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Regionalism and Gravity

By D. Greenaway and C. Milner

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Abstract

Gravity models have been extensively used to evaluate the trade effects of regional trading arrangements, (RTAs), especially over the last 10 years or so. Questions addressed by researchers include, is there a regional bias to trade and are there identifiable trade affects attributable to RTAs? This paper reviews the evidence extant from this literature and evaluates the modelling and methodological issues confronted when applying gravity modelling to the analysis of regionalism. The paper argues that the approach has a distinctive role to play in evaluating trade effects and its application has been enhanced by both the refinement of theoretical underpinnings and development of econometric technique.

Outline

1. Introduction
2. The trade effects of RTAs: Questions and answers
3. Methodological and modelling issues
4. Conclusions and future developments?

Non-Technical Summary

The so-called 'gravity model' has performed remarkably well over a long period of time in explaining bilateral trade flows. At the heart of the model is an emphasis on countries' GDP being a positive determinant of trade and the distance between countries a negative determinant. The analogy with 'gravity' derives from GDP being a proxy for economic mass and distance a proxy for resistance. Despite the fact that, until relatively recently, these forces were not embedded in theoretical models of the determinants of trade, they had very high explanatory power.

One of the issues to which the gravity framework has been applied extensively is in investigating the consequences of regional trading arrangements for trade flows. Gravity models have been deployed to address several questions: is there a regional bias to trade?; do RTAs actually stimulate trade?; is there a 'domino effect' associated with RTAs?

In this paper we review the literature on gravity modelling and regional trading arrangements. Although the empirical literature dates back to the late 1960s/early 1970s, most work has been completed over the last decade or so: partly in response to the proliferation of RTAs; partly as a consequence of the refinement of theoretical underpinnings; partly due to the increased availability of better quality data. The consensus from this literature is that positive trade effects are associated with RTAs, even when we control or distance, countries that are members of an RTA typically trade more with each other than might be expected. There is also some evidence pointing to domino effects, i.e. the proliferation of RTAs raises the likelihood of further RTAs being formed.

The paper also reviews recent work on the theoretical foundations to the gravity model and econometric issues associated with their implementation. With regard to the former, considerable progress has been made in embedding gravitational forces in core trade models, with both competitive and imperfectly competitive market structures. With regard to econometric issues, refinements have taken place to clarify the appropriate specification not only for identifying trade effects but also estimating trade potentials.

The paper ends by contrasting gravity modelling with alternative approaches, particularly computable general equilibrium modelling (CGE), concluding that the two approaches are complements rather than substitutes.

1. Introduction

The latter part of the twentieth century was characterised by a major wave of regional trading agreements (RTAs) being concluded. Since the GATT's inception, well over 100 agreements have been notified under Article XXIV arrangements, which waive the non-discrimination obligation enshrined in Article I. This *new regionalism* has spawned an enormous literature on its determinants and complementarity or otherwise with multilateralism. The literature on both these issues has been surveyed elsewhere[1] and neither feature prominently in this paper. Instead we focus on another dimension of the literature, namely the trade effects of regional integration - the new regionalism has given a renewed impetus to evaluating trade effects. Our focus is on the use of gravity modelling in investigating such effects, though *en passant* we do comment on its utility vis-à-vis alternative methodologies for simulation/estimation.

As is well known, over a long period, the gravity model has performed remarkably well as an empirical framework for explaining bilateral trade flows. Its use has enjoyed something of a resurgence in recent years, partly because of more systematic efforts to reinforce its theoretical underpinnings (see, for example, Deardorff, 1998; Evenett and Keller, 2002) and partly because of the availability of a growing number of 'natural experiments' in the form of RTAs. In this paper we evaluate the use to which the gravity framework has been put, the empirical results generated and the methodological issues thrown up.

The remainder of the paper is organised as follows: we begin in Section 2 by considering the research questions addressed by gravity models and review the empirical findings across a wide range of RTAs. Since a number of estimation techniques are used, in Section 3 we evaluate methodological issues and

[1] See, for example Baldwin (1997) on the former and Bhagwati, Greenaway and Panagariya (1998) on the latter.

consider their implications for future work. Section 4 evaluates the contribution which gravity modelling can make, relative to other approaches, its potential for future development, and concludes.

2. The Trade Effects of RTAs: Questions and Answers

Customs union theory, both Vinerian and modern, predicts that RTAs[2] will affect trade flows, both between members of the RTA and between the RTA and non-members. It also tells us something about the factors that will drive these changes in trade flows: the degree of overlap in production within the RTA; the degree of overlap with the rest of the world; differences in production costs within the union; configuration of any pre-RTA tariffs and so on. Theory also gives us clues as to the factors that will determine whether an RTA raises or lowers economic welfare. In general, gravity modelling has been used as a tool for evaluating various aspects of trade effects but not welfare effects.

The standard gravity framework starts from the presumption that economic mass and commercial distance are key explanators of bilateral trade flows and relatively simple models, such as that set out in equation 1, have been remarkably successful in explaining actual bilateral trade flows. Until fairly recently the theoretical underpinnings for equation 1 were, at best, loose. The same can be said of extensions to equation 1, designed to evaluate the impact of RTAs, an issue to which we will return later. Most applications of the gravity model therefore search for evidence of actual or potential effects by adding dummy variables for membership of a particular RTA, rather than trying to estimate particular trade effects, such as trade creation and trade diversion.

[2] There is a range of different forms of integration arrangements, including free trade areas, customs unions, preferential trading areas. We use RTAs as a generic descriptor. For our purposes, it is not important to discriminate between alternative forms of integration arrangements.

$$\ln T_{ij} = \beta_0 + \beta_1 \ln(DIST_{ij}) + \beta_2 \ln(Y_i) + \beta_3 \ln(Y_j) + \varepsilon_{ij} \qquad (1)$$

Where:

T_{ij}	=	bilateral trade between the country pair *i* and *j*
$DIST_{ij}$	=	distance between *i* and *j*
$Y_{i(j)}$	=	GDP or GNP of *i* and *j*

Most gravity analyses of RTAs typically address one or more of the following questions:

- Is there a regional bias to trade? In other words, are regional blocs a natural feature of international trade because countries tend to trade with near neighbours?
- Is there an identifiable RTA effect? In other words, even if there is a regional bias to trade, is intra-regional trade stimulated by the formation of an RTA?
- What is the trade potential associated with integration? In order words, can we estimate how much more trade takes place, or might take place, as a consequence of a particular RTA?
- Is there a 'domino effect' of RTAs on non-members? In other words, does an RTA result in less trade with non-members, thereby increasing the likelihood of them joining the RTA?

Table 1 sets out the details of a large number of studies of regional trade flows using a gravity framework. Not all studies address all questions, nor are they mutually exclusive, but as a minimum they all address the issue of whether intra-regional trade is stimulated by membership of an RTA.

As can be seen from Table 1, the number and range of applications is extensive. The literature stretches back to early contributions such as Aitken (1973) and Brada and Mendez (1985). Most work has, however, been completed since the early 1990s. The reasons for a resurgence of interest in applying the gravity framework to investigate regionalism's potential trade

effects are threefold. First, the upsurge in RTAs negotiated (alluded to earlier) has quite naturally stimulated an extensive research programme on their potential economic effects. Second, the development of theoretical underpinnings to the model has undoubtedly broadened its acceptance as an investigative tool. Third, the potential for using the framework for *ex post* as well as *ex ante* analysis, (i.e. to predict trade potentials and therefore comment on potential adjustment problems), was also seen as useful.

The studies reported in Table 1 cover all of the major RTAs in Europe, North America and Asia. A relatively small but growing number apply to the trade of developing countries. Regionalism in Europe has been subject to more enquiry than any other part of the globe - hardly surprising as the EU is the deepest and most durable RTA worldwide and its succession of enlargements provide a series of natural experiments for researchers. With the conclusion of arrangements like the Canada-US Trade Agreement, NAFTA, APEC and MERCOSUR, regionalism in North and South America and Asia has attracted more attention from gravity modellers.

A fairly common finding from this literature is that positive trade effects are associated with RTAs. Thus, even when we control for distance countries that are members of the same RTA trade more with each other than would otherwise be expected. As long as the conclusion of an agreement does *actually* result in intra-regional (tariff and non-tariff) barriers being reduced, this is hardly surprising. There are, however, undoubtedly RTAs where no effective liberalisation has occurred and where it would be surprising to find positive trade effects. As is apparent from Table 1, these are not cases that have attracted a great deal of research effort. But it is the case that in those instances where analysts have investigated RTAs where little real integration has occurred, trade effects are absent, sometimes even negative. Thus Hassan (2001) finds negative effects for both ASEAN and SAARC in Asia; Sharma

and Chua (2000) reported no RTA effects for ASEAN; nor did Finger, Ng and Soloaga (1998) and Soloaga and Winters (1999) for MERCOSUR.

Recent work has gone beyond the simple 'yes/no' question of whether RTAs have a positive trade effect to quantification of effects. Here coefficient estimates from a gravity model with and without an RTA variable are used to comment on 'regional bias' and 'trade potentials'. A well-known example of the former is Frankel, Stein and Wei (1995) who investigate whether regional blocs are 'natural'. Put differently, do geographical clusters of countries trade more with each other, (after controlling for distance, common borders and common language), even in the absence of a formal RTA? The answer in some regions of the world, Latin America and Western Europe, was 'yes'; but in others (East Asia and North America) 'no'. They do go on to explore whether commitments to an RTA exaggerates this regional bias and find in all cases that it does and is of growing significance through time (even in the EU).

Those studies predicting trade potentials ask a slightly different question: if an RTA is concluded, how much additional intra-regional trade might be expected.[3] This has been most widely applied to preferential trade arrangements between the EU and the Central and Eastern European countries (CEECs) with good examples being Hamilton and Winters (1992), Gros and Gonciarz (1992) and Nilsson (2000). The objective behind this kind of analysis is both to quantify potential trade effects and use this as a basis for speculating on potential adjustment pressures that might follow from further integration. The key finding here is that the RTA arrangements that have been put in place to prepare transition economies for accession, in particular the Europe Agreements, have stimulated substantial growth in EU-CEEC trade. The conclusion from this work is that most adjustment has already occurred and the expected effects of further EU enlargement to the east will be modest.

[3] As we shall see in the next Section, the appropriate econometric framework for estimating trade potentials is controversial.

Another political economy issue which gravity models have been used to investigate is domino effects - the idea that if an RTA is created, the perceived threat posed to non-Members pushes them either to petition for membership or form their own RTA. Thus, once bloc formation is underway, there is an inherent dynamic that results in RTAs growing and multiplying. Greenaway (2000) and Sapir (2001) are examples of this application; the latter focuses on Western Europe, the former on a range of RTAs. Both find evidence to support the idea that domino effects may have been important in stimulating enlargements in the case of the EU and the creation of new RTAs elsewhere in the world.

As is clear from this brief review, regionalism has been a fertile domain for the application of the gravity model, with researchers using it to identify both qualitative and quantitative trade effects. Intuitively it seems like an appropriate research tool to investigate trade effects. But, are its theoretical underpinnings secure and the estimation techniques used robust?

3. Methodological and Modelling Issues

The application of the gravity framework has not in fact been uncontroversial, for two reasons. First, until comparatively recently the model appeared to exist in a vacuum in the sense that it lacked solid or even coherent theoretical underpinnings; second, again until relatively recently, a number of econometric issues related to estimation remained unresolved.

Theoretical Foundations

As we saw earlier, the most parsimonious version of the gravity equation has bilateral trade between two countries as a function of the product of their GDPs and the distance between them. Although it is intuitively plausible that

bigger countries located closer to each other are likely to trade more with each other, until recently this was not embedded in any theoretical model of international trade. The early literature (Tinbergen, 1962; Pöyhönen, 1963) did offer a range of intuitive explanations for the relationship and Leamer and Stern (1970) derived the relationship from a probability model of transactions, but none of these relied on standard trade model. Thus there was no formal representation of the role of technology, factor endowments, demand differences or any of the underlying structural differences we associate with the determinants of trade. That shortcoming has now been addressed by a series of papers beginning with Anderson (1979) and including Bergstrand (1985, 1989), Helpman and Krugman (1985), Deardorff (1998), Anderson and van Wincoop (2001) and Eaton and Kortum (2001).[4]

Essentially, what these papers have done is to provide theoretical underpinnings for gravity's forces of resistance and mass. Thus Anderson (1979) uses Armington preferences in a model of homogenous goods to derive a role for transport costs, modelled iceberg fashion and on the assumption that distance and transport costs are related. If all goods are traded, national income is then the total value of traded goods and Armington preferences ensure that bigger countries, which have more traded goods, trade more. Bergstrand's (1985) (1989) papers develop the analysis further and Anderson and van Wincoop (2001) refine it to incorporate the 'relative distance effect', i.e. the likelihood that trade will be greater between two (geographically) peripheral countries than between two core countries, after controlling for bilateral distance and country size. The recent paper of Eaton and Kortum (2001) also uses an iceberg framework with homogenous goods but embeds gravitational forces in a Ricardian setting. But, of course, much of recorded trade is in differentiated goods. Helpman and Krugman (1985) address this by embedding the equation in a model of monopolistic competition with

[4] For an excellent evaluation of these and other papers, see Harrigan (2002).

increasing returns to scale, which also has the virtue of yielding predictions regarding the sectoral pattern of trade.

So it can no longer be said that the gravity model exists in a theoretical vacuum now that it has in fact been shown to be derivable from a number of models of trade in homogenous and differentiated goods, (and Evenett and Keller, 2002) is an elegant demonstration of how the data can be used to discriminate between alternative theories). But all of this work is directed at multilateral trade flows in a world without RTAs. Put differently, we still do not have a theory of customs unions in which gravitational forces are embedded. The closest we have are attempts like Bikker (1987) to extend the gravity model to allow for substitution between trade flows (from different directions or sources), allowing in principle for the analysis of trade creation and diversion within a gravity framework.

The recent strengthening of the standard gravity model, and the increased credibility of using it to test alternative models of trade, provide an increased opportunity for further refinement of the theoretical framework to allow for differential regional trade effects on bilateral trade flows within and outside regions. But with increased theoretical sophistication will come further empirical challenges to separate genuine regional trade effects from empirical specification errors. It is such issues that the econometric literature is increasingly recognising and grappling with.

Econometric Issues

Equation 2 below, which is taken from Frankel, Stein and Wei (1995) but could in fact have been taken from one of any number of papers, is a 'standard' gravity estimating equation with dummies included to capture integration effects:

$$\log(T_{ij}) = \alpha + \beta_1 \log(Y_i.Y_j) + \beta_2 \log(Y_i./\ pop_i.Y_j\ /\ pop_j) + \beta_3 \log(DIST_{ij})$$
$$+ \beta_4 (ADJ_{ij}) + \gamma_1 (EA_{ij}) + \gamma_2 (EU_{ij}) + \gamma_3 (NAFTA_{ij}) + u_{ij}$$

(2)

where *Y* and *DIST* are as in (1)

and *pop* = population

ADJ = dummy variable for adjacency in countries with common borders

EA, EC, NAFTA = regional dummy variables for the EU and NAFTA membership and East Asia location.

The dependent variable is total trade (i.e. exports plus imports) between pairs of countries in a given year. The first four independent variables are standard gravity terms; the final three are intercept dummy variables intended to test for the effects of membership of regional groupings in East Asia, the European Community and North America respectively. Typically this model is estimated in cross section or pooled data on total trade. Positive and significant coefficients on the regional dummies are taken as evidence of an RTA effect. The actual coefficient estimates can then be used, as in Nilsson (2000) for example, to predict in sample or out of sample trade potential.

The validity and reliability of results from estimating models like equation 2 have been challenged by a number of authors. Dhar and Panagariya (1999) argue that total trade ought not to be used as the dependent variable, because in so doing one is imposing equality of coefficients for imports and exports. Their proposed solution is to estimate separate equations for exports and imports. They also argue that pooling data for different countries then fitting the same equation for all countries in the sample imposes identical coefficients across countries and this too induces mis-specification. The proposed solution here is to estimate the equation separately for individual countries using time series data. Egger (2002) also argues against relying on a cross-section framework on the grounds that estimated coefficients are a composite of within and between effects. He argues that a panel framework is the most appropriate methodology for disentangling time invariant and country specific effects.

In investigating the actual or potential trade effects of economic integration, there are a number of other specification, methodological and estimation issues that should be carefully considered. Take the case of the specification of the 'distance' effect, where it is used to examine actual trade effects of integration. As Polak (1996) neatly demonstrates, the use of absolute distance between trading partners is problematic. The weighted average (absolute) distance of some countries from their trading partners is much lower than others. Thus European countries (and their heavy dependence on adjacent trading partners) are much more 'favourably located' in these terms than many South-East Asian countries, (with high dependence also on more distant European and other OECD markets). In terms of the residuals from an estimation of a standard gravity model, many of these countries appear to over-trade relative to predicted levels. Introducing a dummy variable to capture the additional effects of regional integration in these circumstances may lead to incorrect inferences. Polak (1996) specifically criticises the use of the above approach by Frankel, Stein and Wei (1995) to search bilateral trade data for 'hidden' regional trading areas or arrangements. In contrast to the finding reported earlier about the East Asia region, Frankel *et al* report a highly significant APEC dummy for a number of years. One solution proposed by Polak is to estimate a revised gravity relationship, replacing absolute distance with 'relative' distance (bilateral distances divided by the weighted average of all countries' bilateral distances). Alternatively, if absolute distance is to be retained, he proposes the use of separate country dummies with a free coefficient to capture 'locational' advantage or disadvantage, akin to Linneman's (1966) pioneering econometric work.

But whatever adjustments are made to the specification of the gravity relationship, one should be cautious about using any systematic difference between actual and *in-sample* predicted trade flows as evidence of under- (or over-) used trade potential (and therefore in turn possibly of actual or potential

regional trading arrangement effects). Indeed, large systematic differences are likely to indicate instead the mis-specification of the estimated model. The danger of in-sample projection is strongly made by Egger (2002) and illustrated in the context of the work used to identify the potential integration of effects of the EU and former COMECON member states after the collapse of the Soviet bloc. That approach is used, for example, by Baldwin (1994) and Nilsson (2000). By contrast, other authors (Wang and Winters, 1991; Hamilton and Winters, 1992) have taken the gravity model parameters estimated from the 'natural' trading arrangements of EU or OECD countries to predict 'out-of-sample' trade flows for Central and Eastern European countries, if they were to become as integrated in the regional trading system as the in-sample countries. To argue in favour of an out-of-sample methodology in principle does not mean that an in sample method should not be used for particular purposes or where an out-of-sample analysis is impossible. In the case of intra-industrial country trade, it is hardly possible for example to examine European integration effects without including intra- and extra-European trade in the sample set. It does, however, mean that *ex-ante* trade potentials should not be inferred from systematic biases in error terms and that *ex post* trade effects revealed from regional dummy variables may be capturing specification errors as opposed to genuine regional integration effects.

As indicated above, estimation method is likely to be an important issue for the interpretation of gravity model coefficients. OLS cross sectional or time-averaged (two-way) panel estimation for example eliminate an important dimension of variation in bilateral trade flows, namely time variation, and are likely to result in inconsistent estimates (see also Mátijas, 1997). In addition to being able to allow for fixed time effects, one has the option in panel data of choosing between fixed or random bilateral exporter or importer (or total) trade effects. One can, of course, test the consistency of each of these but the estimation method may also be fashioned by the timescale in which one is

interested. Estimates from fixed (or consistent random effects) models reflect shorter-run responses of trade flows, whereas a 'Between Model' should reflect long run influences. An appropriate estimation method and specification of the gravity model lowers the risk of interpreting mis-specification and parameter inconsistency as revealed or potential integration effects.

4. Conclusions and Future Developments?

As explained in section 2, gravity modelling is most appropriately deployed to investigate the (impact) trade effects of regionalism. Of course, the estimated trade effects can be used alongside other information or with related simulation models to quantify the by-product implications of trade effects for production, employment, consumption and ultimately welfare. Indeed, since an estimated model can also be used to infer changes in trade associated with integration-induced changes in explanatory variables, such as trading partners incomes, the gravity approach may have advantages over many alternative methodologies. There are other potential advantages. For example many of the alternative forms of ex-post evaluation methods, which seek to establish an *anti-monde* of trade without regional integration (eg residual imputation and market shares modelling). These tend to concentrate on the regional importing country and largely neglect what is happening in exporting countries (often using the convenient but implausibly strong assumption of infinite supply elasticities). By contrast, gravity modelling is strong on the capturing separate importer and exporter effects, especially within regions. But the composite within region trade effect will, however, be some combination of trade creation and diversion effects. Thus far gravity modelling rarely tried, or tried unconvincingly, to decompose these effects. The simultaneous use of regional and non-regional membership dummies, with negative coefficients expected on the latter, is the device adopted by some researchers. Aside from the obvious econometric problem caused by general coverage of the sampled countries dummy variable, the interpretation of the non-regional dummy in the

presence of any model mis-specification gives rise to the problems we discussed earlier about the use of regional dummies. In this regard further theoretical work on endogenising the factors influencing differences in substitutional relationships between different pairs of countries would be beneficial, and would enable empirical work to incorporate parameter heterogeneity into the modelling strategy.

One might of course ask, why bother with this refinement, when there is an alternative methodology for capturing both aggregate and compositional, (e.g. importer/exporter, industry and total trade flows, and within and outside region) trade, production and welfare effects of regionalism. Multi-sector and multi-country computable general equilibrium (CGE) modelling offers the scope to change tariff barriers in a discriminatory manner and to allow for differential imperfect substitutability by products and by origin and destination. In practice of course there is an enormous difference in the scale of the research investment associated with gravity and CGE analysis. Multi-country CGE models invariably are constrained to grouping large numbers of individual countries into arbitrary or established regions or in to major trade nations and residual groupings; both for modelling and data availability reasons. In many ways data constraints mean that such models remain to a considerable extent theoretical with illustrative numbers for many of the key behavioural parameters. The methodology is not therefore, at this stage of development necessarily superior to gravity modelling for addressing the questions we identified earlier in this paper. As a result, one may well view gravity modelling as much as a complement to CGE modelling as an alternative. Empirical gravity models can provide information for CGE models on bilateral trade elasticities with respect to incomes, prices and transaction cost barriers. It can also in future, especially with expanded panel data sets and refinement of econometric specification, provide guidance as to the regional grouping of trading partners and to substitutional patterns in trade across countries.

In conclusion, the prospects for extending the use of gravity modelling in the context of investigating regionalism are substantial. Its role in both measuring and testing is likely to expand. We are already beginning to see a more discriminating and careful application of models, allowed by panel data and stronger theoretical underpinnings. We are also beginning to see the extension of the empirical work to gravity influences on both trade and FDI. There is a large and interesting research agenda still to be completed.

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Table 1: Gravity Modelling of RTAs

Study	*Countries*	*Time Period*	*RB*	*RTA*	*TP*	*DE*
Egger (2002)	OECD, CEECs	1986-97			✓	
Nilsson (2002)	EU, ACP	1973-92		✓		
Hassan (2001)	SAARC, ASEAN, NAFTA, EEC	1996, 1997	✓	✓		
Sapir (2001)	EU, EFTA	1960-92		✓		✓
Nilsson (2000)	EU, CEECs	1989, 1992		✓	✓	
Greenaway (2000)	All RTAs	1965-93	✓			✓
Sharma and Chua (2000)	ASEAN, APEC	1980-95	✓	✓		
Dhar and Panagariya (1999)	EC, E. Asia, NAFTA	1980-91	✓	✓		
Endoh (1999)	EEC, NAFTA, CMEA	1960-94	✓	✓		
Soloaga and Winters (1999)	All RTAs	1980-96		✓		
Bayoumi and Eichengreen (1998)	EEC, EFTA	1956-92	✓	✓		
Finger, Ng and Soloaga (1998)	CARICOM, NAFTA, MERCOSUR	1988-96		✓		
Gros and Gonciarz (1996)	CEECs, EU	1992		✓	✓	
Frankel, Stein and Wei (1995)	All RTAs	1965-90	✓	✓		
McCallum (1995)	CUSTA, NAFTA	1988		✓	✓	
Frankel (1993)	All RTAs	1980-90	✓	✓		
Frankel and Wei (1993)	All RTAs	1965-90	✓	✓		
Brada and Mendez (1985)		1970, 1973, 1976		✓		
Aitken (1973)	EEC, EFTA	1951-67	✓	✓		

Note: RB, RTA, TP and DE refer to whether the studies referred to investigate regional bias, the trade effects of RTAs, trade potentials and domino effects respectively.