Mean Normalized Foreign Stock Holdings	0.05	0.06
Mean Normalized Consumption	1.01	1.01
Mean Share of Wealth Invested Domestically	0.61	0.59
Mean Share of Wealth Invested Abroad	0.27	0.31
σ(Normalized Bond Holdings)	0.00	0.00
σ(Normalized Domestic Stock Holdings)	0.08	0.08
σ(Normalized Foreign Stock Holdings)	0.04	0.05
σ(Normalized Consumption)	0.05	0.05
σ(Share of Wealth Invested Domestically)	0.22	0.20
σ(Share of Wealth Invested Abroad)	0.10	0.11
Median Normalized Bond Holdings	0.00	0.00
Median Normalized Domestic Stock Holdings	0.06	0.08
Median Normalized Foreign Stock Holdings	0.03	0.04
Median Normalized Consumption	1.00	1.01
Median Share of Wealth Invested Domestically	0.68	0.65
Median Share of Wealth Invested Abroad	0.32	0.35
σ(Normalized Earnings)	0.10	0.10

Notes to Table 1: Normalized variables are normalized with respect to the permanent component of labor income (P_{it} in the text). The reported numbers are generated using the time invariant distributions associated with each model, as described in the text. Other parameters are: $\delta = .05$, mean equity premium is 6 percent in both the domestic and foreign stock market, standard deviation of excess returns is 18 percent in both markets, the standard deviation of the exchange rate is 13 percent, $\sigma_u = .1, \sigma_n = .08$. When no saving takes place, the share of wealth in domestic stocks is set to zero.

Table 2: Time Series Moments from varying coefficient of relative risk aversion when the correlation between the domestic and foreign stock market is zero while the correlation between permanent labor income shocks and domestic stock returns equals 0.3

	$\rho = 2$	$\rho = 5$
Mean Normalized Bond Holdings	0.00	0.00
Mean Normalized Domestic Stock Holdings	0.00	0.00
Mean Normalized Foreign Stock Holdings	0.14	0.15
Mean Normalized Consumption	1.01	1.01
Mean Share of Wealth Invested Domestically	0.00	0.00
Mean Share of Wealth Invested Abroad	0.87	0.89
σ(Normalized Bond Holdings)	0.00	0.00
σ(Normalized Domestic Stock Holdings)	0.01	0.01
σ(Normalized Foreign Stock Holdings)	0.13	0.13
σ(Normalized Consumption)	0.05	0.05
σ(Share of Wealth Invested Domestically)	0.01	0.01
σ(Share of Wealth Invested Abroad)	0.33	0.32
Median Normalized Bond Holdings	0.00	0.00
Median Normalized Domestic Stock Holdings	0.00	0.00
Median Normalized Foreign Stock Holdings	0.08	0.09
Median Normalized Consumption	1.01	1.01
Median Share of Wealth Invested Domestically	0.00	0.00
Median Share of Wealth Invested Abroad	1.00	1.00
σ(Normalized Earnings)	0.10	0.10

Notes to Table 2: See Table 1.

Table 3: Time Series Moments from varying coefficient of relative risk aversion when the correlation between the domestic and foreign stock market is 0.3 and 0.7 while the correlation between permanent labor income shocks and domestic stock returns equals zero

	Correlation is 0.3		Correlation is 0.7	
	$\rho = 2$	$\rho = 5$	$\rho = 2$	$\rho = 5$
Mean Normalized Bond Holdings	0.00	0.00	0.00	0.00
Mean Normalized Domestic Stock Holdings	0.10	0.11	0.12	0.13
Mean Normalized Foreign Stock Holdings	0.05	0.05	0.02	0.03
Mean Normalized Consumption	1.01	1.01	1.01	1.01
Mean Share of Wealth Invested Domestically	0.61	0.63	0.76	0.77
Mean Share of Wealth Invested Abroad	0.27	0.27	0.12	0.12
σ(Normalized Bond Holdings)	0.00	0.00	0.00	0.00
σ(Normalized Domestic Stock Holdings)	0.08	0.09	0.10	0.10
σ(Normalized Foreign Stock Holdings)	0.04	0.04	0.03	0.03
σ(Normalized Consumption)	0.05	0.05	0.05	0.05
σ(Share of Wealth Invested Domestically)	0.23	0.22	0.29	0.27
σ(Share of Wealth Invested Abroad)	0.10	0.10	0.07	0.07
Median Normalized Bond Holdings	0.00	0.00	0.00	0.00
Median Normalized Domestic Stock Holdings	0.06	0.09	0.08	0.11
Median Normalized Foreign Stock Holdings	0.03	0.04	0.01	0.02
Median Normalized Consumption	1.00	1.01	1.00	1.01
Median Share of Wealth Invested Domestically	0.68	0.69	0.88	0.86
Median Share of Wealth Invested Abroad	0.32	0.31	0.12	0.14
σ(Normalized Earnings)	0.10	0.10	0.10	0.10

Notes to Table 3: See Table 1.

Table 4: Fixed Costs Generating Home Equity Bias

	I. Equity Premium = 6%, C1=0,C2=0	II. Equity Premium = 6%, C1=0.3,C2=0
$\rho = 2$	1.0	6.4
$\rho = 5$	2.6	15.4
	III. Equity Premium = 6%, C1=0,C2=0.3	**IV. Equity Premium = 6%, C1=0,C2=0, No FX risk**
$\rho = 2$	0.6	1.5
$\rho = 5$	1.7	3.6

Notes to Table 4: The table reports the fixed costs necessary to generate foreign stock market non-participation as a percentage of mean labor income (at an annual horizon). C1 is the correlation between the permanent labor income shocks and the stock market return innovations. C2 is the correlation between the domestic and the foreign stock market innovations. No FX risk refers to the case where there is no foreign exchange rate risk. ρ is the CRRA coefficient. The discount rate equals five percent, the mean earnings growth rate equals 3 percent, the standard deviation of permanent shocks (σ_n) equals .08 and the standard deviation of transitory shocks (σ_u) equals .1. The standard deviation of foreign and domestic stock market returns is set at 18 percent, the equity premium is set to six percent in both domestic and foreign markets and the standard deviation of exchange rate changes is set to 9 percent.

No correlations; ρ=2 or 5

Fig.1 : Normalized Consumption

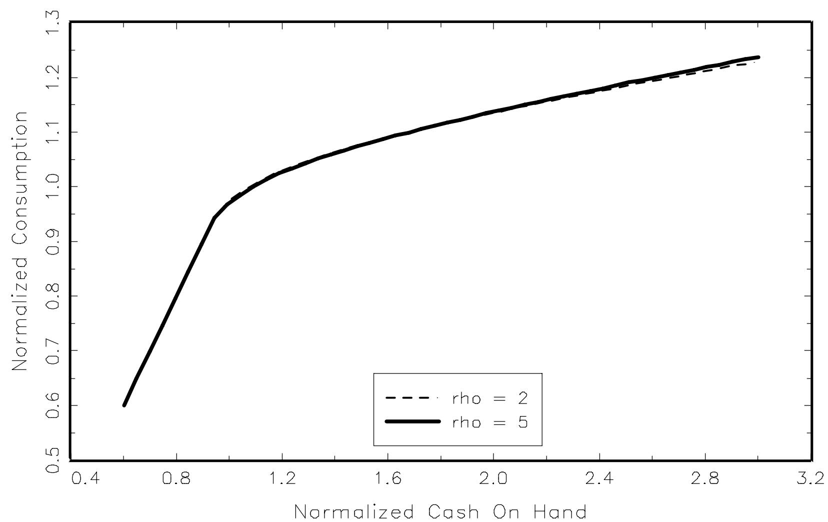


Fig.2 : Share of Wealth in Domestic Stocks

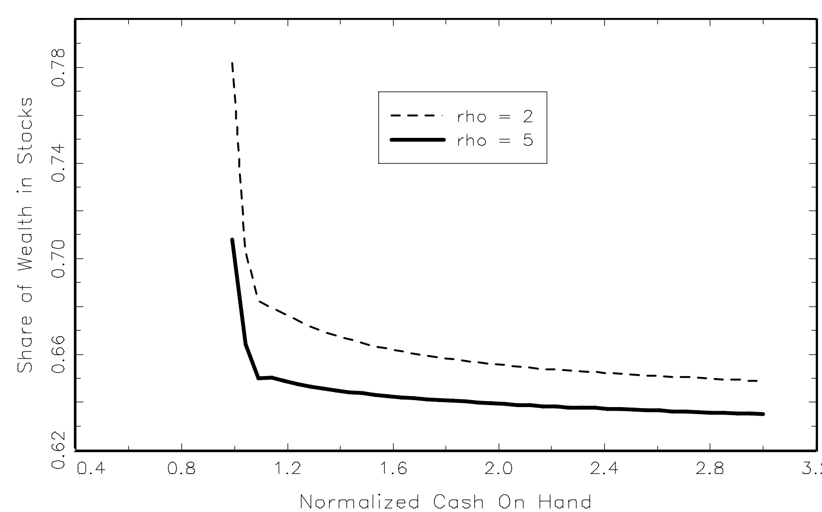


Fig.3 : Share of Wealth in Foreign Stocks

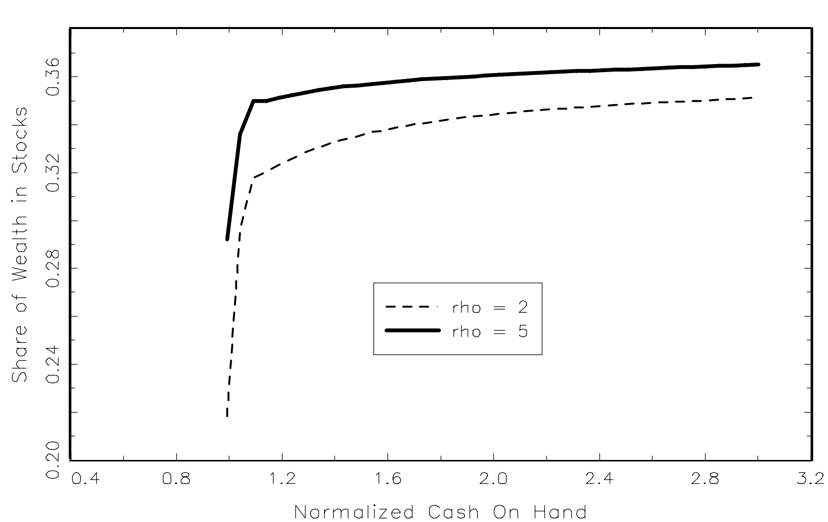
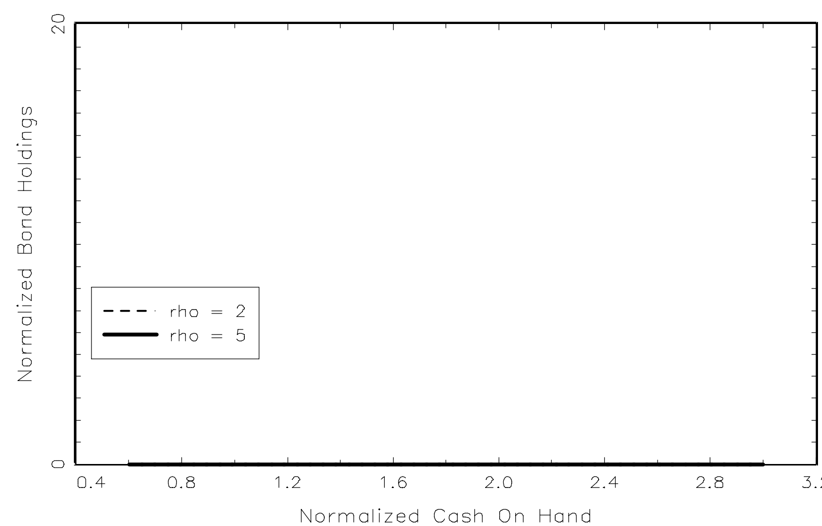


Fig.4 : Normalized Bond Holdings



Correlation between permanent earnings and domestic stocks = 0.3; ρ=2 or 5

Fig.5 : Normalized Consumption

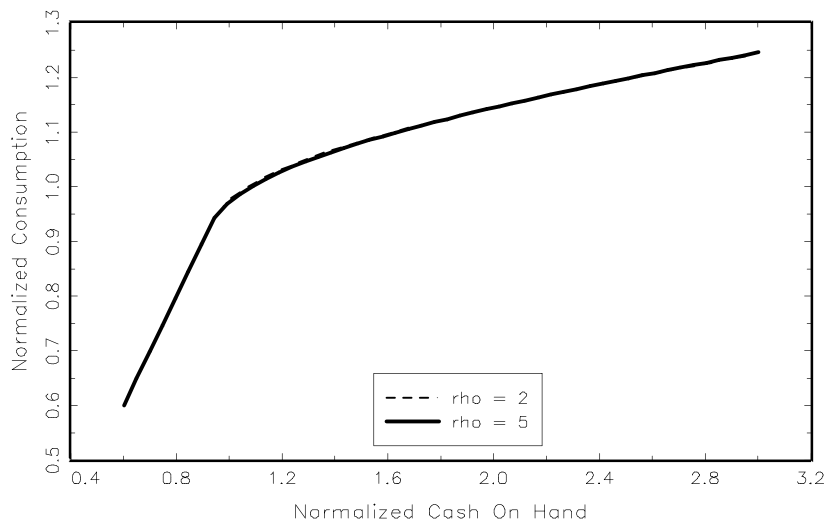


Fig.6 : Share of Wealth in Domestic Stocks

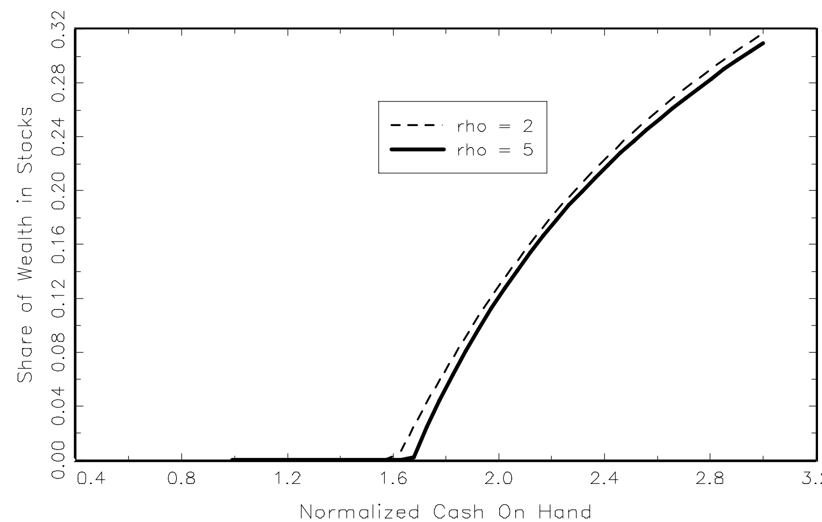


Fig.7 : Share of Wealth in Foreign Stocks

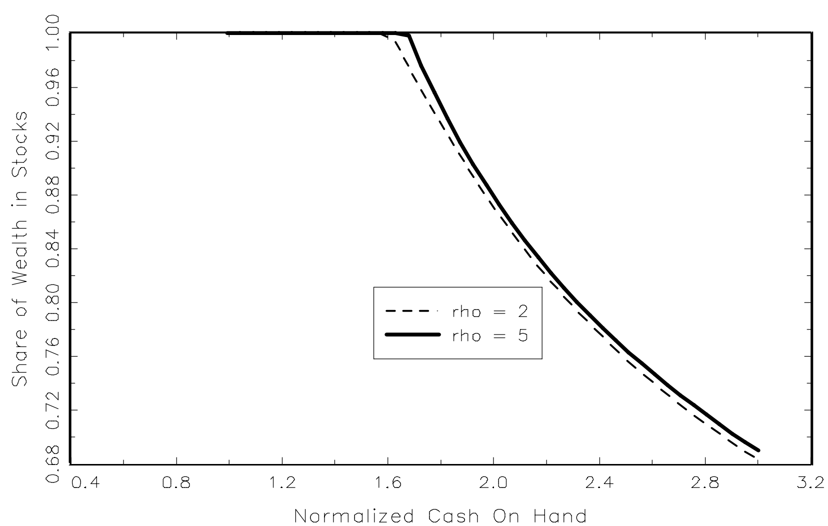
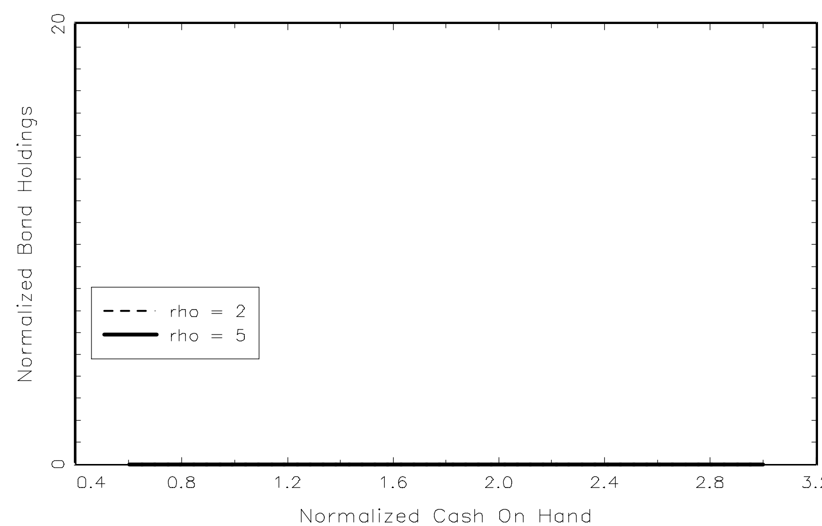


Fig.8 : Normalized Bond Holdings



Correlation between domestic and foreign stocks is either 0.3 or 0.7; $\rho=2$

Fig.9 : Normalized Consumption

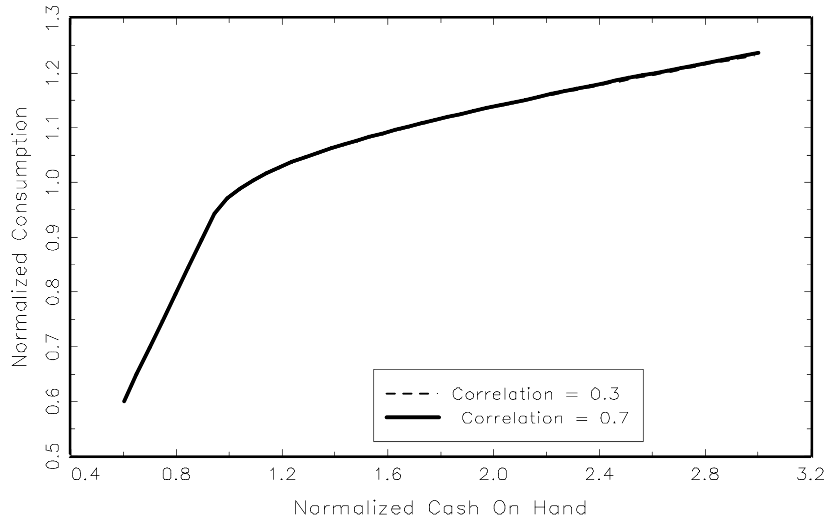


Fig.10 : Share of Wealth in Domestic Stocks

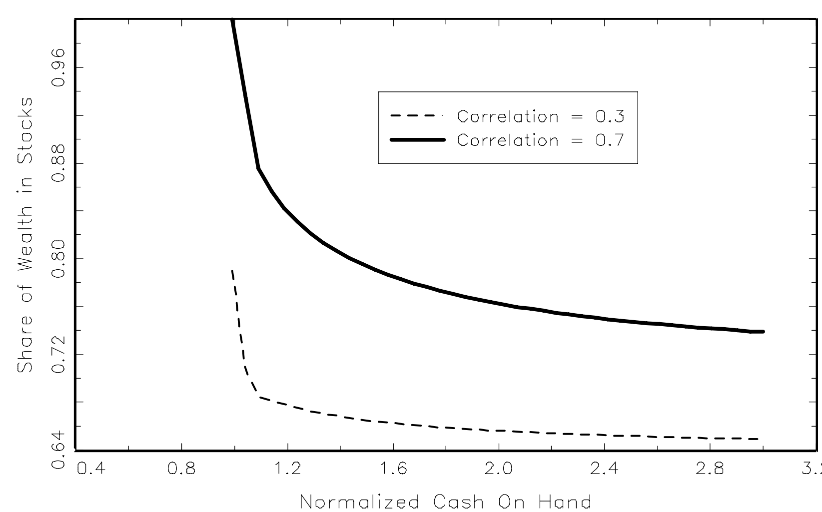


Fig.11 : Share of Wealth in Foreign Stocks

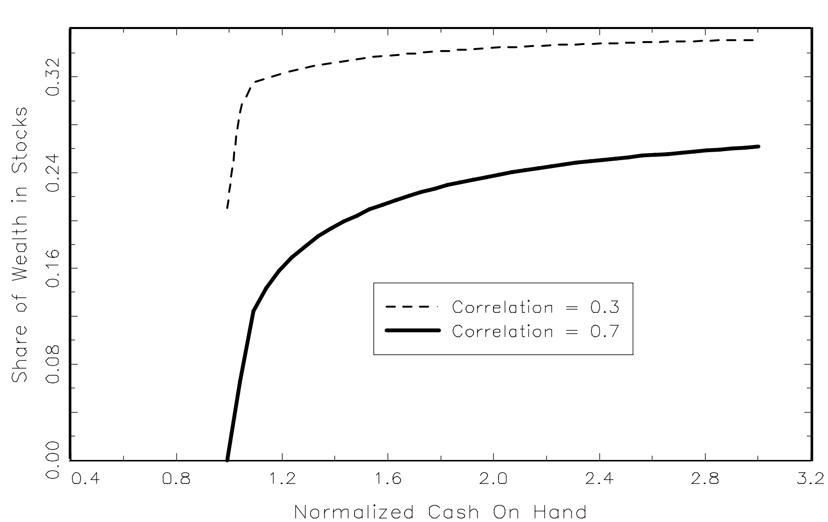
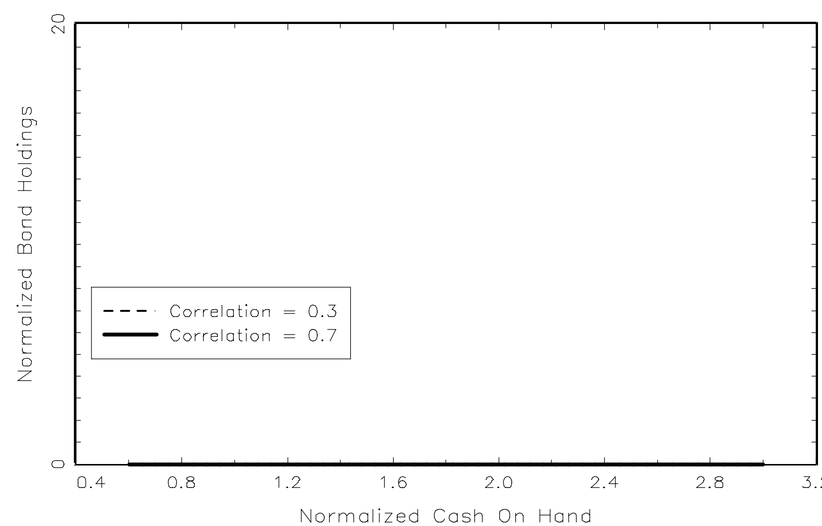


Fig.12 : Normalized Bond Holdings



Varying exchange rate risk and correlation between earnings–domestic stocks, ρ=2 or 5

Fig.13 : Share of Wealth in domestic stocks

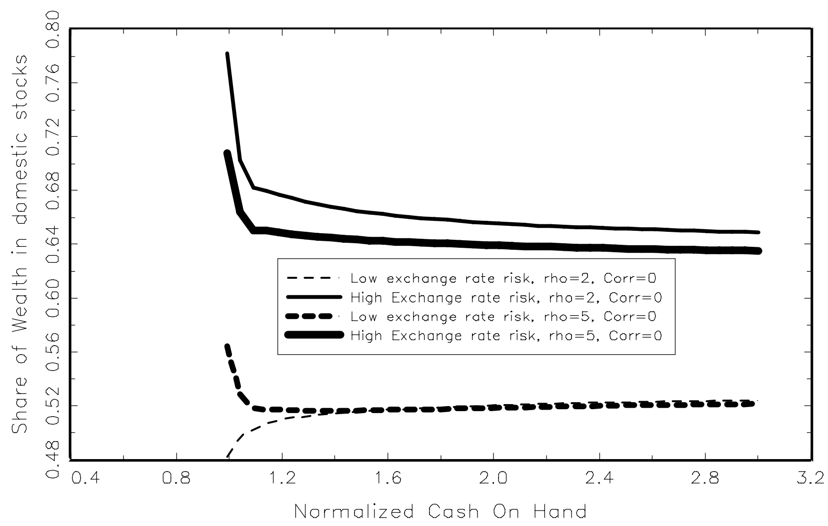


Fig.14 : Share of Wealth in Foreign Stocks

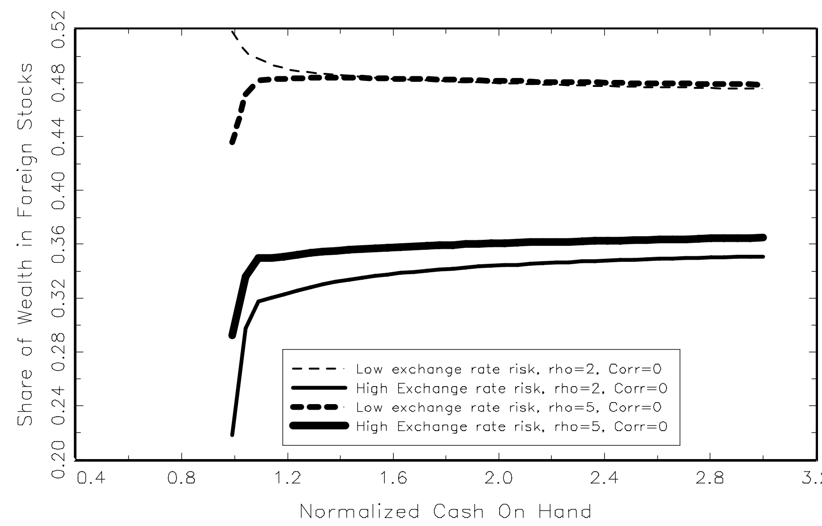


Fig.15 : Share of Wealth in Domestic Stocks

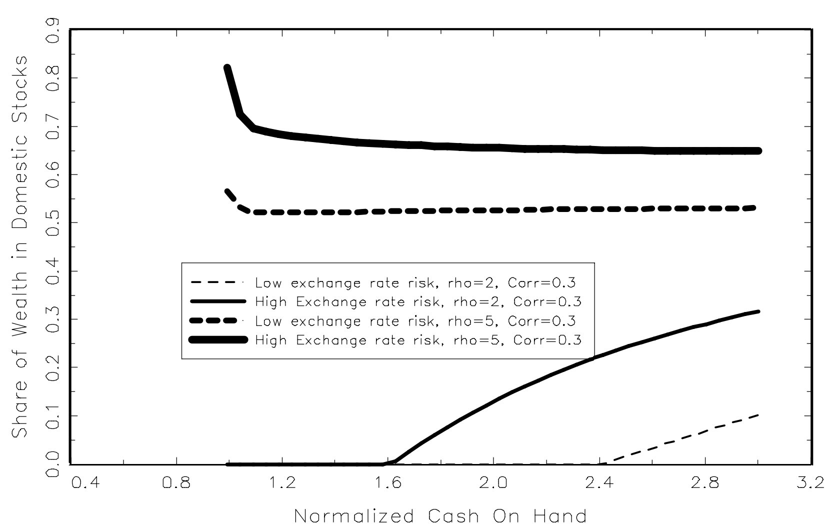


Fig.16 : Share of Wealth in Foreign Stocks

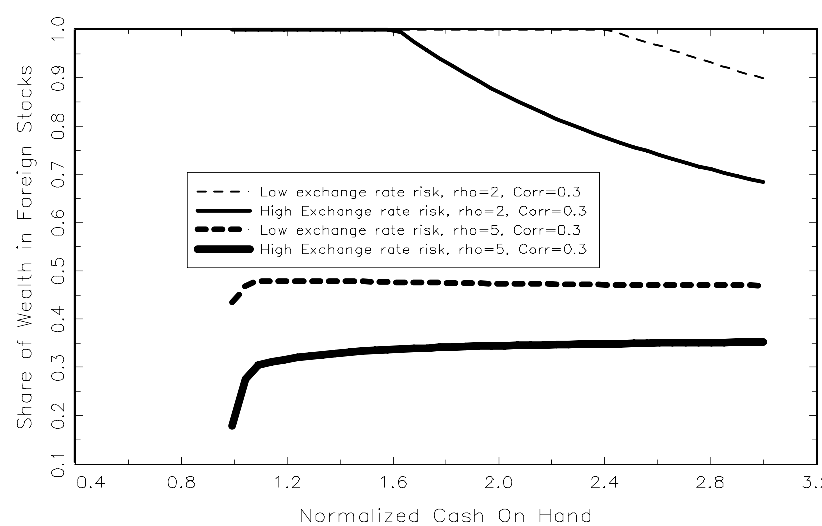


Fig.17 : Invariant Distributions: No Correlations

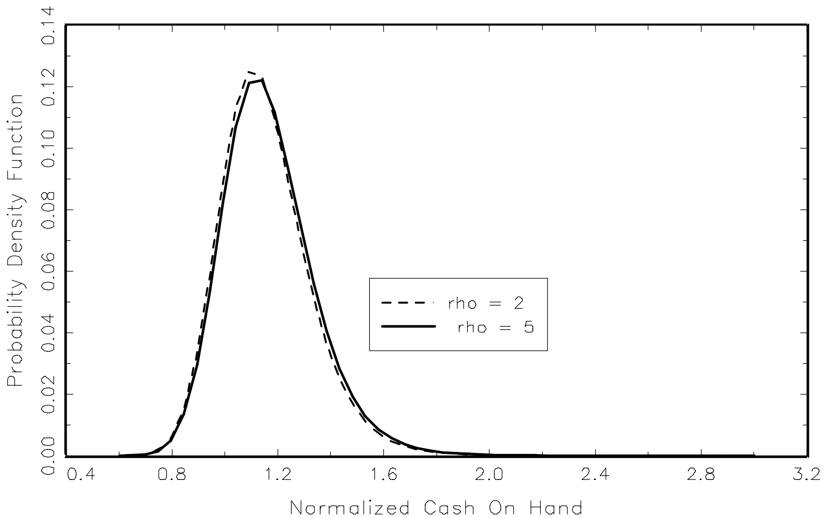


Fig.18 : Invariant Distribution: Corr Dom Stocks/Earnings =0.3

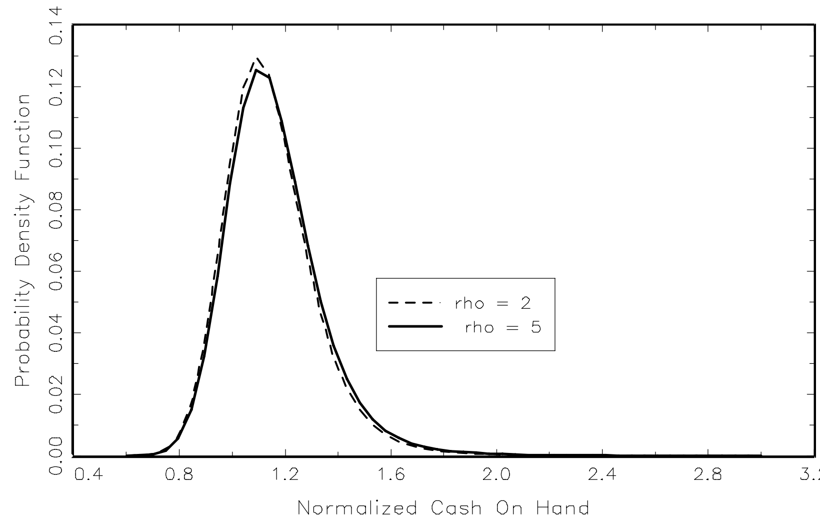


Fig.19 : Threshold Foreign Market Entry Costs

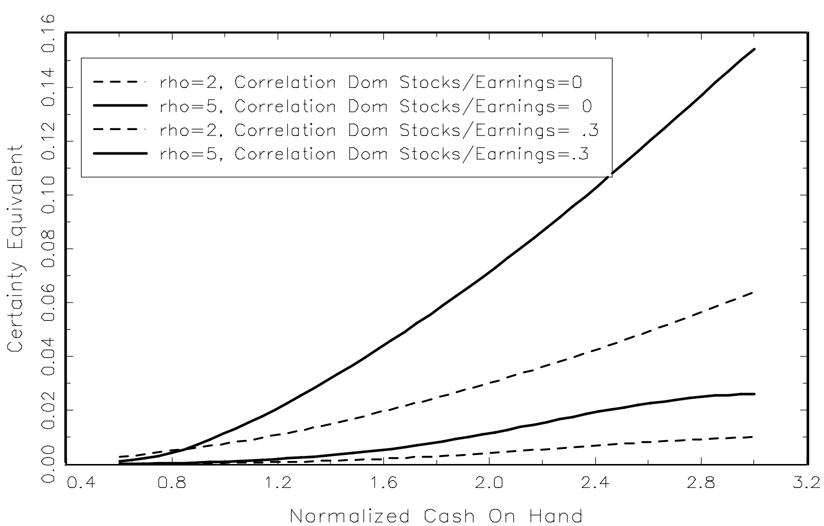
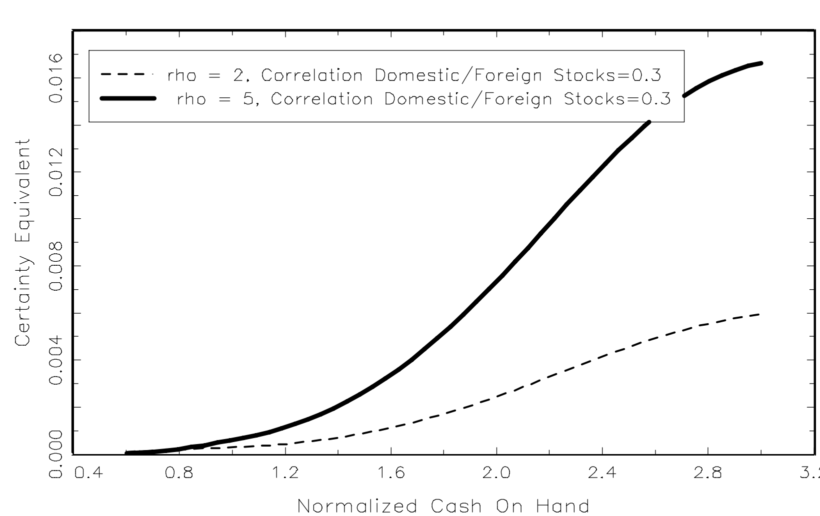


Fig.20 : Threshold Foreign Market Entry Costs



SELECTED RECENT PUBLICATIONS

Anil K. Bera and Yannis Bilias, Rao´s Score, Neyman´s C (α) and Silvey´s LM Tests: An Essay on Historical Developments and Some New Results, *Journal of Statistical Planning and Inference,* forthcoming.

Bertaut C. and M. Haliassos, Precautionary Portfolio Behavior from a Life - Cycle Perspective, *Journal of Economic Dynamics and Control*, 21, 1511-1542, 1997.

Bilias Y., Minggao Gu and Zhiliang Ying, Towards a General Asymptotic Theory for the Cox model with Staggered Entry, *The Annals of Statistics*, 25, 662-682, 1997.

Blundell R., P. Pashardes and G. Weber, What Do We Learn About Consumer Demand Patterns From Micro-Data?, *American Economic Revie*w, 83, 570-597, 1993.

Bougheas S., P. Demetriades and T. P. Mamouneas, Infrastructure, Specialization and Economic Growth, *Canadian Journal of Economics,* forthcoming.

Caporale W., C. Hassapis and N. Pittis, Unit Roots and Long Run Causality: Investigating the Relationship between Output, Money and Interest Rates, *Economic Modeling*, 15(1), 91-112, January 1998.

Caporale G. and N. Pittis, Efficient estimation of cointegrated vectors and testing for causality in vector autoregressions: A survey of the theoretical literature, *Journal of Economic Surveys*, forthcoming.

Caporale G. and N. Pittis, Unit root testing using covariates: Some theory and evidence, *Oxford Bulletin of Economics and Statistics*, forthcoming.

Caporale G. and N. Pittis, Causality and Forecasting in Incomplete Systems, *Journal of Forecasting*, 16, 6, 425-437, 1997.

Clerides K. S., Lach S. and J.R. Tybout, Is Learning-by-Exporting Important? Micro-Dynamic Evidence from Colombia, Morocco, and Mexico, *Quarterly Journal of Economics* 113(3), 903- 947, August 1998.

Cukierman A., P. Kalaitzidakis, L. Summers and S. Webb, Central Bank Independence, Growth, Investment, and Real Rates", Reprinted in Sylvester Eijffinger (ed), Independent Central Banks and Economic Performance, Edward Elgar, 416-461, 1997.

Dickens R., V. Fry and P. Pashardes, Non-Linearities and Equivalence Scales, *The Economic Journa*l, 103, 359-368, 1993.

Demetriades P. and T. P. Mamuneas, Intertemporal Output and Employment Effects of Public Infrastructure Capital: Evidence from 12 OECD Economies, *Economic Journal*, July 2000.

Eicher Th. and P. Kalaitzidakis, The Human Capital Dimension to Foreign Direct Investment: Training, Adverse Selection and Firm Location”. In Bjarne Jensen and Kar-yiu

Wong (eds), Dynamics,Economic Growth, and International Trade, The University of Michigan Press, 337-364, 1997.

Fry V. and P. Pashardes, Abstention and Aggregation in Consumer Demand, *Oxford Economic Paper*s, 46, 502-518, 1994.

Gatsios K., P. Hatzipanayotou and M. S. Michael, International Migration, the Provision of Public Good and Welfare, *Journal of Development Economics*, 60/2, 561-577, 1999.

Haliassos M. and C. Hassapis, Non-expected Utility, saving, and Portfolios, *The Economic Journal*, 110, 1-35, January 2000.

Haliassos M. and J. Tobin, The Macroeconomics of Government Finance, reprinted in J.Tobin, Essays in Economics, vol. 4, Cambridge: MIT Press, 1996.

Haliassos M. and C. Bertaut, Why Do So Few Hold Stocks?, *The Economic Journal*, 105, 1110- 1129, 1995.

Haliassos M., On Perfect Foresight Models of a Stochastic World, *Economic Journal*, 104, 477-491, 1994.

Hassapis C., N. Pittis and K. Prodromidis, Unit Roots and Granger Causality in the EMS Interest Rates: The German Dominance Hypothesis Revisited, *Journal of International Money and Finance*, 18(1), 47-73, 1999.

Hassapis C., S. Kalyvitis and N. Pittis, Cointegration and Joint Efficiency of International Commodity Markets", *The Quarterly Review of Economics and Finance,* 39, 213-231, 1999.

Hassapis C., N. Pittis and K. Prodromides, EMS Interest Rates: The German Dominance Hypothesis or Else?" in European Union at the Crossroads: A Critical Analysis of Monetary Union and Enlargement, Aldershot, UK., Chapter 3, 32-54, 1998. Edward Elgar Publishing Limited.

Hatzipanayotou P., and M. S. Michael, General Equilibrium Effects of Import Constraints Under Variable Labor Supply, Public Goods and Income Taxes, *Economica*, 66, 389-401, 1999.

Hatzipanayotou, P. and M.S. Michael, Public Good Production, Nontraded Goods and Trade Restriction, *Southern Economic Journal,* 63, 4, 1100-1107, 1997.

Hatzipanayotou, P. and M. S. Michael, Real Exchange Rate Effects of Fiscal Expansion Under Trade Restrictions, *Canadian Journal of Economics,* 30-1, 42-56, 1997.

Kalaitzidakis P., T. P. Mamuneas and Th. Stengos, A Nonlinear Sensitivity Analysis of Cross-Country Growth Regressions, *Canadian Journal of Economics,* forthcoming.

Kalaitzidakis P., T. P. Mamuneas and Th. Stengos, European Economics: An Analysis Based on Publications in Core Journals, *European Economic Revie*w, 1999.

Kalaitzidakis P., On-the-job Training Under Firm-Specific Innovations and Worker Heterogeneity, *Industrial Relations*, 36, 371-390, July 1997.

Ludvigson S. and A. Michaelides, Does Buffer Stock Saving Explain the Smoothness and Excess Sensitivity of Consumption?, *American Economic Review*, forthcoming.

Lyssiotou Panayiota, Dynamic Analysis of British Demand for Tourism Abroad, *Empirical Economics*, forthcoming, 2000.

Lyssiotou P., P. Pashardes and Th. Stengos, Testing the Rank of Engel Curves with Endogenous Expenditure, *Economics Letters*, 64, 61-65, 1999.

Lyssiotou P., P. Pashardes and Th. Stengos, Preference Heterogeneity and the Rank of Demand Systems, *Journal of Business and Economic Statistics*, 17 (2), 248-252, April 1999.

Lyssiotou Panayiota, Comparison of Alternative Tax and Transfer Treatment of Children using Adult Equivalence Scales, *Review of Income and Wealth*, 43 (1), 105-117, March 1997.

Mamuneas, Theofanis P., Spillovers from Publicly – Financed R&D Capital in High-Tech Industries, *International Journal of Industrial Organization*, 17(2), 215-239, 1999.

Mamuneas, T. P. and Nadiri M. I., R&D Tax Incentives and Manufacturing-Sector R&D Expenditures, in *Borderline Case: International Tax Policy, Corporate Research and Development, and Investment*, James Poterba (ed.), National Academy Press, Washington D.C., 1997. Reprinted in *Chemtech*, 28(9), 1998.

Mamuneas, T. P. and Nadiri M. I., Public R&D Policies and Cost Behavior of the US Manufacturing Industries, *Journal of Public Economics*, 63, 57-81, 1996.

Michaelides A. and Ng, S., Estimating the Rational Expectations Model of Speculative Storage: A Monte Carlo Comparison of three Simulation Estimators, *Journal of Econometrics*, forthcoming.

Pashardes Panos, Equivalence Scales in a Rank-3 Demand System, *Journal of Public Economics*, 58, 143-158, 1995.

Pashardes Panos, Bias in Estimating Equivalence Scales from Grouped Data, *Journal of Income Distribution*, Special Issue: Symposium on Equivalence Scales, 4, 253-264,1995.

Pashardes Panos., Bias in Estimation of the Almost Ideal Demand System with the Stone Index Approximation, *Economic Journal*, 103, 908-916, 1993.

Spanos Aris, Revisiting Date Mining: ´Hunting´ With or Without a License, *Journal of Methodology*, July 2000.

Spanos Aris, On Normality and the Linear Regression Model, *Econometric Reviews*, 14,195-203, 1995.

Spanos Aris, On Theory Testing in Econometrics: Modeling with nonexperimental Data, *Journal of Econometrics*, 67, 189-226, 1995.

Spanos Aris, On Modeling Heteroscedasticity: The Student's t and Elliptical Linear Regression Models, *Econometric Theory*, 10, 286-315, 1994.