EXPLAINING BILATERAL TRADE FLOWS IN IRELAND USING A GRAVITY MODEL: EMPIRICAL EVIDENCE FROM 2001-2011

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The concept of equilibrium was borrowed by the first economic philosophers from the field of physics, and this tradition was continued in the formation of the gravity model of trade. In this paper, Yannick Lang analyses Ireland's bilateral trade from 2001-2011 and succeeds in showing that trade flows are explained well using a gravity model approach.

Introduction

When Tinbergen and Pyhonen first stated a model similar to the model of gravity developed by Newton not much theoretical evidence existed. There was no deeper theoretical reason for why the income of two countries should have a positive effect and the distance a negative effect on bilateral trade flows. Nor was there any theoretical reason why this relationship should be multiplicative rather than additive. Tinbergen and Pyhonen only gave economists an intuitive explanation not theoretically based on existent models which explain trade flows, such as those of Ricardo or Heckscher Ohlin. Much has changed since the pioneers revealed this quite simple relationship. Gravity models have become the most important models to explain bilateral trade flows. Data seems to fit gravity formulations well independent of the research topic. A lot of papers supported its validity in terms of statistical significance.

This paper will follow the empirical wave of papers confirming Gravity Models importance in modeling bilateral trade flows by applying it to Irish trade data. Is a gravity model going to explain Irish bilateral trade flows well? Confirming its validity for the 1xN country case with Ireland would emphasize the importance of gravity models applied to single country analysis. Apart from this it would also give economists a benchmark for their research related to Irish bilateral trade flows. If not, this report would state an exception in the usage of Gravity models. Not fitting a gravity formulation, Irish trade data would stand from much research that supports the success of Gravity models for other countries.

Literature Review

This chapter gives an overview of the research that has already been undertaken since the first formulation of the gravity model in 1962 and 1963. The first part of this chapter presents the theoretical models, while the second provides some empirical studies related to this topic.

Theoretical Background

It has already been described that in the first years of the gravity model a reasonable theoretical foundation did not exist. Nevertheless in the years after the first wave of empirical papers some economists provided the gravity formulation with a theoretical foundation. Not long after the pioneers of the gravity model, Linnemann added more variables to the original standard version in 1966, and used a Walrasian General Equilibrium model, being the first researcher to start a limited but still theoretical discussion (Linnemann, 1966). Deardoff criticized this approach later by stating that there are too many explanatory variables in the Walrasian model for it to be reduced to the very simple form of the gravity model (Deardorff, 1998). It seemed like in the early years of the model the theoretical foundation was not as important, as it was simply fitting the data too well. Leamer, for example, only used the Heckscher Ohlin model to motivate his explanatory variable in his regression analysis but did not quite explain if the Heckscher Ohlin approach was consistent with the used Gravity Model (Leamer, 1974).

Following this first stream of papers with weak theoretical foundations, more researchers tried to find a reasonable model that could explain the good performance of econometric work based on the gravity model. Several attempts based their reasoning on product differentiation. The first of these was Anderson. He assumed simple Cobb Douglas preferences and the so called "Armington assumption", which became more and more important in the theoretical foundation of the gravity model. The Armington assumption simply states that products are differentiated by the country of origin (Anderson, 1979). A similar approach was taken by Jeffrey Bergstrand in his series of papers about explaining bilateral trade flows theoretically. While the differentiation of goods was still to be assumed in accordance with the Armington assumption, Bergstrand used CES (constant elasticity of substitution) preferences rather than simple Cobb Douglas preferences to derive his results (Bergstrand, 1985). In his following paper he went one step further by using a different approach for product differentiation. He assumed monopolistic competition and therefore included product differentiation on the level of the firm rather than the countries' level (Bergstrand, 1989). Bergstrand acted like a mediator between the early developed models basing product differentiation on the Armington assumption and the models presented by Krugman and Helpman that strongly argued in favor of monopolistic competition being the key driver of product differentiation (Helpman and Krug-

man, 1985).

A lot of research has been done by now to explain the theoretical foundation of the gravity model. They all seem to be consistent with the behavior of Gravity Equation. Why is that so? Deardoff, who also showed that the Gravity Equation is consistent with the classical Heckscher Ohlin model, stated in 1998 that the Gravity model is consistent with any other plausible model. The reason for this is simple. The Gravity Equation is, just like Newton's Apple falling on his head, "a fact of life" that cannot be neglected (Deardorff, 1998).

Empirical Background

A lot of researchers, especially econometricians, favour the Gravity model. Being able to generate stable and highly significant coefficients on income and distance and high R squares led to a flood of empirical papers, of which only a limited range will be presented in this section.

Evaluating Trade-Policy Issues was probably the most important issue analyzed by Gravity Models. Wall assesses the effect of trade barriers against the US in 1996, and finds that without any of those barriers US exports would have been 26.2 per cent higher than they were in the very same year with the barriers being present. The effect of imports was with 15.4 per cent, slightly smaller but still quite high (Wall, 1999). Another important question in this context was whether or not borders have negative effects on trade. McCallum proved that borders indeed seem to decrease trade flows (McCallum, 1995). Furthermore one could even use the Gravity model to test what effect a single currency market would have on bilateral trade flows of the member state, a question that was important after the establishment of the Euro in 2002. It has been answered by Rose, who shows that a single currency area will have a positive and strong effect on bilateral trade flows (Rose, 2000).

But the strength of the gravity model doesn't seem to be limited to the analysis of policy issues. Non policy issues became more and more important over the last years. Migration flows (Helliwell, 1997), capital flows (Portes and Rey, 1998) and the flows of FDI [Foreign Direct Investment] (Brenton et al., 1999) all seem to fit a gravity approach, making it a very strong tool in empirical research.

Model and Data

Having some idea about the theoretical and empirical history of gravity models, we can now start applying this model to an explicit market. The data used in the following empirical section of the paper has been extracted from various sources. Most of the data, including geographical and historical variables like distance, common official language and colony, have been extracted from the CEPII database which is commonly used for

gravity equations (The GeoDist databaseCEPII, 2013). Macroeconomic variables like GDP (gross domestic product) or Population were taken from the World Bank database (The World Bank DataBank, 2013). Bilateral trade flow data for Ireland can be accessed from the IMF (International Monetary Fund, Direction of Trade Statistics - IMF, 2013). The gravity model that is going to be used in this report takes the following form:

$$\ln Tijt = \alpha + \beta 1 \ln Yit + \beta 2 \ln Yjt + \beta 3 \ln Pit + \beta 4 \ln Pjt + \beta 3 \ln Dij + \mu k + Zkij + \varepsilon it$$

Tijt = bilateral trade volume between country i and country j in year t (Note: country i in this report will only be Ireland)

Yit = Ireland's GDP in million US $ in year t for t = 2001, , 2011

Yjt = Ireland's trading partners' GDP in million US $ in year t

Pit = Ireland's population in millions in year t

Pjt = Ireland's trading partners' population in million in year t

Dij = Distance between Ireland and its trading partners

Zkij = Vector of Dummy variables with Zkij representing common official language and colony

While most empirical work done so far tested the gravity models for an NxN country sample this report will focus on Ireland and its bilateral trade flows to potential partner countries, resulting in a 1xN sample. This approach and the model stated above follow the analysis of Chang-Hyun Sohn, who examined Korean's trade patterns (Sohn und Yoon 2001). The index i in the general formulation of gravity equations will be fixed to Ireland while the index j still varies and takes the value of each individual trading partner over the time horizon t for the years from 2001 to 2011.

Most empirical papers use exports measuring the trade flows between countries. It has been pointed out that imports are usually more influenced on a political basis than exports, and could therefore lead to distortion issues (Gruber und Vernon 1970). Nevertheless, the following analysis will use all possible bilateral trade flow measures: Exports, Imports and Total = Exports + Imports (in current US dollars). This is mainly done to see how robust the estimated results are.

Furthermore, it is noteworthy that the underlying dataset is panel data, with partner countries of Ireland being the panel variable. Advanced econometric techniques

are used to tackle the problems arising from this specific kind of data. There are three possible approaches for the analysis of panel data: Pooled OLS; Fixed Effects Models and Random Effects Models. While a Pooled OLS does not account for heterogeneity of countries and therefore only estimates one intercept for all partner countries of Ireland, Fixed and Random Effects actually model this systematic difference. Nevertheless Random Effects models make more sense in a gravity formulation as they can also estimate time invariant variables. Therefore the results presented in the following sections were all estimated with robust random effects models to tackle the possible problem of heteroscedasticity.

Empirical Results

Can Irish trade patterns actually be explained by a model as simple as the gravity model? The answer to this question is given in this section of the report using the data presented and described in the previous section.

Using exports (1), imports (2) and total bilateral trade flows (3) as dependent variables, Table 1 shows the derived results. Exports are presented first and in further detail due to the possible distortion issues described in the previous section of the other measures leaving exports as the most valuable instrument to measure trade flow data. For this reason coefficients and significance will be extracted in the following analysis from the first model.

VARIABLES	(1) RANDOM Exports	(2) RANDOM Imports	(3) RANDOM Total
Log(GDP) of Partner in million	1.444***	1.941***	1.535***
	(0.106)	(0.0403)	(0.0168)
Log(GDP) of Reporter in million	1.489***	1.592**	1.563***
	(0.351)	(0.808)	(0.539)
Log(Population) of Partner in million	-0.356***	-0.476***	-0.381***
	(0.104)	(0.0547)	(0.0184)
Log(Population) of Reporter in million	-5.874***	-9.961***	-6.589***
	(1.209)	(2.160)	(1.376)
Log(Weighted Distance)	-1.211***	-0.988***	-1.064***
	(0.160)	(0.0484)	(0.0413)
comlang_off	1.135***	0.884***	1.027***
	(0.220)	(0.0849)	(0.0345)
Colony	-1.142***	0.236	-0.602***
	(0.442)	(0.167)	(0.133)
Constant	-11.69***	-16.04**	-13.29***
	(3.321)	(6.694)	(4.745)
Observations	1,684	1,571	1,688
R-squared	0.81	0.63	0.81
Number of year	173	10	10

*Table 1: Gravity Model for Ireland: Exports, Imports and Total Trade flows (Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1)*

All variables are included in log form in accordance with the gravity model, meaning that they can be interpreted as elasticities. An increase in an Irish trading partner's GDP in millions of US dollars by 1 per cent will increase Irish exports to the partner country by 1.44 Per cent. Significance can be reported at a 1 per cent level. This means that the null hypothesis that Irish trading partners GDP in millions of US dollars does not have any effect on Irish exports can be rejected at a 1 per cent level. Irish GDP increases of 1 per cent will increase Irish exports by 1.489 per cent (Significant on a 1 per cent level). Population also reports the expected effect. Countries with larger populations tend to be less open than smaller countries. This could be derived from simple international trade theory analyzing the effect of a tariff for a relatively small and a relatively large country. While small countries always lose economic welfare, the effect for large countries tends to be positive. In the model presented in the table we see that a 1 per cent increase in population of the partner country decreases exports by 0.356 per cent (Significant at the 1 per cent level). Another important parameter in gravity models is the distance parameter, representing any kind of transport costs or trade barriers that could inhibit trade flows. This parameter seems to be a little bit higher than reported in recent gravity models, stating it would be between 0.7 and 1. Nevertheless, it is still highly significant at the 1 per cent level and can be interpreted as an increase in weighted distance by 1 per cent will decrease exports by 1.211 per cent.

The dummy variables accounting for historical and cultural differences or similarities of countries are also highly significant at the 1 per cent level. Having English as an official language (as in Ireland) leads to export flows to this partner country that are 1.14 per cent higher than to countries with another official language. Ireland being a former colony of the trading partner seems to reduce exports significantly by 1.14 per cent.

Generally speaking, one can say that the gravity model seems to fit bilateral trade flow data quite well. Imports and Total bilateral trade flow data show almost the same results as the non distorted exports measure which shows that the model used is robust across different model specifications.

Conclusion

The starting question of this report was whether Irish bilateral trade flows can be explained by a gravity approach. After an empirical analysis and a detailed discussion in the previous chapter it seems that Irish trade flows indeed seem to be quite well estimated with a gravity approach. Coefficients and statistical significance are consistent with what other economists found for other countries.

It is noteworthy that this paper only focused on the basic version of the gravity model. It has been shown that the gravity model can be seen as a benchmark to explain Irish bilateral trade flows. More variables can be added using the estimated variables above as control variables to evaluate, for example, trade policy issues for Irish market.

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