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Abstract

We investigate the role of information asymmetries and inflation hedging in shaping international equity portfolios. We confirm, in a multinational setting, Cooper and Kaplanis (1994) result of no inflation hedging motive driving investors' behavior and find evidence of a crucial role for financial market development and trade linkages.

JEL classification: F21, F30, F36, G11, G14, G15

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Introduction

Against the predictions of the modern portfolio theory on potential benefits from international equity market diversification (Markowitz, 1952; Sharpe, 1964; Levy and Sarnat, 1970; Solnik, 1974), investors actually hold a disproportionately small amount of foreign equities. The evidence of lack of diversification, often referred to as "home equity bias", is documented by many authors (French and Poterba, 1991; Tesar and Werner, 1995, among others).

Information asymmetry and investor hedging behavior have often been addressed by the literature as potential determinants of home bias. The informational motive is presumably the most appealing and intuitive explanation of the home bias puzzle: investors tend to allocate their funds towards assets they are more familiar with (Coval and Moskowitz,1999; Grinblatt and Keloharju, 2001). The relevance of hedging uninsurable sources of risks, such as inflation risk, has also been widely investigated in the literature (Cooper and Kaplanis, 1994; Baxter and Jermann, 1997). In particular, when the Purchasing Power Parity does not hold, the investor-consumer wants to hedge the risk entailed by consuming a bundle of goods subject to a country-specific inflation risk. If there is a positive correlation between domestic inflation and domestic asset returns there is scope for hedging the inflation risk through an appropriate long position in domestic assets. The same reasoning applies to the possibility of exploiting inflation-return covariances in a multinational setting by choosing an optimal international portfolio allocation. A combination of these two factors, inflation hedging and information asymmetry, may potentially shed some light on the puzzling evidence of international portfolios.

In this work we investigate how inflation hedging and informational factors influence not only the choice between home and foreign assets but also the fraction of the foreign portfolio invested in different countries. Considering bilateral portfolio holdings is indeed crucial when the objective is not justifying the home bias phenomenon but, more broadly, understanding the determinants of investor's portfolio choice. We claim that the hedging motive might actually drive investors' decisions but not be easily identifiable in a dichotomic home-foreign setting. In fact, many "familiarity" factors - hard to be captured - might induce to overinvest domestically so hiding other relevant factors. At the same time, eventual informational issues are more likely identifiable when splitting the foreign portfolio into its country components.

We depart, on the one hand, from Cooper and Kaplanis (1994) approach in the sense that we test the inflation hedging motive on the overall international portfolio rather than on domestic investments only. On the other hand, we generalize the recent empirical work on international equity portfolios (Ahearne et al., 2004; Lane and Milesi-Ferretti, 2008) accounting also for the inflation risk. Our findings confirm, in a multinational setting, Cooper and Kaplanis (1994) result of no inflation hedging motive and evidence a crucial role for financial market development and trade linkages in driving international portfolio choice.

The paper is structured as follows. In the first section we briefly review the theoretical and empirical literature on home bias and equity portfolio investments. In the second section we build the theoretical framework. In the third section we describe the data. The fourth section defines the variables and concludes with some key descriptive statistics. In the fifth section we define the econometric setting. In the sixth section we show the empirical results. The seventh section finally concludes.

1 Literature review

Until very recently, the empirical work on international portfolio allocation has almost coincided, due to bilateral data limitations, with the research on home bias. Even though our paper does not deal explicitly with the home bias puzzle, it is worth summarizing here the major contributions to this literature. Since the seminal paper by French and Poterba (1991) much work has been done in order to explain the so-called "equity home bias" puzzle, that is the bias towards domestic assets observed in international stock portfolios. The candidate explanations proposed by the literature can be broadly grouped into those focusing on institutional factors and those focusing on investors' behavior[1].

The strand of literature based on institutional factors is also the earliest (Black, 1974; Stulz, 1981; Tesar and Werner, 1995). It tries to explain the lack of portfolio diversification through the existence of barriers to international investment such as restrictions on international capital flows, withholding taxes and transaction costs. However, the relaxation of capital controls which occurred over the last decades has not significantly induced a parallel drop in home bias pointing to the inadequacy of the institutional explanation. Since then a new strand of literature centered on investors' behavior emerged, giving rise to three different approaches: the *sentiment*-based explanation, the risk hedging explanation and finally the information asymmetry explanation.

French and Poterba (1991), spousing the *sentiment*-based approach, suggest that investors may simply be relatively more optimistic about their domestic markets. This assertion is empirically supported by Strong and Xu (2003) and Li (2004) showing that fund managers or investors in general are more optimistic about their home stock market. This approach, however, just tautologically asserts that investors choose a given portfolio allocation because they like it more than other feasible allocations, not providing any rational explanation for this behavior.

The second approach is focused on the investor's behavior aimed at hedging specific sources of risk such as inflation (Cooper and Kaplanis, 1994) or risks deriving from non

[1] See Lewis (1999) for a detailed survey on equity home bias.

tradable assets such as labor income (Tesar, 1993; Baxter and Jermann, 1997; Baxter et al., 1998; Coen, 2001; Pesenti and van Wincoop, 2002). Cooper and Kaplanis (1994), building on the Adler and Dumas (1983) model, develop a theoretical framework integrating inflation risk and deadweight costs. They conclude that home bias cannot be explained by inflation hedging[2] unless investors are characterized by unlikely low levels of risk aversion. Coen (2001), extending the Adler and Dumas (1983) model to integrate human capital risk, also finds that home bias cannot be explained by either inflation or labor income hedging motives. Other contributions are more focused on the omission of a non-traded asset in the portfolio. Tesar (1993) shows that consumers' intertemporal preferences over traded and non-traded goods may skew portfolios towards claims on domestic output. Baxter and Jermann (1997), considering the implications of non-traded human capital for portfolio composition, find results that deepen the home bias puzzle instead of solving it. They show, indeed, that returns to human and physical capital are very highly correlated so that hedging the risk associated with human capital should involve a short position in national equities. Pesenti and van Wincoop (2002) investigate to what extent non-tradables - consumption and leisure - can affect the portfolio allocation decision in otherwise integrated capital markets. They find that hedging against non-tradables shocks can account for only a small portfolio bias toward domestic assets.

Finally, the third approach is centered on information asymmetries faced by investors and represents probably the most prolific literature on home bias (Gehrig, 1993; Kang and Stulz, 1994; Coval and Moskowitz, 1999; Pagano et al., 2002; Portes and Rey, 2005). Grossman and Stiglitz (1980) in a fundamental paper assert the impossibility of informationally efficient markets: as information is costly, price cannot perfectly reflect all available information otherwise there would be no market compensation in spending resources to obtain

[2] The inflation hedging motive in portfolio choice shoud induce higher investment in stocks whose return is more highly correlated with home inflation in order to minimize the inflation risk.

information. This paper opened the way to a series of theoretical works addressing the informational asymmetry motive as the major cause of the observed portfolio allocations. Gehrig (1993) derives a simple noisy rational expectations model where, even in equilibrium, investors remain incompletely informed and may on average be better informed about the risk characteristics of domestic stocks. Hence, foreign investments appear, on average, more risky and investors rationally skew their portfolios towards the less risky domestic assets. Empirical support to the informational asymmetry motive comes from Coval and Moskowitz (1999) and Grinblatt and Keloharju (2001) who find in the US and Finland, respectively, the preference of investors for local firms. Similarly, Kang and Stulz (1997) find out that foreign investors overweight shares of large firms and of firms with good accounting performance, providing further support for the information asymmetry explanation.

2 Theoretical framework

2.1 General ICAPM: inflation hedging

Cooper and Kaplanis (1994), building on the Adler and Dumas (1983) model, consider how far the observed positions in domestic assets can be explained by inflation hedging motives. Their results reject the hypothesis of inflation hedging as justification of the disproportionate domestic investment: the joint hypothesis of a positive coefficient of risk aversion and a positive correlation between domestic return and inflation is strongly rejected. This outcome confirms the very early critique by Lintner (1975) and Fama and Schwert (1977) assessing the inadequacy of equities to hedge the inflation risk.

We claim that the hedging motive might actually drive investors' decisions although it might be hidden by familiarity factors in a *home-foreign* setting. By allowing for *bilateral* stock positions in several foreign countries we might be able to disclose it. We model the inflation risk in the investor's problem following the Adler and Dumas (1983) International Capital Asset Pricing Model. We consider L investors investing in N stocks and one risk-free asset[3]. Lacking data on the specific securities exchanged between individuals, we assume that investors are restricted to hold national market indexes. Consequently, considering one investor and one asset per country, we deal with L source countries and N host countries. Hence, the vector of weights will have dimension $(N+1)$x1 while the variance-covariance matrix of returns will have dimension NxN since the $(N+1)th$ asset is riskless. All variables are expressed in a common currency chosen as numeraire[4].

The investor's constrained optimization problem is the following

$$\underset{w_j}{Max}\ E\int_t^T V(C,P,s)ds \tag{1}$$

$$sub \quad dW = \left[\sum_{j=1}^{N} w_j(\mu_j - r) + r\right] Wdt - Cdt + \sum_{j=1}^{N} w_j \sigma_j dz_j \tag{2}$$

where W is the nominal wealth, μ_j is the instantaneous expected rate of return, r is the riskless instantaneous nominal interest rate, σ_j is the instantaneous standard deviation, C is the nominal rate of consumption, P is the price level index, V - expressing the instantaneous rate of indirect utility - is a function homogeneous of degree zero in (C,P) and w is the vector of investor's portfolio shares.

The instantaneous total rate of return on the market portfolio of country j is

[3] As shown by Solnik (1974) and Sercu (1980), currency risk is hedged through bonds exclusively. We, therefore, consider the optimal risky portfolio made up only by equities implicitly assuming that investors hedge these stocks through an optimal combination of home and foreign bonds (Cooper and Kaplanis, 1994).

[4] As shown by Solnik (1974) and Sercu (1980), the portfolio composition is independent from the numeraire considered.

$$dY_j/Y_j = \mu_j dt + \sigma_j dz_j$$

where z_j is a Wiener process and dz_j is a standard Gauss Wiener process with zero mean.

The price index of investor l in the measurement currency follows the Brownian process

$$dP_l/P_l = \pi_l dt + \sigma_{l,\pi} dz_{l,\pi}$$

where π_l is the expected value of the instantaneous rate of inflation and $\sigma_{l,\pi}$ is the standard deviation of the instantaneous rate of inflation.

Denoting by $J(W, P, t)$ the maximum value of (1) subject to (2), we define by λ the investor's relative risk aversion coefficient

$$\lambda = -\frac{J_{WW}}{J_W} W$$

where J_W and J_{WW} are, respectively, the first and second partial derivative of $J(.)$ with respect to W.

This yields the optimal solution

$$\mu_j = r + (1-\lambda)\sigma_{j,\pi} + \lambda \textstyle\sum_{k=1}^{N} w_k \sigma_{j,k}$$

and the vector of optimal portfolio shares is given by

$$\tilde{\mathbf{w}}_l = \tfrac{1}{\lambda} \begin{pmatrix} \boldsymbol{\Omega}^{-1}(\boldsymbol{\mu} - r\mathbf{i}) \\ 1 - \mathbf{i}'\boldsymbol{\Omega}^{-1}(\boldsymbol{\mu} - r\mathbf{i}) \end{pmatrix} + (1 - \tfrac{1}{\lambda}) \begin{pmatrix} \boldsymbol{\Omega}^{-1}\boldsymbol{\varpi}_l \\ 1 - \mathbf{i}'\boldsymbol{\Omega}^{-1}\boldsymbol{\varpi}_l \end{pmatrix} \qquad (3)$$

where $\mathbf{i}$ denotes a Nx1 vector of ones, $\boldsymbol{\Omega}$ is a NxN matrix of instantaneous variances-covariances of nominal rates of returns and $\boldsymbol{\varpi}_l$ is a Nx1 vector of covariances between nominal asset returns and country l's rate of inflation. The last element in each vector refers to the riskless asset. The first term in parentheses of the above equilibrium condition is often called "logarithm portfolio"[5], that is the portfolio driven by excess return and variance-covariance considerations, while the second is the "hedge portfolio", that is the portfolio hedging the investor's inflation risk.

The vector of weights in the investor l's equity portfolio is then

$$\mathbf{w}_l = \mathbf{\Omega}^{-1} \left\{ \tfrac{1}{\lambda}([\boldsymbol{\mu} - r\mathbf{i}] + \left(1 - \tfrac{1}{\lambda}\right)[\boldsymbol{\varpi}_l] \right\} \tag{4}$$

2.2 General ICAPM: inflation hedging and information asymmetries

Cooper and Kaplanis (1994) use the return reduction approach that is the most reasonable way of modelling direct transaction costs. However, since recent literature (Ahearne et al., 2004; Berkel, 2004) has documented the failure of the direct costs' explanation, we focus on "indirect" costs, i.e. information asymmetries which are integrated in the model following the Gehrig (1993) approach. The informational barriers are assumed to modify the variance-covariance matrix in such a way that foreign investors perceive a higher variance of the asset issued by country k than the investor residing in country k[6].

In particular we assume that each investor has a perceived variance about foreign assets that is increased by the associated information costs while no information costs are associated to home investments.

For each investor l the vector of equity portfolio shares, $\mathbf{S}_l$, will be

$$\mathbf{S}_l = \mathbf{C}_l^{-1}\mathbf{\Omega}^{-1}\left[\tfrac{1}{\lambda}(\boldsymbol{\mu} - r\mathbf{i}) + \left(1 - \tfrac{1}{\lambda}\right)\boldsymbol{\varpi}_l\right] \tag{5}$$

[5] It is the portfolio held by the investor characterized by a unitary coefficient of risk aversion, i.e. a logarithmic utility function.

[6] In a standard setting with asymmetric information (Grossman and Stiglitz, 1980), an informed investor has a lower perceived variance due to her private signal but, at the same time, her perceived expected return is generally different from the uninformed investor's. This implies that a "foreign-bias" should sometimes be observed when the domestic investor notices bad signals. Our perspective on information asymmetry is, instead, closer to the concept of "model uncertainty" or "Knightian uncertainty" (Epstein and Miao, 2003; Uppal and Wang, 2003). Roughly speaking, we assume that the foreign investor's perceived uncertainty is higher than the domestic investor's one, though both face the same perceived return.

$$
\mathbf{C}_l = \begin{bmatrix} (1+c_{l1}) & 0 & \cdots & \cdots & 0 \\ 0 & \ddots & \ddots & & \vdots \\ \vdots & \ddots & (1+c_{lj}) & \ddots & \vdots \\ \vdots & & \ddots & \ddots & 0 \\ 0 & \cdots & \cdots & 0 & (1+c_{lN}) \end{bmatrix}
$$

where $\mathbf{C}_l$ is a NxN diagonal positive definite matrix and c_{lj} is the bilateral cost of asset j borne by country l's investor. As it is hard to find an empirical counterpart for bilateral costs, c_{lj} is often decomposed into two parts: the "outward cost" (c_l), i.e. the cost faced by an investor to transfer funds out of her own country l, and the "inward cost" (c_j), i.e. the cost faced by an investor to "enter"country j.

$$
(1+c_{lj}) = f((1+c_l),(1+c_j)) \tag{6}
$$

As $(1+c_{lj})$ stands for the informational asymmetry cost between country l and j, its reciprocal $\dfrac{1}{1+c_{lj}}$ captures the informational efficiency between country l and country j. In this setting the minimum value taken by $(1+c_{lj})$ is 1 and corresponds to the full information case, that is the case in which investor l invests in domestic assets ($c_{ll}=0$). If $c_{lj}=0$ for any (l,j) pair then $C_l = C_l^{-1} = I$ and we return to the usual formulation (4) without information costs.

The equilibrium condition on stock market j ensures that the equilibrium stock return equates the overall demand for stock j to its supply, that is its market capitalization. The demand for asset j depends on the aggregate demand for the "logarithm portfolio" - the demand driven by excess returns and variance-covariance considerations - and on the aggregate demand for the "hedge portfolio" - the demand driven by inflation hedging motives. After dividing both sides of our equilibrium condition by the total world capitalization the equilibrium condition becomes

$$\mathbf{MS} = \mathbf{\Phi}\mathbf{\Omega}^{-1}\left[\tfrac{1}{\lambda}(\boldsymbol{\mu} - r\mathbf{i}) + \left(1 - \tfrac{1}{\lambda}\right)\sum_{l=1}^{L} MS_l \varpi_l\right] \tag{7}$$

In the above expression, $\mathbf{\Phi}$ is a NxN diagonal matrix and the generic element ϕ_j on the diagonal is the average informational efficiency of asset j ($\phi_j = \sum_{l=1}^{L} MS_l \dfrac{1}{1+c_{lj}}$)[7]. When the bilateral information cost is split into source country-specific cost and host country-specific cost, as specified above, ϕ_j can be expressed as

$$\phi_j = f(\sum_{\substack{l=1;\\ l\neq j}}^{L} MS_l \frac{1}{1+c_l} + MS_j, (1 - MS_j)\frac{1}{1+c_j} + MS_j) \tag{8}$$

Let us define $\mathbf{D}_l = \mathbf{C}_l\mathbf{\Phi}$ (where $\mathbf{D}_l$ is again a diagonal matrix). We can rewrite expression (5) as

$$\mathbf{S}_l = \mathbf{D}_l^{-1}\mathbf{\Phi}\mathbf{\Omega}^{-1}\left[\tfrac{1}{\lambda}(\boldsymbol{\mu} - r\mathbf{i}) + \left(1 - \tfrac{1}{\lambda}\right)\boldsymbol{\varpi}_l\right] \tag{9}$$

where $D_{lj} = \phi_j C_{lj}$ and $\dfrac{1}{D_{lj}} = \dfrac{\frac{1}{1+c_{lj}}}{\phi_j}$

Now, substituting the equilibrium condition (7) into (9) we get the following result

$$\mathbf{S}_l = \mathbf{D}_l^{-1}\mathbf{MS} + \left(1 - \tfrac{1}{\lambda}\right)\mathbf{C}_l^{-1}\mathbf{\Omega}^{-1}\left(\varpi_l - \sum_{l=1}^{L} MS_l \varpi_l\right) \tag{10}$$

We can now observe how the covariance vector in parentheses pre-multiplied by the inverse of the variance-covariance matrix of returns is a vector of regression coefficients (Cooper and Kaplanis, 1994).

[7] To compute the average informational efficiency we proxy country l's share of world wealth by MS_l, i.e. country l's share in the world stock market capitalization (Cooper and Kaplanis, 1994). Also to compute the weighted average return-inflation covariance vector ($\sum_{l=1}^{L} MS_l \varpi_l$) each investing country l is weighted by MS_l to proxy country l's share of world wealth corrected by country l's relative (to world average) informational advantage.

$$\mathbf{\Omega}^{-1}\left(\varpi_l - \sum_{l=1}^{L} MS_l \varpi_l\right) = \mathbf{b}_l \equiv \begin{pmatrix} b_{l1} \\ \vdots \\ b_{lj} \\ \vdots \\ b_{lN} \end{pmatrix} \tag{11}$$

If we define by p_l the inflation rate of country l then $\sum_{l=1}^{L} MS_l \varpi_l$ is the average world inflation rate and $\mathbf{b}_l$ turns out to be the vector of coefficients of the multiple regression of $(p_l - \sum_{l=1}^{L} MS_l p_l)$ on the vector of nominal returns. The regression coefficient $\mathbf{b}_l$ reflects how far the returns can explain the deviation of investor l's inflation rate from the average inflation. The variation of the inflation rate constitutes a factor of risk the investor wants to hedge through optimal investment in risky assets. The higher the correlation of stock j's return with the deviation of country l's inflation from the average, the higher the share of country j's assets held by country l, since stock j is a good hedge against inflation risk.

3 Data

In our analysis we use two datasets in order to exploit both the cross-sectional and the time dimension[8]: the US-based panel (*Survey of Current Business*) and the pooled CPIS (*IMF*). The choice of considering the pooled CPIS dataset is motivated by the objective of enlarging the analysis from a US-based perspective to a wider set of investing countries. At the same time, due to the limited time dimension of the CPIS dataset, available only for 3 non consecutive years, we chose to adopt also the US-panel dataset which is available for

[8]Both surveys collect and security-level data from the major custodians and large end-investors. The dataset of US holdings of foreign equities is available at www.bea.gov/scb/index.htm. The CPIS dataset is available at www.imf.org/external/np/sta/pi/datarsl.htm.

a longer, though still limited, time span (9 years). The joint analysis of the pooled CPIS and the US-panel should make our findings more general and comparable to the existing empirical literature adopting either of the two datasets.

The first dataset is a US-based (unbalanced) panel of 17 countries for 9 years (1994-2002) for a total of 153 observations. It is drawn from different issues of the *Survey of Current Business* (1996-2004)[9].

The second dataset is a pooled dataset of 13 investing countries. The first CPIS conducted by IMF was relative to the end-1997 period and since 2001 this survey has been released annually. The CPIS provides a unique perspective on cross-country bilateral equity positions enabling the implementation of empirical analysis on international portfolio allocation for a large set of investing countries. We consider in this work the first three editions, 1997, 2001 and 2002. Unlike other papers using the same dataset (Lane and Milesi-Ferretti, 2008), we choose to limit the analysis to a subset of the countries participating in the survey. We selected them on the basis of their financial and, more broadly, economic importance. Moreover, since our theoretical model predicts all non zero weights, we made a choice of source and host countries so as to have non zero holdings for all countries included[10]. By pooling together the 1997-2001-2002 databases, we obtain about 900 observations (13 source countries, 23 host countries, 3 years)[11].

As far as regressors are concerned, to estimate the inflation hedging coefficients we de-

[9] The host countries are: Australia, Canada, Germany, Finland, France, Hong Kong, Ireland, Italy, Japan, Mexico, the Netherlands, Singapore, Spain, Sweden, Switzerland, the United Kingdom and the United States.

[10] Alternatively, some authors prefer to include all investing and destination countries and run a Tobit regression, accounting also for zero portfolio holdings (Lane and Milesi-Ferretti, 2008).

[11] The investing countries considered are: Austria, Belgium, Canada, Denmark, Finland, France, Italy, Japan, the Netherlands, Spain, Sweden, the United Kingdom and the United States. Germany and Switzerland are not among the investing countries since they did not participate in the 1997 survey. The host countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Portugal, Singapore, Spain, Sweden, Switzerland, the United Kingdom and the United States.

rived the stock returns from *Datastream-Thomson Financials* and the inflation rates from the *International Financial Statistics* (*IFS*). To construct the proxies for information efficiency we derived Gross Domestic Product, Population size and Trade Flows from *IFS* and *OECD National Accounts* and M3 monetary aggregate and Stock Market Capitalization from *Datastream-Thomson Financials*.

4 Variables definition and descriptive statistics

4.1 Variables definition

4.1.1 Dependent variable: portfolio shares

The datasets adopted contain information on foreign holdings only and do not include domestic positions. In order to derive the dependent variable in our analysis we need to retrieve the share of foreign assets. To accomplish this objective we drew from the *International Financial Statistics* (*IFS*) the outstanding foreign equity portfolio investments and the corresponding liabilities and then derived the "foreign share", FS[12]

$$FS_{i,t} = \frac{(FA)_{i,t}}{(MCAP_{i,t} + FA_{i,t} - FL_{i,t})} \tag{12}$$

FA stands for "foreign equity assets", FL for "foreign equity liabilities" and $MCAP$ for "stock market capitalization". After obtaining the foreign share FS it is possible to recover the share of each foreign asset in the overall portfolio.

[12] Baele et al. (2004) and Sorensen et al. (2008) follow the same procedure dealing with the CPIS dataset.

4.1.2 Regressors: Information asymmetry variables

Since the information asymmetries are not directly observable, in the empirical implementation we have to make use of proxies. The suggested proxies indicate the reciprocal of information cost, i.e. information efficiency. We consider six alternatives to proxy information efficiency.

The first three variables can be labeled as "size" proxies, i.e. proxies referred to the size of the source and host country. The first proxy is the (logarithm of) Gross Domestic Product per capita ($\log(GDP/POP)$). Lane and Milesi-Ferretti (2008), among others, consider this variable as a broad indicator of market efficiency. The second proxy, the M3 monetary aggregate over GDP ($M3/GDP$), is meant to capture financial market efficiency[13]. The third proxy, more directly linked to stock market, is the market capitalization over GDP ($MCAP/GDP$) and associates the size of stock market capitalization to efficiency (Lane and Milesi-Ferretti, 2008). This measure of financial development has been linked to economic growth (Beck et al., 2000) and access to external finance (Rajan and Zingales, 1998).

The last three variables can be labelled as "trade" proxies as they are proxies related to trade linkages between source and host countries. In particular, they are connected with international trade flows (imports and exports) and imply a sort of information spillover from the goods market to the stock market. The "openness measure" ($(IMP + EXP)/GDP$) has been heavily adopted in the literature (Lane and Milesi-Ferretti, 2008; Ahearne et al., 2004), the basic intuition being that trade flows may have informational content relative to financial markets. Portes and Rey (2005) find that the distance is a time-invariant proxy for

[13] Either the credit to private sector or M2 (Berkel, 2004) are usually adopted as indicators of development of the financial sector. Since both the credit to private sector and the M2 monetary aggregate were not available for all countries and years considered in our sample, we chose the M3 monetary aggregate. Anyway, in support of our choice, it is worth noticing that a larger monetary aggregate should better capture the degree of sophistication of the financial sector.

information barriers driving equity flows. Since "gravity" models in trade literature show that trade flows are strongly correlated with distance, we expect trade flows to capture information factors with the notable advantage of being time-varying. The idea of capturing the separate impact of the two components, imports (IMP) and exports (EXP), is stimulated by Lane and Milesi-Ferretti (2008). They analyze the CPIS 2001 issue finding no role for exports in explaining portfolio holdings, thus conjecturing that the significant effect of imports was due to risk-sharing reasons rather than to informational motives[14]. Results evidencing a significant impact of exports on portfolio holdings would then support the informational motive.

It is now worth making a technical point. As anticipated in the theoretical section, the bilateral informational proxy is constructed as a function of source and host country variables (6). To provide some robustness to our results, the functional form combining the country-specific variables can be additive or multiplicative, as explained in detail in the Appendix. Furthermore, these bilateral informational proxies enter the regression analysis in a transformed fashion in order to normalize to zero the lower bound of informational costs corresponding to domestic investments. To this purpose, the original variable is divided by one plus itself so that the informational efficiency of domestic investment tends to one as informational costs tend to zero[15]. This normalization procedure allows to make all proxies, potentially different in size, directly comparable, so that a different magnitude in regression coefficients reflects their different explanatory power.

[14] See Lane and Milesi-Ferretti (2008) for further details on the role of imports in portfolio allocation decisions. Note that, in a companion paper (Lane and Milesi-Ferretti, 2007), they spouse the informational motive to account for the strong linkages between bilateral trade in goods and bilateral equity holdings.

[15] See Appendix A for further technical details.

4.1.3 Regressors: Inflation hedging coefficients

The inflation hedging coefficient $\mathbf{b}_l$ in (11) is estimated by regressing the deviation of country l's inflation rate from the world average inflation on stock returns.

$$(p_l - \sum_{l=1}^{L} MS_l p_l)_t = b_{l0} + \sum_{j=1}^{J} b_{lj} R_{lj,t} + \varepsilon_{ljt} \qquad (13)$$

Following Cooper and Kaplanis (1994), we instrument return $R_{lj,t}$ by its lagged value $R_{lj,t-1}$ where the orthogonality condition $E(R_{lj,t-1}\varepsilon_{ljt}) = 0$ holds. A GMM regression is, therefore, implemented returning consistent estimates of the b_{lj} coefficients.

To estimate the above expression we use monthly data for the 5 years previous to the date in which portfolio holdings are reported. Accordingly, for 1994-stock holdings in the US panel, we use the nominal returns for the period January 1990-December 1994, while for 1995 portfolio positions we refer to the January 1991-December 1995 period. Cooper and Kaplanis (1994) consider a unique portfolio position at the end of 1987 and consider the returns for the period January 1978-December 1987. To estimate the coefficients they use a number of observations twice as large as ours, implicitly assuming that the relation inflation-returns is stable for such a long period. We instead do not rely so much on the stability of this relationship especially for the more recent years in our sample period since stock markets experienced periods of instability. We therefore give up the inferential advantages of a larger sample limiting our analysis to the five preceding years. It is worth stressing that the choice made by Cooper and Kaplanis (1994) was driven by the fact that their explicit objective was making inference on the domestic inflation hedging coefficient, while in our analysis the hedging coefficients represent only an intermediate step toward our final purposes.

4.2 Descriptive statistics

In Table 1 we report some descriptive statistics relative to portfolio shares and stock market shares of CPIS investing countries. In column 1 we show the stock market share of the investing country, in column 2 the domestic investment and in column 3 the overall investment in the 23 countries within the opportunity set. A comparison between column 2 and column 1 immediately shows that all countries considered display a strong home bias towards domestic assets: Austria appears to be the only country investing less than half of its portfolio in domestic assets. Looking at the third column we notice that the included destination countries, which represent about 94% of the world stock market capitalization, cover almost the overall portfolio investment of the 13 countries analyzed so stressing the negligible investment in emerging markets[16].

Table 2 reports the key descriptive statistics of the variables adopted to construct the proxies of informational efficiency, distinguishing between source and host countries. The reported variables show a standard deviation across source and host countries ranging from 0.10 to 0.15. It reflects a noticeable variability since it represents, depending on the considered proxy, from one-fourth to one-half of the mean value taken by the variable. The only exception is the logarithm of per capita gross domestic product showing a standard deviation lower than 0.01 and a mean value from two to four times larger than the other variables. The remarkable difference in variability is attributable to the logarithmic transformation making observations closer on a cardinal basis. However, as stated above, all variables enter the regression properly transformed (see Appendix A) to be consistent with a zero information cost relative to domestic assets, so that all proxies are made comparable and the logarithmic transformation does not represent an issue.

[16] The last row of column 3 reports the portfolio share (0.981) invested by the US within the CPIS dataset (23 countries). The corresponding value in the US panel dataset (17 countries) is 0.976, very close to the figure reported here.

5 Econometric setting

Cooper and Kaplanis (1994), who aimed at finding a justification for the home bias puzzle, limited their statistical analysis to the test of the b_{ll} coefficient, that is the inflation hedging coefficient relative to domestic holdings. Our objective is, instead, to test the role of inflation hedging in explaining international portfolio choice. To this purpose, we plug the inflation hedging coefficients estimated according to (13) into the equilibrium condition (10) which can be rewritten as[17]

$$\mathbf{S}_l = \mathbf{D}_l^{-1}\mathbf{MS} + \left(1 - \tfrac{1}{\lambda}\right)\mathbf{C}_\mathbf{l}^{-\mathbf{1}}\mathbf{b} \tag{14}$$

or in terms of individual asset

$$S_{lj} = \frac{1}{D_{lj}} M S_j + \left(1 - \tfrac{1}{\lambda}\right)\frac{1}{C_{lj}} b_{lj} \tag{15}$$

It can be noticed that the information efficiency factor enters our equation in a non linear way. How country j's market share determines the demand for asset j depends on the information efficiency of investor l relative to the average[18]. Investor l, for the fraction of her portfolio related to equity returns and variance, the "logarithm portfolio", will hold a share of assets greater (or smaller) than the market share in proportion to $\frac{1}{D_{lj}}$ (inverse of *relative* information asymmetry cost). As far as the "hedge portfolio" is concerned, the country j's share in investor l's portfolio is determined by the inflation hedging properties of the considered stock b_{lj}, proportionally to $\frac{1}{C_{lj}}$ (inverse of *absolute* information asymmetry

[17] Note that the errors of the main regression need not be adjusted for the inclusion of the estimated $\mathbf{b}$. In fact, we are not replacing a population variable with its estimate, as the variable in (11) is the estimated coefficient not the population one.

[18] As in Obstfeld and Rogoff (2001) the share of country j's equity held by country l is a decreasing (increasing) function of the bilateral trading cost (efficiency) between l and j relative to the average trading costs between country j and all other countries.

cost).

We substitute the dependent variable S_{lj} with the observed actual country shares ACS_{lj}[19]

$$ACS_{lj,t} = q_0 + q_1 S_{lj,t} + \varkappa_{lj,t}$$

Finally, our estimable equation will be[20]

$$ACS_{lj,t} = a_0 + \beta_1 MS_{j,t} + \beta_2 b_{lj,t} + \beta_3 pr_{lj,t} + \beta_4 r\_pr_{lj,t} + +\eta_{lj,t} \tag{16}$$

where pr_{lj} is the proxy of absolute information efficiency between country l and j, while r_pr_{lj} is the proxy of relative (to world average) information efficiency between country l and j.

The proxy, by definition, captures the unobservable variable with a measurement error. This error makes the proxy included in the regression correlated with the regression disturbance thus invalidating any coefficient estimates. To ensure the necessary orthogonality condition between the error and the regressors we instrument the proxy by its lagged value. For both datasets, we implement an Instrumental Variable (*IV*) regression: a Panel Two Stage Least Squares (*2SLS*) regression is run for the US panel dataset and a Pooled *IV-2SLS* regression is implemented for the CPIS pooled dataset. In the inference analysis we consider White cross-section covariances, robust to cross-correlation and heteroskedasticity. In the US panel dataset we account for the period fixed effect, removing the period specific mean from the dependent variable and the exogenous regressors, performing the

[19] Note that the possibility of measurement error in the *dependent* variable does not cause any endogeneity problem, as it totally translates into the regression disturbance.

[20] Although the model is non linear in the relevant variables, we chose to estimate a linear regression model. We are interested, in fact, in finding out the individual coefficient relative to each regressor rather than the one related to the interaction of two variables as it would not allow to disentangle the separate effects. Furthermore, since we are adopting proxies of information efficiency, our objective is to pick up the *sign* of the relevant coefficients rather than their exact size.

specified regression on the demeaned data. Similarly, we include a time dummy in the pooled dataset so as to account for the period effect.

We expect a positive sign for the coefficient of MS_j[21] and a positive sign for the coefficient of informational proxies; indeed, the higher the information efficiency between country l and country j, the higher the observed share of asset j in country l's portfolio should be. We expect a positive sign also for $\hat{\beta}_2$, the estimated coefficient of the inflation hedging factor: the higher the investor l's inflation response to stock j return (i.e. the effectiveness of inflation hedging of stock j), the higher the demand for stock j will be.

We consider two alternative ways of constructing the proxy of the bilateral efficiency factor, the additive one and the multiplicative one. These alternative functional specifications, differently combining source country and host country variables, allow us to check the robustness of our results[22].

6 Results

In Table 3 we report a summary of the results of the inflation hedging regression (13). We show for each destination asset j its average value b_j, that is the average, over all investing countries l, of the b_{lj} coefficients obtained as estimates from the regression (13). From this table we can infer the inflation hedging properties of each stock. A positive mean for b_j implies that, on average, asset j is a good hedge against inflation and so investors should go long on it to hedge inflation risk. Irish stocks, for instance, which show the higher positive hedging coefficient (0.219), should be held on average to hedge inflation (0.068). On the contrary, the German market, which shows the higher negative inflation hedging coefficient

[21] Note that, for each year in our sample, portfolio positions refer to December, 31st while the market shares refer to December, 28th in order to avoid endogeneity due to simultaneous equations. We have also run regressions instrumenting MS_j with its lagged value obtaining very similar results.

[22] See Appendix A for details on the cost/efficiency function specifications.

(-0.182), should be shorted, on average, for inflation hedging purposes (-0.054). It is worth noticing that for each stock j the minimum value of the b_{lj} coefficients is always negative, meaning that at least one country should go short on asset j, and the maximum is always positive, meaning that at least one country should go long on asset j. It implies that there is no stock asset that should be held or shorted by *all* investors to hedge inflation.

We use the coefficients derived from the inflation hedging regression to estimate the coefficients in the main regression. In Table 4 and 5 we report the results when the cost function is additive, while in Table 6 and 7 we report the results when the cost function is multiplicative. Table 4 and 6 show results, under different cost specifications, adopting the "size" proxies, while Tables 5 and 7 adopt the "trade" proxies. Odd-numbered columns in each table refer to the US panel while even-numbered columns refer to the CPIS dataset.

As predicted by ICAPM models, we find a positive coefficient for MS_j, the market share of the host country: the higher is the market share country j the higher is, *ceteris paribus*, the investment in that country[23]. When considering the inflation hedging factor, on the contrary, we find that the estimated coefficients do not match those predicted by the theory. For the CPIS dataset, under all specifications, the coefficient is either positive non significant or negative significant. These findings point to a rejection of the inflation hedging motive as determinant of international portfolio allocation. For the US panel the picture is less neat: under both cost function specifications, when the proxies adopted are either the GDP per capita or the ratio market capitalization to GDP, the coefficient for b_{lj} is positive and statistically significant, being equal to 0.036 and 0.083 for GDP/POP and MCAP/GDP, respectively. In terms of economic significance, it means that if a stock j has an inflation hedging factor larger than stock k by one unit, it translates into a higher share

[23] There is one single case in which the coefficient on MS_j is negative. This is the case in which the Gross Domestic Product per capita is adopted as proxy in the US panel with the additive cost function specification (Table 4, column 1). As motivated later, GDP/POP turns out to be a not reliable proxy of information asymmetry.

in the US portfolio by almost 4 percentage points when GDP/POP is used as proxy and by more than 8 percentage points when MCAP/GDP is used as informational proxy. This evidence suggests that, at least for the US, portfolio investment might be partially explained by inflation hedging motives as long as the two "size" variables are accepted as reliable efficiency proxies. However, when considering the US panel dataset, we have to take into account that the variability of the "constructed" bilateral proxy is mainly due to the cross-sectional variation of the host country variable since the adopted proxies are, *per se*, quite persistent. It may therefore be the case that some of the "constructed" bilateral proxies capture *host* country specific variables rather than *bilateral* specific variables, making the multicollinearity with the regressor MS_j a serious issue. Indeed, the correlation between the pr_{lj} constructed over the $\log(GDP/POP)$ proxy and MS_j is about 0.9[24]. This problem can be also evidenced considering the coefficient of MS_j when the proxy adopted is the $\log(GDP/POP)$. For the US panel dataset, the coefficient for MS_j is always positive, statistically significant and larger than 0.7 except when the GDP per capita is adopted as informational proxy (Table 4, column 1). In this case, the coefficient on MS_j is negative, although non significant, suggesting that the coefficient on the proxy might be actually capturing, at least partially, the effect of the market share on portfolio investments[25] This evidence casts some doubts on the adoption of the GDP per capita as proxy, at least for the US panel. The inflation hedging motive is therefore not rejected only if the US is the investing country and MCAP/GDP is the proxy. In all other cases, there is evidence against the inflation hedging motive as determinant of international portfolio investment that generally confirms - in a multinational setting - the Cooper and Kaplanis (1994)

[24]The other proxies seem to be more reliable since their correlation with MS_j is below 0.6. The multicollinearity of the informational proxies with MS_j is not an issue, instead, for the pooled CPIS dataset. The presence of many investing countries, in fact, ensures that the variability of the "constructed" bilateral proxy depends also on the investing side so determining a lower correlation with MS_j.

[25]Note that also in Table 6, where the proxy is GDP/POP but the cost function is multiplicative, the coefficient of MS_j is small and non significant, although positive.

findings.

When considering the coefficients of the proxies we have to make some general remarks. First of all, the proxies' coefficients display all the expected positive sign, with the exception of the coefficient of EXP/GDP in the US panel with additive cost function (Table 5, column 5). Secondly, there are some notable differences between the CPIS pooled dataset and the US panel dataset. For CPIS we observe robust and statistically significant results for all the informational proxies considered, except for the GDP/POP proxy for which the coefficient of the relative proxy (r_pr) is positive but non statistically significant[26]. On the contrary, for the US panel we can identify only a subset of reliable proxies. As already mentioned, the GDP per capita is a critical proxy as revealed by the negative coefficient on MS_j. Also the M3/GDP proxy should be handled with caution. In fact, it shows a non significant coefficient for the relative proxy variable (Table 4, column 3) in the additive cost function case while it shows a low and non significant coefficient for MS_j in the multiplicative cost function specification (Table 6, column 3). As shown in Tables 5 and 7, also the EXP/GDP appears to be a critical proxy in the US panel: the coefficient of the absolute proxy (pr) is indeed negative and significant when the additive cost function is adopted. To sum up, the proxies fully reliable for the US panel dataset are the market capitalization per GDP, the openness measure and the import to GDP ratio, while for the CPIS all proxies with the exception of GDP/POP can be considered reliable.

The size of proxies' coefficients is not very informative and hardly interpretable because of the very nature of the proxies, aimed at capturing the direction of the latent variable rather than the exact size of its impact. This issue is particularly relevant in our setting since we do not deal simply with a proxy variable capturing a latent variable but with a "constructed" bilateral proxy variable which is, in turn, a function of proxy variables.

[26] Note that this evidence makes the adoption of the GDP/POP proxy critical also for the CPIS dataset.

This inevitably makes even less immediate the interpretation of the size of the proxy coefficient in terms of the effect of the latent variable on the dependent variable. However, by comparing the size of the significant coefficients across different proxies we can at least infer their *relative* economic impact on portfolio investments. We will ignore throughout the analysis the GDP/POP variable since, as noted above, it seems to be a critical proxy for both datasets, and will focus on the other proxies. When comparing the additive cost function to the multiplicative one it seems evident that the coefficients' *sign* does not depend on the cost function specification while the coefficients' *size* does. The coefficients of the *absolute* proxies (pr) are, indeed, smaller in the additive cost function case than in the multiplicative one whereas the opposite holds for the coefficients of the *relative* proxies (r_pr).

Before proceeding with the analysis it is worth stressing the different role of the *absolute* and *relative* informational efficiency factor. The pr is aimed at capturing the informational efficiency factor which enters the equilibrium condition multiplied by the inflation hedging factor, while the r_pr captures the informational efficiency relative to the world average and enters the equilibrium condition multiplied by the market share of the destination asset. In this work we find a very limited role for the inflation hedging motive, restricted to the case of the MCAP/GDP proxy in the US panel dataset. In this unique case we have to take into account the size of the coefficients of both pr and r_pr. For both cost specifications, we find that the impact of the absolute proxy pr, i.e. of the proxy operating through the inflation hedging motive, is stronger than the impact of r_pr: it is twice as large in the additive case and ten times larger in the multiplicative case. For the other cases analyzed, however, we uncover no role for the inflation hedging factor so that only the relative proxy (r_pr) plays a role in determining portfolio allocations. In other words, only MS_j and the relative informational efficiency proxy (r_pr) matter in shaping international equity portfolios. Restricting to reliable proxies for the two datasets, we find, comfortingly, that the *relative* impact of the different r_pr adopted does not depend on the cost function specification. As far as the "size" proxies are concerned there is no possibility of comparability across proxies in the US panel, since the only reliable proxy is the MCAP/GDP. In the CPIS dataset, instead, the impact of the M3/GDP factor is larger than the impact of the MCAP/GDP in both specifications and thus determines a stronger effect of the sophistication of financial market on international portfolio allocation. As for the "trade" variables, the impact of the openness measure is larger than the impact of the IMP/GDP in the US panel under both cost specifications. A similar pattern can be found in the CPIS dataset: the coefficient of the openness measure is the largest one and the coefficient relative to the EXP/GDP ratio is the smallest one, regardless of the cost specification adopted.

The findings of this paper are consistent with the recent empirical literature as we find strong evidence that the information asymmetry motive leads equity portfolio composition. In particular, our results point to the importance of financial market development and trade linkages. However, in contrast with Ahearne et al. (2004), we find a role for US import flows in explaining foreign portfolio holdings; also, differently from Lane and Milesi-Ferretti (2008), we find that both imports and exports play a role in explaining portfolio positions for large investing countries, except for the US[27]. Finally, in contrast with the theory and in line with Cooper and Kaplanis (1994), our results find no robust support for the inflation hedging motive also when bilateral foreign investments are taken into account.

[27] It is worth pointing out that we use a different US-based dataset than Ahearne et al. (2004) since they use a cross-country dataset while we use a panel dataset. Also the dataset used by Lane and Milesi-Ferretti (2008) does not coincide with ours. They, in fact, use all investing and destination countries in the 2001 CPIS release while we use only major investing countries and a selected sample of destination countries for the years 1997-2001-2002.

7 Summary and conclusions

We derived a theoretical variation of the original Adler and Dumas (1983) portfolio allocation model including information asymmetries. We investigated, within this theoretical framework, the role of inflation hedging and information asymmetries using a regression approach rather than a test-based approach as in Cooper and Kaplanis (1994). We find evidence, in a bilateral setting, of a general rejection of the inflation hedging motive as suggested in a home-foreign dimension by Cooper and Kaplanis (1994). This result is, however, even more drastic: it suggests not only that home bias cannot be explained by inflation hedging but, more generally, that investors do not consider stocks as valid instruments to hedge inflation. This result justifies the existence and the recent increasing demand for instruments such as indexed bonds aimed at hedging a real source of risk such as inflation. Also, our findings on the role of information asymmetries are in line with the existing empirical literature. As in Warnock (2002) and Ahearne et al. (2004), we find evidence of the important role for information asymmetries in determining bilateral bias in the US portfolio. The same results are confirmed for a wider set of large investing countries in the CPIS pooled dataset. Trade flows and development of financial market turn out to be the proxies better capturing informational efficiency. These results suggest that emerging markets, such as China and India, should succeed in lowering the informational barriers through strong trade linkages and sharp growth in stock market shares, as to attract an increasing international demand and allowing diversification opportunities not yet fully exploited.

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A Technical Appendix: bilateral cost/efficiency functions

The functional expressions for the average information efficiency $\mathbf{\Phi}$ and the $\mathbf{D}_l^{-1}$ are the following

$$\phi_j = \left(\sum_{\substack{l=1;\\ l\neq j}}^{L} MS_l \frac{1}{1+c_l} + MS_j \right) \left((1-MS_j) \frac{1}{1+c_j} + MS_j \right)$$

$$0 \leq \frac{1}{D_{lj}} = \frac{\left(\frac{1}{1+c_l}\right)\left(\frac{1}{1+c_j}\right)}{\left(\sum_{\substack{l=1;\\ l\neq j}}^{L} MS_l \frac{1}{1+c_l} + MS_j \right) \left((1-MS_j) \frac{1}{1+c_j} + MS_j \right)} \leq$$

$$\frac{1}{\left(\sum_{\substack{l=1;\\ l\neq j}}^{L} MS_l \frac{1}{1+c_l} + MS_j \right) \left((1-MS_j) \frac{1}{1+c_j} + MS_j \right)} = \frac{1}{D_{ll}}$$

where $\frac{1}{D_{lj}}$ represents the deviation of investor l from the world average information efficiency. It is equal to 1 if the investor has a composite information costs' structure equal to the average: in this case investor l will hold the same logarithm portfolio as the average one. The share related to the hedge portfolio is, instead, proportional to the absolute level of total cost the investor has to face to hold this stock. It can also be noted as the highest information efficiency is of course for investor l investing domestically and it determines, *ceteris paribus*, a higher portfolio share in home assets.

In terms of econometric implementation, we use proxies capturing the *reciprocal* of information cost, i.e. information efficiency. Therefore, we define a variable χ_{lj} capturing $\frac{1}{c_{lj}}$ or, if we use the inward-outward information decomposition, two variables χ_l and χ_j capturing $\frac{1}{c_l}$ and $\frac{1}{c_j}$, respectively[28].

By simple substitution, considering the two possible ways (additive or multiplicative) of defining C_{lj} and, consequently, D_{lj}, we obtain for the additive cost function specification

[28] In the case of investor l holding domestic assets $c_{ll} = 0 \implies \chi_{ll} = \infty$ and $\frac{\chi_{ll}}{1+\chi_{ll}} \longrightarrow 1$.

$$\frac{1}{C_{lj}} = \frac{\chi_l}{1+\chi_l} + \frac{\chi_j}{1+\chi_j} \quad \text{and} \quad \frac{1}{D_{lj}} = \frac{\frac{\chi_l}{1+\chi_l}+\frac{\chi_j}{1+\chi_j}}{\left(\sum_{\substack{l=1;\\ l\neq j}}^{L} MS_l \frac{\chi_l}{1+\chi_l}+MS_j\right)+\left((1-MS_j)\frac{\chi_j}{1+\chi_j}+MS_j\right)}$$

and for the multiplicative cost function specification

$$\frac{1}{C_{lj}} = \frac{\chi_l}{1+\chi_l}\frac{\chi_j}{1+\chi_j} \quad \text{and} \quad \frac{1}{D_{lj}} = \frac{\frac{\chi_l}{1+\chi_l}\frac{\chi_j}{1+\chi_j}}{\left(\sum_{\substack{l=1;\\ l\neq j}}^{L} MS_l \frac{\chi_l}{1+\chi_l}+MS_j\right)\left((1-MS_j)\frac{\chi_j}{1+\chi_j}+MS_j\right)}$$

We use the proxies mentioned in the text ("size" and "trade" variables) in order to estimate χ_l and χ_j . The transformation allows to normalize to zero the information costs relative to home holdings ($c_{ll} = 0 \Rightarrow C_{ll} = (1 + c_{ll}) = 1$) therefore

$$\frac{1}{C_{ll}} = 1 \quad \text{and} \quad \frac{1}{D_{ll}} = \frac{1}{\left(\sum_{\substack{l=1;\\ l\neq j}}^{L} MS_l \frac{\chi_l}{1+\chi_l}+MS_j\right)\left((1-MS_j)\frac{\chi_j}{1+\chi_j}+MS_j\right)}$$

It can be noticed that $0 < \frac{\chi_{lj}}{1+\chi_{lj}} \leq 1$ and $\frac{\chi_{lj}}{1+\chi_{lj}}$ is an increasing function of χ_{lj}: the higher χ_{lj} (the lower c_{lj}, the information cost) the higher the share of the corresponding stock j in portfolio l.

In our estimable equation (16)

$$ACS_{lj,t} = a_0 + \beta_1 MS_{j,t} + \beta_2 b_{lj,t} + \beta_3 pr_{lj,t} + \beta_4 r\_pr_{lj,t} + +\eta_{lj,t}$$

pr_{lj} is the "absolute efficiency proxy" and captures $\frac{1}{C_{lj}}$ while r_pr_{lj} is the "relative efficiency proxy" and captures $\frac{1}{D_{lj}}$.

The normalization of information costs has been induced by the need of defining information costs related to domestic investment. Since it is not possible to size, for instance, the degree of openness of country k to country k itself, we have been forced to set an upper bound to information efficiency (represented by domestic investments, normalized to 1) and scale the other proxies accordingly. The normalization procedure, anyway, has the notable advantage of making all proxies, potentially different in magnitude, directly comparable and the relative size of their coefficients easily interpretable.