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ABSTRACT

How Remote is the Offshoring Threat?*

Advances in communication technology make it possible for workers in India to supply business services to head offices located anywhere. This has the potential to put high-wage workers in direct competition with much lower paid Indian workers. Service trade, however, like goods trade, is subject to strong distance effects, implying that the remote supply of services remains limited. We investigate this proposition by deriving a gravity-like equation for service trade and estimating it for a large sample of countries and different categories of service trade. We find that distance costs are high but are declining over time. Our estimates suggest that delivery costs create a significant advantage for local workers relative to competing workers in distant countries.

JEL Classification: F10, F14, F15 and F16
Keywords: distance, gravity, services and trade

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1 Introduction

In 1995, the title of a Richard Freeman paper asked "Are your wages set in Beijing?" He motivated the paper in part by referring to the large increase in "*manufacturing* imports from third world countries." A decade later the terms of the debate have shifted. A more up-to-date title would be "Are your wages set in Bangalore?" Promoting his bestseller *The World is Flat*, Thomas Friedman (2005) wrote of how he had "interviewed Indian entrepreneurs who wanted to prepare my taxes from Bangalore, read my X-rays from Bangalore, trace my lost luggage from Bangalore and write my new software from Bangalore." The earlier focus was on China as a major exporter of goods to the United States but now attention has turned to India as a supplier of services. In either case, workers in high-wage countries are concerned about maintaining living standards in the face of competition with foreigners who are willing to work for much lower wages.

Imports of services from low-wage nations merit special attention for three main reasons. First, the service sector employs about three times as many workers as the goods-producing industries. Second, the service sector contains a relatively large share of highly educated workers. These two facts imply a widening range of workers potentially facing competition from their counterparts in poor countries. The third special feature of services is that recent technological progress has been much more revolutionary with respect to moving ideas than it has with respect to moving objects. Since many services involve idea transmission, improved communication technologies can—in principle—place third-world service providers in direct competition with service workers in the developed world.

This paper investigates the extent to which service trade has managed to overcome the impediments created by geographic distance and institutional differences. We model the "international market for services" and generate a gravity-like model of service trade. We posit that physical distance, differences in time zones, languages, and legal systems, all raise the costs of employing foreign service workers. These costs may vary across service sectors and may change over time. We estimate the model using data for 64 countries over the period 1992–2004. The theoretical model and estimates of distance effects allow us to calculate the wage premium a firm would be willing to pay to avoid the costs associated with remote provision of services.

Two recent studies have estimated gravity models for total services using 1999–2000 OECD data. Kimura and Lee (2006) use data for ten OECD countries and 47 partners to compare gravity estimates for aggregate services and trade. They estimate distance elasticities for services trade of around -0.6, slightly larger in absolute value than their estimates for goods trade for the same set of countries. These distance elasticities are smaller (in absolute value) than those typically found in the gravity literature of goods trade (see Disdier and Head, 2008). Mirza and Nicoletti (2004) use 20 OECD reporting countries and 27 partners to test their theory that labour market characteristics in home and host countries interact in determining service trade. They also find relatively small trade-impeding effects of distance.

Our analysis makes a number of contributions to the literature. By using Eurostat rather than OECD data, we can examine disaggregated service trade categories. This allows us to separate services that are the subject of the offshoring debate—professional services such as financial, computer, and communication services—from those that are not such as transportation, tourism, and government services. We are also able to utilize longer time-series to evaluate changes in distance effects since 1992. In addition, our model provides theoretical underpinnings for a service gravity equation and the structure for evaluating the protection that distance affords local service workers in terms of wage premia.

The paper is organized as follows. Section 2 discusses international service trade statistics and provides an overview of the growth of different subcategories of service trade. In Section 3, we derive a gravity-like specification for service trade based on the notion of an international market for services. We explain how the model is implemented in section 4 and display and discuss the econometric results. In section 5, we make use of our estimates to calculate the wage premium a firm would be willing to pay to avoid the costs associated with remote provision of services. We conclude in section 6.

2 Data on service trade

The source of international service trade data is the Balance of Payments (BoP) that measures service transactions between resident and non-resident entities. Thus, these data cover three of the four modes of international service supply defined in the General Agreement on Trade in Services—cross-border supply (mode 1), consumption abroad (mode 2), and the presence of natural persons (mode 4). The first mode reflects remote provision of services whereas the latter two refer to consumers or sellers travelling abroad to make transactions. The BoP excludes mode 3—commercial presence—representing foreign affiliates sales to host-country consumers.

If the focus is on domestic workers, excluding commercial presence may be useful. Remote provision of services from foreign countries may pose a direct threat to domestic workers. Likewise a foreign service provider travelling to provide its services arguably takes a job that otherwise would be provided domestically. However, a foreign company that creates a local affiliate and employs local workers (commercial presence) may *create* jobs for domestic workers rather than destroy them. Jobs may be lost to the extent that the local affiliate imports upstream services from the home country, but these transactions are captured in the BoP as a service import.

Bilateral service trade flows are compiled by the OECD and Eurostat, the European Union's (EU) statistical agency. The World Bank's *World Development Indicators* (WDI) provides service trade data on a multilateral basis. WDI provides the most time and country coverage, 1976–2004 for 192 countries. These data are useful for summarizing world trends but cannot be used for bilateral flow estimation. Of the sources of bilateral trade, Eurostat has longer time coverage: 1992–2004 versus 2000–2003 for the OECD.[1] Its data is also much more disaggregated, as the OECD just covers four categories of service trade whereas Eurostat provides finer subcategories of services. Eurostat data is based on reports of 25 EU countries plus Norway, Bulgaria, Romania, Turkey, United States, and Japan.[2] Our regression analysis uses Eurostat data because it offers the best time series and sectoral information.

Figure 1: Service classifications in the Extended Balance of Payments

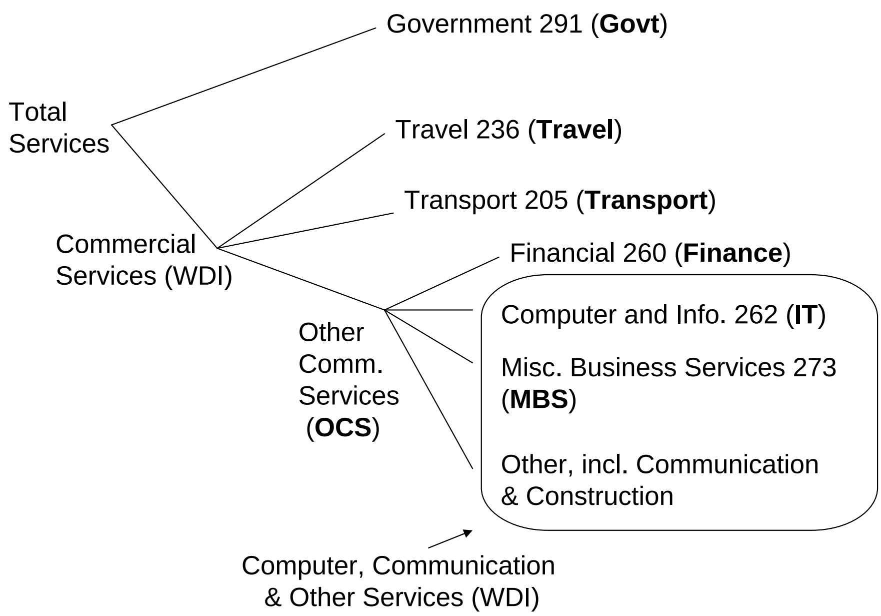


Figure 1 shows the various service sectors studied in this paper. It displays in bold the abbreviations we use to refer to service subcategories and the 3-digit numbers represent

[1]A smattering of Eurostat data is available starting in 1985, but the data set is not complete enough to be useful until 1992.

[2]OECD data reflects on reports of 29 countries. Oddly, this data set does not provide reports for OECD members Iceland, Switzerland, and Poland but does contain reports for non-OECD countries Hong Kong and Russia.

the Extended Balance of Payments Services (EBOPS) codes. The OECD breaks down service trade into Government, Transport, Travel, and Other Commercial Services subcategories. Government services are primarily provided by embassies, consulates, and military agencies. Transport services are charges of freight and passenger carriers for moving goods and people internationally, while travel data reflect expenses abroad by business and personal travelers. WDI goes a bit further than the OECD by dividing Other Commercial Services into two groups: 1) Financial Services and 2) Computer, Communication and Other Services. With the finer disaggregation by Eurostat, we are able to use information on Computer and Information as well and Miscellaneous Business Services, the latter including legal, accounting, advertising, and management consulting, as well as call centres. Further disaggregation is available in Eurostat but there are too few positive observations for statistical analysis of this data.

Figures 2 and 3 use WDI data to show the growth of service trade relative to other activities and the changing composition of service trade. In Figure 2, we show how world services and goods value added, service and goods (merchandise) exports, and exports of Other Commercial Service (OCS) have grown over time. Each series is expressed as an index relative to its 1977 value (set equal to 100). We observe rapid growth in trade starting around the mid-1980s with OCS trade growing the most. The service sector has grown faster than the goods sector and trade growth outstrips growth in value added. Since the indexes are graphed on a log scale, the rising gap between the export and value added indexes indicates the ratio of trade to value added is rising. A natural interpretation is that both goods and services are becoming more tradable over time.

The WDI data provides information on the shifting composition of service trade. As portrayed in Figure 3, Transport was the leading sector in 1977, accounting for over one-third of service exports. Government represented almost 10% of trade. The figure shows both these sectors' shares fall over time whereas the shares of services trade accounted

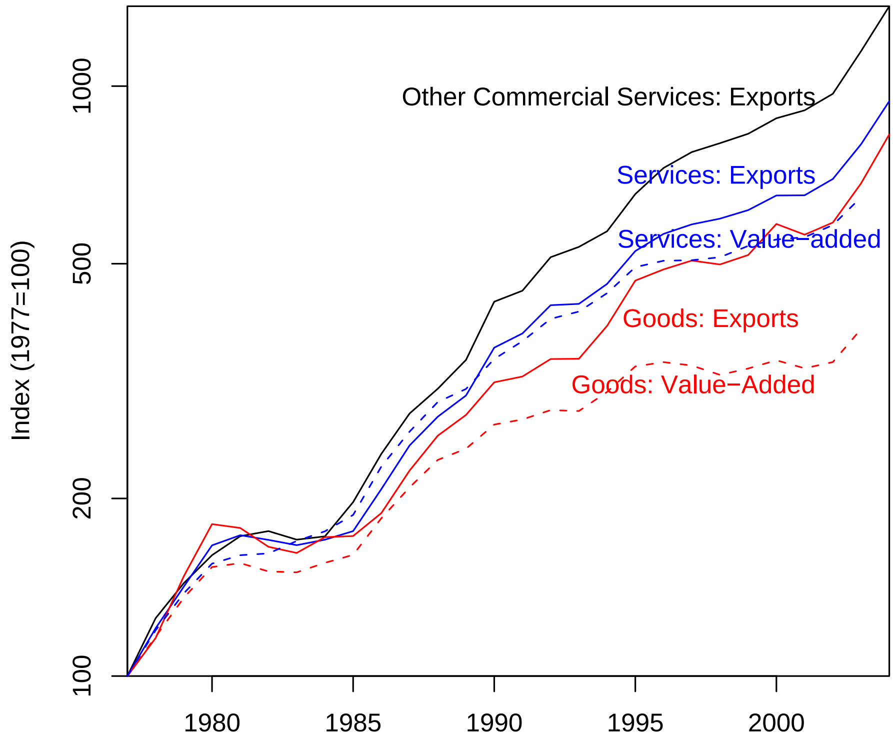


Figure 2: The growth of trade and production of goods and services

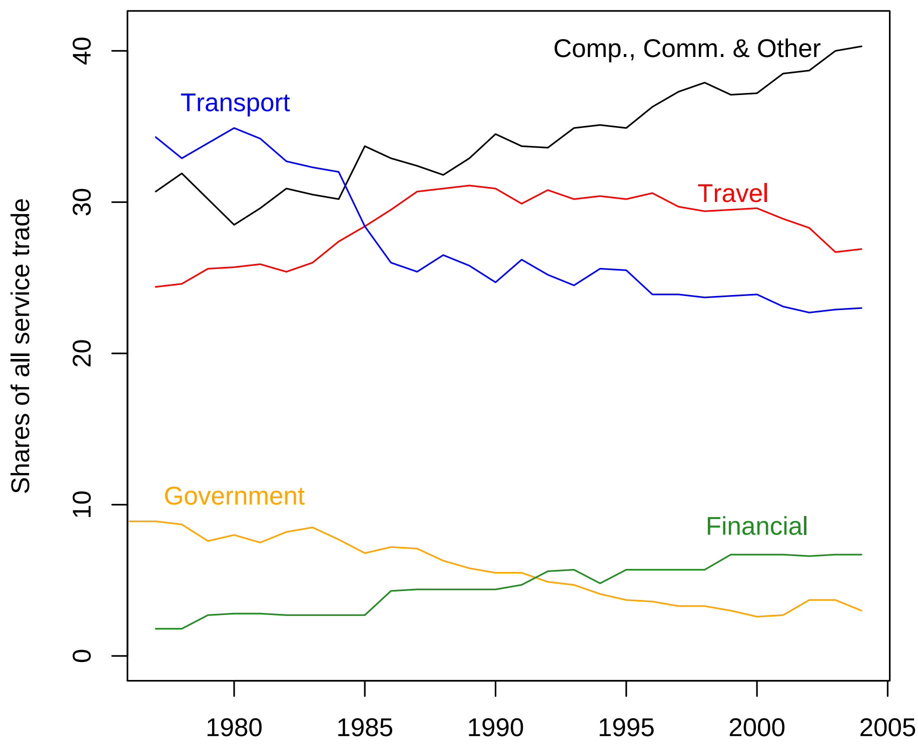


Figure 3: The changing composition of service trade

for by Computer, Communication and Other Services and Financial Services have risen to 40.3% and 6.7% respectively. Together, the two figures reveal that service trade is growing rapidly and its composition has shifted towards Other Commercial Services.

Eurostat compiles information on service debits and credits (imports and exports) so bilateral service export information is available for many more countries than the reporting countries. In 2004, Eurostat provides non-missing data on Other Commercial Services trade for 2,222 bilateral pairs. There are somewhat more observations for total services and much fewer for more disaggregated categories. In all cases, the coverage declines substantially in earlier years: non-missing OCS observations total 1298 in 2000, 390 in 1995, and 174 in 1992. Countries of interest such as India and China enter as partners in the Eurostat data through their transactions with reporting Eurostat countries. Trade between two non-reporters, such as China and India, are unavailable in this data set.

Table 1: Worldwide Service Trade

Period:	Value 2004	Growth % 1977–2004	Eurostat share 2004
Total Services	2258.5	13.3	0.75
Comp., Comm., & Other	910.9	15.0	0.77
Travel	607.3	13.9	0.66
Transportation	520.5	10.8	0.67
Financial	151.8	21.9	0.25
Government	67.9	6.7	0.20

Note: Value, expressed in billions of US dollars, reflects world exports as recorded in *World Development Indicators*. Growth is the annual percent change from 1977–2004. The Eurostat share represents the trade of Eurostat reporting countries as a percentage of world trade in 2004.

Table 1 provides information on the coverage of the Eurostat data. The first two columns lists the value of service trade and its subcategories as well as their 1977–2004 growth rates. Service trade was $2.3 trillion that year. We observe that Financial Services and Computer, Communication and Other Services were the fastest growing subcategories. The third column lists the ratio of 2004 Eurostat data to WDI data. Eurostat-country trade accounts for three-quarters of the aggregate service trade reported in WDI. Computer, Communication and Other Services appears well covered (77%) but Eurostat accounts for only 20% of Financial Services trade.

The ensuing regression analysis will consider the various subcategories of services available from Eurostat. The offshoring debate has focussed on such activities as call centres and computer-related services. Thus, we separate less relevant categories of service trade such as Transportation, Travel, and Government from Other Commercial Services. We anticipate that trade costs of services will vary across the type of service and using disaggregated data allows us to measure different trade costs across subcategories. We also investigate how distance effects change over time, an exercise that is feasible given the 1992–2004 times series information available in the data set.

3 A model of bilateral services trade

To give our statistical analysis some formal foundations, we now develop a model of the determination of bilateral service offshoring flows. The derivation draws heavily on the Eaton and Kortum (2002) model of trade in goods. The exposition follows the Head and Ries (2006) model of bilateral FDI stocks.

In the Heckscher-Ohlin-Vanek model of trade in goods, workers are immobile between nations. However, they can export their labour services embodied in the form of goods. In contrast, the key idea of service offshoring is that a firm can replace the services of domestic workers *directly* with the services of workers residing in foreign countries ("offshore"). Foreign workers can supply their services via communication technologies or via temporary visits to the domestic producer's facility.

Let there be S_d service "positions" in the destination country d and N_o "candidates" in the origin country. Let π_{od} denote the fraction of positions in country d that are filled by candidates from country o. The number of jobs offshored to each origin country is therefore given by

$$S_{od} = \pi_{od} S_d, \text{ where } \sum_o S_{od} = S_d. \tag{1}$$

To specify π_{od}, we assume that each position is filled by the candidate who offers her services at the lowest unit labour costs inclusive of the costs of "delivering" a unit of the service from o to d. Unit labour costs of origin o are wages divided by productivity, w_o/z_o. Delivering services from o to d consumes additional labour time in order to produce a service suitable to the preferences of consumers in the destination market. This might involve travel, training, or translation time so we use T_{od} to represent the hours required per unit of service output. If the origin workers incur the delivery costs, then delivery labour costs are given by $w_o T_{od}$. Assuming that the same productivity adjustment applies to both producing and delivering services, let $T_{od} = \tau_{od}/z_o$, where τ_{od} is a parameter increasing in the distance between o and d. Combining production and delivery costs yields the *delivered* unit labour costs $(w_o/z_o)(1 + \tau_{od})$.[3] We can model the objective function of the firm as maximizing the negative of the log of the delivered unit labour costs.

$$\mathcal{U}_{od} = -\ln[(w_o/z_o)(1 + \tau_{od})] = \ln z_o - \ln w_o - \ln(1 + \tau_{od}). \tag{2}$$

To maintain tractability, one must impose very specific functional forms. First let candidate-worker productivity, z_o, be distributed Fréchet. The cumulative distribution function (CDF) of z_o is $\exp\{-(z/\kappa)^{-\theta}\}$, where θ is an inverse measure of productivity variation and κ is a location parameter. Then the distribution of $\ln z_o$ takes the Gumbel form with CDF $\exp(-\exp(-\theta(\ln z - \ln \kappa)))$, where $\ln \kappa$ is the mode of the distribution of $\ln z_o$. The maximum of N Gumbel draws retains the Gumbel form with the mode increased to $\ln \kappa + (1/\theta) \ln N$. Assuming that each service position goes to the most

[3] This specification, in which delivery costs magnify unit labour costs, is chosen primarily for analytic tractability. It mirrors the "iceberg" assumption conventionally made for trade in goods.

qualified candidate in country o, and that countries differ in terms of the size of their candidate pool (N_o) and their modal productivity ($\ln \kappa_o$), the objective function can be re-expressed as

$$\mathcal{U}_{od} = \ln \kappa_o + (1/\theta) \ln N_o - \ln w_o - \ln(1 + \tau_{od}) + \epsilon_{od}, \tag{3}$$

where ϵ_{od} is a zero-mode, independent, identically distributed Gumbel variable with CDF $\exp(-\exp(-\theta\epsilon))$.

The Gumbel distribution assumption is extremely useful because the distribution of the probability that a given draw of ϵ_{od} is the maximum draw takes the tractable form of the multinomial logit. The law of large numbers implies that the fraction of jobs going to origin o will converge on that probability as S_d becomes large. Using these results we obtain

$$\pi_{od} = \text{Prob}(\mathcal{U}_{od} > \mathcal{U}_{o'd} \mid o' \neq o) = \frac{\exp[\ln N_o + \theta(\ln \kappa_o - \ln w_o - \ln(1 + \tau_{od}))]}{\sum_i \exp[\ln N_i + \theta(\ln \kappa_i - \ln w_i - \ln(1 + \tau_{id}))]}. \tag{4}$$

The value of the service flows created by offshoring, denoted V_{od}, is given by the number of jobs offshored multiplied by the price paid to the offshore service providers. In the model, the service provider receives w_o. Hence, $V_{od} = w_o S_{od}$. This formulation is equivalent to FOB pricing for trade in goods. Substituting (4) into (1), we can express expected bilateral exports of services as

$$V_{od} = w_o S_{od} = w_o \pi_{od} S_d = N_o S_d \kappa_o^\theta w_o^{1-\theta} (1 + \tau_{od})^{-\theta} P_d^\theta, \tag{5}$$

where $P_d \equiv [\sum_i N_i (w_i(1+\tau_{id})/\kappa_i)^{-\theta}]^{-1/\theta}$. This expression resembles the gravity equation for trade in goods in that expected bilateral flows are increasing in the product of origin and destination size variables (N_o and S_d) and decreasing in measures of bilateral delivery costs, τ_{od}. Better access to a larger set of low-wage, high-productivity workers, i.e. a *low* P_d, implies that a higher fraction of the positions in country d will be taken by workers from other countries, thereby reducing bilateral offshoring to country o.

Additional insight into how the parameters of the model might be estimated emerges by re-expressing the right-hand side as

$$V_{od} = \exp[\underbrace{\ln N_o + \theta \ln \kappa_o - (\theta - 1) \ln w_o}_{\text{Exporter effect}} + \underbrace{\ln S_d + \theta \ln P_d}_{\text{Importer effect}} - \underbrace{\theta \ln(1 + \tau_{od})}_{\text{Bilateral delivery cost}}]. \tag{6}$$

This equation shows that bilateral service flows can be separated into a origin o-specific term, a destination d-specific term, and a bilateral (od) delivery cost term. Compressing the exporter and importer effects into one term each, we obtain a more compact expression for expected bilateral service flows:

$$V_{od} = \exp[\mathrm{FX}_o + \mathrm{FM}_d - \theta \ln(1 + \tau_{od})]. \tag{7}$$

This formulation closely resembles the FDI equation of Head and Ries (2006). Aside from the exponential form, these equations are also close to the trade equations estimated by Eaton and Kortum (2002). An equation observationally equivalent to (7) could be developed by assuming that firms demand differentiated inputs as in Ethier (1982). Suppose that firms have production functions in which varieties of business services enter with a constant elasticity of substitution, σ. This will lead to a version of equation (7) in which the fixed effects have different structural interpretations and $\sigma - 1$ takes the place of θ.[4] We find the model of differentiated candidates competing for a single position to be more appealing because it adheres more closely to the public discussion of offshoring.

[4]See footnote 20 of Eaton and Kortum (2002) for a comparison of heterogeneous productivity and differentiated products derivations of the gravity equation and Anderson and van Wincoop (2003) for analysis of the structural interpretation of the importer and exporter fixed effects. The equivalence between the aggregate predictions of a model with discrete choice of the best variety versus a model where expenditures are spread over all varieties was initially demonstrated in Anderson et al. (1992).

4 Results

We begin by specifying the estimation equation and our measures of delivery costs. In order to compare distance effects for services to those that have been estimated for goods, subsection 4.2 provides regression results for goods and services under standard gravity and fixed effects specifications. Subsection 4.3 displays estimates of distance effects for different subcategories of service trade. In the final part of this section, we examine the robustness of the results to estimation methods that impose fewer restrictions on the error term and the evolution of the coefficients.

4.1 Model implementation

We fit the model to 1992–2004 Eurostat data. In order to implement the model, we need to choose variables that proxy for the delivery costs, τ_{od}, impeding service exports from country o to country d. We follow standard practice in assuming that $\ln(1+\tau_{od})$ is linear in log geographic distance, $\ln D_{od}$, and a vector of indicator variables designed to measure the trade-fostering linkages, $\boldsymbol{L}_{od}$, between the origin and destination country. We augment this specification by including the difference in time zones between origin and destination, denoted Δ_{od}, which anecdotal accounts suggest to be especially important for service trade. Adding an error term, u_{od}, to represent a potentially large set of additional omitted determinants of bilateral delivery costs, yields

$$\ln(1+\tau_{od}) = \delta \ln D_{od} + \nu \Delta_{od} - \boldsymbol{\lambda} \boldsymbol{L}_{od} + u_{od}. \tag{8}$$

The mean of u_{od} is likely to change over time due to advances in technology that facilitate trade over all dyads. Hence, it is important to allow for time-varying means for u_{od} which we accomplish with a full set of year dummies.

We posit that geographic distance, D_{od}, raises delivery costs for services by increasing time devoted to travel, training, and translation. It is measured as the population-weighted average of the great-circle distances between cities in the origin and destination countries. In order to explore how distance costs have changed over time, we also interact distance with a time trend.

To the extent that electronic communication is a good substitute for face-to-face interaction, travel becomes unnecessary and geographic distance becomes less relevant. However, even with email and teleconferencing, East-West distance can matter because of time zone differences (Δ_{od}). There will be a negative effect due to difficulties in coordinating with sleeping colleagues during one's working day. On the other hand, having wide time zone differences can make it possible for a company to operate over a 24-hour business day. We can think of the former benefit of proximity as the "synchronization effect." The latter benefit of differences in time zones is the "continuity effect." As the effects oppose each other, the expected sign of ν is ambiguous.

Standard components of $\boldsymbol{L}_{od}$ include colonial relationships and a shared language. We add one more variable, shared legal origins, that we suspect might matter particularly for service trade. Thus, the linkages vector comprises

$$\boldsymbol{L}_{od} = \{\text{Colony}_{od}, \text{Language}_{od}, \text{Legal}_{od}\}.$$

The common legal system dummy variable should account for the bilateral ease of signing commercial contracts between the two countries. A common legal system makes it less costly to adapt national contracts or to seek information about the rules prevailing in the foreign partner country. We therefore expect this dummy to enter positively. Finally, a common language and a colonial relationship have been shown in many studies to promote bilateral trade in goods and FDI. The sources and construction of all the components of τ are described in the Data Appendix.

To obtain the estimating equation, we substitute equation (8) into (7), yielding

$$V_{od} = \exp[\mathrm{FX}_o + \mathrm{FM}_d - \theta\delta \ln D_{od} - \theta\nu\Delta_{od} + \theta\boldsymbol{\lambda}\boldsymbol{L}_{od}]\eta_{od}, \tag{9}$$

where $\eta_{od} \equiv \exp(\theta u_{od})$ is a multiplicative error term with an expectation of one. We will refer to minus the coefficient on log distance, $\theta\delta$ in the model, as the "distance effect." If η_{od} is log-normal (which would be the case if u_{od} is homoskedastic and normally distributed) then the maximum likelihood estimates of the parameters can be obtained via a linear-in-logs regression:

$$\ln V_{od} = \mathrm{FX}_o + \mathrm{FM}_d - \theta\delta \ln D_{od} - \theta\nu\Delta_{od} + \theta\boldsymbol{\lambda}\boldsymbol{L}_{od} + \ln \eta_{od} \tag{10}$$

Equation 10 is our baseline specification. In the robustness section, we employ two alternative specifications that provide consistent estimates in the presence of heteroskedastic, non-normal errors.

Before presenting regression results it is useful to examine the data graphically in Figures 4 and 5, where we take the United Kingdom and France's imports of Other Commercial Services imports as examples. We control for differences in economic size across origins by dividing imports by the origin country's GDP. The scatter plots clearly exhibit downward slopes and the lines in the figures depict univariate regression lines fitted to the data. The OLS distance effects are 0.64 and 0.86. Given the log scale, these slopes imply that a 10% increase in distance decreases imports by 6–9%.

Figure 4 also illustrates the influence of three of components of the delivery cost vector τ_{od}: sharing a common language, sharing the same legal origins, and having ever been in a colonial relationship. For the UK, these indicators mainly lie above the regression line, suggesting that, for a given distance, the UK imports more from countries with whom it has linguistic, legal, or historical ties. For France, countries French-speaking

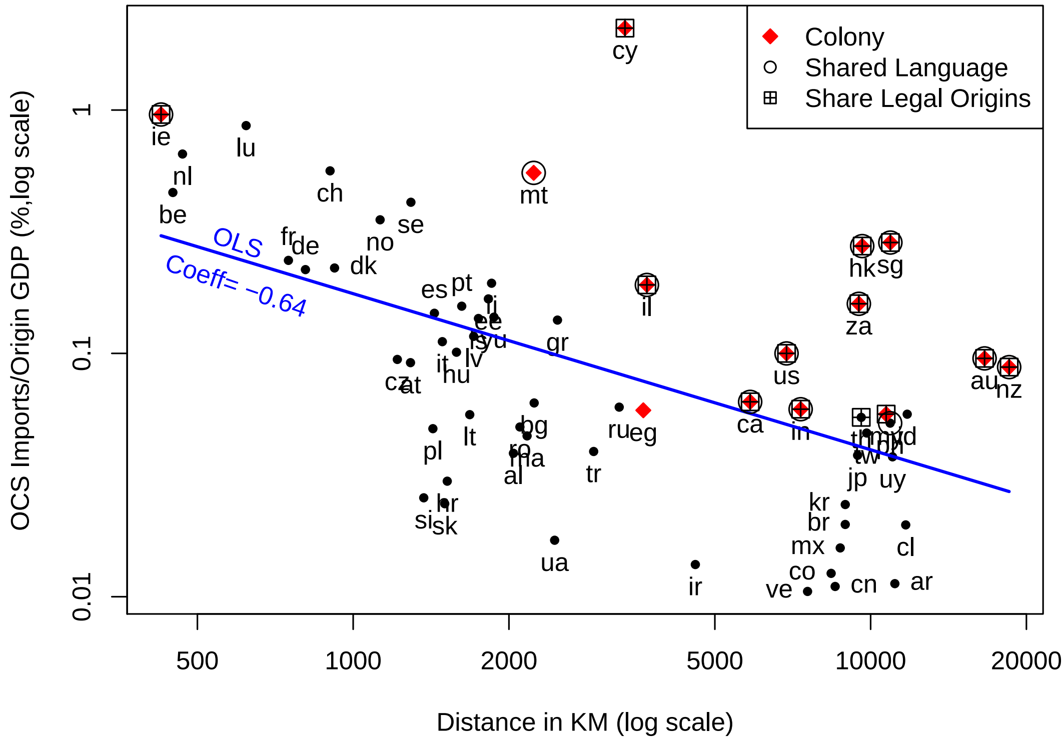


Figure 4: The impact of distance on Canadian imports of Other Commercial Services (OCS), 2000–2004 averages

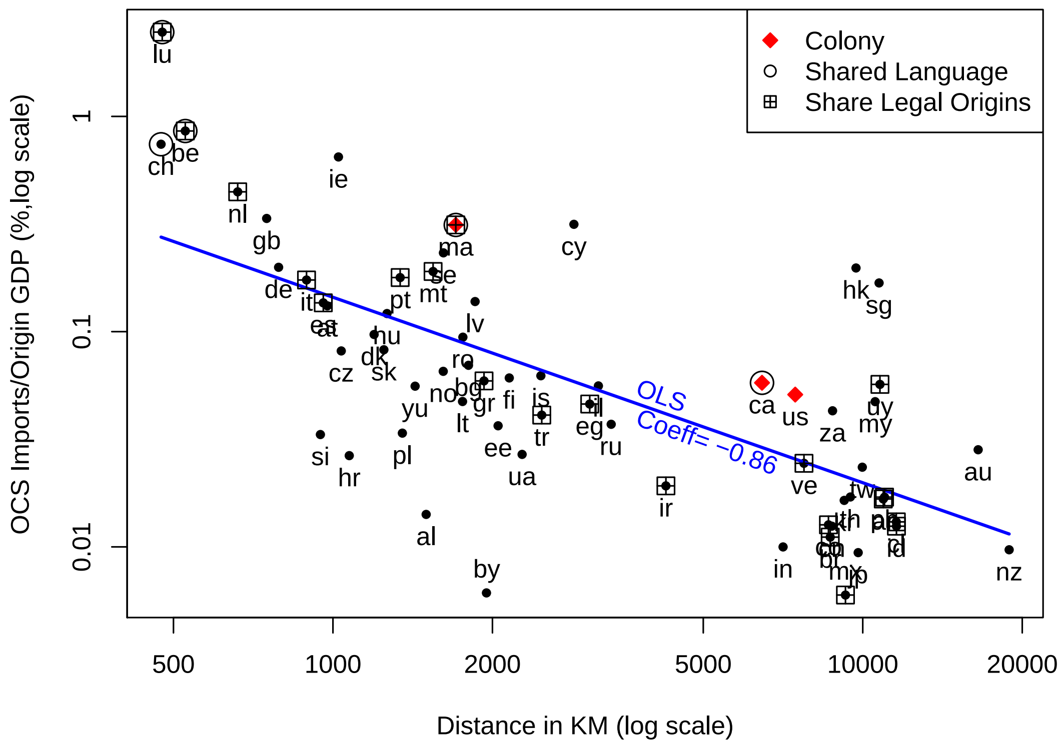


Figure 5: The impact of distance on French OCS Imports, 2000–2004 averages

countries and former colonies are above the regression line but countries with common legal systems appear scattered around the line.[5]

4.2 Distance effects for goods and services

The first set of regression results are shown in Table 2 where we compare distance effects for goods and Other Commercial Services under different specifications.[6] We focus on OCS rather than all services because it excludes government, transportation, and travel, categories of service trade that are not represented in our model nor the subject of the offshoring debate. Since few existing studies estimate a trade equation with the importer and exporter fixed effects shown in equation (10), the first four columns reporting "standard" gravity estimates where the fixed effects are replaced with population and income per capita of each country. We report only the coefficients on the trade cost proxies. The first two columns display results for OCS and goods using all available observations. Since the distance effect for goods is known to depend on the sample used for estimation, the last four columns confine the sample the 8,948 observations where *both* OCS and goods flows are non-missing and non-zero.[7] The final two columns portray results for the common sample when we include time-varying importer and exporter fixed effects.

We refer to minus the coefficient on distance as the "distance effect." It comprises a base effect corresponding to 1992 and a time trend. We observe that the base effect tends to be higher for OCS than goods, especially in the specifications that incorporate fixed effects. Estimates of the trend are positive and significant for OCS across samples and specifications, indicating that the trade-diminishing effect of distance is becoming less pronounced over time. In the preferred fixed-effect specification shown in column (5), the

[5]Note that the Eurostat data do not report France's service imports from most of its former colonies in Africa.

[6]Data on merchandise trade comes from data from the IMF's *Direction of Trade Statistics* (DoTS).

[7]The sample is reduced primarily because our DoTS data stops in 2003 and DoTS does not provide trade data for Taiwan in electronic format.

1992 estimate of the distance effect is 2.443 and the trend term is 0.082. These estimates imply that the distance effect for OCS trade in 2004 falls to 1.459 ($= 2.443 - 12 \times 0.082$).

The trend for the distance coefficient for goods in the full sample (200,147 observations) shown in column (2), is small and negative (-0.006) and statistically significant. This implies the distance effect for goods is *growing* over time. Combes, Mayer and Thisse (2006) graph the upward trend in distance effects estimated in cross-section data from 1870 to 2003 using worldwide bilateral goods trade data. Berthelon and Freund (2006) examine industry-level trends and find that most are insignificant but about a quarter show significantly stronger distance effects. Disdier and Head (2008) conduct a meta-analysis of 1467 distance effects estimated in 103 papers and find rising distance effects since the 1960s. We corroborate the rise in estimated distance effects here using the standard gravity specification on the sample of all positive trade flows.

Trends in the distance coefficient for goods vary by specification, however. The trend shown under standard gravity and the common sample (column 4) is insignificant. In column (6), we observe that incorporating fixed effects and using the common sample yields a distance trend estimate of 0.025 that is significant at the 10% level. Contrasting results of trends in distance effects under standard gravity and fixed effects specifications might be explained by entry into the sample of distant countries with low trading propensities. If low trading propensities are not fully explained by other covariates such as population and income, then they are reflected in the distance effects. The fixed effects, however, account for trading propensities of entrants and produces trends in distance effects for goods that are consistent with the proposition of falling trade costs.

Table 2 reveals that colonial relationships and shared language and legal systems generally exert positive and significant effects on bilateral trade. In the fixed effects regressions shown in the last two columns, the effects of colonial relations and shared legal origin are somewhat stronger for OCS than goods. When we use fixed effects,

Table 2: OCS vs Goods in Gravity and FE Specifications

	(1) OCS	(2) goods	(3) OCS	(4) goods	(5) OCS	(6) goods
ln avg dist	-1.339^a	-1.385^a	-1.357^a	-1.190^a	-2.443^a	-1.826^a
	(0.080)	(0.024)	(0.087)	(0.063)	(0.150)	(0.111)
ln avg dist $\times$ trend	0.020^a	-0.006^a	0.014^c	0.005	0.082^a	0.025^c
	(0.007)	(0.002)	(0.008)	(0.005)	(0.019)	(0.014)
Time zone diff.	0.016	0.069^a	0.030	0.067^a	0.046^a	0.065^a
	(0.018)	(0.006)	(0.019)	(0.015)	(0.016)	(0.011)
Shared Language	0.725^a	0.596^a	0.750^a	0.259^c	-0.042	0.130^c
	(0.149)	(0.037)	(0.177)	(0.137)	(0.097)	(0.077)
Colonial Relation	0.679^a	1.047^a	0.688^a	0.443^a	0.462^a	0.335^a
	(0.148)	(0.077)	(0.166)	(0.133)	(0.081)	(0.059)
Shared Legal origins	0.456^a	0.381^a	0.388^a	0.427^a	0.668^a	0.469^a
	(0.078)	(0.028)	(0.086)	(0.063)	(0.052)	(0.029)
Observations	11390	200147	8948	8948	8948	8948
R^2	0.770	0.654	0.780	0.820	0.891	0.918
Fixed effects	t	t	t	t	ot, dt	ot, dt
Clustering	od	od	od	od	dt	dt

Note: Standard errors in parentheses with ^{a}, ^{b} and ^{c} respectively. Columns (1)–(4) include origin and destination log population and log per capita income. The R^2 in columns (5) and (6) include explanatory power of all FEs.

shared language enters insignificantly for OCS and has a small positive effect on goods trade.

Across specifications, time zone differences have a positive, significant, and remarkably stable effect on goods trade, a result in contrast to the negative coefficients reported in Stein and Daude (2006). They consider the log of imports plus exports for 17 OECD countries and 58 partners in 1999 (988 observations), incorporate importer and exporter fixed effects, and use slightly different covariates than us. In regressions designed to approximate their sample and specification, our estimate of the effect of time zone differences remains similar in sign, magnitude and significance to the ones reported in Table 2.[8]

Time zone differences for OCS trade are also positive but they only exert significant effects in the fixed effects regressions. This results suggest that the continuity effect (ability to operate around the clock) dominates the synchronization effect (need to coordinate during business hours). However, the continuity effect should be absent for goods and yet we obtain positive estimates, which suggests to us that time difference effects should be interpreted with caution.

The full-sample, standard gravity specification in column (2) imply that the distance effects estimates for goods range from 1.385 in 1992 to 1.451 in 2003. These are higher than what have been estimated in the literature: Disdier and Head's (2008) quantitative survey reports the mean estimate of the distance effect to be 0.9. The high distance effect we find is largely attributable to inclusion of time differences: when we estimate the column (2) specification without this variable, the coefficient on the base effect falls to -1.178 and the trend is unchanged. Both time zone differences and distance reflect geographic separation and are highly correlated (around 0.83 in cross-section). In the estimates in the goods regression reported in column (2), the promotion of trade associated with time zone differences is "offset" by a large distance effect.

[8]Following their description, we used 1999 DoTS data and the same formulation for the dependent variable and the same set of covariates. As they do not specify the exact countries in their sample, we confined the sample to Eurostat reporting countries and their trading partners (1119 observations).

The results for the common sample reveal that the specifications fit OCS trade nearly as well as goods trade as reflected in the comparable R^2s in the last four columns of Table 2. In the preferred fixed effect specification shown in the final two columns, we observe that the distance effects for services were initially higher than those for goods but are falling more rapidly. OCS and goods distance effects are 2.443 and 1.826 in 1992 and fall to 1.541 and 1.551 in 2003. The similarity in the estimated magnitude of goods and OCS distance effects suggests that there might be a common source that accounts for the majority of the distance effect observed for both types of trade. Grossman (1998) argues that transport costs are unlikely to explain the distance effects estimated for goods. Instead he suggests, "I suspect [we need a] model with imperfect information where familiarity declines rapidly with distance. Perhaps it is a model with very localized tastes (as in Trefler's 'home bias', 1995), which are historically determined and change only slowly with experience." These two mechanisms could work equally well to explain distance effects for services. Interestingly, Blum and Goldfarb (2006) find an OLS distance effect of 1.2 for "digital goods" consumed over the internet. They attribute the finding to cultural differences that are increasing in geographic distance.

4.3 Distance effects for different categories of service trade

We now turn attention to how the distance effects for Other Commercial Services compare to other categories of service trade—Total, Finance, IT, and Miscellaneous Business Services. We employ importer-year and exporter-year fixed effects and report results for each category in Table 3.

Column (2) displays results for OCS. They are slightly different than the fixed effects results in column (5) of Table 2 because we use the full sample as opposed to the sample common to positive goods observations. The trend in the distance effect for total services shown in column (1) is a bit lower than that for OCS, 0.064 compared to 0.091. The

Table 3: Fixed effects linear model for different types of services

	(1) Total	(2) OCS	(3) Finance	(4) IT	(5) MBS
ln avg dist	-2.199[a]	-2.455[a]	-1.839[a]	-1.624[a]	-1.875[b]
	(0.124)	(0.142)	(0.191)	(0.236)	(0.905)
ln avg dist × trend	0.064[a]	0.091[a]	0.030	0.033	0.026
	(0.014)	(0.016)	(0.022)	(0.025)	(0.092)
Time zone diff.	0.051[a]	0.029[c]	0.136[a]	-0.015	0.218[a]
	(0.013)	(0.015)	(0.024)	(0.025)	(0.062)
Shared Language	-0.104	-0.137[c]	-0.008	-0.502[a]	-0.755[a]
	(0.071)	(0.076)	(0.106)	(0.135)	(0.196)
Colonial Relation	0.587[a]	0.496[a]	0.251[b]	0.668[a]	0.325[c]
	(0.067)	(0.070)	(0.110)	(0.126)	(0.191)
Shared Legal origins	0.687[a]	0.673[a]	0.468[a]	0.357[a]	0.620[a]
	(0.039)	(0.045)	(0.056)	(0.080)	(0.099)
Observations	12794	11390	6126	4455	3473
R^2	0.803	0.811	0.800	0.731	0.825

Note: Standard errors in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are clustered within destination-year and estimation is *within* destination-year. Origin-year intercepts are included but not reported.

base distance effect is higher for OCS than total services but somewhat offset by a less positive effect of time zone differences. The estimated distance effects for service trade are much higher than those found for total services by Kimura and Lee (2006) and Mirza and Nicoletti (2004). While part of this difference is due to our use of fixed effects and inclusion of time zone differences (that enter positively), we find larger effects than those in the literature even in a standard gravity framework.

Distance effects for Finance, IT, and MBS are somewhat smaller in 1992 than those for OCS but diminish less rapidly. By 2004, the distance effects for Finance and MBS, 1.479 and 1.563, are larger than those for OCS, 1.363, whereas IT's distance effect is the lowest at 1.228. Shared language has perverse negative signs for IT and MBS, whereas estimates of the effect of colonial relationships and shared legal origins are positive, significant, and generally comparable across categories.

Recall that Miscellaneous Business Services includes legal, accounting, advertising, and management consulting services as well as call centres. Time zone differences are estimated to be positive and significant, a result consistent with the need to establish international call centre networks that operate around the clock. However, the number of observations are relatively small for this service category and thus estimates are not measured with precision.

4.4 Robustness

The specification employed in the previous subsection follows the theory in allowing for origin-year and destination-year fixed effects. The specification assumes constant coefficients on the dyadic trade cost measures except for distance, which has a linear trend. In this subsection, we estimate equation (7) on year-by-year basis. As before, the FX and FM are time-varying. Now all the coefficients determining τ_{odt} vary freely across years. One advantage of the year-by-year approach is that it allows for non-linear and even non-monotonic paths for the distance effect over time.

The year-by-year approach reduces the number of country effects in each regression by a factor of 1/13. This makes it feasible to estimate two generalized linear models (GLM) that require iterative estimation methods that do not converge with the large set of *ot* and *dt* dummy variables.[9] There are two important motivations for GLM regressions. First, as emphasized in the recent paper by Santos Silva and Tenreyro (2007), least squares estimation of equation (10) only yields consistent estimates of the parameters of (7) if the multiplicative error term on the *level* of trade, η_{od}, is homoskedastic and log-normally distributed.

We employ two GLM methods that relax the restrictions on η_{od} and yield consistent and asymptotically normal coefficients as long as the conditional mean assumption for trade is correctly specified, i.e. if the expectation of η_{od} is one. The first method, Poisson QMLE, is efficient in its class when the *variance* of trade is proportional to its expected value. The second method, Gamma QMLE, is efficient when the *standard deviation* of trade is proportional to its expected value. Poisson QMLE places more weight on observations for which the predicted level of trade is high than Gamma QMLE or the linear-in-logs model. The Poisson QMLE and Gamma QMLE have the additional feature of incorporating the zero trade flow observations that are excluded by linear-in-logs regressions (nine percent of the sample for OCS from 1992–2004).[10]

There are two limitations associated with the year-by-year regressions we estimate. First, there are too many coefficients to report. Since our focus is on distance, and how it evolves over time, we display only the annual distance effects (the absolute value of the coefficient on log distance) and their 95% confidence intervals. A second concern is the high correlation between time zone differences and distances that we commented on

[9]Despite the name, GLMs are only linear in the sense that the expectation of the dependent variable is a function of a linear-in-parameters index; in our case $\mathrm{E}[Y \mid X] = \exp(X\beta)$.

[10]Additional discussion and motivation for the GLM approaches is supplied by Manning and Mullahy (2001), Santos Silva and Tenreyro (2007), and Wooldridge (2002, pp. 648–661).

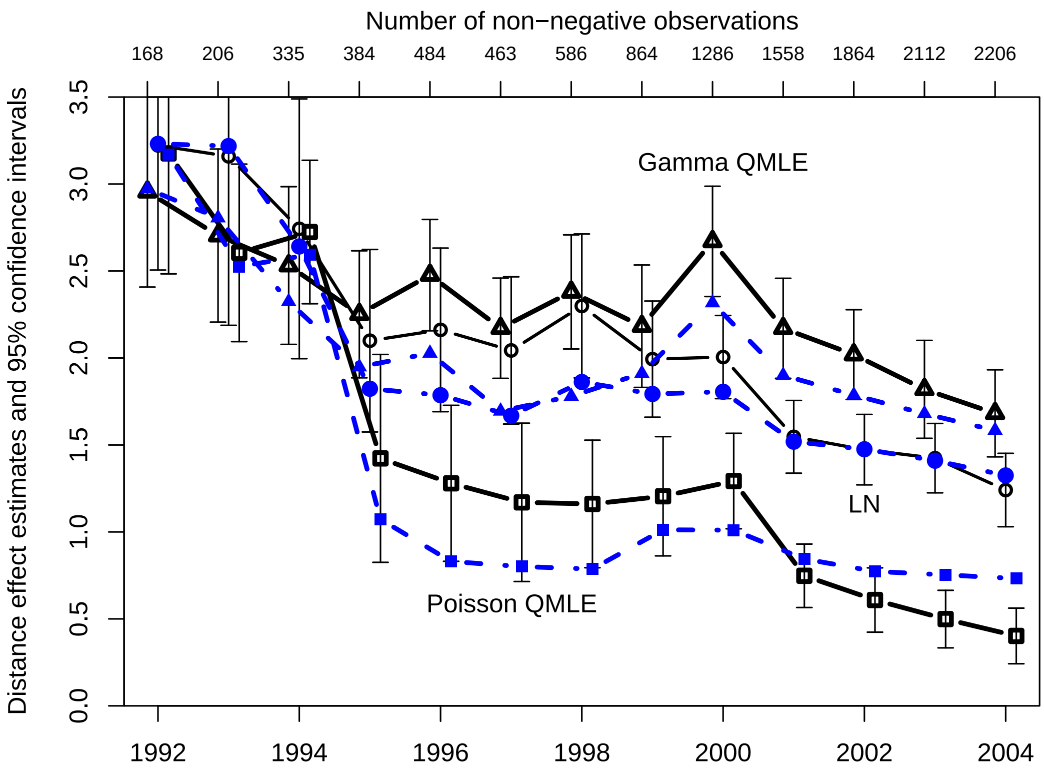
earlier. When both effects are allowed to vary over time, the total change in the impact of geographic separation cannot be seen by inspecting distance coefficients alone. We can neutralize this issue by re-estimating the model excluding time differences.

Figure 6 contains plots of the annual estimates of the distance effect for Other Commercial Services. The figure shows results for our three estimation methods and contrasts results for the full specification with a restricted specification that excludes time zone differences. The black lines marked with open triangles are Gamma QMLE, those with open squares are Poisson QMLE, and those with open circles are linear-in-logs least squares specifications. We label the last of these "LN" since it is the maximum likelihood estimator if trade flows are distributed log-normally. The blue lines (gray in B&W printouts) with solid point markers show the estimates for each method when the regression excludes time zone differences. We show the sample size (including zeros) along the upper horizontal axis.

The results depicted in Figure 6 reinforce two of the main features of the pooled linear method reported in Tables 2 and 3: Distance effects for offshoreable services are large but declining over time. A gradual linear trend seems broadly consistent with the annual estimates for Gamma and LN if one takes into account the wide confidence intervals for the early samples. For Poisson QMLE the results depend somewhat on whether one includes time zone differences as a regressor. Controlling for time zone effects, the impact of distance appears to decline steadily, reaching 0.4 in 2004. Upon inspecting the other annual coefficients, we found that the time zone difference also has a trending coefficient, which starts out positive but becomes negative after 2000. Removing this variable leads to a more pronounced decline in distance effects in the early 1990s, after which they settle near one.

The results displayed in this figure are comforting in that they confirm the view that distance effects for commercial services start very large and end up in the vicinity of

Figure 6: Estimated distance effects for Other Commercial Services, 1992–2004



distance effects for goods. One interpretation is that reductions in communication costs have facilitated service trade greatly relative to a situation in which frequent travel was essential. However, to the extent that familiarity and trust are still declining in distance, geography remains as an important inhibitor of trade in both goods and services. The hypothesis that changes in distance effects might reflect improvements in the speed of international flow of information receives some corroboration in recent work by Griffith et al. (2007). They find that the home bias in time to first citation for patents has declined substantially since 1990.

One disturbing aspect of Figure 6 is that Gamma and Poisson QMLE are *both* supposed to provide consistent estimates of the underlying parameters under the same assumptions. Yet we see that as sample size increases the coefficients from these two methods do not converge. Recall that Poisson QMLE puts greater weight on large predicted trade observations than does Gamma QMLE. It would appear that among the newly added observations, the high expected trade dyads have smaller distance effects than the low expected trade dyads. These results suggest the possibility of cross-dyad heterogeneity in distance effects, a phenomenon that is not predicted by existing models of bilateral trade.

The general picture that emerges from our regression results is that the standard gravity equation and the more sophisticated FE specifications explain service trade just as well as they explain trade in goods. We find strong distance effects, especially for the service categories that are the subject of the offshoring debate. These distance effects have evolved to become similar in magnitude to distance effects estimated for goods. Unlike goods, however, OCS distance effects exhibit a downward trend in all the econometric specifications.

5 Calculating the proximity premium

To assess the economic significance of our results, we use our theory to calculate the "wedge" between productivity-adjusted wages that protects domestic workers from foreign competition. Recall that we assume firms minimize delivered unit labour costs, $(w_o/z_o)(1+\tau_{od})$ and that bilateral delivery costs depend on distance with an elasticity of δ. We can use these assumptions to investigate how much higher unit labour costs a firm would be willing to pay to avoid the delivery costs associated with remote suppliers.

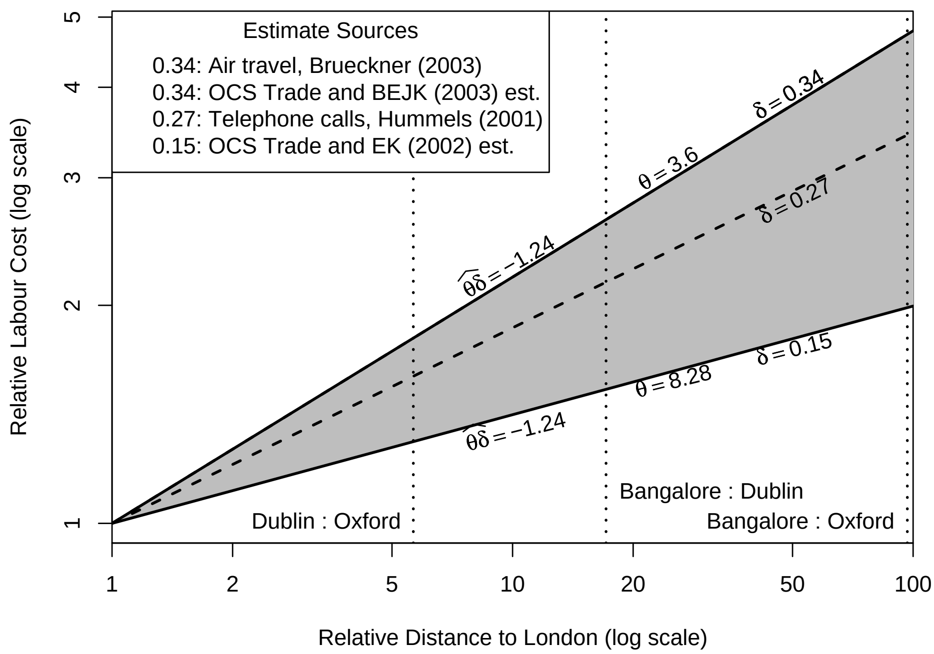
Suppose a supplier located at a nearby origin denoted $o = n$ is being compared to a more remote supplier from $o = r$. We will consider the case where the only determinant of service delivery costs that differs between supply origins n and r is distance to the destination market. The service importer in the destination country is indifferent between the two suppliers when $(w_n/z_n)D_{nd}^{\delta} = (w_r/z_r)D_{rd}^{\delta}$. Rearranging and assuming $D_{rd} > D_{nd}$,, we have the *proximity premium* as

$$\mathrm{PP} = \frac{w_n/z_n}{w_r/z_r} = \left(\frac{D_{rd}}{D_{nd}}\right)^{\delta} \geq 1.$$

The firm is willing to pay nearby workers higher wages even if productivity were the same in countries n and r. To obtain an idea of the magnitude of the PP at various distances, we require plausible values of δ.

Direct calculation of δ is difficult since the delivery costs associated with services are not readily observable. If all service provision required face-to-face interaction, one could estimate δ by regressing business travel costs on bilateral distance. Brueckner (2003) finds a distance elasticity of 0.34 for international airfares in 1999. This could be an under-estimate of δ since it does not include the time-costs of travel. However, to the extent that electronic communication can substitute for travel, the 0.34 could also be an over-estimate. We can obtain an estimate of δ based on electronic communication using Hummels' (2001) regression of telephone call rates on distance using 1993 OECD data. His elasticity of 0.27 is probably an overestimate since increased competition in telecommunications—and the growth of the internet—have almost certainly lowered the elasticity of electronic communication costs with respect to distance.

Figure 7: Illustrative values of the proximity premium



The problem with direct measures of δ is that they do not capture information costs. If one accepts the Grossman argument that distance is a proxy for familiarity then we need a measure of δ that incorporates the costs of imperfect information. For this we should use our estimates of the effect of distance on service trade. Recall from equation (9) that the coefficient on distance in a trade equation is a compound parameter given by $-\theta\delta$. Dividing by an estimate of θ, the inverse measure of the dispersion of productivity, we could infer δ from the distance coefficient using the formula $\hat{\delta} = \widehat{\theta\delta}/\hat{\theta}$.

We calculate the wedge for 2004 that applies to workers producing Other Commercial Services. The pooled regressions shown in Tables 2 and 3 and the annual coefficients shown in Figure 6 provide a range of possible estimates of the distance effect, $\widehat{\theta\delta}$. We select the 2004 linear-in-logs specification in which $\widehat{\theta\delta} = 1.24$ because that value lies between the Gamma and Poisson estimates.

Eaton and Kortum (2002) use the relationship between trade and prices to estimate $\hat{\theta} = 8.28$. Bernard et al (2003) use firm-level export information from the US to estimate $\hat{\theta} = 3.6$. Since estimates $\sigma - 1$, derived from regressions of trade on tariffs or freight costs, can be interpreted as estimates of θ, the studies surveyed by Anderson and van Wincoop (2004) are also relevant. They write that "the literature leads us to conclude that σ is likely to be in the range of five to ten." This corresponds to a θ range of four to nine, quite close to the range of θ derived from the Eaton and Kortum and Bernard et al. studies.

Using Eaton and Kortum (2002) to obtain the upper bound for θ and Bernard et. al (2003) for the lower bound, δ ranges between $1.24/8.28 = 0.15$ and $1.24/3.6 = 0.34$. Figure 7 displays the proximity premia as a function of relative distance using four estimates of δ: the lower and upper bounds based on estimated distance effects, the air transport elasticity, and the telephone elasticity. By coincidence, the air transport and upper bound estimate are the same (out to two decimal places).

The Figure highlights examples of relative distances from London using dotted vertical lines. As a short domestic distance, we use the 83km from London to Oxford, whereas the obvious long international distance is the 8,027km to Bangalore. Hence, a reasonable range for relative distance would be one to 100. The estimates based on our bilateral service trade equations imply London service purchasers are willing to pay 30% (assuming $\theta = 8.28$) to 80% (assuming $\theta = 3.60$) more for service suppliers in Oxford rather than Dublin. The relative proximity of Dublin versus Bangalore is worth 53% to 163% higher labour costs. Finally, workers in Oxford can be paid 99% to 373% more than workers in Bangalore in productivity-adjusted wages and yet still be attractive to a London service purchaser.

These calculations establish the economic significance of the estimated distance effects. However, there are three caveats worth mentioning. First, we rely upon a model that makes specific parametric assumptions on productivity dispersion and service delivery costs. Second, our estimates of relative delivery costs exclude costs other than distance. Finally, even though we have attempted to bound the size of the distance-created wedge by combining optimistic and pessimistic estimates, we derived our range for θ from a small number of studies of trade in goods. Obtaining estimates of θ for services should be a research priority.

6 Concluding remarks

The service sector is becoming more important and service trade is growing relative to service output. The globalization of services creates opportunities for service exporters but challenges for those domestic workers whose productivity-adjusted wages are higher than foreign providers. Many discussions of services—see in particular Blinder (2006)—imagine a dichotomy in which some services, such as family doctors, are inherently non-tradeable, whereas others, such as call centres, are costlessly tradeable over very large distances. According to this dichotomy, large shares of service jobs are now "at risk" of being offshored to low-wage nations. A key empirical prediction of the dichotomy is that we should find no marginal effects of distance on international trade in services.

We hypothesize instead that the cost of utilizing foreign services is a continuous increasing function of distance. We provide a model of the market for international services that generates a gravity-like equation for service trade. We estimate the model for different service categories. Distance effects for the categories that include offshoreable services are statistically and economically significant throughout the sample period. In calculations based on plausible parameter values, service purchasers are willing to pay almost five times more for nearby ($\approx$ 100km) than for remote ($\approx$ 10,000km) service providers. However, distance effects for most services have been declining in recent years. If these trends continue, local service workers will increasingly find themselves in closer competition with foreign suppliers.

Appendix on Data Sources

Service trade

The Eurostat data is available online at `http://epp.eurostat.ec.europa.eu/` under the "Economy and Finance" Theme as *Balance of Payments—International Transactions, International Trade in Services (since 1985).* We downloaded multilateral service trade data from the World Bank's *World Development Indicators* (WDI) at `http://devdata.worldbank.org/dataonline/`.

Trade cost proxies

Distance, D, common language, and colonial relationships come from the CEPII bilateral database (`http://www.cepii.fr/anglaisgraph/bdd/distances.htm`). For distance we use "distw," a population-weighted average of the great-circle distances between the 20 largest cities in the origin and destination countries. We use the Ethnologue-based version of common language that equals one if a language is spoken by at least 9% of the population in both countries. *Legal* is from Andrei Schleifer's Data Sets web page (`http://post.economics.harvard.edu/faculty/shleifer/Data/qgov_web.xls`). We calculate time differences as the average number of hours—between 0 and 12—separating two countries. Denoting hours after GMT with H, $\Delta_{od} = \min\{\mid H_o - H_d \mid, 24 - \mid H_o - H_d \mid\}$. Time zones were obtained from Wikipedia.

Population and GDP

World Development Indicators Online (`http://devdata.worldbank.org/dataonline/`), provides population and GDP (in current USD) for all countries in our study except Taiwan, for which we obtained the data from a Taiwanese government website (`http://eng.stat.gov.tw/ct.asp?xItem=15062&ctNode=3567`).

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