# Home Bias and Expected Returns: A Structural Approach

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**Abstract**

We study the effect of the home bias on international asset pricing by extending the core-satellite approach of active asset allocation to an equilibrium analysis. In this framework, investors combine a common core portfolio with an active investment in their home asset. In equilibrium, the core portfolio will deviate from the global market portfolio in characteristic ways, which we exploit to propose a new test of the home premium in expected returns. Unlike previous findings, our evidence suggests that the premium is almost negligible even though the home bias is substantial. This result is mainly driven by the generally high correlation of index returns and the distribution of the relative level of the home bias across countries.

*Keywords:* Home bias, Asset pricing, International diversification, Implied expected return, Core-satellite approach, Home preferences, Equilibrium model

*JEL:* G11, G12, G15, G02, F30

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## 1. Introduction

Most stock market investors overweight their home country with respect to a well-diversified international portfolio - a behavior known as home bias.[1] The bias is so strong and widespread that it has an important role to play in international asset pricing.[2] This role is complex because the home bias in one country has consequences for the asset holdings of investors in other countries. If, for example, the investors in a large country show a particularly strong home preference, they will claim a large share of stocks from their home country for themselves. Therefore, they will outbid other investors who, as a consequence, have to tilt their portfolios away from this country. To make this happen, the expected returns of stocks in this country must be lower than in a world without home bias. For different degrees of home bias in different countries, this mechanism results in a non-trivial interplay of home bias and expected returns. We study this interplay theoretically and empirically in order to address three research questions: What are the theoretical determinants of the relation between home bias and expected returns? How large is the home premium in stock returns? And finally: is the home bias driven by market frictions or rather by behavioral aspects such as familiarity?

Answering these questions requires a structural approach. As a starting point, we take the model of Treynor and Black (1973), which is well known for establishing the theoretical foundation of the core-satellite approach in asset allocation. Treynor and Black (1973) analyze the optimal portfolio decision of an active investor who holds a subjective view of expected abnormal returns (alphas) of a limited number of assets and assumes that the other assets are fairly priced. As a result, the optimal portfolio consists of two parts: a passive

[1] Grubel (1968) published the first study on welfare gains of internationally diversified portfolios. Solnik (1974a) and Grauer et al. (1976) were the first to propose equilibrium models of international asset pricing.

[2] A local bias is also found in hedge funds, see Clemens et al. (2020).

portfolio that is optimal for an investor without active views (core portfolio) and an active portfolio that consists of the stocks perceived as mispriced (satellites). The weights of the stocks in the active portfolio are chosen in accordance with the degree of mispricing and the specific risk involved. We apply this framework to our setting by expressing the home preference of investors in terms of a positive alpha for their home asset.[3] Thus, investors will combine the passive (core) portfolio, which is internationally well diversified, with their home asset (satellite). In general, the equilibrium implications of active investment decisions following Treynor and Black (1973) are not known. In our setting, however, with the home asset as the only active component, we are able to extend the model to a partial equilibrium. The market clearing condition is that for each country, the active holding of home investors and the passive holdings as part of the core portfolio add up to the total asset supply.

The core portfolio is identical to the optimal portfolio of investors who do not themselves exhibit a home preference (while other investors do). We call this the passive portfolio (as a synonym for core portfolio). If the passive portfolio is equal to the market portfolio, this means that the structure of expected returns is unaffected. This situation can be called a symmetrical home bias. If, however, the home bias is asymmetrical, the structure of expected returns is distorted, which is reflected in deviations of the passive portfolio from the market portfolio. The main idea of this paper is to exploit these deviations for our empirical estimation of expected returns. This approach is in the spirit of Cooper and Kaplanis (1994) who propose "tests based on predictions about portfolio holdings" (p. 47). Our approach also provides alpha estimates that allow us to examine the third research question on the drivers of the home preference.

Our main empirical result is that the passive portfolio is so close to the market portfolio

[3]See, similarly, Levy and Levy (2014) and French and Poterba (1991).

that the effect of the home bias on expected returns is small. It is not sufficiently large to be detected in ex post returns. This is true despite the home bias being generally very pronounced, with substantial differences across countries. Nevertheless, the effect on expected returns is small for four reasons. First, several large countries show a similar degree of home bias so that their relative weight in the passive portfolio is largely unaffected. This applies in particular to the large US market. In addition, markets with an above-average level of home bias (Japan, China) can be substituted by markets with a below-average level (UK, Canada) that are home to many global companies in different sectors. Second, international asset returns are highly correlated, which means that a change in the expected return of one country has a strong impact on its weight compared to other countries. Therefore, small adjustments in expected returns are sufficient to render the core portfolio instead of the market portfolio optimal (see Levy and Levy, 2014). Third, the correlations are particularly high among countries with a strong weight in the global market, which reinforces the second argument. Finally, the home bias tends to be more pronounced in developing countries whose influence on the global portfolio is relatively small.

With respect to the sources of the home preference (third research question), we find that investors from countries with high specific risk, who would benefit most from international diversification, attach a particularly high alpha reward to their home asset. This puzzling observation appears to be driven by frictions in developing markets of investing abroad and large cultural distances to other countries.

There exists an extensive literature on the home bias and its determinants, but few articles provide an equilibrium analysis.[4] Our paper is most closely related to the work of

[4]See Bergin and Pyun (2016) for an equilibrium model on how bilateral equity holdings depend on the overall covariance structure.

Solnik and Zuo (2012), who present a global equilibrium model in which investors maximize expected utility based on a utility function that incorporates foreign aversion. The foreign aversion or, equivalently, the home preference results from regret when investors hold foreign assets that achieve lower returns than the home assets. The model is solved using the two-moment Arrow-Pratt approximation. Solnik and Zuo (2012) derive two major conclusions from their theoretical analysis. The first is that expected returns are affected by *differences* in national home preferences and not the level as such. This means "that traditional asset pricing would hold in a world where investors have similar levels of home preference across the world" (Solnik and Zuo, 2012, p. 290f). The second major conclusion is that the relationship between differences in national home preferences and expected returns is opposite to the one that prevails in a world with segmented financial markets (Lau et al. (2010), Errunza and Losq (1985), Karolyi and Stulz (2003)). The segmentation in the model of Lau et al. (2010) results from a regulation that forces investors to invest a certain share of their wealth into home assets. The higher the enforced home investment is, the higher the specific risks investors have to bear. Thus, home assets are valued lower to compensate for the specific risk through a higher expected return. This effect, however, is reversed when markets are integrated as in Solnik and Zuo (2012). In this case, the higher expected returns intended as a compensation for the specific risk borne by home investors would *attract* international investors, while the opposite is needed: to keep other investors at bay, the expected returns must be *lower*.

This paper is also closely related to Levy and Levy (2014) and Levy (2017) who highlight the importance of the average correlations between markets. In highly correlated markets, the home bias will persist even when the costs of foreign investment are low and specific risk is not compensated by higher expected returns (see also Bhamra and Coeurdacier, 2014).

Another important factor considered in our model is the size of the stock market in relation to the wealth of national investors as studied by Hong et al. (2008) for regions in the USA.

The model presented here is consistent with the findings of Solnik and Zuo (2012).[5] Its novel contribution is that it highlights the significance of how the passive portfolio is structured in equilibrium. This insight allows us to propose a new structural estimation approach as a complement to prior tests based on realized returns. It is difficult to achieve conclusive evidence from realized returns, given the variability of annual returns, the small sample size and the high stability of the home bias on the country level (relative to other countries) over time. Our results, which are clearly different from previous literature,[6] are supported by economic arguments on the relevant driving factors (specific risk; level of cross-correlations; market size relative to other markets; market size relative to the wealth of investors) and their relationships. We also complement previous studies with a more recent sample period (2004-2019).

The remainder of the paper is structured as follows. Section 2 presents the theoretical framework and Section 3 the estimation method. We describe the data in Section 4 and report the empirical results in Section 5. In the results section, we first show the overall and country-specific level of home bias over time. We then estimate how strongly the home bias distorts the passive portfolio and what this implies for expected returns. Third, we examine whether the home preferences are better explained by familiarity or market frictions. Finally, we take a brief look at the relation of home bias and the cross-section of realized returns. Section 6 concludes.

[5] In fact, the main result equations are identical, which is interesting in itself because the model setup is very different. We state the exact correspondences in the theoretical framework section.

[6] Solnik and Zuo (2012) report (with all caution) an estimate of the home bias premium of almost -1% per month.

## 2. Theoretical Framework

### *2.1. Assumptions*

We consider a global financial market consisting of countries $l = 1, \ldots, n$, each of which is represented by one tradable asset, which we can think of as a stock index portfolio. We assume that all investors have a unique country of origin and that they are sufficiently small not to have market power. We use the short form "investor $l$" for an investor from country $l$. We only consider income from financial assets.[7]

We assume that home investors receive a surplus $\alpha_l$ to the expected return $\mu_l$ of their home asset. Thus, investors in our model hold heterogeneous views of expected asset returns: from the perspective of investors from outside country $l$, asset $l$ provides an expected return of $\mu_l$, while from the perspective of home investors, it provides an expected reward of $\mu_l + \alpha_l$. A first economic rationale for the surplus $\alpha_l$ is that home investors bear lower transaction costs of investing in country $l$ than foreign investors. A second interpretation is that $\alpha_l$ captures a non-monetary benefit that reflects a preference of investors for the assets of their country of origin. In the following, we use the term "home reward" for the alpha component in expected returns.

Following standard portfolio theory, we assume that investors have a horizon of one period. They exhibit exponential utility with risk aversion parameter $\lambda > 0$ (Arrow-Pratt coefficient of absolute risk aversion) so that expected utility is a linear function of the portfolio's expected return and volatility.

Following Treynor and Black (1973), we assume that the single-index model of Sharpe (1963) holds approximately. This assumption implies a simplified covariance structure which

[7] Labor income risk could also be an important determinant of the home bias; see, e.g., Heathcote and Perri (2013).

allows to decompose optimal portfolios into a passive and an active part.[8] The passive component corresponds to the optimal portfolio of investor $l$ in case of $\alpha_l = 0$. In the Treynor and Black (1973) model, the passive portfolio is the market portfolio. In our extended model, however, the passive portfolio will generally deviate from the market portfolio because the structure of expected returns is "distorted" by the active asset holdings of home investors. Analogous to Treynor and Black (1973), we assume that the index in the single-index model is this passive portfolio.[9]

### *2.2. Active Asset Allocation*

Let $C$ denote the passive (core) portfolio that is optimal for investors without home preference. The optimal stock portfolio of investor $l$ consists of the passive portfolio with weight $x_l^C$ and the home asset with weight $x_l^H$, where $x_l^C + x_l^H = 1$. The home asset is the only active holding of investor $l$ because, from her perspective, it is the only asset with (possibly) nonnegative alpha. Treynor and Black (1973) show that the optimal weight $x_l^H$ is given by:[10]

$$x_l^H = \frac{\frac{1}{\lambda}\frac{\alpha_l}{\sigma_{\epsilon_l}^2}}{1 + (1-\beta_l)\frac{1}{\lambda}\frac{\alpha_l}{\sigma_{\epsilon_l}^2}}, \tag{1}$$

where $\alpha_l$ is the home reward in country $l$, $\sigma_{\epsilon_l}^2$ is the variance of specific risk of asset $l$, $\beta_l$ is the return exposure of asset $l$ with respect to portfolio $C$, and $\lambda$ is the premium (excess return) per unit of variance risk of the passive portfolio:

$$\lambda := \frac{\mu_C}{\sigma_C^2}. \tag{2}$$

[8] In the regret-theoretic model of Solnik and Zuo (2012), the same decomposition arises from the two-moment Arrow-Pratt approximation of expected utility, see Eq. (6) in their paper.

[9] As is well known, this index definition is, in a strict sense, inconsistent because the index is not exogenous and therefore implies some covariation of specific returns. Otherwise, the returns of the assets in the passive portfolio could not exactly add up to the index return.

[10] See the derivation in the Appendix.

According to Eq. (1), the optimal weight of the home asset crucially depends on the abnormal return $\alpha_l$ per unit of specific risk $\sigma^2_{\epsilon_l}$, which is known as the Treynor-Black appraisal ratio. The beta adjustment in the denominator of Eq. (1) arises from the fact that a home asset with high beta provides a strong indirect exposure to the index so that direct index holdings are less prevalent.

If the active weights of the home assets, $x_l^H$, are known, we can compute implied alphas by solving Eq. (1) for the implied home rewards, which gives:

$$\alpha_l = \lambda \sigma^2_{\epsilon_l} \frac{x_l^H}{1 - (1 - \beta_l)\, x_l^H}. \tag{3}$$

*2.3. Market Clearing*

Let $w_l^I$ denote the share of global wealth owned by investors from country $l$; $w_l^M$ the weight of asset $l$ in the global market portfolio $M$; and $w_l^C$ the weight of asset $l$ in the passive portfolio $C$ ($\sum_l w_l^I = \sum_l w_l^M = \sum_l w_l^C = 1$). Let $W^G$ denote the dollar value of global wealth (equal to the global market capitalization). It is divided in home investments and the passive portfolio $C$. The total wealth $W^C$ invested in the passive portfolio is given by the sum of passive investments made by investors from all countries $l$, so that $W^C = \sum_l x_l^C w_l^I W^G$, where $w_l^I W^G$ is the wealth of investor $l$. Market clearing requires that for each asset $l$, the amount that investors from country $l$ invest actively in their home asset and the amount invested in asset $l$ through global holdings of the passive portfolio must add up to asset $l$'s market capitalization:

$$x_l^H w_l^I W^G + w_l^C W^C = w_l^M W^G. \tag{4}$$

Solving Eq. (4) for $x_l^H$, we obtain:[11]

$$\begin{aligned} x_l^H &= \left( \frac{w_l^M W^G - w_l^C W^C}{w_l^M W^G} \right) \frac{w_l^M}{w_l^I} \\ &= \left( 1 - \frac{w_l^C}{w_l^M} \frac{W^C}{W^G} \right) \frac{w_l^M}{w_l^I}. \end{aligned} \tag{5}$$

In equilibrium, Eqs. (1) and (5) hold simultaneously and determine the structure of the core portfolio $w_l^C$, the active asset holdings $x_l^H$ and the overall passive investment $W^C$.

Eq. (5) reveals three components of the home bias measured by $x_l^H$. First, the overall impact of the home bias measured by the proportion of total wealth that is invested in the passive portfolio ($W^C/W^G$). The higher this proportion is, the less pronounced is the global home bias. Formally, this global level is equal to the average home bias: $\bar{x}^H = \sum_i w_i^I x_i^H = 1 - W^C/W^G$. Second, the country-specific level of the home bias measured by the ratio $w_l^C/w_l^M$. If the weight of asset $l$ in the passive portfolio $C$ is smaller than its weight in the market portfolio $M$, home investments in country $l$ are more important than on average in other countries so that a smaller part of asset $l$ is available for global investors. These two elements are combined in the bracket term in Eq. (5) which expresses the amount of active home investments in country $l$ as a proportion of the market capitalization of asset $l$. Since $x_l^H$ is the active home investment as a proportion of the wealth of investor $l$, the third component $w_l^M/w_l^I$ serves as a scaling factor: the larger the stock market in country $l$ is compared to the wealth of investor $l$, the more pronounced the home bias of investor $l$ must be to account for a given difference between $w_l^C$ and $w_l^M$.

To assess the importance of the home bias for expected asset returns, we translate the

[11] After some transformations, we obtain the same equation when solving Eq. (7) in Solnik and Zuo (2012) for $\theta_i$. We state the following correspondences: $x_i^H$ in this paper corresponds to $\theta_i$ in Solnik and Zuo (2012); $w_i^I$ to $w_i$; $w_i^M$ to $m_i$; $w^M$ to $\boldsymbol{M}$; $w^C$ to $\boldsymbol{M} - \boldsymbol{\Delta}$; $w^M - w^C$ to $\boldsymbol{\Delta}$; $w_i^M - w_i^C$ to $\delta_i$; $\bar{x}^H = \sum_i w_i^I x_i^H$ to $\theta_W$ and $V$ to $\boldsymbol{\Omega}$.

structures of the passive portfolio and the market portfolio into corresponding vectors of expected returns. Let $w^C = \left(w_1^C, \ldots, w_n^C,\right)'$ and $w^M = \left(w_1^M, \ldots, w_n^M,\right)'$ denote the vectors of weights in the passive portfolio and market portfolio, respectively. For a given variance-covariance matrix $V$ of asset returns, the implied expected excess returns are given by:

$$\mu_{imp}^C = \lambda V w^C \quad \text{and} \quad \mu_{imp}^M = \lambda V w^M. \tag{6}$$

*2.4. A Closer Look at the Home Bias Measure*

Our home bias measure is the active home investment $x_l^H$, i.e. the home investment in excess of the investment at home as part of the passive portfolio $C$. Other studies have used a measure of home investment in excess of the share of the home asset in the market portfolio $M$ (Kho et al., 2009; Solnik and Zuo, 2012):[12]

$$HB_l = 1 - \frac{f_l}{f_l^M}, \tag{7}$$

where $f_l$ is the proportion of wealth of investor $l$ invested abroad and $f_l^M$ is the share of foreign assets (from the perspective of country $l$) in the market portfolio. $HB_l$ is zero if investor $l$ chooses a proportion of her foreign investments that is equal to the share of foreign assets in the global market portfolio. Without any investments abroad, the home bias measure becomes one. Within our model, $HB_l$ as defined in Eq. (7) can be written as:

$$\begin{aligned} HB_l &= 1 - \frac{1 - \left(x_l^H + \left(1 - x_l^H\right) w_l^C\right)}{1 - w_l^M} \\ &= \frac{w_l^C - w_l^M}{1 - w_l^M} + \frac{1 - w_l^C}{1 - w_l^M} x_l^H. \end{aligned} \tag{8}$$

[12] Solnik and Zuo (2012) refer to measure $HB_l$ in Section 6.2 and use this measure in the empirical analysis, but also refer to the equivalent of $x_l^H$ as the "normalized home preference" (p. 279).

Eq. (8) shows that $HB_l$ does not incorporate the effect of home preferences on the composition of the passive portfolio. In case of $x_l^H = 0$ (no home bias in country $l$), $HB_l$ will still be positive if $w_l^C > w_l^M$. There appears to be a home bias because the higher weight of asset $l$ in the passive portfolio is (mis)interpreted as an active overweighting of the home asset by investor $l$.[13] For $x_l^H = 1$, we obtain $HB_l = x_l^H$. The deviation between the two measures becomes smaller the higher the level of home bias is.

## 3. Estimation Method

Our estimation proceeds in three steps. First, we estimate the $w^C$ vector, i.e., the composition of the passive portfolio, and translate these weights into implied expected returns using Eq. (6). Our asset pricing test is based on the deviations of these implied returns from the market implied returns.[14] Second, we simultaneously estimate the global passive investment amount, $W^C$, and the active home investments, $x_l^H$, according to Eq. (5). These are used in the third step to compute the alphas of the home assets, $\alpha_l$, from Eq. (3).

The first and second step need further exploration. The intuition of our estimation of $w^C$ in the first step is as follows. As an example, consider the estimation of the weight of US stocks compared to Canadian stocks in portfolio $C$. Assume that the sample consists of 41 countries in total. In our model, investors from the other 39 countries (other than the USA and Canada) hold US stocks and Canadian stocks only as part of the common

[13] Ultimately, the interpretation depends on how the home bias is defined. In line with measure $HB_l$, any deviation of the share of home assets in an investor's portfolio from the share of these assets in the market portfolio would indicate a nonzero home bias. In this case "it is sufficient that investors of a single country be foreign averse to induce a home bias in every country" (Solnik and Zuo, 2012, p. 281). However, the home preference of investors in a single country affects the holdings of other investors only by means of a modified composition of the common core portfolio. This is not considered a component of the home bias when its definition requires an active home investment in line with measure $x_l^H$.

[14] A similar test based on the equilibrium model of Solnik and Zuo (2012) would be to estimate $\boldsymbol{\Delta}$ (see Eqs. (7) and (8) on p. 279) and to compare the expected returns of Eq. (8) with market implied returns. The optimal portfolio of an investor without home preference in the model of Solnik and Zuo (2012) is $\boldsymbol{M} - \boldsymbol{\Delta}$.

core portfolio. Thus, theoretically, the ratio of US holdings and Canadian holdings is the same for all of them. To estimate this ratio, we aggregate the US holdings as well as the Canadian holdings across these 39 countries. If, for instance, the US aggregate turns out to be twice as high as the Canadian aggregate, this means that the weight of US stocks in portfolio $C$ is twice as high as the weight of Canadian stocks. Repeating the same procedure for the country pair USA and France, we can infer the relative weight of French stocks in the portfolio $C$ compared to US stocks, which also determines the relative weight of French stocks with respect to Canadian stocks. With further pairs, the structure of portfolio $C$ is successively completed.

To formalize this procedure, let $F_{k,x}$ denote the dollar investment of investor $k$ in asset $x$. In our model, each investor $k$ holds foreign assets $i$ and $j$ with $i \neq j$ and $k \notin \{i, j\}$ only as part of the passive portfolio $C$ so that the ratio $r_{i,j}$ of these asset holdings corresponds to the ratio $w_i^C / w_j^C$:

$$r_{i,j} := \frac{w_i^C}{w_j^C} = \frac{\sum_{k \notin \{i,j\}} F_{k,i}}{\sum_{k \notin \{i,j\}} F_{k,j}}. \tag{9}$$

Because we observe the $F_{k,x}$ for all combinations of $k$ and $x$, we can use Eq. (9) to estimate $r_{i,j}$ for all $i, j$. Within our model, it is sufficient to compute the ratios $r_{i,j}$ for $j = i + 1$ ($i = 1, \ldots, n-1$), because the weights $w_q^C$ ($2 \leq q \leq n$) are then obtained by $w_q^C = w_1^C \prod_{i=1}^{q-1} r_{i,i+1}$ with $w_1^C$ chosen such that the weights add up to one. Within the model, the resulting $w^C$ vector does not depend on the ordering of assets $i = 1, \ldots, n$. However, if the actual investments do not perfectly correspond to the two-fund structure of home asset and passive portfolio $C$, the ordering of assets becomes relevant. Therefore, we compute $w^C$ for 100 random orderings and take the mean value as our final estimate.[15]

[15] In repeated tests of 100 simulations we verify that the standard error of the mean is negligible.

The second step of the estimation is implemented as follows. Given the estimate of $w^C$, the only remaining unknown on the right-hand side of Eq. (5) is the global passive investment amount $W^C$. Any level of $W^C$ is consistent with an equilibrium: for a given $W^C$ and $x_l^H$ from condition (5), $x_l^C = 1 - x_l^H$ ensures the right amount of passive investments, i.e., $W^C = \sum_l x_l^C w_l^I W^G$.[16] To find the applicable level of $W^C$, we can exploit the aggregate amount of foreign investments because, in our model, foreign investments only occur via the passive portfolio. More specifically, we choose $W^C$ such that the theoretical amount of aggregate foreign investments is equal to the actual aggregate foreign holdings:[17] $\sum_l x_l^C \left(1 - w_l^C\right) w_l^I W^G = \sum_l F_l$, where $F_l$ is the actual holding of foreign assets by investor $l$.

## 4. Data and Descriptive Statistics

Our main data source is the Coordinated Portfolio Investment Survey (CPIS) of the International Monetary Fund. CPIS has been used in different studies on the home bias, e.g., by Fidora et al. (2007), Solnik and Zuo (2012) and Mishra (2015). The participating countries biannually report their foreign portfolio holdings, divided into equity investments and long-term and short-term bonds, of which we only use the equity holding data. CPIS was launched in 1997 with 29 countries. Since 2001, the survey has been updated every year, and since 2013, every six months. In 2014, 70 countries participated, among them all 46 countries classified by MSCI as developed or emerging countries with the exception of China, Taiwan, Qatar, Peru and the United Arab Emirates. India has participated since 2004 and China since 2015. In 2014, the participating countries represented approximately 88% of the world

[16] Summing up both sides of Eq. (5) over all $l$ and multiplying with $w_l^I W^G$, we obtain: $\sum_l x_l^H w_l^I W^G = W^G - W^C$, which implies the specified expression for $W^C$.

[17] The theoretical investment of investor $l$ in foreign markets is equal to the share of her investment in portfolio $C$ times the share of foreign investments within portfolio $C$ times the wealth of investor $l$.

market capitalization. Since then, with the inclusion of China in 2015, the representation is clearly higher than 90%.

The absence of China in CPIS until 2014 appears problematic because in 2014, China's stock market had a market capitalization of USD 6 trillion (IMF, 2018) and ranked second in size after the US. For this reason, we fill the data gap for China using additional mutual fund data. It is important to note that China was only absent from CPIS as a participating country; it was, however, included as a destination for investments of CPIS participants. Therefore, we can estimate the amount invested by Chinese investors at home as the difference between China's total market capitalization and the aggregate holdings of CPIS countries in China. What is missing in the years until 2014 is the corresponding amount of Chinese investments in foreign countries. For this, we assume that the ratio of Chinese foreign investments and home investments is the same as the ratio of foreign assets and home assets in the portfolios of Chinese mutual funds. We extract the fund holding data from the shareholder database of Thomson Reuters Eikon. The same procedure is applied to Taiwan.

The CPIS guidelines state that participating countries should only report the holdings of their own residents (IMF, 2002, p. 5). However, it is particularly difficult to implement this rule in the case of off-shore countries. For example, if a UK investor invests in a mutual fund in Ireland that buys assets in continental Europe, this might falsely be reported as an investment of a UK resident in Ireland instead of continental Europe and an additional investment of Ireland in continental Europe. As a consequence, the importance of off-shore countries as a destination of investment flows and the foreign investments of off-shore countries would be overestimated (Solnik and Zuo, 2012, p. 282). This problem appears to be severe for Ireland and Hong Kong. According to CPIS reports, the aggregate holdings of foreigners in these two countries exceed their total market capitalization, which clearly indicates that

these countries often serve as a transit destination and not the final destination of investment flows. For this reason, we exclude Ireland and Hong Kong from our sample.

Our sample includes all countries that participated in CPIS in the sample period from 2004 to 2019 and that were included in the MSCI index family (overlap of 41 countries). We add China and Taiwan to the database and exclude Ireland and Hong Kong as described above, which results in a final sample of 21 developed countries and 20 emerging countries. In the following, we only consider investment holdings within this sample of 41 countries.

We collect country-level data on investor wealth, foreign and home investments and stock index returns for each of the 41 countries. These data allow us to obtain straight-forward estimates of the composition of the market portfolio, $w^M$, the market share of investors, $w_l^I$, and the global investment amount, $W^G$, at the end of each year of our sample period. We estimate year-end values of betas $\beta_l$ with respect to the core portfolio and the specific return variances $\sigma^2_{\epsilon_l}$ based on monthly returns over the last five years. The variance-covariance matrix $V$ with elements $V_{i,j}$ is set up in line with the single-index model, so that $V_{i,j} = \beta_i \beta_j \sigma^2_C$ for $i \neq j$ and $V_{i,i} = \beta_i^2 \sigma^2_C + \sigma^2_{\epsilon_i} \forall i$ . We assume a market risk premium, $\lambda$, according to Eq. (2) of 1.39. This estimate is based on a worldwide annualized equity risk premium relative to Treasury bills of 4.2% and a world equity volatility of 17.4% as reported in Dimson et al. (2019) for updated data of Dimson et al. (2002) from 1900 to 2018.

Table 1 lists the countries and shows their market capitalization weights ($w_l^M$) for the first year of the sample period (2004), two mid-sample years (2009, 2014) and the last year (2019). For 2019, we also report the share of wealth of investors from each of the countries ($w_l^I$) and the share of investors' foreign and home investments ($SF_l$ (%) and $SH_l$ (%), respectively).

Table 1: **Descriptive statistics: global stock markets.** $w_l^M$ is country $l$'s weight in the market portfolio, $w_l^I$ is the share of wealth of investors from country $l$, $SF_l$ (%) and $SH_l$ (%) are the shares of investors' foreign and home investments, respectively.

| | | 2004 | 2009 | 2014 | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| Country $l$ | Code | $w_l^M$ (%) | $w_l^M$ (%) | $w_l^M$ (%) | $w_l^M$ (%) | $w_l^I$ (%) | $SF_l$ (%) | $SH_l$ (%) |
| Developed markets | | | | | | | | |
| Australia | AUS | 2.20 | 2.89 | 2.09 | 1.81 | 1.95 | 33.65 | 66.35 |
| Austria | AUT | 0.24 | 0.25 | 0.15 | 0.15 | 0.18 | 54.39 | 45.61 |
| Belgium | BEL | 0.73 | 0.55 | 0.57 | 0.38 | 0.44 | 51.34 | 48.66 |
| Canada | CAN | 3.36 | 3.87 | 3.42 | 3.01 | 3.79 | 47.32 | 52.68 |
| Denmark | DNK | 0.42 | 0.38 | 0.48 | 0.51 | 0.59 | 54.93 | 45.07 |
| Finland | FIN | 0.50 | 0.40 | 0.30 | 0.34 | 0.33 | 44.03 | 55.97 |
| France | FRA | 4.26 | 4.26 | 3.19 | 3.42 | 2.61 | 24.02 | 75.98 |
| Germany | DEU | 3.22 | 2.66 | 2.57 | 2.29 | 2.00 | 41.30 | 58.70 |
| Israel | ISR | 0.26 | 0.44 | 0.32 | 0.29 | 0.31 | 33.76 | 66.24 |
| Italy | ITA | 2.16 | 1.36 | 0.86 | 0.78 | 0.73 | 35.33 | 64.67 |
| Japan | JPN | 9.99 | 7.57 | 6.99 | 7.48 | 6.77 | 17.75 | 82.25 |
| Netherlands | NLD | 1.43 | 1.22 | 1.19 | 1.31 | 1.44 | 71.83 | 28.17 |
| New Zealand | NZL | 0.12 | 0.08 | 0.12 | 0.13 | 0.17 | 48.09 | 51.91 |
| Norway | NOR | 0.39 | 0.48 | 0.34 | 0.34 | 1.29 | 81.83 | 18.17 |
| Portugal | PRT | 0.19 | 0.11 | 0.09 | 0.10 | 0.09 | 24.42 | 75.58 |
| Singapore | SGP | 0.60 | 1.08 | 1.20 | 0.83 | 1.27 | 48.97 | 51.03 |
| Spain | ESP | 2.63 | 3.28 | 1.58 | 0.92 | 0.73 | 22.66 | 77.34 |
| Sweden | SWE | 0.93 | 0.94 | 1.00 | 0.95 | 1.13 | 42.96 | 57.04 |
| Switzerland | CHE | 2.27 | 2.36 | 2.32 | 2.13 | 1.43 | 34.95 | 65.05 |
| United Kingdom | GBR | 7.50 | 5.93 | 5.11 | 3.18 | 2.84 | 64.85 | 35.15 |
| United States | USA | 46.05 | 34.37 | 42.28 | 45.04 | 46.86 | 17.89 | 82.11 |
| Emerging markets | | | | | | | | |
| Brazil | BRA | 0.92 | 3.01 | 1.34 | 1.45 | 1.13 | 2.20 | 97.80 |
| Chile | CHL | 0.33 | 0.54 | 0.38 | 0.25 | 0.30 | 25.62 | 74.38 |
| China | CHN | 1.21 | 7.91 | 9.51 | 10.25 | 9.70 | 1.95 | 98.05 |
| Colombia | COL | 0.06 | 0.33 | 0.24 | 0.17 | 0.18 | 14.06 | 85.94 |
| Czech Republic | CZE | 0.07 | 0.10 | 0.04 | 1.20 | 1.19 | 0.98 | 99.02 |
| Egypt | EGY | 0.07 | 0.21 | 0.11 | 0.05 | 0.04 | 0.24 | 99.76 |
| Greece | GRC | 0.35 | 0.26 | 0.09 | 0.06 | 0.05 | 7.08 | 92.92 |
| Hungary | HUN | 0.07 | 0.06 | 0.02 | 0.04 | 0.03 | 24.16 | 75.84 |
| India | IND | 1.03 | 2.67 | 2.38 | 2.54 | 2.08 | 0.09 | 99.91 |
| Indonesia | IDN | 0.19 | 0.46 | 0.67 | 0.63 | 0.54 | 1.61 | 98.39 |
| Korea, Republic | KOR | 1.18 | 1.89 | 1.94 | 1.66 | 1.52 | 23.02 | 76.98 |
| Malaysia | MYS | 0.51 | 0.65 | 0.75 | 0.50 | 0.53 | 16.76 | 83.24 |
| Mexico | MEX | 0.48 | 0.80 | 0.78 | 0.50 | 0.39 | 2.66 | 97.34 |
| Philippines | PHL | 0.08 | 0.20 | 0.42 | 0.34 | 0.29 | 0.30 | 99.70 |
| Poland | POL | 0.19 | 0.34 | 0.27 | 0.18 | 0.16 | 4.08 | 95.92 |
| Russian Federation | RUS | 0.54 | 1.72 | 0.62 | 1.10 | 0.95 | 0.54 | 99.46 |
| South Africa | ZAF | 1.25 | 1.84 | 1.52 | 1.31 | 1.29 | 10.75 | 89.25 |
| Taiwan | TWN | 1.41 | 1.62 | 1.69 | 1.45 | 1.96 | 47.68 | 52.32 |
| Thailand | THA | 0.32 | 0.38 | 0.69 | 0.70 | 0.61 | 3.30 | 96.70 |
| Turkey | TUR | 0.27 | 0.52 | 0.35 | 0.23 | 0.19 | 0.31 | 99.69 |

## 5. Empirical Results

### *5.1. Degree of Overall and Country-Specific Home Bias*

Figure 1 shows that the share of the global passive portfolio increased from approximately 20% in 2004 to 30% in 2019. With the exception of the years of the financial crisis, the ratio $W^G/W^C$ increased steadily, indicating a decreasing importance of the overall home bias (Solnik and Zuo, 2012, p. 285). However, the overall home bias is still very substantial at the end of the sample period, with 70% of funds invested actively at home.

The degree of the country-specific home bias measured by $x_l^H$ becomes apparent from Figure 2. The countries are sorted by ascending home bias in 2019. The bars represent year 2019, the colored lines years 2004, 2009 and 2014. The bars of emerging markets are grey-shaded. In 2019, 17 of the 41 sample countries exhibit an active home investment of 0.8 or larger; 16 of these are emerging markets. In general, developed markets tend to have a smaller home bias level than emerging markets (see white vs. grey-shaded bars). In 2019, only six markets invest less than 50% of their funds at home, namely Norway, the Netherlands, the United Kingdom, Austria, Denmark and Belgium. In former years, the $x_l^H$ values tend to be even higher, which is in line with the decreasing trend of the overall bias shown before.

### *5.2. Deviation of Passive Portfolio from Market Portfolio and Distortion of Expected Returns*

Figure 3 illustrates the difference between the market portfolio $M$ and the passive portfolio $C$ for four years of the sample period. On the x-axis, the countries are sorted in descending order of their weight in the market portfolio. The cumulative market portfolio weights are shown as circles on the scale of the left-axis. The circles are filled if the corresponding country is an emerging market. The line represents the cumulative weights of the passive portfolio. On the left, the line tends to be located below the circles, which indicates that the largest

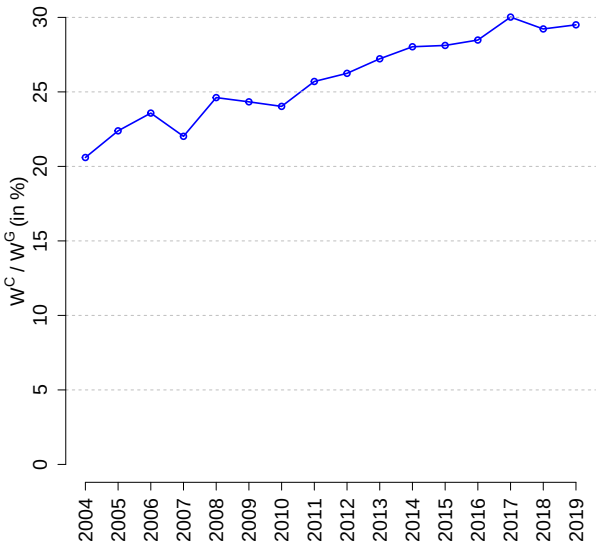


Figure 1: **Estimated percentage of aggregate holdings in the passive portfolio over time**

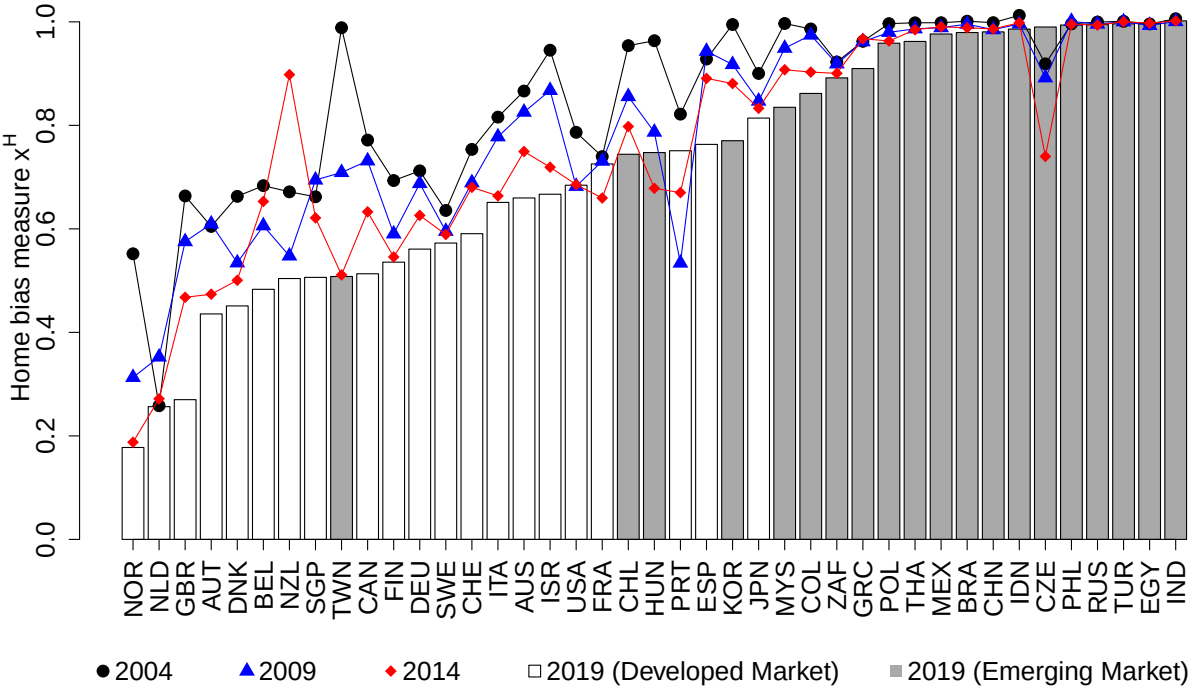


Figure 2: **Active home investments by country in 2004, 2009, 2014 and 2019.** The country codes are specified in Table 1.

stock markets are underrepresented in the passive portfolio. This discrepancy is larger in 2004 than in 2019. Overall, however, the cumulative weights suggest that the structure of the passive portfolio is very similar to the structure of the market portfolio.

The reason for the similarity of portfolios $M$ and $C$ is that the ordering of countries is more or less the same: countries with a strong market capitalization are also relatively important in the passive portfolio. However, if we control for country size, the differences between the weights $w_l^M$ and $w_l^C$ are often substantial, which is apparent from the bars in the same figure. They show the ratio $w_l^C/w_l^M$ on the scale of the right axis. For several countries, this ratio is above 2 or below 0.5. Thus, while the overall composition of the portfolios is similar, the differences on the country level are considerable. As expected, the ratio $w_l^C/w_l^M$ is negatively related to the degree of the home bias $x_l^H$: if the assets of country $l$ face strong demand of home investors, their share in the global passive portfolio will be smaller than in the market portfolio (see Eq. 5). The cross-correlation coefficients per year between $x_l^H$ and $w_l^C/w_l^M$ lie between $-0.68$ and $-0.83$.

Next, we analyze by how much the expected asset returns have to change so that the tangency portfolio in $(\mu\sigma)$-optimization is portfolio $C$ instead of the market portfolio $M$. Figure 4 shows the difference $\mu_{imp}^C - \mu_{imp}^M$ of implied expected returns according to Eq. (6) for all countries and years. The countries on the x-axis are sorted in descending order of the mean difference from 2004 to 2014. The crucial result is that the differences are small. With the exception of China, the absolute deviations are always below 0.2 percentage points. For China, the expected return implied in $C$ is up to 0.5 percentage points smaller than the expected return implied in $M$, which reflects the small weight of China in the passive portfolio compared to the market portfolio. The differences of implied returns are so small mainly for two reasons. First, as described before, portfolios $C$ and $M$ are quite similar,

and second, the returns of large equity markets are strongly correlated so that a shift in the weight of one of these countries can be well compensated by adjusting the weights of other countries.[18]

Even though the differences $\Delta\mu_l := \mu^C_{imp,l} - \mu^M_{imp,l}$ are small, they are systematically related to the degree of home bias. In 2019, for example, the cross-sectional regression $\Delta\mu_l = \alpha + \beta x^H_l + \epsilon_l$ (with 41 observations) results in an estimated slope coefficient $\beta$ of $-0.065$. This is highly significant in a statistical sense ($t$-value of $-3.3$; $R^2$ of 21.3%) but not so in an economic sense because the difference between a complete home bias and no home bias corresponds to a difference in expected returns of only 0.065 percentage points per year. Overall, our model estimates suggest that the distortions of expected returns caused by differential home bias levels are small.

### *5.3. Home Reward and Country-Specific Risk*

Figure 5 shows the estimated implied alphas ($\alpha_l$) according to Eq. (3) for our 41 countries and the sample years from 2004 to 2019. The countries on the horizontal axis are ordered in descending order of their mean alpha across the sample years. All alpha estimates are positive, which reflects the universal phenomenon of overweighting home assets, and they tend to decrease during the sample period, which is consistent with our previous observation of an increasing share of passive investing.

The estimated alphas are partly substantial. Several estimates lie between 5% and 10%, and the highest observations are near 25%. Such high values, however, are only found in small countries. Since these countries do not provide an effective diversification on their own, investing primarily at home has severe consequences that investors will only tolerate if

[18] Lu and Vivian (2020) and Errunza et al. (1999) show that even a portfolio of domestic securities can mimic foreign indices and provide benefits similar to international diversification.

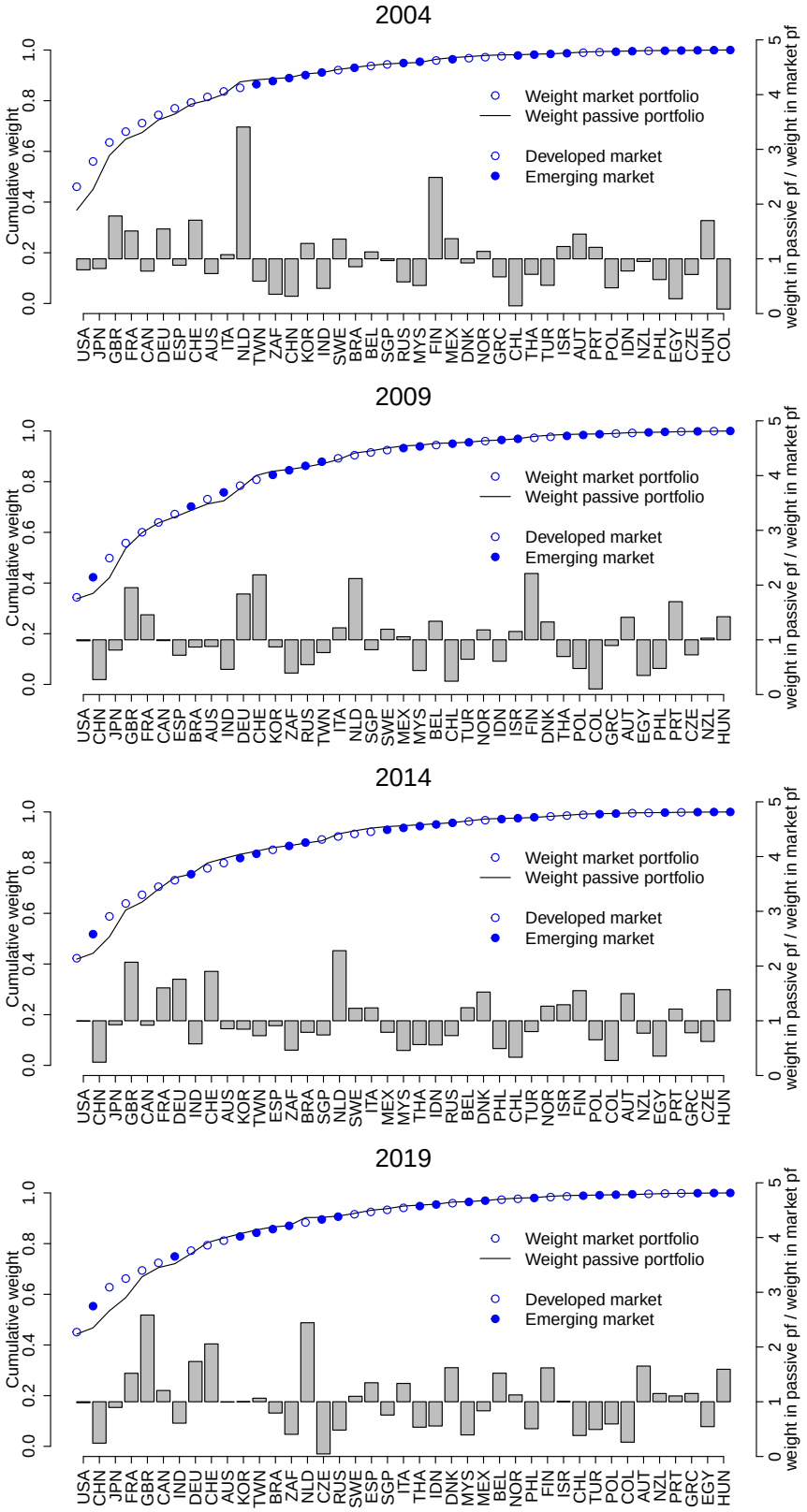


Figure 3: **Comparison of market portfolio and passive portfolio.** The points and lines show the cumulative weights (left scale). The bars show the ratio of weights in the passive portfolio and the market portfolio (right scale). The country codes are specified in Table 1.

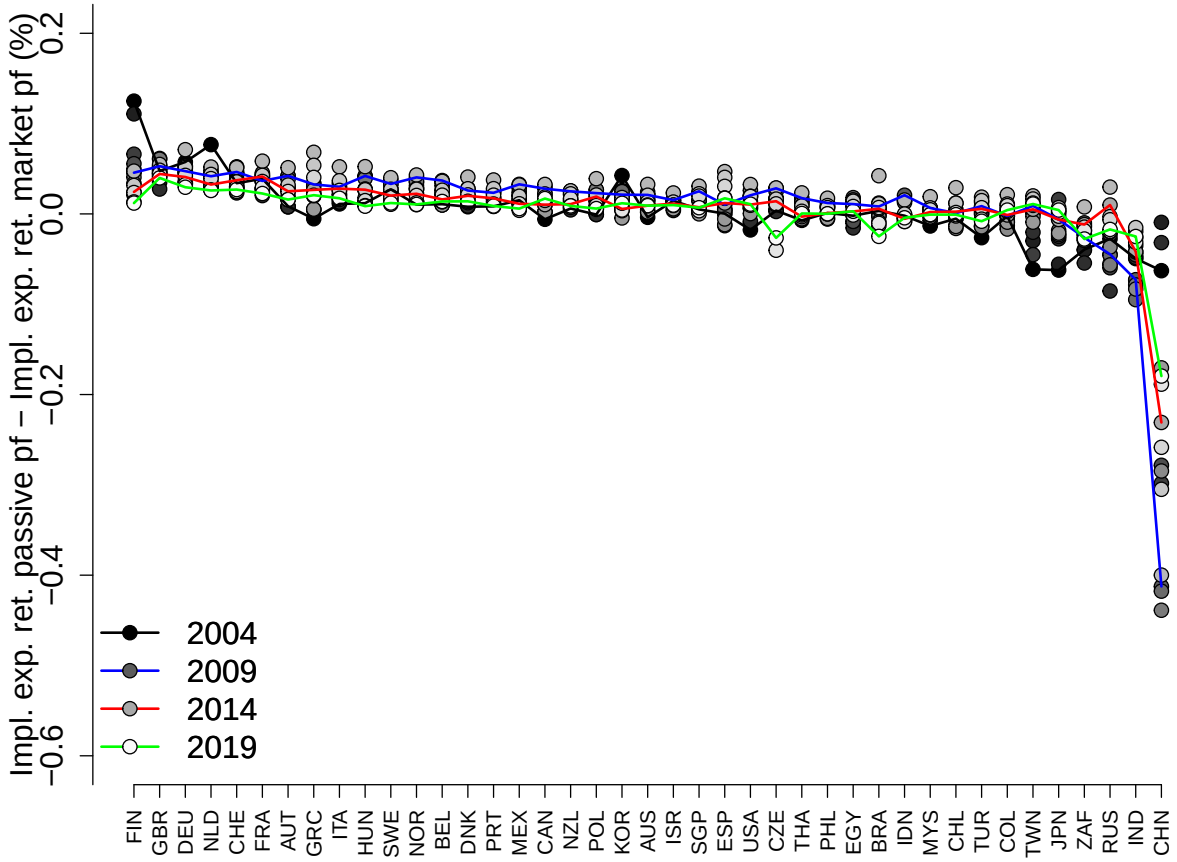


Figure 4: **Difference of expected returns implied in the passive portfolio and expected returns implied in the market portfolio (in percent per annum).** The graph contains one point per year and country for 41 countries and all years from 2004 to 2019 with lighter grey shades for more recent years. The observations of four years (2004; 2009; 2014; 2019) are connected through a line. The countries are sorted in descending order of the mean difference from 2004 to 2019. The country codes are specified in Table 1.

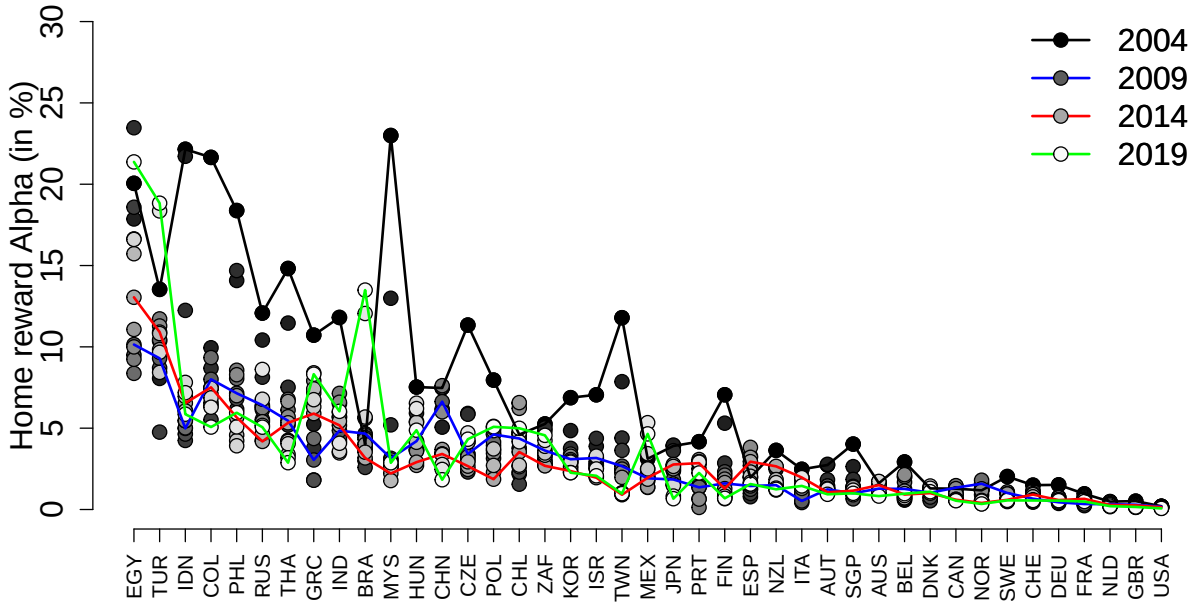


Figure 5: **Alpha estimates by country and year (in percent per annum).** The graph contains one point per year and country for 41 countries and all years from 2004 to 2019, with lighter grey shades for more recent years. To highlight the observations of the first year, two mid years and the last year of the sample period, these are connected through a line. The countries are ordered in descending order of their mean alpha across the sample years. The country codes are specified in Table 1.

their alpha reward of home investments is accordingly high. Formally, this can be seen from Eq. (3): the higher the specific risk of the home assets ($\sigma_{\epsilon_l}$) is, the smaller the home bias for a given home reward. If the home reward were the same for all countries, we would find an inverse relationship of specific risk and home bias across countries. Empirically, however, $x_l^H$ is *positively* associated with $\sigma_{\epsilon_l}$ (e.g., correlation coefficient of 0.60 in 2019), which means that investors from countries with high specific risk do not compensate for this risk by putting more emphasis on diversifying internationally. On the contrary, they tend to focus more strongly on their risky home market. This is only consistent with rational investor behavior if the home reward is particularly high in countries with pronounced specific risk.

### *5.4. Sources of the Home Reward: Familiarity or Market Frictions?*

In the following, we carry out a regression analysis to examine the sources of the home reward. We draw the explanatory variables mainly from previous literature.[19] Similar to Chan et al. (2005), we group the variables into the following categories: (i) economic development; (ii) stock market development; (iii) investor protection; (iv) capital flow frictions; (v) familiarity; and (vi) country classification.[20] In predicting the signs of associations between explanatory variables and alpha, we must stay in line with our theoretical framework. For example, it is true that a large and typically well-developed stock market tends to attract funds from the outside so that the share of assets held by home investors might be relatively small. This link, however, is already considered in our equilibrium model as the large stock market has a corresponding weight in the passive portfolio. In principle, only two explanations for alpha are justified within the model. The first explanation refers to differential

[19] For a review, see Ardalan (2009). A factor we cannot consider is relative optimism as examined in Solnik and Zuo (2016). There is also evidence that financial education (Giofré, 2017) and more comprehensive corporate disclose (Eichler, 2012) can reduce the home bias.

[20] We do not consider the variation of the home bias among individual investors within a country. This variation is studied by Karlsson and Nordén (2007).

transaction costs, meaning that transaction costs of investing at home are smaller than the costs of investing abroad. Thus, investing at home provides a reward in the amount of the transaction costs difference. The transaction costs generate barriers that lead to de facto segmentation of international asset markets (Bekaert et al., 2011).[21] The second explanation is familiarity, meaning that investors have a preference for their home assets not because of specific risk-return characteristics but because they feel more confident with more familiar asset holdings (Huberman, 2001).

Against this background, we conjecture that wealthy countries with highly developed stock markets and a high level of investor protection provide investors with a sophisticated financial infrastructure including wealth management solutions and easy access to international financial markets. In such an environment, the transaction costs of investing abroad will not be much higher than the transaction costs of investing at home. Thus, we hypothesize that proxy variables for economic development, stock market development and investor protection are negatively related to alpha. Capital flow frictions have the opposite effect because they favor home investments. The proxy variables for familiarity are also expected to be positively associated to alpha.

We use the following proxy variables for economic and stock market development: GDP per capita, GDP growth, foreign trade volume, stock market capitalization and stock market turnover. Our measures of capital flow restrictions are an index of capital control and a trade-weighted index of exchange rate volatility. The latter index is included because exchange rate risk is supposed to be an important impediment to international diversification. Proxies for investor protection are measures of shareholder rights, the level of minority shareholder

[21] Transaction costs have strongly decreased over time. Tesar and Werner (1995) and Warnock (2002) find that transaction costs do not help to explain the home bias.

protection, requirements with respect to corporate transparency and the quality of state governance (see Dahlquist et al. (2003) and Kho et al. (2009)). Our familiarity measures are designed to capture the geographical and cultural distance to other countries (see Grinblatt and Keloharju, 2001), where a larger distance translates into a larger conjectured alpha at home.[22] Specifically, the proxy variables are the average geographical distance to other sample countries, the proportion of sample countries sharing the same main language, the stock market capitalization of neighboring countries and the share of foreign residents. Our last category consists of two country classifications. The Emerging Market dummy variable might be regarded as a summary measure for core aspects of the other categories because emerging markets differ from developed markets in terms of their economic development, their stock market development and the degree of investor protection. We also include a Eurozone dummy variable to account for the fact that Eurozone countries are part of a common integrated market. Table 2 defines the proxy variables in more detail and specifies the data sources. Table 3 shows descriptive statistics. Because of missing data, we exclude Egypt and Taiwan from the following analysis. Therefore, we include data for 39 countries over 16 years (624 observations).

We carry out pooled regressions of implied alpha on different sets of explanatory variables. We include time fixed effects to take account of shifts in the overall level of alpha that are not explained by our explanatory variables. Table 4 shows the results.[23] The proxies for economic development alone explain 49.0% of the cross-sectional variation of alpha (see column 1 in Table 4). GDP per capita is the most important variable, as predicted with a negative coefficient (significant at the 1% level). Among the proxies for the stock market

[22]The cultural distance is related to the risk and return characteristics, see Kim et al. (2015).

[23]We have performed the same analysis separately for the subsamples of developed and emerging markets, but have not included the results in this paper. They are available on request.

Table 2: **Variables and data sources**

| Variable | Description and source |
|---|---|
| *Economic Development* | |
| GDP per Capita | GDP per Capita in US-Dollar. World Development Indicators (WDI, World Bank) |
| GDP Growth | Yearly growth of GDP. WDI (World Bank) |
| Foreign Trade Volume | Volume of imports and exports scaled by GDP. WDI (World Bank) |
| *Stock Market Development* | |
| Capitalization | Stock market capitalization as a percentage of GDP. WDI, Thomson Reuters Eikon |
| Turnover | Ratio of the total value of stocks traded to the market capitalization. WDI, OMX Nordic Exchange, Thomson Reuters Eikon |
| *Investor Protection* | |
| Shareholder Rights | Index to assess shareholder rights on a scale from 0 (poor) to 10.5. Doing Business Database (World Bank) |
| Minority Protection | Index to assess the protection of minority shareholders on a scale from 0 (poor) to 10. Doing Business Database (World Bank) |
| Corporate Transparency | Index to assess the transparency of companies on a scale from 0 (poor) to 9. Doing Business Database (World Bank) |
| State Governance | Governance index constructed using principal component analysis based on six governance indicators. World Governance Indicators (World Bank) |
| *Capital Flow Frictions* | |
| Capital Control | Index to measure imposed restrictions on capital in- and outflows on a scale from 0 (no restrictions) to 10. The Economic Freedom Network |
| Exchange Rate Volatility | Annualized volatility of monthly changes in a country's real exchange rate index. Bank for International Settlements |
| *Familiarity* | |
| Distance | Average distance between a country's capital and the capitals of all other countries of the sample. CEPII |
| Common Language | Share of countries with a common official language of a country. CEPII |
| Capitalization Neighbors | Sum of market capitalization weights of a country's neighboring markets. WDI (World Bank), Thomson Reuters Eikon |
| Foreign Residents | Share of foreign-born population. WDI (World Bank) |

Table 3: **Descriptive statistics: proxy variables for sources of home preference.** The table reports average values per country in the period from 2004 to 2019.

| | | Economic Development | | | Stock Market Development | | Investor Protection | | | | Capital Flow Restrictions | | Familiarity | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | Code | GDP per Capita ($) | GDP Growth (%) | Foreign Trade Volume (%) | Capitalization (%) | Turnover (%) | Shareholder Rights | Min. Protection | Corp. Transparency | State Governance | Cap. Control | Ex-Rate Vol. (%) | Distance (km) | Com. Language (%) | Capitalization Neigh. (%) | Foreign Residents (%) |
| Developed markets | | | | | | | | | | | | | | | | |
| Australia | AUS | 51262 | 2.84 | 41.95 | 107.53 | 72.72 | 5.00 | 5.80 | 8.00 | 3.93 | 6.54 | 7.74 | 12774 | 20.45 | 0.00 | 26.07 |
| Austria | AUT | 46882 | 1.59 | 100.87 | 31.76 | 40.32 | 8.00 | 6.50 | 7.00 | 3.79 | 6.68 | 1.80 | 5245 | 6.82 | 6.47 | 15.30 |
| Belgium | BEL | 43723 | 1.65 | 154.71 | 68.85 | 42.20 | 4.00 | 5.80 | 6.00 | 3.19 | 5.33 | 2.15 | 5419 | 13.64 | 7.77 | 9.94 |
| Canada | CAN | 44995 | 2.48 | 65.05 | 120.32 | 71.56 | 6.00 | 7.70 | 6.00 | 4.00 | 2.79 | 5.85 | 8352 | 27.27 | 36.63 | 20.24 |
| Denmark | DNK | 57353 | 1.49 | 99.42 | 81.73 | 69.50 | 8.00 | 7.20 | 9.00 | 4.40 | 2.55 | 2.37 | 5310 | 0.00 | 2.75 | 9.00 |
| Finland | FIN | 46519 | 1.32 | 76.79 | 87.34 | 95.61 | 7.00 | 5.70 | 6.00 | 4.51 | 6.10 | 2.64 | 5409 | 2.27 | 2.47 | 4.55 |
| France | FRA | 39930 | 1.28 | 58.42 | 81.71 | 70.25 | 6.00 | 6.50 | 8.00 | 2.97 | 4.19 | 2.37 | 5504 | 6.82 | 8.72 | 11.45 |
| Germany | DEU | 42604 | 1.46 | 81.47 | 46.37 | 114.80 | 8.00 | 6.00 | 7.00 | 3.68 | 6.30 | 2.95 | 5259 | 6.82 | 8.87 | 13.81 |
| Israel | ISR | 32145 | 3.79 | 68.38 | 75.63 | 37.34 | 7.00 | 7.50 | 9.00 | 1.67 | 2.81 | 4.87 | 5756 | 20.45 | 0.18 | 26.88 |
| Italy | ITA | 34664 | 0.12 | 54.29 | 33.32 | 154.16 | 8.00 | 6.30 | 7.00 | 1.34 | 2.79 | 2.38 | 5454 | 2.27 | 6.04 | 8.40 |
| Japan | JPN | 39796 | 0.83 | 31.84 | 88.58 | 117.18 | 7.00 | 6.00 | 5.00 | 3.14 | 3.56 | 7.88 | 8685 | 0.00 | 0.00 | 1.61 |
| Netherlands | NLD | 49658 | 1.50 | 140.45 | 91.46 | 90.77 | 7.00 | 5.70 | 7.00 | 4.13 | 1.12 | 2.74 | 5405 | 2.27 | 3.30 | 11.03 |
| New Zealand | NZL | 36131 | 2.56 | 57.04 | 35.78 | 15.40 | 8.00 | 8.30 | 7.00 | 4.42 | 2.83 | 7.28 | 14155 | 20.45 | 0.00 | 21.40 |
| Norway | NOR | 82990 | 1.62 | 70.05 | 59.44 | 70.54 | 8.00 | 7.50 | 9.00 | 4.29 | 5.05 | 5.28 | 5454 | 0.00 | 2.43 | 10.66 |
| Portugal | PRT | 21551 | 0.76 | 74.43 | 34.04 | 57.60 | 4.00 | 5.70 | 6.00 | 2.54 | 4.81 | 1.90 | 6212 | 2.27 | 1.89 | 7.48 |
| Singapore | SGP | 49108 | 5.38 | 367.38 | 222.92 | 43.38 | 8.00 | 8.30 | 8.00 | 3.83 | 3.27 | 2.64 | 9014 | 27.27 | 0.59 | 41.55 |
| Spain | ESP | 29312 | 1.39 | 59.60 | 77.17 | 103.37 | 10.00 | 6.50 | 8.00 | 2.20 | 6.58 | 2.58 | 5949 | 9.09 | 3.76 | 11.36 |
| Sweden | SWE | 52873 | 2.20 | 85.21 | 110.52 | 100.09 | 9.00 | 7.20 | 7.00 | 4.33 | 6.78 | 4.66 | 5376 | 2.27 | 0.79 | 14.46 |
| Switzerland | CHE | 74852 | 2.03 | 114.73 | 217.12 | 58.51 | 8.00 | 5.00 | 6.00 | 4.30 | 6.20 | 4.80 | 5401 | 13.64 | 7.80 | 26.45 |
| United Kingdom | GBR | 43129 | 1.56 | 57.94 | 113.13 | 65.30 | 8.00 | 7.80 | 8.00 | 3.54 | 3.35 | 5.47 | 5556 | 20.45 | 0.20 | 11.49 |
| United States | USA | 52305 | 2.01 | 27.75 | 132.70 | 174.92 | 4.00 | 6.50 | 5.40 | 3.13 | 5.48 | 4.20 | 8719 | 20.45 | 3.84 | 13.90 |

Table 3: continued

| Country | Code | Economic Development | | | Stock Market Development | | Investor Protection | | | | Capital Flow Restrictions | | Familiarity | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | GDP per Capita ($) | GDP Growth (%) | Foreign Trade Volume (%) | Capitalization (%) | Turnover (%) | Shareholder Rights | Min. Protection | Corp. Transparency | State Governance | Cap. Control | Ex-Rate Vol. (%) | Distance (km) | Com. Language (%) | Capitalization Neigh. (%) | Foreign Residents (%) |
| Emerging markets | | | | | | | | | | | | | | | | |
| Brazil | BRA | 9098 | 2.37 | 25.87 | 53.20 | 65.38 | 7.00 | 6.50 | 8.00 | -0.14 | 6.66 | 11.63 | 10639 | 2.27 | 0.43 | 0.33 |
| Chile | CHL | 12574 | 3.71 | 66.39 | 103.91 | 15.57 | 10.00 | 6.50 | 2.00 | 2.80 | 5.43 | 7.04 | 12268 | 9.09 | 0.21 | 2.10 |
| China | CHN | 5744 | 9.03 | 48.73 | 55.32 | 198.75 | 1.00 | 4.50 | 9.00 | -1.18 | 9.66 | 4.65 | 7765 | 6.82 | 7.87 | 0.06 |
| Colombia | COL | 5934 | 4.08 | 37.28 | 44.04 | 13.79 | 6.00 | 7.30 | 6.00 | -0.73 | 8.65 | 9.03 | 10638 | 9.09 | 1.74 | 0.27 |
| Czech Republic | CZE | 19203 | 2.88 | 136.98 | 65.85 | 44.02 | 8.00 | 6.00 | 5.00 | 2.22 | 6.44 | 5.11 | 5243 | 0.00 | 3.28 | 3.50 |
| Egypt | EGY | 2505 | 4.52 | 49.29 | 37.99 | 40.51 | 2.00 | 4.30 | 5.00 | -1.72 | 4.92 | NA | 5829 | 4.55 | 0.31 | 0.41 |
| Greece | GRC | 23355 | -0.61 | 59.95 | 34.10 | 44.93 | 8.00 | 6.30 | 7.00 | 1.06 | 6.92 | 4.39 | 5495 | 0.00 | 0.36 | 11.09 |
| Hungary | HUN | 13596 | 2.23 | 156.30 | 20.47 | 65.34 | 8.00 | 5.50 | 7.00 | 1.66 | 5.86 | 6.58 | 5246 | 0.00 | 0.36 | 4.11 |
| India | IND | 1374 | 6.82 | 46.23 | 78.16 | 68.12 | 10.00 | 7.30 | 6.00 | -0.53 | 10.00 | 5.51 | 6891 | 20.45 | 7.02 | 0.46 |
| Indonesia | IDN | 2914 | 5.46 | 48.84 | 41.14 | 30.41 | 6.00 | 5.70 | 5.00 | -0.99 | 8.56 | 8.27 | 9562 | 0.00 | 0.60 | 0.13 |
| Korea, Republic | KOR | 25451 | 3.59 | 83.83 | 82.59 | 153.65 | 7.00 | 7.30 | 9.00 | 1.94 | 4.52 | 6.55 | 8163 | 0.00 | 0.00 | 1.76 |
| Malaysia | MYS | 9071 | 5.04 | 158.44 | 134.52 | 31.06 | 8.00 | 8.00 | 7.00 | 0.90 | 9.28 | 4.20 | 8842 | 6.82 | 1.93 | 7.69 |
| Mexico | MEX | 9447 | 2.23 | 64.72 | 34.31 | 26.13 | 8.00 | 6.00 | 4.00 | -0.46 | 8.41 | 7.98 | 10480 | 9.09 | 36.63 | 0.78 |
| Philippines | PHL | 2412 | 5.82 | 67.62 | 65.70 | 15.59 | 1.00 | 4.20 | 7.00 | -0.96 | 9.23 | 4.58 | 8996 | 20.45 | 0.00 | 0.25 |
| Poland | POL | 12383 | 4.07 | 88.31 | 32.71 | 37.07 | 8.00 | 6.30 | 7.00 | 1.73 | 8.03 | 6.90 | 5233 | 0.00 | 4.16 | 1.74 |
| Russian Federation | RUS | 10489 | 2.93 | 50.26 | 46.36 | 47.12 | 8.00 | 6.00 | 8.00 | -1.73 | 5.13 | 9.72 | 5474 | 0.00 | 8.02 | 8.03 |
| South Africa | ZAF | 6197 | 2.45 | 60.07 | 250.75 | 28.85 | 8.00 | 7.00 | 4.00 | 0.65 | 9.23 | 11.41 | 9160 | 20.45 | 0.00 | 3.90 |
| Taiwan | TWN | NA | NA | NA | 185.90 | NA | 7.00 | 7.00 | 9.00 | 2.39 | NA | 3.66 | 8508 | 6.82 | 0.00 | NA |
| Thailand | THA | 5223 | 3.64 | 128.41 | 82.87 | 76.84 | 4.00 | 6.70 | 7.00 | -0.57 | 8.46 | 4.38 | 8284 | 0.00 | 0.59 | 4.46 |
| Turkey | TUR | 10081 | 5.34 | 51.78 | 26.93 | 162.32 | 8.00 | 7.00 | 7.00 | -0.36 | 7.79 | 11.64 | 5484 | 0.00 | 0.36 | 2.50 |

development (column 2), the size of the stock market in relation to GDP is most important, but the $R^2$ amounts to only 7.6%. The only significant proxy variable of investor protection is state governance, but its association with alpha is so strong that the regression for investor protection (column 3) has an $R^2$ of 51.0%. The two proxies for capital flow frictions are both significant with the predicted sign ($R^2$ of 36.0%; column 4). Additionally, two proxies for familiarity are significant at the 1% level in the predicted direction, namely the market capitalization of neighboring countries and the share of foreign residents (column 5). The estimated coefficient of the emerging market dummy is highly significantly positive (column 6) while the coefficient of the Eurozone dummy is insignificant. The country classifications alone explain 45.0% of the variation of alpha.

The explanatory variables most closely associated with alpha are economically related. In particular, GDP per capita is related to state governance (correlation coefficient of 0.84), the emerging market dummy (-0.83), foreign residents (0.63) and capital control (-0.53). These results are consistent with the view that wealthy countries with efficient institutions exert less capital control and are more open to migrants, which is associated with better integration in international financial markets (lower frictions) and greater openness to foreign investments (smaller familiarity bias). However, column 7 in Table 4 for the comprehensive regression shows that measures of capital control and familiarity contribute explanatory power in addition to GDP per capita. With the inclusion of all explanatory variables, the $R^2$ rises to 63.3%.

Within the subsample of developed markets (untabulated), the explanatory power is much smaller. GDP per capita is again negatively associated with alpha when only economic development proxies are considered. However, even this relation is significant only at the 10% level in the comprehensive regression. The estimated coefficients for the subsample

Table 4: **Determinants of implied alpha.** Results of pooled regressions with time fixed effects. The dependent variable is implied alpha. The explanatory variables are defined in Table 2.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| ln(GDP per Capita) | $-0.022^{***}$ | | | | | | $-0.012^{**}$ |
| | (−8.003) | | | | | | (−2.465) |
| GDP Growth | −0.043 | | | | | | −0.013 |
| | (−0.424) | | | | | | (−0.197) |
| Foreign Trade Volume | 0.001 | | | | | | 0.003 |
| | (0.429) | | | | | | (0.879) |
| Capitalization | | $-0.015^{**}$ | | | | | $-0.010^{**}$ |
| | | (−2.431) | | | | | (−2.451) |
| Turnover | | −0.005 | | | | | 0.004 |
| | | (−0.593) | | | | | (0.781) |
| Shareholder Rights | | | 0.001 | | | | −0.002 |
| | | | (0.544) | | | | (−1.473) |
| Minority Protection | | | 0.001 | | | | 0.004 |
| | | | (0.526) | | | | (1.304) |
| Corporate Transparency | | | −0.001 | | | | $-0.004^{**}$ |
| | | | (−0.564) | | | | (−2.038) |
| State Governance | | | $-0.012^{***}$ | | | | $-0.004^{**}$ |
| | | | (−7.901) | | | | (−1.999) |
| Capital Control | | | | $0.005^{***}$ | | | $0.001^{*}$ |
| | | | | (5.822) | | | (1.822) |
| Exchange Rate Volatility | | | | $0.331^{***}$ | | | $0.197^{**}$ |
| | | | | (3.363) | | | (2.272) |
| ln(Distance) | | | | | 0.017 | | $-0.014^{*}$ |
| | | | | | (1.500) | | (−1.723) |
| Common Language | | | | | 0.0005 | | $-0.060^{*}$ |
| | | | | | (0.008) | | (−1.824) |
| Capitalization Neighbors | | | | | $-0.073^{***}$ | | $-0.068^{**}$ |
| | | | | | (−2.688) | | (−2.092) |
| Foreign Residents | | | | | $-0.148^{***}$ | | $0.098^{***}$ |
| | | | | | (−3.524) | | (2.890) |
| Emerging Markets Dummy | | | | | | $0.044^{***}$ | 0.004 |
| | | | | | | (8.305) | (0.867) |
| Eurozone Dummy | | | | | | 0.004 | −0.003 |
| | | | | | | (0.844) | (−0.589) |
| Observations | 624 | 624 | 624 | 624 | 624 | 624 | 624 |
| $R^2$ | 0.490 | 0.076 | 0.510 | 0.360 | 0.252 | 0.450 | 0.633 |
| *Note:* | | | | | | | $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01 |

of emerging markets are similar to the coefficients found for the total sample, but the $R^2$-coefficients are clearly smaller. This is not surprising because the variation of alpha is much larger if developed and emerging markets are both included.[24]

At the beginning of this section, we addressed the puzzling observation that investors from countries with high specific risk, who would benefit most from international diversification, exhibit a particularly pronounced home reward (which then leads to a strong home bias). Our regression results suggest that the two main drivers of this result are frictions in developing countries of investing abroad and a larger cultural distance to other asset markets.

### *5.5. Robustness*

As has been shown in Figures 2-5, our results are similar in different years of the sample period. We repeat the analysis of the last section (on the determinants of implied alpha) for the subperiods 2004-2011 and 2012-2019 and obtain similar results as reported in Table 4.

Varying the market risk premium $\lambda$ between 0.75 and 2.5 reveals that it has a scaling effect on the level of implied returns and alpha estimates in line with Eqs. (3) and (6), but the main relationships and the conclusions are fully confirmed. We also verify that the results are robust with respect to rolling windows of 48 and 84 months (instead of 60 months) for estimating betas and the variance-covariance matrix $V$.

### *5.6. Home Bias and the Cross-Section of Realized Returns*

The theoretical considerations in Section 2 suggest that the degree of home bias is negatively related to expected returns. However, the model is not only informative about the sign of the home premium but also about the effect size. According to our analysis, this effect

[24]Cooper et al. (2018) analyze a specific home bias measure and find pure home bias only in emerging markets.

size is too small to be detected in realized returns. Therefore, finding a significantly negative premium would not confirm but contradict our model.[25]

An additional complexity is that the relationship is supposed to be non-linear and context-dependent because the effect of a change in the degree of home bias in one country depends on the importance of this country in the world market as well as the degree of home bias in all other countries. Our structural estimation was designed to take this into account. In this section, we ignore these interdependencies and non-linearities and perform a standard asset pricing test based on Fama and MacBeth (1973) regressions.[26]

The dependent variable is the excess return of MSCI country indices in year $t+1$. It is regressed on the year $t$ data for the home bias measure $x_l^H$, two risk measures and different control variables. The two risk measures (Beta and Specific Risk) are based on 60 monthly return observations of the MSCI country index and the MSCI World index (rolling window). The control variables represent the five categories of country characteristics introduced in Section 5.4 as possible determinants of the home reward $\alpha$. In each category, we select the variable with the closest association to the home reward (Capitalization; State Governance; Capital Control; Foreign Residents; GDP per Capita).

The results of the Fama-MacBeth regressions (16 years, 39 countries) are shown in Table 5. In all specifications, the home bias coefficient is small and clearly insignificant, which

[25] In their Test II, Solnik and Zuo (2012, p. 289) devise "a tighter testing of the theory" which is based on the model's structural relations but still relies on realized returns. The test uses estimates of the covariance matrix of index returns ($\mathbf{\Omega}$) and of the deviations ($\mathbf{\Delta}$) of portfolio holdings from the market portfolio. Then, the effect size predicted by the theory is directly available as $\lambda\mathbf{\Omega\Delta}$.

[26] Solnik and Zuo (2012) perform a panel regression in first differences as one part of their analysis (Test II). The underlying idea is that an increase in a country's home bias reduces its expected return so that the country index rises and the contemporaneous index return is positive. This implies a positive association of changes in the home bias and excess index returns. However, a positive relation might be spurious because an above-average return in the home country will give the home asset more weight. Assume, e.g., that at time $t$-1 investor $i$ invests 40% of her wealth in foreign markets that represent 80% of the market portfolio. Thus, the home bias measure $HB_i$ (see Eq. 7) is 0.5. Further assume a rate of return of the home asset from $t$-1 to $t$ of 10% while it is 0 for foreign assets. At time $t$, the share of foreign holdings is 40/106 in the portfolio of investor $i$ and 80/102 in the market portfolio, which implies a new home bias $HB_i$ of 0.52.

is consistent with our structural estimation. The high standard errors do not come at a surprise, given the limited sample size, the relatively short estimation period and the strong fluctuations of annual returns.

Table 5: **Fama-MacBeth regressions.** The sample consists of 16 years and 39 countries. The dependent variable is the excess return of MSCI country indices in year $t+1$ ($t = 2004, ..., 2019$). The $R^2$ values specified are those of a pooled regression of index returns on the explanatory variables. $t$-values are given in brackets.

| | Fama-MacBeth Regressions | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $x_l^H$ | −0.002 | 0.025 | 0.021 | −0.038 | −0.040 | −0.032 |
| | (−0.035) | (0.509) | (0.439) | (−0.585) | (−0.563) | (−0.444) |
| Specific Risk | | −0.648 | −0.717 | −0.988 | −1.056 | −1.589** |
| | | (−0.763) | (−0.809) | (−1.250) | (−1.350) | (−2.125) |
| Beta | | −0.029 | −0.028 | −0.023 | −0.014 | 0.010 |
| | | (−0.746) | (−0.743) | (−0.598) | (−0.337) | (0.249) |
| Capitalization | | | −0.0004 | 0.006 | 0.010 | −0.0002 |
| | | | (−0.029) | (0.430) | (0.624) | (−0.013) |
| State Governance | | | | −0.009 | −0.009 | 0.008 |
| | | | | (−1.397) | (−1.189) | (1.059) |
| Capital Control | | | | | −0.0005 | −0.004 |
| | | | | | (−0.127) | (−1.166) |
| Foreign Residents | | | | | −0.052 | 0.048 |
| | | | | | (−0.648) | (0.551) |
| ln(GDP per Capita) | | | | | | −0.051*** |
| | | | | | | (−2.907) |
| Constant | 0.048 | 0.090 | 0.096 | 0.165* | 0.167* | 0.652*** |
| | (0.729) | (1.273) | (1.226) | (1.707) | (1.724) | (3.289) |
| Observations | 624 | 624 | 624 | 624 | 624 | 624 |
| $R^2$ | <0.001 | 0.026 | 0.037 | 0.038 | 0.039 | 0.058 |
| *Note:* | | | | | | *p<0.1; **p<0.05; ***p<0.01 |

## 6. Summary and Concluding Remarks

The overall strength of the home bias has decreased over time but is still substantial. It is present in all 41 countries of our sample, albeit in varying degrees. In equilibrium, it is precisely these *differences* across countries that determine the impact of the home bias on international asset pricing. The stronger the country-specific home bias is, the lower the

expected return of the country asset. Prior literature has focused on testing this directional prediction. Our contribution is to use a structural approach that allows a quantitative assessment. In this framework, the adjustments in expected returns become apparent from differences between the global market portfolio and the optimal portfolio of an investor without home preference.

We find that the expected returns implied in these two portfolios are very similar. In fact, the differences are so small that it would not be possible to detect them in tests based on ex post returns.[27] The economic factors driving this result mainly have to do with the relative level of the home bias in different countries and the generally high correlation of index returns. The US and other large markets are positioned close to the global average home bias so that their expected returns do not need to be modified to trigger portfolio adjustments. Some important Asian countries show a persistent above-average home bias, but this does not condemn global investors to suffer losses in diversification given that the UK and Canada welcome global investors with a below-average home bias and a broad share offer. The high average correlation of international asset returns helps to balance such imbalances without requiring substantial changes in expected returns. Our brief analysis of the cross-section of realized returns is consistent with this finding, even though this analysis remains, as expected, inconclusive.

A striking observation is that investors from countries with high specific risk, who would benefit most from international diversification, show a particularly high home preference. This phenomenon appears to be mainly driven by a focus on familiar markets. Moreover, frictions of investing abroad still appear to be relevant in developing countries.

[27] A structural approach can help to avoid false positive results. In this sense, our approach fits well into the discussion about possible false discoveries of determinants of expected returns (see Harvey et al. (2016), Harvey and Liu (2019), Harvey and Liu (2020), Hou et al. (2020)).

One limitation of our study is related to the CPIS database. China only participates since 2015 so that we had to make additional assumptions about Chinese investments in former years. Another concern is that CPIS data are not always precise in identifying the final destination of investment flows. A base assumption of our theoretical framework is that investors are allowed to invest globally, but barriers such as transaction costs produce de facto segmentation. Also, the theory assumes a specific market model with only one global factor. While a global market factor can explain an important part of the variation of national index returns, the actual return dependencies are more complex.[28] In addition, foreign investors do not necessarily hold a national market portfolio (see Kang and Stulz, 1997, for disaggregated foreign investments in Japan). It is also true that investors actually hold diverse portfolios rather than simple combinations of a passive global portfolio with their home asset. However, we believe that the model captures the main trade-offs to be considered and thus gives insight into the reasons why the home premium is supposed to be small despite the substantial home bias.

[28]See, e.g., Solnik (1974b), Solnik (1974c), Erb et al. (1994), Bekaert (1995), Goetzmann et al. (2005), Carrieri et al. (2007), Bekaert et al. (2009), Christoffersen et al. (2012)

## Appendix

We analyze the optimal asset allocation of an investor from country $l$ ($l = 1, \ldots, n$). Her portfolio consists of the passive (core) portfolio with weight $x_l^C$ and country asset holdings $x_l^i$ for $i = 1, \ldots, n$. In what follows, we focus on the structure of the risky part of the portfolios.[29] This part is then combined with the riskless asset according to the investor's risk preference.

As proposed by Treynor and Black (1973), it is useful to define new assets $i = 1, \ldots, n$ which provide access only to the specific asset returns $\epsilon_i := r_i - \beta_i r_C$, where $r_i$ is defined as asset $i$'s total excess return and $\beta_i$ as its return exposure with respect to the return of portfolio $C$, $r_C$. The "specific-return assets", together with portfolio $C$, allow us to build the same portfolios as can be built with the original assets. To replicate the portfolio $(x_l^1, \ldots, x_l^n, x_l^C)$ with a portfolio $(y_l^1, \ldots, y_l^n, y_l^C)$ of the new (specific-return) assets plus the unmodified passive portfolio $C$, the weights of assets $i = 1, \ldots, n$ remain unchanged to maintain the same exposure to specific returns.[30] The index holding, however, has to be adjusted to also include the index exposure previously achieved indirectly by investments in assets $i$. This indirect index investment is now replaced by a direct holding of index $C$.[31] Therefore, portfolios of the original and newly defined assets are identical if the following conditions hold:

$$y_l^i = x_l^i, \quad i = 1, \ldots, n; \qquad y_l^C = x_l^C + \sum_{i=1}^{n} \beta_i x_l^i. \tag{10}$$

For our investor from country $l$, all specific-return assets have an expected return of zero except for the home asset, which has an expected return of $\alpha_l$. Because assets $i$ for $i \neq l$ would add specific risk to the portfolio without contributing to expected return, these assets

[29] This means that $x_l^C + \sum_i x_l^i = 1$.

[30] The investments $x_l^C$ and $y_l^C$ provide pure index exposure. By definition, the passive return is not affected by abnormal expected returns of home assets. These are included in the specific returns $\epsilon_l$.

[31] Since $x_l^C + \sum_i x_l^i = 1$, this means that the sum of the new weights $y$ is generally not equal to one.

are not included in the optimal portfolio. Therefore, only the index $C$ and the home asset have to be considered, and the portfolio expected return and variance can be written as:

$$\mu_p = y_l^C \mu_C + y_l^H \alpha_l; \qquad \sigma_p^2 = (y_l^C)^2 \sigma_C^2 + (y_l^H)^2 \sigma_{\epsilon_l}^2, \tag{11}$$

where $\mu_C = \mathbb{E}[r_C]$ , $\sigma_C^2 = Var(r_C)$ and $\sigma_{\epsilon_l}^2 = Var(\epsilon_l)$. Differentiating expected utility $EU = \mu_p - \frac{1}{2}\lambda\sigma_p^2$ with respect to $y_l^C$ and $y_l^H$ and setting the result equal to zero, we obtain the following ratio $w_0$ of optimal asset holdings:[32]

$$w_0 := \frac{y_l^H}{y_l^C} = \frac{\alpha_l/\sigma_{\epsilon_l}^2}{\mu_C/\sigma_C^2} = \frac{1}{\lambda}\frac{\alpha_l}{\sigma_{\epsilon_l}^2}, \tag{12}$$

where $\lambda$ is defined as the market premium per unit of variance risk for the passive portfolio:

$$\lambda := \frac{\mu_C}{\sigma_C^2}. \tag{13}$$

Switching back from Eq. (12) to the original asset holdings, we can rewrite ratio $w_0$ using the link between original and new assets provided by Eq. (10):

$$w_0 = \frac{y_l^H}{y_l^C} = \frac{x_l^H}{x_l^C + \beta_l x_l^H}. \tag{14}$$

Since the original asset weights add to one, we can replace $x_l^C$ in Eq. (14) by $x_l^C = 1 - x_l^H$. Solving for $x_l^H$ and inserting the expression for $w_0$ from Eq. (12) then gives:

$$x_l^H = \frac{w_0}{1 + (1-\beta_l)w_0} = \frac{\frac{1}{\lambda}\frac{\alpha_l}{\sigma_{\epsilon_l}^2}}{1 + (1-\beta_l)\frac{1}{\lambda}\frac{\alpha_l}{\sigma_{\epsilon_l}^2}}. \tag{15}$$

[32]This optimization does not consider the constraint $x_l^C + x_l^H = 1$, or equivalently, $y_l^C + (1-\beta_l)y_l^H = 1$; see Eq. (10) with $x_l^i = 0$ for $i \neq l$. The constraint does not have an impact on the ratio of optimal weights.

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