Assessing the Impact of Communication Costs on International Trade

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Abstract: Communication costs are frequently cited as an important determinant of trade costs, but without any supporting empirical evidence. We test this relationship by incorporating alternative measures of communication costs in a model of bilateral trade. We find that international variations in communication costs indeed have a significant influence on trade patterns. Furthermore, estimates using disaggregated data reveal that the impact of communication costs on trade in differentiated products is larger than on trade in homogenous products - by as much as one-third.

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Non-Technical Summary

Recent research suggests that trade costs have a strong influence on the pattern of specialization and trade, but there is surprisingly limited empirical research on the determinants of trade costs. The existing literature identifies a range of barriers that separate nations, but then typically focuses only on transport costs. Although communication costs figure prominently in intuitive explanations and casual observations, they have played little role in the formal analysis of trade costs. This paper seeks to examine whether this neglect matters, and whether the inclusion of the magnitude and variation of communication costs across partner countries can add value to existing explanations of the pattern of trade.

We develop a simple multi-sector model of "impeded" trade that generates testable hypotheses in a gravity-type estimation framework. Our main proxies for bilateral communication costs are the per-minute country-to-country calling prices charged in the importing and exporting countries. The use of bilateral variations in prices yields estimates that are superior to the ones obtained from country-specific measures of communication infrastructure used in previous studies. We find that international variations in communication costs indeed have a significant influence on bilateral trade flows - both at the aggregate level and for most individual sectors disaggregated according to the 2-digit SITC classification.

Since information and communication needs are likely to be much greater for differentiated goods, we test whether trade in these products is more sensitive to variations in the costs of communication. Using the well-known Rauch classification of product heterogeneity, our estimates suggest that the impact of communication costs on trade in differentiated products is as much as one-third larger than on trade in homogenous products. Finally, we verify, to the extent possible, that the significance of communication costs is not driven by their endogeneity or by omitted variables.

Introduction

Economists have long recognized the importance of communication costs in international trade (Harris, 1995). Discussions of the causes of growth in world trade in the last quarter of the 20th century frequently cite technological progress in telecommunications and associated declines in communication costs as an important contributor. In particular, it has been argued that the emergence of international production networks has been driven by improved communication links that facilitated the coordination of geographically dispersed production processes (see, for example, Krugman, 1995, and Venables, 2002).

Yet we have virtually no empirical insight on how much communication costs matter for trade and how important they are relative to other components of trading costs. Firm-based surveys frequently list the costs and quality of telecommunications as an important factor in trade and investment decisions. For example, Spinanger (2001) reports evidence from a survey of 14 major textiles and clothing producers in Hongkong (with activities throughout Asia and around the world), which identifies the quality of telecom infrastructure as a key factor in decisions on export-oriented foreign direct investment—more important than policies affecting trade and investment, labor costs, and education and training of workers. Limão and Venables (1999) construct an index of infrastructure density—including availability of telecommunications—and find that it is a significant determinant of bilateral trade costs. Similarly, Freund and Weinhold (2000) analyze the effect of Internet diffusion—measured by a country's number of web hosts—on trade and find an increasing and significant impact from 1997 to 1999. While these studies provide interesting insights regarding the relevance of *communication infrastructure*, they do not offer evidence on how international *communication costs* affect export and import patterns.

This study is a first attempt to directly quantify the effect of communication costs on bilateral trade, both in the aggregate and across different product categories. By employing country-to-country calling prices, the econometric investigation relies on bilateral variations in communication costs between trading partners. This approach is likely to yield superior estimates compared to the ones obtained from country-specific measures of communication infrastructure.

The paper is organized as follows. We first briefly discuss how communication costs might influence trade (Section I). We then introduce communication costs into a gravity-type model that will form the basis of our empirical investigation (Section II). After describing the data used in this study (Section III), we present the structural estimation results and test the validity of our findings with alternative model specifications (Section IV). Some concluding remarks are offered at the end (Section V).

I. Communication costs, trade costs and trade

Recent research suggests that trade costs have a strong influence on the pattern of specialization and trade. The insights of economic geography models depend critically on the size of trade costs (Krugman, 1991). Trade costs have also been seen as influencing the choice between trade and investment (Markusen and Venables, 2000, Brainard, 1998). More recently, Obstfeld and Rogoff (2000) have argued that the introduction of trade costs helps explain not just the "home market bias" but a variety of puzzles in the field of international macroeconomics.

In view of this growing prominence, it is surprising that there is limited empirical research on the *determinants* of trade costs. The existing literature identifies a range of barriers that separate nations—distance, time, information, etc.—but then typically focuses only on transport costs.[1] Although communication costs figure prominently in intuitive explanations and casual observations, they have played little role in the formal analysis of trade costs. This paper seeks to examine whether this neglect matters, and whether the inclusion of the magnitude and variation of communication costs across partner countries can add value to existing explanations of the pattern of trade. The explicit inclusion of communication costs could also shed some light on how far proxies for trade costs such as distance represent the cost of moving goods rather than the cost of moving information.

Our study focuses on both aggregate bilateral trade and trade in different categories of products. Rauch (1999) has persuasively argued that the heterogeneity of manufactures along the dimensions of both characteristics and quality limits the scope for prices to convey all the

[1] Hummels (1999) has undertaken pioneering work in this area.

necessary information. Therefore, there is little scope for international commodity arbitrage either through organized exchanges or "globally scanning" traders. Instead, connections between buyers and sellers are made through a search process. In facilitating this process, Rauch emphasizes the importance of proximity and preexisting ties that result in trading networks rather than markets. We do not doubt that such networks play an important role, but it would seem that the costs and quality of communication links are also an important determinant of the ease with which information is transmitted. Since the information and communication needs are much greater for differentiated goods, trade in these products is likely to be more sensitive to variations in the costs of communication (Harris, 1995).

Modeling the role of communication costs is not, however, straightforward. For example, whether communication costs are seen to affect the fixed or variable costs of trade depends on the role that communication plays in the transaction. If communication is primarily relevant in facilitating search for trading partners, then its costs could be seen as affecting the fixed or sunk costs of trading – which is the view Freund and Weinhold (2000) take of the impact of the Internet and Harris (1995) of communication networks.[2] Communication between the supplier and consumer is, however, also necessary for other reasons, e.g. transmission of product specifications and timing of production processes. In many cases, the consumer and producer often need to interact in order to jointly produce a customized product that has the desired characteristics. The extent of such interaction evidently depends on the nature of the product, and could affect both the fixed and variable costs of trade.

We assume, nevertheless, that communication costs affect trade primarily by influencing variable trade costs between two nations. This assumption allows us to draw on the large literature that links trade costs to trade performance. Specifically, we can develop a simple multi-sector model of "impeded" trade that generates testable hypotheses in a gravity type estimation framework. The gravity equation is widely regarded as a successful device to empirically model international trade and is well-founded in economic theory.[3] In contrast, the

[2] Such pre-sale activities as price-negotiations, etc. can also be assumed to affect the fixed costs.

[3] Various studies have shown that the gravity equation can be derived from a variety of trade models that can result in countries' perfectly specializing in a particular good. These models include the simple Ricardian and Heckscher-Ohlin trade theories as well as the newer theories with increasing returns to scale and monopolistic competition.

literature on search costs and buyer/seller matching does not offer tractable models that easily lend themselves to empirical application.

It is not obvious how fixed costs could be incorporated into the gravity framework. While Freund and Weinhold (2000) argue that the Internet reduces sunk costs of trading, they eventually estimate an equation that is little different from the standard gravity model. Evans (2000) does amend the standard model to incorporate fixed trading costs that differ across producers. The implication is that some producers would not recover the fixed cost of exporting and so not all output is available to be exported. Empirically, this implies using an appropriately scaled down level of aggregate output in the gravity equation. Failure to make this adjustment implies that the variable trade cost term is (dis)credited with the trade impeding impact of fixed trade costs. This finding in fact supports the approach taken here, because our objective is to measure the aggregate impact of telecommunications costs rather than to identify the precise channel through which they act.

II. Introducing communication costs into a gravity type model of bilateral trade

The purpose of this section is to develop an empirical model that will allow us to empirically explore how cross-country variations in communication costs affect bilateral trade. We consider a representative consumer in the importing country j who maximizes the following utility function defined on the production of all countries:

$$U^{j} = \prod_{k} \left[\left(\sum_{i} b_{ik} c_{ijk}^{(s_k - 1)/s_k} \right)^{s_k/(s_k - 1)} \right]^{r_{jk}}, \tag{1}$$

where c_{ijk} is country j's consumption of sector k's good produced by country i, s_k the elasticity of substitution between any pair of countries' products in sector k, and b_{ik} is a weight parameter. Preferences are assumed to be Cobb-Douglas over sectors and CES within sectors, whereby r_{jk} is country j's (constant) share of expenditure devoted to sector k. Consumers in j derive their

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See, for example, Anderson (1979), Helpman and Krugman (1985), Bergstrand (1985 and 1989) and Deardorff (1998).

income, Y_j, from producing domestic products x_{jk} at prices p_{jk}. They face trade cost inclusive prices of consumption goods $t_{ijk} p_{ik}$, where the trade cost factor t_{ijk} is assumed to be equal to one for the domestically produced good and greater than one for foreign produced goods. Constrained maximization of (1) leads to optimal consumption levels

$$c_{ijk} = \frac{1}{t_{ijk} p_{ik}} r_{jk} Y_j b_{ik}^{s_k} \left(\frac{t_{ijk} p_{ik}}{p^I_{jk}} \right)^{1-s_k}, \tag{2}$$

where p^I_{jk} is an index of trade cost inclusive prices

$$p^I_{jk} = \left(\sum_i b_{ik}^{s_k} t_{ijk}^{1-s_k} p_{ik}^{1-s_k} \right)^{1/(1-s_k)}. \tag{3}$$

Multiplying (2) by the trade cost inclusive price $t_{ijk} p_{ik}$ yields the value of exports from country i to j in sector k, T^k_{ij}:

$$T^k_{ij} = r_{jk} Y_j b_{ik}^{s_k} \left(\frac{t_{ijk} p_{ik}}{p^I_{jk}} \right)^{1-s_k}. \tag{4}$$

We assume that the trade cost factor t_{ijk} is a function of country j's ad-valorem tariff as applied to imports from j in sector k, tar_{ijk}, the geographic distance (as a proxy *inter alia* for transport costs) between countries i and j, D_{ij}, the costs of communication between the two trading partners, C_{ij}, and the usual set of variables capturing other ties between the exporting and importing countries (adjacency and common language), E_{ij}. We choose the following Cobb-Douglas functional form for the trade cost function:[4]

[4] Hummels (1999) has pointed out the counterintuitive implications of a multiplicative trade cost function: the impact of a percentage change in one trade cost variable depends on the level of the other(s). He proposes a trade cost function in which the individual components enter additively. This functional form has the additional advantage that the estimation of the resulting non-linear gravity equation can separately identify the substitution elasticity and the trade cost parameters. We tried to estimate a similar model using a linear trade cost function

$$t_{ijk} = \alpha_k (1 + tar_{ijk}) D_{ij}^{\delta_k} C_{ij}^{\gamma_k} E_{ij}^{\lambda_k} . \tag{5}$$

Since the import tariff variable is a direct measure of trade costs, the definition of the trade cost factor implies a proportional relationship between t_{ijk} and $(1 + tar_{ijk})$. With this assumption, (4) can be transformed to:

$$T_{ij}^{k} = \rho_{jk} Y_j \beta_{ik}^{\sigma_k} \left(\frac{p_{ik}}{p_{jk}^{I}} \right)^{1-\sigma_k} \alpha_k^{1-\sigma_k} (1 + tar_{ijk})^{(1-\sigma_k)} D_{ij}^{\delta_k (1-\sigma_k)} C_{ij}^{\gamma_k (1-\sigma_k)} E_{ij}^{\lambda_k (1-\sigma_k)} , \tag{6}$$

The variables on the right hand side are a mix of exogenous and endogenous variables. To fully estimate the model, one would need to specify supply conditions. This would complicate the analysis significantly, as exogenous determinants of trade (technology, factor endowments) interact with endogenous location effects (firms locate production close to final demand, in order to minimize on trade costs). However, in this study we are primarily interested in estimating the effect of communication costs on trade costs and trade substitution. We can therefore proceed by employing importer and exporter specific dummy variables that account for the country specific exogenous and endogenous variables, and rely entirely on the bilateral variation in the trade cost variables to estimate their impact on trade (Hummels, 1999).[5] The advantage of this approach is that our empirical model embeds alternative supply determinants of trade. The resulting gravity type equation for bilateral trade between i and j in sector k can be expressed as:

$$\ln T_{ij}^{k} = A_i^k + B_j^k + (1 - \sigma_k) \ln(1 + tar_{ijk}) + \phi_D^k \ln D_{ij} + \phi_C^k \ln C_{ij} + \phi_E^k \ln E_{ij} + \varepsilon_{ij}^k , \tag{7}$$

where A_i^k is a set of exporter fixed effects, B_j^k is set of importer fixed effects, ε_{ij}^k is a normally distributed error term, $\phi_D^k \equiv \delta_k (1 - \sigma_k)$, $\phi_C^k \equiv \gamma_k (1 - \sigma_k)$, and $\phi_E^k \equiv \lambda_k (1 - \sigma_k)$.

Obviously, the better substitutes countries' goods are for one another, i.e. the higher the value of σ_k, the greater is the extent to which bilateral trade between the two countries is impeded by

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incorporating communication costs. However, we were not able to obtain non-linear least squares estimates for our estimation sample.

[5] Hallack (2001) and Reddings and Venables (2001) use a similar approach in their econometric models of bilateral trade.

trade costs. Thus, while being potentially small compared to the value of trade, international variations in trade costs can exhibit a strong influence on global trade patterns.[6] The estimation of f_D^k, f_C^k, and f_E^k does not permit the direct identification of the trade cost elasticities d_k, g_k and l_k. However, the coefficient on the tariff variable yields an estimate of the substitution elasticity, which permits indirect imputation of the trade cost elasticities and, in particular, allows comparison of these elasticities across sectors.

A neat feature of our estimation equation (7) is that the inclusion of exporter and importer fixed effects can correct for the omission of variables that are country specific (e.g., non-tariff barriers, differences in inland transportation costs, availability of export finance). In fact, it could be argued that equation (7), while derived from a specific model, has general application: any model explaining bilateral trade could be expected to result in an exporter specific effect, an importer specific effect, and factors determining trade costs between two trading partners. At the same time, it is important to emphasize that we only measure the effect of trade costs on trade substitution. We do not capture the possibility that a country with overall high costs of communication or transport may in total trade less compared to a country where the overall level of these costs is lower.

III. Data sources

We collected cross-sectional data on the dependent and exogenous variables for the year 1999. Bilateral trade flows and import tariffs are from the World Bank's World Integrated Trade Solutions (WITS) database. We work with import data, which are reported on a cost-insurance-freight (cif) basis and therefore include international freight and insurance charges. Information on applied bilateral import tariffs accounts for preferential trading arrangements.[7] We constructed our tariff variable as the weighted average bilateral imported tariff over all 4-digit SITC product groups belonging to the more aggregate product group used in the estimation.

[6] This argument is at the core of the study by Obstfeld and Rogoff (2001).

[7] For a number of countries, tariff data was unavailable for the year 1999. In these instances, we used the year closest to the estimation period. In a few cases, we 'extrapolated' missing bilateral tariffs by taking the average of an importer's bilateral tariff over a range of source countries.

Variation in the importer's tariff across export sources can therefore be due to either trade preferences or a non-uniform tariff structure combined with a varying composition of bilateral trade. The latter can be interpreted as a reflection of the 'Armington assumption' employed in our structural model (i.e., that imports from different sources are imperfect substitutes for one another).

The distance measure refers to the straight-line distance between nations' capitals and was taken from the City Distance Calculator provided by VulcanSoft.[8] As variables capturing other ties between exporters and importers, we used the standard set of dummy variables for sharing a common border and a common language (English, Spanish, French, Portuguese, and Arabic).

We assembled two proxies to capture the communication-related effect of trade costs, each with certain pros and cons. Our first proxy is the per-minute bilateral calling prices charged in the importing and exporting countries, as reported in the ITU's Direction of Traffic Statistics. Current exchange rates from the IMF International Financial Statistics were used to convert the prices into U.S. dollar values. For each country only the calling prices of the 20 most popular destinations were listed in the ITU database, which limits the number of observations available for estimation. Because the simultaneous availability of bilateral price data for the importing *and* exporting countries is limited, we tested these two proxies in separate regressions.[9]

Our second proxy is the product of each country's calling price to the United States. Since the United States is always among the top 20 destinations, use of this proxy allowed us to substantially increase the size of the sample. However, the proxy has two drawbacks. First, calling prices to the United States may not be representative of a country's overall tariff structure. Secondly, in contrast to the two bilateral calling price variables, the variation in one country's calling prices across trading partners is not directly measured, but constructed by multiplying two country-specific variables. The latter approach introduces a bias if the telecom proxy employed is correlated with other country-specific variables that influence bilateral trade and if those variables enter the regression equation in a multiplicative functional form.

[8] The software can be freely downloaded at www.vulcansoft.com.

[9] The sample that includes calling prices for both exporting and importing country has less than 500 observations. Tentative OLS regressions using this small sample led to similar findings as the ones presented in this study.

Table 1 presents summary statistics on the dependent and independent variables used in the empirical analysis. It is interesting to note the large variation in the costs of international communication. Thus, the 1999 calling price to the United States ranged from 9 cents per minute for the Netherlands to $8.91 per minute for Syria. Most dramatically, bilateral calling prices ranged from less than one-tenth of one cent per minute (for a call from Vietnam to several neighboring countries) to $9.80 per minute (for a call from Syria to Japan).

Tables 2 presents partial correlations among the dependent and independent variables (in natural logs). Tariffs, distance and communication costs are all negatively correlated with bilateral trade. The distance term itself is weakly correlated with the "constructed" telecom proxy (product of U.S. calling prices), but shows a stronger correlation with the bilateral calling prices. The correlation between the two bilateral calling prices is weak and not statistically significant. This finding is surprising, as operators at both ends of a bilateral route face the same accounting rate.[10] It suggests that differences in factor costs, market structures, elasticities of demand and pricing regulations play an important role in determining international tariffs. For the purpose of this study, the weak correlation between the two bilateral calling prices is actually advantageous, as we can separately assess the role of communication costs incurred by the exporting and importing country.

IV. Structural estimation results

Aggregate trade flows

We start by estimating a single-sector version of equation (7), using aggregate bilateral trade in 1999 as the dependent variable and ordinary least squares estimation technique (Table 3). The coefficient on the tariff variable is negative and statistically significant. The implied substitution elasticity ranges from –3.3 to –3.8. The coefficients on distance and each of the three telecom proxies are negative and statistically significant at the 1 percent level. The border and language

[10] The accounting rate is the wholesale price negotiated between national telecommunications operators for terminating international calls. It is symmetric in the sense that a carrier from country A faces the same accounting rate for settling traffic in country B as the carrier from country B for settling traffic in country A. See, for example, Yun et al (1997) and Galbi (1998) for further explanation.

dummy variables either show a significant positive coefficient or are not statistically different from zero (except on coefficient on Arabic language which shows a significant negative coefficient). The explanatory power of the model is quite high, with R-squares ranging from 0.809 to 0.927.[11]

These estimations were subject to several robustness tests, which are described in the Annex. We tested a model specification that is closer to the functional constraints imposed by the CES preferences. We also addressed potential biases stemming from non-random selection of samples. These additional estimations did not lead to fundamentally different results, but the coefficients on the "pure bilateral" telecommunications price variables were more stable than the "constructed bilateral" telecommunications proxy. In view of these findings and their superior econometric properties, we conclude that the two "pure bilateral" price variables are better measures of the effect of communication costs on bilateral trade.

Disaggregated trade flows

Our second set of estimates are sectoral gravity equations using trade flows disaggregated according to the 2-digit SITC classification.[12] We only present estimation results with regard to the two bilateral calling price variables, distance and the tariff variable (in Table 4 for the bilateral calling price of the exporting country and in Table 5 for the bilateral calling price of the importing country).[13] The sectors are sorted by descending value of the ratio of the coefficient on the bilateral calling price to the coefficient on the tariff variable—the imputed trade cost elasticity with respect to communications costs. Virtually all estimated coefficients on distance and calling prices have the expected negative sign and the great majority of the coefficients are

[11] Note that the distance coefficient is smaller in the estimations with the two bilateral calling price variables, for which sample sizes are substantially smaller. One explanation could be that the 'pure bilateral' proxies exert a stronger offsetting effect on the distance coefficient than the product of calling prices to the U.S. Indeed, running the former regression without any telecom proxy yields a distance coefficient that is about 0.2 higher, which equals approximately the partial correlation between distance and bilateral calling prices (Table 2a). While the distance coefficient with a hypothetical 0.2 increase is still smaller than the large sample estimates, it is consistent with the gravity literature, which typically reports distance coefficients around or somewhat above unity (see, for example, Rose (2000) or Limão and Venables (1999)).

[12] We excluded two sectors from the estimation ("electric current" and "gas"), because the number of observations in the concerned 2-digit SITC group was too small to permit meaningful estimations.

[13] We also estimated sectoral gravity equations using the product of U.S. calling prices. While the estimated coefficients mostly showed the expected signs, the results did not reveal any interesting patterns across sectors. In view of the inferior econometric properties of this variable, we decided to not present these results here.

statistically significant. The coefficients on the tariff variable are also mostly negative and statistically significant.[14]

The sorting of sectors by the imputed trade cost elasticity suggests that communication costs are relatively more important in sectors that exhibit a greater extent of product differentiation or low international transport costs. Examples of these sectors include chemical materials, pharmaceutical products, specialized machinery. Could it be that communication needs in the case of differentiated products are greater and that trade in these products is therefore more sensitive to variations in the costs of communication?

To explore this question more formally, we employed the product classification developed by Rauch (1999), who divides internationally traded commodities into three groups. The first group includes all goods that are traded on organized exchanges and consist of homogenous commodities such as cement, steel or tobacco. The second group includes goods that are not traded on organized exchanges but nevertheless possess reference prices. This category of goods still largely consists of homogenous products, such as certain chemicals for which prices are listed in specialized trade publications. The third product group includes all other commodities and thus encompasses all differentiated goods for which significant buyer-seller interaction is necessary.

We estimated sectoral gravity equations using trade flows classified according to Rauch's three product groups, again confining our estimates to the two bilateral calling price proxies (Table 6). The results reveal several interesting patterns. First, the estimated coefficient on the tariff variable is not statistically different from zero in the case of differentiated products, suggesting a low elasticity of substitution (close to unity). However, it is negative and statistically significant in the case of reference priced products (only when using the importer's calling price) and negative, statistically significant and greater in absolute size in the case of products traded over organized exchanges. Our result is consistent with the expectation that the elasticity of

[14] The average value of the tariff variable for the exporter calling price sample is, in fact, substantially larger than the corresponding value in the comparable one-sector gravity estimation presented in Table 3. This result is consistent with findings in the literature that substitution elasticities are larger at the sectoral level than at the aggregate level (Hummels, 1999 and Gallaway et al, 2000). However, this 'disaggregation effect' is not found in the importer calling price sample.

substitution is larger for more homogenous products, leading to a greater sensitivity of bilateral trade to changes in trade costs.

Second, the estimated distance coefficients for differentiated products are smaller in absolute value than the coefficients for reference priced products, and the coefficients on the latter are again smaller than the ones for products traded over organized exchanges. In other words, in line with our structural model, the rising substitution elasticity leads to a greater sensitivity of bilateral trade to distance. This result is in contrast to Rauch (1999) who finds the coefficient on distance to be larger in absolute value for differentiated products. He argues that the trade-inhibiting effect of distance is likely to be larger in the case of differentiated products, for which greater buyer-seller interaction is necessary.[15]

Third, the estimated coefficient on the exporter's calling price is not statistically different from zero for products traded over organized exchanges, suggesting that communication cost conditions in the exporting country are of little importance for pure homogenous commodities.

Fourth, the impact of the importer's calling price on trade in differentiated products is substantially larger than on trade in reference priced products and trade in homogenous products. In fact, we observe an overall 'downward trend' in the coefficient on the telecom proxies as we move from differentiated to homogenous products. Since our estimated substitution elasticity shows a reverse 'upward trend,' the implied elasticity of trade costs with respect to the communication cost proxy is substantially larger for differentiated products than for homogenous products. These results confirm our initial observations based on the sectoral estimations described above. In the Annex, we corrected for a possible bias in our estimates for Rauch's product groups due to a non-random selection of samples, but the results did not change.

[15] To test whether this result is due to the inclusion of the communication cost proxy, we excluded telecommunications costs from our model and reran the regressions in two scenarios. The first, using the entire dataset available in the absence of telecom bilateral prices, reproduced the Rauch finding, i.e. distance seemed to matter more for differentiated goods. In the second, using only data for which bilateral telecom prices were available, the distance coefficient preserved the pattern observed in our initial regressions including the telecom variables, except that its overall magnitude was slightly larger. These results suggest that the Rauch result is not robust to changes in the sample.

The sectoral estimates reveal that the importer's calling price consistently has a larger effect than the exporter's calling price.[16] Two explanations are possible. One is that the exporter's expenditure on international telecommunications is likely to be included in observed trade values, whereas the importer's expenditure may not be. In the derivation of the econometric model, we implicitly assumed that trade values are inclusive of all trade costs. A more general specification would allow for a share of trade costs to be excluded in recorded trade values. It is easy to verify that in this case the estimated coefficient on the communication cost proxy can be expressed as:

$$f_C^k \equiv g_k(a_k - s_k),$$

where a_k $(0 \le a_k \le 1)$ is the (geometric) share of communication costs implicitly included in trade values. Hence, if a larger share of communication costs is part of observed trade values (as one would expect in the case of the exporter's calling price), the trade-inhibiting effect of telecommunications is dampened.

The other more speculative explanation is that communication costs affect the fixed costs of trading, and that the relative impact on exporters and importers differs across the type of products. Note that if the impact were on the variable costs alone, then who actually pays the cost would be irrelevant because the incidence of those costs would be independently given by the elasticities of demand and supply. With fixed costs of trade, it does matter who actually pays—even though some costs may be passed through prices. Our findings suggest, for example, that suppliers play a virtually passive communication role where homogeneous goods are concerned, and that importers bear a larger burden of communication in the case of differentiated products.

Alternative specifications

Our results accord with intuition, but we must ensure that the revealed importance of telecommunications is not attributable to any specification errors in our structural model. Such

[16] The larger relative impact of the importer calling price was found for the sectoral estimates in Tables 4 and 5, as well as for the Rauch product group estimates in Table 6. This difference is also evident when controlling for possible selection biases in the two samples (see Annex Table A3).

errors could be due to omitted variables and endogeneity. In this sub-section, we address each of these problems to the extent feasible.

First of all, we could have excluded determinants of trade costs that are correlated with communications costs. Perhaps the most important such omission is the cost of transportation, which is only imperfectly captured by bilateral distance. Unfortunately, no comprehensive data source exists for bilateral freight charges. Based on national customs data, Hummels (1999) has assembled a dataset that includes commodity-specific ad-valorem transport cost figures for six importing countries (Argentina, Brazil, Chile, New Zealand, United States, and Uruguay). In spite of the small size of the sample, we tested our model for this set of importing countries for the year 1994.[17]

We introduce the ad-valorem freight variable into the gravity equation (7), by constructing a new variable of directly measured trade costs, $(1+tar_{ijk}+f_{ijk})$, which leads to a better estimate of the substitution elasticity s. Since we only have relatively few observations on the bilateral calling price variables, we run this regression at the 2-digit SITC level.[18] This is feasible because our tariff and transport cost variable are available at that level of disaggregation. The drawback with this procedure is that we implicitly assume that all the independent variables affect each of the 2-digit SITC product groups in an identical way.[19]

Table 7 presents our estimation results. The tariff plus transport cost variable performs according to expectations: it has a negative sign and is statistically significant at the 1 percent level. The implied elasticity of substitution ranges between –5.3 and –6, which in line with the previous literature (see Hummels, 1999), but larger than in the 'world gravity' model. The

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[17] We thank David Hummels for sharing the transport cost data. The dataset actually includes Paraguay as a seventh importing country, but we had to exclude Paraguay due to the unavailability of data on our telecom proxies. We complemented the ITU information with more comprehensive data on the 1994 international calling tariffs for the United States, Brazil and Uruguay. These data were provided to us by national regulators and telecom operators. We did not test the 'constructed telecom proxy' of calling prices to the United States, as this variable cannot, by definition, be constructed for the United States and would have caused a substantial reduction in the number of observations.

[18] The regression at the aggregate level could only be run with less than 300 observations and did not produce statistically significant coefficients on the communication cost proxies.

[19] Inclusion of product group specific fixed effect could, in principle, account for sectoral heterogeneities, but this approach would take us away from our structural estimation equation (7).

coefficients on the two telecom variables take the expected negative value, are statistically significant at the 1 percent level (exporter's calling price) and 5 percent level (importer's calling price) and are comparable in magnitude to our earlier results.[20]

The estimated coefficient on distance takes a similar negative value as in Table 3 and is always statistically significant at the 1 percent level. This result offers an insight to the so-called 'distance puzzle' in explanations of bilateral trade (Loungani et al., 2002): even after explicitly controlling for transport and communications costs, distance has a strong impeding effect on bilateral trade. In other words, distance seems to capture trade-inhibiting factors other than concurrent transport and communication costs.[21]

A second problem could be that telecommunications costs are endogenous to bilateral trade. For example, international calling prices may themselves be influenced by bilateral trade flows. One possibility is that stronger commercial ties and greater telecommunications traffic between two nations may allow operators to reap economies of scale and lower operating costs. Conversely, it could be that country pairs with more trade and thus greater communications needs exhibit lower demand elasticities and this may lead international operators—many of which are still monopolies—to raise prices substantially above marginal costs.

It is customary to address endogeneity problems by using the instrumental variable approach in a two stages least squares estimation. In our case, it is not obvious what the appropriate instruments would be, especially since we wish to capture bilateral variations in our telecom variables, and the specific nature of the endogeneity problem is not clear. Nevertheless, we constructed three different instruments: the product of the two trading partners' bilateral accounting rate with the United States; a dummy variable that is one if there was competition for

[20] We also performed Rauch product group estimates, using the transport-cost inclusive dataset. Again, to generate more variation in the data, we performed these regressions at the 4-digit SITC level, which is the level on which the Rauch classification is based. While the importer's calling price is only statistically significant in the case of differentiated goods, the pattern of coefficients emerging for the exporter's calling price suggests that communications costs are most important for reference-priced goods, followed by homogeneous and differentiated products. One important caveat with regard to these results is that they are based on markedly different sample sizes, and so there are doubts about their comparability.

[21] The border and language dummies also perform according to prior expectations, although the dummies for Spanish and Portuguese language are not statistically different from zero. R-squares are relatively low, ranging between 0.337 and 0.386. This is due to the fact that estimations are performed on disaggregate trade flows which show greater noise than aggregate trade flows or trade flows belonging to the same product group.

international services on both ends of the bilateral route; and the product of a country specific proxy capturing the extent to which incumbent public telecommunications operators were privatized.[22] The three variables performed according to expectations in the first stage estimation (positive sign for the accounting rate, negative sign for the competition and privatization proxies), although the privatization variable was not always statistically significant. The second stage estimation results for the aggregate 'world gravity model' are presented in Table 8. The coefficient on the instrumented calling prices is significantly negative and much larger than the estimate in the earlier OLS regression (Table 3), taking a value of –2.806 in the case of the importer's calling price.[23]

These results underline a concern that is in fact also raised by our earlier estimates: the unexpectedly large impact of telecommunication costs—and trade costs more generally—on trade. Taken at their face value, our estimates suggest, for example, that a halving of the importer's calling price leads to a 42.5 percent increase in aggregate bilateral trade. These are large values even if bilateral communication costs are seen as proxies for the quality and ease of communication between two nations. The large impact of the trade cost proxies is not new to our study or to communications costs per se, however. Take the distance coefficient, which is in line with estimates found in the literature. A doubling of the exporter-importer distance reduces bilateral trade by up to 50 percent, which can hardly be justified in pure transport cost terms.[24]

The existing literature offers at least two explanations. One is that trade costs affect bilateral trade through channels other than the 'simple' trade substitution mechanism underlying the gravity equation. Hummels (1999) suggests that the trade cost proxies may pick up endogenous supply responses by firms choosing production locations to minimize trade costs. If endogenous

[22] Specifically, the latter variable is defined as one plus the equity share in the incumbent operator that was in private hands. The data on competition in international telecommunications and the extent of privatization was obtained from the ITU-World Bank Telecommunications Policy Database.

[23] We also performed instrumental variable regressions for the three 'Rauch' product groups. The coefficients on the calling price variables are much larger in absolute value than those obtained from the aggregate regression, although the exporter calling price is not always statistically significant.

[24] Hummels (1999) provides some estimates of the elasticity of ad-valorem transport costs with respect to distance, ranging between 0.2 and 0.4 depending on the transport mode. Given that transport, on average, does not make up more than 10 percent of the value of traded goods, this implies an elasticity of the transport cost factor—one plus the ad-valorem transport cost—with respect to distance of 0.02 to 0.04, implying a much smaller price premium. This point was originally noted by Grossman (1998).

supply effects simply lead to a reallocation of resources between individual sectors k, then they are captured in our estimation equation.[25] However, each individual sector k still lumps together fairly heterogeneous sub-groups, and so our trade cost proxies may in fact pick up endogenous location effects operating at a more disaggregate level.[26]

A second possibility is that our trade cost proxies measure not only trade costs but also differences in consumer preferences over products from different locations. The utility function in equation (1) assumes that consumers in all importing countries j put equal preference weights, b_{ik}, on products from the same sources i. A more general specification would allow these weights to differ across exporting countries. It is easy show that these bilateral weights, b_{ijk}, are then not absorbed by the country-specific fixed effects. If these bilateral weights are correlated with the proxies we took as measuring trade costs alone, then it is possible that the estimated coefficients in the gravity equation capture the effect of both bilateral trade costs and bilateral preferences (see Balistrery and Hillberry, 2001). However, while it is plausible that distance and language proxies are related to bilateral preferences, such a relationship is less obvious in the case of telecommunication costs.

V. Conclusion

The link between communication costs and the pattern of trade has been based previously more on intuition than evidence We tested this relationship by incorporating alternative measures of communication costs in a standard model of bilateral trade. International variations in communication costs were shown to have a significant influence on trade patterns. Furthermore, estimates using disaggregated trade data revealed that communication costs have a greater impact on trade in differentiated products than on trade in homogenous products.

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[25] Obviously, in the aggregate, one-sector version of the gravity equation there is no room for endogenous supply responses.

[26] Another possibility to the 'simple' substitution mechanism is that trade costs have a fixed, as opposed to a variable character, as already pointed out above. It has been shown that small differences in partner-specific fixed costs—incurred either by the consumer or the producer—can yield large swings in trade flows (Evans, 2000).

The paper should, nevertheless, be seen only as a first step in understanding the role of communication in trade, and its broader objective is to provoke both theoretical and empirical research in this area. Several basic questions deserve more detailed attention. What precisely is the nature of communication between importers and exporters? How does it differ across product categories, final goods and intermediate, homogeneous and differentiated? How does it differ for intra-firm trade relative to inter-firm trade? What types of costs are incurred, variable or fixed? Who bears these costs and when does it matter? Greater information on these issues, would make it possible to address grander questions, such as the role of communication in facilitating the development of international production chains, or more generally, influencing the pattern of global integration.

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Table 1: Summary statistics

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Bilateral trade	8,302	614,814	4,631,744	0.001	201,000,000
Distance	11,554	7,868	4,351	78	19,920
Weighted average tariff	8,614	0.099	0.115	0.000	3.270
Bilateral calling price	12,769	5.052	2.812	1.000	9.000
Calling price to US	8,588	1.293	1.207	0.092	8.909

Note: Dataset covers bilateral trade of 107 countries.

Table 2: Partial correlation between variables

	Bilateral trade	Distance	Exporter calling price	Importer calling price	Product of calling prices to US	Tariff
Bilateral trade	**1**					
Distance	**-0.192**	**1**				
Exporter calling price	**-0.316**	**0.236**	**1**			
Importer calling price	**-0.450**	**0.236**	0.128	**1**		
Product of calling prices to US	**-0.502**	**0.080**	**0.273**	**0.273**	**1**	
Tariff	**-0.195**	**0.039**	0.036	**0.117**	**0.269**	**1**

Notes: All variables are expressed in natural logarithms. Bolded figures are statistically significant at the 1 percent level.

Table 3: Gravity model using aggregate trade flows, 1999

Dependent variable: T_{ij}	(1)	(2)	(3)
Distance	-0.651***	-0.582***	-1.085***
	(-9.14)	(-9.93)	(-24.04)
Tariff	-2.342*	-2.693***	-2.801***
	(-1.89)	(-2.89)	(-3.47)
Bilateral calling price of exporter	-0.943***		
	(-5.90)		
Bilateral calling price of importer		-0.848***	
		(-5.79)	
Product of calling prices to the US			-2.325***
			(-23.44)
Common border	Correct	Correct	Correct
Language dummies			
English	Correct	Correct	Correct
Spanish	Insignificant	Insignificant	Correct
Portuguese	Insignificant	Insignificant	Insignificant
French	Insignificant	Correct	Correct
Arabic	Insignificant	Wrong	Correct
Number of observations	1,231	1,116	4,179
F-statistic	385.37***	1463.79***	127.8***
R-square	0.902	0.927	0.809

Notes: OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level. 'Correct' indicates a dummy variable as the expected positive sign and is statistically significant at least at the 10 percent level; 'insignificant' indicates a dummy variable is not statistically different from zero; and 'wrong' indicates a dummy variables has a wrong negative sign and is statistically significant at least at the 10 percent level.

Table 4: Sectoral estimates using the bilateral calling price of the *exporting* country, 1999

SITC2 code	Sector	No. of obs	Distance	Bilateral calling price	Tariff	Ratio calling price to tariff
22	Oil seeds and oleaginous fruit	700	-0.655	-1.114	-0.743	1.500
71	Power generating machinery/ equipment	951	-0.774	-0.724	-0.514	1.409
12	Tobacco and tobacco manufactures	671	-0.556	-0.826	-0.739	1.117
73	Metalworking machinery	841	-0.618	-0.700	-0.707	0.990
54	Medicinal and pharmaceutical products	884	-0.614	-1.358	-1.490	0.911
62	Rubber manufactures,n.e.s.	928	-0.603	-1.256	-2.093	0.600
56	Fertilizers, manufactured	569	-0.749	-1.491	-2.992	0.498
55	Essential oils & perfume materials	975	-0.925	-1.071	-3.564	0.301
72	Specialized machinery	1,012	-0.758	-0.761	-3.047	0.250
52	Inorganic chemicals	834	-0.870	-1.061	-4.487	0.236
77	Electrical machinery/apparatus n.e.s.	1,077	-0.888	-0.720	-3.116	0.231
59	Chemical materials and products.	894	-0.904	-0.534	-2.431	0.220
2	Dairy products and birds' eggs	588	-0.864	-0.923	-4.242	0.218
84	Articles of apparel/clothing accessories	1,098	-0.967	-0.644	-2.975	0.217
74	General industrial machinery	1,054	-0.641	-0.897	-5.123	0.175
68	Non-ferrous metals	878	-0.987	-0.965	-5.984	0.161
69	Manufactures of metal	1,073	-0.746	-0.889	-5.540	0.160
9	Miscel.edible products and preparations	861	-0.858	-0.840	-5.471	0.154
7	Coffee, tea, cocoa, spices	1,024	-0.646	-0.431	-2.825	0.152
41	Animal oils and fats	458	-0.430	-1.051	-6.961	0.151
51	Organic chemicals	870	-0.513	-0.847	-5.791	0.146
57	Explosives and pyrotechnic products	381	-0.452	-1.093	-7.639	0.143
4	Cereals and cereal preparations	854	-0.986	-0.653	-4.635	0.141
63	Cork and wood manufactures	1,046	-0.822	-0.931	-7.078	0.132
33	Petroleum, petroleum products	828	-1.588	-1.296	-10.364	0.125
58	Artif.resins,plastic materials	878	-0.823	-1.264	-10.377	0.122
85	Footwear	881	-0.741	-0.797	-6.603	0.121
28	Metalliferous ores and metal scrap	819	-1.148	-0.728	-6.189	0.118
67	Iron and steel	877	-1.028	-0.810	-6.922	0.117
6	Sugar, sugar preparations and honey	841	-0.939	-0.552	-4.786	0.115
61	Leather and leather manufactures	919	-0.684	-0.828	-7.186	0.115
82	Furniture and parts thereof	1,023	-0.711	-0.818	-7.265	0.113
21	Hides, skins and furskins, raw	601	-0.611	-0.336	-3.144	0.107
5	Vegetables and fruit	1,067	-0.670	-0.892	-8.761	0.102
66	Non-metallic mineral manufactures	1,085	-0.615	-0.703	-7.060	0.100
87	Professional & scientific instruments	1,018	-0.598	-0.692	-7.194	0.096
53	Dyeing, tanning and coloring materials	840	-0.637	-0.853	-9.117	0.094
1	Meat and meat preparations	661	-1.036	-0.461	-5.031	0.092
64	Paper, paperboard, paper-pulp/board	942	-1.082	-1.149	-12.985	0.088
65	Textile yarn, fabrics, made-upart.	1,108	-0.723	-0.832	-9.428	0.088
89	Miscellaneous manufactured articles, nes	1,170	-0.914	-0.375	-4.353	0.086
75	Office machines/data processing equip.	999	-0.703	-0.707	-8.239	0.086
83	Travel goods and handbags	921	-0.735	-0.414	-4.949	0.084

SITC2 code	Sector	No. of obs	Distance	Bilateral calling price	Tariff	Ratio calling price to tariff
3	Fish,crustaceans,mollucs,	967	-0.796	-0.430	-5.578	0.077
81	Sanitary, heating and lighting fixtures	873	-0.842	-0.619	-8.154	0.076
0	Live animals chiefly for food	474	-0.885	-0.597	-8.088	0.074
32	Coal, coke and briquettes	437	-0.768	-0.888	-12.556	0.071
88	Photographic and optical goods, watches	939	-0.506	-0.305	-4.855	0.063
76	Telecom. and sound recording apparatus	1,023	-0.680	-0.542	-8.958	0.060
42	Fixed vegetable oils and fats	698	-0.369	-0.662	-11.211	0.059
26	Textile fibres and their wastes	923	-0.743	-0.307	-5.592	0.055
27	Crude fertilizers and crude materials	916	-1.089	-0.331	-11.797	0.028
25	Pulp and waste paper	519	-1.489	-0.180	-19.625	0.009
43	Animal-vegetable oils -fats	614	-1.002	0.134	-2.981	n/a
23	Crude rubber (incl. synthetic/reclaimed)	616	-0.825	-0.111	1.284	n/a
78	Road vehicles (incl. air cushion vehicles)	996	-0.969	-0.832	2.721	n/a
79	Other transport equipment	801	-0.727	-1.006	3.081	n/a
24	Cork and wood	893	-1.018	-0.418	0.737	n/a
29	Crude animal and vegetable materials	1,037	-0.620	-0.986	1.327	n/a
11	Beverages	881	-0.614	-0.374	0.327	n/a
8	Feeding stuff for animals	765	-0.758	-0.953	0.266	n/a
	Average:	859	-0.795	-0.749	-5.243	0.098

Notes: OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

Table 5: Sectoral estimates using the bilateral calling price of the *importing* country, 1999

SITC2 code	Sector	No. of obs	Distance	Bilateral calling price	Tariff	Ratio calling price/tariff
11	Beverages	980	-0.509	-1.782	-0.169	10.557
59	Chemical materials and products, n.e.s.	1,070	-0.814	-1.612	-0.164	9.858
29	Crude animal and vegetable materials	994	-0.777	-0.741	-0.263	2.822
82	Furniture and parts thereof	1,069	-0.986	-1.020	-0.383	2.664
8	Feeding stuff for animals	882	-0.833	-1.707	-0.726	2.352
51	Organic chemicals	1,031	-0.441	-1.710	-1.018	1.680
41	Animal oils and fats	597	-0.837	-1.296	-1.707	0.759
55	Essential oils & perfume materials	1,074	-0.727	-1.945	-2.797	0.695
62	Rubber manufactures, n.e.s.	1,073	-0.819	-1.447	-2.096	0.690
23	Crude rubber (incl. synthetic/reclaimed)	789	-0.828	-1.196	-2.177	0.549
6	Sugar, sugar preparations and honey	973	-1.089	-1.650	-3.035	0.544
9	Miscel.edible products and preparations	1,038	-0.916	-1.987	-3.683	0.540
67	Iron and steel	1,061	-0.907	-1.588	-2.988	0.532
26	Textile fibres and their wastes	987	-1.110	-0.764	-1.463	0.522
84	Articles of apparel, clothing accessories	1,077	-0.911	-1.112	-2.143	0.519
52	Inorganic chemicals	1,032	-0.775	-1.592	-3.165	0.503
7	Coffee, tea, cocoa, spices	990	-1.074	-1.343	-2.851	0.471
68	Non-ferrous metals	1,030	-0.936	-1.827	-4.148	0.441
88	Photographic/ optical goods, watches	1,048	-0.615	-1.761	-4.010	0.439
24	Cork and wood	814	-0.851	-0.925	-2.145	0.431
58	Artif.resins,plastic materials	1,060	-0.851	-2.099	-5.169	0.406
66	Non-metallic mineral manufactures	1,091	-0.655	-1.274	-3.616	0.352
28	Metalliferous ores and metal scrap	788	-0.788	-0.883	-2.541	0.348
65	Textile yarn,fabrics,made-upart.	1,095	-0.843	-1.150	-3.446	0.334
2	Dairy products and birds'eggs	853	-1.075	-1.375	-4.151	0.331
61	Leather, leather manufactures	939	-0.696	-1.212	-3.927	0.309
85	Footwear	981	-0.764	-1.595	-5.186	0.308
27	Crude fertilizers and crude materials	1,012	-1.084	-1.360	-4.443	0.306
22	Oil seeds and oleaginous fruit	725	-1.279	-0.667	-2.459	0.271
12	Tobacco and tobacco manufactures	748	-0.548	-1.045	-4.034	0.259
83	Travel goods and handbags	995	-0.673	-1.046	-4.071	0.257
4	Cereals and cereal preparations	1,020	-1.020	-1.845	-7.210	0.256
3	Fish, crustaceans, mollucs,	891	-0.874	-1.164	-4.643	0.251
1	Meat and meat preparations	813	-1.399	-1.024	-4.196	0.244
63	Cork and wood manufactures	1,033	-1.007	-0.812	-3.478	0.234
64	Paper, paperboard, paper-pulp/board	1,081	-1.165	-1.521	-6.978	0.218
33	Petroleum and petroleum products	1,022	-1.543	-1.218	-5.686	0.214
81	Sanitary, heating and lighting fixtures	1,023	-0.970	-1.112	-5.584	0.199
75	Office machines & data process. equip.	1,061	-1.105	-0.907	-4.581	0.198
42	Fixed vegetable oils and fats	876	-1.145	-0.852	-4.334	0.197
79	Other transport equipment	932	-0.870	-0.830	-4.584	0.181
56	Fertilizers	796	-1.260	-0.891	-5.380	0.166
57	Explosives and pyrotechnic products	521	-0.328	-1.056	-6.609	0.160

SITC2 code	Sector	No. of obs	Distance	Bilateral calling price	Tariff	Ratio calling price/tariff
5	Vegetables and fruit	1,026	-1.153	-0.587	-3.848	0.153
0	Live animals chiefly for food	572	-0.966	-0.859	-5.682	0.151
76	Telecom. & sound recording apparatus	1,070	-0.813	-0.811	-5.512	0.147
21	Hides, skins and furskins	562	-0.554	-0.673	-4.906	0.137
43	Animal-vegetable oils -fats	790	-1.183	-0.359	-4.195	0.086
32	Coal, coke and briquettes	496	-0.881	-1.103	-25.908	0.043
25	Pulp and waste paper	629	-0.983	-0.771	6.727	n/a
87	Professional & scientific instruments	1,066	-0.556	-1.388	6.035	n/a
73	Metalworking machinery	1,003	-0.755	-1.457	4.368	n/a
72	Specialized machinery	1,083	-0.674	-1.246	3.578	n/a
89	Miscellaneous manufactured articles	1,108	-0.742	-1.214	1.909	n/a
53	Dyeing, tanning and coloring materials	1,044	-0.814	-1.690	1.999	n/a
69	Manufactures of metal, n.e.s.	1,101	-0.764	-1.470	1.539	n/a
77	Electrical machinery & appliances	1,096	-0.661	-1.338	0.853	n/a
78	Road vehicles	1,095	-0.864	-1.651	1.024	n/a
74	General industrial machinery	1,093	-0.773	-0.970	0.535	n/a
54	Medicinal and pharmaceutical products	1,070	-0.379	-1.791	0.356	n/a
71	Power generating machinery	1,054	-0.543	-1.399	0.187	n/a
	Average:	950	-0.865	-1.258	-2.760	0.904

Notes: OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

Table 6: Trade in differentiated versus homogenous goods, 1999

Dependent variable: T_{ij}	Differentiated products (1)	Differentiated products (2)	Reference priced products (1)	Reference priced products (2)	Products traded over organized exchanges (1)	Products traded over organized exchanges (2)
Distance	-0.714***	-0.573***	-0.892***	-0.834***	-1.061***	-1.136***
	(-9.35)	(-9.11)	(-9.43)	(-9.02)	(-8.67)	(-10.28)
Tariff	0.793	0.063	-0.440	-1.793***	-3.794*	-2.998***
	(0.72)	(0.06)	(-0.38)	(-2.41)	(-1.87)	(-3.22)
Bilateral calling price of exporter	-0.750***		-0.814***		-0.383	
	(-4.71)		(-4.08)		(-1.42)	
Bilateral calling price of importer		-1.022***		-0.793***		-0.818***
		(-6.82)		(-3.14)		(-3.54)
Common border	Correct	Correct	Correct	Correct	Correct	Correct
Language dummies						
English	Correct	Correct	Correct	Correct	Insignificant	Insignificant
Spanish	Insignificant	Correct	Insignificant	Insignificant	Insignificant	Insignificant
Portuguese	Correct	Insignificant	Insignificant	Insignificant	Insignificant	Correct
French	Correct	Correct	Correct	Insignificant	Insignificant	Insignificant
Arabic	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Number of observations	1,224	1,117	1,197	1,110	1,148	1,083
F-statistic	212.22***	735.64***	185.05***	381.37***	236.17***	87.68***
R-square	0.917	0.932	0.842	0.883	0.726	0.790

Notes: OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level. The classification of product groups is based on Rauch (1999). ‘Correct’ indicates a dummy variable as the expected positive sign and is statistically significant at least at the 10 percent level; ‘insignificant’ indicates a dummy variable is not statistically different from zero; and ‘wrong’ indicates a dummy variables has a wrong negative sign and is statistically significant at least at the 10 percent level.

Table 7: Transport cost inclusive gravity model, 1994

Dependent variable: T_{ij}	(1)	(2)
Distance	-0.645***	-0.678***
	(-6.01)	(-7.64)
Tariff + Transport costs	-5.080***	-4.309***
	(-9.51)	(-13.99)
Bilateral calling price of exporter	-0.924***	
	(-3.10)	
Bilateral calling price of importer		-0.543**
		(-2.50)
Common border	Correct	Correct
Language dummies		
English	Correct	Correct
Spanish	Insignificant	Insignificant
Portuguese	Insignificant	Insignificant
Number of observations	4,932	10,798
F-statistic	45.94***	125.90***
R-square	0.337	0.386

Notes: OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level. 'Correct' indicates a dummy variable as the expected positive sign and is statistically significant at least at the 10 percent level; 'insignificant' indicates a dummy variable is not statistically different from zero; and 'wrong' indicates a dummy variables has a wrong negative sign and is statistically significant at least at the 10 percent level.

Table 8: Gravity model using aggregate trade flows, 1999 (IV estimation)

Dependent variable: T_{ij}	(1)	(2)
Distance	-0.855***	-0.788***
	(-13.69)	(-16.82)
Tariff	-3.037**	-2.428***
	(-2.17)	(-2.58)
Bilateral calling price of exporter	-1.673**	
	(-2.20)	
Bilateral calling price of importer		-2.806***
		(-4.78)
Product of calling prices to the US		
Common border	Correct	Correct
Language dummies		
English	Correct	Correct
Spanish	Insignificant	Correct
Portuguese	Insignificant	Insignificant
French	Insignificant	Correct
Arabic	Insignificant	Wrong
Number of observations	1,187	1,063
F-statistic	17031.30***	1685.02***
R-square	0.899	0.924

Notes: Second stage instrumental variable regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level. 'Correct' indicates a dummy variable as the expected positive sign and is statistically significant at least at the 10 percent level; 'insignificant' indicates a dummy variable is not statistically different from zero; and 'wrong' indicates a dummy variables has a wrong negative sign and is statistically significant at least at the 10 percent level. Bilateral calling price variables are fitted values from a first stage regression, using as instruments the products of accounting rates and proxies for privatization and competition in the provision of international telephone services (as explained in text).

Data Annex

List of countries included in the econometric analysis, using the 1999 trade data:

ALGERIA [b]
ANGOLA [a, c]
ARGENTINA [b]
AUSTRALIA [b]
AUSTRIA [b]
BANGLADESH [c]
BELGIUM [a, c]
BENIN [b]
BOLIVIA [b]
BRAZIL [b]
BURKINA FASO [a,c]
BURUNDI [a]
CAMEROON [b]
CANADA [b]
CENTRAL AFRICAN REP. [a, c]
CHAD [a, c]
CHILE [c]
CHINA: HONG KONG [b]
CHINA: MAINLAND [c]
COLOMBIA [b]
CONGO, REPUBLIC OF [a, c]
COSTA RICA [c]
COTE D'IVOIRE [b]
DENMARK [b]
DOMINICAN REPUBLIC [a, c]
ECUADOR [b, c]
EGYPT [b, c]
EL SALVADOR [c]
ETHIOPIA [a]
FINLAND [b]
FRANCE [b]
GABON [a, c]
GAMBIA, THE [c]
GERMANY [b]
GHANA [c]
GREECE [c]
GUATEMALA [b]
GUINEA [b]
GUINEA-BISSAU [a, c]
GUYANA [a, c]
HAITI [a]
HONDURAS [b]
HUNGARY [b]
ICELAND [b]
INDIA [b]
INDONESIA [b]
IRAN, ISLAMIC REP. OF [b]
IRELAND [b]
ISRAEL [c]
ITALY [b]
JAMAICA [c]
JAPAN [b]
KENYA [c]
KOREA [b]
LIBERIA [a]
MADAGASCAR [b]
MALAWI [c]
MALAYSIA [b]
MALI [c]
MALTA [d]
MAURITIUS [b]
MÉXICO [b]
MOROCCO [b]
MOZAMBIQUE [b]
MYANMAR [a, c]
NEPAL
NETHERLANDS [b]
NEW ZEALAND [b]
NICARAGUA [b]
NÍGER [c]
NIGERIA [b]
NORWAY [b]
PAKISTAN [b]
PANAMA [b]
PAPUA NEW GUINEA [c]
PARAGUAY [b]
PERU [b]
PHILIPPINES [b]
POLAND [b]
PORTUGAL [b]
ROMANIA [b]
SENEGAL [c]
SIERRA LEONE [a, c]
SINGAPORE [b]
SOUTH AFRICA [b]
SPAIN [b]
SRI LANKA [b]
SWEDEN [b]
SWITZERLAND [b]
SYRIAN ARAB REP. [b]
TAIWAN, CHINA [b]
TANZANIA [b]
THAILAND [c]
TOGO [b]
TRINIDAD AND TOBAGO [d]
TUNISIA [c]
TURKEY [b]
UGANDA [c]
UNITED ARAB EMIRATES [a, c]
UNITED KINGDOM [b]
UNITED STATES [c]
URUGUAY [b]
VENEZUELA [c]
VIETNAM [a, c]
YEMEN, REPUBLIC OF [c]
ZAMBIA [a]
ZIMBABWE [b]

Notes:

[a] Exporter, but not importer;

[b] Country reports data on bilateral telecom prices, and is reported as destination for the same variable in reports by at least one other country;

[c] Country does not report data on bilateral telecom prices, but is reported as destination for the same variable in reports by at least one other country;

[d] Country reports data on bilateral telecom prices, but is not reported as destination for the same variable in reports by other countries.

Annex: Robustness tests

In this annex, we present additional econometric estimates to assess how robust our findings are to earlier years of estimation, additional regressors, and alternative model specifications.

First, in a one-sector setup, our model can be extended to yield the well-known gravity equation with unit-elastic income terms. The purpose of this exercise is to test the robustness of our estimation equation (7) vis-à-vis an alternative specification that is closer to the functional constraints imposed by the CES preferences in equation (1).[27]

Dropping the super/subscript k and normalizing each country's product price, p_i, at unity, we can transform equation (4) to:

$$T_{ij} = \frac{Y_i Y_j}{Y^w} \left[\frac{\left(\dfrac{t_{ij}^{1-s}}{\sum_i b_i t_{ij}^{1-s}} \right)}{\sum_h \dfrac{Y_h}{Y^w} \left(\dfrac{t_{ih}^{1-s}}{\sum_g b_g t_{ig}} \right)} \right], \tag{A1}$$

where Y^w denotes world GDP.[28] Similar to the multi-sector models, we can account for country specific variables by employing exporter and importer specific dummy variables. But we can preserve the unit-elastic income terms by specifying our estimation equation in terms of the share of bilateral trade in the product of the two trading partners' GDPs:

$$\ln\left(\frac{T_{ij}}{Y_i Y_j}\right) = A_i + B_j + (1-s)(1+tar_{ij}) + f_D \ln D_{ij} + f_C \ln C_{ij} + f_E \ln E_{ij} + e_{ij}, \tag{A2}$$

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[27] Note that structural derivations of the gravity equations do not always predict a unit-elastic effect of the two income terms. See, for example, Anderson (1979) and Bergstrand (1985 and 1989).

[28] See Deardorff (1998). In equation (A1), bilateral trade depends on incomes and a complex term which captures the trade inhibiting effect of bilateral trade costs. Specifically, the term in the square bracket says that if importing country *j*'s relative trade cost with country *i* is greater than an average of all demander's relative trade costs with *i*, then exports from i to *j* will be correspondingly smaller. The trade inhibiting effect depends crucially on the elasticity of substitution s. If $s = 1$ (the Cobb-Douglas case), the term in the square bracket is equal to one and exports will simply be reduced proportional to the trade cost factor to a level below the "frictionless" benchmark.

Table A1 shows the results of estimating equation (A2).[29] The overall fit of the regression is poorer than in Table 3, with R-squares ranging from 0.45 to 0.73. Nonetheless, it is remarkable that the estimated coefficients on the tariff variable, distance and the two "pure bilateral" calling prices remain largely unchanged. By contrast, the coefficients on the "constructed bilateral" telecom proxy is smaller in value. The latter finding may be explained by the variable picking up the effect of the excluded GDP terms in the regression with unconstrained income elasticities.

Second, our estimations may suffer from a biased selection of samples, especially the regressions with the bilateral calling price variables which only encompass between 1,000 and 1,200 observations. We distinguish between two types of sample selection biases: zero trade flows (which are, by definition, excluded in a log-linear model specification) and the availability of data on our telecom proxy. We employ a Heckman sample selection model to correct for a possible estimation bias in the basic OLS regression. Specifically, we estimate two first-stage probit equations—one for the existence of positive trade flows and one for the availability of telecom data—and include two selectivity correction variables in the main regression.[30] Our explanatory variables in the probit equations are GDP, population and dummies for being a landlocked or island economy of both the exporting and importing country as well as geographic distance and dummy variables for sharing a common language.

Table A2 presents the second stage estimation results of the sample selection model.[31] The estimated coefficients are similar to the ones obtained in the simple OLS regression (Table 3). A notable exception is the coefficient on the product of calling prices to the US, which is much smaller in size, but still significant at the 1 percent level. None of the selectivity correction parameters are statistically significant, except the parameter for non-zero trade flows in the regression using the product of calling prices to the United States. This result suggests a sample selection bias in the larger sample estimates that use the product of US calling prices as the telecom proxy. Correcting for this bias reduces the size of the coefficient on this proxy to a level comparable to the other two calling price proxies.

[29] Countries' GDPs were taken from the World Bank's World Development Indicators.

[30] In doing so, we assume that the error terms in the two probit regressions are uncorrelated.

[31] The first stage probit regressions overwhelmingly show the expected signs and are mostly statistically significant.

We also estimated a sample selection model for the sectoral gravity models using the Rauch classification of products. The second stage estimation results are presented in Table A3. The coefficients on the tariff variable are similar to the simple OLS regressions (Table 6). In the case of differentiated goods the point estimate is now close to zero for both samples, suggesting a substitution elasticity of close to unity. The coefficients on distance are somewhat lower compared to the simple OLS regression (Table 6), whereas the telecom coefficients remain largely unchanged. The conclusions regarding the relative importance of communications costs across the three Rauch product groups remain unchanged. In particular, we observe a 'downward trend' in the coefficient on the importer's calling price as we move from differentiated to homogenous products, whereas the estimated substitution elasticity shows a 'reverse' upward trend. Moreover, the exporter's calling price does not have a statistically significant impact for products traded over organized exchanges. Only three out of twelve sample correction parameters are statistically significant at the 1 percent level and two more parameters are significant at the 10 percent level. Overall, these findings suggest that potential biases from a non-random selection of samples are likely to be small.

Finally, we tested how robust our findings concerning trade in differentiated versus homogenous products are to the product classification used. Rauch (1999) provides an alternative "more liberal" classification, which maximizes the number of commodities that are classified as either organized exchange or reference priced. The OLS estimation results using the "more liberal" classification (not presented here) were very similar to the ones presented in Table 6 and confirmed all the findings discussed in the text.

Table A1: Gravity model using aggregate trade flows (unit-elastic income elasticities), 1999

Dependent variable: $T_{ij}/(Y_iY_j)$	(1)	(2)	(3)
Distance	-0.665***	-0.575***	-1.065***
	(-9.57)	(-9.79)	(-23.38)
Tariff	-2.454*	-2.331***	-2.836***
	(-1.97)	(-2.48)	(-3.45)
Bilateral calling price of exporter	-0.846***		
	(-5.47)		
Bilateral calling price of importer		-0.774***	
		(-5.28)	
Product of calling prices to the US			-0.572***
			(-5.77)
Common border	Insignificant	Correct	Correct
Language dummies			
English	Correct	Correct	Correct
Spanish	Insignificant	Insignificant	Correct
Portuguese	Insignificant	Insignificant	Insignificant
French	Insignificant	Correct	Correct
Arabic	Insignificant	Insignificant	Correct
Number of observations	1,209	1,083	4,079
F-statistic	239.54***	1048.42***	25.27***
R-square	0.731	0.719	0.451

Notes: OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

Table A2: Sample selection model using aggregate trade flows, 1999

Dependent variable: T_{ij}	(1)	(2)	(3)
Distance	-0.415***	-0.507***	-0.990***
	(-3.13)	(-3.93)	(-14.32)
Tariff	-2.529***	-2.319***	-2.634***
	(-2.06)	(-2.46)	(-3.26)
Bilateral calling price of exporter	-0.870***		
	(-5.50)		
Bilateral calling price of importer		-0.748***	
		(-5.07)	
Product of calling prices to the US			-0.785***
			(-8.86)
Common Border	Correct	Correct	Correct
Language Dummies			
English	Correct	Correct	Insignificant
Spanish	Insignificant	Insignificant	Correct
Portuguese	Insignificant	Insignificant	Correct
French	Insignificant	Correct	Correct
Arabic	Insignificant	Insignificant	Correct
Selectivity correction (positive trade)	-1.365	0.862	-2.586***
	(-1.49)	(1.18)	(-7.14)
Selectivity correction (telecom data)	-0.407	-0.199	-0.012
	(-1.57)	(-0.81)	(-0.01)
Number of observations	1,209	1,083	4,079
	(10,710)	(10,710)	(10,710)
F-statistic	976.34***	614.83***	144.44***
R-square	0.907	0.929	0.814

Notes: Second stage OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level. The number of observations in the brackets indicate the number of observations used in the two probit equations.

Table A3: Trade in differentiated versus homogenous goods (sample selection model), 1999

	Differentiated products		Reference priced products		Products traded over organized exchanges	
Dependent variable: T_{ij}	(1)	(2)	(1)	(2)	(1)	(2)
Distance	-0.331***	-0.428***	-0.549***	-0.878***	-0.714***	-0.798***
	(-2.47)	(-3.24)	(-2.90)	(-4.76)	(-3.38)	(-3.94)
Tariff	0.090	0.152	-0.563	-1.940***	-3.767*	-3.150***
	(0.09)	(0.16)	(-0.49)	(-2.62)	(-1.88)	(-3.37)
Bilateral calling price of exporter	-0.614***		-0.733***		-0.268	
	(-3.88)		(-3.62)		(-0.98)	
Bilateral calling price of importer		-0.940***		-0.756***		-0.720***
		(-6.37)		(-3.00)		(-3.08)
Common border	Correct	Correct	Correct	Insignificant	Correct	Correct
Language dummies						
English	Correct	Insignificant	Correct	Correct	Insignificant	Insignificant
Spanish	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Portuguese	Insignificant	Insignificant	Insignificant	Correct	Insignificant	Insignificant
French	Insignificant	Correct	Insignificant	Correct	Insignificant	Insignificant
Arabic	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Wrong
Selectivity correction (positive trade)	-0.060	-5.394***	-0.914	-7.841***	7.338	-1.025
	(-0.02)	(-2.88)	(-0.26)	(-3.00)	(1.50)	(-0.27)
Selectivity correction (telecom data)	-0.769***	-0.056	-0.716*	0.425	-0.909*	-0.719
	(-2.80)	(-0.21)	(-1.89)	(1.33)	(-1.89)	(-1.62)
Number of observations	1,202	1,084	1,176	1,077	1,131	1,050
	(8,055)	(8,055)	(6,981)	(6,981)	(5,844)	(5,844)
F-statistic	228.29***	247.24***	194.34***	1743.83***	234.34***	89.53***
R-square	0.921	0.935	0.844	0.888	0.731	0.796

Notes: Second stage OLS regression with exporter and importer fixed effects and White robust standard errors. t-statistics in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level. The classification of product groups is based on Rauch (1999).