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Explaining the Volume of North-South Trade in Ireland: A Gravity Model Approach*

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Abstract: We address the question of whether the volume of manufacturing trade between Northern Ireland and the Republic of Ireland is more or less than might be expected in the light of international experience. We estimate a gravity equation for bilateral manufacturing trade between 28 developed countries from 1970 to 1992. Using the results as benchmark, we find that North-South trade in Ireland is greater rather than less than might be expected. The finding is robust with respect to a wide range of alternative specifications and alternative ways of measuring the key variables.

I INTRODUCTION

Economic considerations have usually not been primary in debates on the political and constitutional relationships between the two jurisdictions on the island of Ireland. When economic issues are raised, the volume of trade between Northern Ireland and the Republic is often seen as a key variable. In particular, it seems to be widely believed, at least in the Republic, that the current level of trade is "abnormally" low by international standards, and could

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be expected to rise significantly in the event of a permanent political settlement. For example, a recent position paper by the IBEC-CBI Joint Business Council (1998) asserts that, in spite of significant recent growth, "cross-border trade on the island remains lower than that between comparable EU neighbour states".[1]

However, no study to date has tried systematically to assess the level of North-South trade in an international context. In this paper we attempt to do just that. We begin, in Section II, by documenting the trends in North-South trade in recent decades. This raises the question of what benchmark should be used to compare the volume of trade between the two parts of Ireland with that between them and the rest of the world. We consider various *ad hoc* benchmarks before turning to an alternative approach, with a sounder theoretical basis. This is the "gravity" model, which postulates that bilateral trade flows should be positively related to the GNP levels of the countries involved and negatively related to the distance between them. It has proved successful in a variety of applications. In the remainder of the paper, we review the literature on this model and report the outcome of using it as a standard of comparison for assessing the magnitude of North-South trade in an international context.

II A FIRST LOOK AT THE DATA

In this section we provide an overview of the trading relationship between Northern Ireland (NI) and the Republic of Ireland (ROI). This review will help clarify the issue of whether North-South trade is low or high and will help to motivate the more formal analysis in the rest of the paper.

Figure 1 shows the share of ROI trade accounted for by the major trading partners from 1970 to 1992. Trade in this context, and throughout the paper, is defined as the sum of imports and exports of manufactured products (specifically, SITC codes 4 to 9). The main trends are the relative decline in importance of trade with mainland Great Britain (though it still accounts for 33 per cent of the total in 1992) and the increasing importance of other EU countries. In contrast, trade with both North America and Northern Ireland has remained approximately constant as a proportion of total trade, at about 9 per cent and 4 per cent respectively.

Figure 1 suggests that trade with Northern Ireland is a relatively small proportion of total ROI trade. It is presumably this fact which has motivated some to suggest that there is substantial scope for increasing the level of trade between North and South. However, comparisons on the basis of trade shares alone are open to misinterpretation. Any comparison should take account of the

1. Bradley and Hamilton (1999) give further references, including a more pessimistic assessment of the potential for growth in North-South trade by Scott and O'Reilly (1992).

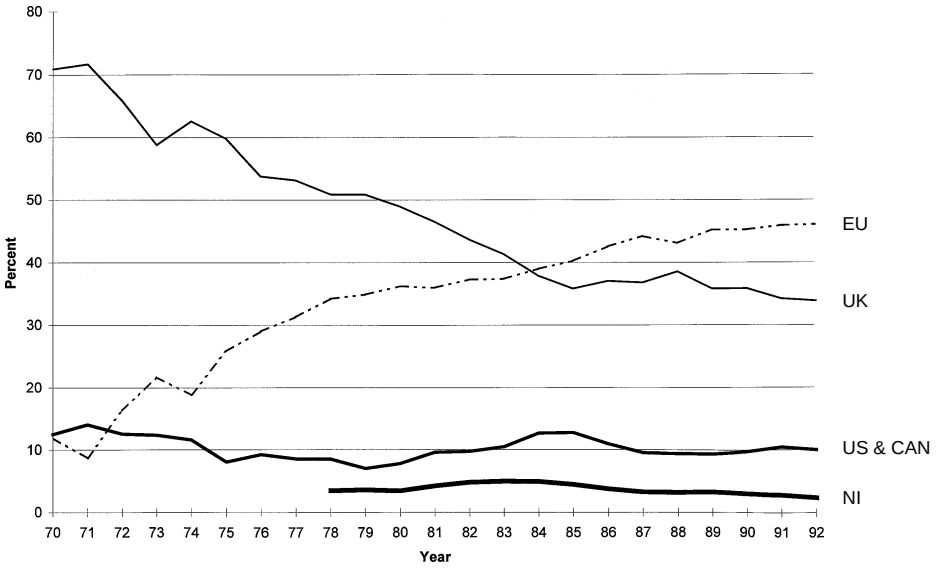

Figure 1: *Irish Manufactured Trade by Partner (Per Cent of Total Trade: SITC 4-9)*

relative size and income of the trading partner. We would expect that, other things being equal, the Republic would trade more with a richer country than with a poorer country. This is so, because we would expect that a richer population would be in a position to buy more (per capita) of the goods produced in the Republic. Similarly, we would expect that the Republic would trade more with a larger country (in terms of population) than with a smaller country, for a given level of income per head.

Figure 2 shows the trend of real GDP per capita (measured in 1990 US dollars) in Northern Ireland, the Republic of Ireland and the United Kingdom as a whole from 1970 to 1992.[2] Real GDP per capita was almost the same in ROI and NI over the sample period, but was up to 50 per cent higher in the UK over the same period. On this basis, we might expect NI to account for a lower share of ROI trade than Britain. Furthermore, the population of Britain is approximately forty times that of Northern Ireland. Again we would expect that this would cause trade with Britain to be substantially higher than that with Northern Ireland. Combining these two factors (population size and GDP per head) we

2. Real GDP per capita is expressed in 1990 US$. The data for ROI and UK come from *International Financial Statistics*, published on CD-ROM by the International Monetary Fund. The data for NI come from the *Regional Statistics of Northern Ireland*. See Section IV for a more detailed discussion.

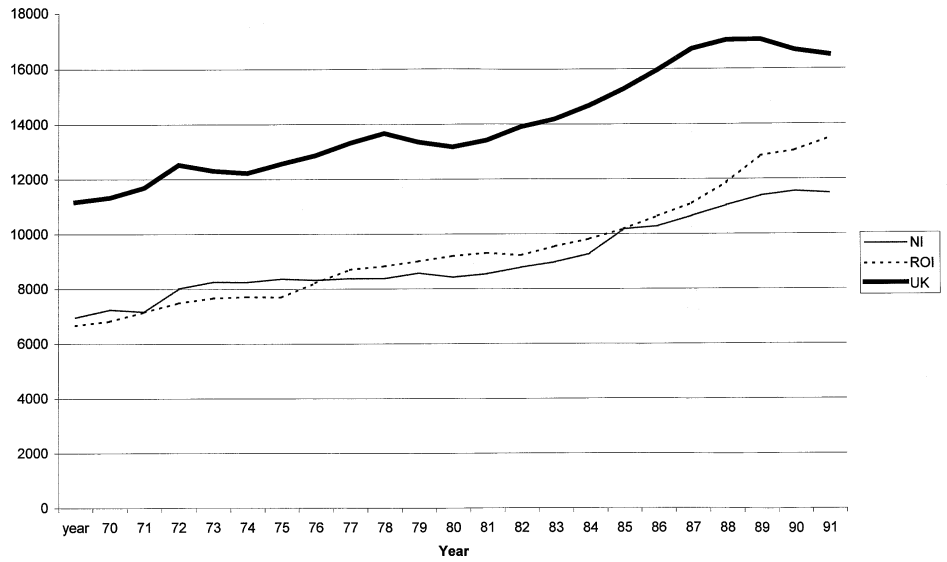

Figure 2: *Real GDP Per Capita (1990 US$)*

might expect that ROI trade with Britain should be up to sixty times trade with Northern Ireland, whereas actual trade with Britain is only ten times actual trade with Northern Ireland. In other words, North-South trade should account for half a per cent of total ROI trade if it was determined on the same basis as trade with Britain. This suggests that existing North-South trade is actually greater rather than less than might be expected.

Of course the analysis so far is very simplistic. Trade with Britain may not be a fair benchmark given the historical relationship between ROI and Britain. A better benchmark would be the average relationship between the Republic and all of its major trading partners. We illustrate this relationship in Figure 3. This figure plots ROI exports to each country versus the destination country's real GDP in 1989.[3] The solid line shows the average relationship, i.e., the fitted line from a regression of (log) exports on (log) GDP. Most countries are close to the fitted line, so GDP is a good predictor of the share of trade. Northern Ireland however is a clear outlier. It appears that we export much more to Northern Ireland than we do to other countries, controlling for the size of the recipient's economy. In other words, the Republic exports far more to the North than it does on average to countries of similar size. Once again, this result suggests that North–South trade is already quite high and that there may not be much scope to increase it.

3. Exports and GDP are in terms of 1990 US dollars and both variables are expressed as logs.

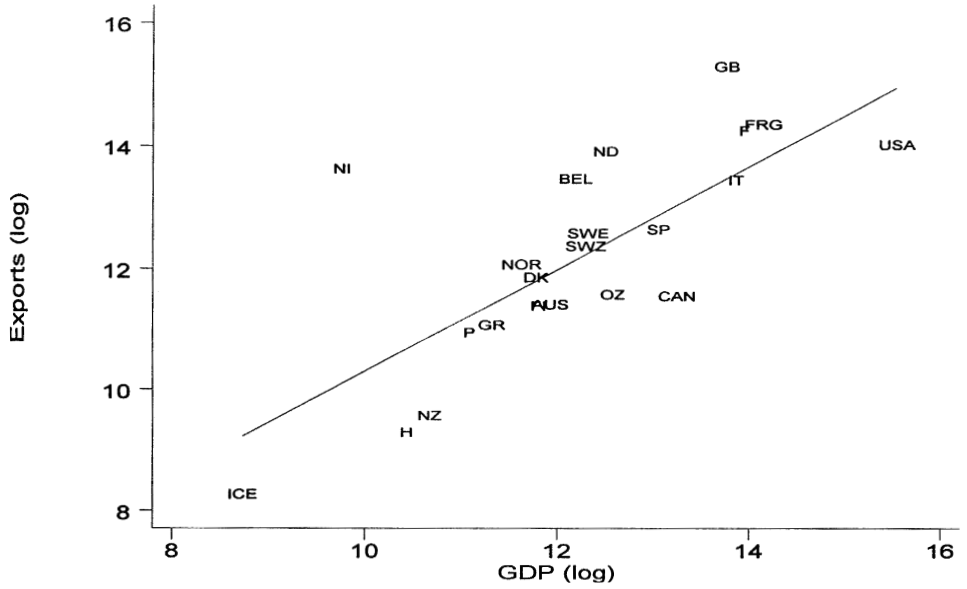

Figure 3: *Irish Exports vs Destination Country GDP in 1989*

Before we can state this conclusion with any degree of confidence, however, we must note that there are many other variables that could, plausibly, exert a significant influence of trade flows. For example, we might expect that two countries which are physically close, speak a common language and share a border would trade more with each other than with other countries. In fact if we look closely at Figure 3 we can see that some of the outliers might be explained by these other variables. For example, the two largest positive outliers (NI and GB) are also those countries that are closest to the Republic and with whom we share a common language. Similarly, some of the negative outliers (such as New Zealand and Hungary) are very far from the Republic either physically or culturally.

To account correctly for trade flows we need to estimate a model that includes all the variables that may influence trade flows. Only then can we correctly judge whether North-South trade is truly an outlier. The model that economists typically use to account for trade flows between countries is known as the gravity model.[4] We outline the rationale of the model in the next section and report estimates of it in Section V.

4. It turns out that the relationship reported in Figure 3 is really a very simple version of the gravity model.

III THEORETICAL FOUNDATIONS OF THE GRAVITY EQUATION

Newton's law of gravity states that the gravitational attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. According to Alonso (1987), it was a Princeton astronomer, James Q. Stewart, who in the 1940s first proposed that similar specifications could have wide application in the social sciences. He found many strong correlations using this functional form, replacing mass by population and gravitational force by some measure of interaction between locations. The gravity equation was subsequently applied to many issues in regional and location economics, with considerable empirical success.

Tinbergen (1962) appears to have been the first to apply the equation to international trade flows, and many others have followed. In this context, the dependent variable becomes the level of bilateral trade between pairs of countries, the explanatory variables may include population and income, and the Newton-Stewart inverse quadratic functional form is typically replaced by a general double-log specification. Equations of this type have now been estimated for a wide range of countries, time periods and levels of disaggregation, and the results have been extremely successful in empirical terms. Leamer and Levinsohn (1995) claim they provide "some of the clearest and most robust empirical findings in economics". In particular, estimates of the elasticity of trade flows with respect to distance tend to cluster around –0.6. (Recall that the corresponding elasticity in Newton's law is –2.)

Paradoxically, as both the surveys of Alonso and Leamer and Levinsohn note, the empirical success of the gravity equation has not made it popular or widely accepted. The problem has been that, at least until fairly recently, the equation has seemed totally *ad hoc*, lacking any theoretical foundation. It also seems to bear no relation to traditional trade theory of the Ricardian and Heckscher-Ohlin types, which have primarily focused on explaining the pattern rather than the volume of trade.

However, in recent years there has been renewed interest in providing theoretical underpinnings for the gravity equation. The first suggested theoretical foundation was by Anderson (1979), who showed that a gravity equation for trade flows was implied by the Armington specification, in which all goods are country-specific. This specification in itself is neutral with respect to alternative theories of international trade. By contrast, Helpman (1987) claimed that gravity equations allow us to discriminate between alternative trade theories. General equilibrium models with monopolistic competition (such as those of Helpman and Krugman (1985)) predict that consumers in each country will wish to import differentiated products from all other countries. As a result, trade volumes should be related to the size of both the importing country

(reflecting demand) and the exporting country (reflecting the number of varieties produced there). By contrast, the standard perfectly competitive Heckscher-Ohlin model of trade predicts that, provided all goods are produced in all countries and factor prices are equalised internationally, trade volumes should be independent of country size. Helpman found that a variant of the gravity equation gave a close fit to bilateral trade data for a sample of OECD countries and he concluded that this provides support for the monopolistic competition model.

However, Helpman's conclusions have been challenged on both empirical and theoretical grounds. At an empirical level, Hummels and Levinsohn (1995) found that his specification worked almost as well as a predictor of trade flows between non-OECD countries, for which the assumption of monopolistic competition is much less plausible. At a theoretical level, Deardorff (1998) shows that a gravity equation can easily be motivated in a Heckscher-Ohlin model without assuming product differentiation. The trick is to relax the assumption that factor prices are equalised internationally, so that countries specialise in producing different goods. Product differentiation on the supply side, and a preference for consuming all goods on the demand side, then imply an equation of the gravity type. This highlights that the key to gravity-type trade is that countries produce different goods (though not necessarily very different ones); whether they do so because of product differentiation by monopolistically competitive firms (as assumed by Helpman) or merely because of specialisation (as assumed by Anderson and Deardorff) is not crucial.

Debate on these issues continues. A recent paper by Evenett and Keller (1998) appears to undermine Deardorff's arguments by confirming that the gravity equation works rather better between countries for which intra-industry trade is more important. Since such trade is presumptively based on imperfect competition, this can be interpreted (and is by Helpman (1998)) as supporting the view that the gravity model is inextricably linked to imperfect competition. However, pending further work on this topic, it still seems that the best conclusion to draw is that of Deardorff: "I suspect that just about any plausible model of trade would yield something very like the gravity equation, whose empirical success is therefore not evidence of anything, but just a fact of life."

These theoretical debates are relevant to the issue of what functional form should be chosen for the gravity equation. Monocausal theoretical models, whether of the Helpman imperfectly competitive variety or the Deardorff perfectly competitive type, typically lead to a specification where the volume of trade is related to the levels of incomes in the exporting and importing countries. Distance is always added, of course, usually with *ad hoc* references to the importance of transportation and communications costs. This implies the specification:

$$\log x_{ij} = \alpha(\log Y_i + \log Y_j) + \gamma \log d_{ij} \qquad (1)$$

where x_{ij} is the volume of trade (imports plus exports) between countries i and j; d_{ij} is the distance between them; and Y_i is the GDP of country i. In applied work, it is customary to add the levels of population as well as those of GDP. This is equivalent to relating trade flows to both GDP and GDP per capita. Bergstrand (1989) derives such a specification from a general-equilibrium model with two differentiated-product industries and two factors, which combines the Heckscher-Ohlin model of inter-industry trade and the Helpman-Krugman model of intra-industry trade based on monopolistic competition. Yet another equivalent specification is to relate trade flows to population and income per capita, and, because of its ease of interpretation, we have chosen to adopt this specification:

$$\log x_{ij} = \alpha[\log(Y_i / P_i) + \log(Y_j / P_j)] + \beta(\log P_i + \log P_j) + \lambda \log d_{ij} \qquad (2)$$

where P_i is the population of country i. The implied coefficients for the alternative specifications can immediately be deduced from estimates of (2): α and β-α are the implied coefficients of log Y and log P respectively; while β and α-β are the implied coefficients of log Y and log (Y/P) respectively.

The final point to note is that, in many applications of the gravity equation, including the present one, the main interest lies not in the coefficients from but rather in the coefficients of various dummy variables which are appended to it. In a typical early application, Aitken (1973) considered the effects of EEC and EFTA membership on trade flows by estimating a gravity equation for bilateral trade flows and including dummy variables which equalled unity when both countries were members of one or other regional grouping. Many applications in the same spirit have been carried out, such as Frankel, Stein and Wei (1998), who use the gravity equation to explore the effects of preferential trade agreements on trade flows; Eichengreen and Irwin (1998), who use it to investigate the historical path dependence of trade patterns; and Dell'Ariccia (1998), who uses it to assess the effects of exchange-rate volatility on trade flows. The equation has also been used in a forecasting way, as in Hamilton and Winters (1992) and Baldwin (1994), who use it to estimate the potential for trade between the EU-15 and the former communist countries of Eastern Europe. McCallum (1995) used it on Canadian and US data to estimate the difference between inter-regional and international trade flows and found that the national border inhibited trade much more than state or provincial boundaries. Engel and Rogers (1996) performed a similar exercise for prices rather than trade flows, and estimated that the Canada-US border was "equivalent" to an intra-national distance of 1,700 miles. The approach we adopt in the remainder of this paper is very much in the spirit of these studies.

IV DATA DESCRIPTION

Our main sample covers 28 developed countries[5] from 1970 to 1992, drawn from the World Trade Database compiled by Statistics Canada. (See Feenstra, Lipsey and Bowen, 1997.) Not every country is observed for every year due to breaks in series, missing values etc. (For example, Portuguese data are available only since 1983.) In total there are 13,038 observations on annual bilateral trade flows. Our sample including Northern Ireland adds data on North-South trade from 1978 to 1992 (trade figures for Northern Ireland compatible with the World Trade Database only became available in 1978), bringing the total to 13,053 observations. We did not have any data on trade between Northern Ireland and other countries.

We consider trade in manufactured goods only (equivalent to SITC categories 4-9). Ideally, we hoped to obtain separate import and export values for each country. We would have preferred to use each country's reported import values to calculate bilateral trade flows, as these are generally more accurate than export values. The available data however, being already on a bilateral basis, did not distinguish between imports and exports. Also, for each country pair, we had two recorded bilateral trade flows. Rather than taking an average of the two, we chose to include both in our dataset. The original data were expressed in current prices in US dollars. To obtain real values of trade, for each year, for each country pair, we took an average of their import and export deflators[6] (expressed in 1990 US dollars), and divided this into their nominal bilateral trade value. For Northern Ireland, we obtained nominal trade values (in Irish pounds) from the Trade Statistics of Ireland. We converted to dollars using the IR£/US$ exchange rate for each year. We converted to real terms using the UK import and export deflators, as separate price deflators are not available for Northern Ireland.

To facilitate comparison across countries and across time we need GDP expressed in a common currency and common base year, i.e., using a common set of prices. Ideally, GDP for all countries should be measured relative to some set of international prices that are standardised and consistent across all countries and time periods. Such data are provided in the Penn World Tables for most countries in the world, but unfortunately not for Northern Ireland. So in order to make our GDP data comparable, we had two options. The first (method A) involves obtaining nominal GDP for each country, expressed in national

5. Australia, Austria, Belgium-Luxembourg, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Malta, Netherlands, New Zealand, Portugal, Norway, Singapore, Turkey, Spain, Sweden, Switzerland, UK and US. Due to data limitations Belgium and Luxembourg are combined.

6. *Source: International Financial Statistics*.

currencies, deflating them by the appropriate national GDP deflator for some common base year, and then converting to US dollars using the nominal exchange rate for that base year. The alternative (method B) is to obtain nominal GDP figures for each country, convert them to US dollars using the nominal exchange rate for each year, and then deflate them all using the US GDP deflator. If Purchasing Power Parity (PPP) held, then the GDP figures obtained under both methods would be the same. As PPP does not hold, we were forced to choose one method. We chose method A, because it accounts for changes in the price level and production basket of each country, whereas the second method implicitly assumes that all countries produce the same goods as the US does. Method A has the disadvantage, however, that it may be sensitive to abnormal exchange rate movements in the base year (1990). We experimented using different base years with method A and also using method B. It turns out that there was no significant difference in any of our results. Therefore, in what follows, we report only the results using real GDP in 1990 US dollars calculated by method A.

For Northern Ireland, we obtained nominal per capita GDP from the Regional Statistics of Northern Ireland. As there are no regional GDP deflators available for the UK, we used the UK GDP deflator to convert the data to real terms (base 1990). We then applied the 1990 UK/US nominal exchange rate (period average) to convert to dollars.

The other variables are relatively straightforward. Distances are measured by great circle air distances between capital cities.[7] The dummy "common border" takes the value one for country pairs with a common land or sea border and zero otherwise. For our purposes, a common sea border is where two countries are separated by a narrow sea or straits.[8] In particular, we set it equal to one for trade between the Republic of Ireland and the UK. The dummy "common language" takes the value one for country pairs with a common language and zero otherwise.[9] The North-South dummy equals one for trade between Northern Ireland and the Republic of Ireland, and zero otherwise.

V EMPIRICAL RESULTS

In this section we estimate a gravity model to account for trade between Northern Ireland and the Republic. In essence we are estimating a more

7. For the US, Canada and Germany, the capital city is replaced by New York, Toronto and Frankfurt respectively.

8. For example, Denmark and Sweden share a common border whereas Germany and Sweden (separated by the Baltic) do not.

9. The distance, contiguity and language variables were taken from the Gravity Model Web Site at http://intrepid.mgmt.purdue.edu/Jon/Data/TradeData.html#Gravity. This site also includes useful concordance files that link the country codes used by many different international datasets.

complicated and rigorous version of the model illustrated in Figure 3, to see whether North-South trade remains an outlier, even when we control for other variables that are known to influence trade world-wide.

From Section III, the basic specification of the gravity model is given by Equation (2). We include dummy variables to indicate whether the two countries share a common border, have a common language and were both members of the European Union in the year in question. In addition we include a time trend (the variable "year") which captures the growth in the volume of world trade and changes in world GDP over time.

Table 1 shows the estimates of the gravity model over all countries in our sample, excluding trade between Northern Ireland and the Republic of Ireland. We estimated this first to check that our data and specification are consistent with other papers using the gravity model. The first column shows the results from estimating Equation (2) using OLS applied to the pooled data set. As it is likely that the variance of the error term is different for different country pairs, we correct the standard errors for heteroscedasticity using White's procedure. All coefficients have the expected sign and their magnitudes are similar to those found in other papers. Trade rises with real GDP per capita. Given income per head, trade also rises with population, indicating that large countries as well as rich countries tend to trade more with each other. Trade falls with increasing physical distance between countries. The estimated elasticity of trade with respect to distance (–0.65) is in line with the general consensus in the literature (as noted in Section III). Trade is higher between countries that share a common border (controlling for the distance between their economic centres) and between countries that share a common language. The EU dummy indicates that, other things being equal, members of the European Union tend to trade more with each other than would otherwise comparable countries. Lastly, the coefficient on year implies that, controlling for other factors, the volume of bilateral trade increased on average by 1.24 per cent *per annum* over the sample period.

The OLS results in column 1 will be inconsistent if the error term is correlated with any of the independent variables. This is very likely in our framework, since it is almost certain that the error term appended to (2) contains a component that is specific to each country pair. If we are willing to make the (reasonable) assumption that the country-pair-specific component of the error term is time-invariant, then we can develop a consistent estimator by performing OLS on variables expressed as deviations from their means.[10] This "fixed effects" estimator is consistent because the differencing process eliminates the time-

10. This is equivalent to performing OLS on first differences of the data when there are only two time periods in the data set.

invariant country-pair-specific component of the error term, leaving the remaining error term uncorrelated with the dependent variables.

The second column of Table 1 shows the results of the fixed effects estimator applied to Equation (2). As explained above, the fixed effects estimator correctly accounts for any unobserved country-pair effects. It does so, however, at the

Table 1: *Gravity Model Excluding North-South Trade*

Variable	*Pooled Regression*[1]	*Fixed Effects*	*Random Effects*
Real GDP per capita	1.1280**	0.7197**	0.8469**
	(0.0435)	(0.0438)	(0.0334)
Population	0.8481**	0.0967	0.8068**
	(0.0224)	(0.0809)	(0.0183)
Distance	–0.6545**	—	–0.6135**
	(0.0361)		(0.0360)
Common Border	0.3054*	—	0.4771*
	(0.1445)		(0.2304)
Common Language	0.3750**	—	0.3287**
	(0.1159)		(0.1151)
EU	0.2723**	0.4103**	0.4315**
	(0.0791)	(0.0255)	(0.0252)
Year	0.0124**	0.0275**	0.0129**
	(0.0030)	(0.0021)	(0.0016)
Constant	–16.2612	–11.2150	–11.0411
	(0.7372)	(0.7041)	(0.5947)
Number of observations	13,038	13,038	13,038
Hausman test	—	127.98 (4 d.f.)	
R^2	0.8268	0.4563	0.8214

Notes: Dependent variable: Bilateral trade flows between Ireland and a sample of OECD countries, 1970-1992; see text for further details.
All independent variables except Common Border, Common Language, North-South and EU dummies, are in logs.
Standard errors in parentheses.
All variables marked ** are significant at 1 per cent level, and those marked * are significant at 5 per cent level. All other variables are statistically insignificant.
[1]Standard errors are corrected for heteroscedasticity within country pairs, using the White method.

cost of eliminating any time invariant variables from the regression.[11] The results are not too different from the OLS case except that the European Union dummy is significantly higher, the effect of GDP per capita is lower and the effect of population is much lower and of borderline significance.[12]

Although consistent, the fixed-effects estimator is of limited usefulness as it fails to provide estimates of the dummy variables. This is particularly important in our context because we are primarily interested in the coefficient of a dummy for North-South trade. For this reason, we employ a random effects estimator. Like the fixed effects estimator, the random effects estimator assumes that the error term is made up of a time invariant country-pair specific component and a general component. Unlike the fixed effects model, however, the random effects estimator models the heteroscedasticity directly. Thus it is a specific case of Generalised Least Squares (GLS). Unfortunately, this GLS estimator will be inconsistent under the same circumstances as the OLS estimator i.e., if the country-pair specific error term is correlated with any of the independent variables. If the random effects estimator is consistent then it should be asymptotically equivalent to the fixed effects estimator.

The third column reports the random effects estimator of Equation (2). The results are similar to the OLS case and different to the fixed effects estimator. The Hausman test of the null hypothesis that the fixed and random effects estimators are the same is decisively rejected. This suggests that the random effects estimator is inconsistent (although such rejections are standard).

Table 2 turns to estimates of the gravity equation including observations on North-South trade. We add to our list of regressors a dummy set equal to one for trade flows between the ROI and Northern Ireland. The results in Table 2 are almost identical to those in Table 1, except for the presence of the North-South dummy. This dummy is significant and positive in the OLS case. In other words, it suggests that Northern Ireland and the Republic trade *more* than would be expected, controlling for the relative sizes of the economies, common language, shared border, distance etc. Furthermore, the magnitude of the effect is huge. North-South trade is 133 per cent larger than trade between any two similar countries. The random effects model produces an estimate that is smaller but still positive. The standard error is large but we can still reject the null hypothesis that the coefficient is less than zero at the 5 per cent level.[13]

11. An alternative approach would be to estimate the equation in levels (like the OLS case) but to include a dummy variable for each bilateral country pair. This approach would have the advantage that we could look at a North-South dummy explicitly. However, this would not allow us to distinguish the contribution of each bilateral country pair dummy from the effects of distance in general. In any case, with 756 country pairs in our sample, it was not feasible to estimate this specification.

12. The coefficient on population was equal to 0.44 and significant at the 1 per cent level if the year dummy was not included in the regression.

13. This is a one-tailed test.

Table 2: *Gravity Model Including North-South Trade*

Variable	*Pooled Regression*[1]	*Fixed Effects*	*Random Effects*
GDP per capita	1.1279**	0.7193**	0.8466**
	(0.0435)	(0.0437)	(0.0334)
Population	0.8481**	0.0966*	0.8068**
	(0.0224)	(0.0808)	(0.0183)
Distance	–0.6545**	—	–0.6135**
	(0.0361)		(0.0360)
Common Border	0.3054*	—	0.4773*
	(0.1445)		(0.2304)
Common Language	0.3750**	—	0.3287**
	(0.1159)		(0.1151)
EU	0.2723**	0.4102**	0.4314**
	(0.0791)	(0.0255)	(0.0252)
Year	0.0124**	0.0275**	0.0129**
	(0.0030)	(0.0021)	(0.0016)
North-South	1.3301**	—	0.8223
	(0.1885)		(1.0082)
Constant	–16.2607	–11.2084	–11.0371
	(0.7372)	(0.7033)	(0.5944)
Number of observations	13,053	13,053	13,053
Hausman Test		128.17 (4 d.f.)	
R^2	0.8268	0.4557	0.8215

Notes: Dependent variable: Bilateral trade flows between a sample of OECD countries, 1970-1992; see text for further details.
All independent variables except Common Border, Common Language, North-South and EU dummies, are in logs.
Standard errors in parentheses.
All variables marked ** are significant at 1 per cent level, and those marked * are significant at 5 per cent level. All other variables are statistically insignificant.
[1]Standard errors are corrected for heteroscedasticity within country pairs, using the White method.

We can also get an idea of the special position of North-South trade by using the estimates of Table 1 to make out-of-sample predictions. We do this by taking the random effects estimates for the sample excluding North-South trade (column three of Table 1) and applying them to the North-South trade data. Figure 4 shows the level of actual North-South trade, the level predicted by the gravity

model and the 95 per cent confidence interval bands based on the standard error of the prediction. We see that the actual level of trade is everywhere above the predicted level and the upper error band.[14]

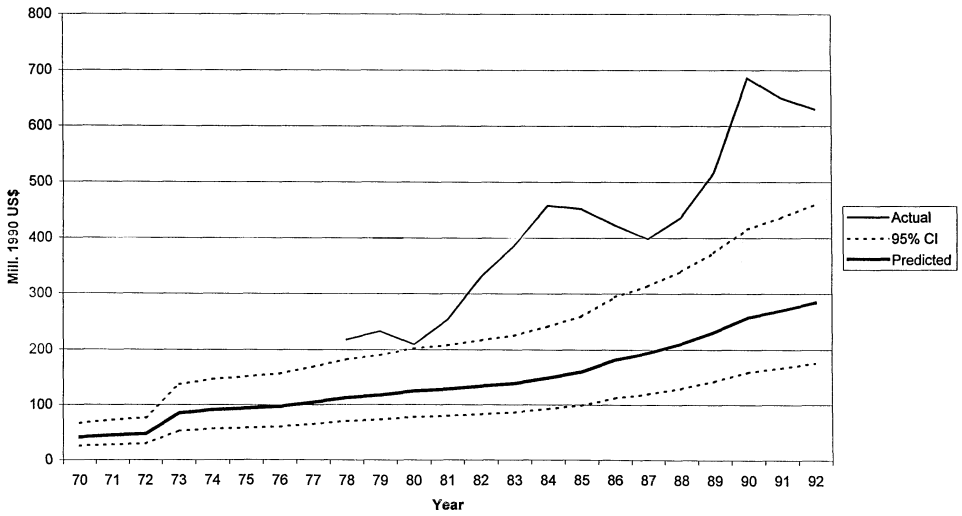

Figure 4: *North-South Trade Actual and Predicted (with 95 Per Cent Confidence Interval)*

It could be objected that both the random effects and OLS models are not to be trusted as they are almost certainly inconsistent. There are two answers to this. First, there is no reason to suppose that this inconsistency would turn a true negative coefficient on North-South trade into a spurious positive one. Second, as we show in the next section, the result is remarkably robust.

VI CHECKS FOR ROBUSTNESS

In this section we report some robustness tests of the result that Northern Ireland and the Republic trade more on average than similar country pairs. The result might be questioned on the basis that a single dummy variable only allows North-South trade to differ from the average across all countries by a fixed amount. It might be the case that trade flows between ROI and NI differ also in their reaction to changes in GDP; i.e., the slopes as well as the intercept might be different. We could account for this by estimating the model separately

14. This procedure is equivalent to interacting the North-South dummy with all the other variables and testing their joint significance.

for North-South trade. However, there are too few observations (only fifteen) for this to be worthwhile, so we compromise and run the model for trade flows between ROI only and all countries (including NI). The results are reported in Table 3.

Table 3: *Gravity Model For Ireland Only*

Variable	*Pooled Regression*[1]	*Fixed Effects*	*Random Effects*
GDP per capita	1.0919**	1.6707**	1.3440**
	(0.1869)	(0.2119)	(0.1501)
Population	0.8671**	–0.8267*	0.7740**
	(0.1068)	(0.3554)	(0.0775)
Distance	–0.5249**	—	–0.4996**
	(0.2004)		(0.1455)
Common Border	1.1295	—	1.5370
	(0.6060)		(0.9136)
Common Language	0.6461	—	0.5307
	(0.4216)		(0.3673)
EU	0.5652**	0.2388**	0.2632**
	(0.1700)	(0.0693)	(0.0691)
Year	0.0338**	0.0295*	0.0225**
	(0.0119)	(0.0125)	(0.0082)
North-South	0.3514	—	0.1943
	(0.4431)		(1.1690)
Constant	–18.5136	–26.4954	–22.0010
	(3.4980)	(3.2154)	(2.6243)
Hausman Test		38.42 (4 d.f.)	
Number of observations	1,088	1,088	1,088
R^2	0.8392	0.0270	0.8281

Notes: Dependent variable: Bilateral trade flows between Ireland and a sample of OECD countries, 1970-1992; see text for further details.
All independent variables except Common Border, Common Language, North-South and EU dummies, are in logs.
Standard errors in parentheses.
All variables marked ** are significant at 1 per cent level, and those marked * are significant at 5 per cent level. All other variables are statistically insignificant.
[1]Standard errors are corrected for heteroscedasticity within country pairs, using the White method.

The coefficients for the Ireland-only regressions in Table 3 tend to be higher (in absolute terms) than those in the corresponding regressions for all countries shown in Table 2.[15] This suggests that the Republic trades more (controlling for GDP, population, distance etc.) than do other countries. On reflection, this is not too surprising given that the Republic is probably the archetypal "small open economy". What is surprising, however, is that the North-South dummy remains positive in Table 3, although it is smaller and statistically insignificant. This suggests that while the Republic trades more on average than other countries, it still trades proportionately even more with Northern Ireland. Because the coefficient on North-South is insignificant, this result cannot be taken as decisive. But it serves to support, rather than undermine, the (significant) results of the last section. It certainly cannot be taken as evidence that the North and South of Ireland trade less than they should.

The results from the previous section might also be questioned on the grounds that Northern Ireland's GDP was under-measured. If true, this would cause the dummy variable to have a spurious positive coefficient that would pick up the effect of the "missing" GDP on trade. Furthermore, in constructing the real GDP data we used the deflator for the UK as a whole because none was available for Northern Ireland specifically. This probably over-estimates the price level in Northern Ireland, and thus our figure for real GDP is probably an under-estimate.

To overcome these problems, we re-estimated the gravity model giving Northern Ireland the same GDP per capita as the UK. Not surprisingly, the coefficient on the North-South dummy became smaller and was not significantly different from zero, but it remained positive. (The coefficient estimate was 0.68 with a standard error of 1.04.) This implies that even if NI had the same income as the UK, the level of North-South trade would be at the level of any two similar countries, if not higher. Since NI, whatever its actual GDP, is almost certainly poorer than the rest of the UK, we can conclude that the level of North-South trade is not below the average level, i.e. the level of trade between any two otherwise similar countries.

One final robustness check is to look at other country pairs to see if they behave in a manner similar to Ireland, North and South. We do this by re-estimating the random effects model reported in Table 2, but this time including dummies for other country pairs as well as for North-South trade. The results of this regression are reported in the first column of Table 4. (We report only the coefficients on the dummy variables, as the other coefficients are almost the same as in Table 2.) The fact that some of the other dummy variables have positive coefficients suggests that trade between the ROI and NI may not be so

15. As the sample size is smaller, the precision of the estimates is also reduced somewhat.

unusual after all. In other words, the two economies may trade more than the average but not more than other pairs of relatively small and closely integrated countries such as Norway and Sweden, for example. It is interesting to note, however, that Northern Ireland and the Republic seem to trade more than do either Spain and Portugal or France and Germany.

We can also get an idea of the importance of other country pairs by using the estimates in Table 1 to create out of sample forecasts for these other countries. This procedure mirrors that used to create Figure 4 for North-South trade. Instead of providing the entire series for all the country pairs we summarise the forecasts in the second and third columns of Table 4. The second column shows the mean of the (log) trade flows between the two countries over the sample period. The third column shows the mean of the predicted (log) trade and, in parentheses, the average forecast error. We can see that the difference between the actual and predicted trade is more than twice the forecast error for North–South, Norway-Sweden and Finland-Sweden.

The results of the last two paragraphs suggest that the, apparently high, level of North-South trade may not be that unusual. Other country pairs also trade more than is predicted by the standard gravity model. The question now becomes whether the level of North-South trade is high in the context of these other country pairs. The distinguishing feature of these country pairs seems to be that they have a common border. This suggests that trade between contiguous

Table 4: *Actual Versus Predicted Trade For Various Country-Pairs, 1970-1992*

Country Pair	*Coefficient*	*Actual Trade*[1]	*Predicted Trade*[2]	
			All Countries	*Contiguous Countries*
Northern Ireland/ Republic of Ireland	0.9201 (1.0113)	5.9686	4.4869 (0.1581)	5.7585 (0.3158)
Norway/Sweden	1.4213 (0.7028)	7.7147	6.1770 (0.0913)	6.8760 (0.1951)
Finland/Sweden	0.7113 (0.7081)	7.4459	6.6690 (0.1317)	7.6203 (0.1916)
France/Germany	–0.3466 (0.7038)	9.8055	10.0262 (0.1037)	9.9718 (0.1973)
Spain/Portugal	–0.1456 (0.7086)	6.6361	6.6362 (0.0923)	6.8464 (0.2493)

Notes: [1]Actual trade represents the log of actual trade.
[2]Predicted trade represents the log of predicted trade.
Standard errors are in parentheses.

countries may be different from trade between non-contiguous countries in a way not captured by the simple additive dummy.

We test this by re-estimating the model separately for a sub-sample consisting solely of countries that share a common border.[16] We can then use these results to predict trade for these various country pairs. These predictions and their associated errors are shown in the last column of Table 4. For every country pair, with the exception of Norway and Sweden, the actual trade figure is well within two standard errors of the predicted level. Thus, this modified gravity model shows that the level of North-South trade is already as high as the trade between the specially selected set of highly integrated trading partners. Yet again, this confirms our original result, implying that there is little reason to expect a dramatic increase in North-South trade in the future. The two parts of the island already trade more than the average, more than Spain and Portugal, more than France and Germany, and as much as some other highly integrated country pairs. One could argue that the two economies on the island of Ireland could become as integrated as Norway and Sweden. But it would be dangerous to base forecasts (never mind policy) on what is obviously an outlier. It is not clear, for example, why Sweden and Norway trade so much with each other compared to Sweden and Finland or Spain and Portugal.

VII CONCLUSIONS

In this paper we have attempted to assess the volume of trade between the Republic of Ireland and Northern Ireland in an international context. We used a gravity model to provide a benchmark for bilateral trade flows, relating them to GDP, population, distance and other characteristics of the trading partners. This approach to modelling trade flows has proved fruitful in many applications and our results are consistent with the growing literature on the topic. For example, controlling for other influences, we found an elasticity of trade flows with respect to distance close to –0.6, the typical value found in other studies.

Our results suggest that the trade volume between Northern and Southern Ireland is definitely not less than might be expected on the basis of international experience, and may even be considerably more. This result is robust with respect to a wide range of alternative specifications of the model and alternative ways of measuring our key variables. For example, our measure of real GDP in Northern Ireland is open to criticism. But, even if we assume that Northern Ireland has the same GDP per head as the rest of the UK (a clear overestimate),

16. This is equivalent to estimating the original model of Table 1, but with the common border dummy interacted with all the other variables.

our model continues to show that the volume of North-South trade is greater than expected. We conclude that, at least for this data set, there is no support for the claim that North-South trade is much lower than between comparable EU countries.

Of course, it is possible that a different picture might emerge if more disaggregated data were used. We have looked only at total manufacturing trade, making no distinction, for example, between traditional and high-technology goods or between homogeneous and differentiated goods. Especially in the light of the theoretical debates summarised in Section III, we might expect these categories to behave in different ways. Further work is needed to investigate this issue. It would also be desirable to assess the volume of North-South trade relative to that between different EU regions rather than between different countries as we have done. Pending other studies of this kind, however, our results point unequivocally to the conclusion that North-South trade is not abnormally low by international standards.

Naturally, it is tempting to apply the results of our study to the ongoing debate about the trade and economic implications of changing institutional relationships within the two parts of Ireland and between them and other parts of the United Kingdom. However, the results do not necessarily lead to simple policy prescriptions. The gravity model provides a standard of comparison against which the level of particular bilateral trade flows can be evaluated. Why one such flow deviates from the norm and whether it might be expected to converge towards it are questions which require a different mode of analysis.

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