Product substitutability and the Distance Puzzle*

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Abstract

We propose a novel explanation of the non-decreasing distance elasticity of trade over 1962-2013, commonly referred to as 'the distance puzzle'. Consistently with previous work, we find that the changing composition of world trade has contributed to making trade less rather than more sensitive to distance. Our original contribution consists in documenting a 35% increase in the perceived substitutability of products traded on the world market over the same period. We find that the Armington elasticity of substitution increased from about 1.7 to 2.3 between 1965 and 2013. This elasticity corresponds to the elasticity of trade flows to trade costs on the intensive margin. In the Armington framework it determines the elasticity of trade flows to trade costs. The evolution of this parameter suffices to explain the non-decreasing distance elasticity of trade.

Keywords: gravity equation, distance puzzle, trade elasticity, trade costs

JEL codes: F15, N70

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Introduction

It is a well-established fact that trade has not become less sensitive to distance over the last 60 years. Disdier and Head (2008) adopt a meta-analytical approach and find that distance impedes trade by 37% more in the 1990s than it did from 1870 to 1969[1]. Head and Mayer (2013) estimate the distance elasticity of trade in successive cross-sections and find that it has doubled in 1960-2005. This increase in the distance elasticity of trade has been dubbed the "distance puzzle", as the common opinion is that technological developments in transportation and communication, e.g. the airplane, the container, and the internet, would have led to the "death of distance" by the end of the 20$^{\text{th}}$ century[2].

In this paper we investigate the empirical relevance of a different mechanism that may help to rationalize the distance puzzle. We make the simple point that the flattening out of the world may go hand in hand with a persistent impeding effect of distance on trade if consumers perceive product bundles shipped out by each country to the world market as increasingly substitutable.[3] We work with the canonical Anderson and van Wincoop (2003) framework to quantify the contribution of this mechanism. We find that the non-decreasing distance elasticity of trade can be explained by the increasing sensitivity of consumers to price differences.

Prominent explanations of the distance puzzle

Recent work rationalizes the distance puzzle in three complementary ways: by pointing out a possible misspecification of the econometric model, by refining the specification of the trade cost function, and, more recently, through the lens of network analysis.

The first strand of the literature investigates the incidence of the estimation method on the distance puzzle. Santos Silva and Tenreyro (2006) advocate estimating the gravity model in multiplicative form using a specific non-linear estimator, the Poisson Pseudo Maximum Likelihood (PPML). Contrary to the canonical loglinear approach, this estimator provides consistent estimates and is robust to rounding error and overdispersion which are both likely features of trade data[4]. The magnitude of the distance puzzle is reduced when the gravity model is estimated in multiplicative form (Bosquet and Boulhol (2015); Head and Mayer (2013)).

[1] See also Berthelon and Freund (2008); Combes et al. (2006); Brun et al. (2005); Buch et al. (2004).
[2] Cairncross (1997); Levinson (2006); Friedman (2007)
[3] Equation (4) in Head and Mayer (2013): the distance effect is a product of two elasticities, the elasticity of trade to trade costs and the elasticity of trade costs to distance. We investigate the evolution of the former.
[4] Santos Silva and Tenreyro (2011) and Fally (2015) provide evidence on desirable properties of the PPML. Head and Mayer (2014) review properties of alternative estimators. See also Bosquet and Boulhol (2015, 2014).

The sensitivity of the distance puzzle to the estimation method is likely due to sample composition effects (Head and Mayer (2013); Larch et al. (2016)). Indeed, the growth of trade has been both intensive in the sense that the volume of established trade relations has increased and extensive in the sense that new trade relations have been established (Helpman et al. (2008); Baldwin and Harrigan (2011)). If trade relations have in priority been established between small and distant partners, the reduction in the number of zeros may have gradually reduced the underestimation of the distance coefficient in the loglinear specification[5]. This explanation echoes Felbermayr and Kohler (2006) who pointed out that the log-linear specification was subject to sample selection bias due to the exclusion of zero trade flows. They conjectured that the distance puzzle was an artefact of reduction in this bias through the extensive margin of trade[6].

The second and most prominent strand of the literature singles out the underpinnings of the trade cost function as key to understanding the distance puzzle. The basic point formulated by Buch et al. (2004) is that the distance elasticity of trade is invariant to reductions in transportation and communication costs if their distribution over distance remains unchanged[7]. Furthermore, while the distance elasticity of transport costs may have decreased (Hummels (2007)), other cost components, such as delays, may have become more distance-elastic (Hummels and Schaur (2013)). More generally, as argued by Head and Mayer (2013), if freight costs account for an ever smaller fraction of distance-dependent trade costs, the distance elasticity of trade will be determined by other, possibly persistent, cost components[8].

A complementary mechanism is proposed in Krautheim (2012) in the heterogeneous firms' framework. He models the informational component of trade costs as a fixed cost which decreases in the number of exporting firms. This refinement of the trade cost function magnifies the distance elasticity of trade because the number of exporters is decreasing in variable trade costs which increase with distance. This magnification mechanism may have been reinforced by the increasing weight of information costs in total fixed costs.

An alternative explanation put forward in models with input-output linkages is that the re-

[5] Larch et al. (2016) attribute the puzzle to the growing bias of the OLS estimates. Using a nonlinear estimator and controlling for the number of exporting firms, they find a decreasing distance elasticity in 1980-2006.

[6] This leaves open the question of the estimator which correctly captures the level of the distance elasticity. Head and Mayer (2013) argue that PPML is giving little weight to small trade flows characteristic of more distant partners. For Santos Silva and Tenreyro (2006) small trade flows are more prone to measurement error.

[7] Egger (2008) argues that the marginal effect of distance on trade is fundamentally non uniform across trade partners and decreasing in the level of bilateral trade. This reinstates increased openness as a possible explanatory factor because a uniform reduction in trade costs has non uniform effects on bilateral trade.

[8] Head and Mayer (2013) propose a typology of persistent but unobserved trade costs. Daudin (2003, 2005) put forward that trade costs may have remained stable as a share of value added.

lationship between total trade costs and transport costs may be non-monotonic. An increasing distance elasticity may be an endogenous outcome of transport cost reductions if they engender a reoptimization of the production process which ends up increasing the relative cost of long-distance trade. One possible mechanism is trade cost magnification through multiple border crossings by goods as a consequence of increased production fragmentation (Noguera (2012); Yi (2010)). Another mechanism formalized by Duranton and Storper (2008) works through quality upgrading. Lower transport costs shift trade towards higher-quality inputs which are more distance-sensitive because their customization requires intensive communication, e.g. more back-and-forth travelling, between upstream and downstream firms.

A shift of focus to the trade elasticity

The focus of the literature on the shape of the trade cost function mirrors the expectation that the distance coefficient moves together with the elasticity of trade costs to distance. But Chaney (2016) provides a theoretical foundation for the gravity equation through the lens of network analysis which demonstrates that the distance coefficient can be invariant to the trade cost function. In Chaney (2016) the rate of distance decay in aggregate trade is linked to the rate of decay in the density of firms which cover that distance with their network of contacts. As the geographic dispersion of the network is increasing in firm size, the shape parameter of the firm size distribution plays a key role in explaining movements in the distance coefficient. Thus, technological advances in transportation increase the geographic dispersion of exports at the level of the firm but have no incidence on the distance elasticity of aggregate trade as long as the stationary firm size distribution verifies Zipf's law.

The link between the distance coefficient and the parameter which captures the degree of structural heterogeneity in the economy is not specific to Chaney (2016). Every theoretical foundation of the gravity model delivers a functional relationship of the distance elasticity with the intensity of the incentive to trade, e.g. the degree of structural heterogeneity in some model-specific dimension. The combination of empirical evidence on the changing shape of the trade cost function with evidence on the stability of the distance distribution of trade indicates that structural heterogeneity may have contributed to the evolution of the distance coefficient. However, empirical evidence on the evolution of structural heterogeneity in the economy since the 1960s is notoriously scarse (Head and Mayer (2013)).

We pursue the idea that a key parameter for understanding movements in the distance coefficient is the one measuring the degree of structural heterogeneity in the economy. Following Arkolakis et al. (2012) we refer to this parameter as the 'trade elasticity'. Because of data limitations inherent to our 60-year perspective, we can only estimate the trade elasticity in the Armington framework. Structural heterogeneity is determined in this framework by perceived product substitutability, i.e. the degree of product differentiation by place of origin.

We estimate the distance elasticity of aggregate trade and the Armington elasticity of substitution between goods of different origin in each year between 1962 and 2013. These two elasticities are identified separately. We deduce the implied evolution of the elasticity of trade costs to distance from the two estimated elasticities[9]. Our main result is that the increase in the Armington elasticity not only rationalizes the non-decreasing distance elasticity of trade but also hints at a reduction in the elasticity of trade costs to distance. We conclude that in the Armington framework the distance puzzle is fully explained by the increasing sensitivity of consumers to price differences. More generally, our results suggest that the distance puzzle may be due to a reduction in structural heterogeneity.

To the best of our knowledge, Berthelon and Freund (2008) is the only paper that studies the impact of changes in perceived product substitutability on the distance coefficient. Using estimates of sectoral Armington elasticities obtained by Broda and Weinstein (2006), Berthelon and Freund (2008) find a positive relationship between the variation in sectoral distance coefficients and the variation in Armington elasticities between 1985-1989 and 2001-2005[10]. Our approach is different from Berthelon and Freund (2008) because we focus on the aggregate Armington elasticity and provide direct estimates of this parameter in each year between 1962 and 2013. Our approach is different from Broda and Weinstein (2006) because we exploit cross-sectional variation in prices and trade shares to infer the extent of substitutability while these authors exploit changes in prices and trade shares over time to identify one point estimate. Our approach enables us to trace out changes in the perceived similarity of the product mix that countries supply to the world market.

We proceed in three steps. First, we examine the hypothesis that the distance puzzle is a by-product of compositional changes in the set of traded goods or of trading pairs. We refute this hypothesis by showing that the distance puzzle is more pronounced in the stable set. Second, we point out that a straightforward nonlinear estimation approach allows identifying the aggregate

[9] Erkel-Rousse and Mirza (2002) do this exercise for just one point in time on a subsample of world trade flows.

[10] Berthelon and Freund (2008) work with 776 sectors defined at the SITC Rev.2 4-digit level. Broda and Weinstein (2006) use time-series variation in prices and market shares for the set of exporters to the US market to get one value for the Armington elasticity in 1972-1988 and another value in 1990-2001.

Armington elasticity. The key intuition follows Imbs and Méjean (2015) who show that a consistent estimate of this elasticity is obtained by implementing a non-linear estimator on sectoral data while constraining sectoral elasticities to equality. In the estimation we instrument unit values - our proxy of prices - with lagged unit values together with the lagged real exchange rates specific to each bilateral relationship to address endogeneity concerns. Third, we present the results of this method and conduct a number of robustness checks.

1 The magnitude of the distance puzzle

In this section we evaluate the sensitivity of the distance puzzle to compositional changes in the set of traded goods and in the set of trading pairs over 1962-2013. Such changes were identified in previous estimations of the loglinearized gravity model as explanatory of movements in the distance coefficient[11]. We estimate the gravity model in multiplicative form and document that the distance puzzle is magnified in the sample of stable pairs and robust to fixing the sectoral composition of world trade.

1.1 The magnitude of the sample composition effect

We use the COMTRADE dataset to make our investigation of the distance puzzle directly comparable to Head and Mayer (2013) and Berthelon and Freund (2008). We work with the 4-digit SITC Rev.1 product classification (600-700 goods) because it provides the longest and most comprehensive coverage of disaggregate bilateral trade (1962-2013). Data on bilateral distance, bilateral trade cost controls such as adjacency, common language, colonial linkages, and data on belonging or having once belonged to the same country are taken from the CEPII[12].

We conduct the estimation on CIF import flows. We restrict the sample to trade in goods which are attributed to specific 4-digit categories and to pairs for which we have data on bilateral trade cost controls. App. A lists the resulting set of countries. For each active pair attributed sectoral flows are summed to obtain total bilateral trade. We refer to the resulting sample as 'the full sample'. It covers between 88% and 99% of reported trade in COMTRADE.

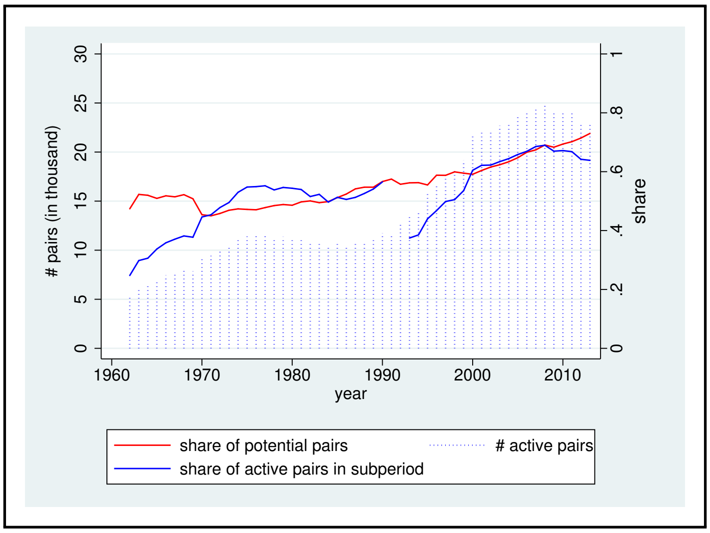
Fig.1 summarizes the main features of the data. The number of active pairs increases more than fourfold in 1962-2013 (in dash, left scale), both because more countries report trade to

[11] Berthelon and Freund (2008) find that changes in the sectoral composition of world trade do not help to explain movements in the distance coefficient in 1985-2005. Head and Mayer (2013) find that the distance puzzle is reduced in the set of stable pairs between 1960 and 2005 when the model is estimated in loglinear form.

[12] See Mayer and Zignago (2011). The database is available at www.cepii.fr. We constructed bilateral distance and bilateral cost controls for East and West Germany, USSR, and Czechoslovakia.

COMTRADE and because more pairs have non-zero trade flows (Helpman et al. (2008)). Active pairs make up between 45% and 73% of the total number of possible trade relationships, with a clear upward trend (in red, right scale).

Figure 1: Active pairs in COMTRADE (1962-2013)



If we focus on the set of pairs that report non-zero trade in at least one year, the share of active pairs increases by 22 percentage points between 1962 and 1990 and by 27 percentage points between 1993 and 2013 (in blue, right scale)[13]. By the end of the sample about 2/3 of pairs which trade at least once between 1962 and 2013 are reporting non-zero trade.

Hence, sample composition effects are substantial. Nonetheless, the bulk of total trade is attributable to the 786 pairs which trade both ways in every year. We refer to this set of stable reciprocal pairs as the 'superbalanced' sample and use it to investigate the magnitude of the sample composition effect[14].

We follow the canonical Anderson and van Wincoop (2003) derivation of the gravity model to express aggregate bilateral trade X_{ij} as a function of bilateral trade barriers τ_{ij}, multilateral trade resistance terms in source i and destination j (resp. Π_i and P_j), and nominal incomes Y_n with $n \in \{i,j,w\}$ where w is world income[15].

[13] We split the sample in two subperiods, 1962-1990 and 1993-2013, to take into account country creation and disappearance in the early 1990s.

[14] The superbalanced sample includes 32 countries listed in App. A. The appendix discusses trade coverage.

[15] This formulation is not specific to the Armington framework. See footnote 20 in Eaton and Kortum (2002) and subsequent discussions of equivalence in Arkolakis et al. (2012); Head and Mayer (2013).

$$X_{ijt} \quad = \quad \left(\frac{Y_{it}Y_{jt}}{Y_wt}\right)\left(\frac{\tau_{ijt}}{\Pi_{it}P_{jt}}\right)^{\epsilon_t} \tag{1}$$

We include the time subscript t not only on each variable but also on the elasticity of trade flows to trade costs ϵ to underline that this parameter is subject to change. In the Armington framework $\epsilon_t = 1 - \sigma_t$ where σ_t corresponds to the elasticity of substitution between goods of different national origin. We seek to quantify the evolution of the elasticity of aggregate trade flows to trade costs. Hence, the key parameter of interest for this paper is the Armington elasticity which captures perceived substitutability of composite goods which differ by their place of production.

As total bilateral trade costs τ_{ijt} are not directly observed for each pair and year, we model them as a function of observable time-invariant bilateral controls which are distance, adjacency, and common language together with persistent but time-varying controls standard in the gravity literature which are historical and current colonial linkages as well as belonging or having once belonged to the same country. We include an unobserved bilateral trade cost component ν_{ijt} assumed to have mean zero conditional on the observables[16]. We denote distance $ð_{ij}$, group the other time-invariant observables in the vector Z and time-varying observables in the vector S_t to get the following specification of the trade cost function:

$$\tau_{ijt} \quad = \quad \exp\left\{\rho_t \ln ð_{ij} + Z'\zeta_t + S_t{}'\varsigma_t + \nu_{ijt}\right\} \tag{2}$$

Replacing (2) in (1), substituting source and destination specific variables with country fixed effects (resp. f_{it} and f_{jt}), defining a constant ξ_t and specifying a multiplicative error term ξ_{ijt} which includes the exponentiated unobserved bilateral trade cost gives the equation to be estimated on aggregate bilateral trade:

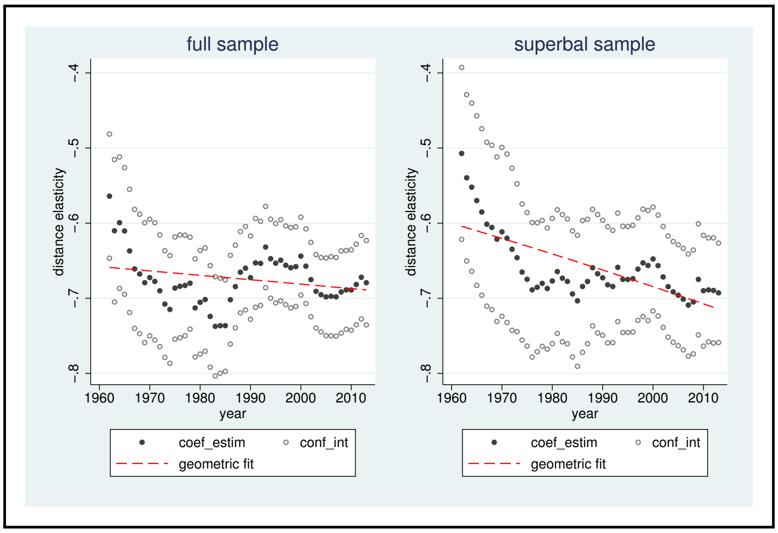
$$X_{ijt} \quad = \quad \exp\left(\xi_t - \delta_t \ln ð_{ij} + Z'\zeta_t + S_t{}'\varsigma_t + f_{it} + f_{jt}\right)\xi_{ijt} \tag{3}$$

To ensure consistency of the point estimates we do not loglinearize the model although switching to a non-linear estimator may entail a loss of efficiency (Manning and Mullahy (1999)). We implement (3) in the full and superbalanced samples using the PPML estimator (Santos Silva and Tenreyro (2006)). The estimation is conducted in cross section. The parameter of interest is the distance elasticity, $-\delta_t$, which corresponds to the product of the distance elasticity of trade costs ρ_t and of the trade elasticity ϵ_t[17].

[16] The error term contains bilateral variation in trade costs due to trade policy. The question of possible changes in the distance distribution of trade costs as a consequence of policy decisions is beyond the scope of this paper.

[17] We follow the notation in Head and Mayer (2013) (see equation (4), p.1205).

Figure 2: The sample composition effect



Results for both samples are shown in fig.2. In the full sample (left pane) the distance effect δ_t increased by 4.5% between 1962-2013 (left pane), but this increase is only marginally significant. In the superbalanced sample (right pane) the increase in the distance effect δ_t is magnified to 18.2%, and this increase is strongly significant[18]. Consistently with previous studies we find that the distance sensitivity of trade has not been reduced over time. Moreover, the distance puzzle is enhanced in the sample of stable trade relationships[19].

We obtain the large confidence intervals shown in fig.2 when we implement the Huber-White correction of standard errors[20]. Standard errors are reduced by an order of magnitude when this correction is not implemented. Considering that the PPML approach already takes into account heteroskedasticity, and that we are looking at these point estimates as if they were descriptive statistics on the whole population, we take the results shown in fig.2 as sufficient evidence of the robustness of the distance puzzle to sample composition effects.

Next, we demonstrate that the distance puzzle is robust to product composition effects. In particular, the non-linearity in the evolution of the distance coefficient disappears once we control for product composition effects (see fig.4 below).

[18] The annualized growth rate is 0.09% in the full sample and 0.33% in the superbalanced sample.

[19] The opposite result holds in the loglinear specification (Head and Mayer (2013)). In OLS the decrease in the distance elasticity due to the elimination of small trade flows between distant partners trumps the increase in the distance elasticity of stable trade relationships.

[20] Switching to the panel approach with the full set of country-year dummies does not achieve significant improvement in precision.

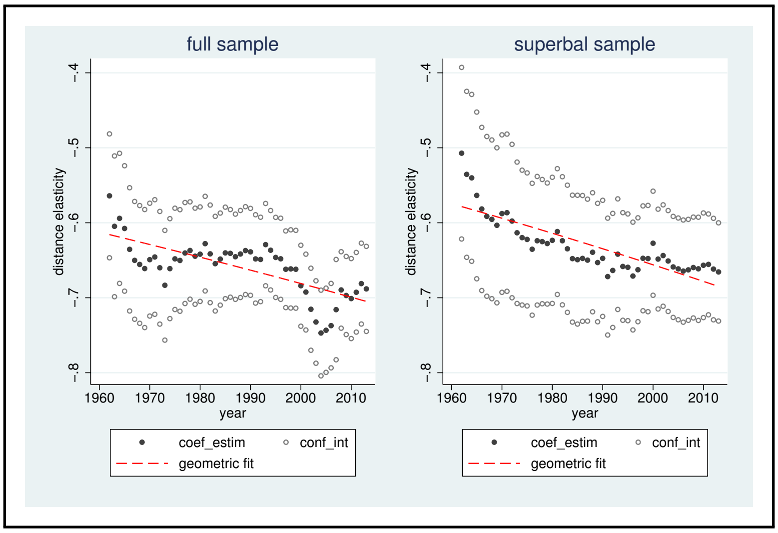
1.2 The magnitude of sectoral composition effects

We assess the incidence of sectoral composition effects in two ways. The first exercise consists in fixing the sectoral composition of world trade. The second exercise consists in fixing the sectoral composition of the bundle supplied by each exporter to the world market.

In the first exercise we fix the sectoral composition of total trade to the initial year of the sample. Denoting each 4-digit sector k and the annual share of the sector in world trade (w,t) by $s^k_{w,t}$, the reweighting procedure fixes the share of each 4-digit sector in world trade to its share in 1962. The reweighted sectoral bilateral flow is $\tilde{X}^k_{ijt} = X^k_{ijt} * \frac{s^k_{w,1962}}{s^k_{w,t}}$. The reweighted sectoral flows are summed for each pair, and the gravity equation is estimated in each year for aggregate bilateral trade.

Results are shown in fig.3. The evolution of the distance coefficient becomes much more linear in the full sample (left pane), and this exacerbates the distance puzzle to a 14.5% increase in δ_t. The impact of this reweighting procedure is about nil in the sample of stable pairs (right pane) where δ_t increases by 18.4%[21]. Indeed, the main incidence of fixing the sectoral composition of world trade is the elimination of short-term fluctuations in the distance coefficient due to fluctuations in the weight of the energy sector. As this sector plays a relatively minor role in trade of stable reciprocal partners, the reweighting procedure has little incidence on the distribution of trade over distance in this sample.

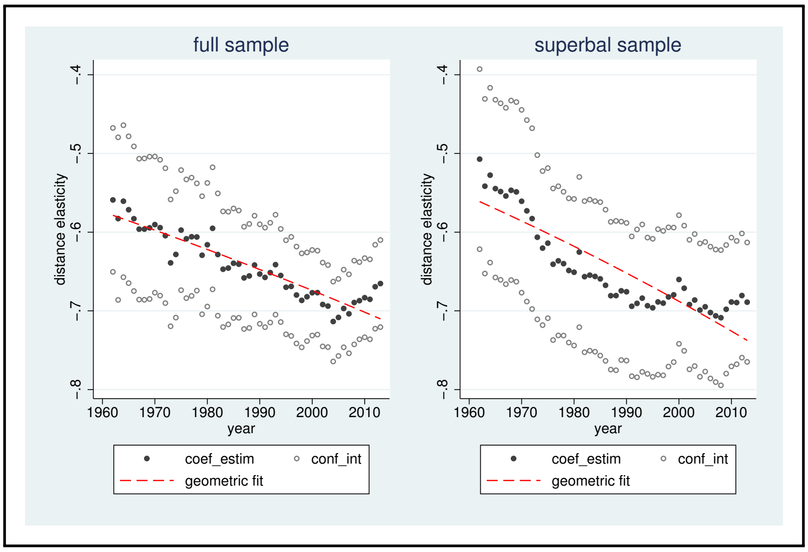
Figure 3: Product composition effect: fixing the world bundle



[21] The annualized growth rate is 0.26(0.33)% in the full (superbalanced) sample. Confidence intervals are reported for the Huber-White correction of standard errors. Without it standard errors are reduced by a factor of 10.

In the second exercise we fix the composition of the bundle supplied by each exporter i to the world market. Denoting the annual share of the sector in world imports from i by $s^k_{i,t}$, the reweighting fixes the share of each 4-digit sector in world imports from i to its share in 1962. The reweighted sectoral bilateral flow is $\tilde{X}^k_{ijt} = X^k_{ijt} * \frac{s^k_{i,1962}}{s^k_{i,t}}$. The resulting sectoral flows are summed for each pair, and the gravity equation is estimated on total reweighted bilateral trade.

Figure 4: Product composition effect: fixing the country bundle



As illustrated in fig.4, fixing the composition of the country-specific composite good exacerbates the magnitude of the distance puzzle. Further, while the degree of precision in the estimation of the gravity equation with the Huber-White correction of standard errors remains similar to the benchmark specification, 87% of the variation in the distance coefficient is attributable to the time trend in the full sample, against just 7% in the benchmark specification[22]. The corresponding annualized growth rate is .40% in the full, and .54% in the stable sample. This corresponds to a 22.7% increase in the distance sensitivity of trade between 1962 and 2013 in the full sample, and to a 31.4% increase in the sample of stable pairs.

We conclude that short-term fluctuations in the distance effect δ_t are likely attributable to product and sample composition effects. But the long-term evolution of the distance effect appears linked to structural changes. These structural changes are more pronounced in the set of stable trade relationships.

[22] In the superbalanced sample 77% of the variation is attributable to the time trend when the product bundle is fixed against 49% when the product bundle is not fixed.

1.3 Summing up: the robustness of the distance puzzle

Table 1: Evolution of δ_t: sample, composition and FTA effects

	FULL			STABLE		
	rate (%)	R-sq	total change	rate (%)	R-sq	total change
Baseline	$.09^{*}$	.07	1.045	$.33^{***}$	.49	1.182
World bundle	$.26^{***}$	.53	1.145	$.33^{***}$	.68	1.184
Country bundle	$.40^{***}$	.87	1.227	$.54^{***}$	.77	1.314

Note: Estimated annualized growth rates reported in col.2 and col.5 are obtained as a geometric fit on the basis of annual point estimates of the distance coefficient in 1962-2013. Col.3 and col.6 report the share of time variation in the point estimate explained with the annualized growth rate.

Table 1 summarizes our findings. The distance puzzle is magnified in the sample of stable pairs and robust to fixing the product composition of world trade. Hence, the non-decreasing distance elasticity of trade is likely to be a structural outcome rather than an artefact of composition effects. These results motivate our focus on structural heterogeneity as a possible alternative explanation of the non-decreasing distance elasticity.

References

Anderson, J. E. and E. van Wincoop (2003). Gravity with gravitas: A solution to the border puzzle. *American Economic Review 93*(1), 170–192.

Arkolakis, C., A. Costinot, and A. Rodriguez-Clare (2012). New trade models, same old gains? *American Economic Review 102*(1), 94–130.

Baldwin, R. and J. Harrigan (2011). Zeros, quality and space: trade theory and trade evidence. *American Economic Journal: Microeconomics 3*(2).

Berthelon, M. and C. Freund (2008). On the conservation of distance in international trade. *Journal of International Economics 75*(2), 310–320.

Bosquet, C. and H. Boulhol (2014). Applying the glm variance assumption to overcome the scale dependence of the negative binomial QGPML estimator. *Econometric Reviews 33*(7).

Bosquet, C. and H. Boulhol (2015). What is really puzzling about the "distance puzzle"? *Review of World Economics 151*(1), 1–21.

Broda, C. and D. E. Weinstein (2006). Globalization and the gains from variety. *Quarterly Journal of Economics 121*(2), 541–585.

Brun, J.-F., C. Carrère, P. Guillaumont, and J. d. Melo (2005). Has distance died? evidence from a panel gravity model. *World Bank Economic Review 19*, 99–120.

Buch, C. M., J. Kleinert, and F. Toubal (2004). The distance puzzle: on the interpretation of the distance coefficient in gravity equations. *Economics Letters 83*, 293–298.

Cairncross, F. (1997). *The Death of Distance: How the Communications Revolution will change our Lives*. London: Orion Business Books.

Chaney, T. (2016). The gravity equation in international trade: an explanation. *Journal of Political Economy (forthcoming)*.

Combes, P.-P., T. Mayer, and J.-F. Thisse (2006). *Economie Géographique*. Paris: Economica.

Daudin, G. (2003). La logistique de la mondialisation. *Revue de l'OFCE* (87), 411–435.

Daudin, G. (2005). Les transactions de la mondialisation. *Revue de l'OFCE* (92), 223–262.

Disdier, A.-C. and K. Head (2008). The puzzling persistence of the distance effect in bilateral trade. *The Review of Economics and Statistics 90*(1), 37–48.

Duranton, G. and M. Storper (2008). Rising trade costs. agglomeration and trade with endogenous transaction costs. *Canadian Journal of Economics 41*(1), 292–319.

Eaton, J. and S. Kortum (2002). Technology, geography, and trade. *Econometrica 70*(5), 1741–1779.

Egger, P. (2008). On the role of distance for bilateral trade. *The World Economy 31*(5), 653–662.

Erkel-Rousse, H. and D. Mirza (2002). Import price elasticities: reconsidering the evidence. *The Canadian Journal of Economics 35*(2).

Fally, T. (2015). Structural gravity and fixed effects. *Journal of International Economics 97*(1).

Felbermayr, G. J. and W. Kohler (2006). Exploring the intensive and extensive margins of trade. *Review of World Economics 142*(4), 642–674.

Friedman, T. L. (2007). *The World is Flat: A Brief History of the Twenty-first Century, 2nd edition*. Farrar Straus & Giroux.

Head, K. and T. Mayer (2013). What separates us? Sources of resistance to globalization. *Canadian Journal of Economics 46*(4), 1196–1231.

Head, K. and T. Mayer (2014). *Handbook of international economics*, Volume 4, Chapter Gravity Equations: workhorse, toolkit, and cookbook. Elsevier.

Helpman, E., M. Melitz, and Y. Rubinstein (2008). Estimating trade flows: trading partners and trading volumes. *Quarterly Journal of Economics 123*(2), 441–487.

Hummels, D. (2007). Transportation costs and international trade in the second era of globalization. *Journal of Economic Perspectives 21*(3), 131–154.

Hummels, D. and G. Schaur (2013). Time as a trade barrier. *American Economic Review 103*, 1–27.

Imbs, J. and I. Méjean (2015). Elasticity optimism. *American Economic Journal: Macroeconomics 7*(3), 43–83.

Krautheim, S. (2012). Heterogeneous firms, exporter networks, and the effect of distance on international trade. *Journal of International Economics 87*, 27–35.

Larch, M., P.-J. Norbäck, S. Sirries, and D. M. Urban (2016). Heterogenous firms, globalization, and the distance puzzle. *The World Economy 39*(9), 1307–1338.

Levinson, M. (2006). *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton: Princeton University Press.

Manning, W. G. and J. Mullahy (1999). Estimating log models: To transform or not to transform? *NBER Technical Working Paper Series 246*.

Mayer, T. and S. Zignago (2011). Notes on CEPII's distances measures: the GeoDist database. *MPRA Working Paper Series* (36347).

Noguera, G. (2012). Trade costs and gravity for value added trade. *unpublished manuscript*.

Santos Silva, J. M. C. and S. Tenreyro (2006). The log of gravity. *The Review of Economics and Statistics 88*(4), 641–658.

Santos Silva, J. M. C. and S. Tenreyro (2011). Further simulation evidence on the performance of the poisson pseudo-maximum likelihood estimator. *Economics Letters 112*, 220–222.

Yi, K.-M. (2010). Can multistage production explain the home-bias in trade? *American Economic Review 100*(1), 364–393.

A Full and superbalanced samples

The full sample contains 205 reporters (R) and 227 partners (P) listed in tables 2 and 3 below. 'S' indicates that the country is present in the superbalanced sample.

In the full sample, several countries shift from reporting trade on an individual basis to reporting trade jointly with another country. This is the case of Belgium and Luxembourg, as well as Eritrea and Ethiopia. For consistency, we use a single country identifier for each of these two pairs. A single country identifier is also used for Yougoslavia and for Serbia and Montenegro. Fig.5 shows the distribution of pairs in the full sample according to the number of years in which the pair reports a positive amount of trade.

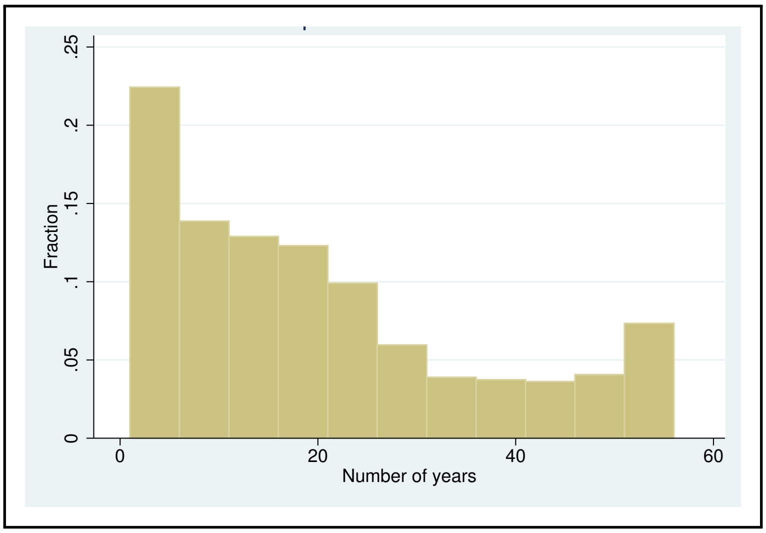


Figure 5: Number of years each pair is present in the sample

The superbalanced sample corresponds to the subsample of pairs which trade both ways in each and every year in 1962-2013. To avoid discarding pairs which fall out of the superbalanced sample because countries split up or reunite at some point in 1962-2013, we introduce several additional single country identifiers before constructing the superbalanced sample. Consequently, Germany is present in the superbalanced sample.[23]

The superbalanced sample comprises 786 trading pairs and corresponds to 32 countries. This is less than the 992 pairs which would be observed if each reporter traded both ways with every other country. Indeed, the set of countries which trade with every other country in each

[23] A single identifier is used for East, West, and reunited Germany. A single identifier is used for the Czech Republic, Slovakia, and Czechoslovakia. A single identifier is used for the USSR and the 15 countries formed after the USSR split up. The 15 countries which constituted the USSR are absent from the superbalanced sample because the USSR is never a reporter to COMTRADE. The Czech Republic and Slovakia also drop out because there is no other country in the sample with which they have two-way trade in every year.

year and which we refer to as the 'square sample' comprises just 21 countries (420 pairs). Trade coverage in the superbalanced sample decreases from 68 to 39% of total trade over 1962-2013 while it is reduced from 54 to 28% for the square sample (see Fig.6).

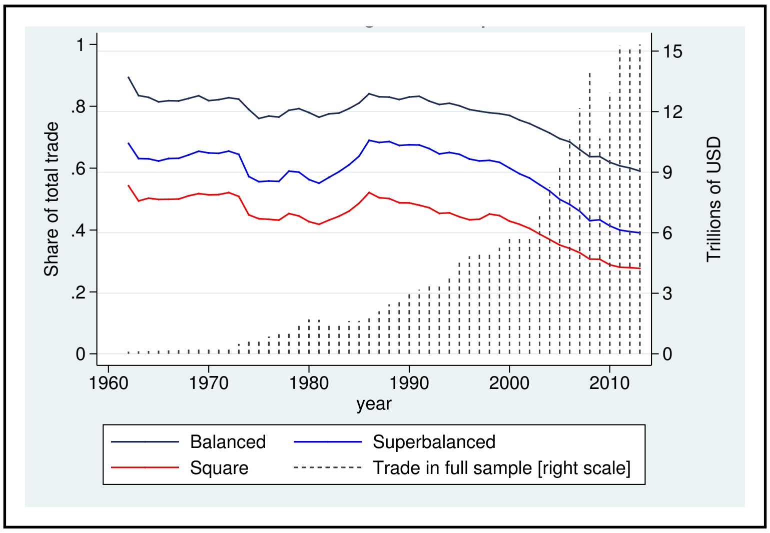


Figure 6: Trade coverage in 1962-2013

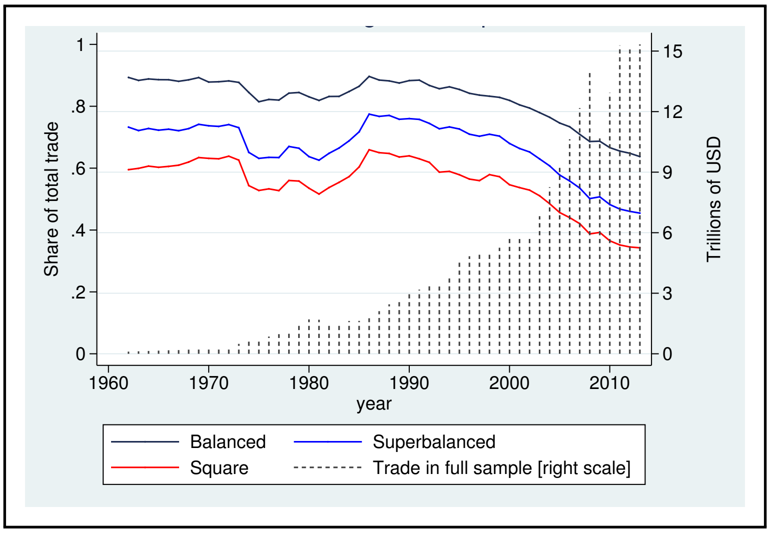


Figure 7: Trade coverage in 1965-2013

To check the sensitivity of trade coverage to the choice of the benchmark year we redefine the set of stable pairs as partners trading both ways in each year in 1965-2013.[24] The superbalanced sample for 1965-2013 contains 1286 pairs that comprise 42 countries (out of 1722 possible pairs). The square sample for 1965-2013 contains 23 countries (506 pairs).

[24] The number of reporters increases from 70 in 1962 to 86 in 1965 to 111 in 1970 and 129 in 1975. But the reduction in trade coverage between the 1970s and the 1990s is qualitatively similar if we choose 1970 or 1975.

As illustrated in Fig.7, the evolution of trade coverage is not sensitive to the choice of the starting year. Albeit from a higher level (73% in 1965), trade coverage drops to 45% by 2013. Indeed, the main reason for the reduction in trade coverage since the mid-1990s is due to the absence of China and of Central and Eastern European countries from the superbalanced sample. These countries drop out because they do not report trade to COMTRADE until the more recent period.[25]

Another way to check the sensitivity of trade coverage to the choice of the starting year is to compute the evolution of trade coverage for the sample of pairs which trade both ways in a specific year. The difference with the superbalanced sample is that we now relax the constraint that the pair have two-way trade in every year in 1962-2013. The share of total annual trade attributable to two-way pairs in 1962 and in 1965 is shown in Fig.8. As previously, the level but not the evolution of trade coverage is affected by the choice of the starting year.

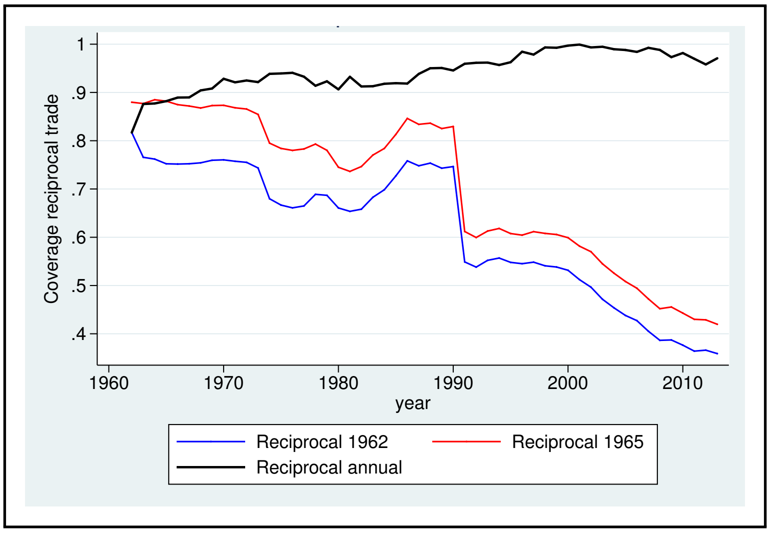


Figure 8: Trade coverage in reciprocal trade

Helpman et al. (2008) document that the enlargement of the set of trading partners did not contribute in a major way to the growth of world trade in 1970-1997 because most of the increase was driven by pairs which traded both ways in 1970. We nuance this finding by showing that since the mid-1990s new reciprocal trade relationships did contribute strongly to the growth of world trade. Fig.8 illustrates that while more than 70% (resp. 80%) of world trade in 1990 is attributable to pairs that traded both ways in 1962 (resp. 1965), less than 40% (resp. 50%) is still attributable to such pairs in 2013.

[25] For example, China reports trade to UN COMTRADE in 1987-2013.

We document that these new trade relationships were formed between countries trading both ways. To illustrate, Fig.8 also shows the share of total trade attributable to pairs which trade both ways in a given year (in black). Since the 1990s more than 95% of total annual trade takes place between pairs which trade both ways. One-way trade flows represent a marginal and decreasing share of world trade. The greater frequency of one-way trade relationships observed in the early years of the sample may be in part attributable to the fact that the number of countries reporting trade to COMTRADE was initially relatively small. Consequently, reported zeros may be at least in part statistical zeros, i.e. non-zero trade flows reported as zeros due to missing reports to COMTRADE.

Table 2: List of countries in the full and superbalanced samples

Country name	**Status**	**Country name**	**Status**	**Country name**	**Status**
Afghanistan	*R;P*	French Polynesia	*R;P*	N. Mariana Islands	P
Albania	*R;P*	French S. Antartic terr.	P	Norway	*R;P*
Algeria	*R;P*	Gabon	*R;P*	Oman	*R;P*
Andorra	*R;P*	Gambia	*R;P*	Pakistan	*R;P*
Angola	*R;P*	Georgia	*R;P*	Palau	P
Anguilla	*R;P*	**Germany**	**R;P;S**	Panama (Fm Panama Cz)	*R;P*
Antigua-Barbuda	*R;P*	Ghana	*R;P*	Papua New Guinea	*R;P*
Argentina	**R;P;S**	Gibraltar	P	**Paraguay**	**R;P;S**
Armenia	*R;P*	**Greece**	**R;P;S**	Peru	*R;P*
Aruba	*R;P*	Greenland	*R;P*	**Philippines**	**R;P;S**
Australia	R;P	Grenada	*R;P*	Pitcairn	P
Austria	R;P	Guadeloupe	*R;P*	Poland	*R;P*
Azerbaijan	*R;P*	Guatemala	*R;P*	**Portugal**	**R;P;S**
Bahamas	*R;P*	Guinea	*R;P*	Qatar	*R;P*
Bahrain	*R;P*	Guinea-Bissau	*R;P*	Reunion	*R;P*
Bangladesh	*R;P*	Guyana	*R;P*	Romania	*R;P*
Barbados	*R;P*	Haiti	*R;P*	Russian Federation	*R;P*
Belarus	*R;P*	Honduras	*R;P*	Rwanda	*R;P*
Belgium-Luxembourg	**R;P;S**	**Hong Kong**	**R;P;S**	St. Helena	P
Belize	*R;P*	Hungary	*R;P*	St. Kitts and Nevis	*R;P*
Benin	*R;P*	**Iceland**	**R;P;S**	St. Lucia	*R;P*
Bermuda	*R;P*	India	*R;P*	St. Vincent-Grenadines	*R;P*
Bhutan	*R;P*	Indonesia	*R;P*	Samoa	*R;P*
Bolivia	*R;P*	Iran	*R;P*	San Marino	P
Bosnia-Herzeg.	*R;P*	Iraq	*R;P*	Sao Tome-Principe	*R;P*
Botswana	*R;P*	Ireland	R;P	Saudi Arabia	*R;P*
Brazil	**R;P;S**	**Israel**	**R;P;S**	Senegal	*R;P*
Br. Virgin Islands	P	**Italy**	**R;P;S**	Serbia-Montenegro	*R;P*
Brunei Darussalam	*R;P*	Jamaica	*R;P*	Seychelles	*R;P*
Bulgaria	*R;P*	**Japan**	**R;P;S**	Sierra Leone	*R;P*
Burkina Faso	*R;P*	Jordan	*R;P*	**Singapore**	**R;P;S**
Burma (Myanmar)	*R;P*	Kazakstan	*R;P*	Slovakia	*R;P*
Burundi	*R;P*	Kenya	*R;P*	Slovenia	*R;P*
Cambodia	*R;P*	Kiribati	*R;P*	Solomon Islands	*R;P*
Cameroon	*R;P*	**Korea**	**R;P;S**	Somalia	*R;P*
Canada	**R;P;S**	DPR of Korea	P	South Africa	*R;P*

Table 3: List of countries in the full and superbalanced samples: Contd.

Country name	Status	Country name	Status	Country name	Status
Cape Verde	*R;P*	Kuwait	*R;P*	Soviet Union	P
Cayman Islands	P	Kyrgyzstan	*R;P*	**Spain**	**R;P;S**
C.African Republic	*R;P*	Lao PDR	*R;P*	Sri Lanka	*R;P*
Chad	*R;P*	Latvia	*R;P*	St. Pierre and Miquelon	*R;P*
Chile	**R;P;S**	Lebanon	*R;P*	Sudan	*R;P*
China	*R;P*	Lesotho	*R;P*	Suriname	*R;P*
Christmas Island	P	Liberia	*R;P*	Swaziland	*R;P*
Cocos Islands	P	Libya	*R;P*	**Sweden**	**R;P;S**
Colombia	**R;P;S**	Lithuania	*R;P*	**Switzerland**	**R;P;S**
Comoros	*R;P*	Luxembourg	R;P	Syria	*R;P*
Congo	*R;P*	Macau (Aomen)	*R;P*		
Dem. Rep. of Congo	*R;P*	Macedonia	*R;P*	Tajikistan	*R;P*
Cook Islands	*R;P*	Madagascar	*R;P*	Tanzania	*R;P*
Costa Rica	*R;P*	Malawi	*R;P*	**Thailand**	**R;P;S**
Croatia	*R;P*	**Malaysia**	**R;P;S**	Togo	*R;P*
Cuba	*R;P*	Maldives	*R;P*	Tokelau	P
Cyprus	*R;P*	Mali	*R;P*	Tonga	*R;P*
Czech Republic	*R;P*	Malta	*R;P*	Trinidad-Tobago	*R;P*
Czechoslovakia	*R;P*	Marshall Islands	P	**Tunisia**	**R;P;S**
Côte d'Ivoire	*R;P*	Martinique	*R;P*	**Turkey**	**R;P;S**
Denmark	**R;P;S**	Mauritania	*R;P*	Turkmenistan	*R;P*
Djibouti	*R;P*	Mauritius	*R;P*	Turks-Caicos Islands	*R;P*
Dominica	*R;P*	**Mexico**	**R;P;S**	Tuvalu	*R;P*
Dominican Republic	*R;P*	Micronesia	P	Uganda	*R;P*
East Germany (DDR)	R;P	Moldova	*R;P*	Ukraine	*R;P*
East Timor	*R;P*	Mongolia	*R;P*	United Arab Emirates	*R;P*
Ecuador	*R;P*	Montserrat	*R;P*	**United Kingdom**	**R;P;S**
Egypt	*R;P*	Morocco	*R;P*	**USA**	**R;P;S**
El Salvador	R;P	Mozambique	*R;P*	Uruguay	*R;P*
Equatorial Guinea	P	Namibia	*R;P*	Uzbekistan	P
Eritrea	*R;P*	Nauru	P	Vanuatu	*R;P*
Estonia	*R;P*	Nepal	*R;P*	**Venezuela**	**R;P;S**
Ethiopia	*R;P*	Netherland Antilles	*R;P*	Vietnam (Fm Vietnam Rp)	*R;P*
Falkland Islands	P	**Netherlands**	**R;P;S**	Wallis-Futuna	*R;P*
Palestine	*R;P*	New Caledonia	*R;P*	West Germany (FRG)	R;P
Fiji	*R;P*	New Zealand	*R;P*	Western Sahara	P
Finland	R;P	Nicaragua	*R;P*	Yemen	*R;P*
France	**R;P;S**	Niger	*R;P*	Yugoslavia (Serbia-Mont.)	*R;P*
French Guiana	*R;P*	Nigeria	*R;P*	Zambia	*R;P*
Niue	P	Norfolk Island	P	Zimbabwe	*R;P*