Non-Equity Risks and Equity Home Bias

Timothy K. Chue*

May 2013

*School of Accounting & Finance, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong. E-mail: Timothy.Chue@polyu.edu.hk. Tel: +(852) 2766-4995. Fax: +(852) 2330-9845. I wish to thank an anonymous referee, Philippe Bacchetta, John Campbell, Lewis Chan, David Cook, Bernard Dumas, Enrique Mendoza, David Ng, Tarun Ramadorai, Wilson Tong, Yong Wang, Steven Wei, Mungo Wilson, Wayne Yu, Chu Zhang, and seminar participants at the North American Summer Meetings of the Econometric Society, the European Finance Association Annual Meeting, the American Finance Association Annual Meeting, and the Australasian Finance & Banking Conference for valuable comments and suggestions. Research support from the Research Grants Council of the Hong Kong Special Administrative Region, China (Project No. PolyU6206/04H), is gratefully acknowledged.

Non-Equity Risks and Equity Home Bias

Abstract

A long literature focuses on equity risks only to conclude that the benefits in holding foreign stocks are substantial, and investors in practice allocate a much too heavy weight of their portfolios to domestic securities. We re-examine this conclusion by using a consumption-based approach, which can take the effects of nontraded wealth into account, even when its returns are not observable. Although there are significant benefits from further international *consumption* risk sharing, these benefits are not attainable using international equities as instruments. These findings are consistent with the ideas of Shiller (1993, 2003) and Athanasoulis and Shiller (2001), who argue that the world's largest macroeconomic risks cannot be effectively shared using existing securities.

JEL Classification Numbers: F41; G11; G15.

Keywords: Equity home bias; International risk sharing; Non-equity risks; Euler equations; Consumption-based models.

1 Introduction

Many previous studies use equity data only to examine the so-called "home bias" phenomenon. Taking the distribution of international equity returns as given, researchers calculate the optimal portfolio allocations that investors should hold. When these theoretical allocations are confronted with investors' actual equity portfolios, which contain a much heavier weight in domestic securities, the investors are said to exhibit "home bias". In essence, these studies show that *foreign equities* can help diversify away *domestic equity risks*, and it is puzzling why investors leave these benefits unexploited.

However, when non-equity wealth has a significant impact on investors' consumption decisions, equity and consumption risks are not the same.[1] And if investors' utility depends on consumption (rather than on equity wealth *per se*), it is consumption risks (rather then equity risks *per se*) that affect investors' welfare. Thus, in evaluating the optimality of investors' home bias in their equity portfolios, one should examine whether *foreign equities* can help diversify away *domestic consumption risks*.

Despite this need to incorporate non-equity wealth into the study of investors' international portfolio choice, to do so in practice poses a formidable challenge, as many components of non-equity wealth are non-traded and their returns not observable. This challenge is at the heart of the debate of whether human capital can help explain equity home bias. Specifically, Baxter and Jermann (1997) find that taking human capital into account deepens the equity home bias puzzle. On the other hand, Bottazzi, Pesenti, and van Wincoop (1996), Palacios-Huerta (2001), and Julliard (2002, 2004) find the opposite result. Engel and Matsumoto (2009) present a DSGE model that, conditional on the nominal exchange rate and with sticky prices, generates a negative correlation between human capital return and the relative return on domestic and foreign equities. Since human capital is not traded and its return not observed, it is controversial how one parametrizes the correlation structure

[1] Heaton and Lucas (2000) find that there is considerable variation across different households in their equity holdings. But even for the age and wealth category of households with the heaviest portfolio weights in equities, the median holding of stocks as a fraction of total assets is still just 17.7%.

Electronic copy available at: http://ssrn.com/abstract=887280

between the return on human capital and equities, and this controversy is the underlying reason for why these studies obtain different conclusions.

We overcome this challenge by evaluating the optimality of equity home bias through examining an investor's Euler equations from optimization, rather than by solving the portfolio choice problem explicitly. In this way, we can take the returns on non-equity wealth into account without having to parametrize or even measure those returns directly. Returns from equities or other sources lead to fluctuations in wealth, which, in turn, cause investors to change their consumption. When investors' marginal utility is a function of consumption only, consumption data already summarize the impact of all components of wealth on the stochastic discount factor, and there is no need to measure their returns directly. By contrast, the traditional portfolio choice approach needs to measure and/or parametrize the returns on all components of wealth before the optimal portfolio allocation can be solved for, and compared with the actual allocation.

Since our Euler equation approach does not require explicit solutions for the optimal consumption and portfolio allocations, our approach does not require any parametric specification of the equity return distributions. This feature is important because specific parametrizations of stock returns are arbitrary, and portfolio problems can be difficult to solve, in the presence of general utility functions and return distributions.

Our approach is related to the work of Lustig and Van Nieuwerburgh (2008), who also use information contained in aggregate consumption growth to infer properties of the unobserved human capital return series. In particular, they find that the returns on financial and human wealth in the U.S. are negatively correlated. But even with Lustig and Van Nieuwerburgh's insight, the consumption-portfolio problem may still be intractable if we follow the traditional portfolio choice approach and allow for general utility functions and return distributions. This concern is particularly important in our context, as those utility specifications that have been found successful in explaining domestic stock returns—thus more likely depict actual investor preferences—are also those that do not readily lend themselves to tractable solutions in portfolio choice problems.

By contrast, our Euler equation approach can be applied, as long as an expression for the stochastic discount factor can be derived. This feature allows us to examine Lettau and Ludvigson's (2001a, b) preference specification—which is a leading consumption-based model that has strong explanatory power for the cross section of expected returns—and yet does not even specify a particular functional form for the utility function, thus ruling out its examination if one takes the traditional portfolio optimization route.

Using this Euler equation approach, we find that the benefit of foreign equities in diversifying domestic consumption risks is not statistically significant, with its point estimate often negative. We show that this finding is not due to mean returns or preference parameters being imprecisely estimated. Rather, it is the covariance structure between domestic consumption risks and foreign equity returns that drives these results. In particular, by replacing foreign equities by hypothetical securities that mimic foreign consumption growth, the benefit of diversification becomes both statistically and economically significant. These results suggest policy implications consistent with the proposals of Shiller (1993, 2003) and Athanasoulis and Shiller (2001), who argue that in order to share the world's largest macroeconomic risks, new securities or contracts have to be introduced. Our finding is also consistent with other recent studies. Brandt, Cochrane, and Santa-Clara (2006) show that the degree of international risk sharing using equities is already high and there is not much room for further risk sharing using existing securities. Heathcote and Perri (2007) show that equity home bias can arise as a result of fluctuations in international relative prices, which, in turn, make domestic assets a good hedge against labor income risks.

Our work provides a link between the equity home bias phenomenon and the vast literature on consumption-based asset pricing. At a fundamental level, this link should not come as a surprise: To decide whether or not home bias in equities is optimal requires us to assess the relative riskiness of domestic versus foreign securities. But a security's riskiness at the aggregate level, in turn, depends on its covariance with the representative agent's marginal utility defined over consumption. Thus, to properly assess a security's riskiness, we need accurate measures of the representative agent's marginal utility. This is the reason why we base our analysis on the preference specification of Lettau and Ludvigson (2001a, b), whose use of the log consumption-wealth ratio as a conditioning variable generates vast improvement in the explanatory power of their model over the basic consumption CAPM. But of course, Lettau and Ludvigson's specification is by no means the only model that can explain domestic returns. Indeed, Colacito and Croce (2011) and Stathopoulos (2012), respectively, make use of long run consumption risks and external consumption habits—two other variations to the basic consumption model—to justify equity home bias.

Our work is also related to previous studies that use either equity or consumption data to study international risk sharing. Lewis (1999) discusses the relationship between the equity-based and consumption-based studies in general, and Lewis (2000) carefully analyzes the reasons why they imply different estimates of diversification benefits. Here, we use *both* equity and consumption data, and examine the benefits to holding more foreign *equities* from a *consumption-based* perspective. As Lewis (1999) emphasizes, since equities make up only a fraction of investors' total wealth, the presence of equity home bias is neither necessary nor sufficient for the presence of consumption home bias. Lewis (1999) goes on to point out that, if firms that produce nontradables are less likely to be public companies, nontradables risks can constitute an additional component of non-equity risks. Lewis and Liu (2012) make use of persistent consumption risks to match the mean and variance of the equity premium and the riskfree rate, and find that the benefit of international risk sharing declines as the importance of the persistent component rises.

We organize the remainder of this paper as follows. Section 2 demonstrates that there is a close link between the home bias phenomenon and the Euler equations that characterize investors' optimal portfolios. Section 3 discusses our empirical estimation strategy for the optimality of investors' portfolios. Section 4 reports the estimation results. Section 5 decomposes the Euler equation pricing errors into two components, one related to the difference in mean returns on international equities and the other related to the difference in their diversification benefit for domestic consumption risks. Section 6 examines if there is room for further consumption risk sharing, by the use of hypothetical securities constructed to mimic the correlation structure of international consumption growth rates. Section 7 concludes.

2 Home bias and Euler equations

To see the link between the home bias phenomenon and the Euler equations of an investor's optimization problem, we examine an investor who has wealth $W_t > 0$ at time t and wants to use this wealth to maximize the expected utility,

$$E_t \sum_{j=0}^{\infty} \delta^j U\left(C_{t+j}\right), \qquad 0 < \delta < 1, \tag{1}$$

where δ is the investor's subjective discount factor and C_{t+j} is her consumption in period $t+j$. To finance future consumption, the investor can transfer wealth over time through the holding of one risk-free bond and N non-redundant, risky securities. We index the N risky securities as securities 1 to N, and denote the real gross return of security i between the end of period t and the end of period $t+1$ as $R_{i,t+1}$, $i = 1, ..., N$. The real gross risk-free return covering the same time period is denoted $R_{f,t}$.[2] Let F_t denote the investor's gross payout on her risk-free bond holdings between the end of period t and the end of period $t+1$, payable in period $t+1$, with a present value of $F_t/R_{f,t}$ at time t. $F_t < 0$ indicates that the investor borrows funds by issuing bonds. The investor holds $s_{i,t}$ number of shares of risky security i between the end of period t and the end of period $t+1$, where a negative number indicates a short position. A share of security i entitles the owner to its dividend stream $d_{i,t}$. Suppose $p_{i,t}$ denote the ex-dividend price of security i at the end of period t, then $R_{i,t+1} \equiv \left(p_{i,t+1} + d_{i,t+1}\right)/p_{i,t}$. Using these notations, the investor's budget constraint in period t becomes

$$C_t + F_t/R_{f,t} + \sum_{i=1}^{N} p_{i,t} s_{i,t} \leq W_t, \tag{2}$$

and her next period's financial wealth is given by

$$W_{t+1} = F_t + \sum_{i=1}^{N} (p_{i,t+1} + d_{i,t+1}) s_{i,t} + Y_{t+1}, \tag{3}$$

[2] The time t subscript denotes the fact that the risk-free return from period t to $t+1$ is known at time t.

where Y_{t+1} is a non-negative random variable that represents the investor's non-equity income in period $t+1$.

The investor's optimization problem (1) is a dynamic programming problem with controls F_t and $s_{i,t}$, $i = 1, ..., N$. The first-order conditions associated with the controls F_t and $s_{i,t}$ are given by the following $N+1$ Euler equations:

$$E_t \left[\frac{\delta U'(C_{t+1})}{U'(C_t)} \right] R_{f,t} = 1, \tag{4}$$

$$E_t \left[\frac{\delta U'(C_{t+1})}{U'(C_t)} R_{i,t+1} \right] = 1, \quad i = 1, ..., N. \tag{5}$$

We assume that the utility function $U(\cdot)$ is concave, strictly increasing, and twice continuously differentiable. These assumptions on $U(\cdot)$, together with the fact that none of the risky securities is redundant ensure the solutions to (4) and (5) are interior, global maxima to the problem (1).[3] Further, when C_t denotes domestic aggregate consumption, and $U'(C_t)$ marginal utility of the domestic representative agent, the Euler equations (4) and (5) are the representative agent's optimality conditions.

Since the seminal work of Lucas (1978), these Euler equations for the representative agent have been used for asset pricing, *taking investor optimization as given.* Our analysis also examines these Euler equations, but our interest is not in asset pricing—in particular, we are not claiming that domestic aggregate consumption "prices" foreign assets. Rather, we take domestic consumption, domestic and foreign stock returns as given, and then *statistically test if the domestic representative agent has made her consumption/portfolio decisions optimally.* Thus, we do not have to solve for any "optimal portfolios", but instead, rely only on *actual* consumption and stock market data to see if the representative agent's Euler equations are satisfied.

2.1 A re-formulation of the optimization problem

The $N+1$ Euler equations as given by (4) and (5) completely characterize the investor's optimal portfolio choice. But the focus of this study is on the home bias phenomenon, rather

[3] If $U(\cdot)$ is strictly concave, there will be a unique, global maximum.

than the optimality of an investor's complete portfolio. Since "home bias" is the phenomenon that investors seem to allocate too much of their stock market wealth to domestic relative to foreign securities, it is a phenomenon about investors' *relative* holdings within their stock portfolio, rather than a statement about their overall level of savings (as a percentage of total wealth), or their overall level of stock holdings (as a percentage of total savings).

In order to evaluate if an investor's *relative* holding of foreign versus domestic securities is optimal *within her overall allocation to stocks*, we re-formulate the portfolio choice problem as follows. In each time period, the investor decides on how much to consume and how much to save. Within the fraction she chooses to save, the investor decides on how much to allocate to stocks. Within the fraction she allocates to stocks, she decides on the distribution among the N securities. The investor still has $N+1$ controls, but they are re-defined to be:

(a) the amount of wealth $\widetilde{F}_t/R_{f,t}$ allocated to risk-free bonds;

(b) the amount of wealth $p_{N,t}\widetilde{s}_{N,t}$ allocated to the N^{th} risky security;

(c) the number of units of zero-cost portfolio i held, denoted $\omega_{i,t}$, where each unit of zero-cost portfolio i is long one unit of wealth in security i and short one unit of wealth in security N, and pays $(R_{i,t+1} - R_{N,t+1})$ units of wealth in period $t+1$, $i = 1, ..., N-1$.

Note that the holding of the $N-1$ long-short portfolios does not involve any cash outflow in period t, so the amount allocated to the N^{th} risky security, $p_{N,t}\widetilde{s}_{N,t}$, represents the investor's net allocation to stocks, and $p_{N,t}\widetilde{s}_{N,t}+\widetilde{F}_t/R_{f,t}$ represents the total amount of savings. In terms of this formulation, the budget constraint becomes

$$C_t + \widetilde{F}_t/R_{f,t} + p_{N,t}\widetilde{s}_{N,t} \leq W_t, \tag{6}$$

and next period's financial wealth is given by

$$W_{t+1} = \widetilde{F}_t + (p_{N,t+1} + d_{N,t+1})\widetilde{s}_{N,t} + \sum_{i=1}^{N-1}(R_{i,t+1} - R_{N,t+1})\omega_{i,t} + Y_{t+1}. \tag{7}$$

The Euler equations that correspond to the $N+1$ controls, $\widetilde{F}_t$, $\widetilde{s}_{N,t}$, and $\omega_{i,t}$, are

$$E_t\left[\frac{\delta U'(C_{t+1})}{U'(C_t)}\right]R_{f,t} \;=\; 1, \tag{8}$$

$$E_t\left[\frac{\delta U'(C_{t+1})}{U'(C_t)}R_{N,t+1}\right] \;=\; 1, \tag{9}$$

$$E_t\left[\frac{\delta U'(C_{t+1})}{U'(C_t)}(R_{i,t+1}-R_{N,t+1})\right] \;=\; 0, \qquad i=1,...,N-1. \tag{10}$$

Since this re-formulation is in fact the same optimization problem from before, it is easy to see that the "new" Euler equations (9) and (10) are just linear combinations of the old ones as stated above in (5). What this re-formulation does, however, is it allows us to separate the investor's decisions of (i) how much to save within total wealth, and (ii) how much stocks to hold within total savings, from (iii) how much foreign or domestic stocks to hold as a fraction of total allocation to stocks. In particular, our question of interest is to examine whether the investor makes her decision (iii) optimally conditioned on her decisions in (i) and (ii). In other words, we examine if the investor's division of her stock portfolio into domestic and foreign securities is optimal, taking her total savings and total allocation to stocks as given.

More formally, we can prove the following proposition regarding the implications of the Euler equation (10) being satisfied.

Proposition 1 *Consider an investor who maximizes expected utility (1) subject to (6) and (7), with the $N+1$ controls $\widetilde{F}_t$, $\widetilde{s}_{N,t}$, and $\omega_{i,t}$ defined above. Taking the investor's choices of $\widetilde{F}_t$ and $\widetilde{s}_{N,t}$ as given, the Euler equation (10) holds if and only if any marginal change of the relative allocation $\omega_{i,t}$, $i=1,...,N-1$, cannot raise the investor's expected utility.*

Proof. To prove necessity, it is enough to show that if the Euler equation (10) does not hold, the investor's expected utility can be raised by altering her relative allocations $\omega_{i,t}$. Suppose $E_t\left[\frac{\delta U'(C_{t+1})}{U'(C_t)}(R_{i,t+1}-R_{N,t+1})\right] > 0$, then an increase in the investor's holdings of security i by ε units of wealth financed with a decrease in her holdings of security N will raise expected utility by $E_t\left[\delta U'(C_{t+1})(R_{i,t+1}-R_{N,t+1})\varepsilon\right]$. This change is feasible and does not affect C_t since it does not require any cash outflow in period t. A similar argument can be made if $E_t\left[\frac{\delta U'(C_{t+1})}{U'(C_t)}(R_{i,t+1} - R_{N,t+1})\right] < 0$.

To prove sufficiency, we show that if the Euler equation (10) holds, any marginal change of the relative allocation $\omega_{i,t}$, $i = 1, ..., N-1$, cannot raise the investor's expected utility. Holding the investor's choices of $\widetilde{F}_t$ and $\widetilde{s}_{N,t}$ constant, note that any marginal increase in the investor's holdings of security i in period t by ε units of wealth financed with a decrease in her holdings of security N will affect expected utility by $E_t\left[\delta U'(C_{t+1})(R_{i,t+1} - R_{N,t+1})\varepsilon\right]$. (Since this change in relative holdings is a zero-cost strategy, C_t is not affected.) But equation (10) implies that this term is zero for all i's. ■

Proposition 1 implies that even if equations (8) and (9) are violated (i.e., F_t and $s_{N,t}$ are not at their global optimum), we can still use equation (10) to test if the investor's relative stock holdings are optimal *locally*, conditional on her allocations F_t and $s_{N,t}$. This utilization of our Euler equations is all the more empirically relevant, as the well-known "risk-free rate puzzle" (Weil, 1989) and "equity premium puzzle" (Mehra and Prescott, 1985) suggest that equations (8) and (9) may not hold in the data. This interpretation is also consistent with the home bias literature, which focuses on investors' relative holdings of domestic and foreign stocks within their total stock holdings, without testing if their total savings or total allocation to stocks are optimal.

Of course, if we already know that the choices of F_t and $s_{N,t}$ satisfy equations (8) and (9), the test of whether the relative allocations $\omega_{i,t}$, $i = 1, ..., N-1$, satisfy equation (10) amounts to a test of whether the $\omega_{i,t}$'s are at a global optimum of the expected utility maximization (1). In practice, the requirement that equations (8) and (9) being satisfied puts discipline on our choice of investor preferences and raises the likelihood that our specification resembles actual investor behavior. For this reason, we focus on the preference specification of Lettau and Ludvigson's (2001a, b), which has been shown to exhibit substantial explanatory power for domestic returns.

3 Empirical tests

The Euler equation for relative returns (10) forms the basis of our tests. To evaluate if the representative investor's existing relative holdings of domestic and foreign securities are optimal, we examine whether the Euler equation $E_t\left[\frac{\delta U'(C_{t+1})}{U'(C_t)}(R_{foreign,t+1} - R_{domestic,t+1})\right] = 0$ is satisfied in the data, where C_t denotes domestic aggregate consumption.

In our empirical tests, we assume the domestic representative investor's utility function takes a particular form, and evaluate if the observed consumption and asset return data are consistent with the investor making optimal portfolio decisions. In other words, we *take the utility function, consumption data, and asset prices as given, and then ask if the representative investor has optimized her portfolio allocation between domestic and foreign securities.* In this regard, our approach is similar to the portfolio choice approach, which also takes investors' preferences as given, and then solves for their optimal portfolios.

By contrast, a long literature in consumption-based asset pricing, which examines the Euler equations (4) and (5), *takes consumption data, asset prices, and investor optimization as given, and then tests if the representative investor's preferences can be described by a candidate utility function.* For example, Lettau and Ludvigson (2001a) take U.S. aggregate consumption and returns on the 25 Fama-French portfolios as given, and assume that the representative agent optimizes her consumption and portfolio choices. Specifically, they evaluate if a model of the representative agent's marginal utility growth that uses the log consumption-wealth ratio as a conditioning variable can be consistent with both the consumption and stock return data.

Brandt (1999) also examines these Euler equations. He *takes asset prices, investor preferences, and investor optimization as given, and then solve for an investor's optimal consumption and portfolio choice.* In other words, Brandt assumes that the Euler equations hold (i.e., the investor under consideration optimizes her consumption and portfolio choice), and then uses the Euler equations to solve for the portfolio weights that support the optimum. By contrast, we take a representative investor's *actual* consumption and portfolio allocations as given, and then examine if those allocations are consistent with the investor having maximized her expected utility (i.e., whether the Euler equations hold empirically).

Harvey (1991) and Dumas and Solnik (1995), among others, examine the international capital asset pricing model and its extensions. The stochastic discount factors in these studies are functions of the returns on the world market portfolio and on certain currency deposits. Although these studies test if the Euler equations implied by these stochastic discount factors are satisfied empirically, they do not directly address our question of interest. In particular, even though these asset-based stochastic discount factors may be successful for asset pricing, it is unclear whether they actually describe the marginal utility growth of a national representative agent who holds a home-biased equity portfolio (in addition to non-equity wealth) and consumes domestic aggregate consumption.

3.1 Preferences

Our analysis examines a representative investor who consumes per capita consumption in her country. We adopt the preference specification of Lettau and Ludvigson (2001a, b), who show that their model has power to explain the cross section of expected returns on the 25 Fama-French (1992) portfolios sorted by size and book-to-market ratio. Lettau and Ludvigson (2001a, b) do not assume a particular functional form for $U(\cdot)$, but instead specify the stochastic discount factor M_{t+1} directly and assume that it depends on cay, a measure of the log consumption-wealth ratio, as a conditioning variable. Specifically, the Euler equation for relative returns becomes

$$E_t\left[M_{t+1}(R_{i,t+1} - R_{j,t+1})\right] = 0, \quad M_{t+1} = b_0 + b_1 \Delta c_{t+1} + b_2 cay_t + b_3 cay_t \Delta c_{t+1}, \tag{11}$$

where $\Delta c_{t+1} \equiv \log\left(\frac{C_{t+1}}{C_t}\right)$ and cay_t is a measure of the log consumption-wealth ratio at time t.[4]

[4]Lettau and Ludvigson (2001b) show that, after making certain assumptions, the consumption-wealth ratio can be expressed as a trivariate cointegrating relation involving three observable variables: log consumption c, log asset wealth a, and log labor income y. See Lettau and Ludvigson (2001b) for further details on the construction of cay, and Lettau and Ludvigson (2001a) for the model's asset pricing implications.

The fact that we can analyze portfolio optimality for a preference specification that does not even specify the functional form of its utility function highlights the advantage of our Euler equation approach. By simply using the stochastic discount factor of Lettau and Ludvigson's (2001a, b) model, we can examine if the observed data on consumption and equity returns are consistent with portfolio optimization.

3.2 Data

We obtain U.S. consumption data on nondurables and services, excluding shoes and clothing, from the U.S. Department of Commerce, Bureau of Economic Analysis. The quarterly data are seasonally adjusted and measured in real terms. To obtain a per capita series, we use a measure of U.S. population created by dividing real total disposable income by real per capita disposable income, also obtained from the Bureau of Economic Analysis. We download an updated series for *cay*, a measure of the U.S. consumption-wealth ratio constructed by Lettau and Ludvigson (2001a, b), from Martin Lettau's website. The appendix to Lettau and Ludvigson (2001b) details the construction of this variable. For other G7 countries, we obtain seasonally-adjusted total household consumption expenditure, population, and CPI, all from the IMF's International Financial Statistics (IFS) database, to construct the real per capita consumption series.

We obtain the value-weighted, total equity return indexes on the G7 countries from Morgan Stanley Capital International (MSCI). Since we perform our analysis from the perspective of the U.S. representative agent, we first obtain international stock returns measured in US dollars, and then deflate them with the U.S. CPI inflation rate.

In some of our tests, we include the returns on the 25 Fama-French portfolios sorted according to size and book-to-market equity (B/M). These portfolios are the intersections of five size and five B/M portfolios on the NYSE, AMEX, and NASDAQ stocks in Compustat. We download the value-weighted returns of these 25 portfolios from Kenneth French's website. We convert nominal dollar returns into real terms by deflating them with the U.S. CPI inflation rate.

Since the consumption-based literature typically uses consumption data at the quarterly frequency, and the MSCI indexes begin their coverage in 1970, we use quarterly data from 1970:2 to 2011:1 for our analysis. Table 1 reports summary statistics of the G7 countries' real stock returns and real consumption growth rates.

3.3 Econometric specification

Previous studies characterize investor home bias as an unconditional phenomenon—investors' average portfolio holdings in practice seem to be tilted toward domestic securities, relative to the optimal allocation from an unconditional portfolio choice problem. At the same time, basing one's international portfolio decisions on conditioning information is usually viewed as a market-timing strategy,[5] rather than diversification. To be consistent with previous studies of the home bias phenomenon, we focus on the unconditional benefit of international diversification, instead of the payoff from international market timing. For this reason, even though the Euler equation for relative returns, (10), holds in every period t (conditioned on information known in that period), we test the unconditional version of (10):

$$E\left[\frac{\delta U'(C_{t+1})}{U'(C_t)}(R_{i,t+1} - R_{N,t+1})\right] = 0. \tag{12}$$

In other words, we ask the question of whether the domestic representative investor's relative holdings of domestic and foreign securities are optimal on average.

On the surface, the unconditional tests do not seem very interesting, as they are only examining whether the utility function in question is consistent with the cross section of expected returns on the country indexes. If there is not much variation in the unconditional expected returns across these indexes, it seems that equation (12) should hold.

This reasoning is flawed. For example, if home bias is not optimal for the U.S. representative agent, we should find that $E\left[\frac{\delta U'(C_{us,t+1})}{U'(C_{us,t})} R_{for,t+1}\right] > E\left[\frac{\delta U'(C_{us,t+1})}{U'(C_{us,t})} R_{us,t+1}\right]$, even though $E\left[R_{for,t+1}\right] \approx E\left[R_{us,t+1}\right]$. This is the case because the exposure of $C_{us,t+1}$ to $R_{for,t+1}$

[5] See Balvers, Wu, and Gilliland (2000) for an example of such a strategy, which is based on the mean reversion of international stock market indexes.

should be lower than to $R_{us,t+1}$, so that foreign securities can serve as a better hedge than U.S. securities can against U.S. consumption movements, i.e., $Cov(\frac{\delta U'(C_{us,t+1})}{U'(C_{us,t})}, R_{for,t+1}) > Cov(\frac{\delta U'(C_{us,t+1})}{U'(C_{us,t})}, R_{us,t+1})$.

Unlike the literature on consumption-based asset pricing, our question of interest is not to test the validity of a given asset pricing model. If that were the case, our focus should be on assets with a larger dispersion in expected returns, such as the Fama-French portfolios. Our goal is not to explain the cross-sectional difference in $E[R_{i,t+1}]$ with a given U, but rather, to investigate if there is a cross-sectional dispersion in $E\left[\frac{\delta U'(C_{us,t+1})}{U'(C_{us,t})} R_{i,t+1}\right]$ for a reasonable U—in particular, whether $E\left[\frac{\delta U'(C_{us,t+1})}{U'(C_{us,t})}\left(R_{for,t+1} - R_{us,t+1}\right)\right] > 0$, which indicates that the holdings of foreign relative to domestic stocks for the U.S. representative investor, with utility function U, are suboptimally low.

3.4 Hypothesis tests

We test the null hypothesis of $E\left[\frac{\delta U'(C_{domestic,t+1})}{U'(C_{domestic,t})}(R_{i,t+1} - R_{domestic,t+1})\right] = 0$, against the alternative of $E\left[\frac{\delta U'(C_{domestic,t+1})}{U'(C_{domestic,t})}(R_{i,t+1} - R_{domestic,t+1})\right] \neq 0$, where $C_{domestic,t+1}$ denotes the per capita consumption in the domestic country, and i indexes the set of $N-1$ foreign countries under consideration. From now on, we label the foreign securities as the first $N-1$ assets, and the the domestic security as the N^{th} asset.

In order to evaluate portfolio optimality with parameters that produce the best fit to domestic returns—hence more likely to describe the domestic representative investor's actual preference—we require the preference under consideration to fit the 25 Fama-French portfolios. Specifically, we add the 25 moment conditions for the Fama-French portfolios to the system we estimate:

$$E\left[\frac{\delta U'(C_{domestic,t+1})}{U'(C_{domestic,t})}(R_{FF,j,t+1} - R_{f,t})\right] = 0, \text{ for } j = 1, .., 25, \tag{13}$$

where $R_{FF,j,t+1}$ is the return on the jth Fama-French portfolio and $R_{f,t}$ is the 3-month T-bill rate. Next, we also include the moment conditions with respect to the equity premium on the market portfolio and the riskfree return, i.e.,

$$E\left[\frac{\delta U'(C_{domestic,t+1})}{U'(C_{domestic,t})}(R_{m,t+1} - R_{f,t})\right] = 0, \text{ and} \tag{14}$$

$$E\left[\frac{\delta U'(C_{domestic,t+1})}{U'(C_{domestic,t})}R_{f,t}\right] = 1. \tag{15}$$

In all the cases we consider, there are more moment conditions than number of preference parameters to be estimated, so the systems are overidentified. When we use the Fama-French moment conditions (13) only in the estimation of the preference parameters, we use a weight matrix that gives equal and positive weight to the Fama-French moments, but essentially zero weights to the relative return moments. When the equity premium and the riskfree rate are also included, we give positive weights to the 27 domestic moments while maintaining zero weights on the relative return moments. We can assign a weight on the equity premium and riskfree rate moments that differs from the one received by the Fama-French moments. This flexibility allows us to examine the robustness of our results to parameter values that generate varying degrees of fit to the domestic moments.

By examining the estimates and standard errors of the moment conditions, we can perform the hypothesis test of whether $E\left[\frac{\delta U'(C_{domestic,t+1})}{U'(C_{domestic,t})}(R_{i,t+1} - R_{domestic,t+1})\right] = 0$ for each i individually. We use the Newey-West method to calculate heteroscedasticity-and-autocorrelation-consistent (HAC) standard errors for the individual moment conditions. We test the validity of all the moments jointly by carrying out a (first-stage) J-test of the overidentifying restrictions, and by calculating the p-value of the model's Hansen-Jagannathan distance.

The first-stage J-statistic is given by $J = \mathbf{m}' var(\mathbf{m})^{-1}\mathbf{m}$, where $\mathbf{m}$ is the vector of moment conditions, $var(\mathbf{m})$ is its variance-covariance matrix, and $(\cdot)^{-1}$ denotes a generalized inverse. If there are p moment conditions and q parameters, J is asymptotically $\chi^2(p-q)$. The Hansen-Jagannathan distance is given by $dist = \sqrt{\mathbf{m}' G^{-1}\mathbf{m}}$, where G^{-1} is the weighting matrix, and we use bootstrap-based p-values to carry out inference on $dist$.

4 Empirical results

The analysis we report in this section examines the Euler equations for the Lettau and Ludvigson's (2001a, b) conditional model, as given by equation (11) above. Throughout this analysis, we treat the U.S. as the home country and the rest of the G7 countries as foreign.

4.1 Estimated parameters: Fama-French portfolios only

Table 2, Panel A reports the results for the case where the preference parameters are chosen to fit the excess returns on the 25 Fama-French portfolios only, so there are 31 moment conditions in total. Moments 1-6 are the moments for the relative returns $(R_{i,t+1} - R_{us,t+1})$. Moments 7-31 are the 25 Fama-French moments. We use the standard ordering of the 25 portfolios: S1B1,..., S1B5, S2B1,..., S2B5, S3B1,..., S3B5, S4B1,..., S4B5, S5B1,..., S5B5, where S1 and S5 denote the smallest and largest size quintiles, and B1 and B5 denote the lowest and highest book-to-market equity, respectively. The GMM weight matrix is specified such that the Fama-French moments receive equal and positive weights, whereas the relative return moments get essentially zero weight.

We report the point estimates, standard errors, t-statistics, and p-values of each moment condition. Since none of the first six moment conditions are significantly different from zero, our null hypothesis that $E\left[M_{t+1}(R_{i,t+1} - R_{us,t+1})\right] = 0$ is not rejected. We also test whether all moment conditions are jointly satisfied by using either a first-stage J-test (with asymptotic p-values), or by calculating the Hansen-Jagannathan distance (with bootstrap-based p-values). We find that the p-values of both tests are well above any conventional significance levels, so we cannot reject the hypothesis that the moment conditions are all satisfied.

On the other hand, we find that the pricing error for the S1B1 portfolio is significantly different from zero at the 5% level. Lettau and Ludvigson (2001a) report similar results—that small growth stocks tend to have negative pricing errors. As a further comparison, we note that the preference parameters (b_0, b_1, b_2, and b_3 in equation (11)) that Lettau and

Ludvigson (2001a) report in their Appendix B are given by 0.99, -26.47, 76.71, and -16,076 respectively, whereas the corresponding values in our sample are 0.64, -98.38, 70.36, and -13,335. This comparison is relevant because Lettau and Ludvigson's (2001a) results, like those we report here, are based on the fitting of their conditional model to the 25 Fama-French moment conditions.

4.2 Estimated parameters: Equity premium and riskfree rate also included

We next consider the case where the preference parameters are chosen to fit the equity premium and the riskfree rate as well. There are now 33 moment conditions in total, where the first 31 are the same as before, and the last two being the equity premium and riskfree rate moments as given by equations (14) and (15). The GMM weight matrix is specified such that the Fama-French, equity premium, and riskfree rate moments all receive equal and positive weights, whereas the relative return moments get essentially zero weight. Table 2, Panel B reports these results. As before, none of the first six moment conditions are significantly different from zero, so our null hypothesis that $E\left[M_{t+1}(R_{i,t+1} - R_{us,t+1})\right] = 0$ is still not rejected. We also find that the p-values of both the J-test and the Hansen-Jagannathan distance are well above any conventional significance levels, so we cannot reject the hypothesis that the moment conditions are all satisfied.

However, one problem with this set of results is the model's poor fit of the last two moments.[6] The pricing errors are statistically significant, with the magnitude on the equity premium moment, at 1.6% per quarter, being economically significant as well. To generate a better fit of these last two moments, we overweight them by a factor of 10 relative to the 25 Fama-French moments in the GMM weight matrix. These results are reported in Table 2, Panel C. As before, none of the six relative return moment conditions are significantly

[6] Note that Lettau and Ludvigson (2001a, b) only fit their model to the Fama-French portfolios, but not the equity premium and the riskfree rate, so our finding here is not inconsistent with any of their reported results.

different from zero. More important, the last two moments now receive a much better fit. The pricing errors on both the equity premium and the riskfree rate are an order of magnitude smaller, although the latter is still statistically significant at the 5% level. Not surprisingly, by overweighting the last two moments, the model's fit on the Fama-French moments declines—but not by much. In fact, the p-values on both the J-statistic and the Hansen-Jagannathan distance increase relative to those reported on Table 2, Panel B, indicating an improvement in the overall fit of the model as a result of the change in the relative weights.

4.3 Known parameters: Lettau and Ludvigson (2001a)

Since our previous analysis estimates the preference parameters and the relative return moments in the same GMM procedure, the estimation uncertainty in the parameters contribute to the standard errors of the moment conditions. To investigate if the lack of significance in the relative return moments is due to the estimation uncertainty of the preference parameters, we assume that the parameters (b_0, b_1, b_2, and b_3 in equation (11)) are known and take on the values of 0.99, -26.47, 76.71, and -16,076, respectively, as reported in Appendix B of Lettau and Ludvigson (2001a).

To carry out tests of the null that $E\left[M_{t+1}(R_{i,t+1} - R_{us,t+1})\right] = 0$, we first estimate the six moment conditions

$$E\left[M_{t+1}(R_{i,t+1} - R_{us,t+1})\right] - e_i = 0, \tag{16}$$

where i indexes the six G7-ex-U.S. countries and the e_i's are parameters to be estimated. We can then write the null hypothesis as:

$$H_0 : e_i = 0, \text{ for } i = 1, .., 6. \tag{17}$$

Using GMM, we test the hypothesis individually for each i, and, through a Wald test, jointly for all i's. The results, reported in Table 3, show that in either case the null hypothesis still cannot be rejected.

5 Decomposing the pricing errors

The pricing error of the relative returns, $E\left[M_{us,t+1}(R_{for,t+1}-R_{us,t+1})\right]$, can be decomposed into

$$\begin{aligned}
& E\left[M_{us,t+1}(R_{for,t+1}-R_{us,t+1})\right] \\
= \; & E\left[M_{us,t+1}\right]\left\{\begin{array}{c}\left[Cov(M_{us,t+1},R_{for,t+1})-Cov(M_{us,t+1},R_{us,t+1})\right]/E\left[M_{us,t+1}\right] \\ +E\left[R_{for,t+1}\right]-E\left[R_{us,t+1}\right]\end{array}\right\}. \quad (18)
\end{aligned}$$

The difference-in-covariance term on the right hand side of (18) measures the diversification gains. The second term on the right hand side of (18), $E\left[R_{for,t+1}\right]-E\left[R_{us,t+1}\right]$, simply measures the difference in expected returns between foreign and domestic securities.

This decomposition shows that there are two reasons for why a positive pricing error (i.e. $E\left[M_{us,t+1}(R_{for,t+1}-R_{us,t+1})\right]>0$) implies that the U.S. representative investor is under-diversified and should increase her relative holdings of foreign equities. The first reason is "diversification gains"—if $Cov(M_{us,t+1},R_{for,t+1})-Cov(M_{us,t+1},R_{us,t+1})>0$, foreign securities offer a relatively higher return than U.S. securities when U.S. marginal utility is high. The second reason is "expected return gains"—if $E\left[R_{for,t+1}\right]-E\left[R_{us,t+1}\right]>0$, foreign equities simply provide higher expected returns.

Aside from providing us with a deeper understanding of the source of pricing errors, this decomposition also allows us to separately evaluate diversification and expected return gains. This exercise is motivated by the well-known difficulty in estimating expected returns precisely. It is conceivable that our failure to reject the condition, $E\left[M_{us,t+1}(R_{for,t+1}-R_{us,t+1})\right]=0$, is due to the imprecision in the estimated mean effect. We evaluate this conjecture by estimating the "decomposed" relative return moment conditions:

$$\begin{aligned}
E\left[M_{us,t+1}\right]\left\{\left[Cov(M_{us,t+1},R_{for,t+1})-Cov(M_{us,t+1},R_{us,t+1})\right]/E\left[M_{us,t+1}\right]\right\} &= 0, \text{ and} \\
E\left[M_{us,t+1}\right]\left\{E\left[R_{for,t+1}\right]-E\left[R_{us,t+1}\right]\right\} &= 0.
\end{aligned}$$

We use the Lettau-Ludvigson stochastic discount factor with estimated parameters, chosen to fit the Fama-French portfolios, the equity premium, and the riskfree rate, with the equity premium and riskfree rate moments being overweighted by a factor of 10 (as discussed in Section 4.2 above). These results are reported in Table 4. We see that the lack of rejection of the relative moment conditions, $E\left[M_{us,t+1}(R_{for,t+1}-R_{us,t+1})\right]=0$, cannot be attributed to estimation noise in mean returns alone—as even the "diversification gains" are not significantly different from zero—indicating that foreign equities do not provide a better hedge against U.S. consumption risks than do U.S. equities.

Our finding here is consistent with the conclusions of Heathcote and Perri (2007) and Lustig and Van Nieuwerburgh (2008). These authors explicitly examine the role of human capital and find that domestic equities are more effective than foreign equities in hedging labor income risks. Since human capital is a major component of total wealth, it is not surprising then that we also find that foreign equities do no better than domestic equities in diversifying domestic consumption risks.

6 Pure consumption-based diversification benefits

But does our finding that foreign equities fail to diversify domestic consumption risks imply that there is no room for further consumption risk sharing? Not necessarily—our finding may be due to the fact that financial markets are incomplete (equity returns do not span consumption risks), rather than consumption risks are already well-shared.

To investigate this possibility further, we evaluate the diversification benefit of a hypothetical foreign security (with return $R^c_{for,t+1}$) relative to a hypothetical domestic security (with return $R^c_{us,t+1}$). The return on the hypothetical security $R^c_{i,t+1}$ is given by

$$R^c_{i,t+1}=\omega_{c,i}cg_{i,t+1}+\left(1-\omega_{c,i}\right)R_f, \tag{19}$$

where $cg_{i,t+1}\equiv\frac{C_{i,t+1}}{C_{i,t}}$ represents the real per capita consumption growth rate of country i. The weight $\omega_{c,i}$ is chosen such that the variance of the return on this hypothetical security $R^c_{i,t+1}$ equals that of country i's stock index return, i.e., $Var(R^c_{i,t+1})=Var(R_{i,t+1})$.

The reason for constructing a consumption security that has the same volatility as equities is that the magnitude of the diversification benefit,

$\left\{[Cov(M_{us,t+1}, R^c_{for,t+1}) - Cov(M_{us,t+1}, R^c_{us,t+1})]/E\left[M_{us,t+1}\right]\right\}$, is sensitive to the volatility of the asset in question. By requiring that $Var(R^c_{i,t+1}) = Var(R_{i,t+1})$, we can be sure that any difference between the diversification benefits of consumption securities $(R^c_{i,t+1})$ and stocks $(R_{i,t+1})$ is due to differences in the assets' correlation structure with $M_{us,t+1}$. In addition, the way we construct R^c_i ensures that the correlation structure among the R^c_i's preserves the correlation structure among the cg_i's. Finally, this scaling affects only the magnitude but not the statistical significance of the estimates of diversification benefits.

As before, we use the Lettau-Ludvigson stochastic discount factor with estimated parameters, chosen to fit the Fama-French portfolios, the equity premium, and the riskfree rate, with the equity premium and riskfree rate moments being overweighted by a factor of 10. Table 5 reports the diversification gains, $\left\{[Cov(M_{us,t+1}, R^c_{for,t+1}) - Cov(M_{us,t+1}, R^c_{us,t+1})]/E\left[M_{us,t+1}\right]\right\}$, that are associated with these hypothetical, foreign consumption securities R^c_i. We see that the magnitude of these gains are around 4-6% per quarter and they are all statistically significant (five at the 5% level and one at the 10% level).

Our findings are consistent with those of Shiller (1993, 2003) and Athanasoulis and Shiller (2001), who argue that—though consumption risks are not well-shared across countries—the benefits of further risk sharing cannot be obtained by the use of existing securities. They suggest that the problem is incomplete markets and propose the introduction of new securities or contracts to share the world's largest macroeconomic risks.

7 Conclusion

Many previous studies focus exclusively on investors' equity holdings to estimate the benefits of international diversification. We re-examine this problem by taking non-equity wealth into account. It is obvious that most of investors' wealth is non-equity wealth, and we are certainly not the first to examine international portfolio allocation while trying to take non-equity risks into account. What sets our work apart is our approach can take the effects of non-equity wealth into account without having to measure its return directly. This advantage is important because many components of non-equity wealth are nontraded and their returns not directly observable.

Since investors make their consumption/portfolio decisions based on total wealth, their marginal utility defined over consumption incorporates the effects from all components of wealth, including those components that the econometrician cannot observe. Using this information contained in investors' marginal utility, we find that foreign equities' benefits in diversifying domestic consumption risks are neither economically nor statistically significant. But this result does not imply that there is no room for further consumption risk sharing—using hypothetical securities that track the covariance structure of international consumption growth rates, we find the benefits from further consumption risk sharing to be highly significant, both economically and statistically.

There are at least two interesting directions for future research. First, we can examine the conditional versions of the Euler equations we study here. Such conditional tests can be interpreted as investigations of the profitability of international market timing strategies. In particular, we can estimate the benefits to an investor in changing her relative holdings of domestic versus foreign equities, conditional on the movements of variables like the domestic and foreign stock market valuation ratios, interest rates, and other macroeconomic factors. A second interpretation of such tests builds on the insights of Engel and Matsumoto (2009). Conditional on the nominal exchange rate, our tests can be viewed as a study of the benefits from holding more foreign relative to domestic equities when currency risks are hedged.

A second interesting direction for further research is to expand the set of test assets under consideration. Our current study examines the returns on country stock indexes only. Since our goal is to evaluate the benefits of diversification at the national, aggregate level, this focus on country indexes is the most natural one. This focus is also consistent with other studies that examine home bias from a macroeconomic perspective. However, our Euler equation approach can also be applied to analyze the value to investors in changing their relative holdings of certain subclasses of stocks. A key advantage of our approach in this context is we can carry out our tests without having to obtain data on portfolio holdings.

This point is important if data on investors' international holdings in different subclasses of stocks (e.g. how much Japanese value stocks UK investors are holding) are lacking.

References

Athanasoulis, S.G. and R.J. Shiller, 2001, "World Income Components: Measuring and Exploiting Risk-Sharing Opportunities," *American Economic Review* 91, 1031-1054.

Balvers, R., Y. Wu, and E. Gilliland, 2000, "Mean Reversion Across National Stock Markets and Parametric Contrarian Investment Strategies," *Journal of Finance* 55, 745-772.

Baxter, M. and U.J. Jermann, 1997, "The International Diversification Puzzle is Worse Than You Think," *American Economic Review* 87, 170-180.

Bottazzi, L., P. Pesenti, and E. van Wincoop, 1996, "Wages, Profits, and the International Portfolio Puzzle," *European Economic Review* 40, 219-254.

Brandt, M.W., 1999, "Estimating Portfolio and Consumption Choice: A Conditional Euler Equations Approach," *Journal of Finance* 54, 1609-1646.

Brandt, M.W., J.H. Cochrane, and P. Santa-Clara, 2006, "International Risk Sharing is Better Than You Think, or Exchange Rates Are Too Smooth," *Journal of Monetary Economics* 53, 671-698

Colacito, R. and M.M. Croce, 2011, "Risks for the Long Run and the Real Exchange Rate," *Journal of Political Economy* 119, 153-181.

Dumas, B. and B. Solnik, 1995, "The World Price of Foreign Exchange Risk," *Journal of Finance* 50, 445-479.

Engel, C. and A. Matsumoto, 2009, "The International Diversification Puzzle When Prices are Sticky: It's Really about Exchange-Rate Hedging not Equity Portfolios," *American Economic Journal: Macroeconomics* 1, 155-188.

Fama, E.F. and K.R. French, 1992, "The Cross-Section of Expected Returns," *Journal of Finance* 47, 427-465.

Harvey, C.R., 1991, "The World Price of Covariance Risk," *Journal of Finance* 46, 111-157.

Heathcote, J. and F. Perri, 2007, "The International Diversification Puzzle Is Not As Bad As You Think," NBER Working Paper No. 13483.

Heaton, J.C., and D. Lucas, 2000, "Portfolio Choice and Asset Prices: The Importance of Entrepreneurial Risk," *Journal of Finance* 55, 1163-1198.

Julliard, C., 2002, "The International Diversification Puzzle is Not Worse Than You Think," working paper, Princeton University.

Julliard, C., 2004, "Human Capital and International Portfolio Choice," working paper, Princeton University.

Lettau, M. and S. Ludvigson, 2001a, "Resurrecting the (C)CAPM: A Cross–Sectional Test When Risk Premia Are Time-Varying," *Journal of Political Economy* 109, 1238-1287.

Lettau, M. and S. Ludvigson, 2001b, "Consumption, Aggregate Wealth and Expected Stock Returns," *Journal of Finance* 56, 815-849.

Lewis, K.K., 1999, "Trying to Explain Home Bias in Equities and Consumption," *Journal of Economic Literature* 37, 571-608.

Lewis, K.K., 2000, "Why Do Stocks and Consumption Imply Such Different Gains from International Risk Sharing?" *Journal of International Economics* 52, 1-35.

Lewis, K.K. and E.X. Liu, 2012, "International Consumption Risk Is Shared After All: An Asset Return View," NBER Working Paper No. 17872.

Lucas, R.E., Jr., 1978, "Asset Prices in an Exchange Economy," *Econometrica* 46, 1429-1445.

Lustig, H. and S. Van Nieuwerburgh, 2008, "The Returns on Human Capital: Good News on Wall Street is Bad News on Main Street," *Review of Financial Studies* 21, 2097-2137.

Mehra, R. and E.C. Prescott, 1985, "The Equity Premium: A Puzzle," *Journal of Monetary Economics* 15, 145-161.

Palacios-Huerta, I., 2001, "The Human Capital of Stockholders and the International Diversification Puzzle," *Journal of International Economics* 54, 309-331.

Shiller, R.J., 1993, *Macro Markets: Creating Institutions for Managing Society's Largest Economic Risks.* (Oxford University Press: Oxford).

Shiller, R.J., 2003, *The New Financial Order: Risk in the 21st Century* (Princeton University Press: Princeton).

Stathopoulos, A., 2012, "Asset Prices and Risk Sharing in Open Economies," working paper, University of Southern California.

Weil, P., 1989, "The Equity Premium Puzzle and the Risk-Free Rate Puzzle," *Journal of Monetary Economics* 24, 401-421.

Table 1. Summary statistics for G7 stock returns and consumption

Panel A reports the mean, standard deviation, and correlation matrix of the gross quarterly returns on the G7 stock market indexes, measured in real U.S. dollar terms. The value-weighted, total equity return indexes in US$ are obtained from Morgan Stanley Capital International (MSCI), which are then deflated by the U.S. CPI inflation rate to obtain real returns.

Panel B reports the mean, standard deviation, and correlation matrix of the real quarterly consumption growth rates of the G7 countries. For the U.S., the real per capita consumption series are constructed using data from the U.S. Department of Commerce, Bureau of Economic Analysis. For the rest of the G7 countries, the real per capita consumption series are constructed using data from the IMF's IFS database. The sample period is from 1970:2 to 2011:1.

Panel A. Summary statistics for real stock returns

	Canada	France	Germany	Italy	Japan	UK	USA
mean	1.020	1.023	1.021	1.014	1.020	1.021	1.016
standard deviation	0.102	0.126	0.119	0.143	0.123	0.120	0.086
Correlation matrix							
Canada	1.000	0.530	0.547	0.446	0.469	0.575	0.793
France		1.000	0.772	0.678	0.470	0.623	0.625
Germany			1.000	0.597	0.430	0.563	0.628
Italy				1.000	0.481	0.493	0.489
Japan					1.000	0.442	0.495
UK						1.000	0.672
USA							1.000

Panel B. Summary statistics for real consumption growth rates

	Canada	France	Germany	Italy	Japan	UK	USA
mean	1.005	1.004	1.006	1.006	1.004	1.006	1.004
standard deviation	0.009	0.009	0.020	0.009	0.014	0.014	0.004
Correlation matrix							
Canada	1.000	0.241	-0.196	0.133	0.020	0.209	0.345
France		1.000	0.133	0.260	0.149	0.221	0.230
Germany			1.000	0.074	0.057	0.109	0.008
Italy				1.000	0.194	0.056	0.178
Japan					1.000	0.306	0.382
UK						1.000	0.341
USA							1.000

Table 2. Euler equations for relative returns: cay with estimated parameters

This table reports the GMM test results of the moment conditions $E[M_{t+1}*(R_{i,t+1}-R_{us,t+1})] = 0$, where $M_{t+1}=b_0+b_1\Delta c_{t+1}+b_2 cay_t+b_3 cay_t\Delta c_{t+1}$, $R_{i,t+1}$ is the return on country i's stock index from period t to t+1, and i = Canada (can), France (fra), Germany (ger), Italy (ita), Japan (jpn), and the UK. In Panel A, we report results where the excess returns on the 25 Fama-French portfolios are included. The system of moment conditions is estimated by GMM. The GMM weight matrix is specified such that the Fama-French moments receive equal and positive weights, whereas the relative return moments get zero weight. The first six moments on Panel A are the moments for relative returns, and the last 25 are the Fama-French moments. The Fama-French portfolios are sorted according to size and book-to-market equity ratios. S1and S5 denote the smallest and largest size quintiles, and B1 and B5 denote the lowest and highest book-to-market equity, respectively. Panel B reports results that include the moment conditions for the equity premium and the riskfree rate as well. Of the 33 moment conditions, the first 31 are the same as in Panel A, and the last two are the equity premium and riskfree rate moments. The GMM weight matrix is specified such that the Fama-French, equity premium, and riskfree rate moments all receive equal and positive weights, whereas the relative return moments get zero weight. Panel C contains the same 33 moment conditions as in Panel B, except that the GMM weight matrix is now specified to overweight the equity premium and riskfree rate moments by a factor of 10 relative to the 25 Fama-French moments. Heteroscedasticity and autocorrelation consistent (HAC) standard errors are shown beside the point estimates. Tests of the overidentifying restrictions are conducted by calculating the first-stage J-test and the Hansen-Jagannathan distance, where the p-values for the J-test is obtained from a chi-sq. distribution and the p-values for the HJ-distance is obtained from the bootstrap. The sample period is from 1970:2 to 2011:1.

Table 2. Euler equations for relative returns: cay with estimated parameters (continued)

Panel A. Parameters chosen to fit the Fama-French moments only

	Moment	s.e.	t-stat	p-val
Can	-0.0059	0.0158	-0.37	0.71
Fra	0.0002	0.0138	0.01	0.99
Ger	-0.0065	0.0131	-0.49	0.62
Ita	-0.0220	0.0208	-1.06	0.29
Jpn	0.0176	0.0276	0.64	0.52
Uk	0.0060	0.0131	0.46	0.65
S1B1	-0.0127	0.0049	-2.60	0.01
S1B2	0.0011	0.0026	0.42	0.67
S1B3	0.0013	0.0035	0.36	0.72
S1B4	0.0060	0.0035	1.69	0.09
S1B5	0.0049	0.0041	1.19	0.24
S2B1	-0.0044	0.0064	-0.69	0.49
S2B2	-0.0054	0.0046	-1.18	0.24
S2B3	0.0031	0.0032	0.97	0.33
S2B4	0.0043	0.0036	1.20	0.23
S2B5	0.0001	0.0049	0.01	0.99
S3B1	0.0023	0.0045	0.52	0.61
S3B2	0.0008	0.0033	0.25	0.81
S3B3	-0.0053	0.0037	-1.44	0.15
S3B4	0.0005	0.0030	0.18	0.86
S3B5	0.0023	0.0041	0.55	0.58
S4B1	0.0050	0.0038	1.30	0.19
S4B2	-0.0003	0.0035	-0.07	0.94
S4B3	0.0050	0.0052	0.96	0.34
S4B4	0.0038	0.0029	1.28	0.20
S4B5	0.0050	0.0058	0.87	0.39
S5B1	-0.0019	0.0042	-0.45	0.65
S5B2	-0.0030	0.0034	-0.86	0.39
S5B3	-0.0022	0.0065	-0.34	0.73
S5B4	-0.0038	0.0039	-0.98	0.33
S5B5	-0.0069	0.0071	-0.98	0.33
J-stat p-value		0.85		
HJ dist p-value		0.83		

Table 2. Euler equations for relative returns: cay with estimated parameters (continued)

Panel B. Parameters chosen to fit the Fama-French moments, the equity premium, and the riskfree rate (equally weighted)

	Moment	s.e.	t-stat	p-val
Can	-0.0203	0.0235	-0.87	0.39
Fra	0.0040	0.0132	0.30	0.76
Ger	-0.0059	0.0139	-0.42	0.67
Ita	-0.0122	0.0200	-0.61	0.54
Jpn	-0.0253	0.0400	-0.63	0.53
Uk	0.0169	0.0153	1.11	0.27
S1B1	-0.0230	0.0088	-2.61	0.01
S1B2	-0.0026	0.0051	-0.51	0.61
S1B3	0.0022	0.0052	0.43	0.67
S1B4	0.0074	0.0054	1.37	0.17
S1B5	0.0051	0.0042	1.20	0.23
S2B1	-0.0055	0.0087	-0.63	0.53
S2B2	0.0002	0.0058	0.04	0.97
S2B3	0.0063	0.0035	1.78	0.08
S2B4	0.0079	0.0055	1.45	0.15
S2B5	-0.0005	0.0064	-0.07	0.94
S3B1	-0.0002	0.0067	-0.03	0.97
S3B2	0.0034	0.0041	0.82	0.41
S3B3	0.0046	0.0040	1.16	0.25
S3B4	0.0067	0.0044	1.54	0.12
S3B5	0.0117	0.0053	2.22	0.03
S4B1	0.0033	0.0055	0.60	0.55
S4B2	0.0020	0.0044	0.46	0.65
S4B3	0.0059	0.0059	1.01	0.31
S4B4	0.0047	0.0042	1.13	0.26
S4B5	0.0000	0.0070	0.00	1.00
S5B1	0.0040	0.0060	0.66	0.51
S5B2	0.0034	0.0035	0.96	0.34
S5B3	-0.0019	0.0078	-0.24	0.81
S5B4	0.0017	0.0055	0.31	0.76
S5B5	-0.0040	0.0085	-0.46	0.64
US premium	0.0162	0.0077	2.11	0.03
Riskfree	-0.0014	0.0005	-2.80	0.01
J-stat p-value		0.70		
HJ dist p-value		0.25		

Table 2. Euler equations for relative returns: cay with estimated parameters (continued)

Panel C. Parameters chosen to fit the Fama-French moments, the equity premium, and the riskfree rate (over-weighting the equity premium and the riskfree rate)

	Moment	s.e.	t-stat	p-val
Can	-0.0180	0.0267	-0.67	0.50
Fra	0.0076	0.0165	0.46	0.64
Ger	-0.0020	0.0171	-0.12	0.91
Ita	-0.0058	0.0262	-0.22	0.83
Jpn	-0.0332	0.0516	-0.64	0.52
Uk	0.0220	0.0197	1.12	0.26
S1B1	-0.0275	0.0129	-2.13	0.03
S1B2	-0.0060	0.0082	-0.72	0.47
S1B3	0.0012	0.0061	0.20	0.84
S1B4	0.0062	0.0062	0.99	0.32
S1B5	0.0053	0.0062	0.86	0.39
S2B1	-0.0068	0.0107	-0.63	0.53
S2B2	0.0030	0.0071	0.42	0.67
S2B3	0.0073	0.0043	1.69	0.09
S2B4	0.0086	0.0075	1.14	0.26
S2B5	0.0011	0.0083	0.13	0.89
S3B1	-0.0024	0.0088	-0.28	0.78
S3B2	0.0044	0.0048	0.91	0.36
S3B3	0.0095	0.0066	1.45	0.15
S3B4	0.0097	0.0065	1.50	0.13
S3B5	0.0164	0.0077	2.13	0.03
S4B1	0.0009	0.0085	0.10	0.92
S4B2	0.0025	0.0051	0.50	0.62
S4B3	0.0061	0.0073	0.84	0.40
S4B4	0.0062	0.0057	1.08	0.28
S4B5	-0.0014	0.0080	-0.18	0.86
S5B1	0.0031	0.0073	0.42	0.67
S5B2	0.0047	0.0044	1.06	0.29
S5B3	-0.0029	0.0088	-0.33	0.74
S5B4	0.0037	0.0079	0.46	0.64
S5B5	-0.0025	0.0101	-0.24	0.81
US premium	0.0025	0.0015	1.71	0.09
Riskfree	-0.0002	0.0001	-2.22	0.03
J-stat p-value		0.86		
HJ dist p-value		0.26		

Table 3. Euler equations for relative returns: cay with known parameters

This table reports the estimates of e_i in the moment conditions $E[M_{t+1}*(R_{i,t+1}-R_{us,t+1})]-e_i=0$, where $M_{t+1}=b_0+b_1\Delta c_{t+1}+b_2cay_t+b_3cay_t\Delta c_{t+1,}$ and the parameters $b_{0,}$ b_1, b_2, and b_3 are assumed to be known and equal to the point estimates obtained by Lettau and Ludvigson (2001a). $R_{i,t+1}$ is the return on country i's stock index from period t to t+1, where i = Canada (can), France (fra), Germany (ger), Italy (ita), Japan (jpn), and the UK. The system of moment conditions is estimated by GMM. Heteroscedasticity and autocorrelation consistent (HAC) standard errors are shown beside the point estimates of e_i. W denotes the Wald test statistic of the joint test that all six e_i's are equal to zero. The p-value is reported beside the test statistic. The sample period is from 1970:2 to 2011:1.

	estimate	s.e.
e_{can}	-0.0069	0.0090
e_{fra}	0.0009	0.0107
e_{ger}	-0.0072	0.0100
e_{ita}	-0.0223	0.0169
e_{jpn}	0.0153	0.0149
e_{uk}	0.0114	0.0088

	estimate	p-value
W	7.068	0.315

Table 4. A decomposition of pricing errors into expected return gains and diversification gains

This table reports the "expected return gains", $E[R_{i,t+1}]-E[R_{us,t+1}]$, and the "diversification gains", $\{[Cov(M_{us,t+1},R_{i,t+1})-Cov(M_{us,t+1},R_{us,t+1})]/E[M_{us,t+1}]\}$, where $M_{us,t+1}$ denotes the Lettau-Ludvigson stochastic discount factor that is estimated to fit the Fama-French, equity premium, and the riskfree rate moments, but with the last two being overweighted by a factor of 10. The system of moment conditions is estimated by GMM. Heteroscedasticity and autocorrelation consistent (HAC) standard errors are shown beside the point estimates. The sample period is from 1970:2 to 2011:1.

		Moment	s.e.	t-stat	p-val
expected return gains	Can	-0.0220	0.0293	-0.75	0.45
	Fra	0.0014	0.0180	0.08	0.94
	Ger	-0.0068	0.0181	-0.38	0.71
	Ita	-0.0034	0.0274	-0.12	0.90
	Jpn	-0.0366	0.0571	-0.64	0.52
	Uk	0.0174	0.0198	0.88	0.38
diversification gains	Can	0.0039	0.0066	0.59	0.55
	Fra	0.0063	0.0086	0.73	0.47
	Ger	0.0047	0.0077	0.61	0.54
	Ita	-0.0024	0.0121	-0.20	0.84
	Jpn	0.0034	0.0113	0.30	0.77
	Uk	0.0047	0.0064	0.73	0.47

Table 5. Pure consumption-based diversification gains

This table reports the "diversification gains",$\{[Cov(M_{us,t+1},R_{i,t+1})-Cov(M_{us,t+1},R_{us,t+1})]/E[M_{us,t+1}]\}$, of hypothetical securities that track the correlation structure of international consumption growth rates, where $M_{us,t+1}$ denotes the Lettau-Ludvigson stochastic discount factor that is estimated to fit the Fama-French, equity premium, and the riskfree rate moments, but with the last two being overweighted by a factor of 10. The system of moment conditions is estimated by GMM. Heteroscedasticity and autocorrelation consistent (HAC) standard errors are shown beside the point estimates. The sample period is from 1970:2 to 2011:1.

		Moment	s.e.	t-stat	p-val
	Can	0.0514	0.0272	1.89	0.06
	Fra	0.0673	0.0271	2.49	0.01
diversification gains	Ger	0.0885	0.0251	3.52	0.00
	Ita	0.0601	0.0217	2.77	0.01
	Jpn	0.0435	0.0163	2.67	0.01
	Uk	0.0429	0.0193	2.22	0.03