Économie internationale 115 (2008), p. 141-164

ÉCONOMIE INTERNATIONALE
INTERNATIONAL ECONOMICS

Disaggregated trade flows and the "missing globalization puzzle"

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Article received on April 28, 2008
Accepted on November 14, 2008

Abstract. This study analyzes the stability of the distance coefficient values over time in the generalized gravity equation of Bergstrand (1989) using both aggregate and disaggregated trade flows among 22 OECD countries recorded for the sample period covering 1970 until 2000. First of all, we find that the missing globalization puzzle, typically observed in empirical gravity models for aggregate trade flows, largely disappears when one estimates a gravity model using disaggregated trade data at the level of individual industries. Secondly, we document that accounting for multilateral price resistance alone can provide some evidence against the missing globalization puzzle. At the same time, the results obtained for a traditional specification of the gravity equation emphasizing the importance of disaggregated trade flows in explaining the distance puzzle remain largely intact.

JEL Classification: F12.
Keywords: Gravity Model; Missing Globalization Puzzle; Distance Coefficient; Multilateral Resistance.

Résumé. Cet article analyse la stabilité dans le temps du coefficient de distance dans l'équation de gravité généralisée de Bergstrand (1989), calculé avec les flux commerciaux aggrégés et désaggrégés pour 22 pays de l'OCDE, sur la période 1970-2000. Nous trouvons d'abord que l'énigme de la globalisation manquante, observée avec les modèles de gravité empiriques sur la base de flux commerciaux agrégés, disparaît si le modèle de gravité est estimé sur données commerciales désagrégées, au niveau des industries prises individuellement. Puis nous montrons que la prise en compte de la seule résistance multilatérale du prix peut contrarier l'existence de l'énigme de la globalisation manquante. En même temps, les résultats obtenus avec un calcul classique de l'équation de gravité, soulignant l'importance des flux commerciaux désagrégés pour expliquer l'énigme de la distance, restent valides.

Classification *JEL* : F12.
Mots-clefs : Modèle de gravité ; énigme de la globalisation manquante ; coefficient de distance ; résistance multilatérale.

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1. Introduction

The "missing globalization puzzle" or "distance puzzle"— a non-declining trade-deterring role of distance in gravity models of trade — is well established in the empirical trade literature. For example, in a review article where 1467 distance coefficient estimates collected from 103 papers are systematically and comprehensively examined, Disdier and Head (2008) report that the trade-deterring role of distance decreased slightly between 1870 and 1950, while there was no sign of further decline in the period that followed, contrary to the common perception of the "shrinking" world. On the basis of their investigation, Disdier and Head (2008, p. 48) conclude that their "... findings represent a challenge for those who believe that technological change has revolutionized the world economy, causing the impact of spatial separation to decline or disappear". A similar observation was made earlier in a paper by Coe, Subramanian, Tamirisa, and Bhavnani (2002, p. 3), where it is pointed out that "globalization is everywhere but in estimated gravity models". One possible explanation for rather high stability over time of the trade-deterring role of distance was suggested by Coe *et al.* (2002) and Coe, Subramanian, and Tamirisa (2007), who argue that the standard gravity models that are usually estimated in the log-linear form are unable to capture a significant decline in trade costs brought by intensified integration of the world economy.

In this paper, we present empirical evidence that challenges this established view that the traditional gravity models are unable to account for the effects of globalization on trade costs, which are usually approximated by the distance variable. More specifically, we show that in a standard specified gravity equation, which is also estimated by a conventional method of least squares, the globalization effects on trade can only be detected as long as one considers disaggregated trade flows. In particular, we find a substantial decline in the value of distance elasticity for most of the three-digit ISIC Rev. 2 manufacturing industries. Our results show that, depending on the industry in question, the (absolute) value of distance elasticity was up to 45 percent lower in 2000 than in 1970. At the same time, our estimation results obtained for the gravity models estimated for all products combined as well as for all manufacturing goods suggest that the (absolute) magnitude of the distance coefficient remains rather stable over time — a standard finding that has given rise to the missing globalization puzzle in the gravity equations.

As an additional contribution of our paper, we provide an explanation of the seemingly counter-intuitive result described above that depending on the level of aggregation, one arrives at different conclusions with regard to the stability of the estimated distance coefficient over time. This may seem a rather puzzling outcome, since one would expect that the dominant pattern observed at the disaggregated level would also be evident at the aggregate level. In order to explain this finding, we check whether changes in the values of the distance coefficients (that should reflect the underlying changes in trade costs) reported for different industries are correlated with changes in the trade volume observed at shorter and at longer distances. The gravity equation implies that if the costs of trade decrease over time, this should be matched by an increase in trade at longer distances at the expense of trade at shorter distances. At the same time, if the relative distribution of trade over distance is stable over time, then the observed distance coefficients estimated in the beginning and at the end of the sample period should also be stable. As expected, we find a substantial and statistically significant correlation between changes in the values of the estimated distance coefficients reported for different industries and changes in the observed trade volume over distance. However, we find that over the observation period, there has been a rather small change in the relative distribution of total trade according to distance, which is consistent with our estimation results at the aggregate level as well as with the earlier empirical evidence summarized in Disdier and Head (2008).

Our last contribution is to investigate the robustness of our results with respect to the introduction of theoretically motivated multilateral price resistance terms in our gravity equations. In this way, we acknowledge the mounting criticism of the traditional gravity equation raised in Anderson (1979) and Bergstrand (1985), and further pursuit of this issue in the seminal paper of Anderson and van Wincoop (2003). We document that accounting for multilateral resistance alone can provide some evidence against the missing globalization puzzle even at the aggregate level, given that the reported distance elasticity declines in the absolute value by about 10% and 17% for total trade and for total manufacturing trade, respectively. At the same time, our results obtained for the traditional specification of the gravity equation emphasizing the importance of the disaggregated trade flows in explaining the distance puzzle largely remain intact: the relative changes measured in the value of distance elasticity for the individual manufacturing industries obtained by these two methods appear to be very similar for all but two industries.

The rest of the paper is organized as follows. In Section 2, we provide a brief review of the related literature and clarify how our paper relates to this foregoing work. Section 3 presents the data used in our study. The model specification is discussed in Section 4. Section 5 presents estimation results obtained for a standard specification of the gravity equation as well as for a gravity equation with multilateral resistance terms. In Section 6, we explore the role of disaggregation in explaining the missing globalization puzzle and illustrate how the aggregation bias, related to averaging out of changes in relative shares of trade observed for individual industries at shorter and at longer distances, could also have contributed to the typical finding of a non-declining trade-deterring role of distance in the existing literature. The final section concludes.

2. Literature review

In this section, we discuss our contribution in relation to the previous literature documenting the missing globalization puzzle in estimated gravity equations and investigating its likely causes. As mentioned in the introduction, the missing globalization puzzle is a rather well established artifact in the empirical trade literature, as recently shown in Disdier and Head (2008) and discussed earlier in Coe *et al.* (2002), Coe *et al.* (2007), and in Leamer and Levinsohn

(1995), *among others*.[2] All these works share a common conclusion that contrary to popular notions of globalization, the world is not "getting smaller". Consequently, this counter-intuitive and resilient result calls for explanations, which were readily provided in trade literature. These can be broadly divided into two categories: explanations based on theoretical models, and explanations based on criticism of the traditional practice of specifying gravity equations in log-linear form, such that these can be easily estimated using the method of least squares.

Coe *et al.* (2002, p. 6) provide in-depth discussion of the following four types of theoretical explanations of the missing globalization puzzle: "the decline in average costs relative to marginal costs of trade over time; the increased dispersion of economic activity; the changing composition of trade; and the importance of relative rather than absolute costs in determining bilateral trade". Next, Brun *et al.* (2005) argue that the observed puzzle may be due to misspecification of the transport cost function in the standard gravity models. Finally, Buch *et al.* (2004, p. 297) argue that stability typically observable over time in the distance coefficient is not altogether surprising because "interpretation of distance coefficients as indicators of a change in distance costs is misleading".

In addition to the studies providing such theoretical considerations, there have been a number of studies arguing that the problem of zero observations inherent in the log-linear estimation approach of the gravity models, and especially various *ad hoc* methods used in the literature to solve this problem, may have created the missing globalization puzzle. For example, Coe *et al.* (2007) suggest solving the missing globalization puzzle empirically by reconsidering a method for estimation of the parameters of the gravity model. In particular, they propose dispensing with the (historically most popular) log-linear form of the gravity equation and directly considering the nonlinear specification. Indeed, using the nonlinear specification of the gravity model, the authors show that the distance coefficient value shows a trendwise decrease over time. At the same time, they conclude that their results "also confirm that the standard log-linear specification does not yield evidence of globalization". Similarly, Felbermayr and Kohler (2006) show that applying a Tobit estimation of the gravity equation may resolve the distance puzzle. Dissecting trade growth after World War II into growth of already established trade relations and growth of newly established trade between countries that had not traded with each other previously, they find that distance plays an ever-decreasing role over time. This, however, has to be viewed in light of their estimation of a gravity model in log-linear form, where such a decline in the value of the distance coefficient was not noticeable. The results of Felbermayr and Kohler (2006) are supported by findings of Rauch (1999) reporting a consistently declining role of distance over the period 1970 to 1990 in the cross-sectional estimates of gravity equations by means of a threshold Tobit model of Eaton and Tamura (1994). The OLS method, also applied in Rauch (1999), indicates a declining role of distance over the period 1970 to 1980 but a subsequent increase in distance effects up to 1990.

2. Other references include Frankel, Stein, and Wei (1997); Head and Mayer (2002); Berthelon and Freund (2004); Buch, Kleinert, and Toubal (2004); Brun, Carrère, Guillaumont, and de Melo (2005); Felbermayr and Kohler (2006), for example.

In our paper, we emphasize the importance of using disaggregated data at the industry level rather than total trade flows, as has been done in the majority of the literature investigating changes in the effects of distance over time. Our results indicate that the declining role of distance that we are able to detect at the level of individual industries tends to be averaged out in the aggregate trade flows, since differential developments within industries could offset each other. In this respect, we provide an additional explanation of the missing globalization puzzle that, in our opinion, has not been sufficiently attended to thus far.

To the best of our knowledge, there is at least one paper (Berthelon and Freund, 2004) that specifically investigates changes in distance effects using disaggregated trade flows at the industry level. Using a sample of 73 countries, Berthelon and Freund (2004) report an estimated change in distance effects for each of 768 industries disaggregated at the four-digit SITC Revision 2 level. Specifically, their results suggest that for most industries the effects of distance stayed constant over the period 1985 to 2000, and for about 25% of industries the role of distance somewhat increased.

Our study differs from the work of Berthelon and Freund in several important respects. In our paper, we investigate the question of the extent to which the missing globalization puzzle holds when estimating gravity equations using not only aggregate trade flows but also trade flows at different levels of disaggregation: (i) for all products combined, (ii) for agriculture, mining and quarrying, and manufacturing products as a whole, as well as (iii) for manufacturing products broken down by 25 three-digit ISIC Rev. 2 industries. To this end, we use the yearly data on trade among 22 OECD countries that encompass the time period 1970 to 2000. This allows us to estimate cross-sectional gravity equations for trade flows at every level of disaggregation and for every year in our sample, and then to directly compare estimates of the distance coefficient in the beginning and at the end of our sample. In contrast to this approach, Berthelon and Freund (2004) do not estimate cross-sectional gravity equations over different periods but instead employ trade growth regressions where they regress observed growth in trade in a particular industry during the observational period on distance and a set of the fixed-effect dummies. This fact limits direct comparison of their results with those reported elsewhere in the relevant literature, as they unfortunately do not report cross-sectional estimates of the distance coefficients over different time periods. Furthermore, their sample period is half as long as ours: it starts in 1985 and ends in 2000. Also, our study employs a much smaller but also more homogeneous sample of countries (22 OECD countries *versus* 73 in Berthelon and Freund (2004)). In the end, our approach produces contrasting conclusions to those reported in Berthelon and Freund (2004). As mentioned above, this discrepancy could be due to differences in the sample period, the choice of countries, and, not least of all, in the method of assessing the changes over time in the values of the estimated distance coefficients.

3. Data

In the empirical analysis, for the dependent variable, we employ the annual bilateral trade flows[3] measured by imports of the years 1970 to 2000 (in US $ million) for all products combined, agriculture, mining and quarrying, manufacturing products as a whole and broken down by 25 three-digit ISIC Rev. 2 industries among 22 OECD countries.[4] For this purpose, the OECD foreign trade figures are appropriately recoded from the original SITC categories.

The data on GNP (in US $ million) are taken from World Bank publications. The distance D_{ij} (in miles) between the countries *i* and *j* is calculated as the shortest line between their economic centers EC_i and EC_j by latitudinal and longitudinal position.[5] The dummy variables cover: adjacency, Adj_{ij}, membership in a preference area: European Union, EU_{ij}, European Free Trade Agreement, $EFTA_{ij}$, the Free Trade Agreement between EU and EFTA, $EU\text{–}EFTA_{ij}$, the North American Free Trade Agreement, $NAFTA_{ij}$, and Asia-Pacific Economic Co-operation, $APEC_{ij}$, in order to capture effects of regional trade liberalisation, ties by language, Lan_{ij}, and colonial-historical ties, Col_{ij}. The value of the dummy variable is 1, if the two countries *i* and *j* have a common land border, belong to the respective preference zone considering the changes over time according to membership, or have the same language or historical ties.[6] Otherwise, the value of the dummy variables is zero.

4. Model specification

We perform our first estimation round using the following traditional specification of the gravity equation:

$$\ln\left(X_{ij}^{a}\right)=\beta_0^a+\beta_1^a\ln\left(Y_i\right)+\beta_2^a\ln\left(\frac{Y_i}{P_i}\right)+\beta_3^a\ln\left(Y_j\right)+\beta_4^a\ln\left(\frac{Y_j}{P_j}\right)+$$
$$+\beta_5^a\ln D_{ij}+\gamma^{a\prime}DUM_{ij}+\eta_{ij}, \qquad (1)$$

where x_{ij}^a denotes the trade flows in the respective ISIC category from a country *i* to a country *j*, the variables Y_i and Y_j denote the GNP of the corresponding countries, P_i and P_j are the population of the exporting and importing countries, respectively, and DUM_{ij} = (Adj_{ij}, EU_{ij}, $EFTA_{ij}$, $EU\text{–}EFTA_{ij}$, $NAFTA_{ij}$, $APEC_{ij}$, Lan_{ij}, Col_{ij})′ is the vector of dummy variables as defined above in Section 3. Observe that (apart from the omitted price terms) equation (1) could be considered as the reduced form of the generalized gravity equation suggested in Bergstrand

3. We deal with the observed zero trade flows in the dependent variables, using the standard practice of substituting those with the minimal value of registered trade of 0.001 US $ million.

4. Our sample includes all member countries in 1993, excluding Iceland and taking Belgium and Luxembourg together.

5. The national capitals were taken as the economic center (EC), except for Canada (Montreal), the United States (Kansas City as a geographical compromise between the East and the West Coast), Australia (Sydney), and West Germany (Frankfurt/Main). The formulae are: $\cos D_{ij} = \sin\varphi_i * \sin\varphi_j + \cos\varphi_i * \cos\varphi_j * \cos(\lambda_j - \lambda_i)$ and $D_{ij} = \arccos(\cos D_{ij}) * 3962.07$ miles for $EC_i = (\varphi_i; \lambda_i)$ and $EC_j = (\varphi_j; \lambda_j)$ with φ = latitude and λ = longitude.

6. 0.5 for second languages and 0.5 for historical ties up to 1914.

(1989), which remains one of the most important studies in the literature that provides a solid theoretical foundation for estimating the gravity equation for trade flows disaggregated by industries. Hence, the *per capita* income of country *i* could be considered as a proxy of the capital-labor endowment ratio of the exporting country, whereas the *per capita* income of country *j* represents the import demand conditions of the importing country.

In our second round, we reestimate the parameters of the gravity equation by explicitly accounting for the presence of the multilateral (and world) resistance terms as suggested in Baier and Bergstrand (2007). In doing so, we acknowledge the fact that our first set of results is based on estimation of the traditional gravity equation, which for almost half a century was a workhorse in the analysis of trade flows. Nevertheless, a more recent strand of the trade literature has questioned the validity of the traditional specification of the gravity equation. First, Anderson (1979) and Bergstrand (1985), and, later, Anderson and van Wincoop (2003) emphasized the role of theoretically-motivated multilateral price resistance terms and eventually argued that a gravity equation is misspecified as long as the corresponding multilateral price resistance terms are neglected while estimating the parameters of the model. Also note that Bergstrand (1989) introduced the price terms into his reduced-form gravity equation specified for disaggregated trade flows. Therefore, in response to the mounting criticism of the traditional gravity equation, we perform a robustness check of our conclusions by estimating the generalized gravity equation of Bergstrand (1989) which explicitly accounts for the price resistance terms. To this end, we employ the recently suggested "*bonus vetus OLS*" approach (see Baier and Bergstrand, 2007). As Baier and Bergstrand (2007) point out, their approach of introducing the price terms into the gravity equation has a number of important advantages over the approach of Anderson and van Wincoop (2003) and that of Feenstra (2002). First, it is based on the standard OLS procedure rather than the more cumbersome nonlinear-least-squares estimation method of Anderson and van Wincoop (2003). Second, the approach of Baier and Bergstrand (2007) allows for explicit estimation of the influence of country-specific variables, e.g., exporter and importer (*per capita*) incomes, on bilateral trade that is otherwise subsumed in the fixed-effects approach of Feenstra (2002). As shown in Bergstrand (1989), it is important to allow for differentiated (*per capita*) income elasticities when estimating gravity equations for disaggregated trade data, as these can be tentatively used in order to address the relative factor intensity of individual industries as well as to provide a tentative classification of the industries into those that tend to produce luxury rather than necessity goods. In addition, as shown in Schumacher and Siliverstovs (2006), the presence and magnitude of the home-market effect can also be inferred from such gravity equations.

The corresponding specification is as follows:

$$\ln\left(X_{ij}^{a}\right) = \boldsymbol{\beta}_0^{a} + \boldsymbol{\beta}_1^{a}\ \ln\left(Y_i\right) + \boldsymbol{\beta}_2^{a}\ \ln\left(\frac{Y_i}{P_i}\right) + \boldsymbol{\beta}_3^{a}\ \ln\left(Y_j\right) + \boldsymbol{\beta}_4^{a} \ln\left(\frac{Y_j}{P_j}\right) + \\ + \boldsymbol{\beta}_5^{a} \ln\ D_{ij}^{MWR} + \boldsymbol{\gamma}^{a\prime} DUM_{ij}^{MWR} + \boldsymbol{\eta}_{ij}, \qquad (2)$$

where the distance and each of the dummy variables are adjusted for the presence of price terms as suggested in Baier and Bergstrand (2007). For example, the adjusted distance variable looks as follows:

$$\ln D_{ij}^{MWR} = \ln D_{ij} - MWRD_{ij} \tag{3}$$

with:

$$MWRD_{ij} = \left[\frac{1}{N}\left(\sum_{j=1}^{N} \ln D_{ij}\right) + \frac{1}{N}\left(\sum_{i=1}^{N} \ln D_{ij}\right) - \frac{1}{N^2}\left(\sum_{i=1}^{N}\sum_{i=1}^{N} \ln D_{ij}\right)\right] \tag{4}$$

where the first term represents the average (log) distance of exporting country *i* to all its trading partners, the second term represents the average (log) distance of importing country *j* from all its trading partners, and the last term represents the world resistance, i.e., the average (log) distance among all trading partners.

Similarly, we adjust each of the dummy variables collected in vector DUM_{ij}^{MWR}, e.g., the transformed EU_{ij} dummy is:

$$EU_{ij}^{MWR} = EU_{ij} - MWREU_{ij} \tag{5}$$

with:

$$MWREU_{ij} = \left[\frac{1}{N}\left(\sum_{j=1}^{N} \ln EU_{ij}\right) + \frac{1}{N}\left(\sum_{i=1}^{N} \ln EU_{ij}\right) - \frac{1}{N^2}\left(\sum_{i=1}^{N}\sum_{i=1}^{N} \ln EU_{ij}\right)\right]. \tag{6}$$

Given the available sample of yearly data that covers the period 1970 to 2000, we estimate equations (1) and (2) — where for simplicity, the time index is omitted — for every year *t = 1970, 1971, … , 2000* using the OLS procedure. The associated standard errors of the regression coefficient estimates were computed using the heteroskedasticity-consistent covariance matrix estimator suggested in White (1980). As a result, we have a time series of 31 cross-sectional estimates of each coefficient. However, since our main concern is to investigate the missing globalization puzzle, we will focus only on the time pattern of the values for the estimated distance coefficient $\hat{\beta}_5^{a,t}$ for *t = 1970, 1971, ..., 2000*. In the following, we will refer to the estimation results from equation (1) as "OLS" and from equation (2) as "BV-OLS". The next section presents the estimation results.

5. Results

In this section, we present and summarize the estimation results of the gravity models described above in equations (1) and (2). As reporting detailed results for every one of the 29 gravity equations estimated for every year from 1970 to 2000 would require extensive space in the form of rather large tables and clearly a great deal of information that extends beyond the scope of our paper, we constrain ourselves to description of the overall goodness-of-fit of the OLS regressions, and comment briefly on the significance of the distance variable in our gravity equations.[7]

7. The detailed set of estimation results is available upon request.

According to our estimation results, the reported goodness-of-fit measure R^2 is consistently high across all industries, both for the OLS and the BV-OLS methods. Moreover, the values of R^2 estimated in the beginning of the period are very close to those estimated in the end of the sample period. For OLS, depending on the individual industry, takes values in the interval between 0.47 and 0.91 with the reported mean value of 0.76 calculated for all 29 cross-sectional regressions estimated for every year from 1971 to 2000. The corresponding values of R^2 for the BV-OLS model are 0.33 and 0.79 with the reported mean value of 0.56. Even so, the values of R^2 tend to be somewhat lower for BV-OLS than for OLS, the distance coefficient estimates obtained by either method are always negative and significantly different from zero at the usual levels.[8] All in all, the empirical success of the standard gravity equations in explaining international patterns of trade also manifests itself in our results. Hence, the results reported below are based on the regression models with rather high explanatory power.

5.1. Estimated distance coefficient

Table 1 presents the estimated values of the distance coefficients obtained from equations (1) and (2) using the cross-sectional data in the beginning and in the end of the available time period. The columns *initial* and *last* contain the estimate of the distance elasticity in the beginning and in the end of our sample period calculated as an average of the corresponding values obtained for the years 1970, 1971, and 1972 and for the years 1998, 1999, and 2000, respectively. This is done in order to smooth the year-to-year variation in our estimates. The values reported in columns *absolute change* are the simple differences between values reported in columns *initial* and *last*. Similarly, the values reported in columns *relative change* are the relative difference between the respective columns that was calculated as the ratio of values in column *absolute change* to modulus values (in order to preserve the sign) reported in column *initial*. Hence, if the "missing globalization" phenomenon were present, then there would be no noticeable and/or systematic changes in the values of the distance coefficient observed over time and, correspondingly, values reported in columns *absolute change* and *relative change* would be close to zero. At the same time, changes with a positive sign indicate a decreasing trade-deterrent role of distance, and changes with a negative sign show an increasing one.

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8. As pointed by a referee, given a rather large number of explanatory variables in our regressions a possible problem of multicollinearity may be present. The typical symptoms of multicollinearity in the regression models are rather low *t*-ratios reported for the estimated coefficients contrasted to rather high explanatory power of the regression that is typically measured by a goodness-of-fit measure R^2. Thus, its main effect is in inflating the reported standard errors (and in lowering the corresponding t-ratios) for coefficient estimates. As a result, a contribution or role of an individual regressor (or a group of regressors) to explanation of the variation in the dependent variable appear less significant (in the extreme case, not significant at all). We have checked whether the described pattern can be found in our regression results paying a special attention to the reported significance level of the estimated distance elasticity — our key interest variable. As described in the main text, all the reported estimates of the distance elasticity are significant at the usual levels. This allows us to conclude that the typical symptoms of multicollinearity are not manifested in our regression models and hence it poses no threat to our results.

Our discussion of the estimated results unfolds as follows. First, we present the results obtained from the traditional specification of the gravity equation given in equation (1). These results are of interest in and of themselves, as they allow us to single out the difference in estimated distance coefficients that can be attributed solely to the use of disaggregated vs. aggregate trade flows. Second, we investigate the robustness of our results by estimating distance coefficients using the *bonus vetus* OLS approach of Baier and Bergstrand (2007), see equation (2).

Table 1 - Estimated distance coefficient

ISIC		OLS			
		Initial	Last	Absolute change	Relative change
	All products	−0.657	−0.742	−0.085	−0.130
1	Agriculture	−0.538	−0.682	−0.144	−0.267
2	Mining. quarrying	−1.142	−1.490	−0.348	−0.305
3	Manufacturing	−0.757	−0.754	0.003	0.004
31	Food. beverages. tobacco	−0.460	−0.484	−0.024	−0.052
321	Textiles	−0.527	−0.641	−0.114	−0.216
322	Wearing apparel	−1.133	−1.164	−0.031	−0.027
323	Leather. leather products	−0.970	−0.527	0.444	0.457
324	Footwear	−0.901	−0.669	0.232	0.258
331	Wood. wood products	−0.973	−1.048	−0.075	−0.077
332	Furniture	−1.333	−1.230	0.104	0.078
341	Paper. paper products	−1.445	−1.199	0.246	0.170
342	Printing. publishing	−1.137	−0.968	0.169	0.149
351	Industrial chemicals	−1.382	−1.028	0.354	0.256
352	Other chemical products	−1.301	−0.860	0.442	0.339
353	Petroleum refineries and products	−1.737	−1.916	−0.180	−0.104
355	Rubber products	−1.214	−1.063	0.151	0.124
356	Plastic products	−1.144	−0.962	0.183	0.159
361	Pottery. china. earthware	−0.825	−0.779	0.046	0.056
362	Glass. glass products	−1.156	−1.119	0.037	0.032
369	Structural clay products	−1.398	−0.949	0.449	0.321
371	Iron and steel basic industries	−1.394	−1.400	−0.006	−0.004
372	Basic non−ferrous metals	−1.316	−1.114	0.202	0.154
381	Fabricated metal products	−1.215	−1.020	0.195	0.161
382	Machinery	−1.232	−1.037	0.195	0.159
383	Electrical machinery	−1.286	−0.991	0.295	0.230
384	Transport equipment	−1.409	−0.918	0.490	0.348
385	Measuring. photo. optical equipment	−1.088	−0.756	0.332	0.305
390	Other manufacturing	−0.938	−0.835	0.103	0.110

Table 1, Continued

ISIC		BV–OLS			
		Initial	Last	Absolute change	Relative change
	All products	−0.934	−0.844	0.090	0.096
1	Agriculture	−1.022	−1.116	−0.094	−0.092
2	Mining. quarrying	−1.493	−2.144	−0.651	−0.436
3	Manufacturing	−0.998	−0.824	0.174	0.174
31	Food. beverages. tobacco	−0.721	−0.767	−0.046	−0.064
321	Textiles	−0.759	−0.881	−0.122	−0.161
322	Wearing apparel	−1.382	−1.515	−0.133	−0.096
323	Leather. leather products	−1.137	−1.227	−0.090	−0.079
324	Footwear	−0.966	−1.365	−0.399	−0.413
331	Wood. wood products	−1.580	−1.619	−0.039	−0.025
332	Furniture	−1.596	−1.516	0.080	0.050
341	Paper. paper products	−2.069	−1.523	0.545	0.264
342	Printing. publishing	−1.296	−1.161	0.135	0.104
351	Industrial chemicals	−1.598	−0.977	0.621	0.388
352	Other chemical products	−1.308	−0.802	0.505	0.387
353	Petroleum refineries and products	−2.156	−2.399	−0.243	−0.113
355	Rubber products	−1.308	−1.161	0.147	0.112
356	Plastic products	−1.509	−1.115	0.394	0.261
361	Pottery. china. earthware	−1.050	−1.304	−0.253	−0.241
362	Glass. glass products	−1.417	−1.226	0.191	0.135
369	Structural clay products	−1.674	−1.388	0.285	0.170
371	Iron and steel basic industries	−1.734	−1.508	0.226	0.130
372	Basic non–ferrous metals	−1.564	−1.198	0.366	0.234
381	Fabricated metal products	−1.433	−1.137	0.296	0.206
382	Machinery	−1.241	−0.966	0.275	0.222
383	Electrical machinery	−1.351	−0.761	0.590	0.437
384	Transport equipment	−1.589	−1.001	0.588	0.370
385	Measuring. photo. optical equipment	−1.087	−0.706	0.381	0.351
390	Other manufacturing	−1.065	−0.907	0.158	0.149

Notes: Columns *initial* and *last* contain estimated values of the distance coefficient β_5 in equations (1) [left panel] and (1) [right panel] computed as the simple average of cross-sectional estimates for the years 1970-1972 and 1998-2000, respectively.
Column *absolute* change contains the difference between values reported in columns *initial* and *last*. Column *relative* change reports the relative difference between values recorded in columns *initial* and *last*. It is calculated as the ratio of values in column *absolute* change to modulus values (in order to preserve the sign) reported in column *initial*.

5.2. Aggregate and one-digit level trade flows

For the results obtained from the gravity equation (1), estimated for the aggregate trade flows as well as for the trade flows broken down by the one-digit ISIC Rev. 2 classification, see the upper-left panel of TABLE 1. The first noticeable finding is that when we look at the aggregate trade flows, the distance elasticity does not show any sign of declining. On the contrary, our estimation results indicate that its (absolute) values increased by about 13 % during the period in question. This observation is consistent with the previous literature that gave rise to the missing globalization puzzle. Nevertheless, when we compare the estimates of the distance elasticity at the beginning and end of our sample for the trade flows disaggregated at the one-digit level, we observe substantial heterogeneity. In both agriculture as well as mining and quarrying, the estimated distance elasticity tends to increase in absolute value, and this increase is much more pronounced than that observed for aggregate trade flows. At the same time, for manufacturing products as a whole, the value of distance elasticity appears to be rather stable over the period in question. Since most trade between OECD countries consists of manufacturing products, this result is also consistent with the outcomes of the earlier studies cited above.

From this exercise, it follows that by estimating a gravity equation using only aggregate trade flows, one may well overlook the heterogeneous development in the underlying disaggregated trade flows. In the next subsection, we compare estimation results obtained for all manufacturing products and for manufacturing products broken down by three-digit ISIC Rev. 2 industries.

5.3. Manufacturing as a whole and three-digit level trade flows

The lower-left panel of TABLE 1 presents estimates of the distance elasticity obtained for each manufacturing industry at the beginning and at the end of our sample. The comparison of these values produces a striking contrast to what we observe for all manufacturing products. Only for two industries — textiles (321) and petroleum refineries and products (353-4) — do we find that the distance elasticity substantially increased in the absolute value. Next, for seven industries including food, beverages, and tobacco (31), apparel (322), wood and wood products (331), furniture (332), pottery, china, and earthenware (361), glass and glass products (362), iron and steel (371), we find that the estimated distance elasticity does not exhibit strong evidence of change in either direction. Hence we conclude that for these industries it remains more or less the same over the observation period. Finally, for the remaining 16 out of 25 manufacturing industries, we find that the reported distance coefficient declined in the range of about 10%-45% when we compare its value in late 1990s-2000 with that in the early 1970s, depending on the particular industry. This finding suggests that the substantial decline of the deterring role of distance observed at the disaggregate level is masked by aggregation. Recall that according to our estimation results obtained for manufacturing products as a whole, the distance elasticity remained constant.

Summarizing, the estimation results presented so far indicate that convincing evidence on the declining trade-deterring role of distance can be found in a standard formulation of a gravity equation, but only as long as one considers disaggregated trade flows. At first glance, this finding may appear somewhat puzzling as the dominant pattern observed at the disaggregated level should also surface at the aggregate level. In Section 6 below, we argue that the discrepancy between what one observes at the disaggregated and the aggregate levels can well be explained by averaging out the effects observed at the less aggregated level in the process of aggregation. But before that, we verify the robustness of the OLS results by comparing them with estimation results obtained using the BV-OLS method.

5.4. Evidence from the BV-OLS approach

The right panel of TABLE 1 presents the estimation results obtained for equation (2). The first and, for our purposes, most important result to be mentioned is that the deterring role of distance appears to decline both for total trade as well as for total manufacturing trade. The corresponding absolute values of the distance elasticity are reported to decline by about 10% and 17%, respectively. This presents a contrast to our findings reported earlier for the traditional specification of the gravity model that omits the multilateral resistance terms and indicates that the persistence of the distance puzzle in the empirical literature could at least partially be explained by the omission of the multilateral resistance in the estimated models. This is a highly interesting finding, since both individual studies addressing the distance puzzle, at least those published in the more distant past, as well as the results reported in Disdier and Head (2008) tend to omit multilateral resistance terms and therefore can be regarded as misspecified.

Our second finding is that the introduction of the multilateral (and world) resistance terms in the gravity equation results in higher values of the estimated distance elasticities. This holds true for the parameter estimates at the beginning and at the end of our sample. Nevertheless, the relative changes in the values of the distance elasticity estimated for the individual manufacturing industries between the beginning and the end of our sample period are very similar for all but two industries (323 and 324) according to both estimation methods.

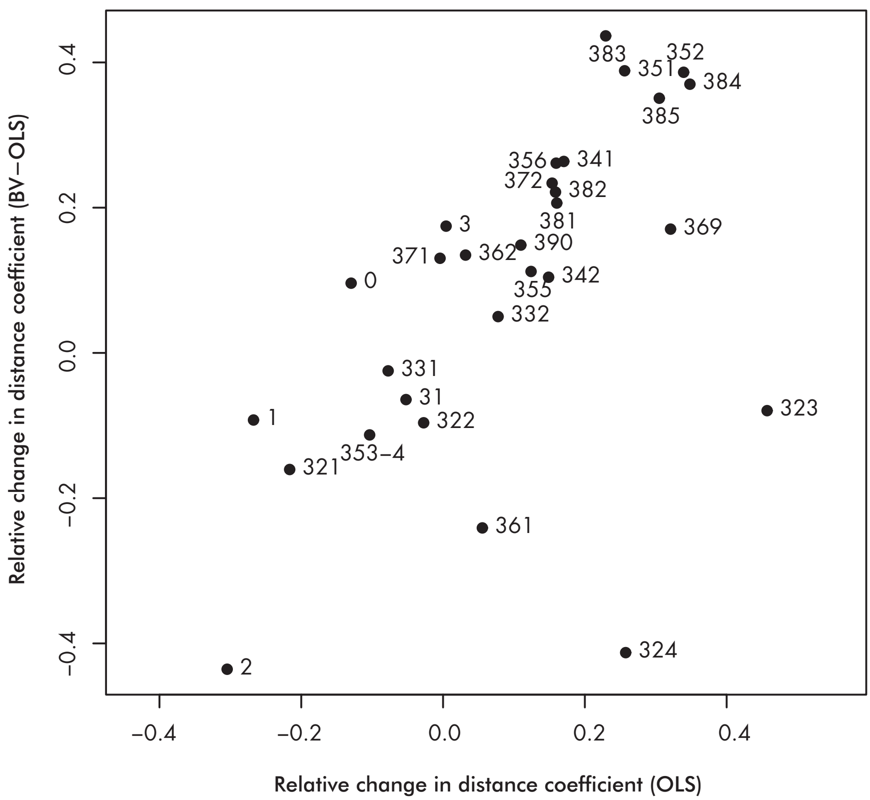
FIGURE 1 contains the cross plot of relative changes in the values of the distance elasticities obtained by the OLS and the BV-OLS procedures. Apart from two outlying cross points — for leather and leather products (323) and for footwear (324), where the discrepancy is widest — the remaining 27 cross points lie rather close to the 45 degree line. Indeed, Pearson's correlation coefficient between the two groups of observations is 0.87 (when industries (323) and (324) are excluded) and 0.63 (when all industries are included). In either case, the null hypothesis that the corresponding correlation coefficient is zero can be decisively rejected at the 1% significance level.[9]

According to the BV-OLS approach, the distance elasticity increased by more than 10% in absolute value in the following four industries: textiles (321), footwear (324), petroleum refineries and products (353-4), and pottery, china, and earthenware (361). At the same time, for five industries including food, beverages, and tobacco (31), apparel (322), leather

9. Pearson's correlation coefficient and the corresponding p-value of the null hypothesis of zero correlation coefficient were calculated using the routine cor.test available in the R programming language, see http://cran.r-project.org/.

and leather products (323), wood and wood products (331), and furniture (332), we find that the estimated distance elasticity does not exhibit strong evidence of change in either direction. For the remaining 16 out of 25 manufacturing industries, we find that the reported distance coefficient declined in the range of about 10%-45% when we compare its value in the late 1990s-2000 with that in the early 1970s, depending on the particular industry. It is worthwhile to emphasize that out of 16 industries where we observed a substantial decrease in the (absolute) value of the distance elasticity by either method, the same 14 industries were selected by both the OLS and the BV-OLS approaches.

Figure 1 – Cross plot of relative changes in the values of the estimated distance coefficients using equation (1) (x-axis) and equation (2) (y-axis)



6. Trade flows and distance

In this section, we provide a tentative explanation of the observed pattern of changes in the value of distance elasticity in the aggregate and disaggregated data. At first glance, we find a puzzling pattern: there appears to be no evidence of a declining role of distance in the aggregate trade flows and rather weak evidence favoring a declining role of distance in all manufacturing flows on the one hand, and rather decisive evidence suggesting a substantial decline in the (absolute) value of distance elasticity for most of the disaggregated manufacturing products on the other. One would naturally expect that a dominant pattern observed at the disaggregated level should also be evident at the aggregate level.

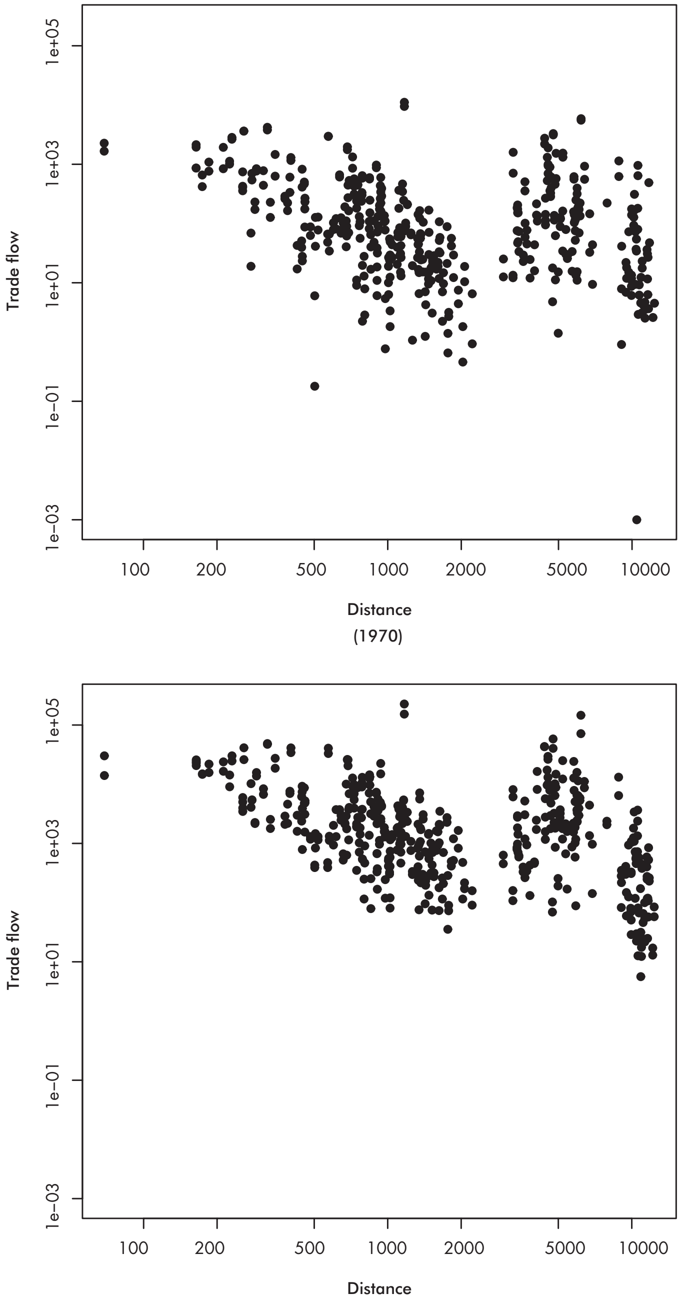
We argue that in order to explain the observed pattern, one should investigate changes in the distribution of trade flows according to the distance associated with these trade flows.

Intuitively, one would expect that the absolute value of the distance coefficient would increase over time as the share of trade at shorter distances gradually increases at the expense of trade at longer distances. And, the other way around, for those industries where we observe a substantial decline in the trade-deterring role of distance, one would expect a (relative) decrease in trade at shorter distances matched by trade enhancement at longer distances.

Lastly, in those industries where the value of the distance coefficient does not seem to change over time, one would expect a roughly constant share of trade occurring at both shorter and longer distances. Now it remains to determine how one can distinguish between shorter and longer distances. Actually, the geography of our dataset suggests a natural divide. To see this, consider FIGURE 2, where the values of observed trade flows for all products combined are plotted against the corresponding distance for the years 1970 and 2000 using the logarithmic scale at both axes. It appears that the trading partners can be divided into two groups: those whose economic centers lie within a distance that is less than 2220 miles and those that lie further away from each other.

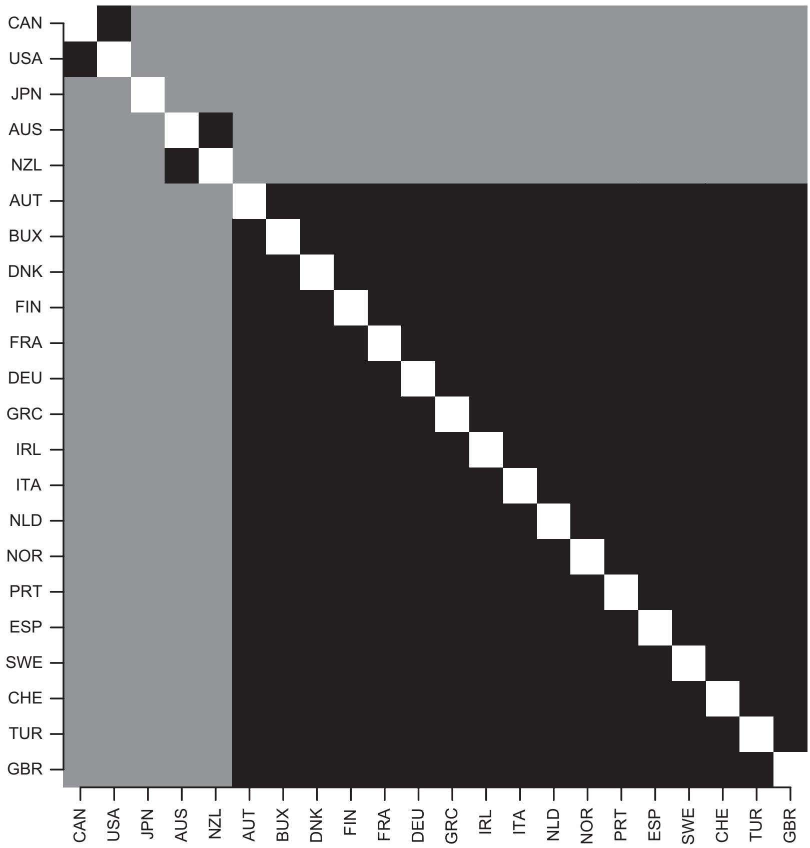
FIGURE 3 summarizes the countries that belong to the former and the latter groups. The former group consists of the pairs of European countries plus such pairs as the USA and Canada as well as Australia and New Zealand (colored in black). The second group of pairs of trading partners are the USA, Canada, Japan, Australia and New Zealand on the one hand and the European countries on the other hand (colored in grey). The latter group corresponds to the trading distances that exceed 2970 to 12400 miles. Note the gap of around 700 miles between the maximum distance between trading partners in the former group and the minimal distance between trading partners in the latter group.

Figure 2 – Cross plot of trade flows for all products combined and distance for 1970 and 2000*



* Both y- and x-axes have the logarithmic scale.

Figure 3 – Pairs of trading partners with shorter (black) and longer (gray) distances between them. The diagonal entries appear in white.*



* The country abbreviation corresponds to the iso-3166 country codes except for Belgium and Luxembourg (denoted BUX).

Next, we compute the shares of trade at the shorter and longer distances observed at the beginning and at the end of our sample period for every ISIC Rev. 2 industry. Similarly to the calculation of changes in the values of the distance elasticity, we compute the average shares of trade for the three years in the beginning of our sample (1970-1972) and for the three years at the end of our sample (1998-2000) in order to smooth the year-to-year variation. The columns *initial* and *last* in TABLE 2 contain the respective shares of trade observed at the longer distances. The column *absolute change* contains the difference between the columns last and initial. Thus, negative figures correspond to a decrease and positive figures indicate an increase in the share of trade between more distant countries.

Table 2 - Share of trade at longer distances

ISIC	Sector	Initial	Last	Absolute change
	All products	0.328	0.329	0.001
1	Agriculture	0.492	0.307	−0.185
2	Mining. quarrying	0.451	0.271	−0.180
3	Manufacturing	0.303	0.332	0.029
31	Food. beverages. tobacco	0.364	0.247	−0.116
321	Textiles	0.248	0.169	−0.080
322	Wearing apparel	0.202	0.167	−0.034
323	Leather. leather products	0.281	0.398	0.117
324	Footwear	0.427	0.232	−0.195
331	Wood. wood products	0.229	0.222	−0.007
332	Furniture	0.041	0.160	0.119
341	Paper. paper products	0.200	0.166	−0.035
342	Printing. publishing	0.284	0.246	−0.038
351	Industrial chemicals	0.272	0.297	0.025
352	Other chemical products	0.315	0.341	0.026
353-4	Petroleum refineries and products	0.127	0.169	0.041
355	Rubber products	0.279	0.258	−0.021
356	Plastic products	0.283	0.164	−0.118
361	Pottery. china. earthware	0.458	0.387	−0.071
362	Glass. glass products	0.241	0.257	0.016
369	Structural clay products	0.174	0.251	0.077
371	Iron and steel basic industries	0.312	0.180	−0.133
372	Basic non−ferrous metals	0.346	0.282	−0.064
381	Fabricated metal products	0.251	0.202	−0.050
382	Machinery	0.313	0.412	0.099
383	Electrical machinery	0.384	0.417	0.033
384	Transport equipment	0.299	0.347	0.048
385	Measuring. photo. optical equipment	0.425	0.548	0.122
390	Other manufacturing	0.482	0.529	0.047

Notes: Columns *initial* and *last* contain the share of trade at longer distances computed as the simple average of corresponding shares for the years 1970-1972 and 1998-2000, respectively.

Column *absolute change* contains the difference between values reported in columns *initial* and *last*.

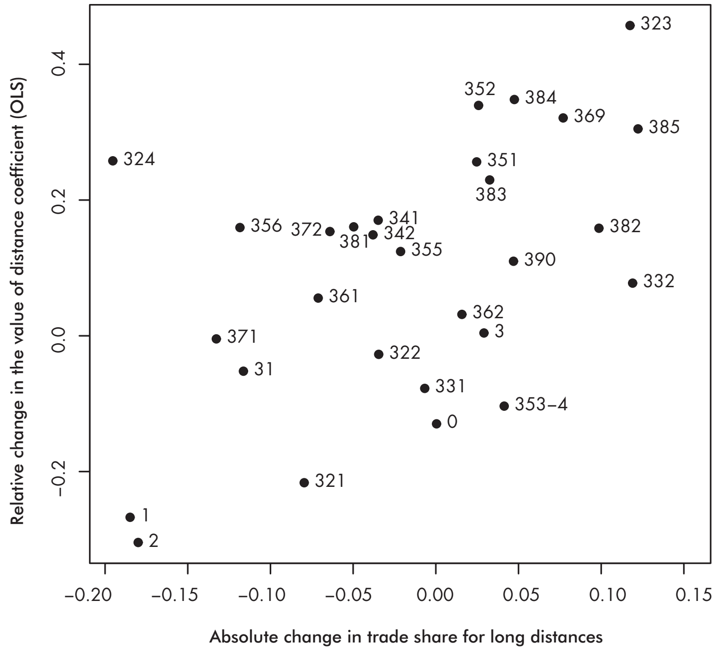
When one compares the changes in the share of trade for all products combined, it is striking that at the aggregate level the share of trade at longer distances does not seem to undergo any changes. At the same time, for agricultural and for mining and quarrying, one observes a tremendous growth in trade at shorter distances at the expense of trade at longer distances. As far as all manufacturing products are concerned, one observes a slight increase in trade at longer distances.

A similar analysis of changes in trade shares for every manufacturing industry is best illustrated in FIGURE 4, where the relative change in the distance elasticity calculated separately by the OLS and the BV-OLS methods is plotted against the absolute change in the share of trade at longer distances. This figure reveals a non-negligible correspondence between those two sets with the respective Pearson's correlation coefficients equal to 0.526[p = 0.003] and 0.534[p = 0.003].[10] Thus, our simple analysis suggests that there is a certain noticeable correlation between industries where we observe positive or negative changes in the value of distance elasticity with changes in the share of trade at shorter and longer distances that took place over the sample period.

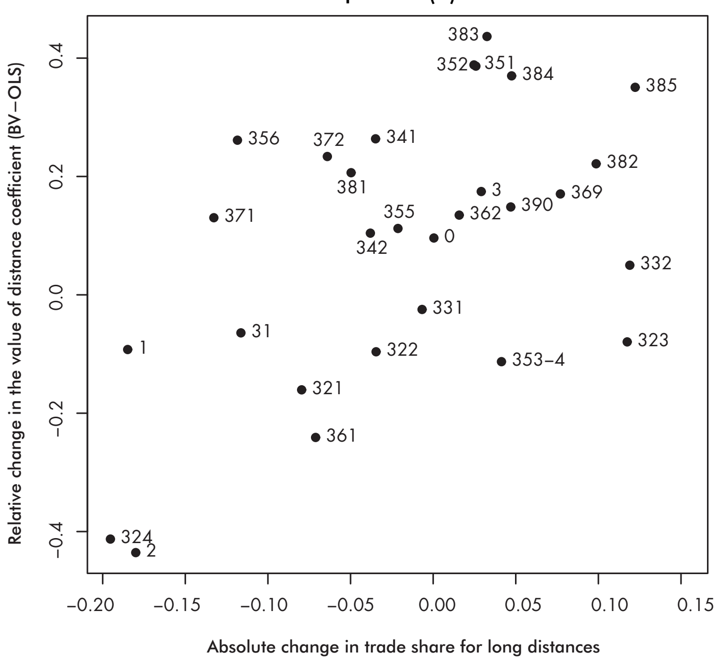
It is worth noting that our finding of a large and statistically highly significant correlation between these measures is rather remarkable given two facts: on the one hand, we measure the effect of distance on trade flows (which we attribute to the changes in transportation costs) controlling for other relevant variables such as income and income per capita of trading partners as well as various mutual cultural, geographical, and institutional arrangements that characterize the trading partners. On the other hand, the simple measure of change in the trade structure over the shorter *versus* longer distances is of course determined by factors beyond the congenital influence of trading costs — for example, by the development in relative total and per capita incomes of closer or more distant countries.

10. We have chosen to report the correlation analysis using the absolute changes in the trade share rather than relative changes due to the fact that all absolute changes are within a similar range. At the same time, the relative changes are influenced by the outlier in the footwear industry (332), where the share of trade at longer distances increased by about 300% whereas for the rest of the industries, changes are within the interval from −45% to 44%. If we omit this outlier and calculate the correlation coefficient between the relative changes in the distance coefficient and in the share of trade for the remaining industries, then the respective Pearson's correlation coefficients are 0.509[p = 0.006] and 0.424[p = 0.024].

Figure 4 – Cross plot of relative changes in the values of the distance coefficient and of absolute changes in the share of trade at longer distances



Equation (1)



Equation (2)

7. Conclusion

In this paper, we suggested an alternative explanation of the missing globalization puzzle typically observable in the gravity equations estimated using aggregate trade flows. First of all, we showed that when estimating the traditional specification of the gravity equation for aggregate trade flows, the estimated values of the distance coefficient show no signs of decline, i.e., the missing globalization puzzle can be also detected in our dataset.

Second, we showed that in the otherwise standard specifications of the gravity equation, the missing globalization puzzle largely disappears when one uses disaggregated data at the industry level. Thus, our first set of results points out that information contained in the disaggregated trade flows can well be lost at the aggregate level.

Third, we suggested an explanation of the, at the first glance, puzzling outcome that depending on the aggregation level in question, one arrives at different conclusions regarding the stability of the estimated distance coefficient over time. The central argument contained in our explanation is that one must investigate the distribution of the trade mass observed over time that takes place at shorter and at longer distances, as the value of the distance coefficient should be affected when countries trade more intensively at shorter or longer distances than before.

The geography of our dataset, which consists of 22 OECD countries, suggests a natural divide. We labelled the country pairs that trade at shorter distances, such as all European countries as well as such neighbors as the USA and Canada and Australia and New Zealand. The rest of the country pairs are separated by either the Atlantic, Pacific, or Indian Oceans and largely represent trade flows between the USA, Canada, Australia, New Zealand, and Japan on the one hand and the European countries on the other, as well as trade flows between those five countries as far as they are not neighbors.

We find that there is indeed a non-negligible and highly statistically significant correlation between the size and sign of changes in the value of the distance elasticity and changes in the shares of trade observed at shorter *versus* longer distances. Thus, changes in the distance elasticity over time do represent differences in the growth of trade between less and more distant pairs of countries that cannot be explained by differences in the growth of total and *per capita* income.

Furthermore, following the recent trend in the theoretical literature on gravity equations, we estimated the gravity model by accounting for the presence of multilateral price resistance. To this end, we use the bonus vetus OLS approach of Baier and Bergstrand (2007). We find that accounting for price terms in the gravity equation alone can provide, at least, some evidence against the missing globalization puzzle. At the same time, our results reported for the disaggregated manufacturing flows on the declining role of distance seems to be largely unaffected by including such multilateral resistance terms in the gravity equation.

The research presented in the present paper could be fruitfully extended in several directions. At present, the traditional specification of gravity equation suggested in the seminal articles of

Tinbergen (1962) and Linnemann (1966) more than four decades ago is no longer the only option for applied trade research. It would therefore be interesting to conduct a comparative analysis of trade-deterring role of distance and, especially, of changes undergone over time as measured using a number of alternative estimation methods that were recently suggested in the literature. In addition to the bonus vetus OLS of Baier and Bergstrand (2007) applied in the current paper, one may consider such alternative estimation methods as Anderson and van Wincoop (2003) and Feenstra (2002), where different ways of accounting for multilateral trade resistance terms are introduced. Similarly, one may cite the approach of Coe *et al.* (2007), which is based on direct estimation of the parameters of the gravity equations using the nonlinear optimization techniques as well as the Tobit model applied in Felbermayr and Kohler (2006). Another relevant extension of the current work is the approach proposed in Head and Mayer (2002). Head and Mayer (2002) point out that distances tend to be systematically overstated in the existing literature and suggest an alternative measure (so-called "effective distance") based on region-to-region proximity which should be a more accurate description of trade distance.

B. S. & D. S.[11]

11. The paper has benefited from comments by Konstantin A. Kholodilin, two anonymous referees, and by participants at the International Conference on Policy Modeling (EcoMod), Berlin, Germany, at the 7th Annual Conference of the European Economics and Finance Society (EEFS), Prague, Czech Republic, at the seminar at the Department of Economic Studies, the Parthenope University of Naples, at the XIIIth Spring Meeting of Young Economists (SMYE), Lille, France, at the seminar at the Swiss Federal Institute of Technology (ETH Zurich), KOF Swiss Economic Institute, Zurich, Switzerland, at the 9th Annual Conference of the European Trade Study Group (ETSG), Athens, Greece, and at the Macroeconometric Workshop, DIW Berlin, Germany.

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