Theoretical and Applied Economics
Volume XXIV (2017), No. 1(610), Spring, pp. 207-214

On the life and death of distance

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Abstract. *Buch et al. (2004) explain the "distance puzzle" suggesting that the distance coefficient only measures the importance of bilateral trade with distant countries relative to closer ones, while a large part of the positive effect of decreased distance costs on trade volumes can be captured in the intercept – expected to be positively influenced. Comparing the course of the intercept when trade growth is included to when removed (using an adjusted specification for the model), we do not seem to find any evidence that the impact of (assumed) decreased distance costs can be traced in the intercept. We also find no "death of distance" in "relative" trade over time, consistent with the majority of literature.*

Keywords: gravity model, distance puzzle, distance coefficient, bilateral trade.

JEL Classification: F14, F17, F60.

1. Introduction

The gravity model has been one of the most prominent empirical models in economics and international trade specifically. However, during the more than half a century it has been around, since it was introduced by Tinbergen in 1962 in his *Shaping the World Economy*, it has gone through ups and downs. Whatever its initial success and wide use in policy, as Bergeijk and Brakman (2010) underline gravity analysis experienced reduced academic popularity in the 1970s and 1980s, due to the lack of a proper economic foundation or, as Anderson (2011, p. 2) puts it, “the absence of an accepted connection to economic theory” rendering the gravity model a respected empirical tool, still problematic in its theoretical foundations (Bergeijk and Brakman, 2010).

Nevertheless, in the last thirty years it has largely regained its popularity thanks to the improvement of its theoretical foundation and the renewed interest of researchers regarding the impact of geography on trade, while the contributions of Anderson, van Wincoop, Bergstrand and Egger have been significant.

In its basic form the gravity model of trade is as follows:

$$T_{ij} = \frac{GDP_i^{b_1} GDP_j^{b_2}}{D_{ij}^{b_3}} \qquad (1)$$

It is commonly estimated in logs including an intercept:

$$\log T_{ij} = int + b_1 \log GDP_i + b_2 \log GDP_j + b_3 \log D_{ij} \qquad (2)$$

where:

$T_{i,j}$ is the bilateral trade between countries i and j, GDP_i the economic mass of country i indicated by GDP_i and $D_{i,j}$ the distance between the two countries. The latter is thought to be used mainly[(1)] as a proxy for transport costs[(2)] and even though it has consistently been statistically significant, the distance effect has proved to be quite controversial among the researchers. Some have argued that as transport costs have been shrinking over time, the same is the case with the significance of distance. This view has often been vividly expressed in titles, such as the famous “The Death of Distance: How the Communications Revolution Is Changing our Lives” (Cairncross, 1997) and “The world is flat” (Friedman, 2005).

Nonetheless, a majority of the research on the gravity model of trade points towards a different direction [(3)]. Leamer and Levinsohn (1995, p. 1387) argue that the distance effect on trade patterns has not been declining as time passes or -putting it simply- opposed to what most would think, “the world is not getting dramatically smaller”. Similarly, Frankel (1997) concludes that there is no evidence suggesting a decrease of the distance coefficient in more than a century of estimates.

Even more surprisingly - for some - Disdier and Head (2008) find that after a small decrease in the distance effect in the period 1870-1950, it even began to rise thereafter, while Carrère and Schiff (2005) argue that the importance of distance has increased for many countries. Berthelon and Freund’s (2008) results from regressions imply that the significance of the distance effect has augmented since 1980, since distance sensitivity has increased for approximately one fourth of the industries and decreased in only a few of them.

The puzzle has often attracted the interest of researchers, who have offered some insight on the relatively constant -or even increasing- coefficient of distance in gravity models of trade over time. Jacks (2009) simply suggests that the increase of the distance effect over time may have been correctly identified and trade costs may have recently not decreased as much as most would think. Leamer and Levinsohn (1995) pose that the increase in trade across oceans can be almost fully explained by the increase in the economic sizes of Europe and Asia emphasizing the decline of the US share of world GDP and the dispersion of economic mass rejecting that the world is shrinking.

Moreover, there have also been more elaborate explanations on the increasing distance coefficient [(4)]. Brun, Carrère, Guillaumont and de Melo (2005) introduce remoteness, as well as an augmented trade barrier function in the gravity equation in order to correct for some misspecification issues in the standard gravity equation which employs distance as a proxy for transport costs or trade barriers. In this way, they find an 11.1 percent decrease in the distance effect on bilateral trade over the period 1962-96 (i.e. coefficient from 1.35 in 1962 to 1.2 in 1996).

At the same time, others have questioned the distance coefficient as a measure that – fully – captures the distance effect or distance costs. Buch, Kleinert and Toubal (2004) characterize the interpretation of the coefficient as an indicator of a shift in distance costs as deceiving showing that proportional changes in distance costs causing proportional changes in trade flows (i.e. DC in $t=1$ are $1/\lambda$ of their level in $t=0$ and trade flows are λ times what they were in $t=0$) do not affect the distance coefficients, but are solely reflected in the intercept. Testing the robustness of these results, they find that even in the case of non-proportionally changing distance costs changes in average levels of exports are reflected in a changing intercept. Of course, they emphasize that in real data this effect is mixed with omitted variables maybe included in the intercept. Further, they argue that the distance coefficient measures how important bilateral economic activities with distant partners are relative to others closer to the home country. Thus, a decrease in the coefficient indicates that trade with the former increases relative to that with the latter, while an increase in the coefficient the opposite.

Motivated by this notion, this paper's aim is to investigate whether increases in bilateral trade due to decreased distance costs are indeed reflected in the intercept of the gravity model. The paper is organized as follows: after this introduction and review of literature, the next section presents the methods and data used, section 3 discusses the results and the last section concludes.

2. Methods and data

We estimate equation (1) both in its standard form and adjusted for growth by removing the percentage increase of both the mean/total trade flow and GDP, that is:

$$AT_{ij}=\frac{AGDP_i^{b_1}\times AGDP_j^{b_2}}{D_{ij}^{b_3}},$$

$$AT_{ij}=T_{ij;t}\times\frac{\sum_{j\neq i}T_{ij;t-1}}{\sum_{j\neq i}T_{ij;t}},$$

$$AGDP_i=GDP_{i;t}\times\frac{\sum_{i=1}^{n}GDP_{i;t-1}}{\sum_{i=1}^{n}GDP_{i;t}}\ \text{(same for j)}$$

n the number of all pairs of countries worldwide [(5)] and t the time trade takes place (where t=0 the base year). In this way, the equation accounts only for the changing significance of trade with close/distant countries and not possible increases in trade flows due to decreased distance costs.

To elaborate on our rationale, since bilateral trade is adjusted for world trade growth [(5)], the two countries' GDPs have also to be adjusted for world GDP growth [(5)], on the grounds that the removed trade growth would stem not only from reduced distance costs (which we want to account for), but also from GDP growth, which Buch et al. (2004) have also assumed to be zero in their analysis. In this way, the equation accounts only for the (intertemporally changing maybe) relative significance of trade with distant/close countries (with the part of the distance effect reflected in the intercept absorbed), but not for the overall increase in trade; the average trade flow and average GDP remain constant.

For each year (apart from the first one), trade flows and GDPs are adjusted for growth relative to the previous used year, that is 10-year-growth, so we are going to compare how the intercept changes from a year's standard model to the next year's standard versus the next year's adjusted model. According to Buch et al. (2004) we expect the intercept to increase more (or fall less) when remaining in the standard model opposed to when we switch to the adjusted one, where the suggested positive effect of reduced distance costs on the intercept has been removed (average level of exports remains constant).

Several standard dummy variables for common official language, contiguousness, present or past colonial relationship, common GATT membership, membership in common regional trade agreement are implemented into the model to mitigate omitted-variable bias [(6)], so equation (2) is estimated in the following form (in both adjusted and standard form):

$$\log T_{ij} = int + b_1 \times \log GDP_i + b_2 \times \log GDP_j + b_3 \times \log D_{ij} + b_4 \times comlangoff_{ij} +$$

$$+ b_5 \times contig_{ij} + b_6 \times colhist_{ij} + b_7 \times comgatt_{ij} + b_8 \times rta_{ij} \qquad (3)$$

Data comes from the CEPII 'light' gravity dataset. The model is estimated with cross-section OLS adding \$1 million to all known zero trade flows [(7)] for years 1966, 1976, 1986, 1996 and 2006 using all country pairs (i.e. 9,373) for which there is available data.

3. Results

The results for both the traditional and the adjusted model are presented in the tables below:

Table 1. *Adjusted model*

	1966	1976	1986	1996	2006
Intercept	0.30542	-0.5749*	-1.8518***	-3.3842***	-4.9791***
	(1.143)	(-2.171)	(-6.846)	(-11.472)	(-16.351)
$Log(AGDP_i)$	0.2095***	0.3777***	0.4539***	0.5714***	0.6670***
	(21.878)	(39.957)	(47.314)	(59.215)	(66.965)
$Log(AGDP_j)$	0.2177***	0.3642***	0.4024***	0.4835***	0.5441***
	(21.774)	(38.248)	(43.694)	(55.832)	(59.522)
$LogD_{ij}$	-0.2382***	-0.4137***	-0.4128***	-0.4566***	-0.4594***
	(-8.634)	(-14.901)	(-14.457)	(-14.222)	(-13.864)
Contiguous	0.0836	0.0532	0.2983*	0.3335**	0.6137***
	(0.668)	(0.437)	(2.437)	(2.668)	(4.785)
Common official	0.1012*	0.1956***	0.1947***	0.3432***	0.4048***
language	(1.983)	(3.917)	(3.863)	(6.659)	(7.665)
Colonial link	0.9417***	1.0818***	1.2382***	1.0354***	0.8354***
	(7.033)	(8.271)	(9.406)	(7.7)	(6.054)
Common GATT	0.0677$^{\cdot}$	-0.0003	0.1027**	0.1106*	0.3175***
membership	(1.647)	(-0.007)	(2.664)	(2.428)	(6.183)
Regional Trade	0.9339***	1.2300***	1.4026***	0.9645***	1.1403***
Agreement	(5.147)	(9.406)	(12.966)	(2.428)	(15.628)
R squared	0.1132	0.2845	0.3629	0.4441	0.5056

Note: ***, **, * and $^{\cdot}$ indicate significance at the 0.1%, 1%, 5% and 10% levels respectively.

Table 2. *Standard model*

	1966	1976	1986	1996	2006
Intercept		-1.0486***	-2.3262***	-3.4561***	-5.7203***
		(-3.876)	(-8.506)	(-12.083)	(-19.385)
$Log(GDP_i)$		0.3696***	0.4409***	0.5593***	0.6577***
		(39.987)	(49.239)	(66.930)	(75.630)
$Log(GDP_j)$		0.3642***	0.4048***	0.4960***	0.5553***
		(38.289)	(44.296)	(59.311)	(63.349)
$LogD_{ij}$		-0.4137***	-0.4297***	-0.5469***	-0.5495***
		(-14.887)	(-14.159)	(-17.605)	(-17.248)
Contiguous	Same as adjusted	0.0561	0.2914*	0.3194**	0.6207***
		(0.462)	(2.400)	(2.650)	(5.052)
Common official		0.2050***	0.2224***	0.3820***	0.4324***
language		(4.102)	(4.444)	(7.691)	(8.554)
Colonial link		1.0836***	1.2133***	0.9349***	0.7259***
		(8.286)	(9.290)	(7.209)	(5.489)
Common GATT		-0.0225	0.1613***	-0.0475*	0.2627***
membership		(-0.587)	(4.238)	(-1.080)	(5.337)
Regional Trade		1.2081***	1.2899**	0.8425***	0.9623***
Agreement		(9.237)	(11.994)	(10.231)	(13.715)
R squared		0.2846	0.3730	0.4832	0.5461

Note: ***, **, * and $^{\cdot}$ indicate significance at the 0.1%, 1%, 5% and 10% levels respectively.

Table 3. *Intercept changes*

	1966 to 1976	1976 to 1986	1986 to 1996	*1996 to 2006*
Standard to standard (growth included)	-1.3540	-1.2780	-1.1298	*-2.2642*
Standard to adjusted (growth removed)	-0.8803	-0.8056	-1.0576	*-1.5230*

Firstly, we notice that the distance coefficient increases from 1966 to 1976 and again from 1986 to 1996, while remains constant for the other two periods, which suggests no “death of distance” in terms of “relative” trade, consistent with most studies. Secondly, regarding the issue in question, even if we disregard the decreasing trend of the intercept in both models -which may stem from other factors than the distance effect, such as the increasing R^2 over time or omitted variables bias- this trend does not appear to be weaker when growth included, whereas according to Buch et al. (2004) analysis the increase in trade flows due to decreasing distance costs would have a positive/increasing effect on the intercept. In fact, growth included the intercept experiences consistently larger decreases compared to when growth is removed.

4. Conclusions

We find the distance coefficient to be persistent in both specifications of the gravity model suggesting no “death of distance” in ‘relative’ trade over time, consistent with the majority of literature. Furthermore, contrary to Buch et al. (2004) analysis suggesting that an overall increase in trade volumes due to a decreasing distance effect would have a positive-increasing effect on the intercept, we do not seem to find any evidence that an (assumed) decreasing distance effect is captured in the intercept. In fact, the intercept experiences consistently larger decreases when growth is included opposed to when removed. All in all, we can conclude that: a) either the distance effect has remained “alive and well” in terms of total trade volume as well or b) if the distance effect has decreased, as most would think, our analysis of the data does not seem to trace its impact in the intercept of the gravity model.

Notes

(1) Even though the basic intuition is that distance affects transports costs, Linnemann (1966) and Frankel (1997), for example, see three kinds of costs related to the distance effect on trade; shipping costs, time elapsed in transporting and cultural unfamiliarity, while Portes and Rey (2005) argue a relation with information costs.

(2) Whatever the scarcity in transport costs data, which is the factor having often led to the employment of distance as a proxy, there are also studies that have directly used the transport costs, such as Baier and Bergstrand (2001), Hummels and Lugovskyy (2006), Hummels (1999), Limao and Venables (2001), Estevadeordal, Frantz and Taylor (2003).

(3) Of course, a decline in the distance coefficient has been found for earlier years. Jacks (2009) documents clear declines in the importance of this effect over time during the nineteenth century.

(4) The efforts so far are not in any case limited to the ones reported here. For some more explanations on the distance puzzle, see Coe, Subramanian and Tamirisa (2007), Boulhol and Serres (2009), Lin and Sim (2012), Buehler and White (2014), Larch et al. (2015).

(5) In practice we use all 9,373 available pairs, so it is those pairs' trade growth and the respective countries' weighted GDP growth (since it depends on how many times each country is in a pair in the data).

(6) Ideally, the dummy variables would also be adjusted for increases in trade agreements etc., but their nature as dummy variables does not allow for it.

(7) That is, we use ln(1+Tij) in the estimation. Silva and Tenreyro (2006) propose the use of the Poisson pseudo-maximum likelihood (PPML) estimator to cope with zero-values and error heteroscedasticity, which is inconsistent with OLS estimation. However, as Gómez-Herrera (2012) underlines, heteroscedasticity does not affect the coefficients' estimates, but only their variance, while Martinez-Zarzoso (2013) finds the PPML estimator to be outperformed by OLS in out of sample forecast. Finally, Egger (2005) suggests that the Hausman-Taylor model be considered for estimation of cross-section gravity models.

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