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The Investment Home Bias with Peer Effect

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Abstract: Observed international diversification implies an investment home bias (IHB). Can bivariate preferences with a local domestic peer group rationalize the IHB? For example, it is argued that wishing to have a large correlation with the Standard and Poor's 500 stock index (S&P 500 stock index) may induce an increase in the domestic investment weight by American investors and, hence, rationalize the IHB. While this argument is valid in the mean-variance framework, employing bivariate first-degree stochastic dominance (BFSD), we prove that this intuition is generally invalid. Counter intuitively, employing "keeping up with the Joneses" (KUJ) preference with actual international data even enhances the IHB phenomenon.

1. Introduction

The investment home bias (IHB) is well documented. For example, the US equity market accounts for about 35% of the world equity market, yet about 75% of Americans' equity investment is allocated to the US market. Hence, the US equity IHB is in the magnitude of 40%. For most commonly employed utility functions, the univariate expected utility maximization also does not support the relatively large domestic investment weight; hence, the IHB puzzle emerges. It is advocated that the bivariate expected utility maximization rationalizes partially or fully the IHB. In this study, we employ the "keeping up with the Joneses" (KUJ) preference, where the investor's wealth and the peer group's wealth are the two attributes of this utility function, analyzing the peer effect on the empirically observed IHB phenomenon.

The basic idea and the intuition of the KUJ argument for rationalizing the IHB phenomenon is as follows: suppose that you know your univariate utility function and that, for a given joint distribution of returns corresponding to the various international markets, you derive with this utility function the optimal investment weights in the domestic market as well as in the foreign markets under consideration. Furthermore, suppose that the optimal domestic investment weight is, say, $p\%$. Now, suppose that you decide to consider, in addition to the joint distribution of returns, one more factor: you also want the performance of your portfolio to be as close as possible to the performance of a certain local stock index. For example, the American investor wants the return on her portfolio to be as close as possible to the return on the S&P 500 index, which, for simplicity of the discussion, is assumed to be the peer's portfolio (the same analysis applies to any other local stock index). Thus, if the investor benefits from having a relatively large correlation with the S&P index, she may have an incentive to increase the domestic investment weight (which generally increases the correlation with the S&P stock index, and if the domestic investment weight is 100%, this correlation is +1) beyond

what is obtained by a maximization of a univariate expected utility function. Therefore, employing KUJ preferences may rationalize the IHB.[1]

Indeed, Lauterbach and Reisman (2004) use the KUJ preference prove that the IHB is rationalized by incorporating the peer effect. However, they use the mean-variance model with some approximations to achieve this result. We analyze in this paper the impact of incorporating the peer effect on the IHB in the most general bivariate expected utility case, not relying on the mean-variance framework and where no approximations of the various mathematical formulas are employed. We define the precise conditions, which guarantee the IHB rationalization, by adding the peer effect. We find that, in this unrestricted analysis, the appealing intuitive explanation of the IHB rationalization by the peer effect is generally wrong. Thus, we conclude that one should seek other economic explanations for the observed IHB phenomenon. For some interesting economic suggestions, see Coeurdacier and Rey (2013) and Berriel and Bhattarai (2013)[2] or other behavioral explanations.

We employ in this study distribution-free bivariate first-degree stochastic dominance (BFSD), with no assumptions on the shape of the bivariate preferences and no approximations. We prove that, despite the above appealing intuition of the peer effect on the optimal domestic investment weight, using the bivariate preferences, the IHB may increase or decrease relative to the univariate optimal domestic investment weight. Moreover, we demonstrate with actual international data that adding the peer effect, counter intuitively, even intensifies the IHB from the American investor's point of view. Hence, the IHB still exists.

The structure of the rest of this paper is as follows. Section 2 provides a brief literature review. Section 3 presents bivariate first-degree stochastic dominance (BFSD) rule and the implied theoretical results. We analyze the various factors affecting the IHB and show that bivariate preferences rationalize the IHB phenomenon only in a limited and unrealistic case. Section 4 is devoted to the commonly employed KUJ preferences, which is a specific set of all the bivariate preferences. We show empirically that the peer effect with KUJ preferences even enhances the IHB puzzle. Section 5 concludes.

2. Literature Review

Vanpée and DeMoore (2012) show that the IHB exists in virtually all countries. The magnitude of the IHB phenomenon is relatively large, characterizing various periods, assets, and countries. While about three decades ago the American investment in the local market was more than 90%, implying a very large IHB, in recent years the IHB phenomenon has been mitigated, yet it is still about 40%. When it comes to fixed-income assets, the home bias is even larger. This phenomenon is not unique to the US and characterizes many capital markets (for a report on the IHB in various countries, regarding equity and fixed-income assets, see (Philips et al. 2012)). Actually, there is evidence that the home bias is even worse than reported (see Baxter and Jermann 1997).

Researchers have analyzed various possible key explanations for the IHB. It is agreed that some portion of the domestic overinvestment may be induced by international trade barriers, foreign exchange risk, and regulation, as well as by a domestic peer group effect. However, with the increase in the rapid flow of information and market efficiency observed over the last few decades, the trade barriers, including possible asymmetrical information, have drastically declined. This may account for the observed slight decrease in the domestic overinvestment phenomenon. However, since 1998, the equity IHB of American investors has stabilized at about 40% (see Levy and Levy 2014).

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[1] Note, we analyze whether the peer effect increases the optimal domestic weight, which partially or fully rationalizes the IHB. The reason is that it is possible that the peer effect increases the optimal domestic weight by, say, 1%, but the IHB is, say, 40%, a case where other factors are needed to explain the observed IHB. In our study, we find empirically that the peer effect even enhanced the IHB; hence, the distinction between partial and full IHB rationalization is irrelevant.

[2] They consider portfolio diversification when macroeconomic factors are incorporated into a two-country general equilibrium model, called the "Open Economy Financial Macroeconomics" model. They conclude that, with this equilibrium model, the home bias is less of a puzzle. Berriel and Bhattarai (2013) also suggest a macroeconomic model (related to the positive association between government spending and return on local stocks) to explain the home bias.

　　　While most empirical studies analyze the IHB at the country level (see French and Poterba 1991; Tesar and Werner 1995), Kang and Stultz (1997), who study the IHB puzzle in Japan, analyze it at the individual firm level, showing that foreign investors hold disproportionally more Japanese shares of firms in the manufacturing industries, large firms, and firms with good accounting performance. Similarly, Dahlquist and Robertsson (2001) identify the characteristics of Swedish firms that attract foreign investors. Lewis (1999), who analyzes the effect of each economic factor that is considered as a barrier for efficient international diversification on the IHB, concludes that the trade barriers cannot explain the magnitude of the existing IHB. Therefore, the IHB puzzle is still an interesting research topic.[3]

　　　Obviously, if the IHB does not incur economic loss, it does not constitute an economic puzzle. Indeed, the intensity of the IHB economic cost changes over time. Levy (2016) analyzes the trend in the IHB phenomenon over time. Moreover, he distinguishes between the economic home bias (EHB), which measures the economic loss in terms of the differences in the certainty equivalent of two alternative international diversification strategies (with and without a home bias) and the IHB, which simply measures the deviations between the optimal international investment weights and the actual investment weights. He reports that, while the EHB was very large in the past, in the last 15 years, the EHB from the American investment point of view has become negligible, despite the existence of about 40% IHB. This reduction in the EHB is induced by the increasing trend in the international correlations. Thus, it seems that for the American investors the IHB is not a major economic puzzle. However, he also reports that for other countries, e.g., France, the EHB is still very large, and the economic puzzle exists. Moreover, in recent years, we have trend reversal in correlations, and a decrease in the average correlation between various markets has been recorded. As a result of this trend reversal, the EHB has recently increased, even for American investors. Thus, for most countries and with the recent trend reversal in correlation also for the US, the IHB still constitutes an economic puzzle that needs an explanation. The employment of the KUJ preference, namely incorporation of the peer effect, is considered as one of the promising paths in explaining the IHB puzzle.

　　　We employ in this paper a bivariate preference. Generally, with bivariate preference, the two variables can take many forms, e.g., wealth and health, climate and income, etc. Our study deals with investment choices. Hence, the two variables are the individual's wealth and the peer group's wealth. The peer group's wealth can be the return on a certain domestic portfolio, and in our case, as mentioned above, we assume, for the simplicity of the discussion and without loss of generality, that it is the return on S&P 500 stock index.

　　　The common view is that the relevant bivariate utility function has a positive cross derivative (we will elaborate on this issue below) and that investors want, among other things, the performance of their portfolio to be as close as possible to the performance of the peer's portfolio, i.e., a large correlation with the S&P stock index is desired.[4] Therefore, we focus our analysis on the positive cross-derivative case. Obviously, despite the desire for having a relatively large correlation with the S&P index, the investor will shift from a portfolio with a small correlation to a portfolio with a large correlation, only if the bivariate expected utility increases by such a shift. We turn to analyze the conditions under which indeed such shift takes place, namely that the IHB can be rationalized with the peer effect.

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[3]　It is interesting to note that, even in a case in which there are no transparent trade barriers, there is a tendency to invest in firms that are geographically located close to the investor's location. This phenomenon is well documented within the US (see Coval and Moskowitz 1999, 2001; Huberman 2001). This indicates that the home bias is a complex phenomenon that is not easy to explain with conventional economic factors.

[4]　Tsetlin and Winkler (2009) advocate that correlation aversion prevails. However, in their model, the two attributes of the bivariate preference directly affect the utility of the decision maker, for example, income and quality of life. In our model, the two attributes are different: the individual's wealth and the peer group's wealth. As relative wealth may affect the individual's utility, it is advocated in the literature that, when some conditions hold, correlation loving prevails.

3. Bivariate First-Degree Stochastic Dominance (BFSD) and the IHB

We would like to stress at the outset that most of the mathematical formulas given in the first part of this section are not new and exist in the literature, albeit in different forms and in different connotations. However, we use these mathematical results, to the best of our knowledge for the first time to analyze the peer effect with KUJ preferences on the IHB phenomenon.

3.1. The Sufficient Conditions for BFSD Implying the IHB Rationalization

Consider an individual with a bivariate preference $U(w, w_P)$, where w denotes the return on the selected international portfolio by the investor under consideration, and w_p denotes the return on the peer's portfolio. We compare two bivariate investment portfolios, *F* and *G*, where the domestic investment weight in portfolio *F* is larger than the domestic investment weight in portfolio *G* (we will elaborate later on the selected portfolios, *F* and *G*). Our aim is to examine the conditions under which *F* dominates *G* by BFSD with the above bivariate utility function, where we first assume two assumptions on the preferences: $\partial U(w, w_p)/\partial w \equiv U_1 \geq 0$ (monotonicity) and $\partial^2 U(w, w_p)/\partial w \partial w_p \equiv U_{12} \geq 0$ (later on we consider also $U_{12} \leq 0$, a case usually not considered in KUJ economic research but emerges as important to our analysis). There is no constraint on the derivative $\partial U(w, w_p)/\partial w_p \equiv U_2$, which can be negative, zero, or positive.[5] If such dominance exists, then all investors, regardless of the precise shape of the bivariate preference, will switch from *G* to *F*. Hence, the optimal domestic investment weight increases, and therefore the peer effect rationalizes the IHB phenomenon.

Note that the main ingredient of the KUJ preference is that the cross derivative (U_{12}) is positive, implying that the individual's marginal utility increases with an increase in the peer group wealth (see Ljungqvist and Uhlig 2000).[6] Therefore, as explained before, it seems that the investor with a positive cross derivative would incline to overinvest domestically, as she prefers her wealth to be positively correlated with the peer's wealth. While the above intuitive explanation is appealing, in the following proposition, it is formally shown that generally only under some specific conditions, indeed a positive cross derivative is tantamount to correlation loving, where correlation loving implies that, by increasing the domestic investment weight, the bivariate expected utility increases. Namely, if the conditions required in the proposition are intact, the investor increases her bivariate expected utility by overinvesting domestically (relative to the optimal univariate expected utility maximization optimal domestic investment weight), and by doing so, the correlation increases. Thus, if the proposition required conditions hold in practice, we have by the KUJ preferences a rationalization of the IHB, and the IHB puzzle may vanish. As we explain below, in practice, the required conditions for IHB rationalization are not intact. Before stating the proposition, we need the following definition:

Definition 1. *Definition of correlation loving (CL): The investor is CL if and only if, by increasing the correlation between her portfolio and the peer's portfolio, the expected bivariate utility increases.*

Hence, CR investors who maximize the bivariate expected utility would increase the domestic investment weight relative to the optimal univariate expected utility weight.

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[5]   Note that a negative sign implies jealousy, and a positive sign implies altruism (see Dupor and Liu 2003).

[6]   Numerous studies suggest replacing the univariate expected utility analysis with the expected bivariate utility analysis with various definitions of the two variables: past and present consumption, consumption of the individual, and consumption of the peer group, the wealth obtained by the individual and the opponent in an ultimatum game, and so forth. For studies that assume that the utility is derived not from the absolute wealth (or consumption) of the individual but from the relative wealth (or consumption), in which the wealth's position relative to the peer group plays an important role, as well as for other factors that do not affect the classic univariate expected utility but affect the bivariate expected utility, see, for example, Abel (1990), Constantinides (1990), Bolton (1991), Rabin (1993, 1998), Galí (1994), Campbell and Cochrane (1999), Bolton and Ockenfels (2000), Dupor and Liu (2003), Zizzo (2003), and Demarzo et al. (2008).

Proposition 1. *Suppose that the investor faces two alternate bivariate prospects, $F(w, w_p)$ and $G(w, w_p)$, where w as well as w_p can take only two different outcomes. As there are only two outcomes, they can be rearranged to have either a correlation of +1 or a correlation of −1. Diversification between w and w_p is not allowed, implying that the marginal distributions are identical (namely, $F_w = G_w$ and $F_{w_P} = G_{w_P}$, regardless of the outcomes arrangement; see, for example, Table 1). Under these specific conditions, the investor with a bivariate preference is CL if and only if the cross derivative is positive, namely $U_{12} \geq 0$. Specifically, under the conditions of the proposition, with CL, the prospect with a correlation of +1 yields a higher bivariate expected utility than any other possible prospect. (For proof, with some other notation, see (Eeckhoudt et al. 2007)).*

Thus, if the conditions of the proposition were intact, the American investor who likes her investment performance to be as close as possible to the S&P index would have a higher expected utility by increasing the domestic investment weight. Actually, under the conditions of the proposition, having a correlation of +1 with the S&P index is optimal, implying that investing 100% domestically is optimal, which creates a negative IHB puzzle (because in practice less than 100% is invested domestically). In short, if the conditions of Proposition 1 are intact, we have:

$$\text{CL} \Leftrightarrow U_{12} > 0 \tag{1}$$

Note that investing more intensively domestically, hence increasing the correlation between the investor's portfolio and the peer's portfolio, generally does not imply CR as defined above. The reason is that, with investment in practice, by increasing the domestic investment weight, although the correlation increases, generally, other parameters of the portfolio may also change, the marginal distributions may change (hence, the conditions of the proposition are violated), and the bivariate expected utility may decrease.

Therefore, the American investor may decide not to decrease the domestic investment weight, despite the desire to have large correlation with the S&P index. However, by the above definition, the investor is CL only if, after considering all effects, the bivariate expected utility increases.

However, note that, by Proposition 1, the marginal distributions are kept unchanged, and the correlation can take only the extreme values of either +1 or −1. This is because in Eeckhoudt et al. (2007) original proposition, each variable can get only two possible values. Hence, by reordering these values, the marginal distributions are kept unchanged. Also, diversification between w and w_p is not allowed, because if it is allowed, the marginal distribution of the individual's wealth, w, generally will not be kept constant. Thus, the statement given in Proposition 1 is suitable to some choices, where the variables are, for example, wealth and health, with only two outcomes (say, bad and good health, high and low income, etc.). As we shall see below, with international diversification, we have more than two outcomes corresponding to each prospect, and diversification is allowed. Hence, the marginal distributions generally change when the selected diversification changes. Therefore, a positive cross derivative in our analysis does not necessarily imply CL. As a result, we may even obtain an IHB phenomenon enhanced with bivariate preferences relative to the univariate IHB, despite the fact that a positive cross derivative is assumed.

Let us turn now to the conditions for BFSD of the distribution of returns of the portfolio with the IHB over the distribution of returns with no IHB. The two portfolios that we compare, F and G, have bivariate density functions, denoted by $f(w, w_P)$ and $g(w, w_P)$, respectively. As we focus on the possible IHB rationalization, it is assumed, as explained before, that F stands for a portfolio with an IHB, that is, the domestic weight in this portfolio is larger than the corresponding weight in G. Thus, if the domestic investment weight in G is equal to the optimal theoretical univariate expected utility maximization domestic weight (say, the international market portfolio), the BFSD of F over G implies that the peer effect rationalizes the IHB phenomenon, as all investors would prefer F over

G.[7] Assuming that $\partial^2(w, w_p)/\partial w \partial w_p) \equiv U_{12} > 0$ with KUJ preference[8] to explain various observed economic phenomena is very common. As seen in Proposition 1, this assumption is an important ingredient also needed to rationalize the IHB phenomenon, so long as the conditions of Proposition 1 hold. Therefore, we examine the role of the cross derivative on the BFSD relation. To examine possible rationalization of the observed IHB with KUJ preferences, we extend the expected utility univariate analysis to the bivariate expected utility analysis by adding the peer effect.

The expected bivariate utility of portfolios *F* and *G* is given by:

$$E_F U = \int_{\underline{w}}^{\overline{w}} \int_{\underline{w_p}}^{\overline{w_p}} U(w, w_p) f(w, w_p) dw dw_p$$

$$E_G U = \int_{\underline{w}}^{\overline{\overline{w}}} \int_{\underline{w_p}}^{\overline{w_p}} U(w, w_p) g(w, w_p) dw dw_p \qquad (2)$$

where $\underline{w}$ and $\overline{w}$ denote the minimal and maximal values of w (which can be $-\infty$ and ∞); similarly, $\underline{w}_P$ and $\overline{w}_P$ denote the minimal and maximal values of w_P. Thus,

$$\Delta_i \equiv E_F U - E_G U = \int_{\underline{w}}^{\overline{w}} \int_{\underline{w_p}}^{\overline{w_p}} U(w, w_p) \left[f(w, w_p) - g(w, w_p) \right] dw dw_p$$

Integrating by parts the above equation with respect to both variables yields:

$$\Delta_i \equiv E_F U - E_G U = \int_{\underline{w_p}}^{\overline{w_p}} \int_{\underline{w}}^{\overline{w}} U_{12}[F(w, w_p) - G(w, w_p)] dw dw_p + \int_{\underline{w}}^{\overline{w}} U_1[G(w) -$$

$$F(w)] dw + \int_{\underline{w_p}}^{\overline{w_p}} U_2[G(w_p) - F(w_p)] dw_p \qquad (3)$$

$$\equiv A + B + C$$

where Δ_i denotes the expected utility difference corresponding to the *i*th investor, $F(w, w_P)$ and $G(w, w_P)$ are the two bivariate cumulative distributions, $F(w) = F(w, \overline{w}_p)$ is the marginal cumulative distribution function of w, $F(w_p) = F(\overline{w}, w_p)$ is the marginal cumulative distribution function of w_P, and U_1, U_2, and U_{12} denote the partial derivatives: $U_1 \equiv \partial U/\partial w$, $U_2 \equiv \partial U/\partial w_P$, and $U_{12} \equiv \partial^2 U/\partial w \partial w_P$, respectively. For the derivation of Equation (3) with slightly different notations, see Levy and Paroush (1974, p. 131) and Atkinson and Bourguignon (1982, pp. 185–86).[9] Note that, as the marginal utility of the peer's portfolio is identical under the various investment strategies (with and without intensive domestic investment). Namely, we have $G(w_p) = F(w_p)$, therefore term *C* in Equation (3) is equal to zero. Thus, the rest of the paper relate only to terms *A* and *B*.

Let us first analyze the relation between Equation (3) (with *C* = 0) and the conditions given in Proposition 1. If each of the two random variables, w and w_p, has only two possible different outcomes, the correlation is either +1 or −1. Also, when diversification between w and w_p is not allowed, the marginal distributions are equal (namely, $G(w) = F(w)$, see also the example given in

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[7]   Obviously, we have a different optimum portfolio for each utility function, but, as we shall see below, the analysis is intact, independent of the assumed preference.

[8]   The KUJ and CUJ literature is very extensive; hence, we mention here only a few of these studies. Abel (1990) and Galí (1994) use this bivariate framework to explain optimal choices. Ljungqvist and Uhlig (2000) examine the role of tax policies in economics with CUJ utility functions. Campbell and Cochrane (1999) assume that the preference is a function of the relative consumption, when the individual's consumption is measured relative to the weighted average of the past consumption of all individuals. In these models, when the peer group's variable (e.g., consumption) is a lagged variable, the model is commonly called the CUJ model, and when the individual's variable and the peer group variable relate to the same time period (e.g., return on investment), it is commonly called the KUJ model. In this paper, we analyze the optimal portfolio investment decision in the KUJ set-up.

[9]   Note that Equation (2) is reduced to the well-known univariate formula employed to derive the FSD rule, where $U_{12} = U_2 = 0$. For more details, see Hadar and Russell (1969) and Hanoch and Levy (1969). Although we focus in this paper on FSD, one can assume risk aversion and employ stronger investment rules; for example, see Rothschild and Stiglitz (1970) and Levy (2015).

Table 1. Hence, in this specific case also term *B* is equal to zero, and we are left with term *A*. If *F* represents the +1 correlation and *G* the −1 correlation, we must have with the two outcomes case that $F(w, w_p) \geq G(w, w_p)$ (see example 1 in Table 1. Hence, in this case by Equation (3), with $B = C = 0$, the condition $U_{12} \geq 0$ is a sufficient condition for dominance of the joint distribution with the +1 correlation over the joint distribution with the −1 correlation (see Equation (3)).[10] It is easy to verify that, in this specific case, $U_{12} \geq 0$ is a necessary and sufficient condition for dominance.[11] Thus, Equation (3) is perfectly consistent with Proposition 1, so long as the conditions given in the proposition are intact. However, Equation (3) corresponds to the general case, as it covers the more realistic scenarios where more than two outcomes are possible. Diversification is allowed, and the marginal distributions are not necessarily equal, hence term *B* is not necessarily equal to zero. As we shall see in this general and realistic case, $U_{12} \geq 0$ is neither a necessary nor a sufficient condition for dominance. We turn now to analyze the possible dominance of the portfolio with the IHB over a portfolio with no IHB in the most general case.

To examine possible rationalization of the IHB phenomenon with bivariate preferences, let us first take a deeper look at the marginal distributions corresponding to the international diversification issue analyzed in this paper. Returning to Equation (3), note that, as mentioned above, it is reasonable to assume that the third term on the right-hand side of Equation (3), term *C*, is equal to zero, as the investor in the capital market generally cannot affect the peer group investment decision; hence, the peer's group marginal distribution is identical under *F* and *G*. This condition conforms to the requirement in Proposition 1, even in the case where more than two outcomes exist. This is a reasonable assumption with the investment choices that we analyze in this study but not with ultimatum games in which the individual decision affects the opponent's outcome. Moreover, in the portfolio investment case, this term is equal to zero, regardless of whether the peer group portfolio is domestic or international. Thus, regarding the issue that we investigate in this paper (investment with a particular stock index as the peer group's portfolio), as advocated above, the sign of the derivative U_2 is irrelevant. Namely, term $C = 0$ and there is no need to assume jealousy ($U_2 < 0$) or altruism ($U_2 > 0$) to obtain our results corresponding to the portfolio investment case. Thus, as for the analysis of the IHB, term *C* is equal to zero, and Equation (3) is reduced to:

$$\Delta_i = A + B. \tag{4}$$

However, note that generally we cannot assume that also term *B* is equal to zero, as by changing the diversification strategy, we change the marginal distribution of the individual's wealth. Thus, with international portfolio diversification, the condition of equal marginal distributions (see term *B* of Equation (3)) required by Proposition 1 does not hold.

To be able to determine whether the peer effect induces an increase in the optimal domestic investment relative to the univariate expected utility optimal domestic investment weight, we need to be more specific regarding the definitions of portfolios *F* and *G* under consideration. We examine here the possible existence of BFSD by considering the two specific portfolios with direct implication to the IHB issue analyzed in this paper. These two portfolios are denoted by F_A and G_M, as defined below.

Definition 2. *G_M is the portfolio with the international market weights. If the American investor holds this market portfolio, she would invest 35% (which is the weight of the American market in the world market) domestically; hence, the IHB does not exist. Distribution F_A stands for the actual aggregate portfolio held by the American investors. Namely, the actual domestic weight held by the American investor is 75%; hence, holding this portfolio implies an IHB of 40%.*

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[10]   Actually, it is required to have at least one strict inequality with the distribution functions as well as with the cross derivative to avoid the trivial case of having $\Delta_i = 0$. In the rest of the paper, when we write such inequalities, we always mean that there is at least one strict inequality, but to avoid a complex writing, we will not write it down everywhere.

[11]   If $U_{12} < 0$, in some range, one can always find a bivariate preference, such that outside this range the cross derivative is close to zero; hence, Δ_i is negative. Therefore, to guarantee that Δ_i is non-negative, the cross derivative cannot be negative.

Assuming that term C is equal to zero, and rewriting Equation (4) in terms of the above two portfolios, we obtain:

$$\Delta_i \equiv E_{F_A}U - E_{G_M}U = \int_{\underline{w}_p}^{\overline{w}_p} \int_{\underline{w}}^{\overline{w}} U_{12}\big[F_A(w,w_p) - G_M(w,w_p)\big]dwdw_p$$
$$+ \int_{\underline{w}}^{\overline{w}} U_1[G_M(w) - F_A(w)]dw \equiv A + B \tag{5}$$

Suppose that without the peer effect the market portfolio is optimal. If $\Delta_i > 0$, the ith investor under consideration who considers also the peer effect prefers the actual portfolio to the market portfolio; hence, the investor increases the bivariate expected utility by increasing the domestic investment weight. However, to have BFSD and IHB rationalization, we need to have that $\Delta_i > 0$ for all investors $i = 1, 2, \ldots n$, regardless of the precise shape of their preferences. A few conclusions, some of them in contradiction to the common view regarding the role of the cross derivative, can be drawn from Equation (5).

First, if $U_{12} \geq 0$ is assumed (as needed in Proposition 1 to justify the rationalization of the IHB), we find that there is no BFSD; hence, in this setting there is no IHB rationalization. The reason is that if $U_{12} \geq 0$, term A of Equation (5) is positive only if $F_A(w,w_p) \geq G_M(w,w_p)$, but this implies that $F_A(w,\infty) = F_A(w) \geq G(w,\infty) = G(w)$, and therefore, term B is negative. The sum $A + B$ may be negative, implying that there is no BFSD.

Surprisingly, in contrast to Proposition 1, the condition $U_{12} \leq 0$ may allow BFSD; hence, it may allow IHB rationalization. We have BFSD and IHB rationalization with $U_{12} \leq 0$ if the following two conditions hold:

$$F_A(w,w_p) \leq G_M(w,w_p) \tag{6a}$$
$$F_A(w) \leq G_M(w) \tag{6b}$$

But as condition (a) implies condition (b), unlike the positive cross-derivative case, these two conditions can simultaneously hold. Therefore, if condition (a) on the joint distribution holds, both terms A and B are positive (with $U_{12} < 0$) and therefore $\Delta_i \geq 0$ for $i = 1, 2, \ldots n$.

Example 1. *The marginal distributions and the BFSD.*

In this example, we demonstrate the relation between the BFSD and the positive cross derivative in the case where the conditions of Proposition 1 are intact, and then we demonstrate the more realistic case, where the marginal distributions are not kept constant; hence, BFSD does not exist, despite the positive cross-derivative assumption.

Suppose that the S&P index return w_p is equal to 3 or 4, each outcome with an equal probability of 0.5. We consider investing in either portfolio F or portfolio G, both yielding return w of either 2 or 5 with equal probability of 0.5. However, F has a correlation of +1 with the S&P index (with joint returns of (2, 3) with a probability of 0.5 and joint returns of (5, 4) with a probability of 0.5). G has a negative correlation of −1 with the S&P index with joint returns of (2, 4) with a probability of 0.5 and joint returns (5, 3) with a probability of 0.5 (see Table 1). All other joint probabilities are equal to zero. Denoting the joint distribution corresponding to the correlation +1 by F_A and the joint distribution corresponding to correlation −1 by G_M, we have with the above example with the joint probabilities the following relationship:

$$F_A(w,w_p) \geq G_M(w,w_p) \text{ for all values } (w,w_p) \tag{7}$$

with at least one strict inequality (see lower part of Table 1 Part a), e.g.,

$$F_A(2,3) = 0.5 > G_M(2,3) = 0,$$

and it is easy to verify that with the marginal distributions, we have:

$$G_M(w) = F_A(w)$$

and

$$G_M(w_p) = F_A(w_p)$$

for all possible values(all marginal cumulative distributions get the values of 0.5 at the lower outcome and 1 at the larger outcome). Therefore, the conditions of Proposition 1 are intact and terms B and C of Equation (3) are equal to zero and we are left only with term A; hence, if the cross derivative is positive, the joint distribution yielding (2, 3) and (5, 4) dominates the joint distribution (2, 4) and (5, 3) for all bivariate preferences with a positive cross derivative. Thus, term A of Equation (3) is positive, and term B is equal to zero; hence, we have BFSD of the joint distribution with correlation +1 over the joint distribution with correlation −1. So far, this example conforms to the conditions given in Proposition 1 and provides the IHB rationalization by adding the peer effect, so long as the cross derivative is positive. Let's turn to another example, where one of the conditions of Proposition 1 is violated.

Table 1. Joint Probability and Joint Cumulative Probability Functions Corresponding to the two Examples Given in the Text.

	Correlation +1			Correlation −1	
	Part (a): The First Example Given in the Text				
	The Probability Functions				
	F_A			G_M	
$w \backslash w_p$	3	4	$w \backslash w_p$	3	4
2	0.5	0	2	0	0.5
5	0	0.5	5	0.5	0
	The Cumulative Bivariate Probability Functions				
w/w_p	3	4	w/w_p	3	4
2	0.5	0.5	2	0	0.5
5	0.5	1	5	0.5	1
	Part (b): The Second Example Given in the Text				
	The probability Functions				
w/w_p	3	4	w/w_p	3	4
2	0.5	0	2	0	0.5
5	0	0.5	10	0.5	0
	The Cumulative Bivariate Probability Functions				
w/w_p	3	4	w/w_p	3	4
2	0.5	0.5	2	0	0.5
5	0.5	1	10	0.5	1

Make now the following change in the previous example: the outcomes with the −1 correlation are 2 and 10 with equal probability of 0.5 rather than 2 and 5 as we have in the previous example. Thus, we simply replaced the outcome 5 by outcome 10 (see Table 1 Part b). All the other outcomes are kept unchanged. Thus, under the choice with a correlation of −1, we have the joint outcomes of (2, 4) or (10, 3) with an equal probability of 0.5, and with the choice corresponding to correlation +1, we have as before the joint outcomes (2, 3) or the outcomes (5, 4) with an equal probability of 0.5. It is easy to verify that as before, also with this change we have:

$$F_A\big(w, w_p\big) \geq G_M\big(w, w_p\big) \tag{8}$$

with at least one strict inequality, e.g.,

$$F_A(2,3) = 0.5 > G_M(2,3) = 0.$$

Hence, if the cross derivative is positive, term A of Equation (5) is also positive. However, with this change, the marginal distribution of the individual wealth also changes, and as cumulative distribution of (2, 10) is located to the right of the cumulative distribution of (2, 5), namely, $G_M(w) \leq F_A(w)$ for all values w, and there is at least one strict inequality, e.g., $G_M(w = 5) = 0.5 > F_A(w = 5) = 1$, see Table 1 Part b (this means that the univariate prospect A dominates prospect M by FSD[12]); hence, term B of Equation (5) is negative. Therefore, $A + B$ may be positive, zero, or negative, and we do not have BFSD, and as a result, the IHB cannot be rationalized in this case, despite the assumed positive cross derivative. Actually, it is easy to find a specific bivariate preference with $U_{12} \to 0$ and U_1 very large such that $A + B < 0$, implying that F does not dominate G.

Finally, even if we stick to the original set of numbers by diversification of say, 0.5 in each asset (w and w_p), the marginal distribution of the individual's wealth becomes either $2.5 = 0.5 \times 2 + 0.5 \times 3$ or $4.5 = 0.5 \times 5 + 0.5 \times 4$ (with equal probability) in the case of a correlation of +1, and either $3 = 0.5 \times 2 + 0.5 \times 4$ or $4 = 0.5 \times 5 + 0.5 \times 3$ (with an equal probability) in the case of correlation of −1 (see Table 1 Part a). Thus, allowing diversification between the two variables the marginal distribution of w is not kept constant, and the conditions required by Proposition 1 are violated, and once again, we do not have BSFD, even where the cross derivative is positive. Moreover, by changing the investment weights, we change the marginal distribution of w. Hence, we do not have BFSD of the +1 correlation joint distribution over the −1 correlation joint distribution.

In sum, with the first example, we have IHB rationalization if diversification is not allowed. In the second example, we do not have IHB, even if diversification is not allowed, let alone if it is allowed. We show below that the case given in Table 1 Part b, where the marginal distributions are not kept constant, conforms to actual stock market data; therefore, KUJ with a positive cross derivative does not rationalize empirically the IHB phenomenon.

3.2. Discussion

We analyze above the dominance condition between two specific portfolios, one with an IHB and one without an IHB. If indeed these are the two portfolios considered by all investors, assuming a positive cross derivative, we do not have dominance of the portfolio with the IHB over the portfolio with no IHB. Thus, a positive cross derivative is not a sufficient condition for BFSD. However, with a negative cross derivative, we may have dominance and, therefore, may obtain IHB rationalization by incorporating the peer effect. The existence of such IHB rationalization depends on the joint distribution of the investor's selected portfolio and the peer's portfolio. If all investors consider the same two portfolios (the market portfolio and the actual portfolio defined above), and if the condition $F_A\big(w, w_p\big) \leq G_M\big(w, w_p\big)$ holds, we have IHB rationalization, so long as the cross derivative is negative. However, generally there is no reason to assume that with actual data this condition is intact. Therefore, we generally do not have IHB rationalization with the above two portfolios, regardless of the sign of the cross derivative.

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[12] Generally, if $F(x) \leq G(x)$ for all values x and there is at least one strict inequality, we say that F dominates G by first degree stochastic dominance (FSD).

In the above analysis, we consider two specific portfolios. In practice, not all investors hold these two portfolios, and each investor has her optimal univariate portfolio and her optimal bivariate portfolio. In this realistic case, only if we have for all investors the optimal domestic investment weight whereby the bivariate utility function is larger than the optimal domestic investment weight corresponding to the univariate framework, we have an IHB rationalization. As such case cannot be analyzed without the information on the preferences of all investors, we analyze below the peer effect on the IHB with the commonly employed KUJ preferences.

4. The IHB with Some Specific KUJ Preferences

We proved above that unless the marginal distributions are kept unchanged with a positive cross derivative, we do not have BFSD, and with a negative cross derivative, the required condition is unlikely to hold; therefore, generally we do not have IHB rationalization, regardless of the sign of the cross derivative. However, it is possible that, despite not having dominance which corresponds to all possible bivariate preferences, for some important and commonly employed KUJ preferences (but not for all bivariate preferences, as we do not have BFSD), with various risk aversion parameters, the peer effect may induce an increase in the domestic investment weight relative to the univariate optimal domestic investment weight. As we shall see below, this is not the case and also the KUJ preferences empirically do no rationalize the IHB.

The procedure for testing the peer effect with KUJ preferences is as follows: We first solve with actual data for the optimum diversification with a univariate preference for various degrees of risk aversion and then solve for the optimum diversification with a KUJ preference with a similar form of the univariate preference but with the incorporation of the peer effect. Using this two-step analysis, we measure the marginal peer group effect on the optimal domestic investment weights. It is shown below empirically that, with the commonly employed KUJ preference with a positive cross derivative, adding the peer group effect does not rationalize the home bias phenomenon. Moreover, the optimal domestic investment weight with the KUJ preference (with a domestic peer group) is found to be even smaller than the optimal domestic investment weight with no peer group effect. Thus, despite the assumed positive cross derivative, which under some conditions implies CL, we find empirically that, counter intuitively, the IHB phenomenon is even enhanced when the peer effect is incorporated. Thus, shifting from univariate utility function to the bivariate utility function with peer effect does not rationalize the IHB and other explanations are called for. Let us elaborate.

4.1. The Optimal Diversification with a Univariate Utility

The empirical analysis given in this section is done from the American investor's point of view. Thus, all the returns are in dollar terms. Similar analysis can be done from other points of view.

With a univariate CRRA utility function, we have:

$$U(w) = [w^{1-\alpha}/(1-\alpha)], \text{ with} \alpha > 0. \tag{9}$$

With n available international assets, we solve for the vector of the investment proportions $\underline{p}$ (where $0 \leq p_i \leq 1$), which maximizes the following expected utility:

$$E\{[(p_{US}y_{US} + p_2y_2 + \ldots.(1 - \sum_{i=1}^{n-1} p_n)y_n)^{1-\alpha}/(1-\alpha)]\} \tag{10}$$

where y_{US} is the rate of return on the US index (a random variable), and y_i is the return on foreign market i, where $i = 2, 3, \ldots. n$, and there are n stock indices, the US index plus $n-1$ foreign indices. Let us specify the corresponding bivariate preferences employed in this study.

4.2. The KUJ Preferences (for $\alpha > 1$)

We discuss below various bivariate functions with a positive cross-derivative, which are natural extensions of the myopic univariate reference. We first employ the bivariate utility suggested by Abel (1990). As this function has a positive cross derivative only for $\alpha > 1$, we also employ a slightly different preference that conforms to the KUJ requirement for the whole range of the risk aversion parameter ($\alpha > 0$). Abel suggests a general bivariate formula that, under some conditions for the various parameters, reduces to:

$$U(w, w_P) = [w/w_P^\gamma]^{1-\alpha}/(1-\alpha) \text{ where} \alpha > 0 \text{ and} \gamma \geq 0. \tag{11}$$

With $\gamma = 0$ this function is reduced to the univariate CRRA function. Hence, this is a neutral extension to the univariate myopic function. Thus, this bivariate preference is a natural extension of the univariate CRRA function, $U(w) = [w^{1-\alpha}/(1-\alpha)]$, which is commonly employed in economic research (see (Merton and Samuelson 1974)) to the bivariate case, in which the peer group effect is incorporated into the analysis. Note also that, when w_p is constant, Equation (11) collapses to Equation (9). As we wish to have monotonicity with regard to w and a positive cross derivative (because with positive cross derivative there is an appealing intuition for an increase in the domestic investment weight), let us examine these two derivatives. Monotonicity always exists with this function, because:

$$U_1 = (w/w_P^\gamma)^{-\alpha}w_P^{-\gamma} = w^{-\alpha}w_P^{-\gamma(1-\alpha)} \geq 0.$$

The cross derivative, which is given by:

$$U_{12} = -\gamma(1-\alpha)w^{-\alpha}w_P^{-\gamma(1-\alpha)-1},$$

is positive only for $\alpha > 1$. Thus, we have a KUJ preference with a positive cross-correlation for $\alpha > 1$. It is worth mentioning that with this function we also have jealousy, namely, $U_2 = \partial U/\partial w_p < 0$.

Generally, in economics, the range of the risk aversion parameter is $\alpha \geq 0$. To avoid the above constraint on α (namely $\alpha > 1$), we also employ the following function:

$$U(w, w_P) = [w^{1-\alpha}/(1-\alpha)][w_P^{1-\beta}/(1-\beta)] \text{ with} \beta < 1. \tag{12}$$

With this preference, the cross derivative is positive for all values $\alpha > 0$, as required by the myopic preference. Once again, when w_p is constant, this function collapses to the univariate myopic preference (multiplied by a positive constant). The partial derivative with respect to w of this bivariate function, given by $\partial U/\partial w \equiv U_1 = w^{-\alpha}w_P^{1-\beta}/(1-\beta) \geq 0$, is positive only for $\beta \leq 1$ and for any value α. As we assume monotonicity in the numerical solution to the optimum investment, we take the $\beta \leq 1$ constraint into account.

The cross-derivative is positive for the whole range of relevant parameters:

$$\partial^2 U/\partial w \partial w_P \equiv U_{12} = w^{-\alpha}w_P^{-\beta} > 0.$$

It is easy to see that, with this function, U_2 may be negative, zero, or positive, depending on whether α is larger than, equal to, or smaller than 1. Therefore, with this function, we allow for jealousy as well as altruism.

Let us write down the equations employed in the derivation of the optimal investment weights with the various preferences. With n available international assets, we solve for the vector $\underline{p}$ (where $0 \leq p_i \leq 1$), which maximizes the expected utility. For the preference suggested by Abel (see Equation (11)), we have:

$$E\{[p_{us}y_{us} + p_2y_2 + \ldots(1 - \sum_{i=1}^{n-1} p_n)y_n]/(w_P^\gamma)\}^{1-\alpha}/(1-\alpha)]\} \tag{13}$$

and with the KUJ preference given by Equation (12) we have:

$$E\{[(p_{us}y_{us} + p_2y_2 + \ldots(1 - \sum_{i=1}^{n-1} p_n)y_n)^{1-\alpha}/(1-\alpha)][y_{us}^{1-\beta}/(1-\beta)]\}, \tag{14}$$

where y_{US} is the return on the US index (a random variable), and y_i is the return on foreign market i, where $i = 2, 3, \ldots n$, and there are n stock indices, the US index plus $n - 1$ foreign indices.

4.3. Data and Results

The purpose of the empirical analysis given below is to examine the peer effect with some specific preferences on the IHB phenomena with actual data in the case where BFSD does not necessarily exist. It is not intended to find the optimal investment portfolio for investment, a case where statistical adjustment should be made in the empirical distribution, which is very noisy

We employ the 11 countries' actual *ex-post* joint distribution to analyze the peer group effect on the domestic investment weight from the American investor's point of view.[13] Obviously, the empirical distributions of return of all countries are not identical, and the marginal distribution of the various diversified portfolios under consideration are not identical; hence, the conditions of Proposition 1 are not intact; hence, the BFSD does not exist with positive cross derivative. Yet, it is possible that, with some specific bivariate preferences, the domestic investment weight increases. Thus, we examine whether the above two specific KUJ preferences with a positive cross derivative explain the IHB, despite the fact that we do not have BFSD. We use in the empirical study annual rates of return taken from the Bloomberg MSCI stock indices.

We report the optimum investment weights corresponding to Abel's bivariate preference function (see Equation (13)). The results corresponding to the bivariate function given by Equation (14) are very similar, so for brevity sake they are not reported here in detail. Both forms of the bivariate functions reveal the same surprising results: the commonly employed KUJ preference with a positive cross derivative induces a decrease rather than an increase in the US investment weight. Thus, the adding the peer effect does not rationalize the IHB.

Table 2 reports the results obtained using Abel's preference (see Equation (13)). The table employs the actual 25-year historical data (see Appendix A for the annual rates of return of the 11 countries for the years 1988–2012 and Appendix B for the correlation matrix). Recalling that, for $\gamma = 0$, the bivariate function is reduced to the univariate CRRA function, we see that, by adding the KUJ peer group effect with the domestic peer group, the US investment weight decreases quite sharply.

Table 2. The US optimal investment weights in the US market with Abel's bivariate preferences with empirical data for the period 1988–2012.

γ \\ α	(CRRA Univariate Preference $\gamma = 0$)	0.5	1	2
1 *	0.00	0.00	0.00	0.00
2	0.49	0.39	0.29	0.13
5	0.95	0.82	0.72	0.57

* Only for $\alpha > 1$ do we have a KUJ preference with $U_{12} > 0$. We also have with this function $U_1 > 0$ (monotonicity) and $U_2 < 0$ (jealousy).

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[13] We are aware of the large potential statistical errors involved in the derivation of the optimal investment weight with historical data (see Britten-Jones 1999; Levy and Roll 2010). However, the goal of this empirical analysis is not to derive the optimal investment weights for *ex-ante* investment purposes but rather to demonstrate that, with empirical data covering 11 international markets and 25 years, it is possible that, with some commonly employed KUJ preferences with a positive cross derivative, the peer group effect induces a decrease rather than an increase in the domestic investment weight, which is in contradiction to the equal marginal distribution case and to the economic intuition.

Specifically, with the 11 countries for $\alpha = 2$, we find with no peer group effect (a univariate utility function) that the optimal investment weight in the US is 0.49. Employing Equation (13) (Abel's preference), we find that the domestic investment in the US decreases rather than increases. For example, for $\alpha = 2$ and $\gamma = 1$, the US domestic weight decreases from 0.49 to 0.29. The same is true for the other KUJ preference suggested in this study. Employing Equation (14), we find that with the KUJ domestic peer group effect, for $\alpha = 2$ and $\beta = 0.5$, the optimal investment weight in the US decreases from 0.49 with no peer group effect to 0.39 with the peer group effect (this figure is not reported in a table). Thus, with the KUJ preference with a positive cross derivative, adding the domestic peer group effect decreases rather than increases the optimal US investment weight. Hence, with these specific KUJ preferences, we cannot rationalize the home bias empirically, which confirms the assertion that a positive cross derivative and CL are generally not equivalent. With a positive cross derivative, the investor wishes to increase the correlation by increasing the domestic investment weight but may not do it because other parameters (e.g., mean return) may induce a decrease in the bivariate expected utility by such action. Thus, if all investors have CRRA preference with various risk aversion parameters, the IHB is even intensified with the peer effect, despite the fact that a positive cross derivative implies that, other things being held unchanged, the American investor wants her portfolio to be as close as possible to the S&P stock index.

We turn now to examine whether incorporating the peer effect with a negative cross derivative may increase the optimal domestic investment weight. We employ the function $\left[\frac{w^{1-\alpha}}{1-\alpha}\right] / \left[\frac{w_p^{1-\beta}}{1-\beta}\right]$ (with $\alpha < 1$ and $\beta < 1$). It is easy to verify that the derivative with respect to w is positive (monotonicity) and that the cross derivative is negative. Once again, counter intuitively, we find that with this bivariate utility function with a negative cross derivative, the optimal domestic investment weight of the American investor in the US increases rather than decreases, due to the peer effect. For example, for $\alpha = 2$ and $\gamma = 0.5$, we obtain with this function that the domestic investment weight increases from 0.49 to 0.54. Therefore, we conclude that, with historical data, a positive cross derivative is neither sufficient (see Proposition 1) nor necessary (as demonstrated empirically with a preference with a negative cross derivative) for IHB rationalization.

5. Concluding Remarks

It is well documented in the literature that, in the univariate expected utility framework, the optimal international diversified portfolio generally reveals an investment home bias (IHB), which constitutes a major economic puzzle. In another research strand, it is suggested that investor's welfare is generally determined by relative wealth, relative consumption, relative success in investment, and so on, leading to the development of the bivariate expected utility paradigm, in which keeping up with the Joneses (KUJ) and catching up with the Joneses (CUJ) preferences are probably the most widely employed preferences in the bivariate framework. In this study, we combine these two research strands by investigating whether switching from a univariate preferences framework to multivariate preferences framework enables the rationalization of the empirically observed IHB phenomenon.

As with the bivariate preference, with a positive cross derivative, other things being held constant, the investor wishes the performance of her portfolio to be as close as possible to the performance of a certain local stock index (the peer effect), it is suspected that with a peer effect the investor tends to overinvest domestically (relative to the univariate expected utility domestic optimal investment weight). Hence, the employment of the bivariate preference with a positive cross derivative may rationalize the IHB. We find, theoretically and empirically, that this intuitive explanation is misleading.

While it is proven in the literature that, under some approximation, employing the mean-variance framework with a peer effect indeed rationalizes the IHB, we show in this paper that for unrestricted preferences not confining the analysis to the mean-variance model, counter intuitively, the IHB cannot be rationalized by the peer effect, even when the cross derivative of the bivariate preference is assumed to be positive.

We employ the bivariate first-degree stochastic dominance (BFSD) rule and prove theoretically that bivariate preferences with a positive cross derivative rationalizes the observed IHB, only in the unrealistic case in which the marginal distributions of all possible portfolio under consideration are identical. Of course, this does not hold in practice, as not all international markets are identical, and therefore also the marginal distributions of various selected diversified portfolios are not identical. Thus, even with peer effect, overinvesting domestically may be an inferior investment strategy, hence the IHB cannot be explained by the peer effect.

With actual empirical international stock market data (obviously, with unequal empirical marginal distributions), we find that the commonly employed KUJ preference with a positive cross derivative, which intuitively implies a desire to increase the correlation by overinvesting domestically, decreases rather than increases the domestic investment weight, hence the peer effect even enhances the IHB puzzle. Moreover, once again counter intuitively, we find that, with a bivariate preference with a negative cross derivative, the optimal domestic investment increases. Thus, a positive cross derivative is neither necessary nor sufficient for IHB rationalization.

In sum, employing a general bivariate utility function with peer effect, with no constraints on the preference employed, generally cannot rationalize the empirically observed IHB. Employing the commonly employed specific KUJ bivariate preferences also does not rationalize the IHB. As the IHB is an empirical fact, to rationalize this phenomenon, one needs to seek other explanations and other research strands, as the intuitive explanation of the peer effect for rationalizing the IHB phenomenon is misleading.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The annual rates of return 1988–2012.

Year	USA	Canada	Germany	France	The Netherlands	Norway	Sweden	UK	Australia	Japan	Emerging Markets
1988	0.16	0.18	0.21	0.39	0.16	0.43	0.49	0.06	0.38	0.36	0.40
1989	0.31	0.25	0.47	0.37	0.37	0.46	0.33	0.22	0.11	0.02	0.65
1990	−0.02	−0.12	−0.09	−0.13	−0.02	0.01	−0.20	0.10	−0.16	−0.36	−0.11
1991	0.31	0.12	0.09	0.19	0.19	−0.15	0.15	0.16	0.36	0.09	0.60
1992	0.07	−0.11	−0.10	0.03	0.03	−0.22	−0.14	−0.04	−0.10	−0.21	0.11
1993	0.10	0.18	0.36	0.22	0.37	0.43	0.38	0.24	0.37	0.26	0.75
1994	0.02	−0.02	0.05	−0.05	0.13	0.24	0.19	−0.02	0.06	0.22	−0.07
1995	0.38	0.19	0.17	0.15	0.29	0.07	0.34	0.21	0.12	0.01	−0.05
1996	0.24	0.29	0.14	0.22	0.29	0.29	0.38	0.27	0.18	−0.15	0.06
1997	0.34	0.13	0.25	0.12	0.25	0.07	0.13	0.23	−0.10	−0.24	−0.12
1998	0.31	−0.06	0.30	0.42	0.24	−0.30	0.15	0.18	0.07	0.05	−0.25
1999	0.22	0.54	0.21	0.30	0.07	0.32	0.81	0.12	0.19	0.62	0.66
2000	−0.13	0.06	−0.15	−0.04	−0.04	0.00	−0.21	−0.12	−0.09	−0.28	−0.31
2001	−0.12	−0.20	−0.22	−0.22	−0.22	−0.12	−0.27	−0.14	0.03	−0.29	−0.02
2002	−0.23	−0.13	−0.33	−0.21	−0.20	−0.07	−0.30	−0.15	0.00	−0.10	−0.06
2003	0.29	0.55	0.65	0.41	0.29	0.50	0.66	0.32	0.51	0.36	0.56
2004	0.11	0.23	0.17	0.19	0.13	0.54	0.37	0.20	0.32	0.16	0.26
2005	0.06	0.29	0.11	0.11	0.15	0.26	0.11	0.07	0.18	0.26	0.35
2006	0.15	0.18	0.37	0.35	0.32	0.46	0.45	0.31	0.33	0.06	0.33
2007	0.06	0.30	0.36	0.14	0.21	0.32	0.01	0.08	0.30	−0.04	0.40
2008	−0.37	−0.45	−0.45	−0.43	−0.48	−0.64	−0.49	−0.48	−0.50	−0.29	−0.53
2009	0.27	0.57	0.27	0.33	0.43	0.89	0.66	0.43	0.77	0.06	0.79
2010	0.15	0.21	0.09	−0.03	0.02	0.12	0.35	0.09	0.15	0.16	0.19
2011	0.02	−0.12	−0.17	−0.16	−0.12	−0.09	−0.15	−0.03	−0.11	−0.14	−0.18
2012	0.16	0.10	0.32	0.23	0.21	0.20	0.23	0.15	0.22	0.08	0.19

Appendix B

Table A2. The correlation matrix for the period 1988–2012.

	USA	Canada	Germany	France	The Netherlands	Norway	Sweden	UK	Australia	Japan	Emerging Markets
USA	1	0.68	0.79	0.83	0.85	0.48	0.76	0.86	0.58	0.44	0.52
Canada	0.68	1	0.77	0.76	0.75	0.84	0.88	0.79	0.81	0.67	0.78
Germany	0.79	0.77	1	0.90	0.89	0.70	0.80	0.84	0.72	0.59	0.68
France	0.83	0.76	0.90	1	0.88	0.66	0.84	0.83	0.75	0.62	0.67
The Netherlands	0.85	0.75	0.89	0.88	1	0.73	0.77	0.93	0.75	0.45	0.66
Norway	0.48	0.84	0.70	0.66	0.73	1	0.79	0.75	0.83	0.55	0.76
Sweden	0.76	0.88	0.80	0.84	0.77	0.79	1	0.80	0.79	0.80	0.74
UK	0.86	0.79	0.84	0.83	0.93	0.75	0.80	1	0.78	0.42	0.65
Australia	0.58	0.81	0.72	0.75	0.75	0.83	0.79	0.78	1	0.63	0.83
Japan	0.44	0.67	0.59	0.62	0.45	0.55	0.80	0.42	0.63	1	0.67
Emerging Markets	0.52	0.78	0.68	0.67	0.66	0.76	0.74	0.65	0.83	0.67	1

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