Chapter 6

Identifying export potential using a gravity model[1]

The wealth of a neighbouring nation, however, though dangerous in war and politics, is certainly advantageous in trade … as the rich man is likely to be a better customer to the industrious people in his neighbourhood, than a poor, so is likewise a rich nation (Smith, Moral Sentiments, 386 - as found in Brue, 2000: 78).

6.1   Introduction

The gravity model, with foundations in the physical sciences, has consistently proven to be a useful tool for the analysis of bilateral trade flows. Chapter 3 traced the history of the various determinants of trade, focusing on the rich theory and selected empirical research. Trade equations were then estimated in the previous chapter, focusing on the determinants of export volumes and prices. While early trade theorists focused on relative prices, new trade theorists identified problems with these theories and suggested alternatives. It is therefore useful to determine the impact of distance, other barriers to trade, friction and demand-side variables using the gravity model. The model can then be used to identify markets with unrealised potential.

The gravity model first applied to international trade in the 1960s, Linneman (1966), Pöyhönen (1963) and Tinbergen (1962)[2]) has been used in the social sciences since the latter half of the nineteenth century to explain migration and other social flows in terms of the gravitational forces of human interaction. As in physical science, the bigger and closer the units are to each other, the stronger the attraction. The analogy with "gravity" derives from GDP being a proxy for economic mass and distance a proxy for resistance.

The original gravity models were first introduced as atheoretical, albeit plausible, empirical models. The success of these models stems from their empirical robustness and intuitive appeal. Although this model initially was criticised for its lack of theoretical foundations, it has gained credibility as subsequent work established and developed its micro-economic foundations.

The purpose of this chapter is therefore to:

1.   Provide an historic sketch of the development of the gravity model;

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[1]   This chapter forms part of the gravity model research project done by the Investment and Trade Policy Centre (ITPC) for the DTI in March, 2004. Besides the empirical analysis using panel data that was done by Walter de Wet, the remainder was done by André Gouws, the researcher of this thesis.

[2]   Work by Tinbergen developed from early foundations established in Isard (1954).

2. Critically review its theoretical foundations;

3. Appraise the econometric issues; and

4. Use the model to identify markets with unrealised potential.

South Africa, although strategically located on shipping lanes between Europe and the Asia, is relatively far from the world's major markets and has a relatively small economy. Historically it has traded with Europe, North America and Asia. Using the gravity model confirms the determinants of South African export from a bilateral point of view and will also show areas with unexploited trade potential. From a policy perspective it will identify markets with unrealised potential that can inform both sectoral and regional trade promotion strategies.

6.2   Development of gravity models

The early gravity models, in spite of successful empirical applications were viewed with suspicion until Anderson (1979) established firm theoretical foundations. He derived the gravity model from expenditure share equations, assuming that commodities are distinguished by place of production. Helpman (1984) and Bergstrand (1985) went on to demonstrate that the gravity model can be derived from models of trade in differentiated products. Deardorff (1995, 1998) shows that the gravity model is consistent with several variants of the Ricardian and Heckscher-Ohlin models extended to include transport costs. Krugman (1991) formalised geographical proximity's role in the regionalisation process and analysed how proximity leads to production agglomeration and regional bias in trade flows. Regionalisation can be explained by geographical proximity and preferential trade agreements, when holding constant for the size of the trading partners and other variables that stimulate or impede bilateral trade (Frankel, 1997). Rauch (1999) showed that differentiated products exhibited stronger geographical proximity effects than homogeneous products.

Deardorff (1998: 8) contends that the gravity equation does not prove the validity of one theory or another, but simply confirms a fact. All that the gravity equation says "is that bilateral trade should be positively related to the two countries' incomes and negatively related to the distance between them." Grossman (1998) argues that it is this assumption that generates the empirical success of the equation. In a world with perfect specialisation, as an exporting country increases the supply of its products, the importing country will increase its consumption proportionally, increasing the volume of trade between them.

Similar reasoning is found among business economists who form part of the Uppsala School (Johanson & Vahlne, 1977). They classify exporters according to their experience in foreign markets and argue that exporters tend to begin trading with the psychologically closest country (or

shortest psychic distance). Once established, these exporters then extend progressively to countries that are psychologically more distant. The Uppsala School argues that the internationalisation process has four stages:

i.   No regular export activities;
ii.   Exports via independent representatives (agent);
iii.   Foreign sales subsidiary; and
iv.   Foreign production or manufacturing.

There are different levels of commitment at different stages. The reason for the stages is psychic distance[3], which prevent or disturb the flows of information between the firm and the market that are crucial for the internationalisation process (Johanson & Wiedersheim-Paul, 1975). As exporters gain experience and become part of networks, information is shared. This allows members of the network to exploit opportunities that new or inexperienced exporters do not have. Experienced exporters therefore have shorter psychic distances.

Trading nations with a long history will have experienced exporters with long institutional memory and well established networks. Although it can be argued that psychic distance is not relevant in this case, countries will experience attrition, with exporters exiting global markets, supplying only the domestic market. Thus new exporters, without networks and experience, are faced with the challenges of reducing the psychic distance.

6.3   Theoretical foundations

The early literature did offer a range of intuitive explanations for the most parsimonious version of the gravity equation put forward by Tinbergen (1962), which explains bilateral trade contains the following indicative factors:

- Total potential supply of the exporting country on the world market;

- Total potential demand of the importing country on the world market; and

- Impediments to trade between the two countries concerned.

Leamer (1994) finds that development variables offer the best explanation when he measures trade dependence (ratio of imports to GDP) but do not explain the composition of trade. The starting position of the model is a static analysis and therefore does not consider trends in trade flows over time. Prices are also not specified in this model. In the early gravity specifications there was no formal representation of the role of technology, factor endowments, demand

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[3]   The gravity model uses variables such as language and colonisation as proxies to capture this behaviour.

differences or any of the underlying structural differences associated with the determinants of trade.

Anderson (1979), using Armington preferences in a model of homogenous goods, derives a role for transport costs that he models in an iceberg fashion assuming that distance and transport costs are related. Supposing all goods are traded, national income is then the total value of traded goods. Armington preferences ensure that bigger countries, with more tradable goods, trade more. Bergstrand (1985, 1989) develops this further and derives the gravity equations from trade models with product differentiation and increasing returns to scale. Helpman and Krugman (1985) graft the equation into a monopolistic competition model with increasing returns to scale that yields sectoral trade pattern predictions. Deardorff (1998) explains that the gravity equation is consistent with variants of both the Ricardian and Heckschser-Ohlin models. Eaton and Kortum (2002) embed the gravitational forces in a Ricardian setting also using an iceberg framework with homogenous goods. Anderson and van Wincoop (2001) refine the model 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.
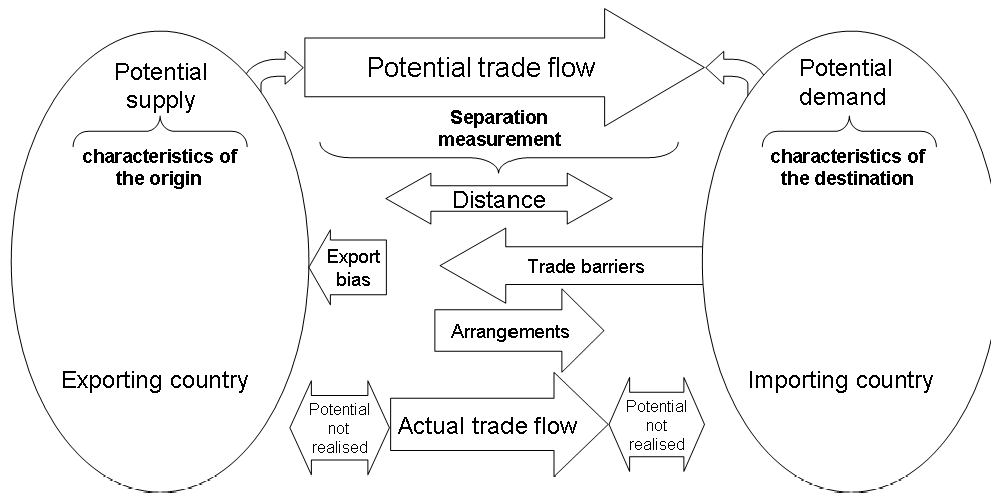
6.4   The design of the gravity model

The gravity model belongs to the class of empirical models concerned with the determinants of interaction. In its most general formulation, it explains a flow F_{ij} (of goods, people, etc.) from an area i to an area j as a function of characteristics of the origin (O_i), characteristics of the destination (D_j) and some separation measurement (S_{ij}):

$F_{ij}=O_iD_jS_{ij}$, $i=1,..,i$; $j=1,..j$ .... (1)

The gravity model is presented graphically in Figure 1 showing that potential supply and demand, determined by the sizes of the economies, predict the potential trade flow between the countries of the trading partners. This flow is subject to certain trade resistance factors that are improved by trade arrangements. Finally, the actual trade flow results, with potential not realised.

Figure 1   The gravity model

Source: Own compilation.

The basic trade gravity model relates to the measure of bilateral trade to the economic mass of the two countries and the distance between them. This is given by:

$$TRADE_{ijt} = \beta_1(Y_{it}Y_{jt}) + \beta_2(P_{it}P_{jt}) + \beta_3 D_{ij} + \mu_{ijt}$$ .... (2)where:

- $TRADE_{ijt}$ is bilateral trade between country i and country j;

- $Y_{it}Y_{jt}$ is the nominal GDP for country i and country j;

- $P_{it}P_{jt}$ is the population in country i and country j; and

- D_{ij} is the distance between country i and country j.

Larger countries are expected to trade more than small countries because, the former tend to innovate more, have more advanced infrastructures that facilitate trade, and generally have more liberal trade policies. The further countries are from each other, the greater the transportation costs, risks, and generally the cost of doing business. It is therefore expected that $\beta_3 < 0$. Trade will be positively affected by the economic mass and therefore $\beta_1 > 0$. Trade will be negatively related to the population $\beta_2 < 0$, indicating that larger countries tend to be more self-sufficient.

μ_{ijt} is given by:

$$\mu_{ijt} = \gamma\kappa + \varphi\lambda_t + \varepsilon_{ijt}$$ ....(3)

where $\gamma\kappa$ and $\varphi\lambda_t$ are fixed effects for other potential determinants of bilateral trade.Translating the above into a mathematical expression, the following model arises:

$$\log X_{ij} = \alpha_0 + \beta_1 \log y_i + \beta_2 \log y_j + \beta_3 \log Y_i + \beta_4 \log Y_j$$
$$+ \beta_5 \log D_{ij} + \beta_6 L_{ij} + \sum_z \alpha_z P_{zij} + \sum_z \alpha_z Q_{zij} + u_{ij} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

where:

- X_{ij} is the total exports from *i* to *j;*

- Y_i, Y_j are the countries' incomes (characteristics of trading partners);

- y_i, y_j are the countries' per capita incomes (characteristics of trading partners);

- D_{ij} is the geographical distance between *i* and *j* (separation characteristic);

- L_{ij} is a dummy for common language between the two countries (characteristics of trading partners);

- P_{ij} is a preferential trade scheme dummy (trade arrangements);

- Q_{ij} is a trade policy dummy (anti-export bias); and

- u_{ij} is the normal random error term.

The sizes of the economies of both the exporting and the importing country are represented by their GDP and population size. The distance between the countries and a dummy for a possible trade arrangement reflects trade resistance.

The gravity model is expanded to analyse sectoral determinants:

$$\log X_{ijk} = \alpha_0 + \beta_1 \log y_i + \beta_2 \log y_j + \beta_3 \log Y_i + \beta_4 \log Y_j +$$
$$\beta_5 \log D_{ij} + \beta_6 L_{ij} + \sum_z \alpha_z P_{zijk} + \sum_z \alpha_z Q_{zijk} + \beta_7 K + u_{ij} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

where:

- X_{ijk} is the total exports of sector *k* from country *i* to country *j;* and

- *K* represents various sectoral dependant determinants.

A high level of income in the exporting country indicates a high level of production, which increases the availability of goods for exports. Therefore, β_1 is expected to be positive, as is β_2 (coefficient of Y_j) since a high level of income in the importing country suggests higher imports. The coefficient estimate for population, β_3, may be positive or negative, depending on whether the country exports less when it is big (absorption effect) or whether a big country exports more than a small country (economies of scale). The expected coefficient of the importer population, β_4, is

similarly ambiguous. The expected distance coefficient should be negative since it is a proxy of all possible trade cost sources.

Disaggregating trade per sector shows unrealised trade and identifies opportunities that South African exporters could exploit. The reasons why the potential is not realised will have to be investigated. This will assist the government in its bilateral trade negotiations and identify areas for government intervention.

6.5   Econometric issues

To explain South African trade, the model is empirically evaluated using the absolute and relative roles of real income growth, real income convergence, tariff reductions and falling transportation costs. Individual effects (α_{ij}) are included in the regressions and can be treated as fixed or as random. From an *a priori* point of view, the random effects model (REM) is appropriate when estimating typical trade flows between a randomly drawn sample of trading partners from a larger population. The fixed effects model (FEM) is appropriate when estimating typical trade flows between an ex ante predetermined selection of nations (Egger, 2000). The Hausman test is used to check whether the REM is more efficient that the FEM model. This will be the case under the null hypothesis of no correlation between the individual effects (α_{ij}) and the regressors.

Because the inherent transformation eliminates these variables, the FEM cannot directly estimate static variables. This is solved by running a second regression with the individual effects as the dependent variable and distance and dummies as explanatory variables:

$$IE_{ij} = \alpha_0 + \beta_1 Lang + \beta_2 Adj + \beta_3 D_{ij} + \mu_{ij} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (6)$$

where IE_{ij} denotes the individual effects, D_{ij} denotes distance, Adj is a dummy taking the value one when two countries share border and zero otherwise and language (Lang) is a second dummy variable taking the value one when a pair of countries share the same language, zero otherwise.

6.6   Data issues

Trade data are never complete and are problematic. A full discussion on the data used is included in Appendix 10. However, in terms of the gravity model, a few specific problems need to be stressed. Bilateral disaggregated trade figures, particularly at an industrial or sector level, are questionable. Traders often under- or over report the value of the export transaction (depending on whether duties are high or incentives can be claimed). This is further complicated by differing currencies, particularly with fluctuating exchange rates. Aggregating trade statistics for a year in one currency and converting it to another at an average exchange rate is problematic. Countries

use different methods to calculate their GDP and other national accounts, although attempts are being made to streamline this. Even dummy variables pose problems. In a country such as South Africa, using English as a language dummy is going to prove significant. Yet, when analysing potential trade arising from the model, countries such as Belgium and the Netherlands, seem to exceed their predicted potential. Afrikaans, Dutch and Flemish are very similar languages and explain this anomaly.

Bayoumi and Eichengreen (1997: 143) note that a common concern in some previous estimates of international trade gravity equations is the pooling of data for industrial and developing countries. The concern arises because the relationship "between trade and economic characteristics may vary between the two groups of countries".

In addition, there is the problem of unit roots. A series is said to contain unit roots or stationary if the mean and autocovariances of the series do not depend on time. Time series data invariably contain unit roots and the results may be spurious.

6.7   Applications

Since the gravity model explains trade flow, T_{ij}, from an area i to an area j as a function of characteristics of the origin, O_i, characteristics of the destination, D_j, and some separation measurement, S_{ij}, certain deductions can be made from analysing the differences between the predicted and actual trade flows. The gravity model shows how it can be customised for different purposes:

- The gravity model is bilateral. It explains trade volumes as a function of size, income, exchange rates, prices (among other factors), and transport costs (and other market access issues) between two countries.

- The gravity model is generally used to estimate either the determinants of the volume of trade or the determinants of the nature of the trade flows (using an index of IIT) as the dependant variable.

- The theory provides foundations to a modelling based on rough indicators that are particularly useful when modelling with unreliable or missing data.

- Discrepancies between predicted volumes (theoretical model) and actual trade data can be explained by specific effects[4.]

- The model can be disaggregated to identify sectoral determinants.

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[4]   Introducing these specific effects tends to compromises the model's forecasting abilities.

(i)   Trade patterns

Trade patterns have also been investigated using gravity-type equations. The trade overlap (i.e. two-way trade within industries) is examined in Bergstrand (1989) and Hummels and Levinsohn (1995): they tabulate bilateral indexes of IIT at the industry level.   These indexes are then aggregated and their weighted average is explained using a gravity equation. Trade types, an alternative method used to disentangle trade in intra- versus inter-industry flows, are explained in Fontagné *et al.,* (1997). They calculate trade types at the 8-digit product level and aggregate the results at the industry level. These trade types are explained using equations integrating gravity-related variables. However, they consider trade shares rather than trade volumes.

The gravity model is used to infer bilateral export potentials. The tabulation of trade potentials is certainly the line of related research that economists have studied the most extensively.   In particular this methodology has been used extensively for Central and Eastern European Countries, (Baldwin, 1993; Festoc, 1996; Gros and Gonciarz, 1995; Havrylyshyn and Pritchett, 1991; Schumacher, 1995 and 1997, and Wang and Winters, 1991). Usually, a gravity equation explaining bilateral trade flows between a sample of countries, where trade is supposed to have reached its potential, is estimated. Dummy variables are used to account for factors that still limit trade. This equation is used in simulation to obtain natural bilateral trade between any pair of countries, given that distance, GDPs and population are systematically available.   This methodology can be applied either at the aggregated or industry level.

(ii)   Border effects or home market bias

Gravity models have been used to investigate a number of empirical regularities including the home market bias and border effects.   One avenue of this empirical research has been to investigate whether border effects inhibit international trade. For example, Helliwell (1996 and 1998) finds that trade between Canadian provinces far outweighs trade between the provinces and US states, taking into account distance and economic mass.   McCallum's (1995) initial investigation suggested that intra-Canada trade was approximately 22 times larger than trade between Canadian provinces and US states; Helliwell's (1998) estimate was similar in magnitude[2]. In similar work, Fitzsimons *et al.,* (1999) use a gravity model to investigate the border effect between Ulster and the Republic of Ireland and find that the gravity model underestimates trade after taking language and common land border into account, despite the two trading partners using different currencies.

(iii)   Role of currencies

Trade is negatively affected in a world with different currencies whose values fluctuate relative to each other. Monetary unions and similar arrangements have been put in place to overcome this trade impediment. The impact currency arrangements have on bilateral trade has been analysed by Frankel and Rose (2002), Glick and Rose (2002), Rose (2000), and Rose and van Wincoop (2001). Rose (2000) argues that two countries sharing the same currency trade roughly three times more than they would if they used different currencies. To capture the partial impact of currency arrangements Rose (2000) takes structural and institutional features into account. These include:

- Common language;

- Common colonial history;

- Trade agreements, etc. (although this might also be correlated with a 'common currency' dummy variable); and

- The impact of currency union is also found to be distinct from currency volatility.

(iv)   Linder hypothesis

The absolute difference in per capita income ($DIFY_{ij}$) can be used to test the Linder hypothesis that countries with similar levels of per capita income have similar tastes, produce similar but differentiated products and trade more among themselves. A negative sign will lend support to this effect. However, this hypothesis will not hold when countries have large domestic differences in per capita income, reflected by high Gini coefficients. Arnon, Spivak and Weinblatt (1995) suggested that a squared difference in per capita income is the variable to identify a possible Linder effect.

(v)   Trade facilitation

Trade facilitation is the simplification and harmonisation of trade procedures through reduced transport costs (Fink *et al.*, 2002; UNCTAD, 2001; Wilson, Mann & Otsuki, 2003; and World Bank 2000). With declining traditional barriers to trade – falling tariff barriers and attempts to reduce non-tariff barriers – attention is now being focused on other impediments to trade. As a result, trade facilitation is a growing issue. Trade facilitation is conducted by way of reducing transport cost, customs clearance, inventory, communications, and standards. Bougheas, Demetriades and Morgenroth (1999) showed that transport costs are a function not only of distance but also of public infrastructure. They augmented the gravity model by introducing additional infrastructure variables (stock of public capital and length of motorway network). Their model predicts a positive relationship between the level of infrastructure and the volume of

trade, which is supported using data from European countries. Logistics at ports and customs are costly and can be reduced. Hummels (2001) showed how improved ports facilities, efficient and modern customs regimes improved trade. A multi-dimensional approach was adopted by Wilson *et al.,* (2003) to analyse various aspects of trade facilitation.

(vi)   Integration

Gravity models have been extensively used to address the issue of the impact of trade policies such as regional trade agreements on trade flows. Generally, these models use a dummy variable, which, if positive and significant, attributes trade to regionalism. Cernat (2001) for example, recently analysed South-South regional trade arrangements.

(vii)   Trade potential

Trade potential is calculated based on the parameter estimates. Generally the formula is applied to a wide range of countries commonly grouped according to their level of development. For each exporting country *i,* from a particular group, it is possible to calculate the expected export volume, $\hat{X}_{ij}$, to each of its partner countries *j,* according to gravity specification. To adjust the trade potential for systematic effects, the *a posteriori* fixed effect F_i is defined as:

$$F_i = \frac{\sum_j X_{ij}}{\sum_j \hat{X}_{ij}} \quad \text{..} \quad (7)$$

The trade potential TP_{ij} is calculated as:

$$TP_{ij} = F_i \hat{X}_{ij} \quad \text{..} \quad (8)$$

This procedure calculates trade potential using "fixed effects" for countries not used in the estimation. These systematic effects capture the factors that would explain why a country would trade more (less) with the rest of the world than if it was based solely on the determinants of trade in the gravity equation. Similarly, the fixed effects are now specific to the importing country *j* or the *a posteriori* fixed effect $F_j,$ is formally defined as:

$$F_j = \frac{\sum_i X_{ij}}{\sum_i \hat{X}_{ij}} \quad \text{..} \quad (9)$$

Accordingly, the trade potential TP'_{ij} is calculated as:

$$TP'_{ij} = F_j \hat{X}_{ij} \hspace{1em} .... \hspace{1em} (10)$$

The trade potentials calculated with a fixed effect for the importer (TP'_{ij}) are different from the trade potentials calculated with a fixed effect for the exporter (TP_{ij}).

6.8   Limitations of the gravity model

Despite its empirical success, the gravity model has not been free from criticism. A frequent complaint, though no longer prevalent, relates to its lack of theoretical foundations (Leamer, 1994). Deardorff (1998) argues that the basic regressors of gravity models – distance and income – are actually implied by a wide variety of theoretical models. Similarly, Evenett and Keller (1998) show that much of the success of the gravity equation relies on increasing-returns-to-scale-based theories of trade. Their analysis is, however, focused on the proportionality of the volume of trade to the trading countries' incomes and not on its relationship to trade resistance or on the role of the demand side. Feenstra, Markusen and Rose (2001) argue that empirical gravity models can be used to discriminate between alternative trade theories.

On the empirical side, Polak (1996: 538) is concerned with the misspecification and inbuilt bias of the gravity specifications. He is concerned about the downward bias for distant countries and upward for "close-by countries". Hamilton and Winters (1992: 109) also call for a "more differentiated measure of distance". Brulhart and Kelly (1999), include a remoteness indicator (calculated as the average of a country's distances to its trading partners, weighted by the partners' GDPs) in their ordinary least squares (OLS) estimation. Concerned with the "highly restrictive log-linear specifications" widely-specified in gravity-type models, Fik and Mulligan (1998) suggest the use of Box-Cox transformations.

Until recently, most authors continued to estimate and report OLS estimates for the gravity equations and ignore possible misspecification caused by the nature of measurement problems associated with data collected for aggregate spatial units. Such data are characterised by the presence of spatial effects. This is caused by various degrees of spatial aggregation, spatial externalities and spillover effects and spatial structure or Homoskedasticity, resulting from "heterogeneity inherent in the delineation of spatial units and from contextual variation over space" (Anselin, 1998: 1). Under these conditions traditional econometric techniques are no longer applicable, since spatial effects do, separately or in combination, impact upon the properties of the traditional estimators and statistical tests. He holds that in the presence of spatial effects, the appropriate technique is that of spatial econometrics, which enables validation for

multiple sources of misspecification in spatial models and testing for spatial dependence when other forms of misspecification are present (Anselin, 1998: 2) and it can deal with the multidirectional nature of spatial dependence, which often precludes the use of OLS.

6.9   Applying the gravity equation to identify markets with potential for South African trade

As described above, the gravity model can be used to identical unrealised market potential. This potential may be ascribed to factors not captured by variables specified in the gravity equation. In other words, friction is added to trade by market specific determinants. This section will describe how the gravity model is applied to South African trade and used to calculate unrealised potential.

The gravity model has limited application for small and weakly diversified economies, since it actually gives the trade potential of a country, as if it was relatively diversified. Therefore despite selection bias, the model is tested using a sample of 50 countries (South Africa's top markets in 2000) for the period from 1980 to 2000. (A complete list of countries, their reason for inclusion and the problem of selection bias are included in the Appendix 16.) For the individual sectors, the model covers the period from 1988 to 2000. Trade specialisation and complementarities between the countries are not taken into account in an aggregated gravity approach and explains the large residuals. This is particularly true for small or weakly diversified economies, with one or two major export commodities. The trade potential is therefore only indicative for poorly diversified countries, and therefore the sample is limited to 50 countries.

As described in section 5.2.2, an export determination model combining both export supply and export demand elements into a single (gravity) equation. This is justified in the grounds that South African exporters are price takers. The gravity elements are included to explain frictions encountered in international trade. Panel estimation overcomes the degree of freedom problems experienced in single equations. With 50 countries, and 21 years of observations, the number of data points amounts to 13 650, where individual time series estimation only gives 21 data points per country. The number of countries was limited because of data problems. However, the purpose of the model for this study is to determine in which markets potential exists. (These issues are discussed in Appendix 16.) The equation[5] to be estimated is therefore given as:

$$
\begin{aligned}
x_{ijt} = C_0 &+ \beta_1 ex_{jt} + \beta_2 dist_{jt} + \beta_3 pcy_{jt} + \beta_4 prodl_{jt} \\
&+ \beta_5 infra_{jt} + \beta_6 ERP_i + \varepsilon_i + \eta_t
\end{aligned}
\qquad \text{... (11)}
$$

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[5]   Lower case indicates that the variable is expressed in natural logs.

where:

- x_{ijt} =   exports from South Africa to country j (where subscript i denotes specific sector where applicable);

- C_0 =   common intercept;

- EX_{jt} =   exchange rate between South Africa and country j. The exchange rate is used as a proxy for relative prices;

- $dist_{jt}$ =   the distance in miles between South Africa and country j;

- pcy_{jt} =   per capita GDP of the country j;

- $prodl_{jt}$ =   GDP of country j divided by the area of country j. This is a proxy of how well a country uses its land area relative to GDP;

- $infra_{jt}$ =   index containing a comprehensive rating for the infrastructure of a country. The higher the rating, the greater the infrastructure of the country.;

- ERP_{it} =   effective rate of protection for exports of sector i;

- ε_j =   country specific random effect; and

- η_t =   white noise residual.

In panel estimation different models can be estimated, a fixed effect, a random effect or a pooled model. The random effects estimation is used after testing for both random and fixed effects. A general-to-specific approach was used in obtaining the final specification that is given by equation 53. The final specification estimation is reported in Table 1. For expositional reasons, the random effects for each country are reported in Appendix 17. This gives the bilateral effects with each of the 50 countries' total export estimation. All signs are as expected.

Table 1   Total exports: Random effects model estimation

Sample	1980 - 2000	
Independent variable	X_{jt}	
Variable	Coefficient	Std. Error
C_0	3,07	1,87
ex_{it}	-0,017	0,04
$dist_{it}$	-0,72	0,49
$prodl_{jt}$	0,64	0,14
pcy_{it}	0,62	0,15
$infra_{it}$	0,80	0,15
ERP_t	-0,96	0,07
Adj R-squared	0,79	

(i)   Exchange rate

The exchange rate used was the indirect quote, i.e. foreign currency per rand (ZAR). Therefore, an increase in the exchange rate will signify a strengthening of the rand. As the rand strengthens against the currency of the country to which South Africa exports, one would expect exports to decline. This is indeed the case, with a negative sign for the coefficient. The magnitude of the coefficient is relatively small. Rapid short-run depreciations, nevertheless, will in most cases result in actual exports overshooting the potential level. Over the long run, however, the exchange rate effect becomes less severe.

(ii)   Distance

A country that lies geographically further from South Africa is expected to attract less exports, especially due to transport cost. The coefficients indicate that this is indeed the case. Although the influence of distance is significant for total exports, it might not be an obstacle for some individual sectors, depending on the goods and services produced in the particular sector. Transport costs for goods to the developed world declined substantially during the last decade compared with the 1980s, and therefore is a less important factor in determining trade.

(iii) Use of land

A large country (abundant land) is generally expected to have a greater demand for imports from abroad. The ratio of GDP to land area was used to control for the fact that some countries have large areas of land but a relatively small GDP. This is the case with Canada and Russia. However, the coefficient indicates that as a country's GDP increases relative to land area, exports to these countries will increase.

(iv) Per capita GDP

The higher the income per capita for a country, the greater the demand for imports, and thus South African exports. Table 1 shows that this effect is quite strong, with the positive coefficient of 0,62 indicating that a 1 per cent increase in per capita income of trading partners will lead to a 0,62 per cent increase in exports to the rest of the world.

(v)   Infrastructure

This is a comprehensive rating of a county's infrastructure that includes various factors, from roads, telecommunications to institutions. A higher rating indicates a better infrastructure. Better

infrastructure should lead to higher trade and therefore more exports from South Africa to this country. The coefficients indicate that this is indeed the case.

(vi)   Effective rate of protection.

The effective rate of protection[6] has the strongest effect. The negative sign indicates that as the effective rate of protection increases, exports decrease. For the total export function of South Africa, a 1 per cent increase in g will almost lead to a 1 per cent decrease in exports. In other words if the tariff on the final product (t) is high, g will be high and it will thus be a disincentive to exports.

If the tariff on the imported inputs is high the effective rate of protection will be low. Although the effective rate of protection for South Africa has come down significantly since 1994 (Rangasamy and Harmse, 2002: 344), further liberalisation would benefit export.

6.9.1 Diagnostics of the model

The two most common panel unit root tests are Levin, Lin and Chu (2002) and Im, Pesaran and Shin (1997). However "relatively little about the size and power" of panel unit root test when any of the distribution assumptions underlying their construction is violated (Bornhorst, 2003:1). Nevertheless, the model seems to be well specified and robust in all cases. The factors used in the estimation are derived from theory and other empirical studies and can therefore be considered as the core factors determining trade.

6.9.2 Policy implications

(i)   Anti-export bias

Although this model used the effective rate of protection as a variable rather than the anti-export bias, it can be seen that protection has a devastating impact on the volume of exports. As protection decreases, an increase in South African exports can be expected. Since a 1 per cent decrease in the effective rate of protection will almost lead to a 1 per cent increase in exports, liberalisation has a beneficial impact trade volumes and confirms the results of the estimates in Chapter 5.
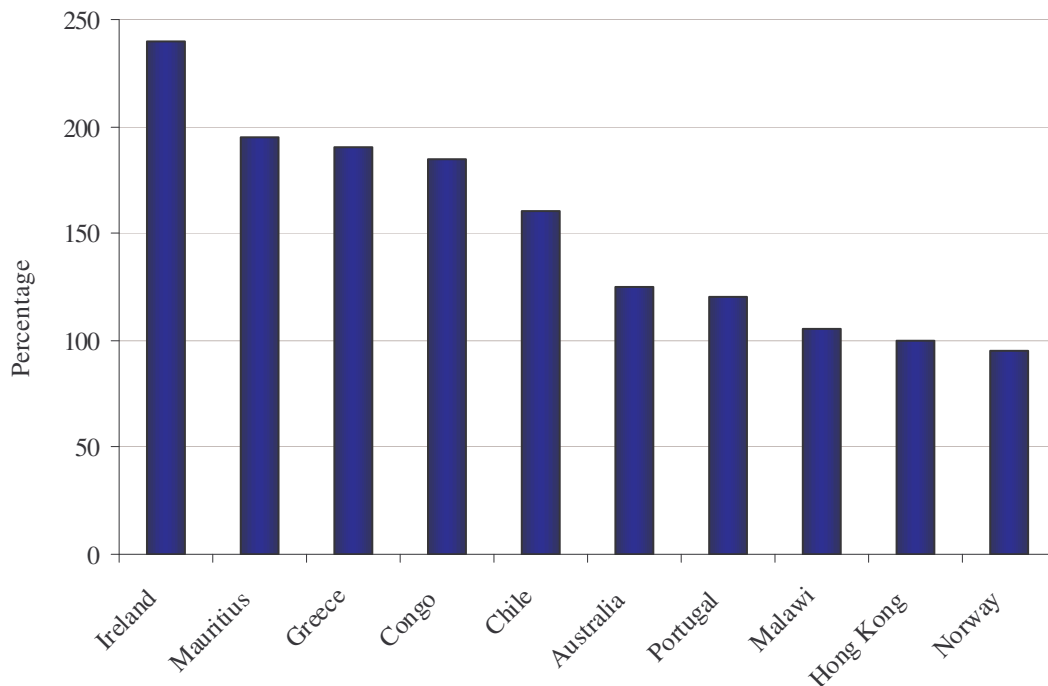
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[6]   The effective rate of protection is calculated as: $g = \dfrac{t - a_i t_i}{1 - a_i}$

with g = effective rate of protection to producers of a final commodity; a_i = the ratio of the cost of the imported input to the price of the final commodity in the absence of tariffs; t = nominal tariff rate on consumers of the final product; and t_i = the nominal tariff on the imported input.

(ii)   Trade potential

Given this model, it is possible to calculate potential exports to an individual country based on the fundamentals. Given potential exports, the policy-maker can compare it with actual exports, and determine where and to which country exports are under-performing. This, of course, is very important for trade policy. Figure 2 shows the 10 leading countries in terms of potential exports.

Figure 2   The ten countries with largest potential[7]

Source: ITPC (2004: 32).

There are many factors that can explain why South Africa has not realised its potential and these require further investigation. Policy-makers and trade promotion officials should meet with foreign importers and domestic exporters to determine the causes. Disaggregated trade data will also cast light on this. Once these causes have been ascertained, the gravity model can be refined to include the new factors and quantify the impact that these causes actually have on trade.

6.10 Furniture exports

The sheer volume of data and reports that are generated would make for tedious reading. Nevertheless, based on the information gained from the previous chapters, one sector, the

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[7] This is the percentage gap between potential exports predicted by the gravity model and actual exports realised.

furniture sector is chosen to test the applicability of the gravity model at a sectoral level. The reasons are:

- It has exhibited consistent growth;

- It is labour intensive; and

- It is not sensitive to price (differentiated product).

A general-to-specific approach was used in obtaining the final specification that is given by:

$$x_{ijt} = C_0 + \beta_1 ex_{jt} + \beta_2 Dist_{jt} + \beta_3 PCY_{jt} + \beta_4 prodl_{jt}$$
$$+ \beta_5 infra_{jt} + \beta_6 ERP_i + \beta_7 Sanctions + \varepsilon_i + \eta_t \quad \text{..(12)}$$

where:

- x_{jt} = furniture exports from South Africa to country j (where subscript i denotes the furniture sector);

- C_0 = common intercept;

- ex_{jt} = exchange rate between South Africa and country j. The exchange rate is used as a proxy for relative prices;

- $Dist_{jt}$ = the distance in miles between South Africa and country j;

- PCY_{jt} = per capita GDP of the country j;

- $prodl_{jt}$ = GDP of country j divided by the area of country j. This is a proxy of how well a country uses its land area relative to GDP;

- $infra_{jt}$ = index containing a comprehensive rating for the infrastructure of a country. The higher the rating, the greater the infrastructure of the country;

- ERP_{it} = effective rate of protection for exports of sector i;

- $Sanctions$ = a dummy variable to capture the impact of sanctions;

- ε_j = country specific random effect; and

- η_t = white noise residual.

All variables, where possible, are in their natural logarithmic form. Income variables (per capita GDP and relative GDP) were not significant and therefore dropped from the equation and the model reported is:

Table 2   Furniture exports: Random effects model estimation

Sample	1980 – 2000	
Independent variable	X_{jt}	
Variable	Coefficient	Std. Error
C	7,198630	5,129291
Exchange rate	-0,268954	0,110038
Distance	-2,652461	1,339434
Infrastructure	1,543787	0,521007
Effective rate of protection	-2,715951	0,209726
Adj R-squared	0,803691	

6.11 Export potential

The results are similar to the trade equations and neither the sanctions nor the income variables were significant. However, distance is a significant and positive explanatory variable. This would seem to indicate that furniture, which is bulky, is easier to export to markets that are relatively close – transport costs may play a role after all.

Table 3   Actual and potential furniture exports in 2000[8]

Country	Actual ($m)	Potential ($m)	%	Country	Actual ($m)	Potential ($m)	%
Taiwan	35	251,2152	717,76	Switzerland	182	306,5473	168,43
India	14	87,19465	622,82	Ireland	1782	2749,494	154,29
China	6	35,5058	591,76	UK	83722	103540,7	123,67
Argentina	13	65,64825	504,99	Turkey	36	43,57929	121,05
Chile	29	81,98432	282,70	Malawi	1533	1814,648	118,37
Hong Kong	99	268,9873	271,70	Mozambique	8475	9968,167	117,62
Congo	741	1882,798	254,09	Israel	737	818,4596	111,05
France	8085	19467,88	240,79	Indonesia	6	6,559445	109,32
Netherlands	1189	2666,855	224,29	Iran	22	23,64872	107,49
Zambia	6482	12083,03	186,41	Kenya	1037	1085,739	104,70
Mauritius	585	1085,44	185,55	UAE	1448	1495,618	103,29
Brazil	35	62,201	177,72	Zimbabwe	2128	2116,712	99,47

Source: Own calculations using World Trade Analyser (2004) data.

The above table ranks the exports according to the potential percentage increase. Some markets exhibit a large potential growth rate off a very small base. This points to a country such as France with a relatively large base and it should therefore be investigated. The problem may be to do with market access issues (especially non-tariff barriers), simply a lack of information about the market potential on the part of exporters, or other market forces. The proposed research should point out trends in the style and brand names that attract premium prices. At this stage it is mere

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[8]   Note: The percentage gap between actual and potential ??

speculation. Entrepreneurs need to identify and to satisfy the need. The role of government in this regard will be dealt with in the next chapter.

The disbursement of markets with potential is rather wide. There is no geographic area, or culture, that particularly stands out. The demand is spread across the globe. Exporters can therefore target various markets and spread their risks.

6.12   Conclusion

The focus of this chapter was on bilateral demand factors, although certain supply-side factors such as the effective rate of protection was included to estimate the impact of trade policy on exports. A standard gravity equation for potential bilateral exports was used to achieve this using a combination of macroeconomic variables (size, income, exchange rates, prices etc.) between trade partners. Indicators of transportation costs between countries and more generally, market access variables, are also added and are used to explain trade patterns.

Given that the purpose of this study is to inform policy, countries with the greatest potential are identified. Further analysis is now required to ascertain why the potential is not achieved. The obvious reason is market access. The model would be considerably improved with the inclusion of tariffs and an indicator of non-tariff barriers. Detailed bilateral research, at a sector, industry or product level needs to be undertaken. An analysis of South African exports and partner countries' imports needs to be undertaken. In addition, sectoral import demand equations can be estimated that will give elasticities and identify other demand and market access issues.

Armed with information from the trade and export price equations and the bilateral trade information from the gravity model, the enterprise-level determinants are missing. Since many of the products that are being exported can be classified as differentiated, information is needed about the enterprise. The next chapter will attempt to do identify enterprise determinants by drawing on other research and using qualitative techniques.