BANK FOR INTERNATIONAL SETTLEMENTS

BIS Working Papers

No 658

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Monetary and Economic Department

August 2017

JEL classification: F14, F34, F65, G21

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This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

The Distance Effect in Banking and Trade

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August 30, 2017

Abstract

The empirical gravity literature finds geographical distance to be a large and growing obstacle to trade, contradicting the popular notion that globalization heralds "the end of geography". This distance puzzle disappears, however, when measuring the effect of cross-border distance relative to that of domestic distance (Yotov, 2012). We uncover the same result for banking when comparing cross-border positions with domestic credit, using the most extensive dataset on global bank linkages between countries. The role of distance remains substantial for trade as well as for banking where transport cost is immaterial – pointing to the role of information frictions as a common driver. A second contribution is to show that the forces of globalization are also evident in other, less prominent, parts of the gravity framework.

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1 Introduction

Many settings with diverse theoretical foundations give rise to gravity equations that fit the patterns of international trade and finance surprisingly well (Head and Mayer, 2014, provide a thoughtful survey). The gravity model posits that trade between countries increases in their combined economic mass, and decreases in the geographical distance and other barriers separating them. In the age of globalization, it appears a foregone conclusion that sweeping technological change continuously works to lower transport and information costs, ultimately to the point where physical distance becomes inconsequential.

Surprisingly, the empirical gravity literature finds an outsized effect of distance on trade; this is one of the most documented findings in international economics. The typical estimate implies that a doubling of distance between countries cuts the volume of trade by nearly half.[1] Distance not only curbs trade much more than actual transport costs could explain (Anderson and van Wincoop 2004); the estimated distance effect appears to gain strength over time. This finding, known as the *distance puzzle*, is at odds with broad facts of globalization (Disdier and Head, 2008). Methodological advances have since cast doubt on earlier studies estimating gravity models in log-linearized form and possibly without fixed effects for origin and destination countries (Head and Mayer, 2014). Improved methods generally weaken, but do not overturn, the distance puzzle – with one exception: based on the insight that structural gravity models only identify *relative* frictions, Yotov (2012) resolves the distance puzzle in trade by estimating separately the effects of cross-border distance and domestic (internal) distance to show that the *difference* falls over time.

In this paper, we estimate gravity equations for trade and banking side by side to show that the distance puzzle has a counterpart in international finance. In both cases, the puzzle disappears when setting cross-border transactions against domestic activity. Even so, the effect of distance remains sizeable – in banking as large as in trade, as our matched-sample results suggest. Since banking faces no transport costs as such, this finding points to information frictions as a common driver. Support for this view comes from additional regressions focusing on information-sensitive lending to non-banks, access to information on foreign markets via branches and subsidiaries, and time zone differences as an impediment to the exchange of information during business hours.

A second, novel contribution of the paper is to broaden the view to other elements of the

[1] In meta-analyses of more than 2500 estimates from 159 papers, the average elasticity of trade flows with respect to distance is close to -0.9 (Disdier and Head, 2008, and Head and Mayer, 2014).

gravity framework where the forces of globalization surface. The global component that scales all bilateral trade flows and asset holdings has steadily trended up as transport and information costs have been declining. And the expansion of bank linkages between countries (the extensive margin) shows that international banking overcomes greater distances over time.

A number of papers have estimated gravity equations for international banking, but ours is the first to apply theory-consistent methods to the most comprehensive dataset on global banking. Precursors include Rose and Spiegel (2004), Buch (2005), Aviat and Coeurdacier (2007), Coeurdacier and Martin (2009), Papaioannou (2009), Houston, Lin and Ma (2012), Herrmann and Mihaljek (2013), and Brüggemann, Kleinert and Prieto (2014), in addition to papers focusing on portfolio holdings (e.g. Portes and Rey, 2005, or Lane and Milesi-Ferretti, 2008, Chitu et al, 2015). Importantly, these studies are limited in their methods and data availability, and do not focus on the role of distance over time (except for Buch, 2005).[2] Here, we build a coherent country-to-country network with maximum global coverage from the *BIS Locational Banking Statistics*, one that captures all cross-border positions between two countries transacted via the global banking system since 1977. Drawing on insights from the trade literature, we estimate gravity equations in their multiplicative form including time-varying fixed effects. When expressing the distance effect in cross-border banking relative to that of domestic banking, we indeed find – in parallel to the evidence on trade – that the distance friction in banking falls as globalization advances.

The paper is structured as follows. Section 2 covers the gravity model, its application to international trade and finance, estimation methods and data sources. Section 3 addresses the distance puzzle and its proposed resolution in trade and banking side by side. Section 4 examines other parts of the gravity framework for evidence of globalization, and Section 5 concludes. The appendices explain the international banking data, and report the main regressions in detail.

[2]Several studies use the *BIS Consolidated Banking Statistics*, including Rose and Spiegel (2004), Aviat and Coeurdacier (2007), Coeurdacier and Martin (2009), or Houston, Lin and Ma (2012). The consolidated statistics are less suited for studying the geography of banking: the reporting country is not a source country in the geographic sense, but a banking system consisting of internationally active banks booking claims in many jurisdictions, including financial centers. Studies employing the *BIS Locational Banking Statistics*, either use short samples (Brüggemann et al, 2014), a small subset of reporting countries (Buch, 2005), or older econometric methods (Herrmann and Mihaljek, 2013). None of these papers include data on domestic banking.

2 Methodology

2.1 Gravity in international trade

The pattern of international trade arises as a result of consumer preferences over varieties of goods that different countries specialize in producing (Eaton and Kortum, 2002, Anderson and van Wincoop, 2003). The structural gravity formulation in Anderson and van Wincoop (2003) relates the value of exports from country i to j over a given period to the nominal incomes of residents in the countries of origin Y_i and destination Y_j, as well as to trade costs t_{ij},

$$X_{ij} = \alpha Y_i Y_j \left(\frac{P_i P_j}{t_{ij}} \right)^{\sigma - 1} \qquad \forall\, i, j. \tag{1}$$

Given an elasticity of substitution $\sigma > 1$, trade between two countries falls with the trade costs t_{ij} relative to the price indices P_i and P_j that countries face with all their trading partners (known as multilateral resistance terms).[3] The standard iceberg cost formulation expresses all trade barriers in terms of ad valorem tariffs: it costs $t_{ij} > 1$ per unit value for country j to import goods from i. If p_i is the supply price of goods produced in country i, then $p_{ij} = t_{ij} p_i$ is the price consumers pay in country j. These bilateral trade costs are generally unobserved, and assumed to be a function of geographical distance d_{ij}, and a vector of other bilateral observables z_{ij},

$$t_{ij} = d_{ij}^{\,\rho}\, e^{\gamma' z_{ij}}, \tag{2}$$

where z_{ij} contains indicators equal to zero or one if countries i and j share a language, a common border or a colonial past, or if they participate in a regional trade agreement or in a monetary union (Anderson and van Wincoop, 2004).

Our short rendition of the gravity model fails to do justice to the richness of the literature of this active field. For instance, trade and banking data contain many structural zeros between countries that do not trade with each other; one relevant extension therefore allows for fixed costs that firms face when serving foreign markets (Helpman et al, 2008). Another is to relate the distributions of firm sizes and their export destinations, in order to micro-found the distance coefficient (Chaney, forthcoming).

For most theoretical foundations of the gravity equation, consistent estimation of the distance

[3] Intuitively, these terms counteract t_{ij} because remote countries do not necessarily trade less with *all* other countries, but just relatively more with closer nations. The earlier empirical literature ignored these terms, which led to inconsistent estimates (Head and Mayer, 2014).

coefficient calls for the inclusion of fixed effects for both origin and destination countries (Head and Mayer, 2014). This essentially subsumes Y_i and other country-specific factors (including P_i) into an index O_i describing an origin country's overall export capacity, and an analogous index for each destination, D_i. The gravity equation can thus be written as

$$X_{ij} = \alpha\, O_i D_j\, d_{ij}^{\,\theta}\, e^{\lambda' z_{ij}}, \tag{3}$$

where θ and λ are composite coefficients. In particular, the *distance effect* θ measures the elasticity of trade with respect to distance. From equations (1)-(2), it equals $\theta = (1-\sigma)\,\rho$, the product of two elasticities describing (i) how trade volume falls with trade cost $(1-\sigma < 0)$, and (ii) how trade costs grow with distance $(\rho > 0)$. In this context, the distance effect can be understood as a friction preventing higher volumes of bilateral trade of a frictionless world.

2.2 Gravity in international finance

International trade in financial assets arises from a portfolio diversification motive, giving rise to asset holdings X_{ij} in equity, bonds, or loans. Applied to international finance, the gravity framework is quite remarkable in that it determines the *bilateral* pattern of *gross stocks* of asset holdings. Most theories building on the intertemporal approach to the current account only determine net flows at the country level. Some models lead to an exact gravity equation of the form (3). One example is trade in Arrow-Debreu securities with transaction cost (Martin and Rey, 2004, Coeurdacier and Martin, 2009); another is a setting with N countries issuing securities whose variance appears higher to foreign holders (Okawa and van Wincoop, 2012).[4] In a theory tailored to cross-border banking, Brüggemann, Kleinert and Prieto (2014) derive a gravity equation in a search model where monitoring cost is linear in the distance between banks in country i and firms in country j; distance curbs international lending because it raises loan rates and also reduces the volume of screening between banks and firms across countries.

By analogy to gravity in trade, bilateral financial positions are governed by two forces: the combined financial mass of country pairs, and relative frictions that limit the volume of transactions. Some coefficients have a different interpretation in the context of finance.[5] And in the absence of transport costs, the term t_{ij} in (2) relates to transaction and information costs, as in Portes and Rey (2005) for equity holdings, and in Buch (2005) for cross-border banking.

[4] Okawa and van Wincoop (2012) also show, however, that the conditions giving rise to the exact gravity form are more restrictive in finance than in trade.

[5] In equation (1), the exponent on relative costs relates to risk aversion in Coeurdacier and Martin (2009); in Okawa and van Wincoop (2012) it equals 1.

Importantly, t_{ij} should *only* relate to bilateral frictions, not to asset returns or return correlations (Okawa and van Wincoop 2012). As a result, the gravity equations in trade and finance share similar bilateral observables – including distance, if risk can be assessed more precisely by agents located closer to the issuer, for instance.

Both in banking and trade, information frictions are the leading explanation of why distance matters. In Chaney (forthcoming), acquiring information about potential suppliers and customers is costly, and firms build a network of contacts to trade with. As firms grow over time, they reach more remote counterparties, so larger firms trade over greater distances. This growth process gives rise to an exact gravity equation for international trade with a meaningful role for the distance coefficient that relates to the way firms overcome informational barriers via contacts abroad. In Allen (2014) and Dasgupta and Mondria (2014), costly search and information processing, respectively, leads agents to acquire less information about remote destinations, with similar implications for the pattern of trade. In these models, information frictions amplify or replace transport costs as the driver behind the distance effect.

This logic naturally extends to the context of banking and finance, where information frictions can be substantial. Accordingly, empirical studies sometimes add variables representing frictions, which tends to reduce – but does not eliminate– the size and explanatory power of distance (Portes and Rey, 2005, Papaioannou, 2009, and Houston, Lin and Ma, 2012). Technological advances make it easier to communicate (hard) information over greater distances, as witnessed by the trend of banks gradually extending loans to more distant borrowers (Petersen and Rajan, 2002). Even so, Degryse and Ongena's (2005) results suggest that information asymmetries and transport cost between lenders, borrowers and competing lenders remain substantial enough to allow for spatial price discrimination in loan rates. Mian (2006) even shows that *within* banking groups, greater cultural and geographical distance between a bank's headquarters and its local offices abroad leads those foreign affiliates to avoid relational lending to local firms.

2.3 Estimation and data sources

The trade gravity literature recently cleared some hurdles that had biased earlier estimates of the distance effect. First, the use of time-varying fixed effects helps to ensure econometric consistency in a panel setting. Fixed effects capture all country-specific factors arising from structural gravity, whether observed or not (Baltagi, Egger and Pfaffermayr, 2003, Redding and Venables, 2004). This requires a separate set of fixed effects every period for each origin and destination country, O_{it} and D_{jt}. In our context, the fixed effects capture all factors shaping country $i's$ capacity to extend cross-border credit or hold international portfolios, and destination j's ability to attract bank funding, respectively. The fixed effects will indicate whether certain locations are particularly attractive as investment destinations or funding markets, a distinction used in Cetorelli and Goldberg (2012).

Second, gravity equations should be estimated in their multiplicative form, in levels. Santos Silva and Tenreyro (2006) show that the common practice of taking logarithms to estimate the linearized model (3) by OLS faces two problems: (a) it drops country pairs that do not trade with each other, and (b) it introduces a bias in the presence of heteroscedasticity, overstating the distance effect. To obtain consistent estimates, we apply their Poisson pseudo-maximum-likelihood (PPML) procedure on the full set of country pairs, including reported zeros – which are both frequent and meaningful.

Third, identifying the distance effect from a structural gravity model requires the inclusion of *internal* trade ($i = j$). Anderson and van Wincoop (2003, 2004) show in fact that *relative* trade costs determine the pattern of trade.[6] In their model, all goods are in fixed supply and must be sold somewhere; the implication is that trade flows are invariant to domestic distribution costs which are faced by all agents, including home producers. Hence the Anderson-van Wincoop gravity model only identifies relative costs. Yotov (2012) cogently built this insight into the empirics by estimating separately the effects of cross-border distance and domestic distance.

Based on these methodological advances, we estimate gravity equations for trade and banking period-wise by PPML, with time-varying fixed effects and internal trade and domestic credit data, respectively, of the form

$$X_{ijt} = \begin{cases} \alpha_t \, O_{it} D_{jt} \, d_{ij}^{\theta_t} \, e^{\lambda_t' z_{ijt}} & \forall \, i \neq j \\ \alpha_t \, O_{it} D_{it} \, d_{ii}^{\delta_t} \, e^{\lambda_t' z_{iit}} & \forall \, j = i, \end{cases} \tag{4}$$

with distinct coefficients on cross-border distance θ and domestic distance δ. For distance (d_{ij}), we use population-weighted distance in kilometers from the *Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII), which consistently measures cross-border and internal distances. The traditional measure of distance between two countries applies the great-circle formula to the latitudes and longitudes of the countries' largest city (singular). CEPII's weighted distance measure generalizes this approach to include bilateral distances between the

[6] Since P_i and P_j in equation (1) contain t_{ij} with respect to third countries, the Anderson-van-Wincoop system happens to be homogenous of degree zero in trade costs, as emphasized by Yotov (2012).

largest cities (plural) of both countries, with inter-city distances being weighted by the share of the city in the country's overall population (Mayer and Zignago, 2011). To illustrate, even though Russia's land area is far larger, internal distance for the United States (1,854 km) exceeds that of Russia (1,366 km) because the main cities, Moscow and St Petersburg are closer to each other than the largest US cities to each other. We combine the series "cross-border distance in km, population-weighted" and "internal distance in km, population-weighted", and filled missing bilateral distances with data from nearby countries.[7] For distance between countries, the median (or average) distance across all pairs is 8,054 (or 8,437) kilometers; the comparable internal median (or average) distances are 155 (or 231) kilometers.

Other bilateral variables (z_{ij}) include the same core variables as in Yotov (2012), namely common language, common border (contiguity), and colonial relationship, all from CEPII.[8] A number of variables used in earlier papers are excluded here for theoretical reasons (Okawa and van Wincoop, 2012) or based on their insignificance in many studies (as documented in Disdier and Head, 2008). For trade, X_{ijt} is obtained from the value of imports of destination j from origin i, from the IMF *Direction of Trade Statistics* (DoTS) and CEPII. Internal (domestic) trade is proxied by GDP minus total exports (as in Yotov, 2012, and Head and Mayer, 2014).[9] For "internal banking", we use total domestic credit extended by banks to all sectors (IMF IFS line 32, including interbank positions), and complement missing observations (for offshore centers in particular) by national sources, where available.

The data on cross-border banking are from the *BIS Locational Banking Statistics*. In line with the balance of payments, these statistics are reported following the *residence principle*, and are well suited for studying the geography of banking. As described in Appendix A, we transform the original banking data to a country-to-country network with maximum coverage. The original data are in the "banks-to-country format": internationally active banks in 44 reporting countries report their claims (and liabilities) vis-à-vis all countries and jurisdiction in the world. Accordingly, the conventional use of international banking statistics considers banks'

[7]For 19 jurisdictions not present in the trade data set (mostly offshore centers), we computed an unweighted measure of internal distance based on land area, using the formula $d_{ii} = 2/3 * \sqrt{Area_i/\pi}$, following Mayer and Zignago (2011).

[8]*Common language* equals 1 if origin and destination share a common official language, 0 otherwise; *contiguity* equals 1 if origin and destination share a common border, 0 otherwise; and *colonial relation* equals 1 if origin and destination were in a colonial relationship post 1945, 0 otherwise. Most data are from the CEPII GeoDist database. Missing observations are complemented using data on Andrew Rose's website, and for countries outside the trade sample, using the Penn World Tables, CIA Factbook and internet search.

[9]This simple approach is taken in the interest of maximizing global coverage. Gross production data are available for few countries. Another shortcoming is that internal trade includes trade in services, whereas external trade is largely limited to merchandise trade. The two shortcomings pull the measured size of internal trade in opposite directions, so the overall bias is difficult to sign.

asset side (or their liability side) in isolation, e.g. Buch (2005). This format lacks symmetry, however, since banks in one country report their lending to *all sectors* (banks, corporates, public sector and households) in another.

To match the "country-to-country format" of international trade and capital flows, we combine banks' reported assets and liabilities to obtain a coherent network capturing all cross-border positions between two countries transacted through banks (Appendix A elaborates). This procedure also improves coverage through the use of counterparty information. The resulting dataset includes cross-border linkages on a yearly basis since 1977, between up to 216 countries and jurisdictions (including offshore centers) – excluding only those positions *within* the block of non-reporting countries.

3 The distance puzzle: from trade to banking

This section compares the distance effect in trade and banking side by side, using best-practice estimation. We estimate the gravity equation for trade from 1960 onward, after Europe had restored convertibility on current account within the Bretton Woods System.[10] The global banking sample starts in 1977, at the onset of global financial liberalization (Williamson and Mahar, 1998). Tables 1-3 and Figures 1-3 present our main findings, and Appendices B, C and D contain the full results.

3.1 Trade

The distance puzzle is most striking in the traditional least-squares regression, estimated after log-linearizing the gravity equation (3) with fixed effects as dummy variables (Table 1, upper panel, column "LSDV", full sample).[11] Over the past 50 years, the magnitude of the estimated distance effect $\widehat{\theta}$ appears to have grown from 0.75 to an implausible 1.77 (in absolute value), suggesting that physical distance presents a large and growing obstacle to trade. Distance coefficients typically fall below unity when estimated by PPML, and this is the case here too (column "PPML", full sample). The estimates closer to -1 are in line with a vast literature

[10]There were monetary restrictions on trade among European nations before 1959. Once foreign-exchange markets re-opened in 1959, with the major currencies fully convertible for current-account transactions, the Bretton Woods System came into full operation (Eichengreen, 1996, p. 114).

[11]We follow Yotov's (2012) naming convention here, even though the term LSDV is more commonly used in panel settings.

comprising more than 2,500 estimates of the distance effect in trade (Head and Mayer, 2014). The magnitude implies that a nation trades with a close-by country nearly twice as much as with a similar country located at twice the distance. Importantly, the *upward trend* in the size of the distance effect persists under both estimation methods – and contradicts the view that globalization should diminish the role of distance over time (Figure 1, left panels).

Table 1: The distance effect in trade - main results

Point estimates of distance coefficients

Method:	LSDV		PPML		PPML		PPML	
Sample:	Full sample		Full sample		Intensive margin		Matched sample	
Traditional specification (θ_t)								
Distance, 1960	-0.748***	(0.029)	-0.720***	(0.053)	-0.705***	(0.054)		
Distance, 1980	-1.350***	(0.028)	-0.811***	(0.033)	-0.847***	(0.037)	-0.869***	(0.037)
Distance, 1995	-1.492***	(0.024)	-0.796***	(0.028)	-0.810***	(0.032)	-0.794***	(0.029)
Distance, 2005	-1.701***	(0.024)	-0.901***	(0.027)	-0.894***	(0.033)	-0.886***	(0.028)
Distance, 2012	-1.769***	(0.026)	-0.856***	(0.034)	-0.839***	(0.041)	-0.857***	(0.038)
Delta distance	-1.021***	(0.039)	-0.136**	(0.063)	-0.134**	(0.067)	0.012	(0.053)
Relative specification ($\theta_t - \delta_t$)								
Relative distance, 1960	-1.026***	(0.033)	-0.667***	(0.026)	-0.667***	(0.027)		
Relative distance, 1980	-0.896***	(0.041)	-0.553***	(0.020)	-0.522***	(0.019)	-0.523***	(0.019)
Relative distance, 1995	-0.935***	(0.041)	-0.464***	(0.018)	-0.451***	(0.019)	-0.461***	(0.017)
Relative distance, 2005	-0.841***	(0.047)	-0.407***	(0.017)	-0.411***	(0.018)	-0.415***	(0.018)
Relative distance, 2012	-0.721***	(0.051)	-0.415***	(0.018)	-0.432***	(0.020)	-0.423***	(0.020)
Delta relative distance	0.305***	(0.061)	0.252***	(0.032)	0.235***	(0.033)	0.100**	(0.028)

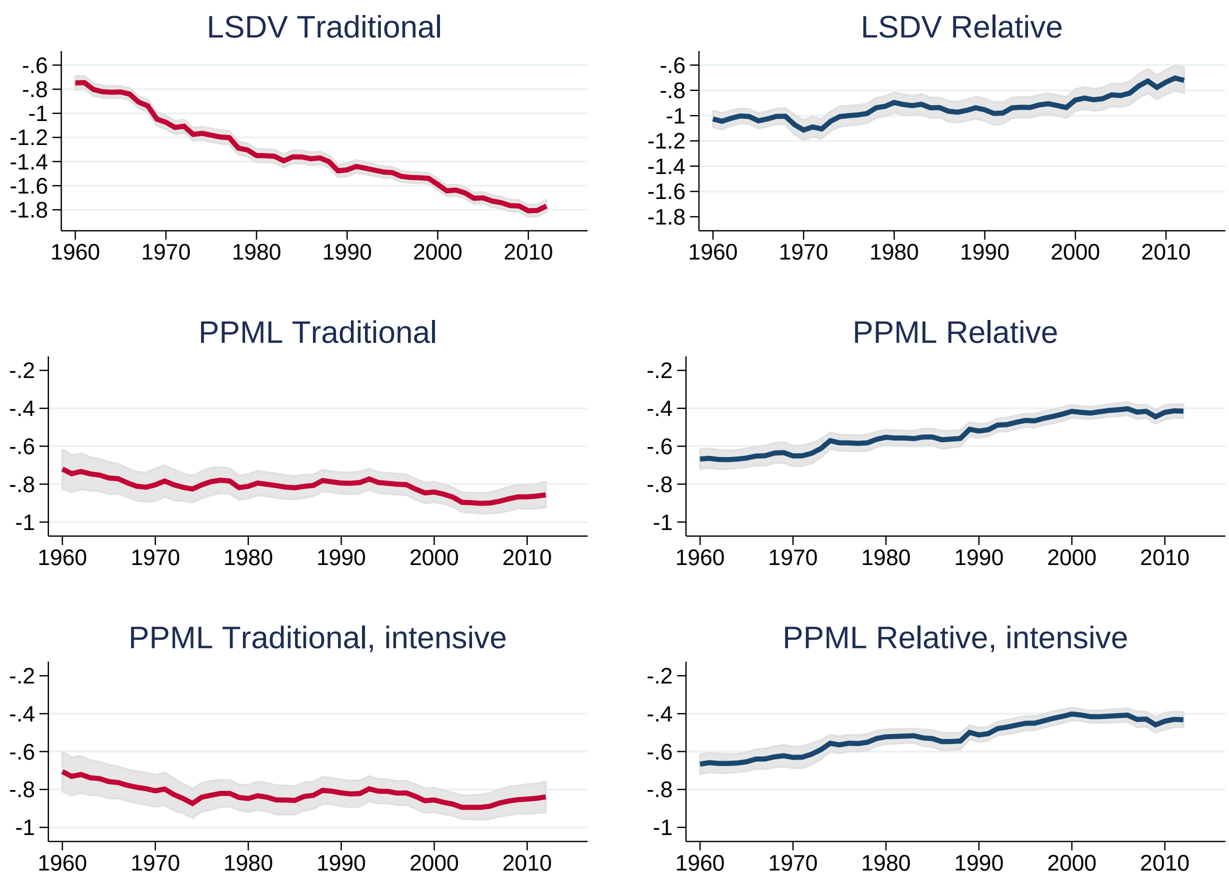
Note: Table 1 reports point estimates of the distance effect in trade for specific years, with robust standard errors in separate columns. Full results are in Appendix B1-B4. The traditional specification (upper panel) is contrasted with Yotov's (2012) relative specification (lower panel) which includes 'internal trade' (see equation (4)). The first column (LSDV) employs least-squares estimation with fixed effects. The remainder are Poisson pseudo-maximum likelihood (PPML) estimates. Regarding samples, column 'Full sample' shows results for all reported country pairs; the 'Intensive margin' sample contains only those country pairs linked through trade already in 1960, ignoring new linkages; and 'Matched sample' includes those country pairs linked through both trade and banking. The final row tests the difference between the last and the first coefficient estimates (Wald-test); a positive significant result is evidence of a decline in the role of distance. Significance levels are marked as: * 10%, ** 5%, *** 1%.

Yotov (2012) sheds new light on the trend puzzle by estimating separately the effects of cross-border distance θ and domestic distance δ, as set out in equation (4).[12] Applied to our sample, the size of the relative distance effect $(\widehat{\theta} - \widehat{\delta})$ now falls over time, both for LSDV and PPML (Table 1, lower panel, full sample columns). This replicates Yotov's result that the effect of international distance has been declining relative to that of domestic distance (Figure 1, right

[12]Bergstrand, Larch and Yotov (2015) propose yet an alternative specification that includes country-pair fixed effects, to estimate the *decline* in the distance effect over time *relative* to a base period.

panels). What follows focuses on PPML estimates, which are preferable for methodological reasons.[13]

Figure 1: Distance in international trade



Note: This figure tracks the estimated distance effect over time for the full trade sample and the intensive margin sample. The upper and middle panels show the results for the whole sample estimated by LSDV and PPML, respectively. The lower panels show the results for the intensive margin sample estimated by PPML. The left panels show traditional estimates $\hat{\theta}$ (along with 95% confidence bands), the right panels show the difference $(\hat{\theta} - \hat{\delta})$, obtained from equation (4). Table 1 provides further detail.

The decline in the relative distance effect is generally significant, and suggests that the distance friction has gradually lost more than a third of its strength over the past 50 years.[14] The final row in the Table shows the change in the estimated distance effects between the last and the

[13]It also yields more reasonable estimates for the bilateral controls (common language, contiguity, and colonial relation) than LSDV.

[14]Specifically, the relative distance estimate for 1960 is -0.667 (Table 1, column 2, lower panel), the starting value in Figure 1 (lower right panel). It is the difference between the coefficients on cross-border distance, $\widehat{\theta} = -0.869$, and on domestic distance $\widehat{\delta} = -0.202$, both shown in Appendix Table B2 (lower panel). By 2012, the relative distance coefficient declined to -0.415 $(= -0.984 + 0.569$, Table B2).

first estimates, and tests the difference by means of a Wald test (row marked "Delta relative distance"). A positive significant result is evidence that the distance effect turned less negative over time. This is also consistent with tight confidence bands around the distance effects in Figure 1. The finding supports a view of globalization that sees integration proceed faster in international than in domestic markets, with external trade costs falling relative to domestic distribution costs.

This still begs the question why the *level* estimate $\widehat{\theta}$ apparently rose even as transport costs and trade barriers have been declining over time (see Appendix B2). One might dismiss the level estimates, since the structural gravity model (if valid) only identifies the relative distance effect $(\widehat{\theta} - \widehat{\delta})$. However, the puzzle has given rise to interesting testable hypotheses in the literature. One is that of a compositional effect between the *intensive margin* (more trade between old trade partners) and the *extensive margin* (new trade linkages). Lin and Sim (2012) show that most of the trade expansion between 1970 and 1995 took place between countries already trading before 1970 (intensive margin); at the same time, new trade links (extensive margin) are forged at longer distances and smaller trade volumes than the prevailing global average. They conjecture (but do not test) that the emergence of new long-distance links trading small volumes accentuates the measured distance effect, producing larger estimates $\widehat{\theta}$ in yearly regressions.

To test this conjecture, we switch off the extensive margin at the country level by restricting the sample to those country pairs that were already connected in 1960 ("Intensive margin" in Table 1 and Figure 1). On the intensive margin alone, the distance puzzle is still present in the traditional specification (Figure 1, bottom left panel), suggesting that trade volumes often grew more between countries closer to each other than the median trade partner. Hence the puzzle is not an artifact of sample composition, and is again absent for relative distance (Figure 1, bottom right panel).[15] While compositional effects contribute to the empirical distance puzzle, its resolution nonetheless hinges on the relation between international and domestic trade.

[15] An analogous experiment focusing on the extensive margin yields a similar conclusion. We allow for an expanding number of international linkages, but switch off the intensive margin by holding the volume of trade constant at the first reported value. Early in the sample, the distance puzzle appears again in levels, not in differences. We do not report the result here, since the experiment does not fully isolate the extensive margin; however, a dataset focusing only on new linkages is too sparse for meaningful comparison.

3.2 Banking

Distance also plays a fundamental role in the context of international banking and finance. Portes and Rey (2005) showed that the gravity model explains cross-border equity flows at least as well as international trade, again with a large distance effect.[16] Table 2 reproduces the trade regressions above for the global banking data. As one might expect, the level estimates of the distance effect are generally smaller for banking than for trade (Table 2 upper panel, full sample columns). But the worsening trend in the distance friction is just as evident (Figure 2 left panel).

Table 2: The distance effect in banking - main results

Point estimates of distance coefficients

Method:	LSDV		PPML		PPML		PPML	
Sample:	Full sample		Full sample		Intensive margin		Matched sample	
Traditional specification (θ_t)								
Distance, 1980	-0.868***	(0.053)	-0.602***	(0.047)	-0.590***	(0.045)	-0.554***	(0.056)
Distance, 1995	-1.081***	(0.037)	-0.886***	(0.049)	-0.890***	(0.050)	-0.877***	(0.050)
Distance, 2005	-1.184***	(0.033)	-0.692***	(0.035)	-0.637***	(0.043)	-0.679***	(0.045)
Distance, 2012	-1.347***	(0.037)	-0.725***	(0.383)	-0.624***	(0.045)	-0.726***	(0.049)
Delta distance	-0.479***	(0.065)	-0.123**	(0.061)	-0.034	(0.063)	-0.172***	(0.074)
Relative specification ($\theta_t - \delta_t$)								
Relative distance, 1980	-0.976***	(0.058)	-0.630***	(0.027)	-0.630***	(0.027)	-0.602***	(0.033)
Relative distance, 1995	-1.088***	(0.052)	-0.583***	(0.034)	-0.547***	(0.036)	-0.426***	(0.037)
Relative distance, 2005	-1.079***	(0.047)	-0.481***	(0.035)	-0.422***	(0.032)	-0.395***	(0.034)
Relative distance, 2012	-1.201***	(0.055)	-0.524***	(0.034)	-0.460***	(0.033)	-0.443***	(0.035)
Delta relative distance	-0.225***	(0.080)	0.106**	(0.044)	0.170***	(0.043)	0.159***	(0.048)

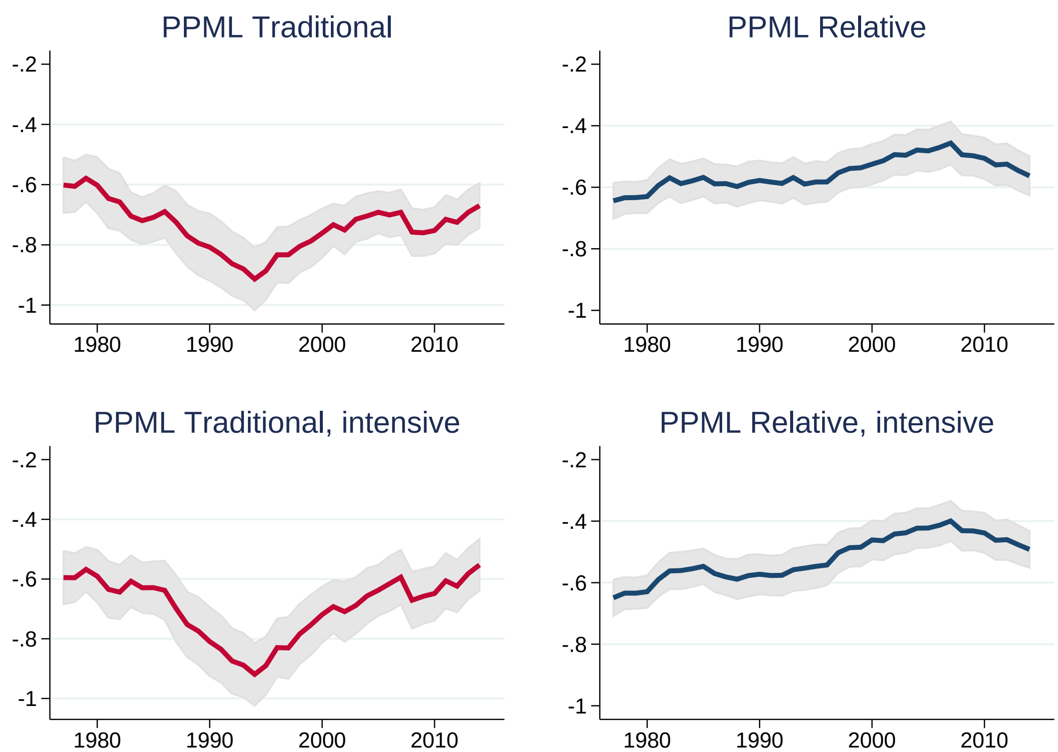
Note: The table reports point estimates of the distance effect for banking, with standard errors in separate columns. Full results are in Appendix C1-C4. It contrasts the traditional specification (upper panel) with the relative specification (lower panel) which includes domestic credit (see equation (4)). The 'Intensive margin' sample contains only those country pairs linked through banking already in 1980, ignoring new linkages. Otherwise, methods, samples and significance levels mirror those in Table 1.

The distance puzzle in trade therefore has a counterpart in international banking, where physical distance should play an even lesser role in the absence of transport cost. It also has an analogous resolution: the puzzle disappears when comparing the distance friction on cross-border banking

[16] Other empirical work on gravity in international finance includes Lane and Milesi-Ferretti (2008), as well as references cited in Okawa and van Wincoop (2012). Papers on international banking are covered below.

activity to that on domestic credit (Table 2, full sample PPML, lower panel).[17] In contrast to the level estimates, the difference $(\widehat{\theta} - \widehat{\delta})$ has declined substantially since 1977 (Figure 2, right panel).[18] A test regressing the relative distance effect on a time-trend returns a positive slope (significant at the 1% level), implying that the relative distance friction fell (became less negative) by 0.16 over the 38 years of the banking sample.

Figure 2: Distance in international banking



Note: This figure tracks the estimated distance effect over time for the full trade sample and the intensive margin sample, both estimated by PPML. The upper panels reproduce the results for the whole sample. The lower panels show those for the intensive margin sample. The left panels show traditional estimates $\hat{\theta}$ (along with 95% confidence bands), the right panels show the difference $(\hat{\theta} - \hat{\delta})$, obtained from equation (4). Table 2 provides further detail.

As was the case for trade, international banking expanded faster than domestic banking activity. The main exception is the reversal since 2008, reflecting the sharp contraction in international

[17]The distance puzzle disappears entirely under PPML; it persists in weaker form in LSDV estimates (which are less reliable for the reasons explained in Section 2).

[18]Half of the results in banking have insignificant internal distance, in contrast to the results for trade. Even so, internal distance needs to remain part of the model for proper identification of the relative distance effect (Yotov, 2012). More generally, covariates that are insignificant by themselves can still have an important effect on other aspects of the estimation.

banking activity in the wake of the global financial crisis (McGuire and von Peter, 2012, 2016). But the secular decline in the relative distance friction since 1980 is broadly in line with trends in globalization and financial liberalization since the 1970s.

The results are similar when offshore centres, tax havens and small financial centres are excluded (Table 3, and Appendix Table D1). Doing so is common in the literature – either for lack of data or because they are intermediaries rather than sources or destinations for international investment (Lane and Milesi-Ferretti, 2008). Removing credit to, from and between these jurisdictions results in a loss of thousands of observations per year (leaving 10,150 for 2012). Yet the results mirror the full-sample findings: (1) the level estimates show the distance puzzle, (2) the distance puzzle disappears through the inclusion of internal distance (which also has a significantly negative effect), and (3) the relative distance effect shows a secular decline before edging up after the global financial crisis.

These results can be compared with earlier studies on international banking. However, these were somewhat limited in their methods and data availability, and did not focus on the role of distance over time – with the exception of Buch (2005). Using a small sample drawn from the *BIS Locational Banking Statistics*, Buch (2005) estimates the distance effect θ to be -0.7 (using LSDV), with no trend between 1983 and 1999.[19] Brüggemann et al. (2014) test their theory for the years 2003-06 on a larger sample (about 20% the size of ours per year), and find point estimates near -0.75 (LSDV) and -0.26 (PPML), well below the size of ours. In a study with better coverage for 1984-2002, Papaioannou (2009) regresses bank *flows* on gravity variables and obtains estimates between -0.82 and -1.13 (LSDV), without the use of country-time fixed effects or PPML.[20] None of these papers include domestic credit for estimating relative distance effects, nor work with a country-to-country dataset.

As was the case for trade, the distance puzzle and its resolution can be observed even for the intensive margin alone ("Intensive margin" in Table 2 and Figure 2). The global banking dataset

[19] The sample available to Buch (2005) was 20 years shorter, and contained the bilateral bank positions of five advanced economies.

[20] We do not attempt a comparison with studies using the *BIS Consolidated Banking Statistics*, including Rose and Spiegel (2004), Aviat and Coeurdacier (2007), Coeurdacier and Martin (2009), or Houston, Lin and Ma (2012). Houston, Lin and Ma (2012), for instance, find implausible distance effects exceeding 1.5 in magnitude.

expands substantially over time, due to both greater financial integration and better reporting coverage.[21] This compositional effect tends to strengthen the measured distance effect: as more distant country pairs with small international bank linkages enter the sample, the distance friction appears to become worse. We remove the extensive margin by restricting the banking sample to those country pairs already connected through banking in 1980 (Appendix Table C3, and Figure 2 bottom panels).[22] Estimating the distance effect on this subsample shows the same pattern: the distance puzzle in the traditional regression (left panel) and its resolution in the relative distance effect ($\widehat{\theta} - \widehat{\delta}$) (right panel). International banking expanded more than domestic banking, even among the financially advanced countries already integrated at the onset of financial liberalization.

In sum, in both trade and banking the findings are in line with facts of globalization, when setting cross-border transactions against domestic activity to focus on the role of distance in relative terms. Even so, in both cases the effect of distance remains fairly large, even in relative terms. To compare the distance effect across trade and banking, we construct a matched sample that includes only country pairs that were linked through *both* trade and banking (Figure 3, based on "Matched sample" columns in Tables 1-2). The resulting trade and banking samples are identical in coverage, and the number of observations expands in lockstep year by year from 1980 onward.[23] The level estimate of the distance effect is larger for trade than for banking, perhaps because trade is subject to transport *and* information costs (Figure 3, left panels). More importantly, by 2012 the relative distance effect is near -0.4 for both trade and banking, or about -0.5 over the sample on average. This magnitude suggests that a doubling of distance curbs *international* trade and bank credit by nearly 30% ($2^{-0.5} = 0.7$) more than would be the case in a domestic context.[24]

[21]See the number of observations in Table C2, and Figure 5, upper panel.

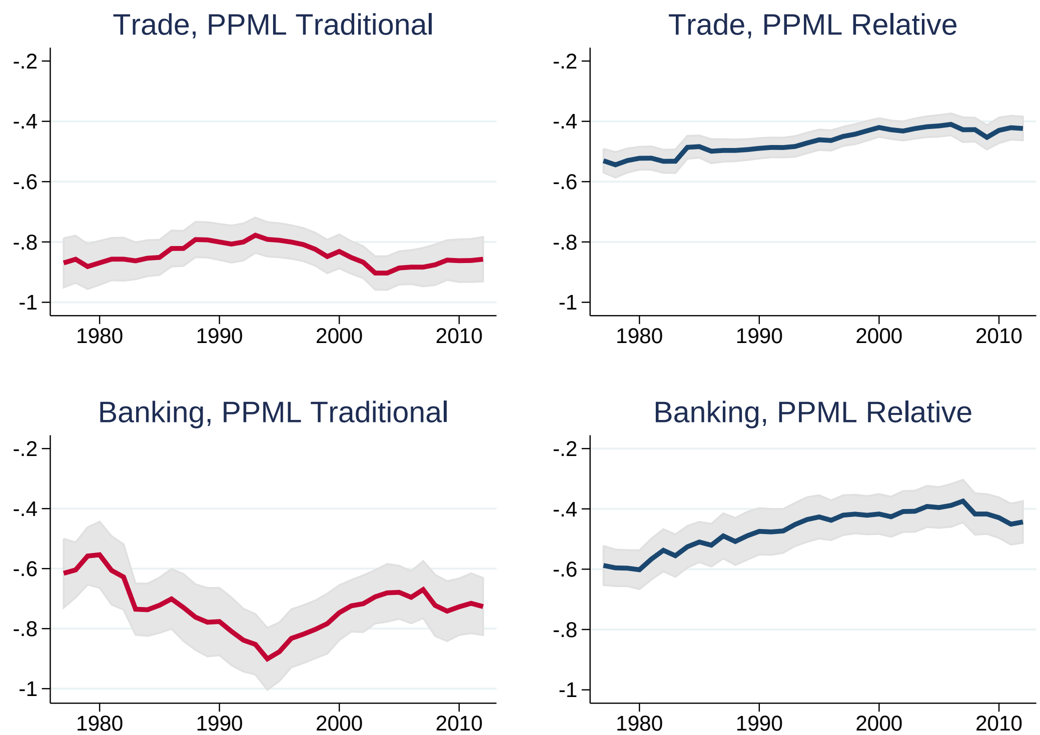
[22]In the construction of the banking network, we distinguish between missing (unreported) positions and true (reported) zeros (see Appendix A). Even so, the growing number of *active* links in the sample represents both newly forged links (zeros turning positive) and newly reported links (unreported turning positive). The experiment focusing on the intensive margin switches off both effects.

[23]For full results, see Tables B4 for trade and C4 for banking. In the trade network, the matching drops from the sample smaller country pairs that are not (reported to be) connected through international banking. In the banking network, the matching mainly drops the links with, and between, offshore financial centers that are absent from trade data.

[24]An exact comparison is complicated by the interaction of border effects and other bilateral factors with

The matched sample results suggest that the magnitude of the relative distance friction remains economically significant in both trade and banking (Figure 3, right panels). This is remarkable, especially in the case of international banking where transport costs do not apply. Indeed, one might expect investors to tilt their portfolios towards more distant countries whose asset returns may be less correlated with domestic returns (Portes and Rey, 2005). The common finding between trade and banking may well point to a common cause.

Figure 3: Distance in trade and banking - matched samples



Note: The figure tracks the estimated distance effect over time (using PPML) for the matched sample which includes only those country pairs linked through both trade and banking. The left panels show traditional estimates $\hat{\theta}$ (along with 95% confidence bands), the right panels show the difference $(\hat{\theta} - \hat{\delta})$, obtained from equation (4). Tables 1 and 2 provide further detail.

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the country fixed effects. The comparison holds for country pairs that share no common language, border or colonial past. Those bilateral variables are set to zero in the estimation of the internal distance effect, following Yotov (2012).

3.3 Does the distance effect represent information frictions?

Recent papers in the trade literature (cited in Section 2.2) stress the role of information frictions, quite independently of physical transport cost. This is also an important aspect in global value chains (GVCs). Globalization is associated with the fragmentation, unbundling and offshoring of production, and as the frictions inherent in these activities subside, the volume of trade increases (Baldwin and Venables, 2013). The presence of informational frictions thus limits the proliferation of GVCs and presents an impediment to trade across great distances. As such, evidence of frictions in GVCs go hand in hand with the continued magnitude of the distance effect well beyond transport cost.

One can draw a parallel between GVCs in trade and financial intermediation in banking. Along the GVC, goods are moved between countries for parts, assembly, and shipping via entrepôts at the different stages of production and distribution. Similarly, it is through international intermediation in financial centres that financial claims are bundled or transformed across instruments, currencies and maturities. The sheer volume of financial flows to, from and between financial centres underlines their importance in global capital flows. As intermediation involves frictions at various stages, informational costs also limit the extent of international intermediation, as was the case for GVCs, and thus help explain the observed distance effects.

To close this section, we run three experiments to shed light on the interpretation of distance as an informational friction. Buch (2005) discusses the distance as a proxy for information costs in international banking, and Portes and Rey (2005) consider information-related variables (e.g. the volume of telephone traffic) in their analysis of equity flows between 14 countries. Unfortunately, data limitations preclude thorough testing for information variables in our sample (200 countries forming 15,000 pairs) going back to the 1980s. We instead devise three regressions to provide indirect evidence for the information hypothesis. The estimates of distance effects are summarized in Table 3, and full results shown Appendix Tables D2-D4.

Table 3: Robustness and information-related results

Point estimates of distance coefficients

Method:	PPML		PPML		PPML		PPML	
Test:	No OFC		Non-banks		Branch/subsidiary		Time zones	
Traditional specification (θ_t)								
Distance, 1980	-0.493***	(0.062)	-0.515***	(0.093)	-0.572***	(0.053)	-0.287***	(0.083)
Distance, 1995	-0.597***	(0.057)	-0.869***	(0.080)	-0.880***	(0.057)	-0.397***	(0.093)
Distance, 2005	-0.537***	(0.058)	-0.570***	(0.044)	-0.653***	(0.039)	-0.506***	(0.073)
Distance, 2012	-0.629***	(0.061)	-0.641***	(0.046)	-0.669***	(0.038)	-0.604***	(0.066)
Delta distance	-0.136	(0.087)	-0.126	(0.104)	-0.097	(0.065)	-0.317***	(0.106)
Relative specification ($\theta_t - \delta_t$)								
Relative distance, 1980	-0.590***	(0.036)	-0.817***	(0.031)	-0.781***	(0.030)	-0.748***	(0.025)
Relative distance, 1995	-0.466***	(0.043)	-0.743***	(0.042)	-0.788***	(0.044)	-0.746***	(0.034)
Relative distance, 2005	-0.397***	(0.040)	-0.653***	(0.044)	-0.734***	(0.038)	-0.594***	(0.033)
Relative distance, 2012	-0.454***	(0.040)	-0.673***	(0.042)	-0.801***	(0.035)	-0.612***	(0.032)
Delta relative distance	0.136**	(0.053)	0.144***	(0.052)	-0.020	(0.046)	0.136***	(0.041)

Note: The table reports point estimates of the distance effect for banking, with robust standard errors in separate columns (full results are in Appendix Tables D1-D4). The "No OFC" robustness test excludes offshore centers, tax havens and small financial centres; "Non-banks" uses non-bank cross-border positions; "Branch/subsidiary" includes an indicator variable for the presence of branches and subsidiaries as an additional regressor; "Time zones" includes 12 time-zone dummy variables as additional regressors.

If the distance effect relates to information, it should be stronger for more information-sensitive forms of credit. To test this conjecture, we split international positions by sector to distinguish interbank lending from credit extended to **non-banks**, which includes corporates and non-bank financials. Credit extended directly to non-bank borrowers, especially when located in other countries, is more information-sensitive than lending to banks – which includes intra-group transfers to affiliates where no information asymmetries arise. In line with this view, the distance effect for the non-bank sample (Table D2) is some 0.15 units larger than the corresponding estimate from the all-sectors sample (Table C2). The relative distance friction again shows a secular decline (-0.82 to -0.65) before edging up after the global financial crisis. Information-sensitive lending thus goes hand in hand with stronger distance effects.

Similarly, if information frictions matter, lending should be greater when banks have better access to information on foreign markets. We condition the amount of credit extended from country i to country j on whether banks from i have **branches or subsidiaries** operating in country j. The input is a matrix of branches and subsidiaries by nationality and location, extracted from the 2015 list of bank offices that report the *BIS Locational Banking Statistics*. The presence of affiliates abroad enters with a large positive coefficient, highly significant every year (Table D3). At the same time, the relative distance friction remains nearly constant around 0.78, while the affiliate dummy offsets part of the distance effect. Having a presence abroad promotes cross-border credit to that market. It is plausible that foreign affiliates relay local knowledge back home, allowing the bank's headquarters to extend more cross-border credit to the destination country, either by funding their local affiliate through intragroup loans, or by taking direct exposure to the borrower in the destination country, in the form of bond-holding or cross-border lending.[25]

A final experiment tests the significance of **time zones**, or distance across longitudes. Time differences complicate the exchange of information during working hours.[26] The most general specification allows for 12 distinct dummies each year, one for each hour time difference. These estimates consistently show that larger time differences have more negative effects on the stock of cross-border credit.[27] Most time zone effects share a common time profile that mirrors the broader globalization trend. The inclusion of time zones weakens the estimated distance effect in Table D4, suggesting that they pick up a key aspect of why distance hampers international finance. This extends the findings of Egger and Larch (2013) who document that time zone differences act as trade barriers in a sample of trade between US states and Canadian provinces.

Taken together, these experiments strengthen the argument that distance effects have to do with informational frictions. Due to data limitations, a fuller treatment using information-related variables is left to future research. The remainder of the paper explores other, less prominent, parts of the gravity framework for evidence of globalization.

[25]Our network of cross-border positions covers four possibilities through which this can occur: direct bond holdings or credit to non-banks, intragroup transfers, and interbank lending to a borrower's bank in the destination country (see Appendix A).

[26]For instance, trading hours in New York and Tokyo are disjoint, but both financial centres have some hours overlap with London.

[27]Table D4 shows the regression excluding domestic credit, because most countries are within a single time zone.

4 Where else does globalization appear?

To understand how falling distance costs and other global trends affect the patterns of international trade and banking, it is helpful to step back and reassess current practice. There is no reason to expect the forces of globalization to concentrate on the distance coefficient alone. We now depart from this singular focus and broaden the view to lesser-noted parts of the gravity framework. Figures 4-5 illustrate some of the new results.

We can think of the gravity model as decomposing total variation in bilateral transaction volumes into three levels: a global component, country-specific factors, and bilateral effects. Our measure of the global component, $\widehat{A}_t$, is the regression constant $\widehat{\alpha}_t$ augmented by the means of the country-time fixed effects $\overline{O}_{it}$ and $\overline{D}_{jt}$ in each period.[28] This ensures that the global component relates to the overall scale of banking or trade, leaving country-specific factors to the centered fixed effects $\widehat{o}_{it}$ and $\widehat{d}_{jt}$. With this normalization, the estimated coefficients should reflect globalization trends as follows:

1. The global component, $\widehat{A}_t$, scales all bilateral positions every period. Developments that are global in scope should be reflected at this level.

2. Country-specific factors, $\widehat{o}_{it}$ and $\widehat{d}_{jt}$, absorb all characteristics shaping a country's overall capacity to engage in trade or banking, relative to others. Developments taking place in multiple jurisdictions raise $\widehat{O}_{it}$ and $\widehat{D}_{jt}$ of many countries simultaneously, and will affect the global component $\widehat{A}_t$ more than the (demeaned) country-specific factors $\widehat{o}_{it}$ and $\widehat{d}_{jt}$.

3. The bilateral coefficients, $\widehat{\theta}_t$, $\widehat{\delta}_t$ and vector $\widehat{\lambda}_t$, capture country-pair-specific variation, since all other variation is swept out by time-varying country fixed effects.

This simple classification helps to broaden the view for where distance-related effects could show up in the gravity framework. First, suppose that transport and information costs become *less sensitive* to distance, i.e. ρ in equation (2) declines. This alters the patterns of trade

[28] The regression constant is identified by normalizing the first (or any other) instance of the fixed effects to zero.

and banking, because it affects pairs of countries differentially (according to their relative remoteness from trade partners). A lower sensitivity favors long-distance transactions more than short-distance transactions: the former fall more rapidly than short-distance costs – until the eventual "death of distance" as $\rho \to 0$.[29] Empirically, such a trend reduces the measured difference between long- and short-distance costs, in line with the evidence above on the distance coefficient in trade and banking.

However, what if transport and information costs became *uniformly* cheaper? This channel is just as plausible in view of falling shipment and telecommunication costs. When the cost per unit of distance falls to a fraction $\tau < 1$, the cost function (2) delivers a proportional reduction of the original costs, from $t_{ij}(\tau d)$ to $\tau^{\rho} t_{ij}(d)$ – as if the world literally "got smaller" through shrinkage.[30] This result holds for *any* distance d, and consequently does not favor longer over shorter distances, or international over domestic markets. Any expansion in trade or banking should therefore raise bilateral transaction volumes proportionately – and thus appear in the global component A_t, not in the distance effect.[31]

Another driver of globalization has been the common pace of *liberalization* since the 1980s, in areas ranging from trade agreements to financial deregulation. The effects will again appear at various levels of the gravity framework: if a policy change opens a single country j to foreign investors, the fixed effect D_{jt} (and d_{jt}) shifts up in line with the country's increased attractiveness as a destination. If all countries liberalize, however, then j's relative attractiveness d_{jt} remains unchanged because D_{jt} increases in all countries, raising the global component

[29] Consider an arbitrary country pair ij at a short distance $d_{ij} = d$ from each other, and another pair n times further apart, with $n > 1$. The cost function for the short distance is $t(d) = d^{\rho}\beta$, where β represents other bilateral factors (held constant) in equation (2). The long-distance cost $t^{+} = t(nd) = t(d)n^{\rho}$, with $\rho \leq 1$ as transport costs are plausibly no more than proportional to distance (Anderson van Wincoop, 2004). Suppose globalization reduces the sensitivity ρ from 1 initially to $k < 1$. Hence, in period 0 it was n times as costly to transport goods (or communicate) over a distance n times as far, but in period 1 doing so is only n^k times as costly $\left(t_1^{+}/t_1 = n^k < n = t_0^{+}/t_0\right)$. Equivalently, in the pre/post comparison, the short-distance cost falls to a fraction $t_1/t_0 = d^{k-1} < 1$ of the previous cost. But long-distance costs fall even further, to $t_1^{+}/t_0^{+} = (nd)^{k-1} < t_1/t_0 < 1$.

[30] In the example of the previous footnote, the cost function goes from $t(d) = d^{\rho}\beta$ to $t(d) = (d\tau)^{\rho}\beta$, with long-distance costs correspondingly $t^{+} = (nd\tau)^{\rho}\beta$. The ratio of long- to short-distance costs remains $t^{+}/t = n^{\rho}$, regardless of τ. Both short- and long-distance costs fall to a fraction τ^{ρ} of their previous costs.

[31] This point was recognized by Buch, Kleinert, and Toubal (2004), who showed by example that a proportional fall in distance costs does not show up in the distance effect but in the constant. Our use of fixed effects weeds out country-specific factors and helps give the constant a clearer interpretation.

A_t instead. Trade creation through bilateral agreements or monetary unions, on the other hand, works through the variables $\lambda_t' z_{ijt}$ in (4): by reducing bilateral frictions, such agreements enhance trade and banking between two countries in a way similar to a common language.[32]

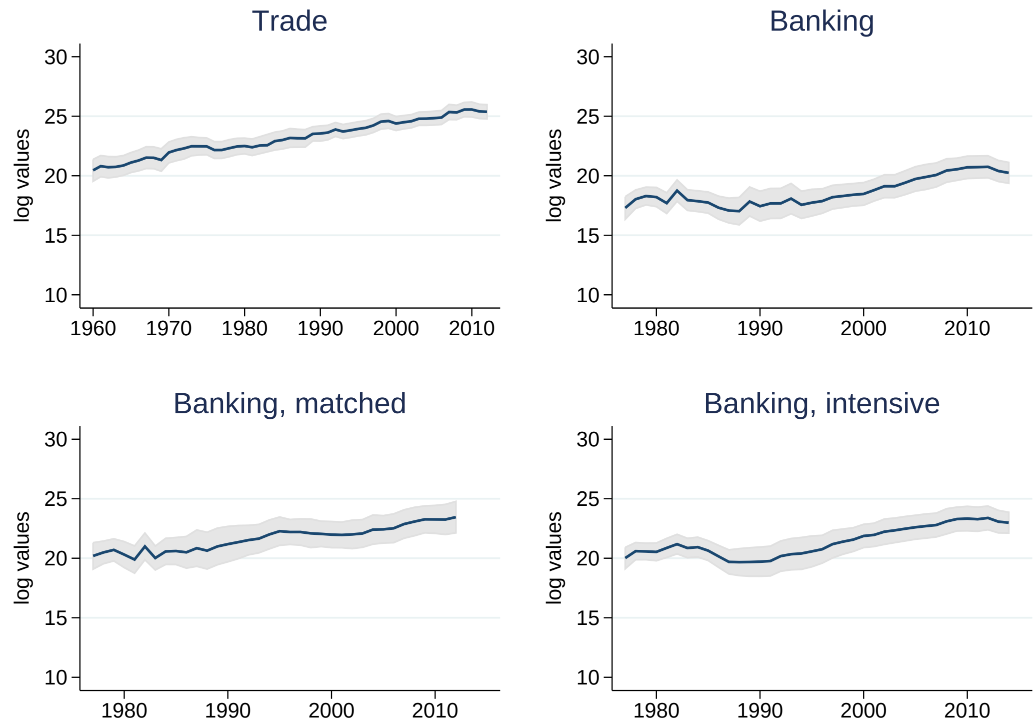
What these thought experiments make clear is that the effects of distance – and of globalization more broadly – are not confined to the distance coefficient alone. Transport and information cost savings, as well as broader developments, may manifest themselves in other, less prominent parts of the gravity framework – notably in the global component, as well as in the extensive margin: as trade and banking with remote countries becomes viable, the number of pairs with direct trade or bank linkages ($X_{ijt} > 0$) increases. The remainder of the paper provides evidence on these two fronts.

First, for the past decades, the *estimated global component* shows rapid growth in both trade and banking (Figure 4). This is consistent with a (proportional) decline in distance costs over time, and with other global developments boosting the scale of trade and banking.[33] The common pace of economic and financial liberalization, and the proliferation of trade agreements and currency unions around the world, surely contributed to the secular rise in the overall volume of trade and banking. Financial factors, such as global liquidity and risk appetite, have further contributed to the expansion of international banking activity in the past decade.

[32] The appendix tables show detailed results, comprising the bilateral factors included in all regressions.

[33] There is a theoretical issue on whether distance can affect the overall scale of trade in the Anderson-van Wincoop model. As explained, their model only identifies relative costs, as goods are in fixed supply and trade flows invariant to domestic distribution costs. However, in the gravity-in-finance model of Okawa and van Wincoop (2012), the invariance to domestic costs no longer holds due to the presence of safe assets. More generally, relaxing the assumptions that separate production and trade patterns allows for an overall expansion of trade in goods and assets as costs fall. Hence, a general decline in t_{ij} can affect the overall volume of trade via the global component A_t, even when relegating the multilateral resistance terms to fixed effects.

Figure 4: Estimates of the global component



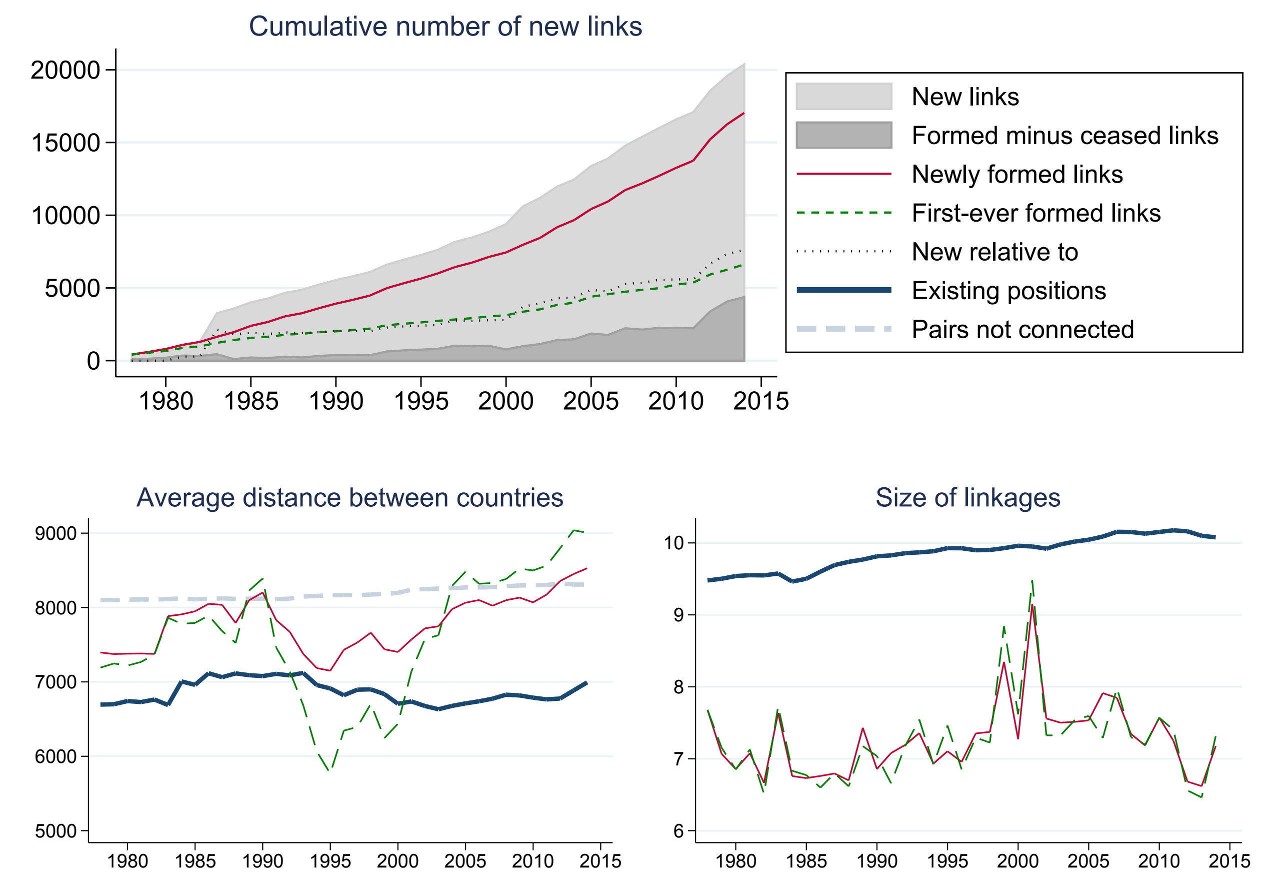
Note: The figure shows in the upper panels the estimated global component $\hat{A}_t$ for the full trade and banking samples, respectively. The global component is the regression constant each period, augmented by the means of the country-time fixed effects, on a log scale. The lower panels show the global component for banking, estimated from the matched and intensive margin samples, respectively (defined in Table 2). The shaded areas are 95% confidence bands.

Second, the *extensive margin* will also reflect globalization trends. As transport and information costs decline, firms start to export to more distant locations, and cross-border banking overcomes greater distances. Figure 5 (upper panel) documents the expansion of international bank linkages between countries since 1977, using several measures. The shaded area cumulates the number of *new links* from year to year. The trend somewhat exaggerates the extensive margin, however. First, new links can be newly formed or newly reported: the latter only enter the sample due to the broadening coverage in the BIS statistics – they may have been active (but unreported) before.[34] Only the series *newly formed links* represents genuinely new relationships, having been reported as zero the year before. A second reason why the series *new*

[34] More precisely, an international bank linkage in a given period can be in one of three states: positive (1), inactive (0), or unreported (*missing*). A positive link could have been in one of those states the year before. Accordingly, the column in a 3x3 transition matrix corresponding to a positive link has three possible entries: continued ($1 \rightarrow 1$), newly formed ($0 \rightarrow 1$), or newly reported ($missing \rightarrow 1$).

links overstates the extensive margin is that links can cease and form again over time. Accordingly, the net number of newly formed links, *formed minus ceased links*, expands more slowly over time. Our narrowest measure, *first-ever formed links*, focuses on country pairs forming an international bank linkage for the first time.[35]

Figure 5: New linkages (extensive margin)



Note: The figure tracks the number (upper panel) and characteristics (lower panels) of new bank linkages between countries over time. All panels share a common legend. The upper panel cumulates the number of new links since 1977, using various definitions explained in the text. The lower left panel contrasts the average distance between countries with *existing links* (thick solid line) and countries *not connected* with each other (thick dashed line) with that of *newly formed links* (thin solid line) and *first-ever formed links* (dashed line). The lower right panel shows the average size of cross-border positions for the same types of links (Log basis 10).

These measures all point to a process of global integration that links more and more countries through international banking over the decades. Newly formed links are smaller and more remote than existing links (Figure 5, bottom panels). In particular, new links tend to form

[35]This not only excludes previously unreported links (as *newly formed* does), it also excludes any linkages that had been positive earlier on, at any point between 1977 and the date shown.

between countries more distant from each other than those pairs already connected through international banking (bottom left panel). The latter feature an average distance of less than 7,000 km between them, whereas new links are formed between countries more than 7,000 km apart on average. This leaves countries that are not linked through international banking more than 8,000 km apart.

At the same time, new linkages are smaller in size than existing bank linkages, by orders of magnitude (Figure 5, bottom right panel). While the size of existing international linkages averaged \$10 billion dollars (10^{10} on the Log_{10}-scale) over the past two decades, new positions were on the order of \$10 to \$100 million dollars.

We have come full circle, in that the regularities highlighted in this section help explain why gravity regressions produce the distance puzzle in the level estimates in spite of globalization. The rise in the global component over time accentuates the distance effect as other bilateral variables $\lambda_t' z_{ijt}$ (and the demeaned fixed effects) remain largely constant over time. And on the extensive margin, the entry of new linkages at longer distances and smaller sizes also enlarges the measured distance effect – even though both are evidence of the declining role of distance in a globalizing world.

5 Conclusion

Traditional estimation of gravity models finds an outsized effect of distance on trade volumes, one that appears to grow over time. This distance puzzle led some observers to quip that globalization is everywhere but in the gravity model. The results in this paper suggest a more nuanced view. First, the distance puzzle can be explained and overturned using the relative specification suggested by Yotov (2012), and our paper extends the same logic and results to international banking. We estimate gravity equations in trade and banking side by side to show that the distance puzzle disappears when setting cross-border banking against domestic banking, using the largest available dataset on global banking.

Second, we show that the effect of falling transport and information costs goes well beyond the estimated distance coefficient. The decline in distance frictions and other forces of globalization also appear in less prominent parts of the gravity framework, notably in the global component and in the extensive margin. These findings now resonate with the facts of globalization, both in trade and banking.

More generally, geographical factors play an important role in international trade and finance as well. Understanding these factors may help to build synergies between the two fields. Obstfeld and Rogoff (2001) show, for instance, that trade costs in goods markets are behind many well-known puzzles in international finance, such as the home bias in equity holdings. In this context it is an open question how far globalization can go. Geographical distance will remain, so will some form of transportation cost and time to delivery; and even costless data transfer will not eliminate soft information asymmetries and cultural differences.

Acknowledgements

We thank Swapan Pradhan and Sebastian Goerlich for sharing expertise on the BIS international banking statistics, and Mario Morelli, Jhuvesh Sobrun and Agne Subelyte for their assistance in compiling trade and macroeconomic data. We are also grateful to Thomas Chaney, Mick Devereux, Thomas Eife, Michael Funke, Galina Hale, Enisse Kharroubi, Cathérine Koch, Gianni Lombardo, Ulf Lewrick, Nuno Limão, Bob McCauley, Pat McGuire, Nikhil Patel, João Santos Silva, Sergio Schmukler, Hyun Song Shin, Yoto Yotov, our discussant Birgit Schmitz and seminar participants at Hamburg University, at the Infiniti Conference 2016 at Trinity College Dublin, and at the Bank for International Settlements, for helpful comments. The views expressed in this paper are those of the authors and do not represent official positions of the institutions they are affiliated with.

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Appendices

Appendix A) Constructing the global banking network

Coverage. The global banking dataset in this paper is built from the *BIS Locational Banking Statistics* (LBS), the most comprehensive source of information on international banking, available at quarterly frequency since 1977. The LBS compile the balance sheets of internationally active banks, along with a geographical breakdown of their counterparties, both aggregated at the country level. The locational statistics are reported following the *residence principle*, consistent with the balance of payments and other national statistics.[36] The concentrated nature of global banking means that the LBS attain broad universal coverage, at least in terms of value. The data contain international assets and liabilities reported by nearly 7,000 banks (subsidiaries *and* branches) in 44 reporting countries as of 2014, comprising the advanced economies, emerging markets and the major offshore centers.[37] The network construction described in this appendix delivers a consistent country-to-country network, and alleviates the problem of an incomplete reporting population at the same time.

Breakdowns. Banks report, on an unconsolidated basis, their international positions: claims on, and liabilities from, all sectors. "International" refers to all cross-border business, plus local positions in foreign currencies; in this paper, we only use cross-border positions, alongside domestic credit from the IMF's *International Financial Statistics*. Banks report their gross assets and liabilities, along with breakdowns by currency, by instrument, and by the sector of the counterparty they lend to and borrow from. Most importantly, banks in every reporting country record these positions vis-à-vis residents in 216 countries and jurisdictions. The bilateral nature of the data thus allows us to construct a coherent network, one that contains all reported positions intermediated through international banks between origin and destination countries.

Banks-to-country format. The BIS data are collected in the "banks-to-country" format, as illustrated in Figure A. However, this format in a bilateral setting gives rise to an asymmetric network: banks in country i lend to banks *and all other sectors* in another country j (dark blue arrows). However, it leaves out some bank flows at the country level: deposits that *firms* place

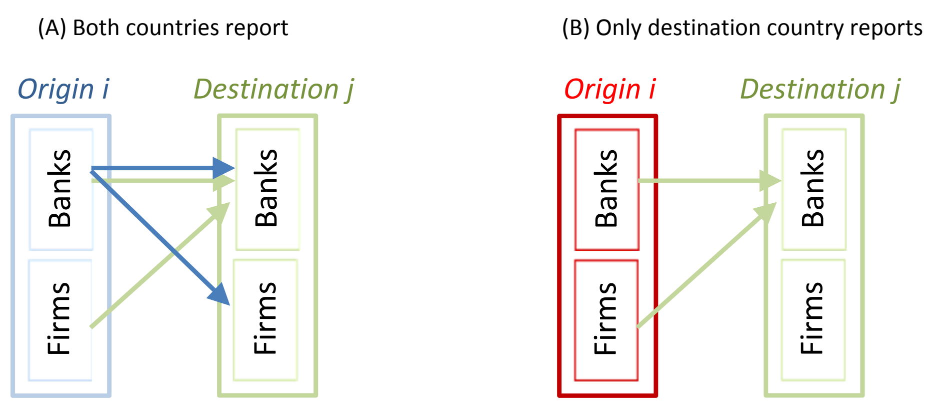
[36]Bank offices report their banking activity in the location of their operations, regardless of the nationality (ownership) of the parent bank. For instance, the United Kingdom reports the international bank positions booked in its jurisdiction, including those of branches and subsidiaries of German banks operating in the UK. (Conversely, the positions that UK-owned banks book in Germany are reported by Germany.) Reported positions are robust to changes in bank ownership following mergers and acquisitions.

[37]Information on reporting practices, and the current list of reporting countries and institutions are available at: http://www.bis.org/statistics/count_rep_practices.htm

with banks abroad also constitute cross-border claims of country i on j (light green arrow). Net positions between i and j are also hard to interpret in this format. Hence, to capture all financial flows between origin and destination that pass through international banks, the dataset must incorporate non-banks to cover all sectors on both sides.

Network format. We transform the "banks-to-country" data to a "country-to-country" network, by overlaying the asset and liability data for all country pairs on which data are reported. This captures the claims of *all* sectors in country i on all sectors in country j transacted via banks, including all blue and green arrows in Figure A. The resulting network leaves out only direct exposures between non-banks (on which comprehensive global data are difficult to find). In this country-to-country network, it is no longer necessary to treat cross-border claims and liabilities separately – they are the rows and columns of the same matrix. The procedure has the added benefit of maximizing coverage by the use of counterparty information: if a country does not report its positions (marked red in Figure A, right panel), one can use the destination country's reported bank *liabilities* to infer the first country's cross-border claims on banks at least.

Figure A: Constructing a country-to-country network



Resolving double-reporting. Interbank positions are reported twice whenever origin *and* destination are BIS reporting countries (the two adjacent arrows in Figure A). In principle, the claims banks in country A hold on banks in B should equal the liabilities banks in B owe banks in A. In practice, the correlation between the double-reported positions exceeds 90%, but the reported amounts generally differ for reasons of coverage. We use the *maximum* between the respective positions reported by two jurisdictions, for several reasons. First, the set of reporting banks ("internationally active banks") is generally smaller than that on the counterparty side ("all banks"), and taking the maximum gets closer to the reporting ideal comprising all banks on both sides. Second, banks may not know the location of their counterparties for the liabilities they issued in the form of tradable debt instruments; by contrast, banks do know the counterparty of the assets they hold. Indeed, in the bilateral interbank data, reported assets exceed liabilities more often (56%) than not. Taking the maximum also addresses the general issue that incentives and reporting systems make underreporting more prevalent than overreporting.

Adjustments. Before building the network, we make several adjustments to enhance the consistency of the banking statistics. The first is to ensure that the set of 216 countries and jurisdictions covers the world without gaps and overlaps.[38] Second, the broadening coverage of the LBS over time requires us to distinguish between reported (true) zeros and unreported positions (missing values). Cross-border positions remain unknown (only) if neither origin nor destination is a BIS-reporting country, and are excluded as missing values from the analysis and regressions. Third, for each reporting country, residuals (such as unallocated debt liabilities) are distributed using the information available in the reported bilateral positions (such as deposit liabilities, where the locations of the counterparties are known); this approach creates no new linkages between country pairs, but scales up existing positions proportionately.

The bilateral claims and liabilities in the final dataset combine all currencies, all instruments (loans and deposits, and holdings of debt securities and equity), and distinguish the sector of the counterparty: *interbank positions* include intragroup transfers between offices of the same banking group, positions with unaffiliated banks and with central banks; *non-bank positions* comprise claims on, and liabilities to, all other sectors, including households, corporations, the public sector and non-bank financial institutions (mutual funds, other funds, CCPs, etc).

[38] On the reporting country side, legacy reporters are consolidated with their successor reporting country; on the counterparty country side, legacy residuals are allocated to legacy countries, which in turn are allocated to the largest successor country, e.g. the German Democratic Republic to (West) Germany.

Appendix B) Gravity estimates for trade

Table B reports detailed regression results for the gravity equation in trade, estimated yearly from 1960 to 2012, and shown below for 1960, 1980, 1985, 1990, 1995, 2000, 2005, 2010, and 2012 (latest year). Significance levels are marked as: * 10%, ** 5%, *** 1%. Parts B1-B4 correspond to the four columns in Table 1 of the main text (see the table notes for further detail). The distance estimate corresponds to $\widehat{\theta}$, the relative distance estimate to $(\widehat{\theta} - \widehat{\delta})$. Figures 1 and 3 show the relative distance coefficients for all years.

B1 Full sample LSDV (detailing Table 1 column 1 in the main text)

Traditional specification

	1960	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.748***	-1.350***	-1.361***	-1.469***	-1.492***	-1.589***	-1.701***	-1.808***	-1.769***
	(0.029)	(0.028)	(0.028)	(0.027)	(0.024)	(0.023)	(0.024)	(0.025)	(0.026)
Contiguity	0.235**	0.247**	0.303***	0.603***	0.943***	0.884***	0.863***	0.616***	0.659***
	(0.104)	(0.123)	(0.110)	(0.113)	(0.102)	(0.101)	(0.108)	(0.108)	(0.115)
Common language	0.421***	0.429***	0.533***	0.650***	0.768***	0.746***	0.904***	0.907***	0.988***
	(0.060)	(0.059)	(0.058)	(0.057)	(0.051)	(0.051)	(0.052)	(0.053)	(0.054)
Colonial relation	1.238***	1.473***	1.335***	1.293***	1.208***	1.118***	0.993***	0.933***	0.871***
	(0.102)	(0.097)	(0.094)	(0.096)	(0.091)	(0.096)	(0.096)	(0.103)	(0.107)
Observations	5591	12065	12485	14839	19832	21750	22394	21352	21667
R-squared	0.677	0.695	0.700	0.703	0.718	0.716	0.722	0.731	0.727

Relative specification

	1960	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.758***	-1.343***	-1.360***	-1.472***	-1.501***	-1.599***	-1.703***	-1.810***	-1.775***
	(0.029)	(0.027)	(0.027)	(0.026)	(0.023)	(0.022)	(0.024)	(0.025)	(0.025)
Internal distance	0.268***	-0.447***	-0.424***	-0.518***	-0.566***	-0.723***	-0.862***	-1.076***	-1.054***
	(0.055)	(0.058)	(0.057)	(0.060)	(0.054)	(0.056)	(0.059)	(0.063)	(0.064)
Relative distance	-1.026***	-0.896***	-0.935***	-0.954***	-0.935***	-0.877***	-0.841***	-0.735***	-0.721***
	(0.033)	(0.041)	(0.040)	(0.045)	(0.041)	(0.043)	(0.047)	(0.049)	(0.051)
Contiguity	0.182*	0.240**	0.278**	0.580***	0.919***	0.863***	0.854***	0.605***	0.643***
	(0.103)	(0.121)	(0.109)	(0.111)	(0.101)	(0.100)	(0.107)	(0.106)	(0.114)
Common language	0.388***	0.397***	0.498***	0.615***	0.734***	0.717***	0.879***	0.886***	0.961***
	(0.059)	(0.059)	(0.057)	(0.057)	(0.051)	(0.050)	(0.051)	(0.053)	(0.053)
Colonial relation	1.244***	1.506***	1.373***	1.334***	1.242***	1.147***	1.022***	0.963***	0.904***
	(0.103)	(0.097)	(0.094)	(0.097)	(0.091)	(0.097)	(0.096)	(0.102)	(0.107)
Observations	5699	12219	12641	15001	20017	21937	22582	21526	21832
R-squared	0.719	0.708	0.713	0.713	0.726	0.723	0.727	0.737	0.732

B2 Full sample PPML (Table 1, column 2)

Traditional specification

	1960	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.720***	-0.811***	-0.819***	-0.794***	-0.796***	-0.842***	-0.901***	-0.867***	-0.856***
	(0.053)	(0.033)	(0.031)	(0.029)	(0.028)	(0.027)	(0.027)	(0.033)	(0.034)
Contiguity	0.332***	0.398***	0.463***	0.504***	0.690***	0.653***	0.452***	0.411***	0.444***
	(0.113)	(0.085)	(0.075)	(0.082)	(0.085)	(0.077)	(0.065)	(0.075)	(0.082)
Common language	0.316***	0.169**	0.281***	0.299***	0.214***	0.150**	0.200***	0.134*	0.073
	(0.109)	(0.071)	(0.064)	(0.063)	(0.067)	(0.066)	(0.067)	(0.069)	(0.070)
Colonial relation	1.001***	0.244**	0.034	-0.006	-0.011	-0.026	0.051	0.093	0.135
	(0.148)	(0.105)	(0.104)	(0.092)	(0.099)	(0.096)	(0.103)	(0.115)	(0.117)
Observations	12744	18533	20731	22800	28860	30209	30275	28680	28680
R-squared	0.763	0.880	0.914	0.919	0.913	0.935	0.906	0.866	0.851

Relative specification

	1960	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.869***	-0.858***	-0.937***	-0.962***	-1.025***	-1.040***	-1.035***	-1.025***	-0.984***
	(0.060)	(0.043)	(0.051)	(0.041)	(0.039)	(0.037)	(0.037)	(0.039)	(0.037)
Internal distance	-0.202**	-0.305***	-0.386***	-0.443***	-0.561***	-0.624***	-0.628***	-0.604***	-0.569***
	(0.085)	(0.060)	(0.072)	(0.057)	(0.054)	(0.052)	(0.052)	(0.057)	(0.053)
Relative distance	-0.667***	-0.553***	-0.551***	-0.520***	-0.464***	-0.416***	-0.407***	-0.421***	-0.415***
	(0.026)	(0.020)	(0.023)	(0.019)	(0.018)	(0.017)	(0.017)	(0.020)	(0.018)
Contiguity	0.049	0.379***	0.407***	0.409***	0.362***	0.430***	0.366***	0.343***	0.416***
	(0.121)	(0.095)	(0.103)	(0.089)	(0.078)	(0.087)	(0.090)	(0.099)	(0.097)
Common language	0.717***	0.306***	0.408***	0.323***	0.294***	0.232**	0.258***	0.113	0.044
	(0.106)	(0.097)	(0.108)	(0.088)	(0.091)	(0.095)	(0.081)	(0.077)	(0.078)
Colonial relation	0.894***	0.365***	0.325***	0.238**	0.205**	0.181*	0.044	-0.016	0.003
	(0.129)	(0.100)	(0.113)	(0.104)	(0.101)	(0.101)	(0.090)	(0.084)	(0.081)
Observations	12852	18687	20887	22962	29045	30396	30463	28854	28845
R-squared	0.995	0.997	0.998	0.998	0.998	0.999	0.998	0.996	0.998

B3 Intensive margin sample, PPML (Table 1, column 3)

Traditional specification

	1960	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.705***	-0.847***	-0.857***	-0.818***	-0.810***	-0.855***	-0.894***	-0.851***	-0.839***
	(0.054)	(0.037)	(0.038)	(0.036)	(0.032)	(0.033)	(0.033)	(0.040)	(0.041)
Contiguity	0.373***	0.381***	0.441***	0.476***	0.596***	0.562***	0.430***	0.445***	0.478***
	(0.112)	(0.077)	(0.076)	(0.082)	(0.082)	(0.079)	(0.074)	(0.093)	(0.103)
Common language	0.303***	0.200***	0.286***	0.349***	0.350***	0.302***	0.293***	0.211***	0.175**
	(0.109)	(0.075)	(0.070)	(0.067)	(0.066)	(0.065)	(0.069)	(0.076)	(0.078)
Colonial relation	0.972***	0.293***	0.084	-0.036	-0.200**	-0.187*	-0.095	-0.046	-0.038
	(0.143)	(0.106)	(0.109)	(0.100)	(0.096)	(0.097)	(0.101)	(0.105)	(0.105)
Observations	10123	10123	10123	10123	10123	10123	10123	10123	10123
R-squared	0.772	0.896	0.916	0.921	0.926	0.946	0.918	0.875	0.863

Relative specification

	1960	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.855***	-0.910***	-0.920***	-0.941***	-1.028***	-1.052***	-1.023***	-0.989***	-0.961***
	(0.061)	(0.044)	(0.052)	(0.045)	(0.045)	(0.041)	(0.043)	(0.048)	(0.043)
Internal distance	-0.188**	-0.388***	-0.388***	-0.429***	-0.577***	-0.651***	-0.612***	-0.549***	-0.529***
	(0.086)	(0.062)	(0.072)	(0.061)	(0.062)	(0.056)	(0.059)	(0.069)	(0.061)
Relative distance	-0.667***	-0.522***	-0.531***	-0.512***	-0.451***	-0.402***	-0.411***	-0.440***	-0.432***
	(0.027)	(0.019)	(0.022)	(0.019)	(0.019)	(0.017)	(0.018)	(0.023)	(0.020)
Contiguity	0.089	0.319***	0.463***	0.435***	0.310***	0.405***	0.420***	0.420***	0.475***
	(0.122)	(0.096)	(0.105)	(0.091)	(0.083)	(0.094)	(0.097)	(0.119)	(0.119)
Common language	0.700***	0.278***	0.355***	0.335***	0.321***	0.268***	0.238***	0.113	0.070
	(0.107)	(0.098)	(0.105)	(0.090)	(0.096)	(0.097)	(0.080)	(0.087)	(0.089)
Colonial relation	0.877***	0.304***	0.204*	0.125	0.017	0.000	-0.090	-0.068	-0.050
	(0.129)	(0.103)	(0.116)	(0.106)	(0.105)	(0.105)	(0.087)	(0.083)	(0.080)
Observations	10217	10217	10217	10217	10217	10217	10217	10217	10217
R-squared	0.996	0.997	0.999	0.999	0.998	0.999	0.999	0.998	0.998

B4 Matched sample, PPML (Table 1, column 4)

Traditional specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.869***	-0.851***	-0.800***	-0.794***	-0.831***	-0.886***	-0.862***	-0.857***
	(0.037)	(0.030)	(0.031)	(0.029)	(0.029)	(0.028)	(0.036)	(0.038)
Contiguity	0.404***	0.442***	0.506***	0.610***	0.614***	0.455***	0.397***	0.420***
	(0.084)	(0.078)	(0.087)	(0.088)	(0.089)	(0.073)	(0.085)	(0.095)
Common language	0.311***	0.346***	0.308***	0.227***	0.131*	0.207***	0.183**	0.162**
	(0.073)	(0.073)	(0.066)	(0.067)	(0.071)	(0.070)	(0.073)	(0.076)
Colonial relation	0.149	-0.156	-0.14	-0.113	0.048	0.073	-0.142	-0.143
	(0.166)	(0.218)	(0.173)	(0.164)	(0.153)	(0.197)	(0.235)	(0.229)
Observations	3943	6320	6634	7606	9010	11460	12043	12043
R-squared	0.914	0.919	0.921	0.921	0.942	0.91	0.871	0.857

Relative specification

Distance	-0.823***	-0.927***	-0.927***	-0.972***	-0.986***	-1.001***	-0.988***	-0.949***
	(0.042)	(0.037)	(0.036)	(0.039)	(0.036)	(0.040)	(0.044)	(0.041)
Internal distance	-0.300***	-0.444***	-0.437***	-0.511***	-0.566***	-0.586***	-0.558***	-0.526***
	(0.060)	(0.053)	(0.051)	(0.054)	(0.049)	(0.056)	(0.064)	(0.059)
Relative distance	-0.523***	-0.484***	-0.489***	-0.461***	-0.420***	-0.415***	-0.430***	-0.423***
	(0.019)	(0.019)	(0.017)	(0.017)	(0.016)	(0.018)	(0.022)	(0.020)
Contiguity	0.400***	0.407***	0.437***	0.400***	0.523***	0.411***	0.379***	0.441***
	(0.105)	(0.106)	(0.092)	(0.088)	(0.096)	(0.102)	(0.115)	(0.116)
Common language	0.425***	0.338***	0.310***	0.367***	0.309***	0.283***	0.188**	0.138
	(0.098)	(0.089)	(0.083)	(0.094)	(0.096)	(0.086)	(0.084)	(0.086)
Colonial relation	0.204	0.191	0.202*	0.179	0.212	0.209	0.041	0.053
	(0.125)	(0.128)	(0.117)	(0.145)	(0.158)	(0.166)	(0.161)	(0.141)
Observations	4057	6446	6768	7767	9175	11626	12197	12186
R-squared	0.999	0.999	0.999	0.999	0.999	0.997	0.997	0.996

Appendix C) Gravity estimates for banking

Table C reports detailed regression results for the gravity equation in banking, estimated yearly from 1977 to 2014, and shown below for 1980, 1985, 1990, 1995, 2000, 2005, 2010, and 2012. Significance levels are marked as: * 10%, ** 5%, *** 1%. Parts C1-C4 correspond to the four columns in Table 2 (see the table note for further detail). The distance estimate corresponds to $\widehat{\theta}$, the relative distance estimate to $(\widehat{\theta} - \widehat{\delta})$. The relative distance coefficients for all years appear in Figures 2 and 3.

C1 Full sample, LSDV (detailing Table 2 column 1 in the main text)

Traditional specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.868***	-1.018***	-0.906***	-1.081***	-1.161***	-1.184***	-1.192***	-1.347***
	(0.053)	(0.037)	(0.039)	(0.037)	(0.035)	(0.033)	(0.033)	(0.037)
Contiguity	0.159	-0.446**	-0.446**	-0.472**	-0.224	-0.432***	0.061	0.223
	(0.168)	(0.190)	(0.195)	(0.197)	(0.166)	(0.152)	(0.161)	(0.196)
Common language	0.278***	0.638***	0.637***	0.533***	0.410***	0.717***	0.820***	0.790***
	(0.075)	(0.068)	(0.069)	(0.071)	(0.070)	(0.063)	(0.067)	(0.070)
Colonial relation	1.283***	1.233***	1.188***	1.355***	1.462***	1.340***	1.302***	1.447***
	(0.116)	(0.114)	(0.115)	(0.120)	(0.131)	(0.121)	(0.143)	(0.164)
Observations	2929	4534	4719	5120	5460	7546	8300	9438
R-squared	0.827	0.830	0.800	0.795	0.757	0.767	0.725	0.729

Relative specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.846***	-1.060***	-0.985***	-1.076***	-1.103***	-1.148***	-1.141***	-1.284***
	(0.059)	(0.044)	(0.042)	(0.044)	(0.041)	(0.036)	(0.036)	(0.040)
Internal distance	0.130	-0.055	0.099	0.012	-0.093	-0.069	0.021	-0.083
	(0.106)	(0.088)	(0.087)	(0.081)	(0.073)	(0.069)	(0.070)	(0.080)
Relative distance	-0.976***	-1.005***	-1.084***	-1.088***	-1.010***	-1.079***	-1.162***	-1.201***
	(0.058)	(0.059)	(0.058)	(0.052)	(0.046)	(0.047)	(0.047)	(0.055)
Contiguity	0.437***	-0.269	-0.281	-0.236	-0.003	-0.314**	0.178	0.361*
	(0.169)	(0.184)	(0.189)	(0.194)	(0.162)	(0.149)	(0.159)	(0.193)
Common language	0.172**	0.534***	0.506***	0.483***	0.433***	0.712***	0.840***	0.827***
	(0.080)	(0.070)	(0.070)	(0.072)	(0.072)	(0.063)	(0.067)	(0.070)
Colonial relation	1.217***	1.176***	1.156***	1.304***	1.390***	1.319***	1.266***	1.424***
	(0.122)	(0.121)	(0.122)	(0.125)	(0.132)	(0.122)	(0.142)	(0.163)
Observations	3052	4668	4859	5289	5633	7718	8471	9602
R-squared	0.819	0.819	0.792	0.786	0.755	0.768	0.730	0.732

C2 Full sample, PPML (Table 2, column 2)

Traditional specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.602***	-0.709***	-0.808***	-0.886***	-0.761***	-0.692***	-0.752***	-0.725***
	(0.047)	(0.041)	(0.057)	(0.049)	(0.042)	(0.036)	(0.039)	(0.038)
Contiguity	0.167	-0.0473	-0.182	-0.144	-0.162	-0.189	-0.0279	0.146
	(0.146)	(0.118)	(0.149)	(0.143)	(0.134)	(0.120)	(0.127)	(0.130)
Common language	0.478***	0.540***	0.388***	0.255**	0.337***	0.539***	0.692***	0.618***
	(0.100)	(0.073)	(0.100)	(0.108)	(0.099)	(0.087)	(0.090)	(0.093)
Colonial relation	0.549***	0.102	-0.030	-0.162	-0.017	-0.038	-0.059	-0.250*
	(0.130)	(0.137)	(0.153)	(0.152)	(0.130)	(0.113)	(0.137)	(0.129)
Observations	5198	8362	8412	9187	10715	14574	15858	15858
R-squared	0.820	0.877	0.846	0.860	0.889	0.932	0.930	0.917

Relative specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.601***	-0.557***	-0.434***	-0.441***	-0.518***	-0.597***	-0.627***	-0.614***
	(0.048)	(0.053)	(0.074)	(0.066)	(0.057)	(0.061)	(0.058)	(0.057)
Internal distance	0.029	0.011	0.144	0.142	0.007	-0.116	-0.122	-0.090
	(0.072)	(0.081)	(0.101)	(0.095)	(0.086)	(0.092)	(0.088)	(0.087)
Relative distance	-0.630***	-0.568***	-0.578***	-0.583***	-0.525***	-0.481***	-0.506***	-0.524***
	(0.027)	(0.031)	(0.033)	(0.034)	(0.033)	(0.035)	(0.034)	(0.034)
Contiguity	-0.544***	-0.740***	-0.569***	-0.518**	-0.580**	-0.597**	-0.510*	-0.400
	(0.186)	(0.240)	(0.209)	(0.256)	(0.243)	(0.255)	(0.275)	(0.274)
Common language	1.118***	1.324***	1.068***	1.123***	1.359***	1.421***	1.619***	1.492***
	(0.158)	(0.191)	(0.181)	(0.221)	(0.222)	(0.238)	(0.276)	(0.272)
Colonial relation	0.922***	0.405	-0.064	-0.199	-0.091	0.341	0.290	0.219
	(0.229)	(0.251)	(0.200)	(0.234)	(0.255)	(0.260)	(0.276)	(0.275)
Observations	5318	8496	8552	9356	10888	14746	16029	16022
R-squared	0.993	0.991	0.990	0.994	0.987	0.966	0.952	0.962

C3 Intensive margin sample, PPML (Table 2, column 3)

Traditional specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.590***	-0.629***	-0.809***	-0.890***	-0.719***	-0.637***	-0.648***	-0.624***
	(0.045)	(0.045)	(0.059)	(0.050)	(0.048)	(0.043)	(0.046)	(0.044)
Contiguity	0.278**	0.111	-0.138	-0.172	-0.150	-0.151	0.000	0.121
	(0.132)	(0.118)	(0.151)	(0.147)	(0.135)	(0.121)	(0.127)	(0.122)
Common language	0.456***	0.461***	0.382***	0.260**	0.238**	0.484***	0.667***	0.596***
	(0.094)	(0.081)	(0.108)	(0.121)	(0.105)	(0.101)	(0.097)	(0.099)
Colonial relation	0.469***	0.210	-0.045	-0.084	0.103	0.071	-0.165	-0.320**
	(0.127)	(0.135)	(0.163)	(0.150)	(0.133)	(0.119)	(0.154)	(0.141)
Observations	2161	2161	2161	2161	2161	2161	2161	2161
R-squared	0.835	0.890	0.861	0.879	0.894	0.939	0.941	0.935

Relative specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.559***	-0.544***	-0.372***	-0.472***	-0.613***	-0.671***	-0.687***	-0.665***
	(0.046)	(0.053)	(0.080)	(0.084)	(0.061)	(0.062)	(0.065)	(0.064)
Internal distance	0.071	0.003	0.201*	0.075	-0.152*	-0.249***	-0.249***	-0.205**
	(0.070)	(0.079)	(0.108)	(0.115)	(0.090)	(0.091)	(0.094)	(0.092)
Relative distance	-0.630***	-0.547***	-0.572***	-0.547***	-0.461***	-0.422***	-0.438***	-0.460***
	(0.027)	(0.029)	(0.033)	(0.036)	(0.032)	(0.033)	(0.033)	(0.033)
Contiguity	-0.527***	-0.811***	-0.571**	-0.546**	-0.650***	-0.613**	-0.582**	-0.502*
	(0.184)	(0.253)	(0.224)	(0.248)	(0.216)	(0.240)	(0.264)	(0.275)
Common language	1.076***	1.304***	1.019***	0.965***	1.104***	1.184***	1.405***	1.302***
	(0.156)	(0.220)	(0.186)	(0.183)	(0.182)	(0.238)	(0.275)	(0.290)
Colonial relation	0.906***	0.421	-0.164	-0.199	-0.137	-0.028	-0.251	-0.376
	(0.238)	(0.262)	(0.209)	(0.237)	(0.254)	(0.282)	(0.276)	(0.272)
Observations	2269	2269	2266	2269	2269	2269	2269	2269
R-squared	0.993	0.992	0.991	0.994	0.991	0.975	0.967	0.971

C4 Matched sample, PPML (Table 2, column 4)

Traditional specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.554***	-0.722***	-0.776***	-0.877***	-0.747***	-0.679***	-0.727***	-0.726***
	(0.056)	(0.047)	(0.057)	(0.050)	(0.047)	(0.045)	(0.048)	(0.049)
Contiguity	0.442***	0.034	-0.036	-0.121	-0.178	-0.178	-0.027	0.118
	(0.147)	(0.122)	(0.155)	(0.147)	(0.153)	(0.132)	(0.142)	(0.146)
Common language	0.287***	0.502***	0.271**	0.105	0.236**	0.471***	0.713***	0.671***
	(0.092)	(0.075)	(0.106)	(0.112)	(0.106)	(0.113)	(0.116)	(0.111)
Colonial relation	0.677***	0.0373	-0.113	-0.241	-0.058	-0.163	-0.096	-0.270*
	(0.135)	(0.151)	(0.151)	(0.169)	(0.143)	(0.130)	(0.183)	(0.159)
Observations	3943	6320	6634	7606	9010	11460	12043	12043
R-squared	0.868	0.893	0.871	0.884	0.883	0.923	0.909	0.908

Relative specification

Distance	-0.686***	-0.720***	-0.728***	-0.885***	-0.832***	-0.862***	-0.866***	-0.876***
	(0.065)	(0.069)	(0.088)	(0.073)	(0.067)	(0.068)	(0.070)	(0.078)
Internal distance	-0.084	-0.210**	-0.254**	-0.459***	-0.415***	-0.467***	-0.437***	-0.433***
	(0.095)	(0.099)	(0.123)	(0.106)	(0.096)	(0.098)	(0.099)	(0.108)
Relative distance	-0.602***	-0.510***	-0.474***	-0.426***	-0.417***	-0.395***	-0.429***	-0.443***
	(0.033)	(0.034)	(0.039)	(0.037)	(0.034)	(0.034)	(0.034)	(0.035)
Contiguity	-0.634***	-0.940***	-0.729***	-0.850***	-0.752***	-0.730***	-0.664**	-0.631**
	(0.224)	(0.275)	(0.217)	(0.216)	(0.241)	(0.279)	(0.309)	(0.305)
Common language	1.061***	1.196***	0.593**	0.474*	0.879***	1.082***	1.345***	1.256***
	(0.203)	(0.247)	(0.270)	(0.267)	(0.241)	(0.306)	(0.360)	(0.377)
Colonial relation	0.845***	0.447	0.148	-0.059	-0.066	-0.077	0.093	-0.014
	(0.261)	(0.282)	(0.242)	(0.311)	(0.319)	(0.311)	(0.346)	(0.337)
Observations	4057	6446	6768	7767	9175	11626	12197	12186
R-squared	0.99	0.99	0.99	1.00	0.99	0.97	0.96	0.97

Appendix D) Gravity estimates for banking - robustness

Table D reports detailed regression results for the gravity equation in banking for the robustness checks described in Section 3.3. They are estimated yearly from 1977 to 2014, and shown below for 1980, 1985, 1990, 1995, 2000, 2005, 2010, and 2012. Significance levels are marked as: * 10%, ** 5%, *** 1%. Parts D1-D4 correspond to the columns in Table 3 (relative specifications for D1-D3, and traditional specification for D4 as most countries are within a single time zone). The distance estimate corresponds to $\widehat{\theta}$, the relative distance estimate to $(\widehat{\theta} - \widehat{\delta})$.

D1 Full sample, PPML, excluding offshore centers

Relative specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.721***	-0.778***	-0.628***	-0.839***	-0.848***	-0.871***	-0.878***	-0.846***
	(0.076)	(0.082)	(0.098)	(0.096)	(0.086)	(0.085)	(0.084)	(0.090)
Internal distance	-0.131	-0.282**	-0.090	-0.373***	-0.428***	-0.474***	-0.444***	-0.392***
	(0.108)	(0.116)	(0.132)	(0.135)	(0.121)	(0.122)	(0.118)	(0.125)
Relative distance	-0.590***	-0.497***	-0.538***	-0.466***	-0.420***	-0.397***	-0.434***	-0.454***
	(0.036)	(0.037)	0(.039)	(0.043)	(0.039)	(0.040)	(0.039)	(0.040)
Contiguity	-0.544**	-0.793**	-0.568**	-0.660**	-0.582**	-0.628**	-0.54	-0.521
	(0.233)	(0.335)	(0.257)	(0.284)	(0.284)	(0.313)	(0.347)	(0.349)
Common language	0.969***	1.083***	0.931***	0.854***	0.907***	1.129***	1.369***	1.343***
	(0.223)	(0.354)	(0.247)	(0.248)	(0.296)	(0.346)	(0.403)	(0.399)
Colonial relation	0.231	-0.168	-0.420*	-0.801***	-1.003***	-0.911***	-0.590*	-0.519
	(0.263)	(0.318)	(0.241)	(0.260)	(0.316)	(0.323)	(0.336)	(0.333)
Observations	4427	5062	5086	5724	7055	9020	10125	10150
R-squared	0.994	0.993	0.994	0.996	0.991	0.974	0.964	0.968

D2 Full sample, PPML, non-bank positions

Relative specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.747***	-0.734***	-0.680***	-0.538***	-0.581***	-0.615***	-0.668***	-0.651***
	(0.054)	(0.054)	(0.078)	(0.062)	(0.072)	(0.084)	(0.082)	(0.074)
Internal distance	0.070	-0.022	0.031	0.205**	0.104	0.039	0.003	0.022
	(0.081)	(0.085)	(0.115)	(0.102)	(0.108)	(0.125)	(0.121)	(0.112)
Relative distance	-0.817***	-0.712***	-0.711***	-0.743***	-0.685***	-0.653***	-0.671***	-0.673***
	(0.031)	(0.033)	(0.039)	(0.042)	(0.039)	(0.044)	(0.043)	(0.042)
Contiguity	-0.794***	-0.727**	-0.649**	-0.47	-0.496	-0.674*	-0.706**	-0.579
	(0.298)	(0.306)	(0.262)	(0.343)	(0.343)	(0.351)	(0.357)	(0.371)
Common language	1.200***	1.373***	1.135***	1.201***	1.426***	1.615***	1.816***	1.676***
	(0.287)	(0.233)	(0.209)	(0.303)	(0.291)	(0.305)	(0.328)	(0.345)
Colonial relation	0.700**	0.284	-0.069	-0.427	-0.380	0.254	0.186	0.052
	(0.277)	(0.244)	(0.230)	(0.264)	(0.304)	(0.371)	(0.329)	(0.308)
Observations	5236	8471	8527	9356	10867	14746	16029	16022
R-squared	0.999	0.999	0.999	0.999	0.997	0.991	0.987	0.988

D3 Full sample, PPML, branch/subsidiary presence

Relative specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.533***	-0.496***	-0.365***	-0.384***	-0.443***	-0.513***	-0.537***	-0.524***
	(0.047)	(0.050)	(0.065)	(0.061)	(0.054)	(0.061)	(0.058)	(0.056)
Internal distance	0.248***	0.249***	0.420***	0.404***	0.315***	0.221**	0.236***	0.277***
	(0.073)	(0.086)	(0.101)	(0.092)	(0.089)	(0.095)	(0.091)	(0.087)
Relative distance	-0.781***	-0.745***	-0.785***	-0.788***	-0.759***	-0.734***	-0.774***	-0.801***
	(0.030)	(0.039)	(0.046)	(0.044)	(0.040)	(0.038)	(0.038)	(0.035)
Contiguity	-0.803***	-0.994***	-0.783***	-0.742***	-0.784***	-0.787***	-0.731***	-0.653***
	(0.188)	(0.233)	(0.193)	(0.252)	(0.230)	(0.242)	(0.254)	(0.251)
Common language	1.093***	1.217***	0.914***	0.955***	1.187***	1.269***	1.428***	1.306***
	(0.155)	(0.188)	(0.184)	(0.221)	(0.212)	(0.224)	(0.253)	(0.252)
Colonial relation	0.811***	0.263	-0.314	-0.474**	-0.375	0.040	-0.024	-0.134
	(0.226)	(0.240)	(0.200)	(0.240)	(0.262)	(0.287)	(0.291)	(0.284)
Dummy, branch/subsidiary	1.041***	1.280***	1.393***	1.414***	1.559***	1.669***	1.835***	1.917***
	(0.138)	(0.150)	(0.201)	(0.198)	(0.165)	(0.147)	(0.151)	(0.137)
Observations	5318	8496	8552	9356	10888	14746	16029	16022
R-squared	0.994	0.992	0.992	0.995	0.99	0.974	0.961	0.970

D4 Full sample, PPML, time zones

Traditional specification

	1980	1985	1990	1995	2000	2005	2010	2012
Distance	-0.287***	-0.367***	-0.216**	-0.397***	-0.422***	-0.506***	-0.590***	-0.604***
	(0.083)	(0.071)	(0.089)	(0.093)	(0.079)	(0.073)	(0.069)	(0.066)
Contiguity	0.173	0.017	0.028	0.091	0.012	-0.018	0.138	0.251**
	(0.125)	(0.112)	(0.147)	(0.146)	(0.134)	(0.124)	(0.118)	(0.121)
Common language	0.347***	0.454***	0.471***	0.325**	0.303**	0.420***	0.537***	0.491***
	(0.116)	(0.087)	(0.106)	(0.130)	(0.125)	(0.105)	(0.104)	(0.101)
Colonial relation	0.502***	-0.086	-0.208	-0.294**	-0.196	-0.095	-0.075	-0.231*
	(0.115)	(0.131)	(0.129)	(0.140)	(0.128)	(0.120)	(0.142)	(0.138)
Time difference (1h)	-0.478***	-0.379***	-0.086	0.155	-0.046	0.004	-0.024	-0.053
	(0.120)	(0.116)	(0.128)	(0.135)	(0.125)	(0.108)	(0.104)	(0.107)
Time difference (2h)	-0.249*	-0.334***	-0.357**	0.054	-0.122	0.017	-0.026	-0.059
	(0.143)	(0.129)	(0.159)	(0.173)	(0.159)	(0.142)	(0.126)	(0.130)
Time difference (3h)	0.046	-0.024	0.193	0.385**	0.380**	0.472***	0.522***	0.306*
	(0.188)	(0.154)	(0.172)	(0.185)	(0.187)	(0.173)	(0.166)	(0.170)
Time difference (4h)	-0.557**	-0.570***	-0.537**	-0.319	-0.354*	-0.306	-0.426**	-0.448**
	(0.223)	(0.179)	(0.210)	(0.231)	(0.215)	(0.224)	(0.208)	(0.212)
Time difference (5h)	-0.809***	-0.635***	-0.849***	-0.385*	-0.204	0.118	-0.0875	-0.310*
	(0.188)	(0.161)	(0.196)	(0.208)	(0.202)	(0.199)	(0.188)	(0.177)
Time difference (6h)	-0.822***	-0.658***	-0.742***	-0.506**	-0.519**	-0.363*	-0.337**	-0.312*
	(0.178)	(0.161)	(0.216)	(0.241)	(0.228)	(0.190)	(0.169)	(0.173)
Time difference (7h)	-1.028***	-1.010***	-1.200***	-1.073***	-0.832***	-0.456**	-0.320*	-0.432**
	(0.197)	(0.161)	(0.186)	(0.215)	(0.202)	(0.201)	(0.173)	(0.179)
Time difference (8h)	-0.990***	-0.885***	-1.223***	-0.761***	-0.621***	-0.229	-0.046	-0.004
	(0.207)	(0.173)	(0.220)	(0.230)	(0.204)	(0.199)	(0.172)	(0.168)
Time difference (9h)	-0.846***	-1.002***	-1.240***	-0.903***	-0.615**	-0.381	-0.383*	-0.285
	(0.262)	(0.228)	(0.240)	(0.263)	(0.246)	(0.244)	(0.225)	(0.224)
Time difference (10h)	-1.168***	-1.129***	-1.544***	-1.124***	-0.659**	-0.239	-0.199	-0.196
	(0.273)	(0.221)	(0.243)	(0.262)	(0.279)	(0.339)	(0.315)	(0.323)
Time difference (11h)	-0.765***	-1.412***	-1.459***	-0.808***	-0.756***	-0.589**	-0.677***	-0.618***
	(0.266)	(0.235)	(0.260)	(0.257)	(0.281)	(0.244)	(0.217)	(0.215)
Time difference (12h)	-0.959***	-1.862***	-1.908***	-1.240***	-1.136***	-0.923***	-0.595*	-0.721***
	(0.281)	(0.284)	(0.278)	(0.333)	(0.345)	(0.272)	(0.321)	(0.262)
Observations	5198	8362	8412	9187	10715	14574	15858	15858
R-squared	0.868	0.913	0.911	0.897	0.913	0.940	0.944	0.926

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