‘Multilateral Resistance’ to International Portfolio Diversification*

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Abstract

Not only are investors biased toward home assets, but when they do invest abroad, they appear to favor countries with returns more correlated with home assets, reducing diversification yet further. This paper argues that understanding this correlation puzzle requires a multi-county theoretical perspective, and we construct an N-country DSGE model that allows for heterogeneous stock return correlations. It shows that bilateral asset holdings depend not only upon the stock return correlation with the destination country, but also on the correlation with all other countries. This effect is analogous to ‘multilateral resistance’ in the trade literature. An empirical study controlling for this multilateral resistance in correlations overturns the result of preceding literature, finding that higher stock return correlation lowers bilateral equity asset holdings as theory predicts, reducing the losses of home bias.

JEL code: F36; F41; G11; G15
Keywords: Stock return correlation; International portfolio diversification; Financial integration; Multi-country model; Equity home bias; Multilateral resistance

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1. Introduction

Home bias in equities is a longstanding puzzle in international finance: investors prefer to hold too many domestic assets, given the diversification benefits of foreign assets (French and Poterba, 1991; see also Coeurdacier and Rey, 2011). A closely related anomaly is that even if investors invest abroad, evidence has suggested they prefer countries with a high correlation in returns to their home country (Portes and Rey 2005, Aviat and Coeurdacier 2007, Lane and Milesi-Ferretti 2008). Because a high correlation lowers diversification potential, this amplifies the investor losses from home bias. Some researchers have explained this second anomaly in terms of a preference for ‘familiarity’ when investing abroad (Huberman 2001, Barberis and Thaler, 2004).

This paper studies the second anomaly, the correlation puzzle, and argues that understanding it requires a multi-country perspective both theoretically and empirically. General equilibrium asset-pricing models have become widespread in international macrofinance research, with the development of higher-order approximation techniques. However, these models are generally two-country frameworks which permit analysis of the first anomaly of home bias, whether to invest abroad, but do not permit analysis of the second anomaly, where to invest abroad. The very few papers that model more than two countries tend to assume the countries are symmetric and have independent returns (such as Baxter, Jermann and King, 1998), so these also cannot study the choice of investors between alternative destination countries. We derive a solution to a general equilibrium model which breaks the independence assumption on capital incomes across countries to allow non-zero covariances among some stock returns, and study how heterogeneous correlations shape portfolio choice.


2 Okawa and van Wincoop (2012), discussed in more detail later in the paper, develop a multicountry model where financial frictions drive portfolio choice among countries. They also consider an extension with a general covariance structure, but their focus is on the role of financial frictions, and they do not explicitly study the effect of stock return correlation on equity holdings.

3 The idea of considering heterogeneous correlations across multiple assets or countries is longstanding in classic finance theory such as the Capital Asset Pricing Model (CAPM). However our model differs in key respects. CAPM presumes that investors take a diversified portfolio, so that it only considers correlations of an asset with the diversified market portfolio. In contrast, our model studies the choice among foreign assets in a context that is consistent with overall home bias in the portfolio, and this produces a different portfolio choice equation below. Another difference is that we take a general equilibrium approach.
The main theoretical implication of the N-country framework is that the optimal share of country $i$’s portfolio in the assets of a foreign country $j$ depends not just on the correlation of returns between countries $i$ and $j$, but also on the correlation of $i$ with all other countries. This has an empirical implication that offers a resolution to the anomaly in the empirical literature. Attempts to estimate the effect of the bilateral correlation on portfolio shares must adequately control for the correlations with all other countries. For instance, suppose the stock return correlation between France and Spain were higher than that between New Zealand and Australia. One might predict less asset diversification between France and Spain than between New Zealand and Australia, because the higher return correlation implies a lower diversification benefit. However, it may be that France has even higher correlations with the other countries surrounding it in Europe that would be an alternative to Spain for diversification, so it might make sense for France to purchase assets in Spain because of the relatively lower correlation compared to the alternatives. Hence, we may find a positive relationship between stock return correlation and bilateral asset holdings when we focus on only the bilateral relationship between country $i$ and $j$ without controlling for the correlations with other countries.

In the international trade literature, an analogous N-country effect was discussed by Anderson and van Wincoop (2003, 2004) with respect to the estimation of the determinants of trade flows. They show that bilateral trade flows are determined not only by bilateral trade costs between two countries but also by average trade barriers with other countries, and they refer to the relative cost of trading with other partners as ‘multilateral resistance’ to trade. While we study returns correlations rather than trade costs, we find that the logic of ‘multilateral resistance’ applies here also, and helps to explain bilateral financial asset holdings in terms of the relative attractiveness of investing in other countries.

We use the theoretical model to suggest an appropriate control for multilateral resistance to returns correlation, to include in our empirical specification. We use a cross-country panel dataset of portfolio equity holdings for 2001-2006. A time-varying output co-movement measure is used as a proxy for stock return correlation based on the empirical evidence that real stock returns are highly correlated with future production growth rates.

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4 As shown in Okawa and van Wincoop (2012), our model with a general covariance structure does not imply an estimation equation that is a standard gravity equation from trade, in which bilateral asset holdings are the product of a country specific variables and a bilateral friction. The portfolio equation implied by our model is a more complex nonlinear relationship, and we take an approximation in order to derive the empirical equation.

5 The Coordinated Portfolio Investment Survey (CPIS), the IMF
Our empirical results show that estimates of the effect of stock return correlation on bilateral equity asset holdings are biased unless we consider stock return correlations with multilateral partners in the empirical specification. When controlling for stock return correlations with other countries, a lower bilateral stock return correlation increases bilateral financial investment between countries, as theory would predict. Our empirical results are robust after controlling for other familiarity factors from previous literature, such as distance, border, common language, etc.

The theoretical portion of our paper is related to Okawa and van Wincoop (2012), which uses a multi-country portfolio model with a financial friction to create a theoretical foundation for an empirical gravity equation for portfolio choice, and uses it to estimate the effect of frictions. Their focus is on the role of financial frictions rather than correlations, and their benchmark model assumes uncorrelated asset returns across countries. We instead focus on the cross-country correlations, excluding frictions from our model, and study how heterogeneous correlations affect home bias in portfolio choice. While Okawa and van Wincoop (2012) do conclude by considering an extension to their model with a general covariance structure, they use it to show that this violates the set of conditions needed to generate a standard gravity equation for estimation. They do not explicitly study how the correlations affect relative asset demands. Our focus is to resolve the correlation puzzle, which is different from their objective of “deriving” a gravity equation in which bilateral asset holdings are the product of country specific variables and a bilateral friction.

An empirical paper that has studied the puzzle of correlations, Coeurdacier and Guibaud (2011), is also related to our paper. Their explanation is based upon the endogeneity of correlations, whereas we emphasize multilateral resistance to returns correlation as an explanation. Our results are robust to controlling for endogeneity, and also suggest the two explanations are complementary. We also differ in developing a micro-founded model of asset holding to inform the empirical specification rather than a mean-variance model.

While the instrumental variable approach of Coeurdacier and Guibaud (2011) is effective in resolving the puzzle in their results, we find that this explanation is sensitive to the specification of the instrument as non-time varying. An alternative but also conventional specification of the instrument using one-period lags of the correlation does not effectively resolve the puzzle on its own. Further, the instrument used in CG, a non-time varying correlation from a period before the sample, resembles the country-pair fixed effects in some of our specifications, which our theoretical derivation shows may also indirectly help control for multilateral resistance in correlations.
In Section 2, we introduce the N country portfolio choice model with returns correlation. Section 3 presents simulations of a 3-country version of the model to illustrate the main theoretical claims and provide intuition. Section 4 derives an empirical specification from the full N-country model. Section 5 presents the empirical results on the international portfolio allocation patterns. Concluding remarks follow in Section 6.

2. Theory: An N country, N+1 asset model

2.1. Set up of the Model

The model generally follows the two-country model of Devereux and Sutherland (2011), but expands to an N-country setting, with non-zero covariance structure on capital incomes. Consider a consumer’s dynamic optimization problem below.

\[ \max E \sum_{k=1}^{\infty} \beta^k U_{i,t+k} \quad \text{for } i=1, \ldots, N \]  
\[ \text{s.t. } W_{i,t} = \sum_{j=1}^{N} \alpha_{ji,t} R_{j,t} + \alpha_{fi} R_{f,t} + Y_{i,t} - C_{i,t} \]  
where \( U_{i,t+k} = \frac{C_{i,t+k}^{1-\gamma}}{1-\gamma} \) and \( W_{i,t} = \sum_{j=1}^{N} \alpha_{ji,t} \)

where \( Y_{i,t} \) is the endowment received by country \( i \), \( W_{i,t} \) is the total net claims of country \( i \)’s agent on all foreign countries at the end of period \( t \) (i.e. net foreign assets of country \( i \)), \( \alpha_{ji,t} \) is the real holdings of country \( j \)’s assets by country \( i \), and \( R_{j,t} \) is the gross real returns of country \( j \)’s assets. We introduce an independent risk-free asset, \( R_{f,t} \), as a risk-free bond that is in zero net supply, as this simplifies derivation of an empirical specification later.\(^7\)

Endowments are the sum of two components,

\[ Y_{i,t} = Y_{i,t}^K + Y_{i,t}^L \quad \text{for } i=1,2,3,\ldots,N, \]  

\(^7\) We assume a risk-free bond in the same manner of Okawa and van Wincoop (2012). This assumption can be justified by the existence of nearly risk-free assets such as insured bank deposits or government bonds. Above all, the assumption is useful to derive an empirical specification for equity holdings. Without the risk-free asset as an anchor asset, the optimal equity holdings would depend additively on the expected returns on all equity, thus making it harder to derive a simple form of empirical specification. Note that our real risk-free bond is not related to exchange rate risk. While a bond is used to allow for hedging exchange rate risk in recent studies, Coeurdacier and Gourinchas (2011) argue that equity holdings are not driven by real exchange rate risk, and Engel and Matsumoto (2009) show similar results in a specific model with nominal rigidities.
where $Y_{i,t}^K$ represents capital income of country $i$, and $Y_{i,t}^L$ represents labor income. The endowments are determined by the following simple stochastic processes.

$$\log Y_{i,t}^K = \log Y_{i,t}^K + \varepsilon_{i,t}^K \quad \text{for } i=1,2,3,\ldots,N.$$ 

$$\log Y_{i,t}^L = \log Y_{i,t}^L + \varepsilon_{i,t}^L \quad \text{for } i=1,2,3,\ldots,N.$$ 

The capital income share and labor income share at the steady state equilibrium are defined as 

$$\delta = \frac{Y^K}{Y} \quad \text{and} \quad 1 - \delta = \frac{Y^L}{Y} \quad (0 < \delta < 1).$$

The log of capital incomes of country $i$ ($i=1,2,3,\ldots,N$) are assumed to be correlated across countries as follows:

$$\begin{pmatrix} \varepsilon_{1,t}^K \\ \vdots \\ \varepsilon_{N,t}^K \end{pmatrix} \sim N \begin{pmatrix} 0 \\ \vdots \\ 0 \end{pmatrix}, \Omega \quad \text{where} \quad \Omega = \begin{pmatrix} \sigma_{11} & \cdots & \sigma_{1N} \\ \vdots & \ddots & \vdots \\ \sigma_{1N} & \cdots & \sigma_{NN} \end{pmatrix}.$$ 

However, the log of labor incomes of country $i$ ($i=1,2,3,\ldots,N$) are assumed to be non-tradable and not cross-dependent.

$$\begin{pmatrix} \varepsilon_{1,t}^L \\ \vdots \\ \varepsilon_{N,t}^L \end{pmatrix} \sim N \begin{pmatrix} 0 \\ \vdots \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_L^2 & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \sigma_L^2 \end{pmatrix}.$$ 

There is covariance between the log of capital and labor income of country $i$ such that

$$\text{Cov}(\varepsilon_{i,t}^L, \varepsilon_{i,t}^K) = \sigma_{LK}^i \quad (i=1,2,3,\ldots,N).$$

The assets are assumed to be one-period equity claims on the home and foreign capital incomes. The real payoff to a unit of the equity of country $i$ in period $t$ is defined to be $Y_{i,t}^K$. The real price of a unit of the equity of country $i$ is denoted as $Z_{i,t-1}^E$. Thus, the gross real rate of return on the equity of country $i$ is

$$R_{i,t} = \frac{Y_{i,t}^K}{Z_{i,t-1}^E} \quad \text{for } i=1,\ldots,N. \quad (4)$$

The price of risk-free bond is denoted as $Z_{t-1}^f$, and the real rate of return on the asset $f$, 

$$R_{f,t} = \frac{1}{Z_{t-1}^f}. \quad (5)$$

2.2. The Asset Market Equilibrium Conditions
We obtain first order conditions with respect to portfolio holdings, $\alpha_{ji,t}$, from the dynamic optimization problem,

$$C_{i,t} = \beta \cdot E_t[C_{i,t+1} \cdot R_{j,t+1}] \quad \text{for } i,j=1,2,3,..N \text{ (N*N FOCs).} \quad (6)$$

Also we have FOCs for a risk free bond, $f$,

$$C_{i,t} = \beta \cdot E_t[C_{i,t+1} \cdot R_{f,t+1}] \quad \text{for } i=1,2,3,..N. \quad (7)$$

A risk-free bond $f$ is used as a numeraire, so $(R_{N,t} - R_{f,t})$ measures the “excess return” on asset $N$. At the end of each period, agents select the portfolio of assets to hold into the following period. For instance, at the end of period $t$, agents in country $i$ select $\alpha_{ji,t}$ ($j \neq i$) to hold into period $t+1$. Thus, the first order conditions for the choice of $\alpha_{ji,t}$ ($j \neq i$) can be written as follows below.

We combine FOCs on $N$ assets for country $i$, and write them in terms of the excess return of country $j$’s asset, $(R_{i,t} - R_{f,t})$,

$$E[C_{i,t+1} \cdot (R_{j,t+1} - R_{f,t+1})] = 0 \quad \text{for } j=1,2,3,..N. \quad (6')$$

Assets are assumed to be in zero net supply, so market clearing in the asset market implies

$$\alpha_{j1,t} + \alpha_{j2,t} + \cdots + \alpha_{jN,t} = 0 \quad \text{for } j=1,\ldots,N. \quad (8)$$

For the risk-free bond, $f$,

$$\alpha_{f,t} = 0. \quad (8')$$

We also have equilibrium consumption plans that satisfy the resource constraint,

$$C_{1,t} + C_{2,t} + \cdots + C_{N,t} = Y_{1,t} + Y_{2,t} + \cdots + Y_{N,t}. \quad (9)$$

2.3. Solution of the Model

2.3.1 First- and Second- order Approximation

Denote with $(\hat{\cdot})$ the log deviations of the variables from the steady state equilibrium:

$$\hat{x} = \log \left( \frac{x}{\bar{x}} \right) \text{ where } \bar{x} \text{ is the value at the equilibrium.}$$

To solve for portfolio holdings, we follow the approach of Devereux and Sutherland (2011) and Tille and van Wincoop (2009). A first-order approximation of the non-portfolio equations (equations (2) for each $N$ country) and a second-order approximation of the Euler equations are needed to express the zero-order
component ($\bar{x}$) of equilibrium portfolios. For simplicity, we assume that N countries’ non-stochastic steady state of wealth is equal to zero ($\bar{W} = 0$).

$$\bar{\alpha}_{1,i} + \bar{\alpha}_{2,i} + \cdots + \bar{\alpha}_{N,i} = 0 \quad \text{for } i = 1, \ldots, N \quad \text{and} \quad \bar{\alpha}_f = 0$$ (10)

A first-order approximation of a country $i$’s budget constraint, equation (2), implies

$$\hat{W}_{i,t+1} = \sum_{j=1}^{N} \hat{\alpha}_{ji} (\hat{R}_{j,t+1} - \hat{R}_{f,t+1}) + \hat{Y}_{i,t+1} - \hat{C}_{i,t+1}.$$ (2')

where $\hat{W}_{i,j} = (W_{i,j} - \bar{W})/\bar{C}$ and $\hat{\alpha}_{ji} = \bar{\alpha}_{ji}/(\bar{\beta}\bar{Y})$.\(^8\)

Take a second-order approximation of the country $i$’s portfolio condition, (6’), to yield

$$E_i[\hat{R}_{j,t+1} - \hat{R}_{f,t+1} + \frac{1}{2} \hat{R}_{j,t+1}^2 - \frac{1}{2} \hat{R}_{f,t+1}^2] = \gamma \cdot E_i[\hat{C}_{i,t+1} (\hat{R}_{j,t+1} - \hat{R}_{f,t+1})] \quad \text{for } j = 1, \ldots, N. \quad (11)$$

From $N$ equations of (11) for country $i$, we make pairs between country $i$ and $k$, and derive $N(N - 1)$ equations like below

$$E_i[(\hat{C}_{i,t+1} - \hat{C}_{k,t+1})(\hat{R}_{j,t+1} - \hat{R}_{f,t+1})] = 0 \quad \text{for } j = 1, \ldots, N, \text{ and } i, k = 1, \ldots, N, k \neq i. \quad (12)$$

The first-order accurate solution for $(\hat{C}_{i,t+1} - \hat{C}_{k,t+1})$ is also straightforward to derive from (2’). Substitute it into (11), and the first-order accurate behavior of $\hat{R}_{j,t+1} - \hat{R}_{f,t+1}$ is particularly simple in this model. First-order approximations of (4) and (5) imply

$$\hat{R}_{j,t+1} - \hat{R}_{f,t+1} = \hat{Y}_j^K - \hat{Z}_{j,t}^E - \hat{Z}_{j,t}^B + O(\varepsilon^2).$$

where $O(\varepsilon^2)$ is a residual which contains all terms of order higher than one, so

$$E_i(\hat{R}_{j,t+1} - \hat{R}_{f,t+1}) = E_i(\hat{Y}_j^K) - \hat{Z}_{j,t}^E - \hat{Z}_{j,t}^B + O(\varepsilon^2).$$

The return on equities must equal to each other, up to a first-order approximation. Moreover, first components of the equity return and bond return are assumed to be equal,

$$E_i(\hat{R}_{i,t+1} - \hat{R}_{f,t+1}) = 0 \quad \text{so}$$

$$\hat{Z}_{j,t}^E - \hat{Z}_{j,t}^B = E_i(\hat{Y}_j^K) + O(\varepsilon^2) \quad \text{where } E_i(\hat{Y}_j^K) = 0.$$

\(^8\) Because $\bar{\alpha}_f = 0$ and $\sum_{j=1}^{N} \bar{\alpha}_{ji} \hat{R}_{j,t+1} \hat{R}_{f,t+1} = \hat{R}_{f,t+1} \sum_{j=1}^{N} \bar{\alpha}_{ji} = 0$.

\(^9\) The zero-order components of asset returns are imposed as $\bar{R}_j = \bar{R}_f = \frac{1}{\bar{\beta}} (i=1,2,\ldots,N)$. 

7
Therefore,
\[
\hat{R}_{j,t} - \hat{R}_{f,t} = \hat{\gamma}^{K}_{j,t} + O(\epsilon^2).
\]
Hence, the distribution of first order components of excess equity returns follows that of first order components of capital incomes like below
\[
\begin{pmatrix}
\hat{R}_{1,t} - \hat{R}_{f,t} \\
\hat{R}_{2,t} - \hat{R}_{f,t} \\
\vdots \\
\hat{R}_{N,t} - \hat{R}_{f,t}
\end{pmatrix}
\sim N
\begin{pmatrix}
0 & \sigma_{11} & \cdots & \sigma_{1N} \\
0 & \sigma_{21} & \cdots & \sigma_{2N} \\
\vdots & \vdots & \ddots & \vdots \\
0 & \sigma_{N1} & \cdots & \sigma_{NN}
\end{pmatrix}
\]

2.3.2. Solution Method

Based on equation (12), we make a matrix system to solve the equity holdings (See Appendix A)
\[
\Pi A = B
\]
\[
A = \Pi^{-1} B
\]
where \(A' = (\tilde{\alpha}_{11} \quad \tilde{\alpha}_{21} \quad \cdots \quad \tilde{\alpha}_{N1} \quad \tilde{\alpha}_{12} \quad \cdots \quad \tilde{\alpha}_{N2} \quad \tilde{\alpha}_{13} \quad \cdots \quad \tilde{\alpha}_{N3} \quad \cdots \quad \tilde{\alpha}_{1N} \quad \cdots \quad \tilde{\alpha}_{NN})\).

\(A'\) is the vector of equity holdings \(N^2 \times 1\). \(B\) is a vector \((N(N-1) \times 1)\) which consists of the variance and covariance of the excess stock returns and the covariance between capital and labor incomes of each country pair. \(\Pi\) is an \(N(N-1) \times N^2\) matrix. See Appendix B for a representation of the \(\Pi\) matrix. With asset market clearing conditions (8) and (8'), and steady state equilibrium conditions (10), we derive the solution of portfolio holdings, \(A\), which is a function of the variance and covariance of the excess returns as well as the covariance between domestic labor and capital income. We present the example of 3×3 model to provide intuition of the model in the next section.

3. Simulation Results with 3×3 Portfolio Allocation Model

To develop intuition, we simulate numerical experiments in a three country version of the model \((N=3)\).\(^{10}\) We demonstrate three points. First, the model is capable of generating equity home bias as an equilibrium portfolio, so as to be a relevant starting point for analysis. Second, even under home bias, the model confirms intuition that when investors choose

\(^{10}\) See the derivation of the 3x3 model in Appendix C.
among multiple foreign assets, they have an incentive to choose those assets with a lower returns correlation with home returns, and thereby maximize the insurance benefit of the foreign assets they do hold. Third, when the model considers heterogeneous correlations across countries, bilateral asset shares can appear to violate this principle, with higher correlations sometimes associated with higher rather than lower asset holdings. But these cases reflect third country effects, and they are still consistent with a portfolio that maximizes hedging benefits.

The input to the simulation consists of a 3×1 correlation between capital and labor income within each country, \( \Lambda = (\sigma_{LK}^1 \ \sigma_{LK}^2 \ \sigma_{LK}^3)' \) as well as a 3×3 covariance matrix among capital returns across countries, \( \Omega = \begin{pmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} \end{pmatrix} \).

The output consists of the 3×3 transformed equity share matrix, \( A \). To help provide economic intuition, we define each component of matrix \( A \) as the ratio of country \( j \)'s equities held by country \( i \) to total equities of country \( i \left( \alpha_{ji} = \frac{\beta Y_i}{Y_i} \right) \), where \( \beta Y_i \) is the total value of equity of country \( i \) (\( i = 1,2,3 \)), and \( \delta = \frac{Y_k}{Y} \) is a capital income share, which is assumed to be 1/3 in our simulations. We add 1 (capital endowment itself) to the domestic equity holdings; thus, the sum of equity holdings of each country is equal to 1.

As seen in the experiments of Case 1, if there is no domestic labor and capital income correlation, \( \Lambda = (0,0,0)' \), countries always have ‘balanced portfolio holdings’(1/3,1/3,1/3), which is similar to the finding of Devereux and Sutherland (2011). Experiments confirm this result is not affected by the correlation structure (\( \Omega \)).
Case 1. Portfolio choice: Depending on the domestic labor and capital income correlation

<table>
<thead>
<tr>
<th>Capital-Labor income correlation</th>
<th>International return correlations</th>
<th>Equity Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) $\sigma_{LK} = 0$</td>
<td>$\Lambda = \begin{pmatrix} 0 \ 0 \ 0 \end{pmatrix}$</td>
<td>$\Omega = \begin{pmatrix} 1 &amp; 0 &amp; 0 \ 0 &amp; 1 &amp; 0 \ 0 &amp; 0 &amp; 1 \end{pmatrix}$</td>
</tr>
<tr>
<td>ii) $\sigma_{LK} &lt; 0$ and close to zero (Bottazzi et al. 1996)</td>
<td>$\Lambda = \begin{pmatrix} -0.1 \ -0.1 \ -0.1 \end{pmatrix}$</td>
<td>$\Omega = \begin{pmatrix} 1 &amp; 0 &amp; 0 \ 0 &amp; 1 &amp; 0 \ 0 &amp; 0 &amp; 1 \end{pmatrix}$</td>
</tr>
<tr>
<td>iii) $\sigma_{LK} &gt; 0$ and close to one (Baxter and Jermann 1997)</td>
<td>$\Lambda = \begin{pmatrix} 0.9 \ 0.9 \ 0.9 \end{pmatrix}$</td>
<td>$\Omega = \begin{pmatrix} 1 &amp; 0 &amp; 0 \ 0 &amp; 1 &amp; 0 \ 0 &amp; 0 &amp; 1 \end{pmatrix}$</td>
</tr>
</tbody>
</table>

Our model follows a strand of the literature that has attempted to explain home bias on financial assets as a hedge against non-tradable labor income (or human capital return) risk (Baxter and Jermann, 1997). Given large exposure to domestic labor income risk, investors should favor either domestic or foreign assets that are a better hedge against their domestic labor income risk. If labor income is negatively correlated with the returns to domestic assets, then labor income risk is hedged by investing in domestic assets, thus leading to a long position in home equity portfolios (Bottazzi, Pesenti, and van Wincoop, 1996, Heathcote and Perri 2009 and Coeurdacier, Kollmann and Martin 2010). In the sub-case ii), we calibrate the labor correlation based on the estimates of Bottazzi et al (1996) to a value less than but close to zero, $\Lambda = (-0.1,-0.1,-0.1)'$. Our model can replicate equity home bias under the assumption of a negative correlation between domestic labor and capital income. We use this as the benchmark calibration of capital and labor income for the remainder of the simulation analysis. When we assume a positive labor and capital correlation in the sub-case iii), there is foreign equity bias that is opposite to the observation in data.
Case 2. Non-zero capital (stock) return correlation (and $\Lambda = (0.1, -0.1, -0.1)'$ for all)

<table>
<thead>
<tr>
<th>International return correlations</th>
<th>Equity Share</th>
</tr>
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<tbody>
<tr>
<td>$\Omega = \begin{pmatrix} 1 &amp; 0.1 &amp; 0.1 \ 0.1 &amp; 1 &amp; 0.1 \ 0.1 &amp; 0.1 &amp; 1 \end{pmatrix}$</td>
<td>$A = \begin{pmatrix} 0.4815 &amp; 0.2593 &amp; 0.2593 \ 0.2593 &amp; 0.4815 &amp; 0.2593 \ 0.2593 &amp; 0.2593 &amp; 0.4815 \end{pmatrix}$</td>
</tr>
<tr>
<td>$\Omega = \begin{pmatrix} 1 &amp; 0.5 &amp; 0.5 \ 0.5 &amp; 1 &amp; 0.5 \ 0.5 &amp; 0.5 &amp; 1 \end{pmatrix}$</td>
<td>$A = \begin{pmatrix} 0.6000 &amp; 0.2000 &amp; 0.2000 \ 0.2000 &amp; 0.6000 &amp; 0.2000 \ 0.2000 &amp; 0.2000 &amp; 0.6000 \end{pmatrix}$</td>
</tr>
<tr>
<td>$\Omega = \begin{pmatrix} 1 &amp; 0.9 &amp; 0.9 \ 0.9 &amp; 1 &amp; 0.9 \ 0.9 &amp; 0.9 &amp; 1 \end{pmatrix}$</td>
<td>$A = \begin{pmatrix} 1.6667 &amp; -0.3333 &amp; -0.3333 \ -0.3333 &amp; 1.6667 &amp; -0.3333 \ -0.3333 &amp; -0.3333 &amp; 1.6667 \end{pmatrix}$</td>
</tr>
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</table>

The experiments of Case 2 explore alternative degrees of international correlation of stock returns, but maintain the assumption that these correlations are identical for all country pairs. We find that a lower stock return correlation causes higher bilateral equity holdings between countries. In sub-case i) and ii), when the stock return correlation between country 1 and 2 increases from 0.1 to 0.5, equity holdings between country 1 and 2 decrease from 0.2593 to 0.2. This confirms the intuition that even under home bias, investors should find low correlations more attractive than high correlations.

Furthermore, stock return correlation affects the overall degree of equity home bias. In sub-cases ii) and iii), equity home bias becomes progressively bigger as a country’s domestic equity holdings increase from 0.4815 to 0.6, and from 0.6 to 1.6667 respectively. The equity home bias becomes more severe because a home country has less incentive to invest in foreign assets which are highly correlated with domestic assets.

The experiments of Case 3 study the effects of heterogeneity among international correlations. On one hand, we find that some bilateral shares support the finding above, that higher stock correlation causes lower equity holdings between countries. In sub-case i) and ii), equity holdings between country 1 and 2 decrease from 0.3333 to 0.3040, when the stock return correlation between country 1 and 2 increases from -0.5 to -0.3.
Case 3. Asymmetric stock return correlation (and $\Lambda = (-0.1,-0.1,-0.1)'$ for all)

<table>
<thead>
<tr>
<th>International return correlations</th>
<th>Equity Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>$i) \Omega = \begin{pmatrix} 1 &amp; -0.5 &amp; 0 \ -0.5 &amp; 1 &amp; 0 \ 0 &amp; 0 &amp; 1 \end{pmatrix}$</td>
<td>$A = \begin{pmatrix} 0.4667 &amp; 0.3333 &amp; 0.2000 \ 0.3333 &amp; 0.4667 &amp; 0.2000 \ 0.2000 &amp; 0.2000 &amp; 0.2000 \end{pmatrix}$</td>
</tr>
<tr>
<td>$ii) \Omega = \begin{pmatrix} 1 &amp; -0.3 &amp; 0 \ -0.3 &amp; 1 &amp; 0 \ 0 &amp; 0 &amp; 1 \end{pmatrix}$</td>
<td>$A = \begin{pmatrix} 0.4579 &amp; 0.3040 &amp; 0.2381 \ 0.3040 &amp; 0.4579 &amp; 0.2381 \ 0.2381 &amp; 0.2381 &amp; 0.4381 \end{pmatrix}$</td>
</tr>
<tr>
<td>$iii) \Omega = \begin{pmatrix} 1 &amp; -0.3 &amp; 0.6 \ -0.3 &amp; 1 &amp; 0 \ 0.6 &amp; 0 &amp; 1 \end{pmatrix}$</td>
<td>$A = \begin{pmatrix} 0.6121 &amp; 0.3576 &amp; 0.0303 \ 0.3576 &amp; 0.4812 &amp; 0.1830 \ 0.0303 &amp; 0.1830 &amp; 0.5794 \end{pmatrix}$</td>
</tr>
</tbody>
</table>

However, a change in stock return correlation between country 1 and 3 affects bilateral equity holdings between country 1 and 2. Less opportunity of international risk-hedging in country 3 lets country 1 divert the original investment in country 3 instead into country 2. Thus, when we compare sub-case i) and iii), if we observe only the bilateral relationship between country 1 and 2, even though the stock return correlation between country 1 and 2 increases from -0.5 to -0.3, bilateral equity holdings increase from 0.3333 to 0.3576. This seems to be puzzling. However, when we consider the role of a third country in a multi-country framework, the positive relationship between stock return correlation and bilateral equity asset holdings can be justified by rational risk diversification behavior. This is one simple example of the principle of third country effects.

4. Empirical Specification

4.1. Empirical Equation

The N-country model above is used to construct the estimation equation. As shown in Okawa and van Wincoop, our model with a general covariance structure does not imply an estimation equation that is a standard gravity equation from trade, in which bilateral asset holdings are the product of country specific variables and a bilateral friction. The equation implied by our model is a more complex nonlinear relationship, and we take an approximation in order to derive the empirical equation. As a benchmark, we derive equity holdings between source country 1 and N destination countries. As shown in Appendix D,
combine equation (11), the second order approximation to country 1’s portfolio equation, with equation (2), the log linearization of the budget constraint evaluated for a country $i=1$, along with market clearing condition for the risk free asset (8’) and zero net supply in the equilibrium.

This implies a system of equations with N unknown variables:

$$\Omega \cdot A_{(i=1)} = H . \quad (14)$$

Thus portfolio holdings can be solved as:

$$A_{(i=1)} = \Omega^{-1} H \quad \text{where } \Omega^{-1} = \frac{1}{\det(\Omega)} adj(\Omega) . \quad (14')$$

where

$$A = \left( \begin{array}{cccc} \tilde{\alpha}_{11} & \tilde{\alpha}_{12} & \ldots & \tilde{\alpha}_{1N} \\ \vdots & \ddots & & \vdots \\ \tilde{\alpha}_{N1} & \ldots & \ldots & \tilde{\alpha}_{NN} \end{array} \right)$$

This implies the portfolio holdings between country 1 and country $j$ (see appendix E for derivation) 12

To facilitate an analytical expression for portfolio holdings, we assume a simple covariance structure.11 As we wish to focus on the relationship between country 1 (source) and the other destination countries, we assume zero covariances among the other countries:

$$\Omega = \left( \begin{array}{cccc} \sigma_{11} & \sigma_{12} & \ldots & \sigma_{1N} \\ \sigma_{12} & \sigma_{22} & \ldots & \sigma_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{1N} & \sigma_{2N} & \ldots & \sigma_{NN} \end{array} \right)$$

This implies the portfolio holdings between country 1 and country $j$ (see appendix E for derivation) 12

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11 Without this special covariance structure, it is hard to derive a simple empirical equation for portfolio holdings. However, we did not assume any restrictions on the covariance of the capital returns in our general equilibrium theory of the previous section of the paper.

12 We assume expected return terms are the same, $EX_{jt}=EX_{kt}$, across countries. Thus, we take out the $EX_{jt}$ term from the summation over $k$. 

13
\[
\widetilde{\alpha}_{jt} = \frac{1}{\text{det}(\Omega_1)} \cdot \frac{EX_{jt}}{\text{Source country specific factor}} \cdot \left\{ \left( \sum_{k=2, k\neq j}^{N} \sigma_{ik} + (1-\delta) \frac{\sigma_{1k}^1}{EX_{jt}} - (1-\sigma_{1j}) \right) \sigma_{1j} + \text{det}(\Omega_1) \right\}
\]

where \( \text{det}(\Omega_1) = 1 - \sum_{k=2}^{N} \sigma_{1k}^2 \), \( EX_{jt} = \frac{1}{\gamma} E_r(\hat{R}_{jt+1} - \hat{R}_{jt+1} + \frac{1}{2} (\hat{R}_{jt+1}^2 - \hat{R}_{jt+1}^2)) \) and, \( \delta = \frac{Y_K}{Y} \).

Note several things about this equation. First, the portfolio shares of the country \( j \) asset respond positively to higher excess returns in country \( j \), \( EX_{jt} \), as one should expect. Second, they also depend on the correlation of stock returns between the source and destination countries, \( \sigma_{1j} \). The sign of this effect depends upon other terms such as the correlation of capital and labor income in the source country 1, \( \sigma_{1k}^1 \), which may carry a negative sign as in the cases shown in our previous section, and \( (1-\delta) \) is a labor share. But note, thirdly, that the portfolio share of the source country 1 with destination country \( j \) also depends upon the sum of the correlation between country 1 returns and all countries other than \( j \), \( \sum_{k=2, k\neq j}^{N} \sigma_{1k} \). This term represents the effects of “multilateral resistance”: even if the correlation with country \( j \) is unattractively high, if the correlations with countries other than \( j \) are even higher, country 1 may have a high share of country \( j \) asset.

The empirical specification is informed by the log of the portfolio solution above, and takes the form:

\[
(\log) \text{Financial asset holdings}_{ijt} = \phi_0 + \phi_1 + \beta_1 SYNCE_{ijt} + \beta_2 \ln Y_{jt} + \beta_3 MT_{ijt} \left( \sum_{k\neq j}^{N} \sigma_{ik,j} \right) + \beta_4 X_{ijt} + \varepsilon_{ijt}
\]  
(16)
A full nonlinear estimation of equation (16) would be prohibitively complicated. The terms in solution (15) that are specific to the destination country, such as $EX_{ij}$, will be represented in our empirical specification with destination country effects, $\phi_j$. This is also true for $\ln Y_{jt}$, which is the log real GDP per capita of a destination country $j$. Source fixed effects will absorb terms in (15) specific to country $i$, such as $\det(\Omega_i)$. The combination of these may also be replaced by country-pair fixed effects, $\phi_{ij}$. $SYNC_{ijt}$ is a monotonic measure for stock return correlation between countries $i$ and $j$ representing $\sigma_{ij}$ in equation (15). We will describe in detail how to construct this measurement in the next section. The higher is the value of $SYNC_{ijt}$, the more symmetric are stock return correlations.

To represent the multilateral resistance term in equation (15), $\sum_{k=2,k\neq j}^N \sigma_{1k}$, we construct a measure $MT_{ijt}$ to capture stock return correlations with other countries. For each country pair $i$ and $j$, we sum the $SYNC$ measure of stock return correlations between country $i$ and all other countries $k$ ($k \neq j$), weighted by country $k$'s income per capita:

$$MT_{ijt} = -\ln \left( \sum_{k=1,k\neq j}^N Y_{kt} \times (-SYNC_{ik}) \right).$$

A large value for $MT_{ijt}$ indicates that there is a high correlation of returns between country $i$ and all other countries other than $j$. So it is expected that the multilateral resistance term is positively associated with bilateral financial asset holdings between countries $i$ and $j$.

We borrow the term “multilateral resistance” from the recent trade literature such as Anderson and van Wincoop (2003, 2004). When researchers investigate bilateral trade flows between countries, they introduce a multilateral resistance term which represents average trade costs of source and destination countries with all other partners. Due to the iceberg trade cost assumption, source and destination country’s price indices imply this multilateral resistance term in the bilateral trade equation. However, many researchers point out that constructing a multilateral resistance term with data is computationally cumbersome, so they

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13 Due to the incidental parameters problem, it is hard to implement non-linear least squares in panel data analysis. While estimating within estimates of the linear equation, we can easily purge the fixed effects from the regression and obtain consistent estimates. However, if the fixed effects are included in the non-linear equation, it is not easy to separate and purge fixed effects during the estimation process. Thus, the estimates can be biased.

14 Country fixed effects and country pair fixed effects are widely used by international trade research. (i.e. country fixed effects: Anderson and van Wincoop 2003, 2004, and country-pair fixed effects: Glick and Rose 2002 and many others)
instead use country fixed effects to minimize measurement errors on the multilateral resistance term.

Our multilateral resistance measure ($MT_{ijt}$) in terms of stock return correlation differs from the multilateral resistance to trade, although the two concepts have similar intuition. First, our multilateral resistance term concerns average stock return correlation. So, we finally investigate how the relative bilateral stock return correlation to average stock return correlation affects bilateral asset holdings. Moreover, we obtain $MT_{ijt}$ from the theory and can construct it using data without computational difficulty.\(^\text{15}\) We also use country or country pair fixed effects with $MT_{ijt}$ not only to control a country’s specific factors in the theory but also to minimize measurement error on the $MT_{ijt}$ term as the international trade literature did. Our $MT_{ijt}$ is time-varying, thus country or country pair fixed effects cannot replace it. A way to control time-varying multilateral resistance in trade is to use country time-varying fixed effects (Baldwin and Taglioni 2006). We also try to introduce country time-varying fixed effects in our regression.\(^\text{16}\) However, this method includes too many dummy variables, which soak up too much of the time series variation to get statistically significant results.

The vector $X_{ijt}$ in equation (16) comprises the other determinants of equity holdings standard in empirical studies, such as distance, border, common language, etc.

4.2. Data and Measurement

4.2.1. Financial Asset Holding Measure (Measure for Financial Integration)

Data for the bilateral portfolio equity holdings, the dependent variable, come from the Coordinated Portfolio Investment Survey (CPIS) published by the International Monetary Fund (IMF). The survey has been conducted annually since 2001 (and for the first time in 1997). The first CPIS involved 29 source economies, while the CPIS has expanded participation up to 67 source economies in 2006, including several offshore and financial centers. In each case, the bilateral positions of the source countries in 218 destination countries/territories are reported.

The CPIS provides a breakdown of a country’s stock of portfolio investment assets by country of residence of issuer. Lee (2008) and Lane and Milesi-Ferretti (2008) point out the shortcomings of survey methods and under-reporting of assets by participating countries

\(^{15}\) Baier and Bergstrand (2009) successfully compute the multilateral resistance term to trade with linear approximation in bilateral trade flow equation.

\(^{16}\) The results of country time-varying fixed effects are available from the authors upon request.
Nevertheless, the survey presents a unique opportunity to examine foreign equity and debt holdings of many participating countries. We choose bilateral equity holdings for the period 2001 to 2006 and take logs. 17

4.2.2. Measure for Stock Return Correlation: Output Growth Co-movement

We use the output growth rate correlation between countries as a proxy for stock return correlation. For instance, the model of simple discounted cash flow valuation maintains that stock prices reflect investors’ expectations about the future real economic variables such as corporate earnings, or its aggregate proxy, industrial production. If these expectations are correct on average, lagged stock returns should be correlated with the contemporaneous growth rate of industrial production. The finance literature has established the empirical relationships between stock returns and production growth rates (Fama (1990) and Schwert (1990) for the U.S. and Choi, Hauser, and, Kopecky (1999) for G-7 countries). Moreover, advantages of using output growth co-movement is that the data are available for a much wider set of countries, and we avoid a simultaneity problem between stock return correlation and bilateral stock holdings because output co-movement is highly correlated with the lagged stock return correlation.

There are various ways to measure output growth co-movement. Previous studies use the 5-year correlation of the cyclical component of output, as measured with the Baxter and King (1999) Band-Pass filter or pure output growth correlation itself during the period (Lane and Milesi-Ferretti 2008). However, these measures are not available year by year and are therefore limited in their time-series information. We introduce a year by year output co-movement proxy to effectively use all the information of the dataset. In addition, financial investment could be sensitive to current or future expected risk factors. Thus, it is important that the stock return correlation measure should be designed to reflect time-varying risk components, being measured year by year. Cerqueira and Martins (2009) show that capturing time variability of business cycle co-movement is worthwhile to verify the accurate effect of other determinants on business cycle synchronization. 18 We construct three different time-varying stock return correlation measures following the previous studies (Alesina, Barro and Tenreyo 2002; Kalemli-Ozcan et al. 2009) to support the robustness of our results.

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17 Equity holdings are reported in terms of millions of U.S. dollars. A unit is converted from millions to thousands. All values are real: we convert nominal value into real term using US GDP deflator (2005=100).

18 When they use time-varying business cycle as a dependent variable, they find the negative effects of financial openness on business cycle synchronization, which differs from the previous findings.
Our benchmark indicator of co-movement is taken from Alesina et al. (2002). It fits the relative log GDP difference between a pair of countries to a second-order auto-regressive process:

\[
\ln \left( \frac{Y_i^t}{Y_i^t} \right) = a_0 + a_1 \ln \left( \frac{Y_{i-1}^t}{Y_{i-1}^t} \right) + a_2 \ln \left( \frac{Y_{i-2}^t}{Y_{i-2}^t} \right) + u_{ij}^t. \tag{17}
\]

The estimated residual of this auto-regression measures the relative output that would not be predictable from the two prior values of relative output. We then use as a measure of co-movement of relative output the (negative) absolute value of the error term:

\[\text{SYNC}_{ijt} = -|u_{ijt}|.\]

This measure differs from Alesina et al. (2002) only in that they use the root mean squared error of the error term over the whole sample rather than the absolute value in each period; our version allows us to capture variation in the measure of co-movement over time. The maximum value of \(\text{SYNC}\) is 0, and progressively lower values of \(\text{SYNC}\) mean that output movement is more asymmetric between countries.

For robustness, we also consider a second measure of co-movement, the negative of divergence, defined as the absolute value of real GDP growth differences between country \(i\) and \(j\) in year \(t\).

\[\text{SYNC2}_{ijt} = -|\ln Y_i^t - \ln Y_{i-1}^t| - |\ln Y_j^t - \ln Y_{j-1}^t|.\]

This simple index is taken directly from Kalemli-Ozcan et al. (2009), based on Giannone et al. (2010). It does not reflect the volatility of output growth of each country in a pair but only captures the co-variation of output growth.

Our measures of co-movement are constructed with real GDP data from Penn World Table 6.3. Both measures are very similar, as indicated by their high correlation, 0.84, with each other.

4.2.3. Other Controls

We control for other important determinants \((X_{ijt})\) of bilateral financial asset holdings identified by previous literature, including specific geographical, political and cultural factors. Financial markets may be more integrated between neighboring countries due to lower transaction and transportation costs. To measure geographical proximity, we use two

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\(^{19}\) They use this measurement to analyze the benefit and cost of the optimal currency area in terms of business cycle which affects the cost of losing independent monetary policy.
variables from Rose and Spiegel (2004): (i) the log of bilateral distance between countries and (ii) a binary variable indicating a shared border.

To control for cultural and historical affinities between countries that can affect cross-border financial asset holdings, we add binary variables for common language, for country pairs with a history of colonization, and for common colonizer. Common language may lower information costs between countries, so investors can more easily access each other’s financial market. The same colonial experience may predict more familiar financial institutions in another country.

We include indicators for currency unions as they may decrease transaction costs and also remove risk from exchange rate volatility (Alesina et al. 2002, and Coeurdacier and Martin, 2009). Previous studies introduce a time zone difference dummy to proxy for communication difficulties when the overlap between office hours is limited (Portes and Rey, 2005 and Lane and Milesi-Ferretti 2008). We include the difference in longitude between countries to measure time difference, where the data is from the CIA World Fact book.

Lane and Milesi-Ferretti (2008) found that OECD countries and emerging market countries differed in the factors determining the pattern of equity investments. So we add an OECD dummy variable coded as 1 if two countries in a pair are both OECD members. This variable also can control for income level and development of financial institution of a country pair.

Recent research about war and trade has found that political tensions between countries hinder bilateral or multilateral economic performance such as trade between countries (Lee and Pyun, 2011). We include the number of years of military inter-state conflicts from 1980 to 2000 to represent how often countries are involved in military conflicts and fail to reach a settlement. Moreover, we control very recent political conflicts between countries. The variable is binary coded as 1 if military conflicts are ongoing for the 2000-2001 period.20

We include the log of real bilateral trade21 (sum of imports and exports between countries and deflated with the U.S. GDP deflator, 2005=100) in line with Aviat and Coeurdacier (2007), and Lane and Milesi-Ferretti (2008).

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20 Military inter-state conflicts dataset is available up to 2001. The data source is from COW project. (http://www.correlatesofwar.org/)
21 Direction of Trade (DOT) in the IMF.
We also introduce domestic stock market capitalization of a host country (logarithm of market capitalization plus one). Domestic stock market capitalization is available for 90 countries from the Global Financial Database.

Lastly, a variable indicates if both a source and a host country have a legal system from the same origin; English (Common), French, German or Scandinavian law. Common legal origin is likely to lead to similar institutions, regulation and custom for financial transaction between countries. We use the Rose and Spiegel dataset that provides the information on legal origins for 107 countries.

5. Empirical Results

5.1. Main Results

Tables 1 and 2 present the estimation results of the effect of international co-movement on bilateral equity asset holdings. We estimate the equation with alternative specifications for the dependent variable and for the co-movement variable, as well as various specifications of fixed effects. Column (1) of Table 1 shows that without any country fixed effects we reproduce the basic puzzle identified in past research: the estimated coefficient on international return correlation ($\text{SYNC}$) is significantly positive at the 1% critical level (Portes and Rey 2005, Aviat and Coeurdacier 2007, Lane and Milesi-Ferretti 2008, Coeurdacier and Guibaud 2011). Despite the theoretical benefits of diversifying the composition of the foreign portfolio, investors seem to prefer countries with fluctuations in returns that are similar to their home country. This result is especially puzzling since the estimation equation controls for the common measures of familiarity across countries in terms of geography, language and culture, and these controls have coefficients of the expected sign.

However, column (2) shows that this puzzle is partly resolved when we include source and host country fixed effects in the regression, which we noted in the theory above could partly control for multilateral resistance in portfolio choice. Column (2) shows that the estimated coefficient of $\text{SYNC}$ becomes negative but statistically insignificant. Further, the result is completely transformed once we include the multilateral resistance term of return correlations, which captures return correlations with the multilateral partners. Column (3)

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Note that although most stock market indices are capitalization-based today, the indices do not capture the growth in the value of the companies listed on stock exchanges. As more companies are listed on stock exchanges, capitalization increases, even if the price of the average stock remains the same.
shows that the estimated coefficient of $SYNC$ becomes significantly negative at the 10% critical level. Thus, we confirm that a higher return correlation lowers bilateral equity asset holdings once we adequately take into consideration correlations with third countries. Furthermore, the estimated coefficient of the multilateral resistance term is significantly positive, as our theory would predict.

Columns (4)-(6) show the results are the same if we define the dependent variable as $\ln(\text{equity}+1)$, to prevent observations from dropping when taking a log of zeros.\(^\text{23}\) Again the coefficient on the measure of stock return correlation initially has the wrong sign, but this is corrected once we control for multilateral resistance in column (7).

Throughout columns (1)-(6) in Table 1 other standard explanatory variables have the expected signs. Higher asset holdings are associated with higher GDP per capita in a host country, as are common language, colonial relationship, and currency union. Distance has a negative effect.

Column (7) includes additional explanatory variables explored in recent research. Bilateral asset holdings is found to be positively influence by bilateral trade in goods and services, as found in Aviat and Coeurdacier (2007), Lane and Milesi-Ferretti (2008) and Lee (2008). Stock market capitalization and common legal origin data are not available for all sample countries, so the number of observation shrinks from 10384 to 9100. The coefficient of $SYNC$ becomes marginally insignificant in this regression. But these additional controls do uncover a significantly negative sign for longitude difference, which measures differences in time zone that prevent investors from responding quickly to fluctuations in the financial market.

Column (8) implements tobit estimation with host and source country fixed effects to consider left censored observations. Most of the estimated coefficients remain as the same as those of column (6), in particular, the estimated coefficient of $SYNC$ is significantly negative at the 5% critical level.

Including country-pair fixed effects is another regression specification which matches the theoretical foundation that we proposed in the previous section. These fixed effects are able to capture any time-invariant correlation (within a pair) between a dependent variable and error term, so they also help address problems of engodeneity and omitted variables. This specification has also been used by the trade literature to help deal with multilateral resistance, though it does not fully obviate the need for our multilateral resistance term, $MT$.

\(^\text{23}\) Our equity holdings are measured in thousands of US dollars. So, 1 means a thousand US dollar.
as this captures multilateral resistance that is time varying whereas country pair fixed effects cannot. Table 2 reports results where country-pair fixed effects are used to control for dyadic characteristics that we cannot observe or otherwise control. While these country pair fixed effects make redundant time-invariant country-pair variables such as distance, border, etc., our variables of interest, SYNC and MT, remain. Thus, the results with country pair fixed effects reinforce the robustness of our results with controlling for a possible heterogeneity within a country pair.

In column (1), the estimated coefficient of SYNC is already negative and significant at 5% critical level, however the addition of our multilateral resistance control (MT) in column (2) makes the estimated coefficient become statistically more significant at 1% critical level as well as larger in magnitude. Country-pair fixed effects seem to contribute to controlling multilateral resistance of returns correlations. But our additional time-varying multilateral resistance control (MT) continues to play a role in correcting the response to bilateral correlation, and its coefficient remains significantly positive at the 1% critical level.

This conclusion is supported under the expanded sample in columns (4)-(6) where we define the dependent variable as ln(equity+1). The coefficient of SYNC initially is negative but insignificant. However, the estimated coefficient of SYNC becomes significantly negative at the 1% critical level once we control for multilateral resistance in column (5).

It is common in the empirical literature to consider year fixed effects to control for common trends or common shocks at a given year. Unlike country fixed effects, which were included in our benchmark empirical estimation, our theoretically derived empirical specification does not call for year fixed effects. Nonetheless, Table 3 reports results with year fixed effects included. Estimates in columns (1) and (2) are very similar to the corresponding results in columns (1) and (2) of table 1, suggesting year fixed effects do not much affect the puzzle of asset holdings associated with high correlations. Column (3) differs from the corresponding column (3) of table 1, in that the multilateral resistance term (MT) is not positive, and the coefficient on SYNC is not statistically significant. So the year fixed effects do seem to overlap with the control we use for multilateral resistance. Substantial collinearity between MT term and year fixed effects is not surprising, as the MT term is computed by taking an average across all countries in the sample excluding one (the destination country). So the computation of MT is very similar across countries, and consequently there is little cross-sectional variation in the MT term.
5.2. An Instrumental Variable Approach

The empirical investigation of the effects of returns correlation on financial asset holdings may encounter an endogeneity problem, as discussed in Coeurdacier and Guibaud (2011). The causality can run in the opposite direction: financial asset holdings between countries (financial integration) may have either a negative effect (Kalemli-Ozcan et al. 2009) or a positive effect (Imbs 2006) on the stock return correlation and output growth co-movement. Hence, the former estimates of returns correlation on bilateral asset holdings might be biased, although the fixed effects that we used partially relieve endogeneity and omitted variable problems by controlling unobserved components which are related to error terms. As a robustness check, this section implements an instrument variable (IV) approach. We use as an instrument the lagged output growth correlation, as suggested by Lane and Milesi-Ferretti (2008).

Panel B of Table 4 presents the first stage regression of IV with country-pair fixed effect estimation. We instrument \( \text{SYNC} \) on its lag. The estimated coefficient of lagged \( \text{SYNC} \) on current returns correlation (\( \text{SYNC} \)) is significantly negative. F-test statistics on the first stage regression all exceed 10, the threshold number recommended by Staiger and Stock (1997). Thus, we can reject the null hypothesis that the IV equation is weakly identified and confirm that the instruments are theoretically and statistically powerful.

Panel A of Table 4 reports estimates from the second stage instrumental variable regressions, beginning with a specification drawn from column (7) of table 1 with source and host country fixed effects. Results confirm the conclusions from previous tables. Comparing columns (1) and (2) shows that once again including our control for multilateral resistance (\( \text{MT} \)) confers statistical significance (at the 10% level) to the negative relationship between

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\( ^{24} \) In fact, the causal effect of financial market integration on output comovement has been a popular topic in the preceding literature, in contrast with the scarcity of work studying our question of the causal effect running the other way. Some theoretical research discusses the implication of limited international financial asset trade (incomplete financial market) on international real business cycles (See Baxter and Crucini 1995; Heathcote and Perri 2002). Moreover, empirical studies inspect the effect of financial asset integration on real economic linkage. The results are mixed and reach no consensus on the effect of financial integration on output co-movement. Kose et al.(2003) finds negligible effects of financial integration on consumption and output correlation in the 1990’s. Kalemli-Ozcan, Sorensen and Yosha (2003) and Kalemli-Ozcan, Papaioannou and Peydró (2009) emphasize that financial integration between countries causes capital reallocation between them. This may promote industrial specialization of each country cause output co-movement to be less synchronized. However, Imbs (2004, 2006) find that an increase in financial integration generates correlated capital flows, which raises business cycle synchronization.

\( ^{25} \) Coeurdacier and Guibaud (2011) also used past correlation as an instrument for current stock return correlation.
equity holdings and returns correlations (SYNC). And once again the coefficient on MT is significantly positive. These results are echoed in the other columns (3) and (4) of Table 4 for country-pair fixed effects specification.

5.3. Robustness Check: Alternative Measure for Returns Correlation

To check the robustness of the results, we repeated our various estimations while replacing the measure for returns correlation (SYNC) with the alternative (SYNC2) proposed by Giannone et al. (2010). Columns (1)-(3) of Table 5 report the estimation results of country fixed effects which correspond to columns (1)-(3) of Table 1. The estimated coefficient of SYNC2 starts as positive in column (1), and becomes insignificantly different from zero once we control for multilateral resistance of returns correlation. Column (4)-(6) implements country-pair fixed effects with the new measure SYNC2 following Table 2. The estimated coefficient of SYNC2 is negative but insignificant in column (4), however the addition of our multilateral resistance (MT) confers statistical significance (at the 10% level) to the negative relationship between equity holdings and returns correlations (SYNC2). The IV results in column (7)-(8) confirm that including our control for multilateral resistance (MT) makes the estimated coefficient of SYNC2 become statistically more significant (at the 5% critical level) as well as larger in magnitude.

5.4. The Patterns of Financial Asset Holdings: OECD versus Non-OECD

This section considers sub-sample regressions of OECD and Non-OECD groups of countries in order to examine any specific patterns of financial asset holdings according to the different level of income and financial development. We categorize source and host countries into either OECD or Non-OECD, and make 4 country pair sub-samples: i) OECD (source) to OECD (destination), ii) OECD to Non-OECD, iii) Non-OECD to OECD, and iv) Non-OECD to Non-OECD.

As reported in Table 6, the estimates on returns correlation are significantly negative for all those cases where the destination country is OECD (odd numbered columns), but statistical significance fails for cases where non-OECD countries are the destination. In the former group, the degree of statistical significance tends to be stronger than in any of our previous tables. It is also interesting that the identity of the source country does not seem to play as important a role as does the destination.
6. Concluding Remarks

This paper studies how asset diversification between a pair of countries is affected by correlations with third countries, in a manner that resembles the multilateral resistance to trade in the recent trade literature. Our N-country theoretical framework offers an explanation for why recent empirical work has found that higher return correlations are sometimes associated with higher portfolio holdings, which is contrary to the pursuit of risk hedging. The model suggests a means for controlling for third-country effects, and empirical specifications implementing these controls reverse the finding of preceding literature.

Hence, we show that a multi-county perspective is required to understand this possible positive relationship between returns correlation and bilateral asset holdings. We also find that heterogeneous stock return correlations among countries contribute to explaining the degree of equity home bias. When stock returns among countries are highly associated, equity home bias becomes more severe because a home country has less international risk diversification incentives to invest in foreign assets which are highly correlated with home assets.

Our empirical results have implications for the benefits of international financial market integration. The recent global financial crisis caused a spillover of negative shocks between closely integrated countries. Due to this negative effect of economic integration, some doubt arises whether the consequence of economic integration is a net positive. However, this paper shows that if one controls for multilateral resistance arising from third-country effects, then holding equities in a foreign country is associated with lower rather than higher output correlations. This highlights the benefit of international financial integration to facilitate risk sharing and raise economic welfare.
References


[28] Heathcote, J. and F. Perri, 2009. The International Diversification Puzzle is Not as Bad as You Think. unpublished manuscript.


<table>
<thead>
<tr>
<th>Method</th>
<th>Dependent variables</th>
<th>Panel FE</th>
<th>OLS</th>
<th>Tobit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ln(equity)</td>
<td>ln(equity+1)</td>
<td>ln(eq)</td>
<td>ln(eq+1)</td>
</tr>
<tr>
<td>Country Fixed Effects</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>SYNC (Measure for stock return correlation)</td>
<td>6.306***</td>
<td>-0.583</td>
<td>-1.264*</td>
<td>8.337***</td>
</tr>
<tr>
<td>(log) Destination GDP per capita (ln $Y_{jt}$)</td>
<td>0.415***</td>
<td>5.191***</td>
<td>4.547***</td>
<td>1.351***</td>
</tr>
<tr>
<td>Multilateral Resistance ($MT_{ijt}$)</td>
<td>0.205***</td>
<td>0.335***</td>
<td>0.115***</td>
<td>0.465***</td>
</tr>
<tr>
<td>Border</td>
<td>0.878***</td>
<td>0.610***</td>
<td>0.610***</td>
<td>0.958***</td>
</tr>
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<td>0.041</td>
<td>0.041</td>
<td>0.063</td>
</tr>
<tr>
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<td>0.410***</td>
<td>0.412***</td>
<td>1.656***</td>
</tr>
<tr>
<td>Colony dummy</td>
<td>0.647***</td>
<td>0.623***</td>
<td>0.621***</td>
<td>0.872***</td>
</tr>
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<td>Common colonizers</td>
<td>-0.435***</td>
<td>0.667***</td>
<td>0.677***</td>
<td>0.027</td>
</tr>
<tr>
<td>Currency Union</td>
<td>1.644***</td>
<td>0.114*</td>
<td>0.116*</td>
<td>1.992***</td>
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<td>Longitude difference</td>
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<td>0.001</td>
<td>0.001</td>
<td>0.002***</td>
</tr>
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<td>Both OECD countries</td>
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<td>1.799***</td>
<td>1.799***</td>
<td>5.873***</td>
</tr>
<tr>
<td># of years of military conflicts, 1980-2000</td>
<td>0.242***</td>
<td>0.065*</td>
<td>0.066*</td>
<td>0.500***</td>
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<td>Military conflict dummy, 2000-01</td>
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<td>0.201</td>
<td>0.2</td>
<td>0.751</td>
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<td>(log) Bilateral trade</td>
<td>0.325***</td>
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<td></td>
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<td>(log) Stock Market Capitalization, Host country (j)</td>
<td>0.450***</td>
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<tr>
<td>Common legal origin</td>
<td>0.044</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observations | 10384 | 10384 | 10384 | 25550 | 25550 | 25550 | 9100 | 25550 |

Adj-R² (Pseudo-R²) | 0.305 | 0.763 | 0.764 | 0.389 | 0.72 | 0.72 | 0.793 | (0.289) |

Note: Robust standard errors are reported in brackets. *, **, and *** are respectively significance level at 10%, 5% and 1%.
Table 2. The Determinants of Bilateral Equity Holdings: Country-pair Fixed Effects

<table>
<thead>
<tr>
<th>Method</th>
<th>Panel FE: Country-pair Fixed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependant variables</td>
<td>( \ln(\text{equity holdings}) )</td>
</tr>
<tr>
<td>( \text{SYNC}_{ijt} )</td>
<td>(1) (-1.495^{**})</td>
</tr>
<tr>
<td></td>
<td>(2) (-2.299^{***})</td>
</tr>
<tr>
<td></td>
<td>(3) (-2.287^{***})</td>
</tr>
<tr>
<td></td>
<td>[0.760]</td>
</tr>
<tr>
<td></td>
<td>[0.722]</td>
</tr>
<tr>
<td></td>
<td>[0.754]</td>
</tr>
<tr>
<td>( \log ) \text{Destination GDP per capita} (( \ln Y_{jt} ))</td>
<td>(4.859^{***})</td>
</tr>
<tr>
<td></td>
<td>[0.312]</td>
</tr>
<tr>
<td>( \text{Multilateral Resistance} (MT_{ijt}) )</td>
<td>0.219^{***}</td>
</tr>
<tr>
<td></td>
<td>[0.030]</td>
</tr>
<tr>
<td></td>
<td>0.100^{*}</td>
</tr>
<tr>
<td></td>
<td>[0.050]</td>
</tr>
<tr>
<td>( \log ) \text{Bilateral Trade}</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>[0.058]</td>
</tr>
<tr>
<td>( \log ) \text{Stock market capitalization} (( j ))</td>
<td>0.605^{***}</td>
</tr>
<tr>
<td></td>
<td>[0.075]</td>
</tr>
<tr>
<td>Observations</td>
<td>10384</td>
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<tr>
<td>Country pairs</td>
<td>2631</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>0.942</td>
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</table>

Note: Pair-clustered robust standard errors are reported in brackets. *,**, and *** are respectively significance level at 10%, 5% and 1%. 
Table 3. Including Year Fixed Effects

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<tr>
<th>Dependent Variable</th>
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</tr>
</thead>
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<tr>
<td><strong>SYNC</strong> (Measure for stock return correlation)</td>
<td>6.237***</td>
</tr>
<tr>
<td></td>
<td>[1.082]</td>
</tr>
<tr>
<td><strong>(log) Destination GDP per capita</strong></td>
<td>0.274***</td>
</tr>
<tr>
<td></td>
<td>[0.049]</td>
</tr>
<tr>
<td><strong>Multilateral Resistance (MT_{ij})</strong></td>
<td>0.258**</td>
</tr>
<tr>
<td>Border</td>
<td>[0.117]</td>
</tr>
<tr>
<td><strong>(log) Distance</strong></td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>[0.048]</td>
</tr>
<tr>
<td><strong>Common language</strong></td>
<td>1.200***</td>
</tr>
<tr>
<td></td>
<td>[0.074]</td>
</tr>
<tr>
<td><strong>Colony dummy</strong></td>
<td>0.586***</td>
</tr>
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<td>[0.148]</td>
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<td><strong>Common colonizers</strong></td>
<td>0.470**</td>
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<td></td>
<td>[0.188]</td>
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<tr>
<td><strong>Currency Union</strong></td>
<td>1.583***</td>
</tr>
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<td>[0.091]</td>
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<td><strong>Longitude difference</strong></td>
<td>0.004***</td>
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<td>[0.001]</td>
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<tr>
<td><strong>Both OECD countries</strong></td>
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<td></td>
<td>[0.067]</td>
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<td>[0.064]</td>
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<td>Military conflict dummy, 2000-01</td>
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<tr>
<td></td>
<td>[0.427]</td>
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<tr>
<td><strong>(log) Bilateral trade</strong></td>
<td>0.373***</td>
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<tr>
<td><strong>(log) Stock Market Capitalization, Host country (j)</strong></td>
<td>0.131***</td>
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<tr>
<td></td>
<td>[0.016]</td>
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<tr>
<td><strong>Common legal origin</strong></td>
<td>-0.459***</td>
</tr>
<tr>
<td></td>
<td>[0.058]</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
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<tr>
<td><strong>Adjusted R²</strong></td>
<td>0.399</td>
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Note: Robust standard errors are reported in brackets. *, **, and *** are respectively significance level at 10%, 5% and 1%.
### Table 4. Instrument Variable Estimation\(^a\)

<table>
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<tr>
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<tbody>
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<td>(1)</td>
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</tbody>
</table>

#### Panel A: Second stage IV estimates: Dependent variable is Financial Asset Holdings

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<tr>
<td>SYNC(_{ijt})</td>
<td>-25.454</td>
<td>-33.468*</td>
<td>-7.280**</td>
<td>-8.380**</td>
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<tr>
<td></td>
<td>[15.595]</td>
<td>[20.022]</td>
<td>[3.005]</td>
<td>[3.260]</td>
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<tr>
<td>(log) Host GDP per capita</td>
<td>4.192***</td>
<td>3.243***</td>
<td>4.034***</td>
<td>3.592***</td>
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<tr>
<td>((lnY_{jt}))</td>
<td>[0.811]</td>
<td>[0.495]</td>
<td>[0.430]</td>
<td>[0.418]</td>
</tr>
<tr>
<td>Multilateral Resistance</td>
<td>--</td>
<td>0.607*</td>
<td>--</td>
<td>0.203***</td>
</tr>
<tr>
<td>((MT_{ijt}))</td>
<td>[0.311]</td>
<td>--</td>
<td>--</td>
<td>[0.059]</td>
</tr>
<tr>
<td>(log) Bilateral trade</td>
<td>0.318***</td>
<td>0.320***</td>
<td>0.093*</td>
<td>0.102**</td>
</tr>
<tr>
<td></td>
<td>[0.020]</td>
<td>[0.021]</td>
<td>[0.052]</td>
<td>[0.052]</td>
</tr>
<tr>
<td>(log) Stock Market</td>
<td>0.481***</td>
<td>0.268*</td>
<td>0.644***</td>
<td>0.576***</td>
</tr>
<tr>
<td>Capitalization((j))</td>
<td>[0.072]</td>
<td>[0.138]</td>
<td>[0.065]</td>
<td>[0.069]</td>
</tr>
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<td>Border</td>
<td>0.578***</td>
<td>0.584***</td>
<td>--</td>
<td>--</td>
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<tr>
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<td>[0.088]</td>
<td>[0.092]</td>
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<td>--</td>
</tr>
<tr>
<td>(log) Distance</td>
<td>-0.352***</td>
<td>-0.352***</td>
<td>--</td>
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<tr>
<td></td>
<td>[0.048]</td>
<td>[0.049]</td>
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<td>--</td>
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<tr>
<td>Common language</td>
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<td>0.493***</td>
<td>--</td>
<td>--</td>
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<tr>
<td></td>
<td>[0.068]</td>
<td>[0.074]</td>
<td>--</td>
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<tr>
<td>Colony dummy</td>
<td>0.222**</td>
<td>0.208**</td>
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<tr>
<td></td>
<td>[0.102]</td>
<td>[0.105]</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Common colonizers</td>
<td>0.781***</td>
<td>0.828***</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>[0.185]</td>
<td>[0.206]</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Currency Union</td>
<td>0.262***</td>
<td>0.282***</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>[0.082]</td>
<td>[0.089]</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Longitude difference</td>
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<td>-0.001**</td>
<td>--</td>
<td>--</td>
</tr>
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<td>[0.001]</td>
<td>[0.001]</td>
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<tr>
<td>Both OECD dummy</td>
<td>1.725***</td>
<td>1.762***</td>
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<td>--</td>
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<td></td>
<td>[0.110]</td>
<td>[0.125]</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td># of years of military conflicts, 1980-00</td>
<td>0.039</td>
<td>0.039</td>
<td>--</td>
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</tr>
<tr>
<td></td>
<td>[0.035]</td>
<td>[0.036]</td>
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<td>Military conflict dummy, 2000-01</td>
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<td>0.317</td>
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<td>Common legal origin</td>
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<td>--</td>
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<tr>
<td></td>
<td>[0.046]</td>
<td>[0.049]</td>
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</tbody>
</table>

#### Panel B: 1st stage IV estimates & Diagnostics: Dependent variable is SYNC\(_{ij(t-1)}\)

<table>
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<tr>
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<th>(1)</th>
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<th>(3)</th>
<th>(4)</th>
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</thead>
<tbody>
<tr>
<td>SYNCP(_{(i-1)})</td>
<td>-0.052***</td>
<td>-0.042***</td>
<td>-0.169***</td>
<td>-0.156***</td>
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<tr>
<td>(a year lagged SYNC)</td>
<td>[0.01]</td>
<td>[0.009]</td>
<td>[0.015]</td>
<td>[0.014]</td>
</tr>
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<td>F- test on IV</td>
<td>26.31</td>
<td>18.44</td>
<td>128.49</td>
<td>131.91</td>
</tr>
<tr>
<td>Country Two-way FEs</td>
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<td>Yes</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Country pair FEs</td>
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<td>--</td>
<td>Yes</td>
<td>Yes</td>
</tr>
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<td>Observations</td>
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<td>9100</td>
<td>9053</td>
<td>9053</td>
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<td>Country pairs</td>
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<td>1911</td>
<td>--</td>
<td>--</td>
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</tbody>
</table>

Note: a. (Clustered robust) standard errors are reported in brackets. *,**, and *** are respectively significance level at 10%, 5% and 1%.  b. We report only the estimation results of SYNCP\(_{(i-1)}\) and omit other variables of the first stage regression in Panel B. The full estimation results of the first stage regression are available from the authors upon request.
### Table 5. Robustness Check: Alternative Measure for Returns Correlation, SYNC2

<table>
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<tr>
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<td><strong>SYNC2</strong></td>
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<tr>
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<td>[0.688]</td>
<td>[0.609]</td>
<td>[0.580]</td>
<td>[0.650]</td>
<td>[4.160]</td>
<td>[4.828]</td>
</tr>
<tr>
<td>(log) Destination GDP per capita (( \ln Y_{jt} ))</td>
<td>0.418***</td>
<td>5.077***</td>
<td>4.565***</td>
<td>6.201***</td>
<td>5.526***</td>
<td>3.406***</td>
<td>3.870***</td>
<td>3.326***</td>
</tr>
<tr>
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<td>[0.027]</td>
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<td>[0.294]</td>
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<td>[0.413]</td>
<td>[0.426]</td>
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<tr>
<td>Multilateral Resistance (( MT_{jt} ))</td>
<td>--</td>
<td>--</td>
<td>0.184***</td>
<td>--</td>
<td>0.233***</td>
<td>0.135***</td>
<td>0.293***</td>
<td>0.097*</td>
</tr>
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<td></td>
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<td>[0.040]</td>
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<td>[0.029]</td>
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<td></td>
<td>[0.092]</td>
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<td>(log) Bilateral trade</td>
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<td></td>
<td></td>
<td>0.097*</td>
<td>0.088*</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.106**</td>
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<tr>
<td>(log) Destination Stock Market Capitalization (( j ))</td>
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<td></td>
<td></td>
<td></td>
<td>0.634***</td>
<td>0.676***</td>
<td>0.584***</td>
</tr>
<tr>
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<td>[0.082]</td>
<td>[0.082]</td>
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<td>(log) Distance</td>
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<td>0.065*</td>
<td>0.065*</td>
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<td>F-test on IV</td>
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Note: a. (Clustered robust) standard errors are reported in brackets. ***,**, and *** are respectively significance level at 10%, 5% and 1%. b. We report only the second stage IV estimation results and omit the first stage regression in Panel b. The full estimation results of the first stage regression are available from the authors upon request.
Table 6. The Patterns of Bilateral Equity Holdings: OECD vs Non-OECD Countries.

<table>
<thead>
<tr>
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<th>OECD</th>
<th>OECD</th>
<th>Non-OECD</th>
<th>Non-OECD</th>
<th>OECD</th>
<th>OECD</th>
<th>Non-OECD</th>
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<td>0.924</td>
<td>0.898</td>
<td>0.859</td>
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</table>

Standard errors are reported in brackets. *, **, and *** are respectively significance level at 10%, 5% and 1%.
Appendix

A. Solving for the portfolio holdings, equation (12)

\[
E_i[(\hat{C}_{i,t+1} - \hat{C}_{k,t+1})(\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0 \quad \text{for } i,j=1,\ldots,N, \text{ and } k=2,\ldots,N, \text{ } k\neq i
\]

\[
E_i[(\tilde{\alpha}_{i1}(\hat{R}_{i,t+1} - \hat{R}_{f,t+1}) + \cdots + \tilde{\alpha}_{Ni}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{i1}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) - \cdots - \tilde{\alpha}_{Ni}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) + (\hat{Y}_{t+1} - \hat{Y}_{k,t+1} - \hat{W}_{t+1} - \hat{W}_{k,t+1}) \times (\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0
\]

\[
= E_i[(\tilde{\alpha}_{i1}(\hat{R}_{i,t+1} - \hat{R}_{f,t+1}) + \cdots + \tilde{\alpha}_{Ni}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{i1}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) - \cdots - \tilde{\alpha}_{Ni}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) + \delta(\hat{Y}_{i,t+1} - \hat{Y}_{k,t+1} + (1 - \delta)(\hat{Y}_{i,t+1} - \hat{Y}_{k,t+1}) \times (\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0
\]

where \( \delta = \frac{Y_k}{\hat{Y}} \) and, \( E_i[(\hat{W}_{i,t+1} - \hat{W}_{k,t+1}) \times (\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0 \)

(\tilde{\alpha}_{i1} - \tilde{\alpha}_{i2}) \text{ cov}(XR_{i,t+1}, XR_{f,t+1}) + (\tilde{\alpha}_{i1} - \tilde{\alpha}_{i2}) \text{ cov}(XR_{2t+1}, XR_{j,t+1}) + \cdots + (\tilde{\alpha}_{Ni} - \tilde{\alpha}_{Nk}) \text{ cov}(XR_{Nt+1}, XR_{j,t+1}) + \delta \text{ cov}(XR_{i,t+1}, XR_{j,t+1}) - \delta \text{ cov}(XR_{i,t+1}, XR_{f,j,t+1}) + (1 - \delta)(\sigma_{Lk}^{i(f,j)} - \sigma_{Lk}^{j(f,k)}) = 0

where \( XR_{i,t+1} = \hat{R}_{i,t+1} - \hat{R}_{f,j,t+1} \)

For instance, country 1 and country 2 have,

\[
(12)' \quad E_i[(\hat{C}_{1,t+1} - \hat{C}_{2,t+1})(\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0 \quad \text{for } j=1,\ldots,N
\]

\[
E_i[(\tilde{\alpha}_{11}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) + \cdots + \tilde{\alpha}_{N1}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{11}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) - \cdots - \tilde{\alpha}_{N1}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) + \hat{Y}_{1,t+1} - \hat{Y}_{2,t+1} - \hat{W}_{1,t+1} - \hat{W}_{2,t+1} \times (\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0
\]

\[
= E_i[(\tilde{\alpha}_{11}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) + \cdots + \tilde{\alpha}_{N1}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{11}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) - \cdots - \tilde{\alpha}_{N1}(\hat{R}_{N,t+1} - \hat{R}_{f,t+1}) + \delta(\hat{Y}_{1,t+1} - \hat{Y}_{2,t+1} + (1 - \delta)(\hat{Y}_{1,t+1} - \hat{Y}_{2,t+1}) \times (\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0
\]

where \( E_i[(\hat{W}_{1,t+1} - \hat{W}_{2,t+1}) \times (\hat{R}_{j,t+1} - \hat{R}_{f,j,t+1})] = 0 \)

\[
= \tilde{\alpha}_{11} \text{ cov}(XR_{1,t+1}, XR_{f,t+1}) + \cdots + \tilde{\alpha}_{N1} \text{ cov}(XR_{Nt+1}, XR_{f,t+1}) - \tilde{\alpha}_{11} \text{ cov}(XR_{1,t+1}, XR_{f,t+1}) - \cdots - \tilde{\alpha}_{N1} \text{ cov}(XR_{Nt+1}, XR_{f,t+1}) + \delta \text{ cov}(XR_{1,t+1}, XR_{f,t+1}) - \delta \text{ cov}(XR_{2t+1}, XR_{f,t+1}) + (1 - \delta)(\sigma_{L1}^{1(f,j)} - \sigma_{L1}^{2(f,j)}) = 0
\]

where \( XR_{i,t+1} = \hat{R}_{i,t+1} - \hat{R}_{f,j,t+1} \)

Thus, based on the above, we have \( N(N-1) \) equations of country \( i \) and \( k \).
B. Matrix Algebra

(12) $A = \Pi^{-1} B$

where $A' = (\tilde{\alpha}_{11} \quad \tilde{\alpha}_{21} \quad \ldots \quad \tilde{\alpha}_{N1} \quad \tilde{\alpha}_{12} \quad \ldots \quad \tilde{\alpha}_{N2} \quad \ldots \quad \tilde{\alpha}_{N3} \quad \ldots \quad \tilde{\alpha}_{1N} \quad \ldots \quad \tilde{\alpha}_{NN}).$

$A'$ is a solution for equity holdings and it is $(N \times N) \times 1.$

$B = \begin{bmatrix}
-\delta \text{cov}(XR_{1t+1}, XR_{1t+1}) + \delta \text{cov}(XR_{2t+1}, XR_{1t+1}) - (1 - \delta)\sigma_{LK}^1 \\
-\delta \text{cov}(XR_{1t+1}, XR_{2t+1}) + \delta \text{cov}(XR_{2t+1}, XR_{2t+1}) + (1 - \delta)\sigma_{LK}^2 \\
\vdots \\
-\delta \text{cov}(XR_{1t+1}, XR_{Nt+1}) + \delta \text{cov}(XR_{2t+1}, XR_{Nt+1}) \\
-\delta \text{cov}(XR_{1t+1}, XR_{3t+1}) + \delta \text{cov}(XR_{3t+1}, XR_{1t+1}) - (1 - \delta)\sigma_{LK}^1 \\
-\delta \text{cov}(XR_{1t+1}, XR_{2t+1}) + \delta \text{cov}(XR_{3t+1}, XR_{2t+1}) \\
\vdots \\
-\delta \text{cov}(XR_{1t+1}, XR_{Nt+1}) + \delta \text{cov}(XR_{Nt+1}, XR_{1t+1}) - (1 - \delta)\sigma_{LK}^1 \\
\vdots \\
-\delta \text{cov}(XR_{1t+1}, XR_{Nt+1}) + \delta \text{cov}(XR_{Nt+1}, XR_{Nt+1}) + (1 - \delta)\sigma_{LK}^N
\end{bmatrix}$

$B$ is an $(N-1)N \times 1$ matrix which consists of 1) variance of excess stock returns (or covariance of stock returns between two countries) and 2) covariance between capital and labor income of country. We generate special variance-covariance matrix of excess stock return between countries, $\Pi,$ like below.
where \( \Pi \) is an \( N(N-1) \times (N \times N) \) matrix. Variance and covariance of excess stock returns are inside the red-line box, otherwise zero.
C. 3×3 model on portfolio allocation

\[ \max E_t \sum_{k=1}^{\infty} \beta^k \frac{C_{i,t+k}^{1-\gamma}}{1-\gamma} \quad \text{for } i=1,2,3. \]

s.t. \[ W_{i,t} = \sum_{j=1}^{3} \alpha_{ji,t-1} R_{j,t} + \alpha_{f,j} R_{f,t} + Y_{i,t} - C_{i,t} \quad \text{where } W_{i,t} = \sum_{j=1}^{3} \alpha_{ji,t}. \]

\( Y_{i,t} \) is the endowment received by country i, \( W_{i,t} \) is the total net claims of country i’s agents on foreign assets at the end of period t (i.e. net foreign assets of country i), \( \alpha_{ji} \) is the real holdings of country j’s assets by country i, and \( R_{j,t} \) is the gross real returns of country j’s assets. Because of capital income correlation across countries, the vector of assets is correlated each other. \( R_{f,t} \) is an independent risk free bond that is in zero net supply.

Combining FOCs and taking a second-order approximation, we derive the 6 equations below:

(i) \( E_t[(\hat{C}_{1,t+1} - \hat{C}_{2,t+1})(\hat{R}_{f,t+1} - \hat{R}_{f,t+1})] = 0 \) for i=1,2,3

\[ = E_t[(\tilde{\alpha}_{11}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) + \tilde{\alpha}_{21}(\hat{R}_{2,t+1} - \hat{R}_{f,t+1})) + \tilde{\alpha}_{31}(\hat{R}_{3,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{12}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1})
- \tilde{\alpha}_{22}(\hat{R}_{2,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{32}(\hat{R}_{3,t+1} - \hat{R}_{f,t+1}) + (\hat{Y}_{1,t+1} - \hat{Y}_{2,t+1}) - (\hat{W}_{1,t+1} - \hat{W}_{2,t+1})] \times (\hat{R}_{f,t+1} - \hat{R}_{f,t+1})] \]

\[ = E_t[(\tilde{\alpha}_{11}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1}) + \tilde{\alpha}_{21}(\hat{R}_{2,t+1} - \hat{R}_{f,t+1})) + \tilde{\alpha}_{31}(\hat{R}_{3,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{12}(\hat{R}_{1,t+1} - \hat{R}_{f,t+1})
- \tilde{\alpha}_{22}(\hat{R}_{2,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{32}(\hat{R}_{3,t+1} - \hat{R}_{f,t+1}) + (\hat{Y}_{1,t+1} - \hat{Y}_{2,t+1}) + (1-\delta)(\hat{Y}_{1,t+1} - \hat{Y}_{2,t+1})] \times (\hat{R}_{f,t+1} - \hat{R}_{f,t+1})] \]

where \( \delta = \frac{\hat{Y}_K}{\hat{Y}} \) and \( E_t[(\hat{W}_{1,t+1} - \hat{W}_{2,t+1})] \times (\hat{R}_{f,t+1} - \hat{R}_{f,t+1})] = 0 \)

for i=1,

\[ = \tilde{\alpha}_{11}\sigma_{11} + \tilde{\alpha}_{21}\sigma_{12} + \tilde{\alpha}_{31}\sigma_{13} - \tilde{\alpha}_{12}\sigma_{11} - \tilde{\alpha}_{22}\sigma_{12} - \tilde{\alpha}_{32}\sigma_{13} + \delta(\sigma_{11} - \sigma_{12}) + (1-\delta)\sigma_{1K} = 0 \]

for i=2,

\[ = \tilde{\alpha}_{11}\sigma_{11} + \tilde{\alpha}_{21}\sigma_{12} + \tilde{\alpha}_{31}\sigma_{13} - \tilde{\alpha}_{12}\sigma_{11} - \tilde{\alpha}_{22}\sigma_{12} - \tilde{\alpha}_{32}\sigma_{13} + \delta(\sigma_{11} - \sigma_{12}) - (1-\delta)\sigma_{1K} = 0 \]

for i=3,

\[ = \tilde{\alpha}_{11}\sigma_{11} + \tilde{\alpha}_{21}\sigma_{12} + \tilde{\alpha}_{31}\sigma_{13} - \tilde{\alpha}_{12}\sigma_{11} - \tilde{\alpha}_{22}\sigma_{12} - \tilde{\alpha}_{32}\sigma_{13} + \delta(\sigma_{11} - \sigma_{12}) = 0 \]
(ii) $E_t[(\hat{C}_{i,t+1} - \hat{C}_{j,t+1})(\hat{R}_{j,t+1} - \hat{R}_{f,t+1})] = 0$ for $i=1,2,3$

$= E_t[\{\tilde{\alpha}_{11}(\hat{R}_{i,t+1} - \hat{R}_{f,t+1}) + \tilde{\alpha}_{21}(\hat{R}_{j,t+1} - \hat{R}_{f,t+1}) + \tilde{\alpha}_{31}(\tilde{R}_{i,t+1} - \tilde{R}_{f,t+1}) - \tilde{\alpha}_{13}(\hat{R}_{i,t+1} - \hat{R}_{f,t+1})
\}
\times (\hat{R}_{i,t+1} - \hat{R}_{f,t+1})]$

$- \tilde{\alpha}_{23}(\hat{R}_{i,t+1} - \hat{R}_{f,t+1}) - \tilde{\alpha}_{33}(\tilde{R}_{j,t+1} - \tilde{R}_{f,t+1}) + (\tilde{Y}_{i,t+1} - \tilde{Y}_{3,t+1}) - (\tilde{W}_{i,t+1} - \tilde{W}_{3,t+1})]$ \times (\hat{R}_{i,t+1} - \hat{R}_{f,t+1})]$

where $E_t[\{(W_{i,t+1} - W_{i,t+1})\} \times (\hat{R}_{i,t+1} - \hat{R}_{f,t+1})] = 0$

for $i=1$,

$= \tilde{\alpha}_{11}\sigma_{i1} + \tilde{\alpha}_{21}\sigma_{i2} + \tilde{\alpha}_{31}\sigma_{i3} - \tilde{\alpha}_{13}\sigma_{i1} - \tilde{\alpha}_{23}\sigma_{i2} - \tilde{\alpha}_{33}\sigma_{i3} + \delta(\sigma_{i1} - \sigma_{i3}) + (1 - \delta)\sigma_{LK} = 0$

for $i=2$,

$= \tilde{\alpha}_{11}\sigma_{i1} + \tilde{\alpha}_{21}\sigma_{i2} + \tilde{\alpha}_{31}\sigma_{i3} - \tilde{\alpha}_{13}\sigma_{i1} - \tilde{\alpha}_{23}\sigma_{i2} - \tilde{\alpha}_{33}\sigma_{i3} + \delta(\sigma_{i2} - \sigma_{i3}) = 0$

for $i=3$,

$= \tilde{\alpha}_{11}\sigma_{i1} + \tilde{\alpha}_{21}\sigma_{i2} + \tilde{\alpha}_{31}\sigma_{i3} - \tilde{\alpha}_{13}\sigma_{i1} - \tilde{\alpha}_{23}\sigma_{i2} - \tilde{\alpha}_{33}\sigma_{i3} + \delta(\sigma_{i3} - \sigma_{i3}) - (1 - \delta)\sigma_{LK} = 0$

We solve the system of equations (i),(ii) (6 equations) with asset market clearing conditions and the steady state assumption of wealth $(\bar{W} = 0)$ (3 equations).

$\tilde{\alpha}_{11} + \tilde{\alpha}_{21} + \tilde{\alpha}_{31} = 0$

$\tilde{\alpha}_{21} + \tilde{\alpha}_{31} - \tilde{\alpha}_{12} - \tilde{\alpha}_{13} = 0$

$\tilde{\alpha}_{13} + \tilde{\alpha}_{23} - \tilde{\alpha}_{31} - \tilde{\alpha}_{32} = 0$

which are derived from $\tilde{\alpha}_{1i} + \tilde{\alpha}_{2i} + \tilde{\alpha}_{3i} = 0$ & $\tilde{\alpha}_{1i} + \tilde{\alpha}_{2i} + \tilde{\alpha}_{3i} = 0$

D. Empirical derivation

To solve for the holdings by country 1 of country $j$ assets, combine the below equation

$(11') E_t[\hat{R}_{j,t+1} - \hat{R}_{f,t+1} + \frac{1}{2}\hat{R}_{j,t+1}^2 - \frac{1}{2}\hat{R}_{f,t+1}^2] = \gamma \cdot E_t[\hat{C}_{i,t+1} (\hat{R}_{j,t+1} - \hat{R}_{f,t+1})]$ for $j=1,2,\ldots,N$

with equation (2’’), the log linearization of the budget constraint evaluated for country $i=1$. 

39
\[(2'') \hat{W}_{t+1} = \sum_{k=1}^{N} \tilde{\alpha}_{k} (\hat{R}_{k,t+1} - \hat{R}_{f,t+1}) + \hat{Y}_{t+1} - \hat{C}_{t+1} \]

where \(\hat{W}_{t+1} = (W_{t+1} - \bar{W}) / \bar{C}\) and \(\tilde{\alpha}_{k} = \alpha_{k} / (\bar{Y})\),

along with market clearing condition for the risk free asset (8') and zero net supply in the equilibrium. Substitute (2'') into (11') and examine the conditions in terms of country specific assets \((j=1,2,\ldots,N)\), then we obtain equations (11'') like below

\[E_t[\hat{R}_{j,t+1} - \hat{R}_{f,t+1} + \frac{1}{2}\hat{\gamma}_{j,t+1} - \hat{R}_{f,t+1} + \frac{1}{2}\hat{\gamma}_{j,t+1} = \gamma \cdot E_t[(\sum_{k=1}^{N} \tilde{\alpha}_{k} (\hat{R}_{k,t+1} - \hat{R}_{f,t+1}) + \hat{Y}_{t+1} - \hat{W}_{t+1} (\hat{R}_{j,t+1} - \hat{R}_{f,t+1})]\]

for \(j=1,\ldots,N\)

Therefore,

\[E_t[\hat{W}_{t+1} (\hat{R}_{j,t+1} - \hat{R}_{f,t+1})] = 0\]

Hence, we have \(N\) equations like below

for \(j=1\), \(E_t[\hat{R}_{t+1} - \hat{R}_{f,t+1} + \frac{1}{2}(\hat{R}_{t+1} - \hat{R}_{f,t+1})]\]

\[= \gamma \cdot E_t[(\tilde{\alpha}_{11} (\hat{R}_{t+1} - \hat{R}_{f,t+1})^2 + \tilde{\alpha}_{21} (\hat{R}_{t+1} - \hat{R}_{f,t+1}) (\hat{R}_{t+1} - \hat{R}_{f,t+1}) + \ldots + \tilde{\alpha}_{N_t} (\hat{R}_{N_t} - \hat{R}_{f,t+1}) (\hat{R}_{t+1} - \hat{R}_{f,t+1})]\]

for \(j=N\), \(E_t[\hat{R}_{N_t+1} - \hat{R}_{f,t+1} + \frac{1}{2}(\hat{R}_{N_t+1} - \hat{R}_{f,t+1})]\]

\[= \gamma \cdot E_t[(\tilde{\alpha}_{11} (\hat{R}_{N_t+1} - \hat{R}_{f,t+1}) (\hat{R}_{t+1} - \hat{R}_{f,t+1}) + \tilde{\alpha}_{21} (\hat{R}_{t+1} - \hat{R}_{f,t+1}) (\hat{R}_{N_t+1} - \hat{R}_{f,t+1}) + \ldots + \tilde{\alpha}_{N_t} (\hat{R}_{N_t} - \hat{R}_{f,t+1})^2 + \delta \hat{Y}_{t+1} + (1 - \delta) \hat{Y}_{t+1} (\hat{R}_{N_t+1} - \hat{R}_{f,t+1})]\]

Solve the expectation terms of the right hand sides of the above \(N\) equations,

for \(j=1\),

\[\frac{1}{\gamma} E_t[\hat{R}_{t+1} - \hat{R}_{f,t+1} + \frac{1}{2}(\hat{R}_{t+1} - \hat{R}_{f,t+1})] = \tilde{\alpha}_{11} \sigma_{11} + \tilde{\alpha}_{21} \sigma_{12} + \ldots + \tilde{\alpha}_{N_t} \sigma_{1N} + \delta \sigma_{11} + (1 - \delta) \sigma_{Lk}\]
for $j=N$, \[ \frac{1}{\gamma}E_t[\hat{R}_{N_t+1} - \hat{R}_{\beta_{t+1}}] + \frac{1}{2}(\hat{R}_{N_t+1}^2 - \hat{R}_{\beta_{t+1}}^2)] = \bar{\sigma}_{11}\sigma_{1N} + \bar{\alpha}_{21}\sigma_{2N} + \ldots + \bar{\alpha}_{N1}\sigma_{NN} + \delta \sigma_{1N} \]

We rearrange these equations,

\[ \frac{(\delta + \bar{\alpha}_{11})\sigma_{11} + \bar{\alpha}_{21}\sigma_{21} + \ldots + \bar{\alpha}_{N1}\sigma_{NN}}{\bar{\alpha}_{11}} = \frac{1}{\gamma}E_t[\hat{R}_{N_t+1} - \hat{R}_{\beta_{t+1}}] + \frac{1}{2}(\hat{R}_{N_t+1}^2 - \hat{R}_{\beta_{t+1}}^2)] + (1 - \delta)\sigma_{1k} \]

\[ \vdots \]

\[ \frac{(\delta + \bar{\alpha}_{11})\sigma_{1N} + \bar{\alpha}_{2N}\sigma_{2N} + \ldots + \bar{\alpha}_{NN}\sigma_{NN}}{\bar{\alpha}_{11}} = \frac{1}{\gamma}E_t[\hat{R}_{N_t+1} - \hat{R}_{\beta_{t+1}}] + \frac{1}{2}(\hat{R}_{N_t+1}^2 - \hat{R}_{\beta_{t+1}}^2)] \]

**E. Derivation of equation (15)**

To solve for portfolio holdings in (14'):

\[ A_{(i=1)} = \Omega^{-1}_1 H \quad \text{where} \quad \Omega_1 = \begin{pmatrix} 1 & \sigma_{12} & \ldots & \sigma_{1N} \\ \sigma_{12} & 1 & 0 & 0 \\ \vdots & 0 & \ddots & 0 \\ \sigma_{1N} & 0 & 0 & 1 \end{pmatrix} \]

we obtain the inverse matrix of $\Omega_1$

\[ \Omega_1^{-1} = \frac{1}{\det(\Omega_1)} \text{adj}(\Omega_1) \]

\[ = \left( \begin{array}{cccccccc} 1 & -\sigma_{12} & -\sigma_{13} & -\sigma_{14} & \ldots & -\sigma_{1N} \\ -\sigma_{12} & 1 - \sum_{k=3,k\neq2}^{N} \sigma_{1k}^2 & \sigma_{13}\sigma_{12} & \sigma_{14}\sigma_{12} & \ldots & \sigma_{1N}\sigma_{12} \\ -\sigma_{13} & \sigma_{12}\sigma_{13} & 1 - \sum_{k=2,k\neq3}^{N} \sigma_{1k}^2 & \sigma_{14}\sigma_{13} & \ldots & \sigma_{1N}\sigma_{13} \\ -\sigma_{14} & \sigma_{12}\sigma_{14} & \sigma_{13}\sigma_{14} & 1 - \sum_{k=2,k\neq4}^{N} \sigma_{1k}^2 & \ldots & \sigma_{1N}\sigma_{14} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ -\sigma_{1N} & \sigma_{12}\sigma_{1N} & \sigma_{13}\sigma_{1N} & \sigma_{14}\sigma_{1N} & \ldots & 1 - \sum_{k=2,k\neqN}^{N} \sigma_{1k}^2 \end{array} \right) \]

Substitute this inverse matrix into equation (14')
\[
A_{(i,l)} = \left( \frac{1}{1 - \sum_{k=2}^{N} \sigma_{lk}^2} \right) \begin{pmatrix}
1 & -\sigma_{12} & -\sigma_{13} & -\sigma_{14} & \cdots & -\sigma_{1N} \\
-\sigma_{12} & 1 - \sum_{k=3,k\neq 2}^{N} \sigma_{lk}^2 & \sigma_{13} & \sigma_{14} & \cdots & \sigma_{1N} \\
-\sigma_{13} & \sigma_{12} & 1 - \sum_{k=2,k\neq 3}^{N} \sigma_{lk}^2 & \sigma_{14} & \cdots & \sigma_{1N} \\
-\sigma_{14} & \sigma_{12} & \sigma_{13} & 1 - \sum_{k=2,k\neq 4}^{N} \sigma_{lk}^2 & \cdots & \sigma_{1N} \\
\vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
-\sigma_{1N} & \sigma_{12} & \sigma_{13} & \sigma_{14} & \cdots & 1 - \sum_{k=2,k\neq N}^{N} \sigma_{lk}^2
\end{pmatrix} \begin{pmatrix}
EX_{lt} - (1 - \delta)\sigma_{LK}^1 \\
EX_{2t} \\
\vdots \\
EX_{Nt}
\end{pmatrix}
\]

where \[
EX_{jt} = \frac{1}{\gamma} \cdot E_i (\hat{R}_{jt+1} - \hat{R}_{jt+1} + \frac{1}{2} (\hat{R}_{jt+1} - \hat{R}_{jt+1}^2))
\]

Then, we choose \( \tilde{\alpha}_{jl} \) which is in the j-th row of \( A_{(i,l)} \) matrix.

\[
\tilde{\alpha}_{jl} = \frac{1}{\det(\Omega_{l})} \left[ -(EX_{lt} - (1 - \delta)\sigma_{LK}^1)\sigma_{lj} + EX_{2l}\sigma_{12}\sigma_{lj} + \cdots + EX_{Nl}\sigma_{1N}\sigma_{lj} + EX_J (1 - \sum_{k=2,k\neq j}^{N} \sigma_{lk}^2) \right]
\]

for \( j = 1, \ldots, N \).

By the constant return assumption across countries, \( EX_{jt} = EX_{1t} = \cdots = EX_{Nt} \)

\[
= \frac{1}{\det(\Omega_{l})} \left[ EX_{jt} \left( \sigma_{1j} + \sigma_{12}\sigma_{1j} + \cdots + \sigma_{1N}\sigma_{1j} + (1 - \sum_{k=2,k\neq j}^{N} \sigma_{lk}^2) \right) \right] + (1 - \delta)\sigma_{LK}^1 \sigma_{lj}
\]

\[
= \frac{1}{\det(\Omega_{l})} \left[ EX_{jt} \left( \sum_{k=2,k\neq j}^{N} \sigma_{lk} - 1 \right)\sigma_{lj} + 1 - \sum_{k=2,k\neq j}^{N} \sigma_{lk}^2 \right] + \frac{EX_{jt} (1 - \delta)\sigma_{LK}^1 \sigma_{lj}}{EX_{jt}}
\]

\[
= \frac{1}{\det(\Omega_{l})} \left[ EX_{jt} \left( \sum_{k=2,k\neq j}^{N} \sigma_{lk} - 1 + (1 - \delta) \frac{\sigma_{LK}^1}{EX_{jt}} \right)\sigma_{lj} + 1 - \sum_{k=2,k\neq j}^{N} \sigma_{lk}^2 \right]
\]

\[
= \frac{1}{\det(\Omega_{l})} \left[ EX_{jt} \left( \sum_{k=2,k\neq j}^{N} \sigma_{lk} - 1 + (1 - \delta) \frac{\sigma_{LK}^1}{EX_{jt}} \right)\sigma_{lj} + 1 - \sum_{k=2,k\neq j}^{N} \sigma_{lk}^2 - \sigma_{lj}^2 + \sigma_{lj}^2 \right]
\]

\[
= \frac{1}{\det(\Omega_{l})} \left[ EX_{jt} \left( \sum_{k=2,k\neq j}^{N} \sigma_{lk} - 1 + (1 - \delta) \frac{\sigma_{LK}^1}{EX_{jt}} \right)\sigma_{lj} + 1 - \sum_{k=2}^{N} \sigma_{lk}^2 + \sigma_{lj}^2 \right]
\]

42
\[
= \frac{1}{\det(\Omega_j)} \mathbb{E} X_{jt} \left\{ \sum_{k=2,k\neq j}^{N} \sigma_{1k} - 1 + (1 - \delta) \frac{\sigma_{LK}}{\mathbb{E} X_{jt}} + \sigma_{1j} \right\} \sigma_{1j} + \det(\Omega_j)
\]

Hence,
\[
\tilde{\alpha}_{j1} = \frac{1}{\det(\Omega_1)} \mathbb{E} X_{jt} \left\{ \sum_{k=2,k\neq j}^{N} \sigma_{1k} + (1 - \delta) \frac{\sigma_{LK}}{\mathbb{E} X_{jt}} - (1 - \sigma_{1j}) \right\} \sigma_{1j} + \det(\Omega_1)
\]

(15)

For comparison, the solution under the case of uncorrelated national returns, as commonly assumed in the literature, would be as follows:

\[
A_{(i=1)} = \Omega^{-1} H \quad (14') \quad \text{with} \quad \Omega = \begin{pmatrix} \sigma_1^2 & 0 & \cdots & 0 \\ 0 & \sigma_2^2 & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_N^2 \end{pmatrix}
\]

Substitute the inverse matrix of \( \Omega \) into equation (14'),

\[
\begin{pmatrix} \tilde{\alpha}_{11} \\ \tilde{\alpha}_{21} \\ \tilde{\alpha}_{31} \\ \vdots \\ \tilde{\alpha}_{N1} \end{pmatrix} = \begin{pmatrix} \frac{1}{\sigma_1^2} & 0 & \cdots & 0 \\ 0 & \frac{1}{\sigma_2^2} & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \frac{1}{\sigma_N^2} \end{pmatrix} \begin{pmatrix} \mathbb{E} X_{1t} - (1 - \delta) \sigma_{LK}^1 \\ \mathbb{E} X_{2t} \\ \vdots \\ \mathbb{E} X_{Nt} \end{pmatrix}
\]

Hence, \( \tilde{\alpha}_{j1} = \frac{1}{\sigma_j^2} \mathbb{E} X_{jt} \).

So country 1’s holdings of country \( j \)’s asset are positively associated with the return on country \( j \)’s asset and negatively associated with the variance of county \( j \)’s asset.