



**A GRAVITY MODEL APPROACH TO ESTIMATING THE
EXPECTED VOLUME OF NORTH/SOUTH TRADE**

May 2009





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Steering Committee Members

| | |
|---------------------|-------------------------------------------------|
| Cathal Fitzgerald | Forfás |
| Martina Lawless | Central Bank of Ireland |
| Michael Smyth | University of Ulster |
| Victor Hewitt | Economic Research Institute Northern Ireland |
| Vincent Hogan | University College Dublin |
| Aidan Gough (Chair) | InterTradelreland |
| Anne-Marie McAteer | InterTradelreland |

*Further work was undertaken by InterTradelreland staff,
Dr Eoin Magennis and Christopher Gardner*

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Glossary of Terms

Dummy variable:

One that takes the values 0 or 1 to indicate the absence or presence of some categorical effect that may be expected to shift the outcome.

Parameter:

A quantity which defines certain characteristics of a function. (e.g. GDP, Distance.)

Contiguous:

Two or more bodies of land which are in physical contact with each other.

Regression:

In statistics, regression analysis is a collective name for techniques for the modelling and analysis of numerical data.

Trade intensity:

How much two countries trade with one another in relation to trade with other countries.

Estimators:

In terms of this report the estimators are; pooled, fixed effects, random effects and Hausman-Taylor.



Executive Summary

The international literature shows that there are significant gains from trade, particularly in raising productivity and driving growth. These arise from a number of sources. For example trade increases competition, which in turn results in higher efficiency and consequently overall growth in economic activity. Trade also results in technology transfer, both in relation to final goods and intermediate inputs. A high-tech machine that is imported will produce output more efficiently. Likewise high-tech components that cannot be sourced locally can, if imported, be used to produce a higher value output. Trade can also foster other relationships between firms such as R&D co-operation.

In this context this report aims to assess whether aggregate and sectoral cross-border trade between Ireland and Northern Ireland is at, above or below the expected level. As such the analysis provides a vital input into the formulation and targeting of policies to promote trade and business development on the island of Ireland and will specifically help in targeting policy interventions as part of the InterTradeIreland trade and business development programmes.

The deviations of actual trade from the expected level is estimated using a gravity model which accounts for the key factors that determine the level of trade flows between trading partners. The model is estimated using a large panel data set covering the 42 most important trading partners of Ireland.

The key finding is that once important economic and geographic factors are taken into account, the level of trade between the two jurisdictions is below the expected level. This finding applies to both total manufacturing trade and the trade for a number of sectors (See Box 1). It is shown that the gap between the actual and the expected level of trade is increasing. For total manufacturing trade over the period 1998 to 2007 the gap between expected and actual North to South trade was 82 per cent while for South to North trade it was 77 per cent.

While the analysis was focused on establishing whether the level of trade between Ireland and Northern Ireland is above, at or below the expected level, the report also highlights a number of possible explanations.

The findings may be explained, at least partly, by the fact that the economies of the two jurisdictions are quite different. Ireland for example, is more outwardly orientated, which is related to the degree to which multinational enterprises dominate a number of sectors.

Consequently, it is not surprising that in a sector such as Electrical and Optical Engineering, which is dominated in Ireland by foreign multinational enterprises, the level of trade is significantly below the expected level. For some sectors such as Food and Beverages and Non-Metallic Minerals, the level of trade was found at about the expected level, which reflects the nature of the goods traded.

The results of the research have important policy implications:

1. The fact that there is a gap between the actual and expected level of trade highlights that there are substantial potential gains from trade to be exploited on the island of Ireland.
2. The unexploited gains from trade are increasing since the gap between the actual and expected level of trade is increasing.
3. The results highlight the need for appropriate policy measures to increase the level of cross-border trade on the island of Ireland, though more detailed analysis may be required to identify such measures, particularly at sectoral level.
4. The fact that some sectors trade at the expected level, does not imply that policies to further increase the level of trade are not warranted. The expected level should be seen as a lower bound target for policy.
5. The analysis in this report focused on manufactured goods, since the data to carry out a similar analysis for services trade is not available. Given the increase in services trade, it is vitally important to address the issue of data availability.

Box 1:
Summary Results for each Sector

| SECTOR | COMMENT |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Food, Beverages and Tobacco | This sector trades at about the expected level. This is likely to be due to similar tastes across both jurisdictions, a greater level of interaction at the firm level and the need for freshness. |
| Textiles and Leather | This sector trades below the expected value. A possible explanation is the importance of a small number of large customers which are largely based in Great Britain (GB) or abroad. |
| Wood | This sector trades below the expected level. A possible explanation is a heavy focus on production for local markets only. |
| Paper and Publishing | This sector trades below the expected level. For South to North trade this is likely to be related to reproduction of recorded media (incl. software) which is dominated by multinationals. |
| Chemicals | This sector trades below the expected level. This is likely to be driven by the high share of multinationals which are serving world markets from their production bases on the island. |
| Rubber and Plastics | This sector trades below the expected level. Production is either focused on local markets or at world markets. |
| Non-Metallic Minerals | This sector trades at about the expected level, primarily due to the low value to weight ratio. |
| Basic Metal products | This sector trades below the expected level. Production is either focused on local markets or at world markets. |
| Machinery and Equipment | This sector trades below the expected level. Production is either focused on local markets or at world markets. |
| Electrical and Optical Equipment | Trade is well below the expected level. This is likely to be driven by the high share of multinationals which are serving world markets from their production bases on the island. |
| Transport Equipment | This sector trades below the expected level. Production is either focused on local markets (e.g. building and repair of pleasure boats) or at world markets (e.g. shipbuilding, or aircraft & aircraft parts). |

1. Introduction

Given the island location and the relatively small scale of the two economies on the island, significant economic benefit can be derived from forging stronger links between Ireland and Northern Ireland. It is well established that there are significant gains from trade. These arise from a number of sources. For example trade increases competition, which in turn results in higher efficiency and consequently overall growth in economic activity. Trade also results in technology transfer, both in relation to final goods and intermediate inputs. A high-tech machine that is imported will produce output more efficiently. Likewise high-tech components that cannot be sourced locally, can if imported, be used to produce a higher value output. Trade can also foster other relationships between firms such as R&D co-operation.

Overall, the international literature on trade shows that increased trade volumes raise productivity and growth and are to be encouraged. For small economies this point is even more important since they can only produce a smaller range of goods and services if scale economies apply. Thus, in a self-sufficient state small economies experience significantly lower living standards than equivalent open economies.

There are a range of links which already exist in one way or another on the island of Ireland. For example strong links exist in the areas of transport (road and rail) and energy (electricity interconnection). Other links between businesses also exist. The *InterTradelreland* report on Business Networks on the island of Ireland highlighted the fact that a significant number of business networks exist, although many of these are locally based and did not have a North/South dimension¹. Furthermore, a key finding was that proximity to the border, perceived barriers and country uncertainty are key drivers of cross-border co-operation.

The *InterTradelreland/ESRI* Survey on Business Linkages on the island of Ireland found that the most important business linkage between firms North and South were imports and exports². Thus, the key representation of economic links is the trade intensity between the two jurisdictions which also implies that trends in the North/South trade intensity are of considerable policy interest.

A greater proportion of firms in Northern Ireland engage in cross-border trade than firms based in Ireland, yet according to the Central Statistics Office (CSO) data the trade flows from Ireland to Northern Ireland exceed those in the opposite direction. This would indicate that those firms in Ireland that do trade with Northern Ireland, trade in greater volumes. Strikingly, figures from the recent *InterTradelreland* Quarterly Business Monitor show that a very significant proportion of firms do not trade between the two jurisdictions, with 72 per cent of Irish firms not exporting to the North and 66 per cent of firms in Northern Ireland not exporting to Ireland.

Previous work on the deviation of North/South trade from the expected level published in 1999 showed that a simple plot of exports from Ireland to Northern Ireland exceed the average given GDP levels in Northern Ireland. However, that analysis indicated that such a cursory look can be misleading and that a thorough analysis, considering all factors that determine trade, needs to be carried out in order to establish whether the North/South trade intensity is as high as one would expect.

¹ See Hunt et al. (2006)

² See Williams et al. (2005).

This report fills the important research gap. Firstly, it provides up-to-date estimates of the degree of deviation from the expected level of trade for exports between Northern Ireland and Ireland. Importantly, this analysis utilises disaggregated data for manufacturing sectors and, in contrast to previous studies, considers North/South imports and exports separately. Furthermore, the time coverage of the dataset is long enough to allow for the analysis of the impact of important policy issues such as the introduction of the Single European Market and the Euro. Both the Single European Market and the Euro might have resulted in a changed trading pattern. In particular, they might have resulted in 'third country' effects as their introduction might have diverted trade from one trading partner to others.

The key task of this analysis is to assess whether aggregate and sectoral cross-border trade is at, above or below the expected level, which identifies the degree to which individual sectors over - or underperform in relation to trade intensity. As such the analysis provides a vital input into the formulation and targeting of policies to promote closer trade integration on the island of Ireland. This will specifically help in targeting policy interventions as part of the InterTradeIreland trade and business development programmes.

This report is organised as follows: section 2 outlines the methodology adopted for the analysis, section 3 outlines the overall estimation results, section 4 analyses the key results regarding the level of trade and finally section 5 summarises the work and identifies policy recommendations. An outline of the technical aspects of the analysis is included in appendix 2.

2. Methodology

In order to understand how the estimates of the deviations from potential trade have been drawn – that is the degree to which trade between two jurisdictions is at, above or below the expected level – it is useful to briefly describe the methodology used. In this section we provide a non-technical description. However, the technical aspects are described in detail in Appendix 2 at the end of this report. The study applies a gravity model to explore the factors driving trade flows in Ireland and to identify whether North/South trade flows should be higher, accounting for all factors. In doing so, this analysis updates and improves upon the earlier work by Fitzsimons et al. (1999).

The gravity model of international trade flows has been widely applied over recent years and it has been found to explain a significant proportion of bilateral trade flows. As the name suggests, the gravity model is based on the assumption that trade is generated by mass or economic size in the importing country, which is proxied by GDP (the gravitational force), and is inhibited by distance (friction). Distance is included in the model to account for transport costs, which intuitively increase with distance. Other types of transaction costs also tend to increase with distance which implies that the relationship between trade and distance not only reflects 'pure' transport costs. In its most basic form it relates bilateral trade to distance between countries and GDP. Higher GDP (high gravity) results in increased trade flows while a greater distance between trading partners inhibits trade. This relationship is estimated using regression analysis and is expressed in terms of parameters such as those mentioned above.

In order to assess the degree to which trade for particular country pairs differs from the expected level, the model is estimated using data for a set of country pairs and since trade fluctuates from year to year, one usually also includes data over a period of time. Two possible approaches can be used to identify the deviation of the actual observed trade flow from that which is expected. Firstly, one can use the estimated parameters to predict the expected level of trade and then compare the actual and expected levels. If one is only interested in a small subset of trade flows, as is the case in our analysis, one can directly estimate the deviation by including a dummy variable for each of the trade flows of interest.

In order for the estimated deviations from the potential/expected trade to be accurate it is important that the specification of the model accounts for the key factors that distinguish the trade flows of interest.

In addition to the gravity variable GDP of the destination country and the friction variable distance, it is customary to include a range of additional variables that capture the trading potential between country pairs. For example, a high level of income in the exporting country indicates a high level of production, which increases the availability of products for export. In many applications the GDP of both the exporting and importing countries are entered jointly.

Geographic and other factors have an important bearing on trade flows. There are a number of key features that might impact particularly on the level of trade between Ireland and Northern Ireland and these need to be reflected in the analysis. Firstly, both trade partners share a common language. Secondly, they are contiguous (share a common border). Thirdly, they are located on an island. Fourthly, they only have one contiguous trade partner³. As EU members both Northern Ireland and Ireland face few or no trade barriers particularly in relation to merchandise trade. They are not landlocked. All these factors can be accounted for, by including indicator variables (dummy variables). Importantly, the island location and unique contiguous trade partner were not included in previous analysis. Including these variables significantly changes the results regarding the deviations from expected trade flows and yields more robust results.

The gravity model was applied using data for 42 countries plus the separate flows between Ireland and Northern Ireland and Great Britain for the broad manufacturing sectors⁴. The time period covered for most of the analysis is 1992 to 2007. However, for aggregate manufacturing trade data for the period 1988 to 2007 was available. The data for trade between Northern Ireland and Ireland was drawn from the CSO⁵.

A number of different estimators are used to determine the parameters of the model. For the purposes of the main text it suffices to identify the estimators as pooled OLS (Pooled), fixed effects, random effects (RE) and Hausman-Taylor (HT). This is done in order to ensure that the results are robust to the estimator used and do not suffer from statistical issues which might give rise to criticism of the results. The pooled OLS and fixed effects estimators are included for completeness, as they can be challenged on a number of statistical and conceptual grounds in the context of the analysis presented here. These estimators are further outlined in the technical appendix 2.

3 The interpretation of contiguous used here relates to a common land border.

4 The countries are Australia, Austria, Belgium & Luxembourg, Brazil, Canada, China, Hong Kong, Costa Rica, Czechoslovakia (Czech Republic after 1993), Denmark, Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Korea (south), Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Russian Federation, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Arab Emirates, United Kingdom. Seven of these countries are islands, four are landlocked and six have only one contiguous neighbour.

5 For a shorter period this data is also available from HMRC and for exports from Northern Ireland to Ireland from the Department of Enterprise, Trade and Investment (DETI). In the technical annexe it is shown that while using alternative sources of data yields slightly different parameters, these results do not differ in a statistically significant way.

3. Results of the Gravity Model

Before outlining the results of the estimation it is useful to consider the expected sign of the parameters. Both GDP and population as gravitational variables are expected to have a positive sign. This reflects that countries with larger GDP have more goods to trade and greater demand for goods to import. Distance as a proxy for transport and other transactions costs is expected to have a negative coefficient i.e. a longer distance between trading partners results in lower trade volumes. Country pairs with a common border, common language and a trade agreement are expected to trade more with each other, therefore a positive co-efficient would be expected. Country pairs, which have the common Euro currency are expected to trade more with each other while the Euro might have a third country impact reducing the volume of trade between Euro members and non-members (captured by separate dummy variables for exporters and importers with the Euro). Landlocked countries tend to trade less while islands tend to trade more. Finally, countries with only one contiguous neighbour might trade less.

3.1 Results of the Aggregate Model

The results for the aggregate model using the specification that is also utilised for the sectoral models are outlined in Table 1. Overall, the results are in line with those found in other gravity model studies suggesting that the results are consistent. In all cases parameters for these variables are found to be correctly signed and highly significant. In other words a higher GDP increases trade while a longer distance inhibits trade. If one considers the results from the random effects model then a 2.2 per cent increase in GDP would compensate for a one per cent longer distance, which illustrates the importance of geographic factors. Larger population results in higher trade. The common border and common language significantly increase trade. A trade agreement between two trading partners also has significant positive impact as one would expect.

Interestingly, a common language or common border have a larger impact than a trade agreement. Having just one contiguous trading partner is more important in terms of exports than it is with regard to imports. Islands tend to export less but import more given all other included factors while landlocked countries trade less. The coefficients for the Euro dummies are slightly surprising in that the dummy variable which accounts for trading pairs, which both have the Euro, is not statistically significantly different from zero. This indicates that the Euro has not had a significant positive impact on trade for these trading pairs. Exporters that have the Euro tend to trade more than those which do not have the Euro while Euro importers tend to import less.

These results concord with those from a simpler model specification used in a recent Forfás report which reviewed the European Single Market⁶. For example, the coefficients for distance, common language and common border found in the Forfás study are not statistically different from those found in this study. The overall ability of the model to explain the variation in the observed data is also very similar in that our preferred random effects model explains about 65 per cent of the variation in the data.

⁶ See Forfas (2008).

Table 1
Estimation Results for Total Bilateral Merchandise Exports 1988-2007

| Variable | Pooled | Fixed Effects | Random Effects | Hausman-Taylor |
|------------------------|----------|---------------|----------------|----------------|
| GDP | 0.62*** | 0.39*** | 0.40*** | 0.39*** |
| Population | 0.16*** | 0.40* | 0.34*** | 0.34*** |
| Distance | -0.92*** | | -0.89*** | -0.88*** |
| Common Border | 0.63*** | | 0.68*** | 0.67*** |
| Common Language | 0.74*** | | 0.73*** | 0.72*** |
| Trade Agreement | 0.02 | | 0.23*** | 0.24*** |
| North to South Dummy | -1.89*** | | -1.70*** | -1.66 |
| South to North Dummy | -1.48*** | | -1.48* | -1.44 |
| Exporter 1 Neighbour | 1.00*** | | 1.03*** | 1.00*** |
| Importer 1 Neighbour | 0.74*** | | 0.76*** | 0.72*** |
| Euro | -0.20 | -0.06 | -0.07 | -0.07 |
| Exporter Euro | -0.002 | 0.15*** | 0.15*** | 0.15*** |
| Importer Euro | 0.04*** | -0.29*** | -0.28*** | -0.28*** |
| Exporter Island | -0.40*** | | -0.49*** | -0.47*** |
| Importer Island | 0.24*** | | 0.10 | 0.09 |
| Exporter Landlocked | -0.09*** | | -0.14* | -0.13 |
| Importer Landlocked | -0.24*** | | -0.30*** | -0.31*** |
| Number of Observations | 31845 | 31845 | 31845 | 31845 |
| R2 | 0.64 | 0.54 | 0.61 | |
| Hausman Test | | | 1024.33*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

An important policy change over the estimated period (1988 to 2007) was the peace process in Northern Ireland. In order to assess the impact of this, a dummy variable was added to the model. This dummy takes a value of one for the period from 1998 onwards for trade between the two jurisdictions⁷. Another important policy change was the introduction of the Single European Market (SEM) in 1992, which for EU members, was expected to increase trade relative to trade flows with non-EU countries. This is accounted for using a dummy variable which takes a value of one from 1992 for EU member pairs. Finally, the fall of the Iron Curtain and the subsequent restructuring has led to significant trade reorientation among Central and Eastern European countries (CEE) culminating in a process towards membership of the EU for 12 countries. In order to account for potential impact of these developments on trade patterns dummy variables for EU accession countries are included.

The results from the estimation of this expanded model are shown in Table 2. Given the crudeness of the dummy variable it is difficult to identify a positive impact of the peace process. For example, it is likely that the dummy variable also picks up the effect of other factors such as the 'Celtic Tiger' boom in Ireland. This was to a significant extent driven by the growth of multinationals which are not producing for local markets. The boom resulted in higher GDP in Ireland but through the growth of multinationals more disproportionate international trade. Thus the results for the 'peace process' dummy should be interpreted with caution. A more appropriate test for a peace dividend would be to estimate a model that includes trade between Northern Ireland and a range of trading partners, reducing the correlation between the peace process dummy and any specific economic trend in just the one trading partner.

Interesting results also emerge with regard to the other additional variables. The SEM resulted in lower trade between EU members relative to trade flows with other countries. This result might be surprising but is backed up by the findings in the Forfás report on the SEM. This report showed that the export intensities for 27 per cent and import intensities of 34 per cent of EU country pairs declined over the period 1992-2006. While the majority of intra-EU trade flows increased in intensity, the country pairs which recorded such a decline were often pairs with significant trade flows such as Belgium and France, the Netherlands and France and Germany and Italy. This result highlights the importance of globalisation which has resulted in faster trade growth internationally than within the EU.

EU accession countries export significantly less but also import less. The adjustment to the structural shock, which the fall of the Iron Curtain resulted in, and the subsequent adjustment process in terms of economic structure might result in this effect varying over time. Results which are not tabulated here show that while allowing the relationship between trade and accession countries to vary across time changes the results on the accession dummy, this does not affect any of the other results. However, this additional analysis showed that accession countries have significantly increased their trade over time.

⁷ An alternative was used where the dummy is one from 1994, the year of the first IRA ceasefire, but the results did not change.

Given the sample period is sufficiently long it is also possible to test whether the estimated parameters change over time. The simplest way to do this is to estimate the model for two separate sample periods. We have split the sample into the period 1988-1995 and 1996-2007⁸. For the North to South dummy the parameter for the earlier period was found to be -1.31 while in the more recent period this has grown to -1.96. Both parameters are statistically significant at the 95 per cent level. This result indicates that the gap between actual and expected North to South trade is growing. For the South to North flows, the same is found in that the parameter increases from -0.79 to -1.65 although the parameter in the latter case found to be significant at the 90 per cent level. However, formal statistical tests show that this parameter variation is not significant and the parameters from the model estimated over the full sample period are valid.

In percentage terms the differences are also interesting. For the earlier period the gap between actual and expected made for North to South trade was 73 per cent increasing to 86 per cent for the more recent period, while for South to North the respective percentages are 55 per cent and 81 per cent. This suggests that the change in the gap has been most pronounced for the South to North trade. It is also striking that the unimprovement is very substantial. Of course these figures are estimated over the average of the samples and it is not appropriate to interpret these as year on year changes.

If one considers the model overall, only a few variables change over time. These are GDP, population and the Euro. With Ireland experiencing very rapid GDP and population growth particularly over the more recent sample, some of the growth in trade deviation can be attributed to this. In other words trade between Ireland and Northern Ireland has not grown as fast as GDP and population. However, other factors are also likely to play a role.

3.2 Results of the Sectoral Models

Before the sectoral results are outlined it is useful to consider the share of trade that is accounted for by each of the sectors. This will provide an important context for the discussion of the results and the subsequent policy implications since some sectors are significantly more important than others.

Figure 1 highlights the importance of the Food, Beverage and Tobacco sector for trade in both directions. Non-Metallic Minerals and Rubber and Plastics are also important and of similar shares in both directions. Chemicals are more important for trade from Ireland to Northern Ireland while the opposite holds for Fuels, Textiles and Wood and Wood products. Electrical and Optical Equipment accounts for a very small share of trade in either direction.

⁸ The detailed results are not reported here in order to conserve space. As the Euro was only introduced in 2000 the Euro dummies were dropped from the estimation for both subsamples in order to yield comparable results.

Table 2

Estimation Results for Total Bilateral Merchandise Exports 1988-2007, including dummies for the peace process, the introduction of the Single European Market and EU Accession Countries

| Variable | Pooled | Fixed Effects | Random Effects | Hausman-Taylor |
|------------------------|----------|---------------|----------------|----------------|
| GDP | 0.57*** | 0.39*** | 0.40*** | 0.39*** |
| Population | 0.17*** | 0.29 | 0.29*** | 0.29*** |
| Distance | -0.94*** | | -0.92*** | -0.93*** |
| Common Border | 0.62*** | | 0.66*** | 0.64*** |
| Common Language | 0.67*** | | 0.66*** | 0.66*** |
| Trade Agreement | 0.13*** | | 0.34*** | 0.32*** |
| Single Market | 0.006 | -0.23*** | -0.21*** | -0.21*** |
| Exporter EU Accession | -1.43*** | | -1.57*** | -1.60*** |
| Importer EU Accession | -0.45*** | | -0.70*** | -0.72*** |
| North to South Dummy | -1.76*** | | -1.71*** | -1.70 |
| South to North Dummy | -1.30*** | | -1.48*** | -1.48 |
| "Peace Process" | -0.88*** | -0.58*** | -0.59*** | -0.58** |
| Exporter 1 Neighbour | 0.84*** | | 0.84*** | 0.82*** |
| Importer 1 Neighbour | 0.67*** | | 0.66*** | 0.65*** |
| Euro | -0.26*** | -0.005 | -0.02 | -0.02 |
| Exporter Euro | -0.17*** | 0.15*** | 0.14*** | 0.14*** |
| Importer Euro | -0.02 | -0.30*** | -0.28*** | -0.28*** |
| Exporter Island | -0.25*** | | -0.29*** | -0.29*** |
| Importer Island | 0.24*** | | 0.15** | 0.15* |
| Exporter Landlocked | 0.38*** | | 0.44*** | 0.44*** |
| Importer Landlocked | -0.14*** | | -0.10 | -0.11 |
| Number of Observations | 31845 | 31845 | 31845 | 31845 |
| R2 | 0.66 | 0.42 | 0.64 | |
| Hausman Test | | | 1024.33*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively. The "Peace Process" dummy is zero for all country pairs except for the North to South and South to North trade flows and is zero for the period up to 1998 and one from 1998 onwards. An alternative specification where the dummy is equal to one from 1994 was also tried but did not change the results.

Figure 1
Sectoral Trade Shares, 2005 SOUTH TO NORTH

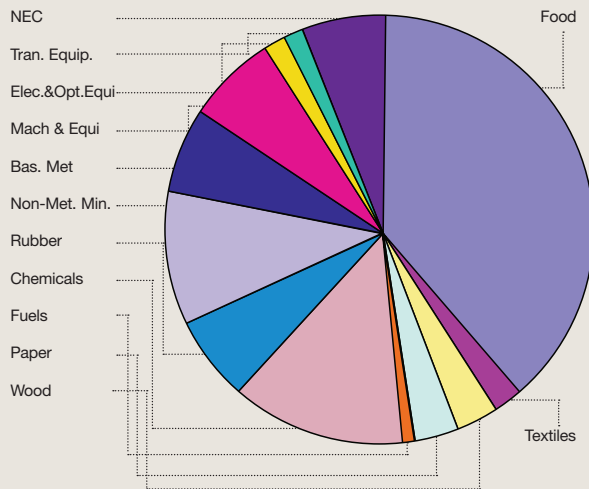
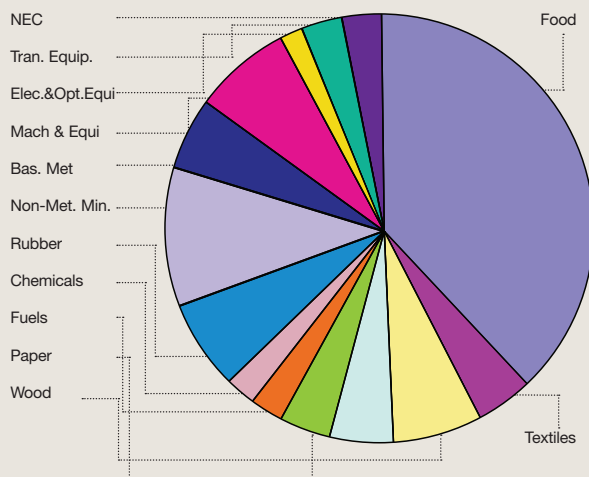


Figure 1
Sectoral Trade Shares, 2005 NORTH TO SOUTH



At the sectoral level the standard model is estimated over the period 1992 to 2007 for 13 sectors. The results for the estimation using the random effects model is shown in Table 3, and all the detailed results can be found in Tables 4 to 16 in Appendix 1.

As in the aggregate model the key gravity model parameters are always of the correct sign and statistically significant in the sectoral model⁹. This holds for GDP, distance, population, common border, common language, importer with just one neighbour and landlocked importer. For seven variables one or two parameters take an unexpected sign while for two variables, namely exporter with the Euro and landlocked exporter, the sign of the parameters varies significantly.

In addition to the sign variation there is some interesting size variation of parameters across sectors. The sector which is most sensitive to changes in GDP is Basic Metals while the least sensitive sector is Wood and Wood Products. In relation to population Textiles and Leather is most sensitive while Fuels is least sensitive. The coefficient for distance varies significantly, having the largest impact on Manufacturing Not Elsewhere Classified (which includes furniture) but has the smallest impact on Food and Beverages which is somewhat surprising. A common border again has the largest impact on Manufacturing Not Elsewhere Classified but the smallest impact on Textiles.

A common language is most important for Paper and Publishing, which is intuitive, and has the smallest impact on Textiles. In relation to the latter it is noteworthy that the coefficient for Paper and Publishing is almost 10 times larger than that for Textiles. A trade agreement has a large positive impact on trade in Paper and Publishing but a negative effect on Fuels. Having just one contiguous trading partner results in larger trade flows for Electrical and Optical Equipment but smaller trade flows for Manufacturing Not Elsewhere Classified. The parameter for the Euro dummy is mostly small, negative and in many cases not statistically different from zero. Exporters with the Euro export more Textiles while they export less Fuels. Importers with the Euro import less but this is most pronounced for Wood and Wood Products and least pronounced for Transport Equipment. Island nations export less Basic Metals but import more Fuels. Finally, being landlocked results in lower imports particularly of Fuels but only marginally of Electrical and Optical Equipment.

⁹ Given the large number of results the focus here is just on those derived from the Random Effects model, which are very similar to those from the Hausmann-Taylor model but in the latter case fewer parameters are statistically significant.

Table 3
Results from the Random Effects Model for each Sector

| Variable | Food, Beverage and Tobacco | Textiles, Leather and Products | Wood and Wood Products | Pulp, Paper and Publishing | Fuels | Chemicals and Chemical Products | Rubber and Plastic |
|------------------------|-------------------------------------|-----------------------------------------|---------------------------------|----------------------------------|----------|------------------------------------------|--------------------------|
| NACE | 15-16 | 17-19 | 20 | 21-22 | 23 | 24 | 25 |
| GDP | 0.46*** | 0.39*** | 0.37*** | 0.42*** | 0.47*** | 0.47*** | 0.38*** |
| Population | 0.22*** | 0.40*** | 0.25*** | 0.33*** | 0.21*** | 0.39*** | 0.32*** |
| Distance | -0.86*** | -0.97*** | -1.07*** | -1.17*** | -1.60*** | -1.15*** | -1.17*** |
| Common Border | 0.84*** | 0.41*** | 1.53*** | 0.78*** | 1.71*** | 0.47*** | 0.80*** |
| Common Language | 1.09*** | 0.17*** | 1.21*** | 1.61*** | 0.77*** | 0.87*** | 0.86*** |
| Trade Agreement | 0.67*** | 0.63*** | 0.60*** | 0.77*** | -0.21 | 0.18 | 0.24* |
| North to South Dummy | -0.38 | -1.12 | -1.31 | -1.78* | -1.01 | -2.39* | -1.66*** |
| South to North Dummy | -0.40 | -1.77 | -1.56* | -1.86* | -1.87 | -1.54 | -1.75** |
| Exporter 1 Neighbour | 0.27** | 1.60*** | 1.23*** | 1.28*** | -0.71 | 1.19*** | 1.51*** |
| Importer 1 Neighbour | 0.41*** | 0.61*** | 0.50*** | 0.50*** | 0.27 | 0.71*** | 0.41*** |
| Euro | -0.04 | -0.09** | -0.08 | -0.09* | -0.01 | -0.05 | -0.18*** |
| Exporter Euro | 0.33*** | 0.41*** | 0.41*** | 0.05* | -0.14 | 0.25*** | 0.12*** |
| Importer Euro | -0.20*** | -0.15*** | -0.36*** | -0.12*** | -0.22 | -0.09*** | -0.22*** |
| Exporter Island | 0.10 | -0.82*** | -1.11*** | -1.22*** | -0.26 | -0.55*** | -0.59*** |
| Importer Island | 0.10 | -0.20* | 0.23 | 0.27** | 0.30* | 0.17* | 0.09 |
| Exporter Landlocked | -0.83*** | -0.09 | -0.02 | 0.15 | -2.41 | 0.36*** | 0.32*** |
| Importer Landlocked | -0.91*** | -0.23 | -0.84*** | 0.67*** | -1.39*** | -0.42*** | -0.49*** |
| Number of Observations | 26,349 | 26,315 | 23,561 | 25,769 | 17,278 | 26,203 | 25,957 |
| R2 | 0.48 | 0.54 | 0.36 | 0.49 | 0.39 | 0.60 | 0.53 |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 3
Continued

| Variable | Non-Metallic Minerals | Basic Metals | Machinery and Equipment | Electrical & Optical Equipment | Transport Equipment | Not Elsewhere Classified |
|------------------------|-----------------------|--------------|-------------------------|--------------------------------|---------------------|--------------------------|
| | 26 | 27-28 | 29 | 30-33 | 34-45 | 36 |
| GDP | 0.41*** | 0.48*** | 0.43*** | 0.44*** | 0.43*** | 0.37*** |
| Population | 0.39*** | 0.35*** | 0.33*** | 0.32*** | 0.36*** | 0.35*** |
| Distance | -1.14*** | -1.15*** | -0.89*** | -0.99*** | -0.92*** | -1.23*** |
| Common Border | 0.81*** | 0.70*** | 0.71*** | 0.48*** | 0.92*** | 0.39** |
| Common Language | 0.85*** | 0.91*** | 0.77*** | 0.96*** | 0.70*** | 1.39*** |
| Trade Agreement | 0.19 | 0.15 | 0.32** | 0.08 | 0.71*** | -0.36** |
| North to South Dummy | 0.39 | -1.46*** | -1.20** | -4.80*** | -2.10*** | -2.35*** |
| South to North Dummy | 0.34 | -1.07* | -1.10 | -4.43*** | -0.54 | -1.95 |
| Exporter 1 Neighbour | 0.70*** | 0.60*** | 1.23*** | 2.34*** | 0.63*** | 1.43*** |
| Importer 1 Neighbour | 0.59*** | 0.67*** | 0.45*** | 1.02*** | 0.29** | 0.47*** |
| Euro | -0.12*** | 0.07* | -0.10*** | -0.09*** | -0.33*** | 0.00 |
| Exporter Euro | 0.10*** | 0.05* | -0.09*** | -0.02 | -0.01 | 0.11*** |
| Importer Euro | -0.10*** | -0.10*** | -0.05** | -0.22*** | -0.04 | -0.28*** |
| Exporter Island | -1.19*** | -1.37*** | -0.94*** | -0.24** | -0.85*** | -1.08*** |
| Importer Island | 0.28*** | 0.07 | -0.09 | 0.05 | 0.30** | -0.06 |
| Exporter Landlocked | 0.56*** | -0.07 | 0.77*** | 0.72*** | 0.07 | 0.16 |
| Importer Landlocked | -0.64*** | -0.56*** | -0.57*** | -0.07 | -0.52*** | -0.13 |
| Number of Observations | 25265 | 26076 | 26187 | 26480 | 25473 | 25735 |
| R2 | 0.55 | 0.59 | 0.55 | 0.51 | 0.46 | 0.44 |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

4. Analysis of the Expected Volume of North to South Trade

This section looks at the key aspect of the analysis, namely the degree to which trade between Ireland and Northern Ireland is at, above or below the expected level, given the factors that have been accounted for in the analysis.

4.1 Analysis of the Aggregate Model

Section 3.1 presents the estimated results for the two models using alternative estimators. In contrast to the sectoral model, a longer data period was available for the aggregate model, which allowed for some additional hypothesis testing. All models indicate that both North to South and South to North flows are below the expected level. In the case of the standard model (Table 1) the result for North to South trade estimated using the random effects model is highly statistically significant while that for the opposite flow is only marginally significant. The results from the extended model (Table 2) are almost identical but in this case the coefficient for South to North trade also turns out to be highly statistically significant.

In order to interpret the parameter estimates it is useful to convert them into percentage deviations. Given that the parameter estimates often have a relatively large standard error it is also useful to construct confidence bands around the parameter estimates. The estimated shortfall of the actual trade over the expected level of trade using the random effect model results from Table 1 imply that the North to South trade flow is 81.8 per cent below the expected level while that for South to North trade is 77.2 per cent below the expected level. These large deviations can be explained by the inclusion of a wide range of factors influencing trade flows. For example, the distance between Northern Ireland and Ireland is the shortest distance, both jurisdictions enjoy a relatively high GDP, both are contiguous and are located on an island. Given these factors one would expect to see very high levels of trade, which according to the estimation are not achieved.

Interestingly, if the dummy variables for single contiguous country, island, landlocked and the Euro are dropped, considerably smaller coefficients and hence trade deviations are predicted¹⁰. Furthermore, the results presented here were subjected to sensitivity analysis by including additional variables, such as a time trend relative US\$ exchange rates. The results are robust to the inclusion of additional variables.

Given the specific locational configuration between Ireland and Northern Ireland it is not surprising to find that once is accounted for this, there is a lower volume of trade than expected. While there are no other islands with two jurisdictions in this sample there are a number of countries that have just one contiguous neighbour. For example, Portugal is only bordered by Spain. Interestingly our model finds that the trade flow from Spain to Portugal is just one percent from the expected level, while trade from Portugal to Spain is 60 per cent below the expected value. On the other hand exports from Canada to the US are 63 per cent higher than expected while those of the US to Canada are 26 per cent higher than expected. Therefore, it is not only trade between Ireland and Northern Ireland that deviates significantly from the expected level.

As was mentioned above, the results are subject to substantial standard deviations resulting in relatively large confidence intervals. In the case of the North to South flows the 95 per cent confidence interval ranges from -90 per cent to -31 per cent, suggesting that the level of trade is definitely significantly below the expected level. However, for the South to North flow the confidence band does include positive values. This does give the possibility that the level of trade in this direction is similar to the expected level, the reality is that trade is below expected levels.

¹⁰ Fitzsimons et al. (1999) did not include these variables in their analysis, as such the results presented here are more robust.

4.2 Analysis of the Sectoral Models

The sectoral results for the key dummy variables are shown in Figure 2 and Figure 3 below. For convenience, the parameters have been converted to percentage deviations from the expected volume of trade.

For all sectors except Non-Metallic Minerals the parameters for the deviations are found to be negative, indicating that the trade between the two jurisdictions is below that expected, even after controlling for the wide range of variables included in the analysis.

With respect to North to South trade the estimated parameters from the random effects model are statistically significant at the 95 per cent level in five out of the 13 cases with a further two estimated parameters that are significant at the 90 per cent level.

For South to North trade just three parameters are statistically significant at the 95 per cent level with a further three being statistically significant at the 90 per cent level. In discussing the statistical significance of the results for these dummy variables it must be borne in mind that each parameter is estimated with just 16 observations so that it is not surprising to find that they are not significant in every case.

For the Food, Beverage and Tobacco and Non-Metallic Minerals sectors, the actual level of trade is approximately as would be expected, allowing for all factors. However, particularly for the Optical and Electronic Equipment sectors, the actual level of trade is very substantially below the expected level.

Some differences also emerge between North to South and South to North trade flows. For example, the level of trade for the Transport Equipment sector is close to expected levels for the South to North flow but is well below expected for the North to South flow.

Figure 2
Estimated Percentage Deviation from Expected Trade, North to South

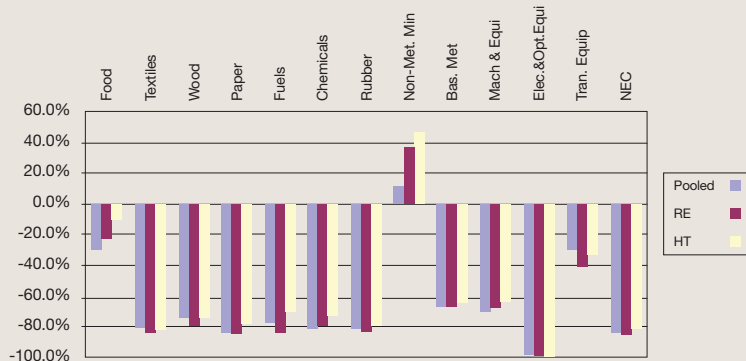


Figure 3
Estimated Percentage Deviation from Expected Trade, South to North



The results for the sectoral analysis show significant variation. The highest deviation from the expected level of trade is found for the Optical and Electrical Equipment sector, with deviations of almost 100 per cent. However, for North to South trade, eight sectors demonstrate the confidence to possibly exceed expected trade. For South to North trade, there are nine sectors that could have a positive deviation from potential trade. For North to South trade the results suggest that actual trade deviated significantly from expected trade for the Rubber and Plastics, Basic Metals, Machinery and Equipment, Electrical and Optical Equipment and Transport Equipment. For the South to North flows the relevant sectors are Fuels, Rubber and Plastics, Electrical and Optical Equipment, and Manufacturing Not Elsewhere Classified (NEC) including Furniture.

The low trade intensity with respect to Optical and Electronic Equipments is likely to be explained by the significant involvement of multinationals in this sector, which are not producing for local market. The vast bulk of their production is destined for export further afield, possibly for assembly in the Far East or for markets in the USA and Europe. A similar argument may be put forward for the Rubber and Plastics sector, but in this context it is surprising that the trade from Chemicals and Pharmaceuticals is not below the expected level. However, it is not surprising that trade for Food, Beverages and Tobacco and Non-Metallic Minerals, which includes products such as cement and other processed building materials such as bricks, is at the appropriate level.

Explaining the differences between sectors is not straightforward as there are likely to be many relevant factors. These include the need for freshness of product, the value to weight ratio, the degree to which the different sectors produce final or intermediate goods and the level of vertical and horizontal integration and the degree to which sectors are dominated by multinationals.

For example, some products are traded more locally. In the case of Food, Beverages and Tobacco tastes are very similar in both Ireland and Northern Ireland, some foods are sourced locally for freshness reasons and there is a degree of integration across the island of Ireland.

In the case of Non-Metallic Minerals, which includes cement and bricks, the value to weight ratio is such that these are not traded extensively over longer distances but tend to be locally sourced. In addition, there is also a degree of integration in the industry where firms have plants in both jurisdictions so that there may also be some intra-firm trade.

The Textiles sector comprises low volume high value output and high volume commercial output. The latter is likely to dominate in the trade statistics. Since the high volume output tends to be purchased by large retailers or is produced on a sub-contract basis for large clothing labels, trade is dominated by a small number of large transactions which tend to be driven by market size. With the small domestic market on the island and few large labels there is limited scope for trade between Ireland and Northern Ireland.

Table 4
Summary Results for each Sector

| Sector | Comment |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Food, Beverages and Tobacco | This sector trades at about the expected level. This is likely to be due to similar tastes across both jurisdictions, a greater level of interaction at the firm level and the need for freshness. |
| Textiles and Leather | This sector trades below the expected value. A possible explanation is the importance of a small number of large customers which are largely based in GB or abroad. |
| Wood | This sector trades below the expected level. A possible explanation is a heavy focus on production for local markets only. |
| Paper and Publishing | This sector trades below the expected level. For South to North trade this is likely to be related to reproduction of recorded media (incl. software) which is dominated by multinationals. |
| Chemicals | This sector trades below the expected level. This is likely to be driven by the high share of multinationals which are serving world markets from their production bases on the island. |
| Rubber and Plastics | This sector trades below the expected level. Production is either focused on local markets or at world markets. |
| Non-Metallic Minerals | This sector trades at about the expected level, primarily due to the low value to weight ratio. |
| Basic Metal products | This sector trades below the expected level. Production is either focused on local markets or at world markets. |
| Machinery and Equipment | This sector trades below the expected level. Production is either focused on local markets or at world markets. |
| Electrical and Optical Equipment | Trade is well below the expected level. This is likely to be driven by the high share of multinationals which are serving world markets from their production bases on the island. |
| Transport Equipment | This sector trades below the expected level. Production is either focused on local markets (e.g. building and repair of pleasure boats) or at world markets (e.g. shipbuilding, or aircraft & aircraft parts). |
| Manufacturing Not Elsewhere Classified | This sector trades below the expected level. |

It has often been argued that the economy in Northern Ireland is a more 'traditional' economy with less competition than the economy in Ireland which is highly integrated into the world economy (Bradley, 2006). As such the deviations of trade from the expected level may reflect differences in the level of development of the sectors in both jurisdictions. If firms in the same sector have a very different level of sophistication, for either product or process, this mismatch may lead to less trade. One aspect of this mismatch is the degree to which sectors are dominated by multinational firms.

A more formal analysis of the relationship of the size of the estimated deviation parameter and the preponderance of multinational firms confirms a significant connection. The correlation coefficients for the relationship between South to North trade and the importance of multinational firms in the number of firms, employment and output of Ireland ranges from -0.41 to -0.47. This suggests that the higher the importance of multinationals, the larger is the gap between expected and actual trade.

Interestingly for the opposite flow (North to South) the correlation with the preponderance of multinationals in Ireland is even stronger (-0.6 to -0.71). This latter finding is likely to be related to the general sourcing policies of these enterprises, in that they either source close to the location of their plant or from within the firm from plants located abroad¹¹.

It should be noted that while there is a relationship between the gap in actual and expected trade and the degree to which a sector is dominated by multinationals, the simple analysis presented here cannot determine the degree to which this gap is explained by this factor. This is highlighted in Figures 4 and 5 which show a scatter plot of the relationship between multinationals and the trade gap. A number of sectors with a relatively low share of multinational involvement have nevertheless high trade deviations. This is the case particularly in the Wood, Rubber and Plastics and Basic Metals sectors.

Figure 4: Relationship Between the Concentration of MNEs and the gap in North to South trade from the expected level

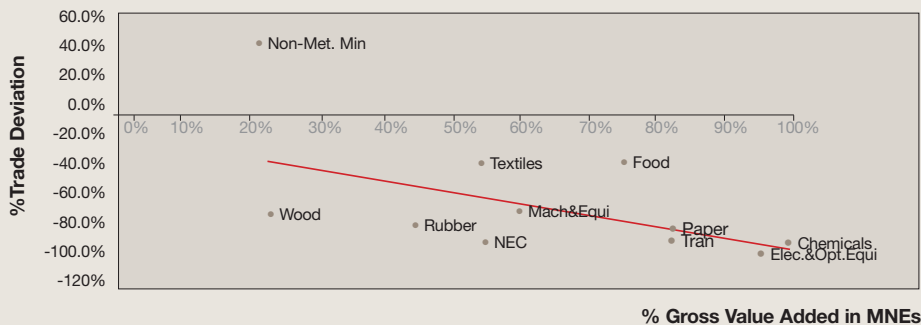
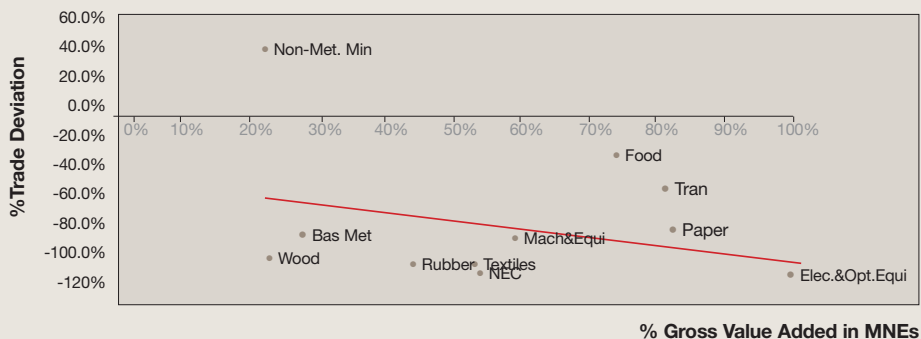


Figure 5: Relationship Between the Concentration of MNEs and the gap in South to North trade from the expected level



¹¹ Ideally one would want to account for this relationship within the estimation but lack of data did not allow for this.

5. Conclusions and Policy Implications

The identification of whether trade intensities on the island of Ireland are above, at or below the expected level is an important task. The island location and the relatively small scale of the economy on the island North and South, implies that significant economic benefit can be derived from forging stronger links between Ireland and Northern Ireland.

This report fills an important research gap by updating and improving on previous analysis on the potential level of trade between Ireland and Northern Ireland. By applying panel data methods to a dataset covering 16 years up to 2007, accounting for a wide range of relevant geographic variables along with the usual gravity model variables, the analysis provides comprehensive results for total exports and exports for 13 manufacturing sectors. The analysis also takes into account the introduction of the Euro which is often seen as a barrier to trade between the two jurisdictions.




The analysis shows that in the majority of cases the trade between Ireland and Northern Ireland is below that expected even after controlling for the wide range of variables included in the analysis. With respect to North to South trade the estimated parameters from the random effects model are statistically significant at the 95 per cent level in five out of the 13 cases with a further two estimated parameters that are significant at the 90 per cent level. For South to North trade three parameters are statistically significant at the 95 per cent level with a further three being statistically significant at the 90 per cent level. This indicates that North to South trade appears to be more generally below expectations while this is only the case to a lesser extent for the South to North flow.

In discussing the statistical significance of the results for these dummy variables it must be borne in mind that each parameter is estimated with just 16 observations so that it is not surprising to find that they are not significant in every case.

Our analysis has a number of important policy implications. Firstly, by identifying that trade between the two jurisdictions is below the expected level, this paper clearly identifies that policy measures to promote trade and business relationships and which remove barriers to trade, whether real or perceived, are justified. Importantly, there is evidence that the deviation from the expected level of trade is increasing, further highlighting the need for appropriate policies.

A close link between trade and other business links has been shown in the international literature. For example, trade is positively related to investment flows across jurisdictions. Trade is also strongly related to technology and skills transfer and migration. An increased level of trade between Ireland and Northern Ireland would also be expected to result in significant benefits through these trade related linkages.


The aim of this study was to identify whether trade between Northern Ireland and Ireland is below, at or above the expected level. What it did not address are the reasons underlying the result that trade is found to be below the expected level. Some issues have already been identified in previous analysis such as the *InterTradelreland* report on *Business Networks on the Island of Ireland* and the *InterTradelreland Survey on Business Linkages*. However, in order to design the appropriate policy measures further work at the sectoral level is necessary.



From a policy perspective it is important to consider where resources are most effectively used to promote trade. Furthermore, it is also important to consider the appropriate policy tools as these may well differ between sectors.

It is unlikely that one can promote trade in the sectors that are dominated by multinationals without significant structural change in the sectors. For example, there may be no demand for certain high tech intermediate products as few firms are operating at a level where they could utilise such inputs. In such cases, enterprise and training/education policy are relevant tools.

An important consideration has to be the market structure and the size of the consumer market locally. If, as in the case of textiles, a significant proportion of output is exported to large retail chains or fashion labels then it is difficult to stimulate trade between the jurisdictions.



In general there is probably more scope to promote trade in sectors which are very homogenous across the island of Ireland. This is most likely in the more traditional sectors. Here, cross-border trade promotion may also stimulate trade with other parts of the world as businesses learn to trade.

An important point to note is that while the level of trade for two industries Food and Beverages and Non-Metallic Minerals is at the expected level, this does not imply that policy measures to promote further trade so that it rises to above the expected level are not warranted.

Finally, this report has only considered trade in manufactured products since the required data to carry out a similar analysis for services is not available. This is an important issue since services trade is growing rapidly. The data gaps need to be addressed urgently, and should not be unduly difficult. For example, if Northern Ireland was identified as a separate trade partner with respect to services trade, as is the case for merchandise trade, it would be relatively straightforward to collect the data using the survey forms developed to collect services trade data in Ireland. This will only have a negligible cost.

Appendix 1. Sectoral Results

Table 5
Estimation Results for Bilateral Exports for Food, Beverages and Tobacco

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.76*** | 0.43*** | 0.46*** | 0.44*** |
| Population | -0.018** | -0.09 | 0.22*** | 0.25*** |
| Distance | -0.87*** | | -0.86*** | -0.79*** |
| Common Border | 0.75*** | | 0.84*** | 0.89*** |
| Common Language | 1.06*** | | 1.09*** | 1.07*** |
| Trade Agreement | 0.32*** | | 0.67*** | 0.81*** |
| North to South Dummy | -0.24** | | -0.38 | -0.27 |
| South to North Dummy | -0.37* | | -0.40 | -0.28 |
| Exporter 1 Neighbour | 0.03 | | 0.27** | 0.29** |
| Importer 1 Neighbour | 0.32*** | | 0.41*** | 0.45*** |
| Euro | 0.26*** | -0.04 | -0.04 | -0.040 |
| Exporter Euro | 0.66*** | 0.30*** | 0.33*** | 0.33*** |
| Importer Euro | -0.10** | -0.22*** | -0.20*** | -0.120*** |
| Exporter Island | 0.27*** | | 0.10 | 0.11 |
| Importer Island | 0.21*** | | 0.10 | 0.12 |
| Exporter Landlocked | -0.89*** | | -0.83*** | -0.79*** |
| Importer Landlocked | -0.82*** | | -0.91*** | -0.87*** |
| Number of Observations | 26349 | 26349 | 26349 | 26349 |
| R2 | 0.51 | 0.34 | 0.48 | |
| Hausman Test | | | 370.5*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 6**Estimation Results for Bilateral Exports for Textiles, Textile Products and Leather and Leather Products**

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.70*** | .36*** | 0.39*** | 0.36*** |
| Population | 0.19*** | -.39 | 0.40*** | 0.40*** |
| Distance | -0.97*** | | -0.97*** | -0.91*** |
| Common Border | 0.39*** | | 0.41*** | 0.48 |
| Common Language | 1.10*** | | 0.17*** | 1.21*** |
| Trade Agreement | 0.35*** | | 0.63*** | 0.70*** |
| North to South Dummy | -1.23*** | | -1.12 | -1.04 |
| South to North Dummy | -1.62*** | | -1.77 | -1.69 |
| Exporter 1 Neighbour | 1.46*** | | 1.60*** | 1.59*** |
| Importer 1 Neighbour | 0.55*** | | 0.61*** | 0.59*** |
| Euro | -0.11* | -0.08 | -0.09** | -0.09* |
| Exporter Euro | 0.38*** | 0.38*** | 0.41*** | 0.41*** |
| Importer Euro | 0.34*** | -0.20*** | -0.15*** | -0.16*** |
| Exporter Island | -0.65*** | | -0.82*** | -0.88*** |
| Importer Island | 0.08*** | | -0.20* | -0.26 |
| Exporter Landlocked | -0.07** | | -0.09 | -0.10 |
| Importer Landlocked | -0.08** | | -0.23 | -0.22 |
| Number of Observations | 26315 | 26315 | 26315 | 26315 |
| R2 | 0.56 | 0.006 | 0.54 | |
| Hausman Test | | | 366.68*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 7
Estimation Results for Bilateral Exports for Wood and Wood Products

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.70*** | 0.33*** | 0.37*** | 0.34*** |
| Population | 0.001*** | -1.71*** | 0.25*** | 0.06 |
| Distance | -1.06*** | | -1.07*** | -0.83*** |
| Common Border | 1.42*** | | 1.53*** | 1.96*** |
| Common Language | 0.96*** | | 1.21*** | 1.41*** |
| Trade Agreement | 0.23*** | | 0.60*** | 0.68 |
| North to South Dummy | -1.59*** | | -1.31 | -1.10 |
| South to North Dummy | -1.42*** | | -1.56* | -1.35 |
| Exporter 1 Neighbour | 0.94*** | | 1.23*** | 1.05*** |
| Importer 1 Neighbour | 0.41*** | | 0.50*** | 0.28 |
| Euro | -0.64*** | -0.048 | -0.08 | -0.06 |
| Exporter Euro | 0.32*** | 0.32*** | 0.41*** | 0.39*** |
| Importer Euro | 0.39*** | -0.48*** | -0.36*** | -0.40*** |
| Exporter Island | -0.72*** | | -1.11*** | -1.55*** |
| Importer Island | 0.52*** | | 0.23 | -0.20 |
| Exporter Landlocked | -0.15*** | | -0.02 | -0.21 |
| Importer Landlocked | -0.66*** | | -0.84*** | -1.04** |
| Number of Observations | 23561 | 23561 | 23561 | 23561 |
| R2 | 0.40 | 0.03 | 0.36 | |
| Hausman Test | | | 450.50*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 8**Estimation Results for Bilateral Exports for Paper and Publishing**

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 1.00*** | 0.35*** | 0.42*** | 0.36*** |
| Population | -0.11*** | -0.12 | 0.33*** | 0.41*** |
| Distance | -1.19*** | | -1.17*** | -0.99*** |
| Common Border | 0.63*** | | 0.78*** | 0.90*** |
| Common Language | 1.51*** | | 1.61*** | 1.60*** |
| Trade Agreement | 0.31*** | | 0.77*** | 1.15*** |
| North to South Dummy | -1.52*** | | -1.78* | -1.44 |
| South to North Dummy | -1.85*** | | -1.86* | -1.51 |
| Exporter 1 Neighbour | 0.97*** | | 1.28*** | 1.33*** |
| Importer 1 Neighbour | 0.51*** | | 0.50*** | 0.57*** |
| Euro | -0.17** | -0.06 | -0.09* | -0.08 |
| Exporter Euro | 0.26*** | 0.01 | 0.05* | 0.05 |
| Importer Euro | -0.40*** | -0.14** | -0.12*** | -.11*** |
| Exporter Island | -0.91*** | | -1.22*** | -1.21*** |
| Importer Island | 0.44*** | | 0.27** | 0.24* |
| Exporter Landlocked | 0.10*** | | 0.15 | 0.23 |
| Importer Landlocked | -0.49*** | | -0.67*** | -0.58*** |
| Number of Observations | 25769 | 25769 | 25769 | 25769 |
| R2 | 0.56 | 0.32 | 0.49 | |
| Hausman Test | | | 1039.93*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 9
Estimation Results for Bilateral Exports for Fuels

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.64*** | 0.40*** | 0.47*** | .29** |
| Population | 0.11*** | -1.49*** | 0.21*** | .42*** |
| Distance | -1.65*** | | -1.60*** | -1.38*** |
| Common Border | 1.44*** | | 1.71*** | 1.90** |
| Common Language | 0.56*** | | 0.77*** | 0.81 |
| Trade Agreement | -0.45*** | | -0.21 | 0.3 |
| North to South Dummy | -0.93*** | | -1.01 | -0.36 |
| South to North Dummy | -1.58*** | | -1.87 | -1.23 |
| Exporter 1 Neighbour | -0.89*** | | -0.71 | -.81** |
| Importer 1 Neighbour | 0.36*** | | 0.27 | 0.33 |
| Euro | -0.18 | 0.02 | -0.01 | -0.01 |
| Exporter Euro | -0.78*** | -0.16 | -0.14 | -0.1 |
| Importer Euro | -0.42*** | -0.29 | -0.22 | -.19*** |
| Exporter Island | -0.02 | | -0.26 | -0.34 |
| Importer Island | 0.26*** | | 0.30* | 0.16 |
| Exporter Landlocked | -2.53*** | | -2.41 | -2.43*** |
| Importer Landlocked | -1.32*** | | -1.39*** | -1.36** |
| Number of Observations | 17278 | 17278 | 17278 | 17278 |
| R2 | 0.4 | 0.03 | 0.39 | |
| Hausman Test | | | 315.81*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 10**Estimation Results for Bilateral Exports for Chemicals and Chemical Products**

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.90*** | 0.43*** | 0.47*** | 0.43*** |
| Population | 0.08** | 0.05 | 0.39*** | 0.45*** |
| Distance | -1.18*** | | -1.15*** | -1.03*** |
| Common Border | 0.36*** | | 0.47*** | 0.56** |
| Common Language | 0.83*** | | 0.87*** | 0.87*** |
| Trade Agreement | -0.17*** | | 0.18 | 0.43*** |
| North to South Dummy | -2.26*** | | -2.39* | -2.18 |
| South to North Dummy | -1.71*** | | -1.54 | -1.32 |
| Exporter 1 Neighbour | 1.00*** | | 1.19*** | 1.22*** |
| Importer 1 Neighbour | 0.74*** | | 0.71*** | 0.77*** |
| Euro | -0.05 | -0.04 | -0.05 | -0.04 |
| Exporter Euro | 0.59*** | 0.21*** | 0.25*** | 0.25*** |
| Importer Euro | -0.33*** | -0.10 | -0.09*** | -0.08*** |
| Exporter Island | -0.25*** | | -0.55*** | -0.53*** |
| Importer Island | 0.33*** | | 0.17* | 0.16 |
| Exporter Landlocked | 0.40*** | | 0.36*** | 0.42*** |
| Importer Landlocked | -0.34*** | | -0.42*** | -0.38** |
| Number of Observations | 26203 | 26203 | 26203 | 26203 |
| R2 | 0.64 | 0.44 | 0.60 | |
| Hausman Test | | | 624.11*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 11
Estimation Results for Bilateral Exports for Rubber and Plastics

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.85*** | 0.33*** | 0.38*** | 0.34*** |
| Population | 0.003 | -0.74*** | 0.32*** | 0.30*** |
| Distance | -1.19*** | | -1.17*** | -1.03*** |
| Common Border | 0.69*** | | 0.80*** | 0.98** |
| Common Language | 0.75*** | | 0.86*** | 0.92*** |
| Trade Agreement | -0.13*** | | 0.24* | 0.42 |
| North to South Dummy | -1.57*** | | -1.66*** | -1.47 |
| South to North Dummy | -1.66*** | | -1.75** | -1.56 |
| Exporter 1 Neighbour | 1.31*** | | 1.51*** | 1.45*** |
| Importer 1 Neighbour | 0.39*** | | 0.41*** | 0.36* |
| Euro | -0.19*** | -0.17** | -0.18*** | -0.17*** |
| Exporter Euro | 0.28*** | 0.06 | 0.12*** | 0.11*** |
| Importer Euro | -0.05 | -0.28*** | -0.22*** | -0.23*** |
| Exporter Island | -0.30*** | | -0.59*** | -0.73*** |
| Importer Island | 0.34*** | | 0.09 | -0.06 |
| Exporter Landlocked | 0.32*** | | 0.32*** | 0.28 |
| Importer Landlocked | -0.32*** | | -0.49*** | -0.53** |
| Number of Observations | 25957 | 25957 | 25957 | 25957 |
| R2 | 0.59 | 0.03 | 0.53 | |
| Hausman Test | | | 1576.43*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 12**Estimation Results for Bilateral Exports for Non-Metallic Minerals**

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.81*** | .35*** | 0.41*** | 0.36*** |
| Population | 0.12*** | -1.03** | 0.39*** | 0.30*** |
| Distance | -1.13*** | | -1.14*** | -1.04*** |
| Common Border | 0.71*** | | 0.81*** | 1.01** |
| Common Language | 0.70*** | | 0.85*** | 0.97*** |
| Trade Agreement | 0.02 | | 0.19 | 0.22 |
| North to South Dummy | 0.47*** | | 0.39 | 0.46 |
| South to North Dummy | 0.10 | | 0.34 | 0.42 |
| Exporter 1 Neighbour | 0.48*** | | 0.70*** | 0.58** |
| Importer 1 Neighbour | 0.62*** | | 0.59*** | 0.46* |
| Euro | -0.34*** | -.10 | -0.12*** | -0.10* |
| Exporter Euro | 0.69*** | .001 | 0.10*** | 0.06** |
| Importer Euro | -0.13*** | -.16** | -0.10*** | -0.10*** |
| Exporter Island | -0.69*** | | -1.19*** | -1.43*** |
| Importer Island | 0.46*** | | 0.28*** | 0.03 |
| Exporter Landlocked | 0.59*** | | 0.56*** | 0.44 |
| Importer Landlocked | -0.46*** | | -0.64*** | -0.78** |
| Number of Observations | 25265 | 25265 | 25265 | 25265 |
| R2 | 0.60 | 0.08 | 0.55 | |
| Hausman Test | | | 690.89*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 13
Estimation Results for Bilateral Exports for Basic Metals and Fabricated Metal Products

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.92** | 0.42*** | 0.48*** | 0.42*** |
| Population | 0.05*** | -0.96*** | 0.35*** | 0.29*** |
| Distance | -1.18*** | | -1.15*** | -1.06*** |
| Common Border | 0.54*** | | 0.70*** | 0.87* |
| Common Language | 0.84*** | | 0.91*** | 1.00*** |
| Trade Agreement | -0.07* | | 0.15 | 0.19 |
| North to South Dummy | -1.46*** | | -1.46*** | -1.39 |
| South to North Dummy | -1.09*** | | -1.07* | -0.99 |
| Exporter 1 Neighbour | 0.48*** | | 0.60*** | 0.51** |
| Importer 1 Neighbour | 0.71*** | | 0.67*** | 0.58*** |
| Euro | 0.04 | -0.06 | 0.07* | -0.06 |
| Exporter Euro | -0.27*** | -0.001 | 0.05* | 0.05* |
| Importer Euro | -0.48*** | -0.15** | -0.10*** | -0.09*** |
| Exporter Island | -0.99*** | | -1.37*** | -1.57*** |
| Importer Island | 0.21*** | | 0.07 | -0.14 |
| Exporter Landlocked | -0.03 | | -0.07 | -0.15 |
| Importer Landlocked | -0.40*** | | -0.56*** | -0.63** |
| Number of Observations | 26076 | 26076 | 26076 | 26076 |
| R2 | 0.63 | 0.08 | 0.59 | |
| Hausman Test | | | 658.30*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 14**Estimation Results for Bilateral Exports for Machinery and Equipment**

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 1.02*** | 0.37*** | 0.43*** | 0.37*** |
| Population | -0.08*** | -0.73*** | 0.33*** | 0.30*** |
| Distance | -0.95*** | | -0.89*** | -0.77*** |
| Common Border | 0.55*** | | 0.71*** | 0.89** |
| Common Language | 0.65*** | | 0.77*** | 0.82*** |
| Trade Agreement | -0.13*** | | 0.32** | 0.45* |
| North to South Dummy | -0.94*** | | -1.20** | -1.09 |
| South to North Dummy | -1.20** | | -1.10 | -0.97 |
| Exporter 1 Neighbour | 1.04*** | | 1.23*** | 1.19*** |
| Importer 1 Neighbour | 0.49*** | | 0.45*** | 0.38* |
| Euro | -0.27*** | -0.08 | -0.10*** | -0.09* |
| Exporter Euro | 0.25*** | -0.16*** | -0.09*** | -0.11*** |
| Importer Euro | -0.44*** | -0.09 | -0.05** | -0.04* |
| Exporter Island | -0.65*** | | -0.94*** | -1.09*** |
| Importer Island | 0.15*** | | -0.09 | -0.25 |
| Exporter Landlocked | 0.79*** | | 0.77*** | 0.73*** |
| Importer Landlocked | -0.36*** | | -0.57*** | -0.63** |
| Number of Observations | 26187 | 26187 | 26187 | 26187 |
| R2 | 0.63 | 0.03 | 0.55 | |
| Hausman Test | | | 3860.45*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 15
Estimation Results for Bilateral Exports for Electrical and Optical Equipment

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.97*** | 0.39*** | 0.44*** | 0.40*** |
| Population | -0.02* | -1.16*** | 0.32*** | 0.20*** |
| Distance | -1.04*** | | -0.99*** | -0.83** |
| Common Border | 0.32*** | | 0.48*** | 0.80 |
| Common Language | 0.84*** | | 0.96*** | 1.07 |
| Trade Agreement | -0.26*** | | 0.08 | 0.14 |
| North to South Dummy | -4.70*** | | -4.80*** | -4.70 |
| South to North Dummy | -4.28*** | | -4.43*** | -4.33 |
| Exporter 1 Neighbour | 2.25*** | | 2.34*** | 2.19 |
| Importer 1 Neighbour | 1.05*** | | 1.02*** | 0.88 |
| Euro | -0.16** | -0.08 | -0.09*** | -0.08 |
| Exporter Euro | -0.21*** | -0.09 | -0.02 | -0.03 |
| Importer Euro | -0.32*** | -0.29*** | -0.22*** | -0.22*** |
| Exporter Island | -0.02 | | -0.24** | -0.50** |
| Importer Island | 0.31*** | | 0.05 | -0.24 |
| Exporter Landlocked | 0.74*** | | 0.72*** | 0.59* |
| Importer Landlocked | 0.12*** | | -0.07 | -0.20 |
| Number of Observations | 26480 | 26480 | 26480 | 26480 |
| R2 | 0.56 | 0.07 | 0.51 | |
| Hausman Test | | | 1462.98*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 16**Estimation Results for Bilateral Exports for Transport Equipment**

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 1.06*** | 0.33*** | 0.43*** | 0.34*** |
| Population | -0.07*** | -1.52*** | 0.36*** | 0.25*** |
| Distance | -0.95*** | | -0.92*** | -0.74*** |
| Common Border | 0.74*** | | 0.92*** | 1.26* |
| Common Language | 0.52*** | | 0.70*** | 0.87* |
| Trade Agreement | 0.29*** | | 0.71*** | 0.83* |
| North to South Dummy | -1.81*** | | -2.10*** | -1.96 |
| South to North Dummy | -0.38 | | -0.54 | -0.39 |
| Exporter 1 Neighbour | 0.46*** | | 0.63*** | 0.47 |
| Importer 1 Neighbour | 0.30*** | | 0.29** | 0.11 |
| Euro | -0.20** | -0.32*** | -0.33*** | -0.32*** |
| Exporter Euro | 0.05 | -0.11* | -0.01 | -0.04 |
| Importer Euro | -0.22*** | -0.12 | -0.04 | -0.04 |
| Exporter Island | -0.49*** | | -0.85*** | -1.22*** |
| Importer Island | 0.55*** | | 0.30** | -0.08 |
| Exporter Landlocked | 0.14*** | | 0.07 | -0.11 |
| Importer Landlocked | -0.31*** | | -0.52*** | -0.76* |
| Number of Observations | 25473 | 25473 | 25473 | 25473 |
| R2 | 0.53 | 0.09 | 0.46 | |
| Hausman Test | | | 1262.95*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Table 17
Estimation Results for Bilateral Exports for Manufacturing Not Elsewhere Classified

| Variable | Pooled | Fixed Effects | Random Effects | Hausman - Taylor |
|------------------------|----------|---------------|----------------|------------------|
| GDP | 0.93*** | 0.32*** | 0.37*** | 0.42*** |
| Population | -0.06*** | 0.16 | 0.35*** | 0.33*** |
| Distance | -1.20*** | | -1.23*** | -1.08*** |
| Common Border | 0.37*** | | 0.39** | 0.51* |
| Common Language | 1.20*** | | 1.39*** | 1.39*** |
| Trade Agreement | -0.64*** | | -0.36** | -0.04 |
| North to South Dummy | -2.47*** | | -2.35*** | -2.09 |
| South to North Dummy | -1.83*** | | -1.95 | -1.68 |
| Exporter 1 Neighbour | 1.21*** | | 1.43*** | 1.49*** |
| Importer 1 Neighbour | 0.44*** | | 0.47*** | 0.52*** |
| Euro | -0.12* | 0.02 | 0.00 | 0.01 |
| Exporter Euro | -0.11*** | 0.09* | 0.11*** | 0.11*** |
| Importer Euro | -0.01 | -0.30*** | -0.28*** | -0.28*** |
| Exporter Island | -0.68*** | | -1.08*** | -1.07 |
| Importer Island | 0.22*** | | -0.06 | -0.05 |
| Exporter Landlocked | 0.17*** | | 0.16 | 0.24 |
| Importer Landlocked | 0.05 | | -0.13 | -0.05 |
| Number of Observations | 25735 | 25735 | 25735 | 25735 |
| R2 | 0.51 | 0.28 | 0.44 | |
| Hausman Test | | | 1893.51*** | |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

Appendix 2. Technical Issues

A2.1 Methodology

Following the call to tender, the study applies a gravity model to explore the factors driving trade flows on the island of Ireland and to identify whether North/South trade flows are at expected levels, accounting for all factors. In doing so, this analysis will update and improve upon the earlier work by Fitzsimons et al. (1999).

A2.2 The Gravity Model

The gravity model of international trade flows has been widely applied over recent years. In relation to trade flows this model was first outlined by Tinbergen (1962) and Pöyhönen (1963) and it has been found to explain a significant proportion of bilateral trade flows¹².

As the name suggests, the gravity model is based on the assumption that trade is generated by mass or economic size, which is proxied by GDP, and is inhibited by distance, which increases transportation and other transactions costs¹³. In its most basic form it relates bilateral trade to distance between countries and a gravity variable, usually GDP. Thus trade flows to the countries with a high GDP (high gravity) but is inhibited by distance.

The gravity model has been widely used to investigate a range of trade issues such as the effect of trading block membership (see Aitken, 1973, Oguledo and MacPhee, 1994, Frankel, Stein and Wei, 1995, and Bayoumi and Eichengreen, 1995), the impact of national borders (see McCallum, 1995 and Anderson and van Wincoop, 2003), the impact of transport infrastructure (Bougheas et al., 1999 and Limao and Venables, 2001), the impact of migration (see Head and Ries, 1998, Rauch, 1999 and Morgenroth and O'Brian, 2008), and the persistence of trade flows over time (see Wei, 1996 or Eichengreen and Irwin, 1998).

A particularly interesting application of the gravity model is to use it to estimate trading potential and deviations from this. In general the approach used for this analysis is to use the gravity model coefficients that are estimated for a particular country with respect to a large set of trading partners to project the changed trade volume following a policy change. Examples of the policy change analysed include the potential opening of the then Soviet Union and Eastern Europe (see Hamilton and Winters, 1992), the break up of the COMECON (see Byers, Iscan and Lesser, 2000), the establishment of new preferential trading arrangements (see Boughanmi, 2008 or Carrere, 2006) and the impact of EU enlargement (see Papazoglou et al. 2006).

A2.3 Applications of the Gravity Model to Irish Data

Just a few studies have made use of the gravity model to specifically consider issues relating to Ireland's trade flow. The study by Fitzpatrick (1984) appears to have been the first such analysis. The model was estimated for both imports and exports for three broad commodity groups namely merchandise, raw materials and other manufactured goods (intermediates). Interestingly this study appears to have been the first to use actual freight rates for the exports equation. The overall findings of that study were that the gravity model fitted well and that Irish trade was not explained by economic similarity between Ireland and its trading partners.

The potential impact of the EU membership of five central and eastern European countries on Ireland's trade flows was considered by Brühlhart and Kelly (1999). They found that actual trade with these countries before they gained EU membership was approximately half of the potential trade.

¹² The gravity model has also found widespread application in studies of migration and commuting flows (see Sen and Smith, 1995, or in the Irish context Morgenroth, 2001a,b)

¹³ Theoretical foundations to the gravity model have been provided by Anderson (1979), Bergstrand (1985, 1989) and Evenett and Keller (2002).

Walsh and Thom (2001) studied the impact of the break of the de-facto currency union between Britain and Ireland in 1979, in response to other papers, which found evidence that a currency union could double the trade volume (see Rose 2000 and Glick and Rose, 2002). However, their results showed that the break of the Anglo-Irish currency union did not result in a halving of trade, and that exchange rate volatility had an insignificant effect on trade volumes¹⁴.

Apart from time series estimates they also provide some estimates using panel data where North/South trade was included separately to trade between Ireland and Great Britain, and where a contiguity dummy variable for the common land border between Northern Ireland and Ireland was included. The coefficient on this dummy was found to be positive but only significant in one specification, which the authors argue was misspecified, suggesting that North/South trade was not more intensive than other trade.

The most relevant study in relation to the terms of reference for this project is that of Fitzsimons et al. (1999) who carried out an analysis of the trade of Ireland where Northern Ireland was an explicit trading partner using data for 1978-1992. They concluded that the trade intensity between the two jurisdictions was no less than expected and indeed may be above what would be expected. However, this finding did not take into account that one would expect a higher trade intensity for two trading partners located on the same island, given that trade with alternative partners would entail substantial additional transport costs.

Their analysis was carried out at the aggregate level and therefore the analysis was unable to assess any possible differences in trade intensity by sector. Finally, given that their sample finished in 1992, any possible peace dividend following the IRA ceasefire in 1994 and the signing of the Belfast Agreement in 1998 was not assessed.

A2.4 Variable Specification

To implement the gravity model it is customary to apply a log-linear functional form which has been found to fit the data well. Apart from the choice of functional form it has been shown that the inappropriate variable specification can result in significant bias of the results.

The first important issue in variable specification is the specification of the dependent variable. In a number of papers total trade, that is imports plus exports, have been specified, and indeed since each flow is observed twice some authors have used the average of both observations. This practice has been shown to be problematic from a theoretical and econometric point of view (see Baldwin and Taglioni, 2006) and the results are only of limited use for policymaking as one cannot identify the individual flows (imports or exports). Another important issue relates to the aggregation of the trade data. In most studies aggregate merchandise trade is used as the dependent variable. However, based on theoretical considerations, the data should be disaggregated into appropriate sectors (see Evenett and Keller, 2002). Indeed a number of studies have used disaggregated data, which also allows much deeper insights for policy analysis (see Bergstrand, 1989 or Chen, 2004).

¹⁴ The latter result confirmed that of Morgenroth (2000).

In addition to the gravity variable GDP of the destination country and the friction variable distance it is customary to include a range of additional variables that capture the trading potential between country pairs. For example, a high level of income in the exporting country indicates a high level of production, which increases the availability of products for export while a high level of income in the importing country suggests higher imports.

In some studies home and destination country populations are also added to augment the gravitational variables and in some cases per capita GDP is also used. This specification is not consistent with the standard derivation of the gravity model as an expenditure system (see Baldwin and Taglioni, 2006). A further important specification issue is the appropriate choice of price deflators. As shown by Baldwin and Taglioni (2006) the common practice to use the US deflator for trade of all country pairs (primarily because of ready availability of the data) results in biased estimates and spurious correlation.

It is common to add dummy variables or other variables, which are thought to explain trade flows to this specification. For example Frankel et al. (1995), add dummy variables for country pairs which share a common language and common border, as well as trading blocks dummy variables, which evaluate the effect of preferential trading agreements. The coefficients for all these dummy variables are expected to be positive since neighbouring countries tend to trade more with each other, a common language makes trade easier and membership of a trade block is expected to facilitate trade. Similarly Fitzsimons et al. (1999) introduce a dummy variable for North/South trade to

assess whether North/South trade is statistically higher than average bilateral trade. While they found a positive coefficient this was not statistically significant.

A2.5 Trade Data

A number of data sources are available for data on bilateral trade. One of the most comprehensive and widely used trade datasets has been collected by the United Nations in form of the COMTRADE database. This database contains detailed bilateral trade flows at the product level. The report uses data for 37 countries which were chosen on the basis of the size of their bilateral trade relationship with Ireland. The data are in current US\$ and were converted to constant US\$ by applying the GDP deflator for the exporting country. In other words, purchasing power parity is not assumed in this analysis.

The data is for 42 countries plus additional flows for trade between Ireland and Northern Ireland and Great Britain respectively. Data for these latter trade flows is not available from internationally available databases so that it was necessary to draw on other sources, namely data collected by the CSO in Ireland. Detailed data at the product level required for the analysis conducted here was only available from the CSO for the period 1992-2007, which limited the sample period somewhat¹⁵.

As trade data is collected with a product breakdown rather than a sectoral breakdown it is necessary to apply concordance tables to match the data into sectors. This also allows for the trade in primary products and livestock to be taken out of the analysis.

¹⁵The COMTRADE data was collected for the period 1988 to 2007, but the data for the period 1988 to 1991 was not used in the analysis.

Applying concordance tables to match from product to sector is not a precise exercise. Applying a number of different concordance tables showed a varying level of matching success including a lower level of matching in recent years. Given that these tables match in the region of 15,000 different products into sectors it is difficult to ascertain the exact cause of any mismatching.

The data is matched into 13 sectors rather than the 14 sectors normally used. The reason for this is that Leather and Leather products turned out to have a significant portion of zero trade flows so a decision was taken to aggregate Textiles and Leather into one broad sector.

Overall there are 1,723 country pairs over 16 years which would yield 27,568 observations. However, in practice trade data was missing for some country pairs so that the total number of observations is slightly smaller. The data was collected for both exports and imports, but since exports from country A to country B are, at least in theory the same as imports into country B from country A, it is only necessary to conduct the analysis for one flow. In common with many papers we choose to model exports. Another approach sometimes followed in the literature is to average over all four observations (the two export flows and the two import flows) for each country pair to estimate the overall trade intensity. However as indicated above, for the present purposes it is more appropriate to consider the flows in each direction.

A2.6 Gravitational Variables

Two gravitational variables are used in the analysis namely GDP and population. The GDP figures are taken from a combination of OECD, IMF and UN sources, in current US\$ and these are converted to constant US\$ using the country specific GDP deflators. The log of the product of country pair constant GDPs in millions of US dollars. Population figures are taken from a combination of the OECD and the World Bank Development Indicators.

For the analysis the log of the product of total population of country pairs is used. This distance is constructed as the distance between the capital cities of the trading countries and is entered into the analysis in logarithms.

A2.7 Dummy Variables

A range of dummy variables are used to account for specific factors that are likely to influence the degree of trade between two countries. These include dummy variables of geographic factors, dummy variables for cultural factors and dummy variables for economic factors such as the existence of a trade agreement between the two countries or the membership in a currency union. Specifically we add dummies for contiguous country pairs (Common Border), dummy variables for countries with only one contiguous country (exporter 1 neighbour and importer 1 neighbour), dummies for countries that are landlocked and dummies for countries that are islands. This extensive list of geographic dummies along with distance between countries should account for the underlying geographic factors. We also add a dummy for country pairs which

¹⁴ The latter result confirmed that of Morgenroth (2000).

have a trade agreement and a dummy for countries which are Euro members. The latter is interesting from a policy point of view since the Euro was introduced roughly in the middle of our sample period and might have significantly altered trade patterns. Not accounting for this might bias the parameters of other factors. Finally, in order to identify whether exports from Northern Ireland to Ireland and those from Ireland to Northern Ireland are above, at or below the expected level, two additional dummy variables for these trade pairs are added (North to South and South to North respectively).

A2.8 Estimation Methodology

The appropriate estimation method and related econometric issues have been shown to have a significant impact on the quality of the estimation results. Firstly, results contained in Morgenroth (2002) show that the choice of sample is important for studies which aim to predict potential trade between certain countries since significant parameter differences were found for estimates using alternative samples. Furthermore, the parameters were found not to be stable over time. The appropriate econometric technique can help in reducing this parameter instability.

It has been shown that the inappropriate modelling of the spatial aspects of the trade patterns can bias the results (see Porojan, 2001 and Baldwin and Taglioni, 2006). In this respect the proper specification of dummy variables and/or the use of appropriate estimators is important.

While Porojan (2001) proposes the use of spatial econometric estimators, Baldwin and Taglioni, (2006) recommend a fixed effects estimator. The latter is a natural choice for panel data while the former is better suited to cross section data.

In terms of the gravity model, the fixed effects estimator can be viewed as a reduced form estimator and it has the advantage that it captures all country specific characteristics in the country specific constant term and avoids misspecification problems. In relation to panel data estimators a number of papers have considered the appropriate estimator. While it was initially believed that the fixed effects estimator was superior (see Egger, 2000), more recent research has recommended the use of the Hausmann-Taylor estimator (see Egger, 2005 and Serlenga et al., 2007). Recently some authors have also highlighted the need to account for the dynamics of trade over time by applying dynamic panel estimators (e.g. De Benedicts and Vicarelli, 2005).

Finally, it has been shown that a number of the estimated parameters in a gravity model could be biased and inefficiently estimated due to endogeneity problems (see Bougheas et al, 1999, Baldwin and Taglioni, 2006 and Morgenroth and O'Brien, 2008). Standard approaches can be used to test for and eliminate the problem of endogeneity.

It is instructive to briefly outline these approaches more formally. Firstly we can write the gravity equation as follows: $\log(X_{ij,t}) = \alpha + \beta_1 \log(Y_{i,t} Y_{j,t}) + \beta_3 \log(D_{ij}) + e_{ijt}$

where $X_{ij,t}$ are exports from country i to country j at time t , $X_{j,t}$ and $Y_{i,t}$ respectively are the GDPs of country i and j , at time t , and D_{ij} is the distance between the capital cities of the two countries and e_{ijt} is a residual. This model could be estimated using ordinary least squares with all observations pooled. This would imply that the two parameters are constant across all country pairs and time, which is unlikely to hold. Furthermore, the pooled OLS estimator is likely to be subject to substantial misspecification problems which are likely to render the estimates biased and inefficient. Consequently a number of alternative estimation techniques have been utilised to account for various issues that apply to panel data, that is, data that have a cross-section and time dimension.

The usual approach is to assume that the residual can be split into unobservable individual effects and a standard remainder disturbance term:

$$e_{ijt} = \mu_{ij} + v_{ijt}$$

Here an allowance is made for county pair individual effects rather than the usual assumption of separate individual effects for exporter and importer.

The fixed effects estimator allows for heterogeneity across cross-section units (in this case countries) and time, but confines this heterogeneity to separately estimated intercept terms. Thus the individual effects are directly estimated. This approach can be applied by adding time and cross-section specific dummy variables to the estimation. The fixed effects estimator captures all time constant effects in the intercept terms, and those effects cannot be separately estimated. It also has the drawback of a significant loss of degrees of freedom, which, given the large data set employed here is not of

great consequence in this application. Importantly the fixed effects estimator is based on the assumption that the individual effects are fixed (hence the name) and that the remainder residual is well behaved and uncorrelated with the explanatory variables. Thus, inference is dependent on the chosen sample, which is a further drawback of the fixed effects estimator in this case, since the sample could easily be changed to include a further country.

The alternative approach is the random effects estimator, which assumes that the individual effects are random (hence the name) and are normally distributed and independent of the remainder residual. It has the advantage of allowing us to estimate the parameters for all the time invariant variables, while allowing for the fact that we are dealing with panel data. However, it also relies on the assumption that the individual effects are uncorrelated with the regressors, which in practice is often not the case, thus rendering them inconsistent. To test for this, a Hausman test is applied which tests whether the parameters from the two models are the same or not.

A method to estimate a random effects model where some of the regressors are correlated with the individual effects has been proposed by Hausman and Taylor (1981) and this estimator has recently been advocated as the appropriate estimator for the gravity model. It uses instrumental variables approach to account for the correlation but assumes that the regressors are not correlated with the remainder residual. As with the standard random effects model the Hausman-Taylor estimator allows us to estimate the parameters of the time invariant variables.

Our estimation strategy is to estimate the pooled regression, a fixed effects model with country pair fixed effects and time fixed effects, a random effects model with fixed time effect and the Hausman-Taylor random effects model with time fixed effects where we allow, GDP to be correlated with the individual effects. GDP might capture underlying structural differences such as sectoral specialisation, technological differences and natural resource other resource endowments, and as such might be correlated with the individual effects. We also report the results of the Hausman test of random versus fixed effects.

A2.9 Sensitivity Analysis

There are a number of sources for data of North/South trade and the choice of data source might drive the nature of the results. This is possible since it has been shown that the different data sources are not consistent (see Anyadike-Danes and Morgenroth, 2003 and Love, Morgenroth and Roper, 2008).

Previous research on the reliability of North/South trade data has shown that there are significant differences between the data produced by the CSO, DETI and HMRC. In particular, the CSO data records significantly smaller trade flows than the DETI data, which in turn shows smaller flows than the HMRC. Therefore, it is plausible to suggest that if an alternative data source was used, the finding that trade between Ireland and Northern Ireland is below the expected level might not hold.

Consequently, it is useful to test the sensitivity of our results with the use of alternative North/South trade data sources. A key reason for using the CSO data is that it is available for a considerably longer time period than the alternative data series from HMRC and DETI. Indeed for the latter, only exports from Northern Ireland to Ireland are available. Therefore, the sensitivity analysis can only be conducted over a shorter period.

The results of this analysis for the preferred random effects model are shown in Table 18. A number of striking results emerge. The overall result that trade is below the expected level is robust for the chosen data source. The coefficient for South to North trade is identical in the CSO and DETI models since DETI only collects data for the opposite flow so that the CSO data is used for South to North trade in both cases. The coefficient for this flow using the HMRC data is similar to that estimated with CSO data. The CSO data results in a larger negative coefficient for North to South trade than the DETI data which in turn results in a larger coefficient than for the HMRC data. However, as is evident from Figure 3 the estimated coefficients are not statistically different from each other and consequently result in relatively small differences in the percentage deviation from the expected trade level.

Figure 6 below shows the point estimates and confidence bands for the results from Table 18, where alternative data sources are used. The results for North to South trade suggest that the shortfall in actual trade over expected trade is at least 40 percent, while that for the opposite flow could be above the expected level.

Figure 6
Point estimates of Percentage Deviation from Expected Trade and Confidence intervals



Table 18

Estimation Results for Total Bilateral Merchandise Exports 1996-2006,
using Alternative Sources for North/South Trade

| Variable | CSO | DETI | HMRC |
|------------------------|----------|----------|----------|
| GDP | 0.61*** | 0.61*** | 0.61*** |
| Population | 0.19*** | 0.19*** | 0.19*** |
| Distance | -0.90*** | -0.90*** | -0.90*** |
| Common Border | 0.65*** | 0.65*** | 0.65*** |
| Common Language | 0.71*** | 0.71*** | 0.71*** |
| Trade Agreement | 0.09 | 0.09 | 0.09 |
| North to South Dummy | -1.95*** | -1.66*** | -1.37*** |
| South to North Dummy | -1.69* | -1.69* | -1.61*** |
| Exporter 1 Neighbour | 1.12*** | 1.12*** | 1.12*** |
| Importer 1 Neighbour | 0.63*** | 0.63*** | 0.63*** |
| Euro | -0.03 | -0.03 | -0.03 |
| Exporter Euro | -0.02 | -0.02 | -0.02 |
| Importer Euro | -0.11*** | -0.11*** | -0.11*** |
| Exporter Island | -0.34*** | -0.34*** | -0.34*** |
| Importer Island | 0.07 | 0.07 | 0.07 |
| Exporter Landlocked | -0.01 | -0.01 | -0.01 |
| Importer Landlocked | -0.31*** | -0.31*** | -0.31*** |
| Number of Observations | 18737 | 18737 | 18737 |
| R2 | 0.72 | 0.72 | 0.72 |

Note: Dependent variable is Bilateral Exports which along with GDP, Distance and Population are logs. All other variables are dummy variables. The estimation includes time specific intercepts. Standard errors have been corrected for heteroscedasticity. ***, ** and * denotes significance at the 99%, 95% and 90% levels respectively.

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The Trade and Business Development Body
The Old Gasworks Business Park
Kilmorey Street
Newry
Co Down
BT34 2DE

Telephone: 028 3083 4100

(048 from Ireland)

Fax: 028 3083 4155 (048 from Ireland)

Textphone: 028 3083 4164

(048 from Ireland)

Email: info@intertradeireland.com

Web: www.intertradeireland.com