The Global Disconnect:
The Role of Transactional Distance and Scale Economies in Gravity Equations

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Abstract

Recent empirical analyses show that asset flows can be modeled by the same "gravity" equations that trade economists have used so successfully for the past few decades. This is something of a surprise. Trade economists do not yet have a unified theory of why gravity models should work—and the situation is worse for asset flows. Reasonable theories would predict that greater distance between countries should generate more asset flows rather than less as the econometric results seem to consistently show. In this paper we discuss how host and source country GDPs, language, and distance—the core explanatory variables in the traditional gravity models—fare in trade and asset flows estimations. While the "distance puzzle" is not resolved, it is considerably reduced by going beyond consideration of physical distance to concepts of transactional distance and scale economies.

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1. Introduction

The nations of the world remain stubbornly apart. Physical separation acts as natural barrier, restricting trade and asset flow linkages across nations. Despite apparent globalization, the constraints due to distance have remained significant. Thus, at a time when globalization is taken for granted—and policymakers and others debate the pros and cons of the associated changes—it is not obvious that the nations of the world are truly coming closer together.

In this paper, we estimate gravity models for trade and foreign direct investment (FDI) flows to explore if comparisons of the two sets of estimates can clarify the role of distance and, hence, the nature of global linkages. Gravity models postulate that bilateral international transactions are positively related to the size of two economies and negatively to the distance between them. A selective literature review suggests that, though they are widely used as empirical benchmarks, coefficients in the gravity equation vary widely and, moreover, do not have straightforward interpretations. In particular, the large fall off observed in trade and investment flows with increasing physical distance remains a puzzle.

Evidence of the global disconnect comes in two forms. First, nations trade in goods and assets to a smaller extent than would be warranted by the gains from increased specialization and possibilities of risk diversification. In a recent contribution Obstfeld and Rogoff (2000) discuss the various disconnections, more commonly referred to as "puzzles." The puzzles are especially troubling in relation to asset flows since national borders should have little or no bearing on investments in financial assets. Thus, the continued persistence of the "home bias" in equity investment (disproportionately high investment by residents in domestic assets) and of the Feldstein-Horioka puzzle (the high correlation between domestic savings and domestic investment) are among the important stylized facts that reflect the limits to international transactions in financial assets. The second set of evidence shows that the international transactions that do occur, both in goods and financial assets, are strongly conditioned by the physical distance between countries. It is this latter evidence—based on so-called "gravity" models—that is the focus of this paper.

But why exactly does distance matter? Most obviously, greater distance can be thought of as a proxy for higher transportation costs. If distance is truly a good proxy for transport costs, then it has a special attraction. Obstfeld and Rogoff (2000) have proposed that transportation costs may, in fact, be relevant not only for trade but also for the constraints in international asset transactions. This line of reasoning could explain the finding that distance appears with a negative and highly significant sign in gravity equations for FDI and for financial assets.

However, there are at least two problems in identifying distance with transport costs. First, Grossman (1998) has argued that for plausible values of transport costs, the distance coefficient in trade equations should be much smaller in magnitude than the typically estimated coefficient. Second, various theoretical models predict that distance should actually appear with a positive sign in asset flow equations. Thus, FDI from a source country may increase with distance if high transport costs make it expensive to export to the host country destination (Brainard 1997). For financial assets, greater distance between source and host country should be associated with reduced correlation of business cycles and hence, through greater possibilities for diversification, to more equity flows (Portes and Rey 2000).

Thus, some authors have pursued the notion that distance captures more than transport costs. More specifically, Rauch (1999) suggests larger distance may be associated with greater information and search costs. Similarly, Eichengreen and Irwin (1998) suggest that trading partners build long-term relationships that embody significant informational capital. When they proxy for such information capital through the addition of the lagged dependent variable as an additional regressor, the distance coefficient—and hence the short-run distance elasticity of trade—drops sharply. However, as we discuss, some have argued that this resolution of the distance elasticity is far from satisfactory. Finally, Portes and Rey (2000) and Portes, Rey, and Oh (2001) deal with the possibility of information ease by adding bilateral telephone traffic as a regressor in the gravity equation for financial asset transactions. They find that ease of information flows is important for those categories of financial assets that are the least standardized or where private information has high value. Once again, the coefficient for physical distance falls when explicit account is taken of ease of communication.

In this paper, we pursue two sources of the global disconnect: "transactional distance and scale economies." Obstfeld and Rogoff (2000) suggest the concept of "transactional distance," which could be thought of as a hedonic measure of physical and informational distance, a more inclusive measure of the costs of undertaking transactions. From a theoretical viewpoint it is this multifaceted transactional distance that creates frictions in goods and asset markets. The possibility that "distance" may be lowered through reducing the barriers to informational flows creates optimism for countries that are located at large distances from the main trading and financial centers.

However, the possibility also exists that information networks are associated with significant scale economies on account of network externalities. Transactional scale economies could thus reinforce agglomeration economies due to proximity or due to paucity of private information (as discussed in Kinoshita and Mody 2001) and thus enhance trade and investment flows between select (typically the richer) locations by reducing the costs of intra-industry trade generated through such forces as preference for variety in consumption, specialization in the production of intermediate inputs, and monopolistic competition.

This paper has two additional sections. We begin with selective review of the "distance puzzle": how does the literature interpret the distance measure and the estimated distance elasticities; how have past efforts incorporated informational distance in gravity models; and what insights do we gain from comparisons across trade and asset gravity models? We then present some new results for trade and FDI gravity equations to assess the importance of information links, consider the endogeneity of such links, and finally discuss the interactions between physical distance and informational infrastructure in driving trade and investment flows.

2. The "Distance Puzzle"

The gravity equation postulates a positive relationship between trade (or investment flows) and the sizes of the host country and source countries and a negative relationship with physical distance between the host and source countries. Size proxies, or scale variables, typically include two of the following three: GDP, population, and per capita GDP. While GDP measures the economic size, there is a theoretical basis for also including per capita income since whether a country is rich or poor may make a difference to its trading and international investment patterns.

As noted above, both trade in goods and services and trade in assets have been found in earlier studies to be strongly negatively correlated with distance, more so than is predicted merely by a consideration of transport costs. This suggests that distance is likely proxying for both transportation and transactions/information costs associated with trade and that further tests are needed to sort out the relative importance of each. This section describes some attempts that have been made in the literature to analyze the implications of distance barriers. Our bottom-line conclusion is that while a number of interesting hypotheses have been advanced and tested in the literature, we are still far away from a convincing explanation for why distance matters.

2.1 Trade in Goods and Services

Gravity models have described bilateral trade flows empirically for four decades now. Until fairly recently, distance was taken as a proxy for transportation costs. In all studies, distance enters the bilateral trade equation with a negative sign and with a magnitude in the range of –1.5 to –0.8. It is almost always statistically significant despite the inclusion of a multitude of other independent variables. Grossman (1998, p. 31) notes that while the sign on the distance coefficient is plausible, the magnitude is not. He presents an illustrative calculation suggesting that if shipping costs are of the order of 5 percent of the value of traded goods, then the distance elasticity should be around –0.03 rather than the much higher values reported in the empirical work.

Eichengreen and Irwin (1998) argue that historical factors are an important omitted variable in many gravity models and that including a lagged dependent variable is a way of capturing such factors. When a lagged dependent variable is included, the estimated (short run) distance elasticity drops in magnitude, and is in some instances close to about -0.10. However, this resolution of the "distance puzzle" appears far from satisfactory. First, as noted by Lawrence (1988, p. 58), "the appearance of lagged dependent variables with large coefficients can be rationalized as lagged adjustment, but it may also indicate serious misspecification." For example, it could be that what is really missing from the gravity model is lagged values of the independent variables. While inclusion of a lagged dependent variable may be thought of as a parsimonious way of including the other lagged independent variables, it imposes the timing of adjustment to all independent variables to be the same; this may be implausible. Second, while inclusion of a lagged dependent variable lowers the estimate of the short run distance elasticity, the estimate of the long-run elasticity still remains quite large.

Anderson and Wincoop (2001) propose that estimating a more theoretically grounded gravity equation can account for the large effect of national borders on the volume of trade observed by McCallum (1995). However, while Anderson-Wincoop's estimation shrinks the size of the border, it does not have much of an impact on the distance elasticity, which remains on the order of –0.80.

Rauch (1999) presents some evidence that proximity and common language/colonial ties are more important for trade in differentiated products than for trade in products traded on organized exchanges. Surprisingly, distance effects are smaller for organized exchange commodities than for differentiated commodities. However, the differences across markets are fairly small and the estimate of the distance elasticity remains in the range of –0.8 to –0.6.

2.2 Multinational Sales and FDI

The literature on multinational sales and FDI typically emphasizes the distinction between horizontal and vertical FDI. As noted by Lim (2001, p. 12), horizontal FDI will tend to replace exports if the cost of market access through exports is high. If transport costs are higher the greater is the distance between host and source countries, then horizontal FDI should increase with distance. However, vertical FDI—where the production process is geographically fragmented—may be discouraged by distance because of the need to ship intermediate inputs and semi-finished products. Since the data on FDI are a mix of horizontal and vertical FDI, the impact of distance is uncertain.

Empirically, Carr, Markusen and Maskus (2001) find that production by foreign affiliates of multinationals decreases with distance between the host and source countries. Other studies that use data on bilateral FDI also tend to find that it decreases with distance. For instance Wei (2000) finds that a "1 % percent increase in distance is associated with a 0.6 % reduction in the FDI." When he uses a modified Tobit estimation technique to account for the zero observations on FDI, the distance elasticity drops to –0.30, but remains highly significant. Similarly, Evenett (2001) finds the distance elasticity in the same range as Wei (2000).

In contrast, Brainard (1997) uses a more direct measure of transport costs, namely, the freight and insurance charges reported by importers. She finds that the higher are such transport costs, the higher is the share of overseas production by multinationals relative to their exports. Hence there is support for the hypothesis that horizontal FDI should increase with transport costs. While this is an appealing direct test of the role of transport costs, Brainard does not include distance as a separate regressor. Hence, she does not provide evidence on whether her transport cost measure accounts fully for the impact of distance on FDI.

2.3 Portfolio flows

Portes and Rey (2000) estimate a gravity equation for trade in financial assets. They note that transportation costs or transactions costs should not play a big role in trade of assets because these assets "are pretty weightless." They add: "And as far as transactions costs are concerned, they seem very small, a few basis points, and not clearly connected with geographical features. Therefore, distance seems a highly improbable variable to encounter in a regression explaining asset trade." If portfolio diversification is an important motive for trade in assets, it might even be argued that distance should increase asset trade if business cycle correlations between countries decrease with distance. Their empirical finding, however, is that distance comes up remarkably strongly with a negative sign in a gravity model estimated using data on cross-border transactions in portfolio equities.

This finding suggests that informational costs have to be at least partly behind the impact of distance on trade. Countries that are near each other probably know more about each other because of greater interaction between their citizens, more media coverage, or greater knowledge of each other languages. Portes and Rey (2000) introduce a measure of bilateral telephone traffic to proxy for transactional distance between countries. Portes, Rey and Oh (2001) further test the relevance of informational barriers by estimating gravity models for trade in different financial assets. Trading in homogenous products such as treasury bonds should pose fewer informational barriers than trade in equities or corporate bonds. Empirically, they find that distance does not matter for trade in treasury bonds (once they control for ease of information flows through their measure of the telephone traffic between countries).

3. Informational Infrastructure in Gravity Equations

In this section, we pursue one avenue for a deeper understanding of the significance of distance between nations: the role of informational infrastructure. Cheaper communications bring the promise of reducing the global disconnect. What is the evidence? We ask three questions:

- To what extent are physical and informational distance correlated?
- Is informational distance between countries endogenous? And, if so, how does accounting for the endogeneity influence the results?
- Do physical and informational distance substitute for or complement each other? And, does the degree of substitution or complementarity vary for developing and developed countries?

3.1 Data and Methodology

The data for the analysis of FDI flows is drawn from the International Direct Investment Database of OECD (www.oecdsource.org).[1] For 12 source countries, FDI flows to 45 host countries are available on an annual basis from 1981-1998.[2] The FDI flows are *inflows* from the host country's perspective. To facilitate comparison, we created a matching

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[1] We used the series on outflows from a source to a host country but also relied on the outward position (stock of FDI) for crosschecking.

[2] The *source countries* are: Australia, Austria, Canada, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, United Kingdom and United States. The *developed host countries* are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. The *developing host countries* are: Argentina, Brazil, Chile, China, Colombia, Ecuador, Egypt, Hong Kong, India, Korea, Kuwait, Malaysia, Mexico, Nigeria, Peru, Philippines, Saudi Arabia, Singapore, South Africa, Taiwan, Thailand, Turkey and Venezuela.

data set for exports from the same source countries to the same host countries, using data from the IMF's *Direction of Trade Statistics*. From the host country's perspective, these are *imports* and we refer to them as such in the rest of the paper. To reduce the noise in the data, we took three-year averages of all variables. This gives us 6 time periods and allows us to control for unobserved host country characteristics through panel data techniques. In principle we have a maximum possibility of 3240 observations (12x45x6); however, on account of missing data we lose some observations.

To obtain "real" flows over time, we deflated the nominal flows by an index of the unit value of manufactured exports obtained from the IMF's *World Economic Outlook*. For our independent variables, we obtained data from a variety of sources: host and source country populations (the World Bank's *World Development Indicators*), real host and source country GDPs (the IMF's *World Economic Outlook*), physical distance between countries (Shang Jin Wei's website: *www.nber.org/~wei*), bilateral telephone traffic (*Direction of Traffic: Trends in International Telephone Tariffs*, International Telecommunications Union) and telephone densities (the World Bank's *World Development Indicators*).

An important substantive issue, with econometric implications, is that over one-third of the FDI flows are zero.[3] In contrast, though trade flows are sometimes modest in size, they are virtually always positive for the pairs in our data set. We would expect, therefore, that the elasticities are greater for FDI; however, to correctly estimate these elasticities we need to consider the bias due to FDI values being censored at zero. Thus, for the FDI flows,

[3] In the actual dataset, a clear distinction was not always made between a zero flow and a missing value. Based on other corroborating evidence, we imputed several "zero" values.

we use the so-called “Tobit” model that estimates the coefficients through a maximum likelihood procedure. This is not necessary for the trade equations. For both trade and investment flows, we control for host country effects.[4]

3.2 Correlation between Physical and Informational Distance

If an important variable was omitted in the equations being estimated and that variable was correlated with distance, then the influence of the omitted variable would be incorrectly attributed to distance. Figure 1 illustrates the problem. Bilateral information capability (I) and trade/FDI are shown in the figure to be characterized by a positive relationship. The influence of physical distance is shown by assuming that for any value of I, a larger distance ($D_2 > D_1$) results in lower volume of trade or FDI, i.e., by shifting the trade/FDI-information relationship down. Thus, the “true” impact of distance would be the vertical difference between the two parallel lines. Now, if it were the case that greater distance was correlated with low information capability, then we would observe two points (T_2,D_2) and (T_1,D_1). Failure to explicitly account for informational distance would then result in inferring a much greater impact of distance measured as the vertical distance between T_1 and T_2 rather than the vertical distance between the two lines. The steeper the slope of the trade/FDI-information curve, the more serious would be the omitted variable bias.

[4] We use random effects models, estimated by STATA using the procedures xtreg and xttobit. We do not use time dummies since these correlate with other variables on the right hand side and we also do not use source country dummies since source countries seem well-characterized by their populations that are slowly moving.

Table 1 considers the consequences of including bilateral telephone traffic as an additional regressor (but not yet controlling for the endogeneity of the bilateral traffic). The main findings are easily summarized. First, both trade and FDI increase with host and source country populations and with country per capita incomes. The size of these coefficients is significantly less than one for trade (with one exception, when it is almost exactly one) but is always higher than one and generally substantially so for FDI flows. Thus, there is evidence of scale economies in FDI, reflecting in part the fact that many country pairs have no FDI transactions and thus FDI is much more concentrated than are trade flows. The size of the coefficients on per capita income also implies that intra-industry activity is much more pronounced for FDI (for similar results, see Eaton and Tamura 1994).

Second, the distance coefficient is negative and highly significant in both sets of equations. Compare column (1) for trade with the corresponding column (3) for FDI. The distance coefficient is somewhat larger in size for FDI. Similarly, the language coefficients are positive—with the relative sizes implying that common language helps FDI more than trade. Thus, both distance and language are consistent with an inference that information costs are higher for FDI, an inference that is reinforced when we consider the influence of bilateral telephone traffic.

Third, when we add bilateral telephone traffic (normalized by the square root of the product of the source and host country GDPs) as an additional regressor (in columns (2) and (4)), we find that this variable is positive and highly significant, with the FDI coefficient again being much larger. At the same time, the coefficients for distance and language fall significantly. The decline in these coefficients, moreover, is greater for FDI than for trade.

In combination, these results suggest that greater physical distance between two countries is associated with lower telephone traffic. In part, therefore, distance proxies for the inability to communicate. That this effect is present even for trade suggests that information and search costs are also important in creating disconnections in trade. That the effect, however, is greater for FDI is not surprising because informational distance has greater relevance for investment decisions that tend to be more irreversible than trade flows. The economic size of these effects is significant. The index of telephone traffic (traffic normalized by the square root of the product of the source and host country GDPs) was about 2.5 in the first three-year period, 1981-1983 and rose steadily to 2.7 in the final three-year period, 1996-1998, an increase of 0.2 units. The coefficient on telephone traffic for FDI is 3.2, implying that an increase in the telephone traffic intensity of 0.2 is associated with roughly a 65 percent increase in FDI. Real FDI flows over the same period increased by about 700 percent.

Finally, in column (5), we present results with the log FDI minus the log of imports as the dependent variable. Though the R-squared for this regression is rather low, it is consistent with the results presented above for the individual flows. FDI is more sensitive to size of host country population and to both host and source country per capita incomes, reflecting the greater scale economies and intra-industry activity associated with FDI. Note that FDI travels greater distances than does trade, consistent with horizontal FDI undertaken to overcome transportation barriers to trade (the distance variable, however, is significant only at the 10 percent level). Common language has a more positive effect on FDI than on trade, reflecting its more intense informational requirements. Also, heavier bilateral telephone traffic leads to more FDI, though this variable is surprisingly not significant (considering the large difference in the individual equations); when we control below for endogeneity of telephone traffic, the sign remains positive and the coefficient then is statistically significant.

3.3 Endogeneity of Telephone Traffic

Bilateral telephone traffic may be endogenous: more trade and FDI may result in greater communication. Also, measured telephone traffic between countries may not accurately reflect their capacity to communicate. Thus, it is important to distinguish between telephone "traffic," the actual volume of calls between nations, and informational infrastructure, or the physical capacity to make calls. While traffic is potentially endogenous and, therefore, may respond to international trade and investment flows rather than "causing" them, the infrastructure (proxied here by telephones per capita in the source and host countries) is slower moving and, over short time spans, can be thought of as exogenous to international flows. Moreover, additional information infrastructure is characterized by strong scale economies due to network externalities—the benefits increase as users are added to the network. Thus, better-developed information infrastructures in two trading economies can reduce transactions costs between those economies at an increasing rate.

Figure 2 illustrates the possibility of endogeneity in telephone traffic, combined with scale economies in information infrastructure. FDI is used as the example, though the same line of thinking can apply to trade also. The steeper curve, marked as the "supply of FDI," reflects the willingness of foreign investors to increase their FDI flows as infrastructure availability improves the ease of communication. The endogeneity arises when foreign investment, in turn, spurs greater bilateral communication—reflected by the line with the smaller slope. Notice, if the curves have the relative slopes as drawn, then the tendency beyond a threshold (the point at which the two lines intersect) would be for more foreign investment to induce greater communications capability, which in turn would spur more investment and so on. In contrast, below the threshold, bilateral investment and communications could both unravel and go to zero. In practice, we do observe that many countries receive no investment from several source countries and that FDI is highly concentrated. We do not see the extreme concentration suggested by figure 2 presumably because there are adjustment costs and other countervailing factors.

To test these propositions, we attempted to control for the reverse causation using instrumental variables for bilateral telephone traffic. The main instruments we used were the telephone densities in the host and source countries. These variables have a statistically significant effect on telephone traffic.[5] We also used year dummies to allow for the possibility of secular increase in telephone traffic. Finally, for the trade equation, we report a result using lagged imports as an additional instrument; though this result is interesting, further work would be necessary to justify the use of the lagged dependent variable as a valid instrument.

Again, a few salient features of the results may be noted (Table 2). First, for trade, it makes a difference whether lagged imports are included or not as an instrument. When, and only when, that variable is included, the coefficient on distance falls sharply, to -0.29. Otherwise, the endogeneity correction does not have much of an effect for the trade equation.

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[5] The correlation between the actual and predicted telephone traffic is about 0.76. See footnotes to Table 2 for a complete description of the "first-stage" regression.

Second, for FDI, the effects observed are robust to the inclusion or otherwise of the lagged dependent variable—the results shown do not include it. The instrumented telephone traffic variable is statistically more significant and quantitatively more important than before. This could either imply that bilateral telephone traffic mismeasures "communications capability" between countries and failure to take the mismeasurement into account biases the coefficient downwards. Alternatively, endogeneity is a serious concern: more investment does increase bilateral traffic, but the stimulus from communications capacity to investment is the stronger relationship, which is camouflaged when endogeneity is not considered. Note that superior communications capability is now seen to more clearly favor FDI than trade (column (4)). Third, the distance coefficient is now *positive* for FDI, strengthening the case that horizontal FDI lies behind the results. The insignificant sign of this coefficient reflects differences across country groups, as discussed below in section 3.4. The clear implication, however, is that properly measured telecommunications capacity is highly correlated with physical distance and direct consideration of "transactional distance" reduces the apparent influence of geography on FDI. The implication, however, also is that strong network economies operate to strengthen ties between countries with sound communications. Fourth, the language coefficients turn negative, as if they primarily proxied better telecommunications, and once we control directly for such capacity, then common language countries are not necessarily favored.

To test the robustness of the informational distance variable, we estimated also a fixed-effects model that controlled for host- and source-country pair dummies. Thus, all unchanging relationships between host and source countries, including distance, linguistic ties, and other possible variables that are omitted by us, are accounted for in this procedure.

This procedure allows us to test if informational distance was merely proxying for some unobserved variables or is still relevant when the observed and unobserved country pair characteristics are controlled for. Columns 5 through 7 of table 2 show the results. The results are robust. Informational distance is clearly important and is more important for FDI than for trade, as the earlier results also showed.[6]

3.4 Are Physical and Informational Distance Substitutes or Complements

Thus far, we have been concerned with explaining the distance puzzle and so have focused on whether the influence of physical distance is exaggerated on account of omitting bilateral information capacity. In this section, we presume that both physical distance and informational distance are relevant in determining trade and FDI flows and ask if these two forms of distance are substitutes or complements.

Three possibilities exist. First, if better information can substitute for physical distance, then we would find (as in figure 3a) that greater physical distance is a disadvantage but less so as information capacity between the countries increases. In this case, we would expect to find a positive sign on the interaction between physical distance and our information variable. Second, the opposite is possible (figure 3b) if the effect of physical distance gets magnified when there is greater information capability, leading to a negative sign on the interaction term. This may occur when, for example, trade in differentiated

[6] Also, instead of estimating the relationship in a panel data setting, we estimated the relationships for each of the six periods that our data permits. These results are very extensive and so are not reported here. The main finding is confirmed: the distance elasticity falls in absolute magnitude with the introduction of bilateral telephone traffic and reduces further, especially for FDI, when endogeneity of telephone traffic is accounted for.

products dominates: such trade is information intensive and benefits from lower freight costs (shorter physical distances). Finally, FDI adds a special consideration since horizontal FDI increases with greater distance while vertical FDI (like trade) is discouraged by greater distance. Figure 3c suggests that horizontal FDI is likely to dominate when bilateral information capability is below the threshold I* and physical distance generates more FDI as information capability becomes less effective. In contrast, when information capacity is above I*, then (as with trade) more vertical FDI occurs, encouraged by shorter distances and greater information transactions capability.

Table 3 presents the results with the interaction term, separately for all countries, developed countries, and developing countries.[7] Consider first the relationships for trade. For all countries, and for the range of values on our information variable, the distance elasticity is always negative; but (as in figure 3b) the elasticity is increasingly negative for higher values of the information index since the interaction term is negative. The implication is that differentiated products' trade has a dominant effect on these regressions and that physical proximity and high information intensity reinforce each other in fostering such trade.

Note, however, from column (2) that this pattern reflects trade within the group of developed countries. Considering the exports from the same host countries to developing

[7] F-tests showed that it is appropriate to distinguish between developed and developing countries. The list of developed and developing countries is in footnote 2.

countries, we find the interaction term to be positive.[8] This is more akin to figure 3a where information capability can substitute for distance disadvantage.

For FDI, developed and developing country patterns are, once again, quite different. For developed countries, for the range of the information index, the distance elasticity values are now almost always *positive*, implying in terms of figure 3c that the bulk of the observations lie to the left of I* where horizontal FDI predominates. Thus, within developed countries, FDI appears to mainly substitute for trade, though the extent of vertical FDI, which is complementary to trade, increases with the capability for information exchange.

For developing countries, as observed above for trade, physical distance acts as a disadvantage for FDI for almost the entire range of telecommunications capacity. Thus, the same forces that limit trade to distant developing countries appear also to restrict FDI. However, once again, as communications improve, they compensate for physical distance and the distance elasticity becomes less negative.

4. Conclusions

In this paper, we demonstrate that a comparison of trade and FDI flows can prove useful in achieving a deeper understanding of global linkages. The good news is that the geographical tyranny of distance is less potent than has been thought. This creates a more optimistic basis for bringing nations together. However, though geography is less powerful

[8] In both the trade and FDI regressions for developing countries, we had to drop the communications variable by itself since its inclusion generated significant multicollinearity and the coefficients were not significant, though they were signed as in the regressions presented.

than implied by many studies, economic forces can act to maintain distance among nations. We find, in particular, that informational infrastructure matters in fashioning global linkages.

Comparing trade and FDI flows, we find that, in keeping with its greater geographical concentration, FDI is more sensitive to scale variables such as population and per capita income. Similarly, FDI is more sensitive to bilateral informational capability.

Key to the reduction of the distance puzzle is the concept of transactional distance, a measure that encompasses the ability to communicate and undertake transactions. Empirically, this can be implemented by adding telephone traffic as an additional regressor in gravity equations, as suggested by Portes and Rey (2000). We find that trade and investment flows increase as “transactional distance” falls. However, since telephone traffic is likely to be influenced by the trade and investment dependent variables, consideration of the potential endogeneity of bilateral telephone traffic is necessary and turns out to have quantitatively important effects for FDI. Once endogeneity is considered, the implausibly large effects of physical distance decline sharply in FDI equations and the distance coefficient actually turns positive, suggesting the prevalence of so-called “horizontal” FDI undertaken to overcome costs of transporting goods. For trade equations, the decline in the distance coefficient depends on the addition of lagged imports as an instrument; further work would be needed to justify this approach.

Our results further suggest that for FDI scale economies can be misconstrued as distance effects. If FDI benefits from scale economies, then firms will concentrate in a limited number of locations. Thus, countries far away from major investment centers may receive relatively small amounts of investment, but this would be the outcome of agglomeration benefits in closely located nations rather than because transportation costs create disincentives to investment in distant locations. In turn, agglomeration may arise due to several reasons: traditional benefits of proximity (Wheeler and Mody 1992), private information costs that cause firms to follow each others' lead (Kinoshita and Mody 2001), or because, as the results in this paper suggest, international information networks are associated with scale economies. Of course, each of these sources of agglomeration is likely to reinforce the other.

Finally, we find that developing countries can invest in superior information infrastructure to overcome the disadvantage of distance, i.e., information flows can substitute for distance. In contrast, within developed countries, physical proximity of nations and greater information capacity reinforce each other, in keeping with the differentiated products nature of the trade and investment flows that benefit from the ability to move goods rapidly and from the greater ease of communication. The evidence is also consistent with the generally held view that the bulk of the FDI within developed countries is "horizontal" in nature.

Table 1: Gravity Models for Imports and Inward Foreign Direct Investment

	DEPENDENT VARIABLE				
	LOG IMPORTS		LOG FDI		LOG FDI-LOG IMPORTS
	(1)	(2)	(3)	(4)	(5)
Log host population	0.636 (8.50)	0.478 (6.44)	1.361 (30.65)	1.821 (16.73)	0.418 (3.63)
Log source population	0.981 (93.17)	1.023 (98.27)	1.358 (34.66)	1.535 (36.36)	-0.006 (-0.21)
Log host per capita income	0.764 (13.74)	0.597 (10.87)	2.471 (36.28)	1.404 (17.35)	0.599 (5.60)
Log source per capita income	0.665 (12.58)	0.767 (15.03)	2.773 (14.88)	3.218 (17.35)	1.390 (10.49)
Log distance	-0.923 (-57.2)	-0.775 (-43.2)	-1.199 (-25.12)	-0.639 (-10.70)	0.084 (1.79)
Common language	0.416 (9.75)	0.179 (4.13)	1.303 (9.66)	0.749 (4.70)	0.738 (6.43)
Telephone traffic		0.952 (16.12)		3.218 (14.10)	0.182 (1.19)
Number of host country groups	44	44	44	44	44
Number of observations	2,870	2,870	2,934	2934	2870
R-squared: within*	0.804	0.821	-	-	0.067
R-squared: between*	0.703	0.663	-	-	0.112
R-squared: overall*	0.751	0.739	-	-	0.078
Log of Likelihood*	-	-	-4697.57	-4650.89	-

Note: All estimates are based on the assumptions of random country effects for host countries. *Z*-statistics are presented in the parentheses.
*Columns (4) and (5) were estimated using the Tobit method to allow for the substantial number of observations with a zero value for foreign direct investment. For these regressions, an R-squared is not reported but the log of likelihood is.

Table 2: Gravity Models for Imports and Inward Foreign Direct Investment: Instrumental Variable Estimates

	ESTIMATION METHOD AND DEPENDENT VARIABLE						
	RANDOM-EFFECTS				COUNTRY PAIR FIXED-EFFECTS		
	LOG IMPORTS	LOG IMPORTS	LOG FDI	LOG FDI-LOG IMPORTS	LOG IMPORTS	LOG FDI	LOG FDI-LOG IMPORTS
	(1A)	(1B)	(2)	(3)	(4)	(5)	(6)
Log host population	0.775 (14.56)	0.547 (7.03)	1.765 (26.79)	0.475 (4.16)	0.881 (34.28)	1.971 (19.90)	0.576 (7.41)
Log source population	1.132 (114.01)	1.010 (84.81)	1.676 (38.96)	0.101 (3.43)	0.793 (21.62))	1.309 (9.61)	0.250 (2.26)
Log host per capita income	0.716 (15.89)	0.710 (12.49)	1.586 (24.13)	0.570 (5.42)	0.813 (33.12)	2.132 (22.34)	0.867 (11.68)
Log source per capita income	1.425 (28.81)	0.778 (13.63)	4.026 (21.17)	1.751 (12.77)	-0.012 (-0.13)	3.881 (10.57)	2.083 (7.29)
Log distance	-0.292 (-13.11)	-0.803 (-28.30)	0.088 (1.01)	0.536 (7.95)			
Common language	-0.480 (-10.97)	0.249 (4.64)	-0.401 (-2.43)	0.098 (0.74)			
Telephone traffic**	3.580 (36.14)	0.651 (5.11)	6.982 (17.25)	2.624 (8.84)	1.167 (10.99)	4.712 (10.90)	1.268 (3.95)
Number of host country groups	43	44	44	44	44	44	44
Number of observations	2407	2,870	2934	2870	2870	2934	2870
R-squared: within*	0.882	0.806	-	0.090	-		-
R-squared: between*	0.778	0.667	-	0.146	-		-
R-squared: overall*	0.802	0.735	-	0.110	0.951		0.558
Log of Likelihood*	-	-	-4614.76	-	-	-4105.81	-

Note: All estimates are based on the assumption of random country effects for host countries. Z-statistics are presented in the parentheses.

*Column (2) was estimated using the Tobit method to allow for the substantial number of observations with a zero value for foreign direct investment. For this regression, an R-squared is not reported but the log of likelihood is.
**Predicted value of telephone traffic using all the right hand side variables in this table (other than telephone traffic, of course) the logs of telephone densities in the host and source countries, and time dummies, plus the log of lagged imports in column 1(a).

Table 3: Interactions between Physical and Informational Distance: Instrumental Variable Estimates

	DEPENDENT VARIABLE					
	LOG IMPORTS			LOG FDI		
	ALL	DEVELOPED	DEVELOP-ING	ALL	DEVELOPED	DEVELOP-ING
	(1)	(2)	(3)	(4)	(5)	(6)
Log host population	0.580 (7.89)	0.917 (6.99)	0.506 (6.17)	1.429 (20.49)	1.500 (14.17)	1.895 (17.65)
Log source population	1.008 (85.19)	0.916 (57.24)	1.110 (63.53)	1.664 (38.41)	1.554 (27.29)	1.830 (26.83)
Log host per capita income	0.710 (12.81)	0.347 (2.18)	0.790 (11.16)	1.617 (25.50)	0.811 (4.37)	1.750 (14.57)
Log source per capita income	0.749 (13.20)	1.059 (12.92)	0.550 (6.54)	4.061 (21.52)	3.955 (15.61)	3.935 (13.65)
Log distance	0.069 (0.43)	0.518 (3.27)	-0.999 (19.87)	0.658 (1.33)	1.902 (3.36)	-2.217 (13.55)
Common language	0.224 (4.18)	0.157 (2.22)	0.186 (2.27)	-0.265 (-1.53)	-0.210 (-0.89)	-0.900 (-3.45)
Telephone traffic**	3.311 (6.61)	4.746 (9.42)		8.637 (5.58)	12.151 (6.84)	
Log Distance X Telephone Traffic**	-0.304 (-5.51)	-0.417 (-7.83)	0.060 (3.27)	-0.187 (-1.11)	-0.630 (-3.29)	0.789 (12.95)
Number of host countries	44	22	22	44	22	22
Number of observations	2870	1416	1454	2934	1416	1518
R-squared: within*	0.808	0.844	0.799			
R-squared: between*	0.667	0.704	0.582			
R-squared: overall*	0.736	0.751	0.736			
Log of Likelihood*				-4619.45	-2642.05	-1965.72

Note: All estimates are based on the assumption of random country effects for host countries.
Z-statistics are presented in the parentheses.

*Columns (4) (5) and (6) were estimated using the Tobit method to allow for the substantial number of observations with a zero value for foreign direct investment. For these regressions, an R-squared is not reported but the log of likelihood is.
**Predicted value of telephone traffic using all the right hand side variables in this table (other than telephone traffic, of course) plus the logs of telephone densities in the host and source countries, and time dummies.

Figure 1: Impact of Omitted Variables

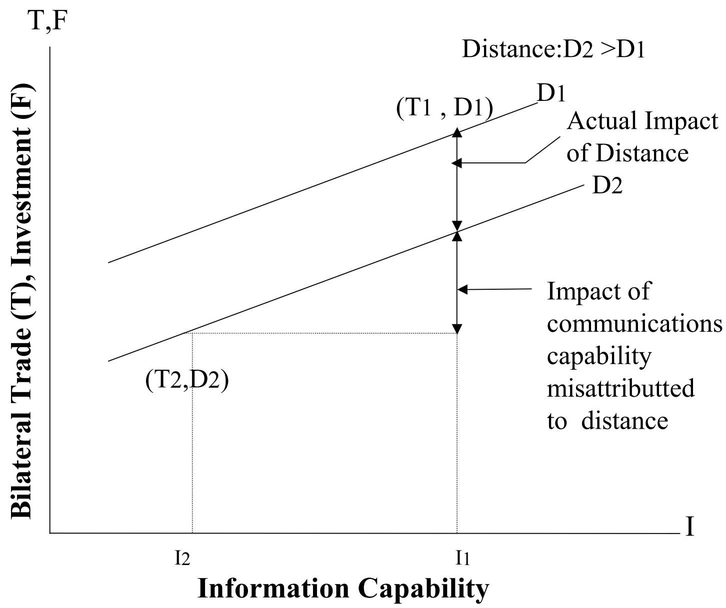


Figure 2: Role of Endogeneity

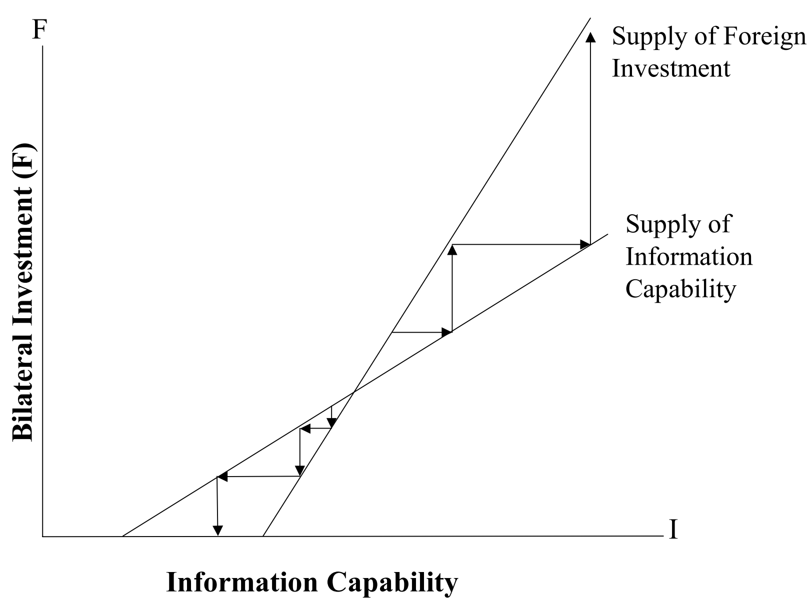
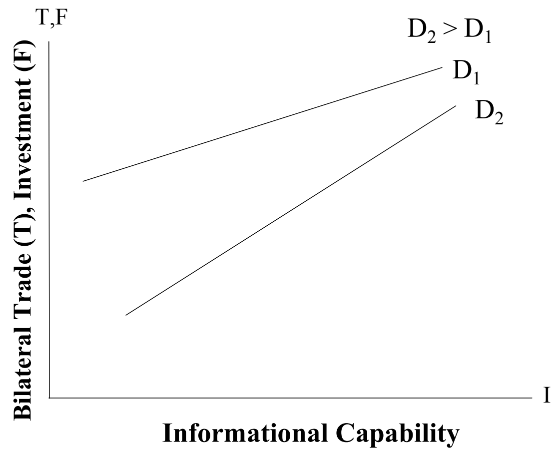
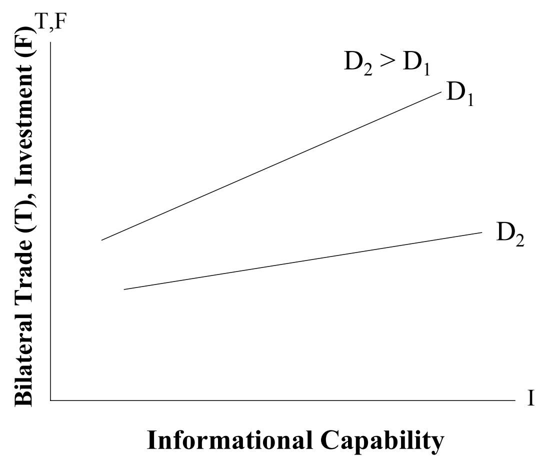


Figure 3: Interaction between Physical and Informational Distance

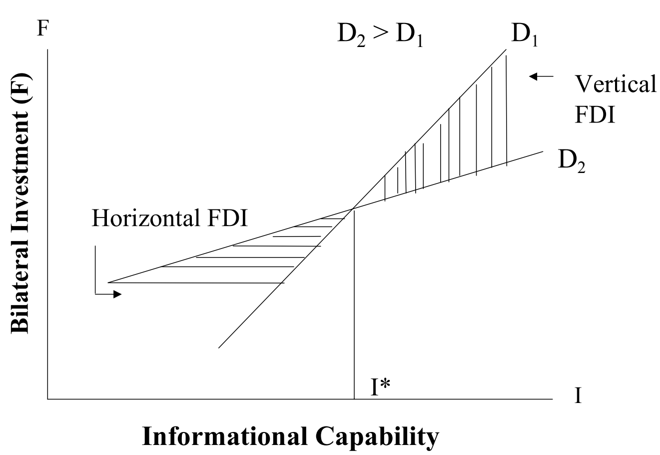
3(a): Information Substitutes for Distance



3(b): Information Reinforces the Distance Advantage



3(c): Horizontal and Vertical FDI



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