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## How remote is the offshoring threat?

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### ABSTRACT

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.

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### 1. Introduction

In 1995, the title of a Richard Freeman paper asked “Are your wages set in Beijing?” (Freeman, 1995) 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*, 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.

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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 65 countries over the period 1992–2006. 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 studies estimate gravity models for total services using 1999–2000 OECD data. Kimura and Lee (2006) use data for 10 OECD countries and 47 partners to compare gravity estimates for aggregate services and trade. They estimate distance elasticities that 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. We examine disaggregated service trade categories, allowing 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 a long 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 traveling 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 sensible. Remote provision of services from foreign countries may pose a direct threat to domestic workers. Likewise a foreign service provider traveling 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, 1976–2006 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: 1992–2006 versus 2000–2006 for the OECD.<sup>2</sup> The Eurostat data are based on reports of the 27 EU countries (plus Croatia, Japan, Norway, Turkey, and the United States) and 33 partner countries. Our regression analysis uses Eurostat data because it offers the longest time series information.

Fig. 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 the extended balance of payments services (EBOPS) codes. Service trade comprises government, transport, travel, and other commercial services (OCS) sub-categories. 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 divides OCS 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 centers. Further disaggregation is available in Eurostat but there are too few positive observations for statistical analysis of this data.

Figs. 2 and 3 use WDI data to display the growth of service trade relative to other activities and the changing composition of service trade. In Fig. 2, we show how world services and goods value added, service and goods

<sup>2</sup> A smattering of Eurostat data is available starting in 1985, but the data set is not complete enough to be useful until 1992.

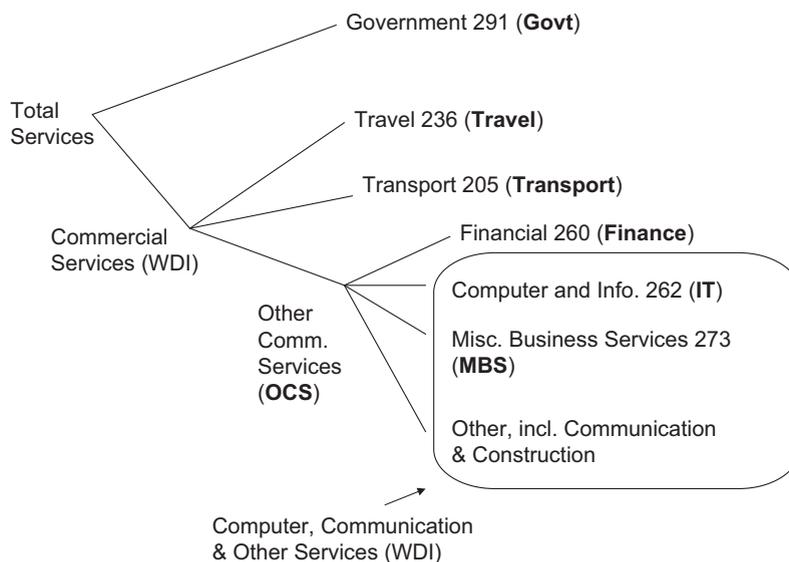


Fig. 1. Service classifications in the extended balance of payments.

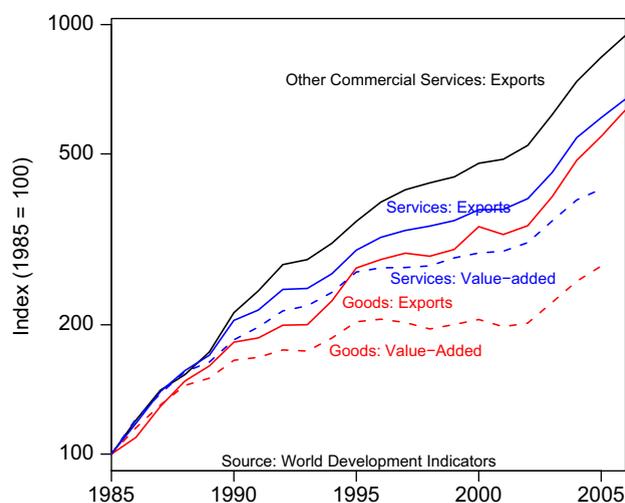


Fig. 2. The growth of trade and production of goods and services.

(merchandise) exports, and exports of OCS have grown over time. Each series is expressed as an index relative to its 1985 value (set equal to 100). We observe rapid growth in exports, 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 gaps 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 provide information on the shifting composition of service trade. As portrayed in Fig. 3, OCS, transport and travel each accounted for about a third of worldwide service exports in 1985. The shares of transport, travel and government services decline over time whereas the share of OCS rose 14 percentage points to reach 48.1% in 2006. Together, the two figures reveal that service trade is growing rapidly and its composition has shifted towards OCS.

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. Countries of interest such as India and China appear as “partners” in the Eurostat data through their transactions with reporting Eurostat countries (“reporters”). Trade flows between two partner countries are unavailable in this data set.

Table 1 provides information on the coverage of the Eurostat data. The first two columns lists the 2006 value of service trade and its subcategories as well as their 1980–2006 growth rates. Service trade was \$2.8 trillion in 2006. We observe that OCS was the fastest growing subcategory, increasing at an annual rate of 9.5%. The third column lists the ratio of 2006

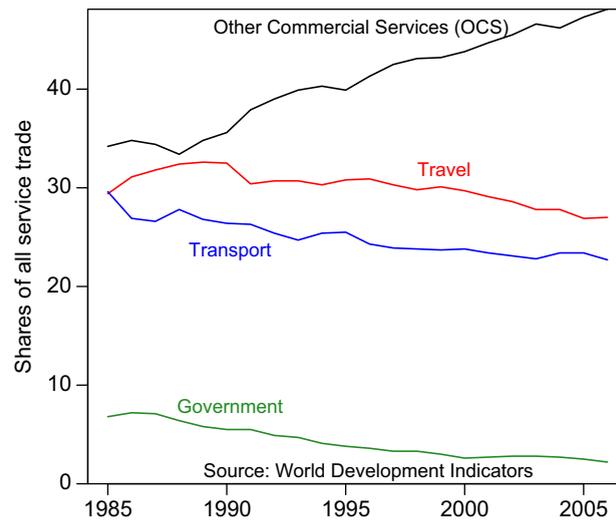


Fig. 3. The changing composition of service trade.

**Table 1**  
Worldwide service trade

Period	Value 2006	Growth (%) 1980–2006	Eurostat share 2006
Total services	2830.3	7.8	0.75
Other commercial services	1360.7	9.5	0.85
Travel	764.1	8.0	0.66
Transportation	642.4	5.9	0.81
Government	63.1	2.9	0.21

Notes: Value, expressed in billions of US dollars, reflects world exports as recorded in *World Development Indicators*. Growth is the annual percent change from 1980 to 2006. The Eurostat share represents the trade of Eurostat reporting countries as a percentage of world trade in 2006.

Eurostat data to WDI data. Eurostat-country trade accounts for three-quarters of the aggregate service trade reported in WDI and 85% of OCS.

Table 2 displays information for the top six reporters and the top six partners in terms of average 2000–2006 OCS exports (data for all 65 countries are reported in Appendix B). The United States is the leading exporter of both total Services and OCS followed by the United Kingdom. The ratio of exports based on Eurostat information to the more complete WDI data is close to one for reporters, indicating the Eurostat information is complete for reporters. Among the Eurostat partners, Hong Kong and India have the highest OCS exports in 2006 according to WDI. China, which placed fifth in OCS that year, is the largest exporter of Total Services among partner countries. The last column reveals that Eurostat data are quite incomplete for partner countries. With the exception of Switzerland, the ratio of Eurostat to WDI exports ranges between 0.10 (India) and 0.31 (China). Our preferred econometric specification incorporates time-varying importer and exporter fixed effects. Country-specific under reporting of trade will be captured by these effects. Under-reporting of partner trade will only introduce bias in the estimated distance effect if under-reporting is correlated with distance between trading partners.

The Eurostat data contain both zeros and missing values. Table 3 lists the number of non-missing OCS trade flows by year for the same set of countries as in the previous table.<sup>3</sup> For the reporters, the maximum number of flows is 128 (import and exports with 64 potential partners). For partners, the maximum is 64 (trade is only available with the 32 reporters). The table shows that the data are quite incomplete prior to 2002. After that year, many of the countries shown in the table trade with most of their potential partners. The table shows “jumps” in the number of trading partners over time that suggest coverage is becoming better. For instance, the count of Ireland’s non-missing import or export data is 0 in 1998, 8 in 2002, and 126 in 2004. The count then falls to 89 in 2006. The United States had 44 non-missing import or export data in 2002 but that increases to 92 two years later. Hong Kong and Singapore had eight flows in 1998 and 26 flows in 2000.

<sup>3</sup> We list only information for even years. Data for all 65 countries are reported in Appendix B.

**Table 2**

Average annual service exports, 2000–2006, as reported by World Development Indicators and Eurostat

Reporters	OCS			Total services		
	WDI	ES	Ratio	WDI	ES	Ratio
<i>Country</i>						
United States	164.8	151.5	0.92	331.2	249.7	0.75
United Kingdom	114.6	104.8	0.91	167.4	156.1	0.93
Germany	65	67.9	1.04	124.4	121.9	0.98
Japan	47.7	44.1	0.92	86	76.2	0.89
France	38.2	44.3	1.16	99.4	95.6	0.96
Ireland	36	26.5	0.74	42.3	31.1	0.74
<i>Partners</i>						
Hong Kong	26	5.4	0.21	52	13.7	0.26
India	25.7	2.5	0.1	35.3	5.1	0.14
Canada	25.5	6.5	0.25	46.9	14.6	0.31
Switzerland	23.4	23.6	1.01	37.4	40.6	1.08
China	20.7	6.5	0.31	54.1	16.8	0.31
Singapore	19.5	5.2	0.27	40	11.8	0.3

Notes: Exports expressed in billions of US dollars. "Ratio" is the ratio of exports reported in Eurostat and exports reported in *World Development Indicators* (WDI).

**Table 3**

Non-missing Eurostat data on other commercial services

Reporters	1992	1994	1996	1998	2000	2002	2004	2006
<i>Country</i>								
United States	18	24	26	28	40	44	92	89
United Kingdom	6	6	94	94	94	118	118	116
Germany	32	32	32	82	98	113	114	116
France	29	31	31	29	74	118	108	113
Japan	17	24	41	44	58	78	88	91
Ireland	0	0	0	0	8	126	124	89
<i>Partners</i>								
Hong Kong	0	2	4	8	26	36	48	58
India	10	16	22	21	30	36	48	56
Canada	12	19	24	26	40	44	50	55
Switzerland	0	2	8	12	34	38	49	60
China	10	15	22	22	30	35	47	53
Singapore	0	2	4	8	26	35	47	55

Notes: Values represent the number of non-missing other commercial services trade flows. For the reporters, the maximum number of flows is 128 (import and exports with 64 potential partners). For partners, the maximum is 64.

The non-missing flows include both positive and zero trade. Our empirical analysis will address alternative ways to handle zero values for trade (which, of course, become undefined in a log specification). The question arises as to whether the missing data should be considered to be zeros.<sup>4</sup> We believe that missing values in the data set are often truly missing, not zero, for three reasons. First, some cells in the original data report "c", indicating data withheld due for confidentiality reasons. Second, the jumps in the number of partners exhibited in our data almost certainly arise from incomplete reporting in some years. Finally, we are able to identify cases where national-level data show positive values of trade when Eurostat reports missing trade: Eurostat reports missing flow of Canada with Denmark, Norway and Spain in 2003 but Canadian national-source data shows positive flows in both directions.

The ensuing regression analysis will consider the various subcategories of services available from Eurostat. The offshoring debate has focussed on such activities as call centers and computer-related services. Thus, we separate less relevant categories of service trade such as transportation, travel, and government from OCS. 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 1992–2006 times series information available in the data set.

<sup>4</sup> Francois and Manchin (2007) and Felbermayr and Kohler (2006) argue this is a reasonable assumption for data on goods trade.

### 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 (2008) 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  $\pi_{od}$  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

$$S_{od} = \pi_{od} S_d \quad \text{where} \quad \sum_o S_{od} = S_d. \quad (1)$$

To specify  $\pi_{od}$ , 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  $\tau_{od}$  is a parameter increasing in the distance between  $o$  and  $d$ . Combining production and delivery costs yields the *delivered* unit labour costs  $(w_o/z_o)(1 + \tau_{od})$ .<sup>5</sup> We can model the objective function of the firm as maximizing the negative of the log of the delivered unit labour costs:

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

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  $\theta$  is an inverse measure of productivity variation and  $\kappa$  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 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

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

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

The Gumbel distribution assumption is extremely useful because the distribution of the probability that a given draw of  $\varepsilon_{od}$  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

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

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

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

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,  $\tau_{od}$ . 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  $o$ .

<sup>5</sup> 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.

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

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

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:

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

This formulation closely resembles the FDI equation of Head and Ries (2008). 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,  $\sigma$ . This will lead to a version of Eq. (7) in which the fixed effects have different structural interpretations and  $\sigma - 1$  takes the place of  $\theta$ .<sup>6</sup> 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. 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, Section 4.2 provides regression results for goods and services under standard gravity and fixed effects specifications. Section 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 (1) a restricted sample that excludes trade between high-income countries and (2) 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 1992–2006 Eurostat data. In order to implement the model, we need to choose variables that proxy for the delivery costs,  $\tau_{od}$ , 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,  $\mathbf{L}_{od}$ , between the origin and destination country. We augment this specification by including the difference in time zones between origin and destination, denoted  $\Delta_{od}$ , 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

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

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 ( $\Delta_{od}$ ). 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  $\nu$  is ambiguous.

Standard components of  $\mathbf{L}_{od}$  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

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

<sup>6</sup> 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).

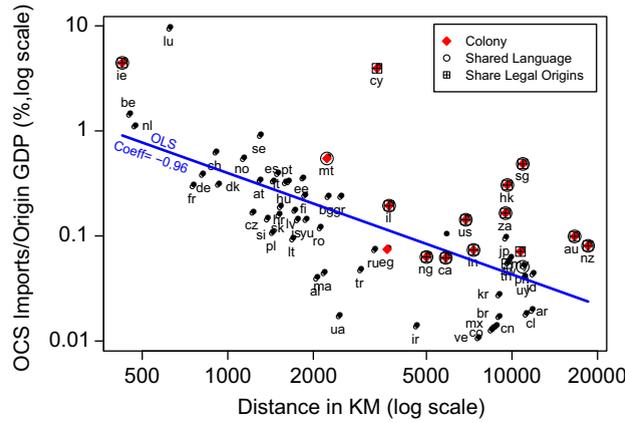


Fig. 4. The impact of distance on British imports of other commercial services (OCS), 2000–2006 averages.

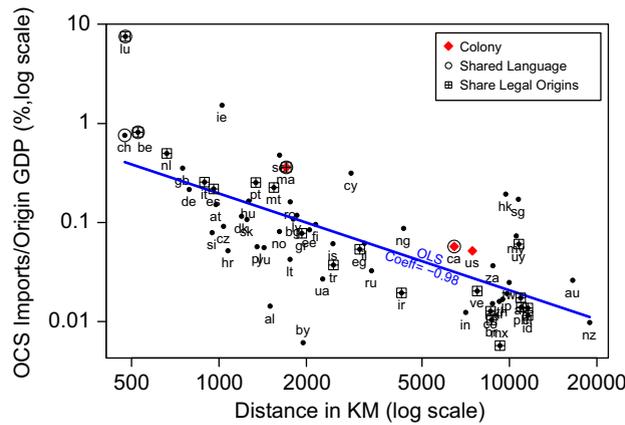


Fig. 5. The impact of distance on French OCS Imports, 2000–2006 averages.

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  $\tau$  are described in Appendix A. The linkage variables are not highly correlated in our sample: The correlation between language and common legal system is 0.23, between language and colonial relationship is 0.38, and between colonial relationship and common legal system is 0.20.

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

$$V_{od} = \exp[FX_o + FM_d - \theta\delta \ln D_{od} - \theta v \Delta_{od} + \theta \lambda \mathbf{L}_{od} + \theta u_{od}]. \tag{9}$$

We will refer to minus the coefficient on log distance,  $\theta\delta$  in the model, as the “distance effect.” If  $u_{od}$  is homoskedastic and normally distributed, then the maximum likelihood estimates of the parameters can be obtained via a standard linear-in-ls regression:

$$\ln V_{od} = FX_o + FM_d - \theta\delta \ln D_{od} - \theta v \Delta_{od} + \theta \lambda \mathbf{L}_{od} + \theta u_{od}. \tag{10}$$

Eq. (10) is our baseline specification. In the robustness section, we employ two alternative specifications that provide consistent estimates even if  $u_{od}$  is heteroskedastic, and/or non-normal.

Before presenting regression results it is useful to examine the data graphically in Figs. 4 and 5, where we take the United Kingdom and France’s imports of OCS 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 0.98 and 0.96. Given the log scale, these slopes imply that a 10% increase in distance decreases imports by about 10%.

Fig. 4 also illustrates the influence of three components of the delivery cost vector  $\tau_{od}$ : 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,

**Table 4**  
OCS vs goods in gravity and FE specifications

	(1) OCS	(2) Goods	(3) OCS	(4) Goods	(5) OCS	(6) Goods
ln avg. dist.	−1.251 <sup>a</sup> (0.073)	−1.510 <sup>a</sup> (0.026)	−1.259 <sup>a</sup> (0.074)	−1.148 <sup>a</sup> (0.053)	−2.216 <sup>a</sup> (0.129)	−1.559 <sup>a</sup> (0.086)
ln avg. dist. × trend	0.012 <sup>b</sup> (0.005)	−0.010 <sup>a</sup> (0.001)	0.009 <sup>c</sup> (0.005)	0.004 (0.003)	0.072 <sup>a</sup> (0.013)	0.008 (0.009)
Time zone diff.	0.002 (0.016)	0.069 <sup>a</sup> (0.006)	0.006 (0.017)	0.065 <sup>a</sup> (0.013)	−0.021 (0.014)	0.046 <sup>a</sup> (0.009)
Shared language	0.712 <sup>a</sup> (0.136)	0.745 <sup>a</sup> (0.040)	0.734 <sup>a</sup> (0.155)	0.227 <sup>b</sup> (0.113)	−0.099 (0.073)	0.119 <sup>c</sup> (0.062)
Colonial relation	0.689 <sup>a</sup> (0.135)	1.023 <sup>a</sup> (0.082)	0.722 <sup>a</sup> (0.148)	0.420 <sup>a</sup> (0.115)	0.594 <sup>a</sup> (0.062)	0.357 <sup>a</sup> (0.047)
Shared legal origins	0.474 <sup>a</sup> (0.070)	0.351 <sup>a</sup> (0.030)	0.432 <sup>a</sup> (0.074)	0.440 <sup>a</sup> (0.056)	0.646 <sup>a</sup> (0.041)	0.458 <sup>a</sup> (0.023)
Observations	15 601	274 700	14 769	14 769	15 108	15 108
R <sup>2</sup>	0.772	0.640	0.777	0.820	0.803	0.855
Fixed effects	<i>t</i>	<i>t</i>	<i>t</i>	<i>t</i>	<i>ot, dt</i>	<i>ot, dt</i>
Clustering	<i>od</i>	<i>od</i>	<i>od</i>	<i>od</i>	<i>dt</i>	<i>dt</i>

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

legal, or historical ties. Francophone countries and former colonies are above the regression line for France but countries using the French legal system appear scattered around the line.<sup>7</sup>

#### 4.2. Distance effects for goods and services

The first set of regression results is shown in Table 4 where we compare distance effects for goods and OCS under different specifications.<sup>8</sup> 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 prior studies did not estimate a trade equation with the importer and exporter fixed effects shown in Eq. (10), the first four columns reporting “standard” gravity estimates where the fixed effects are replaced with the logs of 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 to observations where *both* OCS and goods flows are non-missing and non-zero. The final two columns portray results for the common sample when we include time-varying importer and exporter fixed effects.<sup>9</sup>

We refer to minus the coefficient on distance as the “distance effect.” It comprises a base effect corresponding to 1992 and a time trend. When we confine the sample to be the same (columns 3–6), the base effect is higher for OCS than goods, particularly 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 1992 estimate of the distance effect is 2.216 and the trend term is 0.072. These estimates imply that by 2006, the distance effect for OCS trade had fallen to 1.208 (= 2.216 − 14 × 0.072).

The trend for the distance coefficient for goods in the full sample (274,700 observations) shown in column (2), is negative (−0.010) and statistically significant. This implies the distance effect for goods is *growing* over time. Combes et al. (2008, Fig. 1) 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 in the other two specifications (standard gravity and fixed effects, columns 4 and 6) are positive but insignificant. Contrasting results of trends in distance

<sup>7</sup> Note that the Eurostat data do not report France's service imports from most of its former colonies in Africa.

<sup>8</sup> Data on merchandise trade comes from data from the IMF's Direction of Trade Statistics (DoTS). The regressions are estimated using 1992–2006 data.

<sup>9</sup> The number of observations in the “standard” gravity specification is slightly smaller than those using fixed effects because of missing GDP data for Israel and Malta in 2006 and Cyprus in 2005 and 2006.

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 4 reveals that colonial relationships, shared language, and legal systems generally exert positive and significant effects on bilateral trade.<sup>10</sup> 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, 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 fairly stable effect on goods trade, a result in contrast to the negative effects reported in Stein and Daude (2006) who state that “an additional hour of time difference reduces bilateral FDI by between 17% and 26%, the impact on trade ranges between 7% and 11%” (p. 107). 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. Our attempts to replicate their results using 1999 data for Eurostat reporting countries and their trading partners (1119 observations), the same specification, and the same covariates, produce positive and significant effects of time zone differences.<sup>11</sup>

Time zone differences exert insignificant effects on OCS trade. These results suggest that the continuity effect (the ability to operate around the clock) offsets the synchronization effect (the 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 1.510 in 1992 to 1.650 in 2006. 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  $-1.296$  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.

The results for the common sample reveal that the specifications fit OCS trade nearly as well as goods trade as reflected in the comparable  $R^2$ 's in the last four columns of Table 4. 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 2.216 and 1.559 in 1992 and fall to 1.208 and 1.447 in 2006. The similarity in the estimated magnitudes 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 OCS compare to other categories of service trade—total, finance, IT, and miscellaneous business services. We employ origin-year and destination-year fixed effects and report results for each category in Table 5.

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 coefficients on distance and the distance trend are quite comparable for total services and OCS. The estimated distance effect for total service trade in 2000 is much higher ( $1.629 = 2.141 - 8 \times 0.064$ ) than the 0.6 and 0.2 found for total services in 1999–2000 by Kimura and Lee (2006) and Mirza and Nicoletti (2004), respectively. Possible explanations for this difference include our use of fixed effects and the inclusion of time zone differences (that enter positively). Our results are closer to the 1.0 obtained by Schwellnus (2007, Table 3), who uses Eurostat OCS data and fixed-effects estimation.

Columns (3) and (4) show that trends in the distance effects for finance and IT are also positive and significant. The estimate for MBS is comparable to that for OCS but insignificant ( $t$ -statistic of 1.42). Shared language exhibits perverse

<sup>10</sup> Stein and Daude (2006) find that a common legal system has a positive effect on bilateral FDI.

<sup>11</sup> An issue arises in programming importer and exporter fixed effects when the dependent variable is the sum of imports plus exports—the trading pair corresponding the each observation are both importers and exporters. Stein and Daude do not explain their procedure but our finding of positive time zone differences is robust to different ways of handling the fixed effects and emerges in specifications without fixed effects.

**Table 5**  
Fixed effects linear model for different types of services

	(1) Total	(2) OCS	(3) Finance	(4) IT	(5) MBS
In avg. dist.	−2.141 <sup>a</sup> (0.109)	−2.243 <sup>a</sup> (0.130)	−1.913 <sup>a</sup> (0.152)	−1.882 <sup>a</sup> (0.178)	−2.281 <sup>a</sup> (0.575)
In avg. dist. × trend	0.064 <sup>a</sup> (0.011)	0.077 <sup>a</sup> (0.013)	0.035 <sup>b</sup> (0.014)	0.058 <sup>a</sup> (0.016)	0.068 (0.048)
Time zone diff.	0.012 (0.012)	−0.018 (0.014)	0.145 <sup>a</sup> (0.019)	0.011 (0.021)	0.228 <sup>a</sup> (0.047)
Shared language	−0.148 <sup>a</sup> (0.055)	−0.127 <sup>b</sup> (0.063)	−0.079 (0.086)	−0.326 <sup>a</sup> (0.117)	−0.714 <sup>a</sup> (0.139)
Colonial relation	0.642 <sup>a</sup> (0.053)	0.552 <sup>a</sup> (0.058)	0.241 <sup>a</sup> (0.092)	0.670 <sup>a</sup> (0.101)	0.471 <sup>a</sup> (0.122)
Shared legal origins	0.661 <sup>a</sup> (0.032)	0.650 <sup>a</sup> (0.039)	0.491 <sup>a</sup> (0.047)	0.389 <sup>a</sup> (0.059)	0.575 <sup>a</sup> (0.064)
Observations	17 607	16 002	7778	6008	5642
R <sup>2</sup>	0.803	0.802	0.789	0.729	0.801

Notes: Standard errors in parentheses with <sup>a</sup>, <sup>b</sup> and <sup>c</sup>, respectively, denoting significance at the 1%, 5% and 10% levels. Specifications employ origin-year and destination-year fixed effects and standard errors are clustered by destination-year.

negative signs 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 centers. Time zone differences for this service category are estimated to be positive and significant, a result consistent with the need to establish international call center networks that operate around the clock. Time zone differences are also positive and significant for finance, suggesting that the continuity effect dominates in this industry as well.

#### 4.4. Robustness

We investigate the robustness of our results across three dimensions. First, since the outsourcing debate focuses on service exports from low-wage countries to high-wage countries, we estimate distance effects for the sample that excludes trade between 25 high-income countries as defined by the World Bank.<sup>12</sup> Second, we estimate using two quasi-maximum likelihood estimation (QMLE) methods that impose much weaker conditions on the error term than were implicitly imposed in the linear-in-logs specification. Third, we allow the coefficients on distance (and other trade cost determinants) to vary freely from year to year.

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 Eq. (7) on year-by-year basis. 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  $\frac{1}{15}$ . This makes it feasible to estimate two QMLE methods that require iterative techniques that do not converge with the large set of  $ot$  and  $dt$  dummy variables. There are two important motivations for QMLE regressions.<sup>13</sup> First, as emphasized in the recent paper by Santos Silva and Tenreyro (2006), least squares estimation of Eq. (10) only yields consistent estimates of the parameters of (7) if the error term  $u_{od}$  is homoskedastic and normally distributed. We would like to obtain consistent estimates of the elasticity of trade with respect to distance without imposing such strong requirements on the error term. The QMLE methods have the second advantage of incorporating the zero trade flow observations that the linear-in-logs regressions exclude (7.7% of the sample for OCS from 1992 to 2006).<sup>14</sup>

<sup>12</sup> The countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

<sup>13</sup> The application of these models to count data was pioneered by Gourieroux et al. (1984), who use the term “pseudo” instead of the “quasi” term used by Wooldridge (1997, 2002).

<sup>14</sup> Helpman et al. (2008) develop an alternative method of incorporating zeroes, based on an underlying model of firm heterogeneity. Their method involves a first-stage selection equation into positive trade explained by (i) a set of importer and exporter country dummies, (ii) bilateral trade barriers that also explain trade volumes, and (iii) variables that only explain trade partner selection but not trade volumes. Because our data comprises a larger share of missing observations and a smaller share of “true” zeroes than their paper, many of the variables in (i) and (ii) are perfect predictors of positive trade. Consequently, we can only estimate very incomplete and therefore unreliable versions of the specification.

The QMLE methods yield consistent and asymptotically normal coefficients as long as the conditional mean assumption for trade is correctly specified, i.e. if

$$E(V_{od}) = \exp[FX_o + FM_d - \theta\delta \ln D_{od} - \theta v \Delta_{od} + \theta \lambda L_{od}]. \quad (11)$$

The first method, Poisson QMLE, is efficient in its class when the variance of trade is proportional to its expected value. The second QMLE, the two-step negative binomial (2-step NB), is efficient when the variance of trade is quadratic in the expected value. Denoting the expected level of trade from Eq. (11) as  $m_{od}$ , the variance assumptions underlying the two QMLEs can be represented as

$$\underbrace{\text{Var}(V_{od}) = \sigma^2 m_{od}}_{\text{Poisson}} \quad \text{and} \quad \underbrace{\text{Var}(V_{od}) = m_{od} + \eta^2 m_{od}^2}_{\text{Negative binomial}}.$$

The Poisson QMLE can be estimated using the standard poisson procedure provided in statistical packages as long as the option for robust standard errors is specified. The 2-step NB involves the following procedure<sup>15</sup>: The first step assumes  $\eta^2 = 1$  to obtain estimates of  $m$  which in turn can give an estimate of the variance as  $e_{od}^2 \equiv (V_{od} - m_{od})^2$ . A regression of  $e_{od}^2 - m_{od}$  on  $m_{od}^2$  can then be used to obtain a consistent estimate of  $\eta^2$ . The second stage uses this estimate in a negative binomial estimation. When the NB variance assumption holds and  $\eta^2 > 0$ , the 2-step NB QMLE is more efficient than Poisson QMLE.<sup>16</sup>

Fig. 6 displays the key results for the annual estimates of the distance effect for OCS. Since our focus is on distance, and how it evolves over time, we display only the annual distance effects (coefficient on log distance times minus one) and their 95% confidence intervals. The lines marked with circles are linear-in-logs (labeled “Logs”) least squares specifications, squares are Poisson QMLE, and triangles are 2-step NB QMLE. We show the sample size (including zeros) along the upper horizontal axis.

The figure comprises four panels. Panels (a) shows results for the full sample whereas (b) draws on regressions that exclude observations where both exporter importer are high-income (“rich”) countries. Panels (c) and (d) contrast results for the full specification with an alternative that excludes time zone differences. The motivation for these latter regressions comes from the high correlation between time zone differences and distances (0.83) that we commented on 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 neutralize this issue by making distance the sole measure of physical separation in the specification.

The results depicted in Fig. 6 reinforce two of the main features of the pooled linear method reported in Tables 4 and 5: Distance effects for OCS are large but declining over time. A gradual linear trend seems broadly consistent with the annual estimates for 2-step NB and “Logs” 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 0.53 in 2006. Time zone difference also has a trending coefficient, starting out positive but becoming negative after 2000. Panel (c) reveals that removing this variable leads to a more pronounced decline in distance effects in the early 1990s in the Poisson QMLE specification, after which they settle around 0.8.

While panels (a) and (b) report results for the whole sample, panels (c) and (d) report our estimates for the restricted sample that excludes flows between rich countries. The smaller sample corresponds more closely to the trade flows that are subject to the outsourcing debate. Restricting the sample has the disadvantage, however, of losing information in the estimation of the distance effect—eliminating trade between rich countries reduces the sample of OCS trade flows by 4220 observations (26%), 4162 of which are non-zero trade flows.<sup>17</sup> The size of the sample for each year is given at the top of each panel in the figure.

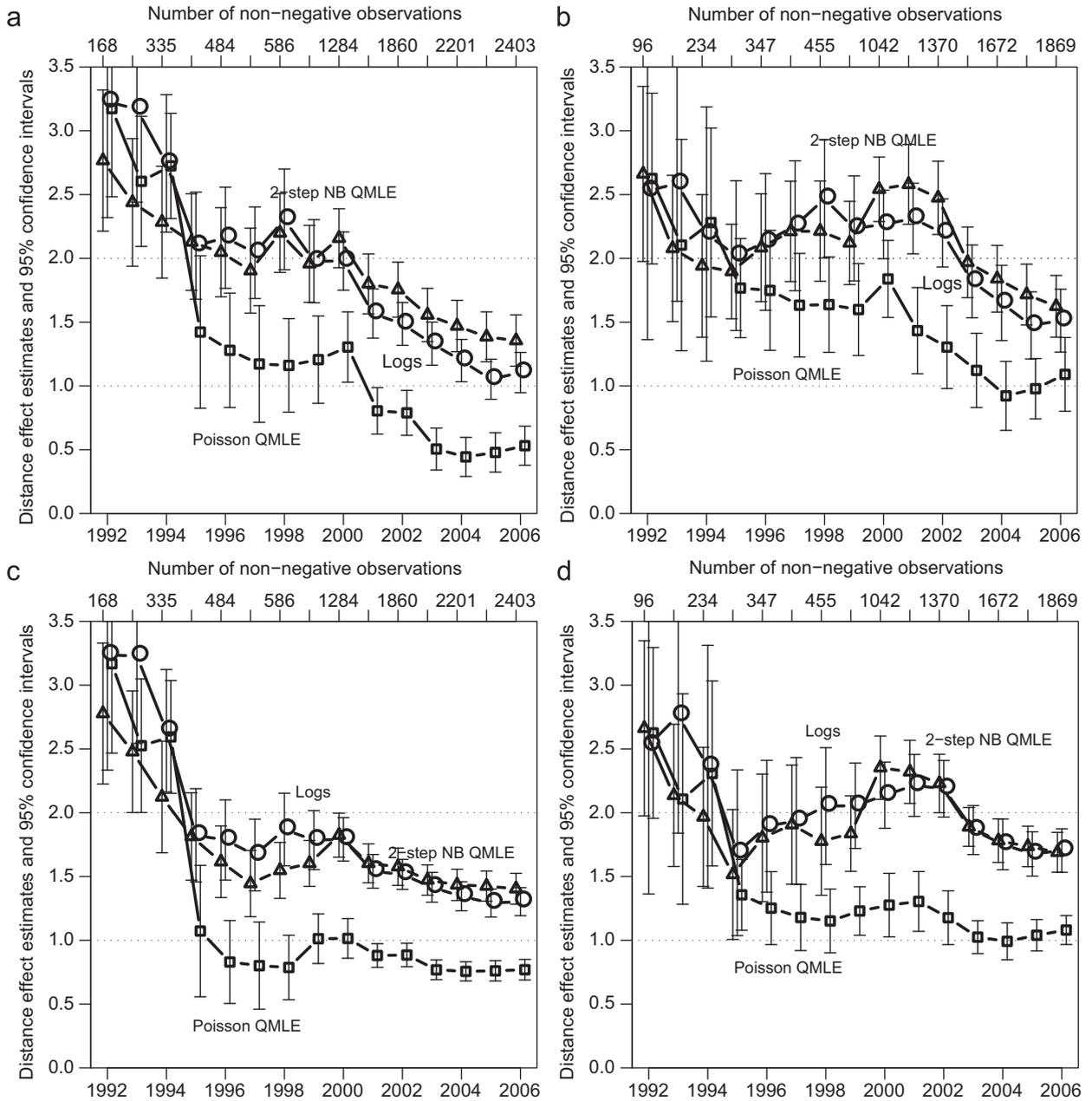
The reduced sample yields similar results concerning the downward trend in distance effects. The main difference is that the “rebound” in the impact of distance that is observed around the year 2000 for the full sample is more pronounced when trade between rich countries is eliminated. In 2006, all estimation methods yield larger distance effects in the restricted sample, indicating that distance effects between rich countries are lower than those between rich and lower income countries.<sup>18</sup> This could arise because communication costs are lower between rich countries, either because travel and communication infrastructure is better or cultural differences are more easily circumvented. The figure certainly does not support the proposition that the world is “flat” in the sense that countries like India are no longer subject to distance effects in their service trade with high-income countries.

<sup>15</sup> The rationale for this method is given by [Gourieroux et al. \(1984\)](#). More detail about the practical implementation can be obtained from [Wooldridge \(1997\)](#). We provide our Stata code at <http://strategy.sauder.ubc.ca/head/sup/>.

<sup>16</sup> Our estimates of  $\eta^2$  range from 0.20 in 1992 to 0.87 in 2005.

<sup>17</sup> The restricted sample includes trade between high-income and lower income countries in both directions. We include exports from high-income to low-income countries because they should be subject to the same set of distance costs as trade in the other direction and provide useful information for estimating distance effects.

<sup>18</sup> [Schwellnus \(2007\)](#) obtains a relatively low estimate of the distance effect for OCS in 2000 for trade between OECD countries, 1.0, using a “Log” specification and fixed effects.



**Fig. 6.** Evolution of distance effects over time. (a) Full spec., full sample; (b) full spec., no "Rich-Rich" obs.; (c) no time zone diff., full sample; and (d) no time zone diff., no "Rich-Rich" obs.

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 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.

The 2-step NB and Poisson QMLE both provide consistent estimates of the underlying parameters under the conditional mean assumption shown in Eq. (11). Therefore the results should only differ because of sampling error. Yet we observe in Fig. 6 that the confidence intervals for the two methods generally do not overlap. Gourieroux et al. (1984) show that the methods differ in the weights they place on each observation. If distance effects vary across sets of trading partners, the

weighting of observations will affect the distance estimate. Thus, the observed differences in the 2-step NB and Poisson QMLE estimates suggest 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  $\delta$ . 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

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

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  $\delta$ .

Direct calculation of  $\delta$  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  $\delta$  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  $\delta$  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  $\delta$  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.

The problem with direct measures of  $\delta$  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  $\delta$  that incorporates the costs of imperfect information. For this we should use our estimates of the effect of distance on service trade. Recall from Eq. (9) that the coefficient on distance in a trade equation is a compound parameter given by  $-\theta\delta$ . Dividing by an estimate of  $\theta$ , the inverse measure of the dispersion of productivity, we could infer  $\delta$  from the distance coefficient using the formula  $\hat{\delta} = \widehat{\theta\delta}/\hat{\theta}$ .

We calculate the wedge for 2006 that applies to workers producing OCS. The pooled regressions shown in Tables 4 and 5 and the annual coefficients shown in Fig. 6 provide a range of possible estimates of the distance effect,  $\widehat{\theta\delta}$ . We select the 2006 linear-in-lags specification in which  $\widehat{\theta\delta} = 1.10$  because that value lies between the 2-step NB 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  $\theta$ , the studies surveyed by Anderson and van Wincoop (2004) are also relevant. They write that “the literature leads us to conclude that  $\sigma$  is likely to be in the range of five to ten.” This corresponds to a  $\theta$  range of four to nine, quite close to the range of  $\theta$  derived from the Eaton and Kortum and Bernard et al. studies.

Using Eaton and Kortum (2002) to obtain the upper bound for  $\theta$  and Bernard et al. (2003) for the lower bound,  $\delta$  ranges between  $1.10/8.28 = 0.13$  and  $1.10/3.6 = 0.31$ . Fig. 7 displays the proximity premia as a function of relative distance using four estimates of  $\delta$ : The lower and upper bounds based on estimated distance effects, the air transport elasticity, and the telephone elasticity.

The figure highlights examples of relative distances from London using dotted vertical lines. As a short domestic distance, we use the 83 km from London to Oxford, whereas the obvious long international distance is the 8,027 km to Bangalore. Hence, a reasonable range for relative distance would be 1–100. The estimates based on our bilateral service trade equations imply London service purchasers are willing to pay 25% (assuming  $\theta = 8.28$ ) to 71% (assuming  $\theta = 3.60$ ) more for service suppliers in Oxford rather than Dublin. The relative proximity of Dublin versus Bangalore is worth 45–141% higher labour costs. Finally, workers in Oxford can be paid 81–313% 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

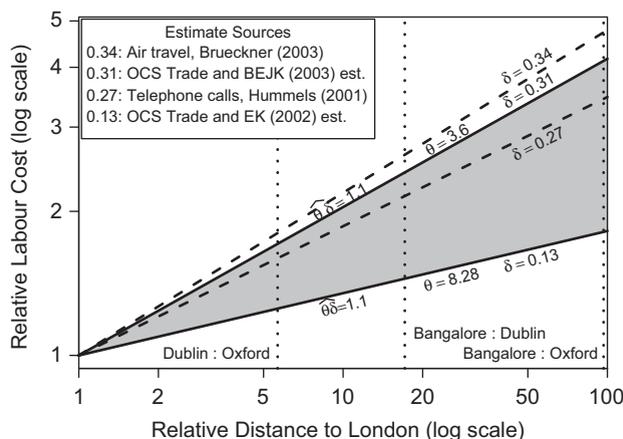


Fig. 7. Illustrative values of the proximity premium.

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  $\theta$  from a small number of studies of trade in goods. Obtaining estimates of  $\theta$  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 nontradeable, whereas others, such as call centers, 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 four times more for nearby ( $\approx 100$  km) than for remote ( $\approx 10,000$  km) service providers. Thus, distance shields workers to a significant extent from the threat of offshoring. However, distance effects for most services have declined substantially. If these trends continue, local service workers will increasingly find themselves in closer competition with foreign suppliers.

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## Appendix A. Data appendix

### A.1. Service trade

The Eurostat data are 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)*. The 1992–2006 data we employ comes from two downloads. We executed the first one in 2006 that provides data through 2004 and the second in 2008 (when we revised the paper). Data for the 1992–2004 period were more complete in the first download, so we just appended 2005 and 2006 data from the 2008 download to the data from the initial download. We construct the OCS category of trade by subtracting the sum of education (895), health (896), and government (291) services from “Other Services” (code 981, total services minus travel and transport). When reports on a bilateral flow from both the importer and the exporter exist, we take the larger of the two. The logic of this procedure is that service trade data are based on surveys

and a larger flow should correspond to a more complete survey. We downloaded multilateral service trade data from the World Bank's *World Development Indicators* (WDI) at <http://devdata.worldbank.org/dataonline/>.

### A.2. 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](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  $H$ ,  $\Delta_{od} = \min\{|H_o - H_d|, 24 - |H_o - H_d|\}$ . Time zones were obtained from Wikipedia.

### A.3. 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>).

## Appendix B. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.eurocorev.2008.08.001.

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