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GRAVITY IN INTERNATIONAL FINANCE

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Abstract

The past decade has witnessed an explosion of papers estimating gravity equations for cross-border financial holdings. The aim of the paper is to develop a theoretical foundation for the empirical gravity literature applied to finance. The gravity specification is closely analogous to that developed for goods trade, even though it is based on a very different type of theory. We show how the theory can be used to estimate international financial frictions and conduct comparative statics analysis with respect to changes in these frictions. We use a dataset for cross-border equity holdings among 24 industrialized countries to illustrate these results.

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1. Introduction

The past decade has witnessed an explosion of papers estimating gravity equations for cross-border financial holdings. This used to be the territory of the international trade literature, in which there is a long tradition of estimating gravity equations that relate trade flows to country size and various proxies for trade barriers. At least three factors are driving this interest in estimating gravity equations applied to international finance. One is the discovery that gravity equations for international asset trade fit the data at least as well as for goods trade. The contribution by Portes and Rey (2005) is central in this regard. Second, the release of the Coordinated Portfolio Investment Survey by the International Monetary fund, which contains bilateral portfolio holdings for 67 countries since 2001, has been a key driver as well and most of the recent contributions use this data set.[1] Finally, there is a wealth of potential policy questions that can be addressed through the estimation of gravity equations, such as the impact on globalization of harmonization of financial regulations or the formation of monetary or trade unions.

The aim of this paper is to develop a theoretical foundation for gravity equations of bilateral financial holdings. This serves several purposes. First, it provides guidance to the empirical work estimating gravity equations. The theory that we develop implies that gravity equations in the literature are almost always estimated incorrectly. Estimation often omits proper fixed effects (source and destination country dummies in a cross-section or country-time fixed effects in a panel). In addition, variables included in the regressions often lack a theoretical justification or cannot be identified once the proper fixed effects are included. We will discuss how to estimate gravity equations correctly, illustrated with an application to a data set of cross-border equity holdings among 24 industrialized countries.

Second, our theoretical gravity specification allows us to compute an overall measure of financial frictions between countries from data on international and intranational financial holdings. This contrasts to the empirical gravity literature, which does not provide measures of overall financial frictions. Moreover, quantity-based measures of financial integration reported in the literature usually involve scaled measures of cross-border asset holdings or capital flows without connection to any theory. Instead, we link these quantities to actual financial frictions based on the gravity theory.

Finally, the theoretical foundation informs us on how to conduct proper comparative statics analysis. If for example one wants to consider the impact of better harmonization of financial regulation, the full general equilibrium impact needs to be considered as changes in asset demand affect asset prices and

[1] A substantial number of papers also use data on external claims by banks from the BIS. Some recent papers that have estimated empirical gravity equations for equity, bond and bank holdings include Ahearne, Griever and Warnock (2004), Aviat and Coeurdacier (2007), Balli (2008), Balli *et al.* (2008), Balta and Delgado (2008), Berkel (2007), Bertaut and Kole (2004), Buch (2000,2002), Chan *et al.* (2005), Coeurdacier and Martin (2009), Coeurdacier and Guibaud (2005), Daude and Fratzscher (2008), de Santis and Gerard (2009), Eichengreen and Luengnaruemitchai (2006), Faruqee, Li and Yan (2004), Forbes (2008), Gande *et al.* (2009), Garcia-Herrero *et al.* (2009), Gelos and Wei (2005), Ghosh and Wolf (2000), Hahm and Shin (2009), Jeanneau and Micu (2002), Kim *et al.* (2007), Lane and Milesi-Ferretti (2005a,b), Lane (2005), Lee (2008), Kim, Lee and Shin (2006), Martin and Rey (2004), Pendle (2007), Portes and Rey (2005), Portes, Rey and Oh (2001), Rose and Spiegel (2004), Salins and Benassy-Quere (2006), Vlachos (2004) and Yu (2009).

equilibrium expected excess returns. In the existing empirical gravity literature these general equilibrium aspects are ignored altogether. We will provide an illustration of a variety of comparative statics experiments in the context of the data set for industrialized countries mentioned above.

The paper has several parallels to the contribution by Anderson and van Wincoop (2003) in the trade literature. Just like in this paper, their work was motivated by a large empirical gravity literature without any theoretical foundation. They showed how to derive a simple and intuitive gravity equation from theory and developed the implications for empirical estimation and comparative statics. The gravity equation that we derive for cross-border asset trade is closely analogous to that derived by Anderson and van Wincoop (2003) for goods trade. Bilateral financial positions depend on *relative* barriers: bilateral financial barriers relative to average barriers (multilateral resistance) faced by both source and destination countries.

However, this is where the parallels end. There are some significant differences in deriving a theoretical gravity equation for bilateral asset holdings versus goods trade. In the trade literature the gravity equation can be derived from a large class of models, including models with product differentiation by country of origin, models with monopolistic competition, the Heckscher-Ohlin model with specialization and even the Ricardian model of Eaton and Kortum (2002). This is not the case for asset trade. The gravity specification that we derive is less robust to changes in key modeling assumptions than in the trade literature. However, while robustness is an attractive feature, it is not a critical one. We will argue that the assumptions leading to the gravity form can be reasonably justified. Moreover, the large and rapidly growing empirical gravity literature in finance clearly calls out for a theory, even if not all roads lead to Rome (i.e. gravity).

There are at least two reasons why deriving a gravity theory for international financial holdings is more involved than a simple extension of gravity theory for goods trade. First, portfolio theory leads to expressions for asset demand that take a very different form than demand for goods. The latter can be derived as a function of relative goods prices by adopting standard CES preferences. Instead, optimal portfolio choice leads to asset demand that depends on the inverse of a covariance matrix of all returns times a vector of expected returns of all assets. The other difference is that international financial frictions are largely related to risk, which plays no role in the gravity literature for goods trade.[2] A variety of barriers, related for example to regulatory systems and language, make the assessment of risk easier for local investors than for foreigners. A substantial literature has documented the relevance of such information asymmetries across countries.[3]

2 It is well known that for near-riskless securities, such as bank deposits, the law of one price holds among industrialized countries (covered interest rate arbitrage).

3 See for example Bae, Stulz and Tan (2008), Ahearne *et al.* (2004), Portes and Rey (2005), Kang and Stulz (1997) any many references in those papers.

We derive a gravity theory for international finance from standard static portfolio theory. Investors can hold claims on risky assets from a large number of countries. Asset returns are affected both by country-specific risk and global risk. In addition we allow for trade in a riskfree asset and in an asset whose return is only related to global risk; both are in zero net supply. We introduce international financial frictions in the form of information asymmetries. In particular, a bilateral information friction between source country j and destination country i is equal to the conditional variance of country i specific risk from the perspective of country j investors relative to that from the perspective country i investors. After imposing asset market equilibrium in all markets we show that this leads to a gravity equation where bilateral financial holdings depend on the product of economic size variables (stock market capitalization in the destination country and total investment in stock in the source country) times the relative financial friction. The relative friction is equal to the bilateral financial friction divided by the product of multilateral resistance terms from the perspective of source and destination counties.

Our approach is different from that in Martin and Rey (2004), who derive a gravity equation for financial holdings when countries trade claims on Arrow Debreu securities. An extension by Coeurdacier and Martin (2007) shows that this can lead to a gravity equation that is similar to that for goods trade, with bilateral holdings depending both on bilateral frictions and multilateral resistance indices of source and destination countries. The reason for this is that demand for Arrow Debreu securities takes a similar form as the demand for goods under CES preferences. The differentiation of goods by type in the trade literature is now replaced by an analogous differentiation of assets by states in which they have a payoff. Standard constant relative risk-aversion expected utility can then be written as a function of Arrow Debreu asset holdings in a way that is analogous to CES utility as a function of consumption of differentiated goods.

While one could argue that Arrow Debreu securities do not literally exist, they can always be combined to create actually observed assets with payoffs in multiple states of nature. However, a gravity equation based on Arrow Debreu securities does not aggregate to a gravity equation for risky assets with payoffs in multiple states of nature. It is therefore hard to apply to actual data on cross-border asset holdings. The empirical gravity literature relates to equity, bond and bank holdings, which all have payoffs in many states. We therefore take a different approach that generates a gravity equation for risky assets that can have any payoff in any state of nature.

An alternative way to derive theoretical gravity equations, suggested by Lane and Milesi-Ferretti (2005a), is a multi-country extension of the model in Obstfeld and Rogoff (2000) that relates barriers in goods trade to portfolio home bias. While theoretically possible, this approach has drawbacks as well. The main problem is that the real exchange rate hedge channel, through which barriers in goods trade affect asset trade in Obstfeld and Rogoff (2000), does not appear to be operative in practice. Using data on equity returns and real exchange rates, van Wincoop and Warnock (2009) show that hedging real exchange rate risk cannot account for portfolio home bias. Consistent with these findings, Coeurdacier (2009) develops an extension of Obstfeld and Rogoff (2000) to show that for realistic model parameters trade barriers cannot generate a portfolio home bias.

The remainder of the paper is organized as follows. Section 2 derives a gravity theory for financial holdings from a static multi country portfolio choice framework. Section 3 draws comparisons to gravity theory for goods trade. Section 4 discusses how to use the gravity equation to estimate bilateral financial frictions and conduct comparative statics analysis with respect to changes in financial frictions. Section 5 provides an empirical illustration of these results, using data for bilateral equity holdings among 24 industrialized countries. It reports estimates of bilateral financial frictions and their relationship to various bilateral observable variables (e.g. whether countries speak the same language, use a common currency or use the same legal system) as well as various source country-specific observables (e.g. the degree of financial market sophistication, regulatory quality, educational attainment). Section 5 also reports results on comparative statics analysis, such as the effect of EMU on global external positions. Section 6 concludes.

2. A Gravity Theory of Financial Holdings

In this section we develop a gravity model for bilateral asset holdings in a one-good, two-period, N country framework.

2.1 The Model

The Assets

There are $N+2$ assets. The first N assets are country-specific risky assets. The gravity equation that we will derive applies to these N assets. We will refer to them as equity, although they could also be other risky assets such as corporate bonds and long-term bonds. The supply of the asset in country i is K_i. One can think of this as the capital stock. The equity claim of country i has a real payoff of D_i in period 2, where

$$D_i = 1 + \varepsilon_i + \theta_i \varepsilon_g \tag{1}$$

Here ε_i is a country-specific payoff innovation and ε_g is a global payoff innovation. The constant term is 1, which is simply a normalization as one can always change the mean payoffs by changing the units of capital. The country-specific payoff innovations are uncorrelated across countries and with the global innovation. We allow the response to global innovations to be country-specific. We assume that ε_g has a mean of 0 and variance σ_g^2. The distribution of country-specific innovation ε_i is discussed below. The price of a country i equity claim in period 1 is Q_i.

The second asset is a riskfree bond that is in zero net supply. The bond pays one unit of the good in period 2 and has a period 1 price of Q_f. Finally, there is an asset whose return is perfectly correlated with the global shock. This asset is also in zero net supply. It has a period 1 price of Q_g and a period 2 payoff of $D_g = d_g + \theta_g \varepsilon_g$. This asset allows agents to hedge global risk separately.

We will write the returns on the $N + 2$ assets as

$$R_i = \frac{D_i}{Q_i} \qquad i = 1 \ldots N \tag{2}$$

$$R_f = \frac{1}{Q_f} \tag{3}$$

$$R_g = \frac{D_g}{Q_g} \tag{4}$$

These assumptions about the asset market structure raise several questions, both in terms of why we made this specific set of assumptions and the realism of these assumptions. First consider the assumption that the payoff of assets can be broken into the sum of a global and a pure country-specific component. In combination with the global asset, this simplifies the portfolio problem significantly. The global asset allows us to hedge the global component of the asset payoffs. This leaves only the country-specific components. But since those are uncorrelated across countries, portfolio demand does not depend on an entire covariance structure of asset payoffs. Instead, as we will see, it simply depends on the expected excess return of the asset (relative to the riskfree asset) divided by the variance of the country-specific return innovation.

However, one could question this simplifying assumption as asset payoffs may be correlated, either positively or negatively, even after controlling for the global component. For example, there may be regional components. In order to evaluate the empirical relevance of our assumption, we conduct a principle component analysis on quarterly stock returns from 2000 to 2007 for 24 industrialized countries. This is the same sample that will be used in section 5 for gravity equation estimation. We find that the average absolute value of the covariance of returns between sets of countries is reduced by 88% after controlling for the first principle component. In other words, the first principle component (which in the model is the global component) explains 88% of the average absolute value of the covariance of asset returns. This implies that there is indeed not much correlation left after controlling for the global component. The *two* largest principle components explain 95% of the average absolute value of the covariance. If we allow for more than one common component in the model, all the results will continue to go through as long as we allow for assets that trade claims on each of the common components (e.g. a global and a regional asset).

This brings us to the global asset. We have already explained how it simplifies the portfolio problem by allowing agents to hedge the common component of asset payoffs. A key question though is how to interpret this asset in practice. One way is to interpret it is as a global equity futures contract, allowing one to buy or sell a claim on the global equity payoff at a futures price of f^g. The payoff on such a contract is

$$1 + \theta_g \varepsilon_g + \sum_{i=1}^{N} (K_i/K)\varepsilon_i - f^g \qquad (5)$$

where K is the global capital stock and $\theta_g = \sum_{i=1}^{N} (K_i/K)\theta_i$. The payoff depends on the global shock through the term $\theta_g \varepsilon_g$ in exactly the same way as the assumed global asset. The only difference is that the term depending on the idiosyncratic shocks is not necessarily zero. However, since the idiosyncratic risk factors ε_i are uncorrelated across countries, the law of large numbers implies that this term will be very close to zero with many small countries.[4] Related to the previous point about additional common factors in asset payoffs, to the extent that there are regional risk factors they can be similarly hedged by allowing for trade in a regional equity futures contract.

A second, and closely related, possibility is to interpret the global asset as an equity futures contract on a set of multinational firms. For such firms country-specific shocks naturally play less of a role as a result of their global operations. A third possibility is to interpret the global asset as a derivative whose payoff is specifically connected to shocks that affect the entire world economy, such as an oil price futures contract.

The final key assumption is the presence of a riskfree bond. The assumption does not require much justification on realism grounds as there is extensive global trade in assets that are nearly riskfree such as insured bank deposits or government bonds. But it is useful to point out that the assumption is critical to derive a simple gravity equation for equity holdings. In the absence of the riskfree asset the optimal portfolio for a particular equity would depend additively on the expected returns on all equity. It is this additivity that is problematic in deriving a gravity form. If demand for goods would depend additively on

[4] This is especially the case if we remove some large countries such as the United States and Japan from the futures contract as they have a big weight K_i/K.

the prices for all the goods rather than on the relative price as in a CES system, we would similarly be unable to derive a gravity specification for goods trade.

We should finally point out that we have abstracted from nominal exchange rate risk. However, this simplifying assumption is not key to the results that follow. It is well-known from the recent literature, particularly Coeurdacier and Gourinchas (2009) and Engel and Matsumoto (2009), that nominal exchange rate risk can be fully hedged when allowing for trade in nominal bonds in all currencies. The optimal portfolio of equity then only depends on risks that are orthogonal to nominal exchange rate risk, which are generally the same for investors from all countries.[5]

Consumption and Portfolio Choice

Agents in country j are born with an endowment of Y_j in period 1 plus a claim on all country j equity. The wealth of country j agents in period 1 after consumption is therefore

$$W_j = Y_j + Q_j K_j - C_j^1$$

where C_j^1 is period 1 consumption.

In period 1 agents decide how much to consume and how to allocate the remainder of the wealth across the $N + 2$ assets. The budget constraint is

$$C_j^2 = W_j R_j^p = (Y_j + Q_j K_j - C_j^1) R_j^p \tag{6}$$

where the portfolio return is

$$R_j^p = \sum_{i=1}^{N} \alpha_{ij} R_i + \alpha_{gj} R_g + \alpha_{fj} R_f \tag{7}$$

Here α_{ij} is the fraction invested in country i equity, α_{gj} the fraction invested in the global asset and α_{fj} the fraction invested in the riskfree asset. These portfolio shares sum to 1.

[5] In our model only net bond positions are determined. Gross bond positions would be determined when allowing for nominal exchange rate risk. But this does not give a gravity form for bilateral bond positions as gross bond positions would then be determined by an optimal hedge of nominal exchange rate risk rather than gravity considerations related to financial frictions that determine the gross equity positions.

Agents maximize

$$\frac{\left(C_j^1\right)^{1-\gamma}}{1-\gamma}+\beta\frac{E\left(C_j^2\right)^{1-\gamma}}{1-\gamma} \tag{8}$$

The first-order conditions for consumption and portfolio choice are

$$\left(C_j^1\right)^{-\gamma}=\beta E\left(C_j^2\right)^{-\gamma}R_j^p \tag{9}$$

$$E\left(C_j^2\right)^{-\gamma}(R_i-R_f)=0 \qquad i=1\ldots N \tag{10}$$

$$E\left(C_j^2\right)^{-\gamma}(R_g-R_f)=0 \tag{11}$$

(9) is the standard consumption Euler equation that represents the tradeoff between consumption in periods 1 and 2. (10) is a portfolio Euler equation that represents the tradeoff between investment in the equity claim of country i and the riskfree asset. Finally, (11) is a portfolio Euler equation that represents the tradeoff between investment in the global and riskfree assets.

The market clearing conditions for country i equity, the global asset and the riskfree asset are

$$\sum_{j=1}^{N}\alpha_{ij}W_j=Q_iK_i \tag{12}$$

$$\sum_{j=1}^{N}\alpha_{gj}W_j=0 \tag{13}$$

$$\sum_{j=1}^{N}\alpha_{fj}W_j=0 \tag{14}$$

The period 1 and 2 goods market clearing conditions are

$$\sum_{j=1}^{N}C_j^1=\sum_{j=1}^{N}Y_j \tag{15}$$

$$\sum_{j=1}^{N}C_j^2=\sum_{j=1}^{N}D_j \tag{16}$$

Information Asymmetry

We assume that due to differences in language and regulatory systems, and easier access to local information, domestic agents are more informed than foreigners about the idiosyncratic payoff innovations on domestic equity claims. From the perspective of agents in country j, ε_i has a mean of 0 and variance

$$\tau_{ij}\,\sigma_i^2 \tag{17}$$

Information asymmetry is therefore captured by $\tau_{ij} > \tau_{ii}$ when $j \neq i$.[6] As a normalization we assume that $\tau_{ii} = 1$, so that σ_i^2 is the idiosyncratic variance from the perspective of local agents.

Since this assumption is critical to the derivation of the gravity equation for asset trade, it deserves further discussion. As pointed out in the introduction, what makes the derivation of a gravity equation for asset trade different from goods trade is that asset trade necessarily involves risk. Without risk there would just be a single riskfree asset that is the same for each country. We know from covered interest rate arbitrage that riskfree returns are indeed equalized across industrialized countries. When introducing financial frictions it is therefore natural to relate them to risk.

There is a substantial body of evidence showing that information asymmetries exist and are relevant in explaining portfolio home bias. Without conducting an extensive survey, we mention just a couple of relevant papers. Bae, Stulz and Tan (2008) find that that the absolute forecast error of annual earnings per share is 7.8% higher for foreign analysts than local analysts. Ahearne *et al.* (2004) find that home bias of U.S. investors relative to other countries is significantly reduced when the stock of foreign countries is traded on centralized exchanges. This reduces information barriers as a result of the regulatory and accounting burden imposed on such foreign firms. Portes and Rey (2005) find that "the geography of information is the main determinant of the pattern of international (financial) transactions", documenting the effect of a variety of informational frictions on cross-border equity flows. Kang and Stulz (1997) document that investors tend to invest in foreign firms for which information barriers are lower (large firms with good accounting performance, low unsystematic risk and low leverage).

Information is not exogenous. Investors may acquire more information about countries that they are less informed about. However, this will not necessarily eliminate information asymmetries. van Nieuwerburgh

6 One might argue that since agents in different countries have different signals about ε_i, the expectation of ε_i should also differ across countries. Nonetheless we keep this expectation equal to zero across all countries. Such an assumption can be justified by a setup as in van Nieuwerburgh and Veldkamp (2009), who consider portfolio home bias under information asymmetries. Their model has a continuum of agents in each country that each receive a different signal. Agents receive higher quality signals (lower variance) for their own country. While the signals, and therefore expectations, differ across agents, the average signal error is assumed to be zero across a continuum of agents, a standard assumption in noisy rational expectation models. Domestic and foreign agents therefore receive the same average signal and have the same average expectation, even though the variance is lower for locals than foreigners.

and Veldkamp (2009) show that information asymmetries will in fact be amplified when allowing agents to acquire information about different asset payoffs. The reason for this is that it is optimal to acquire more information about assets that have a large weight in the portfolio, which happen to be assets that agents are already relatively well informed about.

Our focus on information frictions is particularly aimed at industrialized countries. For developing countries other types of frictions are likely to be at least as important. One such friction is capital controls. In many developing countries covered interest rate parity does not hold as a result of capital controls, so this is not a friction that is specific to risky assets. We also abstract from barriers to investment related to factors such as corruption, which is again not necessarily associated with information asymmetries and is much less relevant for industrialized countries.

We should finally point out that modeling the financial friction τ_{ij} as an information friction differs from the approach in a number of papers that introduce a financial friction simply as a tax that reduces the return on foreign investment. Examples are Tille and van Wincoop (2009a,b), Coeurdacier (2009), Coeurdacier and Guibaud (2005) and Martin and Rey (2004). While doing so is fine to generate an exogenous source for home bias in simple two-country models, this modeling approach leads to strange results in a multi-country setting and will not lead to a gravity specification. In Appendix 2 we derive an expression for bilateral asset holdings under this alternative assumption.

Under this setup the return of investing in country i equity by investors from country j is $R_i - \tau_{ij}$. This additive cost leads to what we refer to as the *Luxembourg effect*. When the asset supply of a country goes to zero (becomes very small), the fraction of its assets held by different countries tends to go to plus or minus infinity. More generally, the fraction of the assets of a small country like Luxembourg that is held by other countries becomes extreme with both excessively large positive and negative numbers.

This happens as long as the financial frictions that other countries face with Luxembourg differ even slightly across countries. Intuitively, portfolio shares depend on an expected excess return, divided by a variance. Differences in financial frictions lead to differences in the expected excess return, so that the portfolio shares invested in Luxembourg differ across countries and therefore differ from the relative supply of Luxembourg assets in the world. But since the latter is close to zero, even small portfolio share differences across countries tend to explode relative to the asset supply of a small country like Luxembourg. The problem is that bilateral asset holdings are not proportional to the size of the destination country as would be the case in any gravity specification. These points are illustrated in Appendix 2.

2.2 Derivation of Gravity Equation

In solving the model we apply the local approximation solution method developed by Tille and van Wincoop (2009a) and Devereux and Sutherland (2009). We focus on what in a more dynamic model would be called the "deterministic steady state" of asset allocation. In more technical terms, this is the zero-order component. Leaving the algebraic derivations to Appendix 1, and omitting the technical order component notation used in the Appendix, we obtain the following intuitive expression for equity portfolio shares:

$$\alpha_{ij} = \frac{1}{\gamma R \sigma_i^2 \tau_{ij}} \left[E\left(R_i - R_f\right) - \frac{\theta_i}{\theta_g} E\left(R_g - R_f\right) \right] \tag{18}$$

where R is the zero-order component of asset returns that is the same for all assets. As is quite standard, portfolio shares depend on the ratio of the expected excess return (second-order component) and the variance of the excess return. As global risk can be separately hedged, both the expected excess return and its variance remove the global components. The expected excess return therefore subtracts the part that is a compensation for global risk. Analogously, the variance of the excess return only refers to country-specific risk.

Now define

$$\frac{1}{p_i} = \frac{1}{\gamma R \sigma_i^2} \mathrm{E} \left[R_i - R_f - \frac{\theta_i}{\theta_g} \left(R_g - R_i\right) \right] \tag{19}$$

The variable p_i is proportional to the inverse of a Sharpe ratio. It therefore depends on a risk to reward ratio: the amount of country-specific risk in asset i as captured by the variance σ_i^2, divided by the reward in the form of the expected excess return. The higher p_i, the lower the demand for the asset. The variable p_i is endogenous as it depends on the second-order component of the expected excess return that in equilibrium adjusts to clear equity markets through second-order changes in asset prices. Given the definition of p_i, portfolio allocation (18) becomes

$$\alpha_{ij} = \frac{1}{\tau_{ij} p_i} \tag{20}$$

Write total equity holdings by agents from country j as

$$E_j = \sum_{i=1}^{N} \alpha_{ij} W_j \tag{21}$$

Substituting (20) yields

$$W_j = E_j P_j \tag{22}$$

where

$$\frac{1}{P_j} = \sum_{i=1}^{N} \frac{1}{\tau_{ij} p_i} \tag{23}$$

Using this, we can write the total equity claim $X_{ij} = \alpha_{ij} W_j$ by country j on country i as

$$X_{ij} = \frac{P_j}{\tau_{ij} p_i} E_j \tag{24}$$

Now impose the asset market clearing condition

$$\sum_{j=1}^{N} X_{ij} = S_i \tag{25}$$

where $S_i = Q_i K_i$ is the country i equity supply. Also define $E = S = \sum_{j=1}^{N} E_j = \sum_{i=1}^{N} S_i$ as the world demand and supply of equity. Then the market clearing condition (25) gives the following solution for p_i:

$$p_i = \frac{S}{S_i} \frac{1}{\Pi_i} \tag{26}$$

where

$$\frac{1}{\Pi_i} = \sum_{j=1}^{N} \frac{P_j}{\tau_{ij}} \frac{E_j}{E} \tag{27}$$

Substituting this solution for p_i back into (23) and (24), we get a gravity specification for bilateral asset holdings that is defined by the following system of equations:

$$X_{ij} = \frac{S_i E_j}{E} \frac{\Pi_i P_j}{\tau_{ij}} \tag{28}$$

$$\frac{1}{P_j} = \sum_{i=1}^{N} \frac{\Pi_i}{\tau_{ij}} \frac{S_i}{S} \tag{29}$$

$$\frac{1}{\Pi_i} = \sum_{j=1}^{N} \frac{P_j}{\tau_{ij}} \frac{E_j}{E} \tag{30}$$

$$P_j E_j = W_j \tag{31}$$

Equations (29), (30) and (31) can be used to jointly solve for P_j, E_j and Π_i for $i = 1,..,N$ and $j = 1,..,N$. Together with the asset supply S_i and the bilateral friction τ_{ij}, this determines bilateral asset holdings X_{ij} in (28).

The gravity equation (28) implies that bilateral asset holdings X_{ij} are driven by two factors. The first is a size factor: the product of total equity holdings E_j by country j and the supply of equity S_i by country i, divided by the world demand or supply. The second factor is a relative friction. Just as is the case for trade flows, bilateral asset holdings are driven not simply by the bilateral friction τ_{ij}, but rather by the relative friction

$$\frac{\tau_{ij}}{\Pi_i P_j} \tag{32}$$

Here Π_i and P_j are so-called multilateral resistance variables that measure the average financial frictions for respectively country i as a destination country and country j as a source country. Given the size factor $S_i E_j / E$, it is this *relative financial friction* that drives the bilateral asset holding X_{ij}.

In order to understand why bilateral asset holdings are driven by this relative financial friction, as opposed to just τ_{ij}, first consider the source country j. Investors from j invest a total of E_j in equity. They will allocate more of this to destination countries for which the bilateral financial friction τ_{ij} is low in comparison to the average financial friction P_j that it faces relative to all destination countries. The relative financial friction (32) is also affected by the multilateral resistance Π_i of the destination country. When Π_i is high, country i faces high financial frictions with many source countries. In order to generate equilibrium in the market for country i equity, it will have to offer a high reward to risk ratio (low p_i). For a given bilateral barrier τ_{ij} this will raise X_{ij}.

3. Comparison to Gravity for Goods Trade

A comparison of the gravity specification (28)-(31) for asset holdings to that for goods trade will depend on what model is adopted for goods trade. We will consider two different models. The first is a model in which there are N differentiated goods, with each country producing a different good, and one homogeneous good. This setup is informative as there is an analogy between the homogeneous good for goods trade and the riskfree asset for asset trade. Neither of them is specific to a particular country. The second model is the Anderson and van Wincoop (2003) model in which there is only trade in differentiated goods. While we will use analogous notation for goods trade as for financial trade, we will add a hat to all variables in the goods trade models in order to separate the two.

3.1 Trade in Differentiated Goods and Homogeneous Good

We will first consider the model with N differentiated goods and one homogeneous good. Assume that utility of agents from country j is

$$\frac{1}{1-\frac{1}{\sigma}}\sum_{i=1}^{N}(\hat{C}_{ij})^{1-\frac{1}{\sigma}}+\hat{C}_{N+1,j} \tag{33}$$

where $\hat{C}_{ij}$ is consumption by country j residents of the differentiated good from country i, $\hat{C}_{N+1,j}$ is the consumption of the homogeneous good and σ is the elasticity of substitution between differentiated goods. Agents maximize (33) subject to the budget constraint

$$\sum_{i=1}^{N}\hat{\tau}_{ij}\hat{p}_i\hat{C}_{ij}+\hat{C}_{N+1,j}=\widehat{W}_j \tag{34}$$

Here $\hat{\tau}_{ij}$ is the tariff equivalent of bilateral trade barriers between i and j, $\hat{p}_i$ is the price of country i goods net of trade costs. $\widehat{W}_j$ is the income of country j, which is equal to the value of its differentiated goods and homogenous good output. The homogeneous good is the numeraire with a price of 1.

Solving the maximization problem, we find

$$\hat{X}_{ij} = \left(\frac{\hat{\tau}_{ij}\hat{p}_i}{\hat{P}_j}\right)^{1-\sigma} \hat{E}_j \qquad (35)$$

$$\hat{P}^{\sigma-1}\hat{E}_j = 1 \qquad (36)$$

where $\hat{X}_{ij} = \hat{\tau}_{ij}\hat{p}_i\hat{C}_{ij}$ is the value of exports of the differentiated good from i to j, $\hat{E}_j$ is total demand for differentiated goods by agents in country j and $\hat{P}_j$ is a CES price index for country j:

$$\hat{P}_j^{1-\sigma} = \sum_{i=1}^{N} (\hat{\tau}_{ij}\hat{p}_i)^{1-\sigma} \qquad (37)$$

The demand equation (35) for goods is analogous to the demand equation (24) for assets. The only difference is that prices and bilateral trade costs are taken to the power $\sigma - 1 > 0$ in the demand equation for goods. In other words, the two equations are exactly the same when you replace τ_{ij} with $\hat{\tau}_{ij}^{\sigma-1}$, p_i with $\hat{p}_i^{\sigma-1}$ and P_j with $\hat{P}_j^{\sigma-1}$. When doing so, the price index (23) is also exactly the same as the CES price index (37).

For both differentiated goods trade and asset trade, demand depends on a relative price. For goods trade this is obvious as demand for a particular differentiated good depends on its price relative to that of other differentiated goods. For financial trade it is less obvious as p_i is not the actual price of an asset, but rather a more abstract concept that is the risk to reward ratio. Just like the price for a good, the higher this risk to reward ratio, the less attractive the asset is and therefore the lower the demand. Equation (24) shows that asset demand depends on a relative price just like demand for goods. What matters for portfolio demand for a particular asset i is not just the risk to reward ratio p_i for that asset, but rather the risk to reward ratio relative to that for other assets. That is why in (24) it is the ratio p_i/P_j that matters, where P_j is a price index that captures the average risk to reward ratio across assets from the perspective of country j.

Finally, total demand for differentiated goods $\hat{E}_j = 1/\hat{P}_j^{\sigma-1}$ (from (36)) is analogous to total demand for equity $E_j = W_j/P_j$. The only difference is that the W_j is replaced by 1. But since W_j is the zero-order component of wealth, which is a constant that does not depend on bilateral frictions (see Appendix 1), this will make no difference for either estimation of the gravity equation or comparative statics related to changes in bilateral frictions (see next section).

Once this analogy of demand equations is established, the analogy of gravity equations is immediate. First impose the goods market clearing condition

$$\sum_{j=1}^{N} \hat{X}_{ij} = \hat{S}_i \tag{38}$$

where $\hat{S}_i$ is the value of output in country i (supply of good i). This is analogous to the asset market clearing condition (25). The solution for $\hat{p}_i^{\sigma-1}$ after imposing goods market equilibrium is analogous to the solution for p_i in (26). Substituting this back into the demand equation (35) we get a gravity system that is analogous to the gravity system (28)-(31) for asset trade:

$$\hat{X}_{ij} = \frac{\hat{S}_i \hat{E}_j}{\hat{E}} \left(\frac{\hat{\tau}_{ij}}{\hat{\Pi}_i \hat{P}_j} \right)^{1-\sigma} \tag{39}$$

$$\left(\hat{P}_j\right)^{1-\sigma} = \sum_{i=1}^{N} \left(\frac{\hat{\tau}_{ij}}{\hat{\Pi}_i} \right)^{1-\sigma} \frac{\hat{S}_i}{\hat{S}} \tag{40}$$

$$\left(\hat{\Pi}_i\right)^{1-\sigma} = \sum_{j=1}^{N} \left(\frac{\hat{\tau}_{ij}}{\hat{P}_j} \right)^{1-\sigma} \frac{\hat{E}_j}{\hat{E}} \tag{41}$$

$$\hat{P}_j^{\sigma-1} \hat{E}_j = 1 \tag{42}$$

3.2 Trade in Differentiated Goods Only

We now show that this analogy between the gravity specifications for goods trade and asset trade is slightly weaker when the asset trade model is compared to a goods trade model in which there is only trade in differentiated goods. Specifically, we consider the model in Anderson and van Wincoop (2003), in which each country has an endowment of a specific differentiated good and there is no homogeneous good.

They derive the following gravity equation:

$$\hat{X}_{ij} = \frac{\hat{S}_i \hat{E}_j}{\hat{S}} \left(\frac{\hat{\tau}_{ij}}{\hat{\Pi}_i \hat{P}_j} \right)^{1-\sigma} \tag{43}$$

$$\left(\hat{P}_j\right)^{1-\sigma} = \sum_{i=1}^{N} \left(\frac{\hat{\tau}_{ij}}{\hat{\Pi}_i} \right)^{1-\sigma} \frac{\hat{S}_i}{\hat{S}} \tag{44}$$

$$\left(\widehat{\Pi}_i\right)^{1-\sigma} = \sum_{j=1}^{N} \left(\frac{\hat{\tau}_{ij}}{\hat{P}_j}\right)^{1-\sigma} \frac{\hat{E}_j}{\hat{S}} \tag{45}$$

$$\hat{E}_j = \hat{S}_j \tag{46}$$

It remains the case that bilateral trade flows $\hat{X}_{ij}$ are driven by the same relative trade barrier as in the previous trade model, which is analogous to the gravity equation for asset trade. The size factor $\hat{S}_i\hat{E}_j/\hat{S}$ remains exactly the same as well. Moreover, the equations (44)-(45) that define the multilateral resistance terms are also exactly the same as before.

The difference is that equation (42), $\hat{P}_j^{\sigma-1}\hat{E}_j = 1$, is now replaced by (46): $\hat{E}_j = \hat{S}_j$. In the Anderson and van Wincoop model agents cannot shift between differentiated goods on the one hand and the homogeneous goods on the other hand. The expenditure on differentiated goods by country j, $\hat{E}_j$, is therefore the same as their income and endowment $\hat{S}_j$. Instead, in the presence of the homogeneous good a rise in multilateral trade resistance $\hat{P}_j$ leads to a shift out of the differentiated goods and into the homogeneous good. This implies a drop in $\hat{E}_j$. The same applies to asset trade as well, where higher information frictions lead agents to shift out of the risky assets and into the riskfree asset.

This difference has implications for both estimation and comparative statics. In the Anderson and van Wincoop specification (43)-(45), exports $\hat{X}_{ij}$ from i to j are unaffected by trade barriers specific to country j. If we multiply all $\hat{\tau}_{kj}$ by λ for $k = 1,..,N$, it is easily verified that $\hat{P}_j$ is multiplied by λ and all trade flows remain unaltered. Intuitively, the allocation of the expenditure $\hat{S}_j$ by country j depends on the trade barriers across the various destination countries. But the expenditure allocation will not change when all these trade barriers rise by an identical multiplicative factor. Another way to put it is that the *relative* trade barrier that j faces with various destination countries remains unaltered as $\hat{\tau}_{ij}/(\widehat{\Pi}_i\hat{P}_j)$ does not change. Therefore trade flows $\hat{X}_{ij}$ do not change either. This result implies that it is impossible to estimate such source country specific barriers from trade data. Moreover, in a comparative statics exercise changes in such barriers will have no effect on trade flows.

But this is no longer the case when allowing for the homogeneous good as we have done, or allowing for the riskfree asset when considering asset trade. A uniform rise in trade or financial frictions of source country j with all destination countries will lead to a shift by country j towards the homogeneous good for goods trade or the riksfree asset for asset trade. Country j will therefore lower its demand for respectively differentiated goods or risky assets. This change in observed goods or asset trade implies that the impact of such source country specific barriers can now be identified from the data. In the next section we will discuss how this is done.[7]

4. Estimation and Comparative Statics

In this section we will describe how to use the gravity system (28)-(31) to estimate the size of financial frictions and conduct comparative statics analysis with respect to changes in financial frictions.

4.1 Estimation

We discuss three estimation methods for the bilateral financial frictions. All three methods are very user friendly. None of the methods require asset price information. No assumptions on the rate of risk aversion are needed. The first two estimation methods involve simple OLS with fixed effects, while the last method gives a very simple explicit expression for overall financial frictions as a function of quantities (international and intranational asset holdings).

The first method is analogous to that commonly used in the trade gravity literature today. We first relate the unobservable bilateral financial frictions to various observables. Specifically, assume that

$$ln(\tau_{ij}) = \sum_{m=1}^{M} \phi_m z_{ij}^m \tag{47}$$

where the z_{ij}^m is an observable variable such as the log distance between i and j. Substituting this into the logarithm of the gravity equation (28), we have

$$ln(X_{ij}) = -\sum_{m=1}^{M} \gamma_m z_{ij}^m + ln(S_i) + ln(\Pi_i/E) + ln(E_j) + ln(P_j) \tag{48}$$

We next replace $ln(S_i) + ln(\Pi_i/E)$ and $ln(E_j) + ln(P_j)$ with respectively destination and source dummies η_i and ξ_j and estimate

[7] It remains the case though that destination country specific barriers have no effect on goods and asset trade and can therefore not be identified. When for a specific destination country i the financial friction τ_{ij} with all source countries $j = 1,..,N$ rises by the same multiplicative factor, the multilateral resistance term Π_i rises by the same factor as well and relative financial frictions remain unaltered. Bilateral financial claims therefore remain unaffected. There is no shift in or out of the riskfree asset as all P_j remain unchanged.

$$ln(X_{ij}) = -\sum_{m=1}^{M} \phi_m z_{ij}^m + \eta_i + \xi_j + \varepsilon_{ij} \tag{49}$$

where the error term can be interpreted for example as data measurement error of bilateral financial holdings. This provides us with estimates of ϕ_m and therefore the relationship between financial frictions and various observables. Note that financial frictions that are specific to either the source or destination country will be swept up in the source and destination dummies and can therefore not be estimated this way.

This procedure differs from estimating gravity equations for bilateral trade flows only in one respect. As noted above, the financial friction τ_{ij} in the financial gravity equation corresponds to $(\hat{\tau}_{ij})^{\sigma-1}$ in the goods gravity equation. Because the bilateral friction $\hat{\tau}_{ij}$ for goods trade is taken to the power $\sigma - 1$, adopting the specification (47) for $\hat{\tau}_{ij}$ implies that in the estimation equation (49) ϕ_m is replaced by $(\sigma - 1)\phi_m$. In that case we only obtain estimates of ϕ_m by making an additional assumption about σ. In the financial gravity equation there is no need to do so. There is also no need to make assumptions about the rate of relative risk aversion.

So far we have implicitly assumed that we have cross-section data. If instead we have panel data, we need to modify the estimation slightly. Assume that the observables that affect financial frictions in general have a time dimension, denoting them $z_{ij,t}^m$. Since $ln(S_i) + ln(\Pi_i/E)$ and $ln(E_j) + ln(P_j)$ will have a time dimension as well, the source and destination dummies will have a time dimension. We then estimate

$$ln(X_{ij,t}) = -\sum_{m=1}^{M} \phi_m z_{ij,t}^m + \eta_{i,t} + \xi_{j,t} + \varepsilon_{ij,t} \tag{50}$$

where for each period t there are separate destination and source dummies $\eta_{i,t}$ and $\xi_{j,t}$. This procedure follows that commonly adopted in the trade literature.[8]

The second estimation method exploits the fact that source country specific barriers can now be identified as well, so that some of the z_{ij}^m can be specific to j (do not depend on i). After substituting $P_j E_j = W_j$ into (48), we have

8 See for example Baldwin and Taglioni (2006) for a discussion.

$$ln\left(\frac{X_{ij}}{W_j}\right) = -\sum_{m=1}^{M} \phi_m z_{ij}^m + ln(S_i) + ln\left(\frac{\Pi_i}{E}\right) \tag{51}$$

We can again replace the sum of the last two terms with a destination country dummy and estimate

$$ln\left(\frac{X_{ij}}{W_j}\right) = -\sum_{m=1}^{M} \phi_m z_{ij}^m + \theta_i + \varepsilon_{ij} \tag{52}$$

This works as long as we have a measure of the total financial wealth W_j of each country, which in the previous method was swept up in the source country dummy ξ_j. Since there is no longer a source country dummy on the right hand side, we can now estimate ϕ_m even for variables z_{ij}^m that are pure source country specific. Of course this method is also easy to extend to panel data by adding a time-subscript to the destination country dummy as before.

In the application in the next section we will estimate trade barriers by estimating (49), (50) and (52) with OLS. While beyond the scope of this paper, we should point out that OLS estimation may not always be appropriate for reasons that are the same as in the trade literature. In particular, biased estimates can result from heteroskedasticity of the error terms, the omission of country pairs with zero bilateral trade and endogeneity of one or more variables z_{ij}^m. Silva and Tenreyro (2006) discuss a pseudo maximum likelihood (PML) estimator that deals with the heteroskedasticity and zeros. As usual, endogeneity needs to be treated on a case by case basis with appropriate instruments.

So far the estimation methods have focused on obtaining estimates of the impact of various observables on the unobserved financial frictions. The third estimation method instead aims at getting an overall measure of financial frictions without relation to observables. In order to do so, use that from (28)

$$\left(\frac{X_{ij}X_{ji}}{X_{ii}X_{jj}}\right)^{-0.5} = \left(\tau_{ij}\tau_{ji}\right)^{0.5} \tag{53}$$

This is equal to a geometric average of bilateral barriers between i and j in both directions.[9] We also have

[9] For an analogous application with regards to goods trade, see Novy (2009).

$$\left(\frac{X_{ij}/W_j}{X_{ii}/W_i}\right)^{-1} = \tau_{ij} \tag{54}$$

These measures provide a very simple relationship between quantities (international and intranational asset positions) and international financial frictions. While quantity measures are frequently reported as indicators of international financial integration, the reported quantities (such as external assets and liabilities as a share of GDP) are generally ad hoc and do not map into measures of actual financial frictions.

These measures of bilateral frictions need to be interpreted with some caution though. In particular, they are more sensitive to measurement error than those relating bilateral frictions to a limited set of observables. With M observables we need to estimate only M parameters ϕ_m. By contrast, the last equation (54) can be used to compute a total of $N(N-1)$ bilateral financial frictions, which is generally much larger. To the extent that some of the bilateral asset positions are measured with error (which is surely the case), the resulting estimates of τ_{ij} will be incorrect.[10] One way to reduce measurement error is to report for each country a geometric average of financial frictions faced with all other countries.

4.2 Comparative Statics

Appendix 3 conducts a full comparative statics analysis of the impact of a change in financial frictions on bilateral asset holdings. It considers the impact of a change in τ_{ij} of any magnitude on bilateral asset holdings X_{kl} for any country pair (k, l). Here instead we will only consider marginal changes in financial frictions and discuss some specific cases of interest.

It is useful to recall the gravity equation

$$X_{ij} = \frac{S_i E_j}{E} \frac{\Pi_i P_j}{\tau_{ij}} \tag{55}$$

Appendix 1 shows that the zero-order components of asset prices are unaffected by changes in financial frictions. Therefore $S_i = Q_i K_i$ and $E = S = \sum_{i=1}^{N} Q_i K_i$ remain unchanged. There will be an effect though through E_j, Π_i, P_j and τ_{ij}.

[10] Estimates of ϕ_m will be systematically biased only to the extent that measurement error in X_{ij} is correlated with z_{ij}^m.

The analysis simplifies by using that $P_j E_j = W_j$. As shown in Appendix 1, the zero-order component of wealth W_j is unaffected by financial frictions. Substituting $P_j E_j = W_j$ into (55), we have

$$X_{ij} = \frac{S_i W_j}{E} \frac{\Pi_i}{\tau_{ij}} \tag{56}$$

Therefore E_j and P_j drop out. Intuitively, a change in P_j has two exactly offsetting effects on financial claims by j on i. On the one hand a rise in P_j lowers the relative financial friction $\tau_{ij}/(\Pi_i P_j)$, which raises X_{ij}. On the other hand, a rise in P_j implies an average rise in financial frictions that leads to a shift by j into the riskfree asset. This lowers E_j, which lowers X_{ij}.

So the bilateral financial claim X_{ij} is only affected through a change in Π_i/τ_{ij}. Substituting $P_j E_j = W_j$ into (30), we have

$$\frac{1}{\Pi_i} = \sum_{k=1}^{N} \frac{1}{\tau_{ik}} \frac{W_k}{E} \tag{57}$$

We can now consider a change in any bilateral friction. (57) tells us the implied change in the multilateral friction Π_i, which combined with (56) gives the change in the bilateral holding X_{ij}.

While one can in principle consider many combinations of changes in bilateral financial frictions, we will only consider three cases of special interest that we summarize in the form of three Results.

Result 1 *If a country reduces the financial frictions that the rest of world faces when investing in its equity, its external equity liabilities will rise and more so the larger and more closed the country is. Its external equity claims will not change and it will increase net lending in the riskfree bond.*

In order to see this, assume that the financial friction of i with all countries $j \neq i$ changes percentagewise by $d\tau/\tau < 0$. Using (57), this implies

$$\frac{d\Pi_i}{\Pi_i} = \left(1 - \frac{X_{ii}}{S_i}\right) \frac{d\tau}{\tau} \tag{58}$$

so that for all trading partners $j \neq i$

$$\frac{dX_{ij}}{X_{ij}} = -\left(\frac{X_{ii}}{S_i}\right)\frac{d\tau}{\tau} > 0 \tag{59}$$

Since $X_{ii}/S_i = (E_i/E)\Pi_i P_i$ it follows that external liabilities rise most for countries that are large (E_i big) and relatively closed (high multilateral resistance Π_i and P_i). For a country i that is large and relatively closed, the main source of equity demand comes from within the country itself. In that case the increased demand for its assets from other countries will not raise p_i much in equilibrium (will not lower the equilibrium expected excess return much). This leads to a relatively large increase of investment by other countries in i's equity as a result of the reduced frictions.

External equity claims do not change. The external claim X_{ji} by i on j depends on Π_j/τ_{ji}, which is unaffected. This is the result of two offsetting factors. On the one hand equity of other countries becomes more attractive as p_i rises. On the other hand, the increase in p_i causes country i to shift out of equity and into bonds. Net lending in bonds will therefore rise. Next we consider the effect of the financial equivalent of a free trade agreement.

Result 2 *If a set of countries form a financial union by reducing information frictions among each other, there will be the financial equivalent of trade creation and trade diversion: an increase in bilateral equity claims among the countries of the union and a reduction of external equity liabilities relative to countries outside the union. However, external equity claims on countries outside the union do not change.*

In order to illustrate this, we consider a union of just 2 countries. The same argument applies to larger unions. For example, assume that two countries i and j reduce bilateral information asymmetries through the adoption of common accounting standards. Frictions in both directions are changed percentagewise by $d\tau/\tau < 0$. After some basic algebra we have

$$\frac{dX_{ij}}{X_{ij}} = -\left(1 - \frac{X_{ij}}{S_i}\right)\frac{d\tau}{\tau} > 0 \tag{60}$$

Claims by j on i therefore rise. An analogous rise takes place for claims by i on j. Now consider a country k different from i and j. We have

$$\frac{dX_{ik}}{X_{ik}} = \frac{X_{ij}}{S_i}\frac{d\tau}{\tau} < 0 \tag{61}$$

This implies a drop of external liabilities by i relative to countries outside the union. An analogous result applies for country j. However, external claims on countries outside the union do not change.

Intuitively, the lower bilateral friction naturally lead i and j to increase demand for each other's assets. This increased demand raises the equilibrium p_i and p_j, making their assets less attractive to other countries. This reduces their external liabilities. However, their external claims on other countries do not change due to two offsetting factors. On the one hand the assets of countries outside the union become less attractive relative to the assets inside the union (relative financial friction rises). On the other hand, overall demand for risky assets rises by countries inside the union as they shift out of the riskfree asset.

Finally, we can consider a change in pure source and destination country specific barriers. As already discussed in the previous section, pure destination country barriers have no effect on cross border asset positions. When $d\tau_{ij}/\tau_{ij}$ is the same across all $j = 1,..,N$, Π_i changes by the same percentage as well. Relative trade barriers will remain unchanged and so will all bilateral asset holdings. The next Result considers a drop in pure source country frictions.

Result 3 *A general reduction in source country financial frictions, for example as a result of investors or the financial industry becoming more sophisticated, leads to an increase in external equity claims on all countries, a drop in external equity liabilities and a rise in net borrowing in the riskfree asset.*

To illustrate this, assume that for source country j, $d\tau_{ij}/\tau_{ij} = d\tau/\tau < 0$ across all $i = 1,..,N$. In that case it is easily verified that

$$\frac{dX_{ij}}{X_{ij}} = -\left(1 - \frac{X_{ij}}{S_i}\right)\frac{d\tau}{\tau} > 0 \qquad i = 1,..,N \tag{62}$$

$$\frac{dX_{ji}}{X_{ji}} = \frac{X_{jj}}{S_j}\frac{d\tau}{\tau} < 0 \qquad \forall i \neq j \tag{63}$$

Intuitively, the drop in the source country financial frictions will make equity more attractive for country j, raising equity claims on all countries. The increased demand of equity by j will raise the equilibrium risk to reward ratios p_i of all countries. This causes all other countries to shift out of equity and into bonds. This includes a shift out of country j equity, lowering country j's equity liabilities. The increased net foreign asset position by j in equity is offset by net borrowing in the riskfree asset.

5. An Empirical Illustration

In order to illustrate these results regarding estimation and comparative statics, we now apply them to a dataset for bilateral equity holdings among a set of 24 industrialized countries. We first discuss the data, then report results on the estimation of international financial frictions and finally report some comparative statics results. We should emphasize that the results in this section are simply meant to be illustrative. The analysis in the previous section can be applied to a wide range of different questions.

While the data used for X_{ij} and many of the variables z_{ij}^{m} have been used previously in the empirical gravity literature applied to bilateral asset holdings, the empirical analysis here nonetheless differs from the empirical gravity literature along four important dimensions. First, estimation is conducted in a way consistent with the theory. In the existing literature appropriate source and destination dummies are often omitted. Even when included, they are held constant in panel data. Second, many of the variables included in empirical gravity literature are hard to justify based on the theory (e.g. asset returns and correlations, taxes, per capita GDP, output correlation). Some of the variables that are included would be swept up if proper fixed effects had been included. Third, we report a measure of overall financial frictions that is grounded in theory. Finally, we provide various examples of comparative statics experiments that take proper account of the general equilibrium implications of changes in financial frictions.

5.1 Data

We will first describe the data for X_{ij} and then discuss the variables z_{ij}^{m} used in the analysis. All data sources for the variables z_{ij}^{m} are described in Appendix 4.

Stock Holdings

We use data on bilateral stock holdings from the Coordinated Portfolio Investment Survey (hereafter CPIS) by the International Monetary Fund. The IMF has conducted a comprehensive survey of external portfolio asset positions (equity, long-term debt and short-term debt) every year since 2001 for 67 source countries versus over 200 destination countries. In addition a survey was conducted in 1997 that included a smaller number of 29 source countries.

It is well known that these data are far from perfect. For a discussion of various data measurement problems, see for example Lane and Milesi-Ferretti (2005a). The IMF surveys the countries, but it is up to the countries themselves how to collect the data. Data from different source countries are therefore not necessarily of comparable quality. It is certainly not the case that the data are all based on careful benchmark surveys such as those conducted by the United States.

We will only use a subset of the CPIS data, including 24 industrialized countries.[11] While the focus on industrialized countries might mitigate measurement issues somewhat, the main reason for doing so is that informational frictions would appear to be the dominant source of barriers to asset trade among developed nations. Barriers associated with capital controls do not apply to this set of countries.

We measure claims X_{ii} of countries on their own stock market as total market capitalization minus total foreign equity claims on country i from the CPIS data.

Financial Frictions

We relate the bilateral financial frictions to both bilateral observables and source country observables. The set of bilateral variables included is as follows:

$$ln(\tau_{ij}) = \phi_1 Home_{ij} + \phi_2 ln(D_{ij}) + \phi_3 Trade_{ij} + \phi_4 Language_{ij} + \phi_5 Adjacent_{ij} + \phi_6 Legal_{ij} + \phi_7 CU_{ij} + \phi_8 Regulatory\ Similarity_{ij} + \phi_9 Time\ Zone_{ij} + \phi_{10} TU_{ij} \qquad (64)$$

where

- $Home_{ij}$ is a dummy that is equal to 1 when $i = j$
- D_{ij} is distance between i and j
- $Trade_{ij}$ is equal to trade between i and j divided by the product of their GDPs
- $Language_{ij}$ is a dummy that is 1 when i and j have a common official language
- $Adjacent_{ij}$ is a dummy that is 1 when i and j share a common land border
- $Legal_{ij}$ is a dummy that is 1 when i and j have the same legal system
- CU_{ij} is a dummy that is 1 when i and j use the same currency
- $Regulatory\ Similarity_{ij}$ is a variable measuring similarity of financial system regulation in i and j
- $Time\ Zone_{ij}$ is a dummy variable that is 1 when i and j are located in time zones that are no more than 2 hours apart
- TU_{ij} is 1 when i and j are in a trade union

[11] They are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. These are 1980 OECD member countries plus Hong Kong and Korea. Luxembourg and Ireland are excluded from the sample because the bias of the survey is particularly acute for small financial centers like them. For example, Luxembourg reports enormous holdings of foreign bonds, which in reality are bonds held by investors from other countries through custodians in Luxembourg.

All these variables can be associated with information frictions. The Home dummy simply captures any type of local information advantage that is not captured by any of the other variables. The distance and adjacency variables capture the fact that smaller distance reduces communication costs and increases human interaction, both of which diminish information asymmetries. The same is also the case for the time zone variable as communication is facilitated when financial markets are open at the same time. The common language dummy captures the reduction in information barriers when agents speak the same language.

The trade variable is defined as

$$\frac{\hat{X}_{ij} + \hat{X}_{ji}}{GDP_i * GDP_j} \tag{65}$$

with $\hat{X}_{ij}$ denoting exports from i to j. More trade leads to increased interaction between countries that may reduce information asymmetries. We also separately include a trade union dummy that is similarly related to trade barriers.

The currency union dummy applies exclusively to the European Monetary Union in our sample. It is a bit of an odd man out in the group of variables that we consider as it is not strictly related to information barriers. While EMU could have contributed to a reduction in information barriers, for example by generating more competition in financial services, the most direct an obvious benefit of EMU is the removal of exchange rate risk. To the extent that exchange rate risk is not covered through forward or swap markets, perhaps because of the associated cost, this removes an element of risk. While this is not the same as a reduction in information frictions, the impact is analogous to a reduction in τ_{ij} within the EMU area. For example, it reduces the risk of German investors investing in Italy relative to the risk that Italians face when investing in Italy. This is exactly what is captured by a drop in $\tau_{Italy,Germany}$.[12]

The legal variable represents the reduction in information barriers when two countries have the same legal system. Following La Porta, Lopez-de-Silanes, Schleifer and Vishny (1998), we consider three legal systems: common law countries, German/Scandinavian civil law countries and French civil law countries.

The regulatory similarity variable is defined as

$$Regulatory\ Similarity_{ij} = -\sum_{k=1}^{21} \left| reg_i^k - reg_j^k \right| \tag{66}$$

[12] We implicitly assume that it does not change risk relative to countries outside the Euro area as the removal of intra-Euro exchange rate risk does not necessarily affect the exchange rate risk relative to non-Euro countries.

where reg_i^k is one of 21 regulatory index measures. This index of regulatory similarity was developed by Vlachos (2004), who shows that more similar financial regulation leads to increased bilateral portfolio holdings. Vlachos (2004) argues that this is likely the result of reduced information costs as differences in disclosure and accounting requirements are more important in explaining bilateral portfolio holdings than for example differences in liquidity and capital requirements.

Apart from this set of bilateral variables, we also consider the impact of a number of variables that are specifically related to the source country as the theory has shown that financial frictions specific to the source country can be identified from the data. We will consider the following set of source country variables:

- $Financial\ Market\ Sophistication_j$ is an index from 1 to 7 of financial market sophistication
- $Freedom\ of\ Press_j$ is an index from 1 to 100 of freedom of the press
- $Regulatory\ Quality_j$ is an index of regulatory quality
- $Anglo - Saxon_j$ is dummy that is 1 when the country is the US or the UK
- $College\ Degree_j$ measures educational attainment as the fraction of the population over 15 with a college degree
- $Size\ Financial\ Sector_j$ is the share of the financial sector in GDP

These can all be interpreted as information variables as well. More sophisticated financial markets are more efficient at collecting and distributing information. The Anglo-Saxon dummy is included separately for the same reason. More freedom of the press implies that information is disseminated better within the country. More education also reduces information frictions. Ehrlich *et al.*(2008) use micro data to show that education increases the portfolio share of risky assets and asset returns. Kaufmann, Kraay and Mastruzzi (2008) summarize the regulatory quality index as follows: "it includes measures of the incidence of market-unfriendly policies such as price controls or inadequate bank supervision, as well as perceptions of the burdens imposed by excessive regulation in areas such as foreign trade and business development". This is a broad variable that relates to regulation of the financial sector and more broadly to the overall economic regulatory environment. In general it is reasonable to conjecture that a poorly regulated economy, both financial and otherwise, will disseminate information less efficiently than a well regulated economy. Finally, the larger the financial sector as a share of GDP, the more information it can be expected to collect and distribute. Table 1 provides summary statistics of all bilateral and source country variables introduced in the trade cost function.

5.2 Estimation Results

We first report the impact of various bilateral observables z_{ij}^{m} on financial frictions (first estimation method), then the impact of source country observables on source country frictions (second method) and finally an estimate of total bilateral financial frictions based on the last method discussed in section 4.1.

Impact of Bilateral Observables on Financial Frictions

Starting with the first estimation method, Table 2 reports estimates of the impact of various bilateral observables z_{ij}^{m} on $ln(\tau_{ij})$. The results are based on a cross-section regression for the year 2005.

We should first emphasize that the information frictions implied by our analysis are extremely large. When only including the Home dummy, it has a large negative coefficient of -5.6. This implies that the international friction τ_{ij} $(i \neq j)$ is on average a factor $e^{5.6} = 270$ times as big as the domestic friction τ_{ii}. This implies the perceived standard deviation of idiosyncratic payoff risk is a factor $270^{0.5} = 16.4$ larger for foreign investors than for local investors. This can only be interpreted as a huge information asymmetry.

It is likely that these numbers overstate the extent of information asymmetries as a result of large insider ownership of stock. Kho *et al.*(2009) report very large insider ownership numbers even for industrialized countries, with on average close to 50% held by insiders. The large insider ownership is optimal given agency problems and therefore does not reflect optimal portfolio allocation. Given the fact that on average close to 80% of stock is held by local residents, on average about 63% of locally held stock is held by insiders. If we take out the insiders, it amounts to reducing the X_{ii} numbers by 63% on average. Equations (53) and (54) suggest that this would lower estimates of τ_{ij} by 63%. But this would still leave the perceived standard deviation of asset returns a factor 10 times as big as for foreign investors than local investors. This remains a very big number.

The very large information asymmetries implied by these results may be less surprising once it is realized that most stock market wealth is held by individual investors rather than informed financial institutions. For example, over the period 1980-2004 on average 48.5% of U.S. stock market wealth was held directly by individual investors. In addition 22.4% was held through pension and retirement funds and 10.1% through mutual funds. These categories are also largely managed by individual investors as they need to decide how to allocate their pension and mutual fund investment across domestic versus global funds. Only 0.4% of stock market wealth was held by brokers and dealers, who can be considered to be well informed.

Large information asymmetries for individual investors may not be so surprising given the fact that investors consider their own employer's stocks to be less risky than domestic stock funds, which in turn are considered less risky than globally diversified funds. These results, from a John Hancock Survey, are discussed in Huberman (2000). This is the case even though of course the stock return of an individual firm has far higher unconditional volatility than that of domestically and globally diversified funds. Huberman (2001), who shows that ownership of stock of regional phone companies in the United States has a strong local bias, attributes this to familiarity. This is a concept closely related to information asymmetries.

We next turn to the other results in Table 2. While distance significantly reduces asset trade, the coefficient on distance becomes insignificant when all controls are included. Particularly the inclusion of the trade variable reduces the effect of distance. While longer distances reduce trade, which reduces information exchange, beyond that the impact of distance is very limited.

The trade variable, common language dummy, currency union dummy and legal variable are all significant and all have the expected sign. With the exception of the legal variable, this remains the case when all bilateral variables are jointly included in the last column. The regulatory similarity variable has the wrong sign and is not significant. The time zone proximity variable has the right sign, but is insignificant. The trade union dummy is significant on its own, and with the right sign, but becomes insignificant once the overall trade variable is included. This is not surprising as belonging to a trade union only affects information exchange to the extent that it affects trade.

When all variables are included, the coefficient on the Home dummy declines to -2.3. One way to summarize this is as follows. All of our observable control variables can jointly explain the bulk of information asymmetries. They account for a standard deviation of country-specific asset return innovations that is on average 5.1 times bigger for foreigner investors than for locals. In addition this asymmetry is increased by another factor 3.2 due to factors not included in the regression (5.1*3.2=16.4).

Table 3 reports results still based on the first estimation method, but using panel data that includes all years 1997 and 2001-2006. The aim of Table 3 is to see whether the impact of EMU, as well as unexplained financial barriers captured by the Home dummy, has changed over time. To that end we introduce a separate Euro dummy and Home dummy for each year of the panel. The Euro dummy is equal to 1 for country pairs that eventually join EMU during our sample. So it is equal to 1 even in 1997, before the start of EMU. In addition we include all other bilateral variables from Table 2 with coefficients that are constant over time. Table 3 only reports the coefficients on the Euro and Home dummies.

The coefficient on the Home dummy has a clear downward trend, dropping from -4.0 in 1997 to -2.9 in 2006.[13] This suggests a significant drop during this period in financial frictions unrelated to the other controls. It is equivalent to a drop in information asymmetries by 43% when measured as the perceived standard deviation of country-specific risk by foreign relative to local investors.

The Euro dummy shows an interesting pattern as well. It has a coefficient of -0.13 in 1997 that is statistically insignificant. This is as expected as EMU was not yet in place, so it could not have lowered trade barriers. Then the coefficient declines to -0.60 in 2001 and -0.81 in 2002 and becomes strongly significant. In subsequent years the coefficient on the EMU dummy does not change much more. These results suggest that EMU reduced trade barriers significantly and without much delay. Note also that these results cast doubt on possible endogeneity with significant integration (high bilateral asset trade) leading to EMU. Our findings suggest that bilateral asset claims only rose after the start of EMU.

Impact of Source Country Observables on Financial Frictions

Table 4 is based on the second estimation method discussed in section 4.1, which allows for the role of source country financial frictions. This method requires an estimate of total financial wealth W_i. Consistent with the model we compute W_i as total equity holdings of country i plus its net foreign asset position in assets other than equity.

The first column presents a baseline result that only includes bilateral variables z_{ij}^m. We should emphasize that when only including such bilateral variables, the results from the first estimation method are more reliable. It controls for all possible source country specific variables by including a source country dummy. To the extent that source country variables are correlated with bilateral variables z_{ij}^m, omitting the source country variables can lead to biased coefficient estimates.

In the subsequent columns of Table 4 we add, one at a time, the various source country variables discussed above. All of them are highly significant and have the expected sign. This is strong evidence that a larger, more sophisticated and better regulated financial industry is more efficient at reducing information barriers. Freedom of the press and more college education also significantly reduce information barriers. As a result of multicollinearity, the individual impact of these source country variables is hard to evaluate when including them jointly in the last column of Table 4.[14]

[13] The coefficient on the 2005 Home dummy is -3.0, while it is -2.3 in Table 2. The difference is explained by the fact that we replaced the currency union dummy in Table 2 with the Euro dummy in Table 3. Each country has a currency union with itself ($CU_{ii} = 1$), while the Euro dummy is only set equal to 1 when $i \neq j$ and both joined EMU. If one takes the sum of the coefficients on the currency union and Home dummies in Table 2, the result is similar to that for the Home dummy in Table 3 for the year 2005.

[14] Another econometric issue is endogeneity, especially for the financial share variable. However, endogeneity would appear to be less relevant for several of the other variables, in particular the education variable.

Measure of Total Bilateral Financial Frictions

Table 5 is based on the third estimation method discussed in section 4.1. It provides estimates of overall bilateral financial frictions. For 3 countries, the US, Germany and Japan, it reports a geometric average of bilateral barriers in both directions with all of their trading partners. Column 1 reports for all countries the average of their bilateral barriers with all trading partners.

The results are sensible. Apart from the fact that these financial frictions are large as already discussed, we see that financial frictions are on average smallest for the US and UK. The United States has the lowest bilateral frictions with the Netherlands, UK and Canada, all countries with which it has close historic ties. Germany has the smallest financial frictions with other European countries, especially France and the Netherlands. Japan has the smallest barrier with the United States. We should also point out that some of the numbers in Table 5 are extreme and probably reflect data measurement problems. As discussed in section 4.1, this estimation method is more sensitive to measurement error in bilateral asset holdings than the previous two methods.

Table 6 repeats column 1 for Table 5 (the average of financial frictions for each country) for the other years of the sample. For 1997 results are not reported for 4 countries due to incomplete data. Consistent with the findings in Table 3, Table 6 confirms a very large drop in financial frictions over the decade from 1997 to 2006. If we consider the balanced sample of countries that excludes the 4 countries for which data are missing in 1997, the simple average of financial frictions drops from 496 in 1997 to 201 in 2006. In terms of standard deviations this implies that country-specific risk was a factor 14.2 larger for foreign than local investors in 2006, versus a factor 22.3 in 1997. The countries with the largest drop in financial frictions (Korea, Singapore, Austria, Finland and Norway) also had the largest frictions to begin with. So there is some evidence of convergence, even though large differences remain in 2006.

5.3 Comparative Statics Results

Tables 7 and 8 report results from various comparative statics experiments. Table 7 illustrates the three Results discussed in section 4.2. We first consider the impact of a 10% reduction in financial frictions that the rest of the world faces when investing in a particular destination country. Columns 1 to 3 of Table 7 report the impact on external positions when repeating this experiment separately for each country as a destination country. These columns therefore really report 24 separate comparative statics exercises.

Consistent with Result 1, external equity claims of the destination country remain unchanged. Also, Result 1 tells us that external equity liabilities rise and more so in large and relatively closed countries. This is confirmed in the third column of Table 7. The largest country, the United States, faces the biggest increase in external equity liabilities, while the Netherlands (a small and relatively open country) faces the smallest increase in external equity liabilities. Finally, the fourth column confirms the increase in external bond holdings described in Result 1.

Result 2 relates to the impact of a financial union that reduces information frictions within the union. While not explicitly aimed at reducing information frictions, EMU removes bilateral exchange rate risk among the countries of the union. Columns 4 and 5 of Table 7 report the impact of EMU. Result 2 implies that there is a type of trade diversion in that bilateral equity claims rise inside the union, while non-union countries reduce their equity claims on union countries. This is reflected in the sharp increase in external equity claims of EMU countries in Table 7, paired with the drop in external equity claims of non-EMU countries.

The last 3 columns of Table 7 consider a 10% drop in source country financial frictions. The experiment is repeated separately for each country as a source country. Consistent with Result 3, this leads to an increase in external equity assets, drop in external equity liabilities and a drop in external bond positions.

Finally, Table 8 reports the impact on external equity holdings of a variety of scenarios that reduce international financial frictions across almost all countries. Column 1 reports the impact of a global currency union. This experiment comes on top of the effect of EMU, which is already in place. Clearly, the effect on global external positions is very large, many times that of EMU. There is now an increase in external positions for all countries, with global external equity positions rising by 75%.

The second experiment involves an increase in international trade by 10%. Under this scenario each country raises its trade with all other countries by 10%. There is a corresponding drop in within country trade, assuming that the total value of production remains unchanged in each country.[15] All countries experience an increase in external equity claims under this scenario, with overall global external positions rising by 8%. This is very close to the 10% increase in goods trade.

The third experiment involves an improvement in regulatory quality in all countries to that of the county with the highest regulatory quality index, which is Hong Kong. This leads to an enormous increase in external financial positions for countries with the lowest regulatory quality (Turkey, Korea, Greece, France, Japan and Italy). At the same time it lowers a bit the external claims of countries that already had a very high regulatory quality index. As countries that see their regulatory quality improve increase demand for external assets, it lowers the equilibrium expected excess returns (raises p_i in our model), which reduces external equity holdings by countries that already have a high regulatory quality index. While this experiment leads to both very large positive and negative changes in external claims, total global external equity positions rise only by a modest 19%.

15 This implies that $\hat{X}_{ii}$ falls by an amount equal to the increase in $\sum_{j \neq i} \hat{X}_{ij}$.

The fourth experiment considers an increase in the size of the financial sector as a share of GDP in all countries to the level of that in the United States, which has the largest financial sector. The results are based on the estimates in column 2 of Table 4. The reduction in information barriers resulting from the sharp increase in the financial sector in many countries leads to an increase in external equity holdings of all but two countries. But overall global external claims rise by only 3%. The reason for this is the substantial drop in U.S. external claims. Similar to improved regulation, the general increase in demand for equity resulting from the reduced information barriers leads to a drop in equilibrium expected excess returns, which lowers demand for foreign equity by U.S. investors.

The last experiment involves removing all financial barriers unrelated to the observables z_{ij}^{m}. This is done by removing the barrier captured by the Home dummy in the last column of Table 2. External positions rise sharply in all countries, with global external claims rising by 255%.

6. Conclusion

The rapidly growing empirical gravity literature on cross-border asset holdings clearly calls out for a theory. The main aim of this paper has been to provide such a theory. We have shown that a couple of judicious, but reasonable, assumptions lead to a gravity specification for cross-border asset holdings that is closely analogous to that for goods trade. We have shown how the gravity equation can be used to estimate international financial frictions and conduct comparative statics exercises with respect to changes in these frictions. Both the estimation methods and comparative statics analysis are user friendly and easy to apply to almost any question of interest.

We have used a dataset for cross-border equity holdings among 24 industrialized countries to illustrate the results. Several conclusions can be reached from the empirical analysis. First, the magnitude of international financial frictions is enormous, suggesting very large information asymmetries. Second, in most countries these frictions have been rapidly declining over the past decade. Third, the financial frictions are related to many bilateral and source country observables that are naturally related to information asymmetries: whether countries speak a common language, use the same legal system, trade a lot and whether the source country has an educated population and a large, sophisticated and well regulated financial industry. Finally, a variety of comparative statics exercises illustrate the potentially large effects on external equity assets and liabilities of removing observable information frictions. The results also show that the impact of EMU on external financial positions was substantial and quick.

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Table 1. Summary Statistics*

Variable	Obs	Mean	StDev	Min	Max
trade	3933	-5.64	1.53	-10.0	-0.2
log distance	576	7.71	1.20	2.7	9.4
home	576	0.04	0.20	0	1
common language	576	0.21	0.41	0	1
adjacency	576	0.11	0.31	0	1
common legal system	576	0.34	0.47	0	1
common currency	576	0.20	0.40	0	1
regulatory similarity	529	0.90	0.31	0	1.6
time zone proximity	576	0.48	0.50	0	1
trade union	576	0.47	0.50	0	1
size financial sector (% of GDP)	22	22.54	4.36	15.5	30.3
regulatory quality	24	1.37	0.39	0.2	1.8
Anglo Saxon	24	0.08	0.28	0	1
financial market sophistication	24	5.91	0.69	4.2	6.8
freedom of the press	24	79.17	13.43	34	91
percentage with college degree	22	73.52	27.91	33.8	139.4

* Note: Trade (3933 observations) is a panel variable. The next 9 variables (576 observations) are country pair specific variables. The last 6 variables (22 or 24 observations) are source country specific. The trade variable is log(X_{ij}*X_{ji}/GDP_i GDP_j). Legal is a common legal origin dummy; adjacency is a sharing land border dummy; common language is a common language dummy; common currency is dummy for sharing the same currency; log distance is the log of bilateral distance; home is dummy that is 1 when i=j; regulatory similarity is a measure of similarity of the regulatory system across a pair of countries; time zone proximity is a dummy that is 1 when the difference in time zones is at most 2 hours; size financial sector respresents the share of the financial sector in GDP; regulatory quality is broad score for regulatory quality; Anglo Saxon is dummy for Anglo Saxon countries; financial market sophistication and freedom of the press speak for themselves; percentage with college degree is the percentage of the population over age 15 that has a college degree.

Table 2. Impact of Observables on Bilateral Financial Frictions in 2005

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
home	-5.63**	-3.89**	-2.27**	-3.38**	-3.85**	-3.75**	-3.31**	-3.99**	-4.00**	-3.92**	-2.36**	-2.32**
	(0.35)	(0.33)	(0.38)	(0.34)	(0.36)	(0.32)	(0.33)	(0.36)	(0.34)	(0.33)	(0.39)	(0.43)
log distance		0.97**	0.30**	0.82**	0.96**	0.87**	0.82**	0.91**	0.83**	0.78**	0.26*	0.11
		(0.07)	(0.11)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)	(0.12)	(0.10)	(0.12)	(0.17)
trade			-0.63**								-0.60**	-0.52**
			(0.08)								(0.09)	(0.09)
common language				-0.81**								-0.57**
				(0.18)								(0.19)
adjacency					-0.06							0.07
					(0.25)							(0.27)
common legal system						-0.47**						-0.21
						(0.11)						(0.12)
common currency							-1.16**					-0.87**
							(0.21)					(0.21)
regulatory similarity								0.06				1.46**
								(0.49)				(0.49)
time zone proximity									-0.38			-0.04
									(0.25)			(0.34)
trade union										-0.75**	-0.27	-0.15
										(0.24)	(0.24)	(0.32)
Observations	540	540	540	540	540	540	540	497	540	540	540	497

Note: The Table reports the impact of various observables on $\ln(\tau_{ij})$. All variables are bilateral in nature and defined in Table 1. Results are based on cross-section estimates of equation 49 for 2005. Standard errors are in parentheses. Significance at 1 (**) and 5 percent (*) levels are indicated.

Table 3. Changes in Financial Frictions Over Time

	home	euro
	(1)	(2)
1997	-4.00**	-0.13
	(0.32)	(0.20)
2001	-3.27**	-0.60**
	(0.32)	(0.20)
2002	-3.38**	-0.81**
	(0.32)	(0.20)
2003	-3.38**	-0.87**
	(0.32)	(0.20)
2004	-3.12**	-0.87**
	(0.32)	(0.20)
2005	-2.96**	-0.91**
	(0.32)	(0.20)
2006	-2.85**	-0.85**
	(0.32)	(0.20)

* Note: The results are based on a panel estimation of equation 50 for the years shown in the Table. The observable variables included are all variables in Table 2, with two differences. First, there is a separate home dummy for each year of the panel, with its coefficient reported in the Table. Second, the common currency dummy in Table 2 is replaced by a separate Euro dummy for each year of the sample that is 1 for country pairs that eventually join EMU during the sample. The Table shows how financial frictions fall over time due to both EMU (last column) and financial frictions unrelated to the various controls (captured by the Home dummy). Standard errors are in parentheses. Significance at 1 (**) and 5 percent (*) levels are indicated.

Table 4. Impact of both Bilateral and Source Country Variables on Financial Frictions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log distance	0.97**	1.17**	0.53**	1.03**	0.76**	0.72**	1.12**	0.84**
	(0.23)	(0.22)	(0.19)	(0.23)	(0.22)	(0.22)	(0.22)	(0.19)
home	-3.75**	-4.10**	-3.12**	-3.95**	-3.56**	-3.08**	-3.94**	-3.50**
	(0.65)	(0.62)	(0.54)	(0.64)	(0.62)	(0.61)	(0.63)	(0.51)
trade	-0.03	0.17	-0.30**	0.08	-0.15	-0.22*	0.02	-0.08
	(0.12)	(0.12)	(0.10)	(0.12)	(0.11)	(0.11)	(0.11)	(0.10)
common language	-0.96**	-0.77**	-0.50*	-0.74**	-0.60*	-0.92**	-0.64*	-0.48*
	(0.27)	(0.27)	(0.23)	(0.28)	(0.27)	(0.26)	(0.27)	(0.23)
adjacency	0.19	0.21	-0.20	0.05	0.03	0.03	0.14	-0.13
	(0.42)	(0.40)	(0.35)	(0.42)	(0.40)	(0.39)	(0.41)	(0.33)
common legal system	-0.49*	-0.53**	-0.34*	-0.55**	-0.47*	-0.35	-0.49*	-0.35*
	(0.21)	(0.20)	(0.17)	(0.20)	(0.20)	(0.19)	(0.20)	(0.16)
common currency	-0.15	-0.06	-0.63*	-0.29	-0.37	-0.55*	-0.39	-0.54*
	(0.29)	(0.28)	(0.25)	(0.29)	(0.28)	(0.28)	(0.29)	(0.24)
regulatory similarity	4.53**	3.56**	3.47**	4.18**	3.92**	4.12**	4.35**	3.00**
	(0.82)	(0.81)	(0.69)	(0.82)	(0.80)	(0.77)	(0.80)	(0.66)
time zone proximity	1.65**	1.58**	1.00*	1.43**	1.28*	1.39**	1.86**	1.27**
	(0.55)	(0.53)	(0.46)	(0.55)	(0.54)	(0.52)	(0.54)	(0.44)
trade union	-2.34**	-2.45**	-1.39**	-2.12**	-1.87**	-1.79**	-2.32**	-1.73**
	(0.53)	(0.50)	(0.44)	(0.52)	(0.51)	(0.50)	(0.51)	(0.42)
size financial sector (%		-0.11**						-0.08**
of GDP)		(0.02)						(0.02)
regulatory quality			-2.88**					-3.87**
			(0.25)					(0.42)
Anglo Saxon				-0.86**				0.12
				(0.26)				(0.24)
financial market					-0.66**			0.73**
sophistication					(0.12)			(0.17)
freedom of the press						-0.08**		0.004
						(0.01)		(0.017)
percentage with college							-0.018**	-0.008*
degree							(0.004)	(0.003)
Observations	335	335	335	335	335	335	335	335

Note: The Table reports the impact of various observables on $\ln(\tau_{ij})$. The first 10 variables are bilateral in nature. The remaining 6 variables are all source country variables. Results are based on cross-section estimates of equation (52) for 2005. Standard errors are in parentheses. Significance at 1 (**) and 5 percent (*) levels are indicated.

Table 5. Geometric Average of Bilateral Financial Frictions*

	World (1)	USA (2)	Japan (3)	Germany (4)
United States	51	1	25	34
United Kingdom	46	14	35	25
Austria	291	121	466	33
Belgium	230	97	470	55
Denmark	304	78	225	141
France	76	35	83	16
Germany	95	34	118	1
Italy	144	60	150	34
Netherlands	53	12	63	19
Norway	197	48	216	91
Sweden	154	44	156	73
Switzerland	113	28	114	29
Canada	358	19	111	18277
Japan	171	25	1	118
Finland	156	67	236	56
Greece	1837	295	2939	439
Portugal	1033	312	1887	191
Spain	389	126	501	59
Hong Kong, China	851	164	216	908
Korea	2355	216	1038	1664
Singapore	970	91	319	809
Average	243	51	171	95

* Note: The table reports average bilateral financial frictions for the year 2005 based on equation (53) in the text. All averages in the Table are geometric averages. The last three columns show the average of financial frictions in both directions for a pair of countries. Within country barriers are normalized at 1. Column 1 reports the average bilateral friction with all countries.

Table 6. Average Frictions by Year*

	1997 (1)	2001 (2)	2002 (3)	2003 (4)	2004 (5)	2005 (6)	2006 (7)
United States	83	66	61	58	54	51	47
United Kingdom	86	67	61	64	56	46	44
Austria	829	442	483	490	316	291	252
Belgium	455	299	255	261	236	230	194
Denmark	391	350	330	363	353	304	279
France	185	124	116	101	83	76	75
Germany		132	120	118	98	95	103
Italy	328	204	175	181	169	144	155
Netherlands	149	61	61	58	47	53	62
Norway	727	342	284	298	256	197	171
Sweden	315	218	202	201	173	154	143
Switzerland		159	126	129	125	113	116
Canada	458	477	469	420	425	358	310
Japan	368	234	228	216	181	171	159
Finland	753	287	205	196	166	156	163
Greece		6017	4121	3473	2619	1837	1827
Portugal	1558	1170	1642	1547	1210	1033	935
Spain	867	444	476	490	415	389	363
Hong Kong		1911	1021	1022	885	851	786
Korea	10260	5151	4171	5625	3041	2355	1522
Singapore	1727	747	776	1116	1013	970	668
Simple Average	496	355	319	323	272	243	224
Balanced Sample Average	496	303	287	294	247	221	201

* Note: The table repeats column 1 of Table 5 for all years of the sample. It reports average financial frictions for all countries during each year of the sample. For each country it is the geometric average of financial frictions with all other countries. Bilateral frictions are computed as the geometric average in both directions based on equation (53) in the text. The averages at the bottom of the table are geometric average across all countries during a particular year of the sample. The balanced sample average excludes the 4 countries for which data a missing in 1997.

Table 7. Illustration of the Comparative Statics Results*

	10% lower frictions of destination country			effect of EMU		10% lower frictions of source country		
	% change external equity claims	% change external equity liabilities	change in net bond position (% of average equity assets and liabilities)	% change external equity claims	% change external equity liabilities	% change external equity claims	% change external equity liabilities	change in net bond position (% of average equity assets and liabilities)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
United States	0.0	10.1	0.8	-2.0	0.0	9.3	-9.3	-2.1
United Kingdom	0.0	7.0	2.5	-2.2	0.0	10.7	-6.8	-5.6
Austria	0.0	7.9	2.1	37.7	18.8	11.1	-7.5	-5.6
Belgium	0.0	8.3	1.8	64.4	27.4	10.9	-7.8	-6.0
Denmark	0.0	8.8	1.5	-1.5	0.0	11.1	-8.2	-5.7
France	0.0	7.5	2.4	33.3	17.4	10.7	-7.2	-4.9
Germany	0.0	6.7	2.6	36.7	13.9	10.9	-6.5	-5.4
Italy	0.0	7.9	2.2	29.7	21.4	11.0	-7.5	-4.3
Netherlands	0.0	4.4	2.4	11.8	9.2	11.0	-4.5	-9.9
Norway	0.0	8.0	1.8	-1.6	0.0	11.1	-7.6	-7.4
Sweden	0.0	7.8	2.0	-1.8	0.0	11.0	-7.5	-6.0
Switzerland	0.0	6.4	2.9	-2.7	0.0	11.0	-6.2	-5.2
Canada	0.0	8.8	1.7	-1.0	0.0	11.0	-8.2	-4.1
Japan	0.0	8.9	1.7	-1.1	0.0	11.0	-8.3	-2.5
Finland	0.0	4.9	3.1	17.2	8.0	11.0	-5.0	-6.0
Greece	0.0	9.0	1.7	17.3	17.2	11.1	-8.4	-2.0
Portugal	0.0	8.0	2.2	60.3	21.3	11.1	-7.6	-4.0
Spain	0.0	8.9	1.7	53.5	22.6	11.0	-8.4	-2.5
Turkey	0.0	9.4	1.4	-7.9	0.0	11.1	-8.7	-1.3
Australia	0.0	8.9	1.7	-1.1	0.0	11.1	-8.3	-3.2
New Zealand	0.0	8.9	1.5	-0.2	0.0	11.1	-8.3	-5.7
Hong Kong	0.0	9.8	1.0	-0.3	0.0	11.0	-9.1	-1.8
Korea	0.0	8.1	2.3	-0.6	0.0	11.1	-7.7	-2.3
Singapore	0.0	9.1	1.5	-0.3	0.0	11.1	-8.5	-3.2

* Note: The table reports the results from three types of comparative statics exercises. Under the heading "10% lower frictions of destination country" the table reports the impact on external financial positions when a destination country lowers its financial friction by 10% relative to all other countries (keeping the within country friction of the destination country unchanged). The table only reports the results for the destination country itself. The experiment is repeated for all countries as a destination country and reported in columns 1 to 3. Columns 4 and 5 report the impact of EMU on international financial positions. In this case there is just one experiment, the introduction of EMU, and the Table reports the impact on external positions for each country. The last three columns report a drop by 10% of all frictions faced by a source country, both relative to other countries and with itself. The experiment is repeated for all countries as source countries and only reports the results for the source country itself. Changes in net bond positions refer to a change relative to the average of external equity assets and liabilities.

Table 8. Percentage Change in External Equity Holdings under Various Scenarios

	Global Currency Union (1)	10% higher Trade (2)	Better Regulation (3)	Larger Financial Sector (4)	Remove Residual Frictions (5)
United States	77.7	8.5	-36.7	-33.7	198.8
United Kingdom	92.8	8.1	-39.9	10.2	298.6
Austria	32.3	8.3	-40.9	53.7	229.0
Belgium	8.9	10.5	31.8	3.1	202.2
Denmark	87.1	7.0	-63.2	65.0	274.2
France	35.2	9.5	248.9	-17.5	225.8
Germany	34.2	9.1	-6.1	6.9	240.6
Italy	42.6	8.8	681.1	38.4	249.3
Netherlands	75.4	5.8	-59.0	32.9	334.4
Norway	89.9	7.0	-2.3	160.6	292.5
Sweden	88.1	6.8	-24.7	60.2	284.9
Switzerland	89.9	7.9	-5.7	64.2	275.4
Canada	98.0	6.6	-21.2	38.5	355.7
Japan	98.4	6.8	262.5	4.1	357.5
Finland	53.5	7.9	-69.0	116.6	229.7
Greece	61.8	9.6	882.9	179.2	294.1
Portugal	15.1	6.3	91.4	58.4	241.7
Spain	17.1	8.5	75.0	92.0	209.0
Turkey	67.3	32.8	13312.5	82.5	148.3
Australia	99.8	8.2	-39.4	10.7	372.4
New Zealand	97.7	6.4	-47.9	11.9	353.0
Hong Kong	76.0	5.4	-74.2	40.2	221.2
Korea	97.1	6.2	1629.0	132.2	346.4
Singapore	97.9	6.2	-59.8	38.0	353.6

* Note: The table reports the results from five comparative statics exercises. Column 1 reports the impact of a global currency union on the external equity claims of all countries. It is based on the results in column 12 of Table 2 by setting the currency union dummy equal to 1 for country pairs that are not already in a currency union. Column 2 reports the impact on external equity holdings when international goods trade rises by 10% across all countries. It is again based on the results in column 12 of Table 2. The last 3 columns report results that are based on column 8 of Table 4. Column 3 reports the impact on external equity claims when all countries improve their regulatory quality to that of the country with the highest regulatory quality (Hong Kong). The fourth column considers the impact when all countries increase the share of the financial sector in GDP to that of the United States, which has the largest financial sector. The last column reports the results when removing all financial barriers unrelated to the observables. This is done by removing the residual barrier captured by the Home dummy.

Appendix 1. Derivation of Portfolio Demand

We apply the local approximation solution method developed by Tille and van Wincoop (2009a) and Devereux and Sutherland (2009) to derive portfolio demand equation (24). We decompose the model variables across components of different orders. Any variable x can be written as the sum of its zero, first and higher-order components: $x = x(0) + x(1) + x(2) + \cdots$. The zero-order component, $x(0)$, is the value of x when all standard deviations of model innovations approach zero. The first-order component is proportional to model innovations. The second-order component is proportional to the variance, covariance or product of model innovations, and so on.

There are a total of $N^2 + 5N + 4$ variables in the model: $N^2 + N$ portfolio shares α_{ij} , α_{gj} ; $N + 2$ asset prices Q_i, Q_g and Q_f; $N + 2$ corresponding asset returns; N period 1 consumption variables $C_{i,1}$; and N period 2 consumption variables $C_{i,2}$. There are $N^2 + 5N + 6$ equations: $N^2 + N$ portfolio Euler equations; N consumption Euler equations; $N + 2$ asset market clearing conditions; 2 goods market clearing conditions; $N + 2$ definitions of asset returns; and N budget constraints. As there are two periods, we can drop two equations due to Walras' Law. We will drop the market clearing conditions for the riskfree and global assets.

We first need to impose the zero-order components of all equations. This gives:

$$R_i(0) = R_g(0) = R_f(0) \equiv R(0) = \frac{1}{\beta}\left(\frac{Y_w}{D_w}\right)^{-\frac{1}{\gamma}} \tag{67}$$

$$Q_i(0) = Q_g(0) = Q_f(0) = \frac{1}{R(0)} \tag{68}$$

$$C_{i,1}(0) = \frac{\beta^{-\frac{1}{\gamma}}R(0)^{1-\frac{1}{\gamma}}}{1+\beta^{-\frac{1}{\gamma}}R(0)^{1-\frac{1}{\gamma}}}(Y_i + Q_i(0)K_i) \tag{69}$$

$$C_{i,2}(0) = W_i(0)R(0) \tag{70}$$

$$\sum_{j=1}^{N} \alpha_{ij}(0)W_j(0) = K_i Q_i(0) \tag{71}$$

where $Y_w = \sum_{i=1}^{N} Y_i$, $D_w = \sum_{i=1}^{N} D_i$ and $W_j(0) = Y_j + Q_j(0)K_j - C_{j1}(0)$.

The next step of the solution method involves jointly imposing the second-order component of the difference in portfolio Euler equations across countries together with the first-order component of all equations. This yields a solution to the zero-order component of the difference across countries in portfolio shares together with the first-order component of all other variables. We will follow this method, with one small difference. Rather than just imposing the second-order component of the difference in portfolio Euler equations across countries, we impose the second-order component of all portfolio Euler equations without taking the difference across countries. This will in addition give us a solution to the second-order component of the N equilibrium expected excess returns (which enter in the p_i that are solved from the zero-order component of the market clearing conditions).

First impose the first-order components of all equations. This gives

$$E(R_i(1)) = E(R_g(1)) = E(R_f(1)) \tag{72}$$

$$R_i(1) = R(0)(\varepsilon_i + \theta_i \varepsilon_g) \tag{73}$$

$$R_g(1) = R(0)\theta_g \varepsilon_g \tag{74}$$

$$R_f(1) = Q_f(1) = Q_i(1) = Q_g(1) = 0 \tag{75}$$

$$C_{j1}(1) = 0 \tag{76}$$

$$C_{j2}(1) = W_j(0)R_j^p(1) = W_j(0)\left(\sum_{i=1}^{N} \alpha_{ij}(0)R_i(1) + \alpha_{gj}(0)R_g(1)\right) \tag{77}$$

Next we impose the second-order component of the portfolio Euler equations. This gives

$$C_{j2}(0)E(R_i(2) - R_f(2)) = \gamma E C_{j2}(1)(R_i(1) - R_f(1)) \tag{78}$$

$$C_{j2}(0)E(R_g(2) - R_f(2)) = \gamma E C_{j2}(1)(R_g(1) - R_f(1)) \tag{79}$$

Using our result in (75) that $R_f(1) = 0$ and the expression for $C_{j2}(1)$ in (77), these equations can be rewritten as

$$\frac{1}{R(0)} E(R_i(2) - R_f(2)) = \gamma \sigma_g^2 \theta_i \left(\sum_{k=1}^{N} \alpha_{kj}(0)\theta_k + \alpha_{gj}(0)\theta_g\right) + \gamma \alpha_{ij}(0)\sigma_i^2 \tau_{ij} \tag{80}$$

$$\frac{1}{R(0)} E\left(R_g(2) - R_f(2)\right) = \gamma \sigma_g^2 \theta_g \left(\sum_{k=1}^{N} \alpha_{kj}(0)\theta_k + \alpha_{gj}(0)\theta_g\right) \tag{81}$$

Substituting (81) into (80) yields

$$\alpha_{ij}(0) = \frac{1}{\gamma R(0)\sigma_i^2 \tau_{ij}} \left[E\left(R_i(2) - R_f(2)\right) - \frac{\theta_i}{\theta_g} E\left(R_g(2) - R_f(2)\right) \right] \tag{82}$$

which is (18) in the text.

Appendix 2. An Additive Friction: the Luxembourg Effect

In this Appendix we will consider an additive financial friction τ_{ij}. We remove the information friction and assume that for all agents the variance of the idiosyncratic component of the country i equity payoff is σ_i^2. Instead we now assume that the return by investors from country j of investment in i is $R_i - \tau_{ij}$. We assume that this is not a loss in resources and that the revenue from this tax is spent right away. Alternatively one can also interpret it as a brokerage fee that is spent right away by the brokers. The costs τ_{ij} is assumed to be a second-order constant. This is to make sure that zero-order portfolio shares are well-defined as they depend on the second-order expected excess return divided by the variance of the excess return.

This change in modeling the friction does not affect the zero and first-order solution discussed in Appendix 1 for all variables other than portfolio shares. It does affect the zero-order solution of portfolio shares that is obtained from the second-order component of portfolio Euler equations. The portfolio Euler equations are now

$$E\left(C_j^2\right)^{-\gamma}(R_i - R_f - \tau_{ij}) = 0 \qquad i = 1 \ldots N \tag{83}$$

$$E\left(C_j^2\right)^{-\gamma}(R_g - R_f) = 0 \tag{84}$$

Their second-order components give

$$E(R_i(2) - R_f(2) - \tau_{ij}) = \gamma\sigma_g^2\theta_i\left(\sum_{k=1}^{N}\alpha_{kj}(0)\theta_k + \alpha_{gj}(0)\theta_g\right) + \gamma\alpha_{ij}(0)\sigma_i^2 \tag{85}$$

$$E\left(R_g(2) - R_f(2)\right) = \gamma\sigma_g^2\theta_g\left(\sum_{k=1}^{N}\alpha_{kj}(0)\theta_k + \alpha_{gj}(0)\theta_g\right) \tag{86}$$

(85) is similar to (80). There are two differences. First, τ_{ij} is now subtracted from the expected second-order component of the excess return on the left hand side. Second, the last term on the right hand side is no longer multiplied by τ_{ij} (information friction removed). (86) is exactly the same as (81).

Substituting (86) into (85) gives

$$\alpha_{ij}(0) = \frac{1}{\gamma\sigma_i^2}\left[E\big(R_i(2) - R_f(2) - \tau_{ij}\big) - \frac{\theta_i}{\theta_g}E\left(R_g(2) - R_f(2)\right)\right] \tag{87}$$

Using the same definition of p_i as in (26) in the text, we can also write this as

$$\alpha_{ij}(0) = \frac{1}{p_i} - \frac{\tau_{ij}}{\gamma\sigma_i^2} \tag{88}$$

Note that the financial friction now enters in the form of a separate additive term in $\alpha_{ij}(0)$ rather than multiplicative in the first term.

We then have

$$X_{ij}(0) = \alpha_{ij}(0)W_j(0) = \left(\frac{1}{p_i} - \frac{\tau_{ij}}{\gamma\sigma_i^2}\right)W_j(0) \tag{89}$$

Imposing asset market equilibrium $S_i(0) = \sum_{j=1}^{N} X_{ij}(0)$ gives

$$\frac{1}{p_i} = \frac{S_i(0)}{W(0)} + \frac{\hat{\tau}_i}{\gamma\sigma_i^2} \tag{90}$$

where $W(0) = \sum_{j=1}^{N} W_j(0)$ is world financial wealth and $\hat{\tau}_i = \sum_{j=1}^{N} (W_j(0)/W(0))\tau_{ij}$ is a weighted average financial friction that destination country i faces with all source countries.

Substituting (90) back into (89) gives

$$X_{ij}(0) = \frac{W_j(0)S_i(0)}{W(0)} + \frac{W_j(0)}{\gamma\sigma_i^2}\left(\hat{\tau}_i - \tau_{ij}\right) \tag{91}$$

Note that the last term is not proportional to the size of the destination country i as it usually is in gravity specifications. This implies that the additive financial friction does not lead to a gravity equation. Moreover, the absence of the size $S_i(0)$ of the destination country is the second term on the right hand side of (91) implies that

$$\frac{X_{ij}(0)}{S_i(0)}$$

will explode to plus or minus infinity when $S_i(0) \rightarrow 0$ and $\tau_{ij} \neq \hat{\tau}_i$. $S_i(0) \rightarrow 0$ corresponds to the source country becoming infinitesimally small, which leads us to refer to this as the Luxembourg effect. It says that for an infinitesimally small country the share of its assets held by a source country j explodes to plus or minus infinity when the bilateral firction that j faces with i differs (even slightly) from the average friction $\hat{\tau}_i$ that i faces with all source countries.

Appendix 3. Comparative Statics

Suppose the friction τ_{ij} changes to $\tau_{ij}^{'}$. We will compute the impact on X_{kl} for any country pair (k,l). Using that $P_l E_l = W_l$, the gravity equation for (k,l) becomes

$$X_{kl} = \frac{S_k W_l}{E} \frac{\Pi_k}{\tau_{kl}} \tag{92}$$

where

$$\frac{1}{\Pi_k} = \sum_{s=1}^{N} \frac{1}{\tau_{ks}} \frac{W_s}{E} \tag{93}$$

As discussed in the text, the zero-order component of wealth W_l of all countries is unaffected by changes in financial frictions, and neither is the value S_k of asset supply of all countries. So the only impact on X_{kl} comes through a change in Π_k and τ_{kl}.

When $k \neq i$ it is immediate that X_{kl} is unaffected. When $k = i, l \neq j$, only Π_k changes. We have

$$\begin{aligned}
X_{kl}^{'} &= \frac{S_k W_l}{E} \frac{\Pi_k^{'}}{\tau_{kl}} \\
&= \frac{S_k W_l}{E} \frac{\Pi_k}{\tau_{kl}} \left(\frac{\Pi_k}{\Pi_k^{'}} \right)^{-1} \\
&= X_{kl} \left(\Pi_k \left(\frac{1}{\Pi_k} - \frac{1}{\tau_{ij}} \frac{W_j}{E} + \frac{1}{\tau_{ij}^{'}} \frac{W_j}{E} \right) \right)^{-1} \\
&= X_{kl} \left(1 + \frac{W_j}{E} \frac{\Pi_i}{\tau_{ij}} \left(\frac{\tau_{ij}}{\tau_{ij}^{'}} - 1 \right) \right)^{-1} \\
&= X_{kl} \frac{1}{1 + \frac{X_{ij}}{S_i} \left(\frac{\tau_{ij}}{\tau_{ij}^{'}} - 1 \right)}
\end{aligned}$$

If $k = i$ and $l = j$, both Π_k and τ_{kl} change. Then

$$X'_{kl} = \frac{S_k W_l}{E} \frac{\Pi'_k}{\tau'_{kl}}$$

$$= X_{kl} \frac{1}{\frac{\tau'_{ij}}{\tau_{ij}} \left(1 + \frac{X_{ij}}{S_i} \left(\frac{\tau_{ij}}{\tau'_{ij}} - 1\right)\right)}$$

Appendix 4. Data Appendix

In this Appendix we further describe the data sources and computation for the variables used in the gravity equation estimation. Bilateral equity holdings data is from the Coordinated Portfolio Investment Survey by the IMF. We calculate home to home equity holdings by subtracting total external equity liabilities of a country, from the Coordinated Portfolio Investment Survey, from the total stock market capitalization of the country. The latter is obtained from the World Development Indicators by the World Bank.

Data on bilateral distance, adjacency and common language are obtained from the database by Rose (2004). For distance from home to home, we use the square root of land area divided by π. This is equal to the radius of a circle whose area is equal to the country area. Country size data are from the World Development Indicators by the World Bank. Time zone data are from CIA World FactBook. We use the time zone of the capital city. Legal origin data comes from La Porta *et al.* (1998). We classify countries into English Origin, French origin and German/Scandinavian origin.

There are three trade unions in the sample. The first is the European Union (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain, Sweden and United Kingdom). The second is the North American Free Trade Agreement (United States and Canada) and the last one is Closer Economic Relations (Australia and New Zealand).

Goods trade data are from the OECD STAN database. Following Helliwell (1996) and Anderson and van Wincoop (2003), total domestic goods trade is approximated as total industrial production in mostly goods-producing sectors, minus goods exports. Both total industrial production and goods traded are from STAN database. The goods-producing sectors are defined as the sum of agriculture, mining, and manufacturing. Since industrial production is expressed in local currency units, we convert it to current USD using period average nominal exchange rates from the IMF IFS (RF-ZF). Trade is divided by the product of GDP of the source and destination countries. Current USD GDP for each country is from the World Development Indicators.

For Freedom of Press, we use data provided by Freedom House. They publish the Global Press Freedom Ranking annually. They rate countries from 1 to 100, with 1 the freest country. We subtract their index from 100 to make the index an increasing function of freedom. We use data from 2005.

Financial market sophistication is drawn from the Global Competitiveness Report 2008-2009, World Economic Forum. Regulatory Quality is from the Worldwide Governance Indicators by the World Bank. For Size of Financial Sector, we use value added of the sector "financial intermediation, real estate, renting and business activities” from OECD-STATS. We divide by GDP, also from OECD.STATS. The series codes are respectively B1GJ-K and B1-GA.

For the percentage of population with a college degree, we use the number of individuals who finished tertiary Type-A education from UNESCO-OECD-Eurostat (UOE) data collection on education statistics. Tertiary Type-A education typically includes university education of four years. We divide by the population over age 15, which is obatined from IMF IFS series YP99P2L1-ST and YP99P3L1-ST. Following Vlachos (2004), we create regulatory similarity variables using 21 sub indexes of regulation related variables from La Porta *et al.* (2006). We refer to Vlachos (2004) for details of the construction.

Finally, for the principle component analysis in section 2.1 we use real stock return data. We use monthly nominal stock index data of each country from OECD.STAT. For Hong Kong, we use the daily Hang Seng index from Yahoo! Finance. Indexes are first converted to USD and then divided by the CPI. Exchange rate data is from IMF IFS series code DE.ZF. US CPI data is from IMF World Economic Outlook.