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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 without much of a theoretical foundation. In this paper we develop a theory for bilateral asset holdings that takes a gravity form. We discuss how to estimate international financial frictions and conduct comparative statics analysis within the context of the theory. We also find though that reasonable extensions of the model no longer generate a gravity form. While this does not significantly complicate estimation and comparative statics analysis, it raises questions about the empirical validity of gravity specifications for cross-border financial holdings that need to be addressed in future work.



## 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.

However, this explosion of empirical work on gravity for cross-border financial holdings has taken place without a solid theoretical foundation. As has been well established in the trade literature (e.g. Anderson and van Wincoop (2003)), estimating gravity equations that are not founded in economic theory can lead to biased estimation results due to omitted variables. It also leads to incorrect comparative statics analysis that does not take into account the general equilibrium effects of changes in cross-border barriers.

This paper is a response to this need for a theoretical foundation of a gravity equation for cross-border asset holdings. We will show that under a certain set of assumptions it is possible to derive a gravity equation for asset trade. We discuss how to estimate cross-border

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[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 et al. (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 (2011), Daude and Fratzscher (2008), de Santis and Gerard (2009), Eichengreen and Luengnaruemitchai (2006), Faruqee et al. (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), Kim et al. (2006), Lane and Milesi-Ferretti (2005a,b), Lane (2005), Lee (2008), Martin and Rey (2004), Pendle (2007), Portes and Rey (2005), Portes et al. (2001), Rose and Spiegel (2004), Veronique and Benassy-Quere (2006), Vlachos (2004) and Yu (2009).

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financial frictions in this context and how to conduct proper comparative statics analysis. The empirical work to date is often inconsistent with the theory in that either proper source and destination country fixed effects are not included or variables are included in the gravity equation that have no theoretical justification for being there (e.g. asset return correlations).[2]

However, we also show that when relaxing the assumptions of the model in many reasonable directions it is no longer possible to write bilateral asset holdings in a gravity form. It is still possible to estimate international financial frictions in this case and to conduct comparative statics analysis. But this is based on more complex non-linear equations that relate bilateral asset holdings to all bilateral financial frictions, measures of country size and asset return risk.

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.

As discussed in Anderson and van Wincoop (2004), two key assumptions are needed to generate a gravity specification for trade in goods where bilateral trade is a product of measures of economic size, a bilateral barrier and multilateral resistance indices. The first is trade separability, which says that total production and expenditure are separable from the bilateral allocation of trade across countries. The second condition is that demand depends on a relative price, such as the price of goods from a particular country relative to an overall price index. These conditions are satisfied in 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).

Such conditions also need to be satisfied to derive a gravity specification for asset trade. A condition analogous to trade separability is that decisions about the overall demand for assets (affected by saving) are separable from the portfolio allocation across assets. This condition is the least problematic and holds in many models. The second condition, that asset demand depends on a relative price, is far less trivial than for goods trade. Asset demand naturally takes a very different form than demand for goods. 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. In that context it is not trivial to relate demand for individual assets to a relative price. Not surprising therefore, we find that a gravity specification for asset trade is much less robust to changes in model assumptions than in the trade literature.

In order to derive our theoretical gravity equation, we start from a simple static portfolio choice framework. Investors can hold claims on risky assets from a large number of countries. Asset returns are affected both by a country-specific and a global component. 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 about the country-specific return components.[3] 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) divided by a 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.

We consider a variety of generalizations of this benchmark model in which the gravity result falls apart. In particular, we consider the case where there do not exist separate assets that allow agents to hedge factors contributing to cross-border return correlations. We also consider different financial frictions that take the form of a tax on foreign returns. And finally, we consider the case of only trade in risky assets, which captures an extreme case of borrowing constraints associated with the riskfree asset. In all these cases it is no longer possible to write bilateral asset holdings in a gravity form as the product of country-specific variables (economic size, multilateral resistance or any other country-specific variable) and a bilateral friction.

There are two other theories in the literature that generate a gravity specification for asset trade. One approach is that by 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 (2009) 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.

The main limitation of this approach though is that it is not applicable to the types of financial holdings for which we have cross-border data: bilateral equity, bond and bank holdings. The reason is that these assets, on which the empirical gravity literature is based, have non-zero payoffs in multiple states. More precisely, if the asset from one country has a non-zero payoff, assets from other countries generally have a non-zero payoff as well. In the AD framework, if the asset of a country has a positive payoff, the assets of all other countries have a zero payoff.[4] Turning the argument around, it is sometimes argued that any risky asset can be written as a combination of AD securities. But the problem is that these will then be a combination of AD securities from different countries, so that the risky asset is not specific to a particular country.

A second alternative way to derive a theoretical gravity equation, 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

[2] There are a couple of exceptions though, including Coeurdacier and Martin (2009), Lane (2005) and Vlachos (2004), where estimation is done in a way that is consistent with the theory that we will develop here. It should also be said that while presently there is no justification for many of the existing empirical gravity specifications, we cannot prove that they have no theoretical foundation. All we can say is that currently there is no theory justifying such specifications and it is best for empirical work to be consistent with existing theory.

[3] A substantial literature has documented the relevance of such information asymmetries across countries. See for example Bae et al. (2008), Ahearne et al. (2004), Portes and Rey (2005), Kang and Stulz (1997) any many references in those papers.

[4] This also implies that correlations between the returns on Arrow Debreu securities are actually negative. To see this, let $r_1$ and $r_2$ be the return on assets that only have a payoff in respectively state 1 and 2 (e.g. $r_1(1)>0$, $r_1(s)=0$ for $s\neq 1$). Assuming that states 1 and 2 have non-zero probabilities $\pi(1)$ and $\pi(2)$, we have $\text{cov}(r_1, r_2)=Er_1r_2-Er_1Er_2=-\pi(1)\pi(2)r_1(1)r_2(2)<0$. This stands in contrast to the generally positive correlation between asset returns across countries when applied to stocks, bonds or bank earnings.