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Abstract

The study applies an "augmented" gravity equation to South Africa's exports of motor vehicles, parts & accessories (SIC 381-383) to 76 countries over the period 1994 to 2003. The study employs a dynamic panel data model to estimate long-run and short-run coefficients. First, it is shown that it takes about 16 months for exports to adjust. Second, a number of variables, namely, importer income, population, exchange rate, distance, free trade agreements are important determinants of bilateral trade flows for motor vehicles, parts & accessories. Third, the gravity model is solved stochastically to determine South Africa's "optimistic", "pessimistic" and "average" potential exports to the 76 countries. Finally, estimates of the degree of variability of "average" potential exports are provided, which show that South Africa's trade with Germany, the United Kingdom and the United States have low variability.

Key words: Gravity equation, dynamic panel data, trade potential, transport equipment and machineries

JEL Codes: E33, E52

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1. Introduction

South Africa's transport industry has become an increasingly important contributor to the country's gross domestic product and exports. The contribution of exports of motor vehicle parts & accessories and other transport equipment to South Africa’s merchandise exports to the rest of the world grew from 2.8 per cent in 1994 to 9.2 per cent in 2004.

A number of multinational original equipment manufacturers (OEMs) are located in South Africa and make a sizeable contribution to the local industry. Examples include BMW, Nissan, Fiat, Ford, Toyota, Volkswagen SA and Daimler Chrysler SA.

A number of initiatives have been put in place to address supply and demand-side problems. These include, among others, establishment of the Motor Industry Development Centre (MIDC) in 1996 as a forum to develop policy and encourage better communication and co-operation among all role players in the industry, fostering cordial bilateral and multilateral trading relations, multilateral trade negotiations in the context of WTO with a view to reducing tariff and non-tariff barriers to exports.

Given the role that transport sector plays in South Africa’s economy and government initiatives to address some of the problems it faces, it is important from a trade policy perspective to determine the potential exports of transport equipments to different countries. A gravity model is one useful tool for such purpose. In its basic form, the gravity model states that the amount of trade between countries increases with their size as measured by national incomes and diminishes with the cost of transportation between them, proxied by the distance between their economic centres.

Many of the gravity models mainly predict trade potential. A case in point is the International Trade Centre (ITC) gravity model called *TradeSim* (International Trade Centre, 2003), which estimates bilateral trade flows of developing countries with any of their partner countries. The fall of the Iron Curtain and the enhanced trade liberalisation following the Uruquay Round in 1995 galvanised many countries to evaluate the trade potential of new trading partners.

Many empirical studies use cross-section data to estimate gravity equations. However, in recent years panel data has been used e.g.Nilsson (2000). The cross-section and panel data analyses are mainly static and basically estimate long-run relationships.

There are basically two approaches to computing trade potential. The first approach obtains *within-sample* trade potential estimates. According to this approach, the residuals of the estimated equation represent the difference between potential and actual trade relations between countries. Nilsson (2000) uses this approach. The second approach derives *out-of-sample* trade potential estimates (e.g. Brülhart and Kelly, 1999). In this approach, parameters are estimated by gravity equation and the same coefficients are applied to project “natural” trade relations between countries. The difference between the observed and predicted trade flows represent the unexhausted trade potential.

Whichever approach used, the finding of untapped trade potential calls for proactive export promotion policies e.g. bilateral and multilateral agreements, trade facilitation etc. On the contrary finding of actual trade exceeding potential trade (successful partnership) implies that trade has reached its potential level and no social cost is anticipated from future integrations.

This paper employs the gravity model to can predict *within-sample* potential trade flows for motor vehicle, parts & accessories (SIC 381-383) given certain conditions. The novelty of the study lies in three areas. First, the employs dynamic panel data to determine the speed of adjustment, long-run and short-run coefficients. Second, the study solves the baseline gravity model stochastically to determine "pessimistic", "optimistic" and "average" potential exports, which makes sense in an uncertain world. Finally, the study determines the degree of variability of "average" potential trade for 76 countries, which is quite important for planning purposes.

The rest of the paper is organised as follows. Section 2 presents the model specification. Section 3 and 4 focus on estimation issues while section 5 present the results. Sections 6 and 7 focus on determination of potential exports and trade variability, respectively. The last section deals with conclusions.

2. Model specification

The gravity model, first applied to international trade by Tinbergen (1962) and Pöyhönen, (1963), 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". Gravity models were originally introduced as atheoretical, albeit plausible, empirical models.

Despite the widespread empirical and policy use, the theoretical foundation has been controversial. Many studies have modified the original Newtonian gravity equation. Bergstrand (1985, 1989) includes the population size, Sattinger (1978) incorporates probability, Oguledo and Macphee (1994) includes price variables.

A basic gravity model is specified as follows;

$$X_{ij} = C \frac{Y_i^{\beta_1} Y_j^{\beta_2} N_i^{\beta_3} N_j^{\beta_4} P_i^{\beta_5} P_j^{\beta_6}}{\theta_{ij}^{\sigma}} \qquad (1)$$

X_{ij} is the foreign price value (e.g. US dollars) of imports of goods by country *i* from country j. C is a constant term. Y_i and Y_j are the importer and exporter income respectively. $\theta_{ij} = (Dis_{ij})^{\gamma}$ is a trade barrier function. Dis_{ij} is the distance between the trading partners. N_i and N_j are importer and exporter population respectively, P_i and P_j are the price levels respectively.

Based on the work of Brun *et al.*(2005) the standard trade barrier function is augmented to reflect crude oil prices, language, preferential trade relations etc.

$$\theta_{ij} = (Dis_{ij})^{\alpha_1} \left(Oil\right)_t^{\alpha_2} e^{\lambda_1 lang + \lambda_2 AFR + \lambda_3 EU + \lambda_4 NAFTA + \lambda_5 MERC + \lambda_6 Asia + \lambda_7 Midest} \qquad (2)$$

Dis_{ij} is the distance in KM between Pretoria and trading partner capital city, *Lang* is English language dummy. Trading partners, whose official language is English are coded 1 and 0 otherwise. EU is European Union dummy (EU members coded 1 and 0 otherwise), AFR is African dummy (African countries coded 1 and 0 otherwise),

$NAFTA$ is North Atlantic Free Trade Agreement dummy (NAFTA members coded 1 and 0 otherwise), $MERC$ is MERCOSUR FTA dummy (MERCOSUR members coded 1 and 0 otherwise). Asia and Midest are dummy variables for Asia and Middle East.

The study follows the approach of Oguledo and MacPhee (1994) and Cheng and Wall (2005) and specifies a generalised gravity panel model, which combines Equations 1 and 2;

$$\begin{aligned} \ln X_{ijt} &= C_0 + \beta_1 \ln EX_{jt} + \beta_2 \ln GDP_{jt} + \beta_3 \ln GDPSA_{it} + \beta_4 \ln Pop_{jt} \\ &+ \beta_5 \ln PopSA_t + \beta_6 \ln oil_t + \beta_6 Z_{ij} + \varepsilon_{ijt} \end{aligned} \tag{3}$$

Where X_{ijt} refers to South Africa's exports to country j, EX_{jt} is exchange rate between South Africa and country j (rand/US dollar). The exchange rate is used as a proxy for relative prices. GDP_{jt} is importer domestic product, $GDPSA_{it}$ is South Africa's GDP, Pop_{jt} is importer population, $PopSA_{it}$ is South Africa's population. oil_t is the crude oil price (US $/barrel). Z_{ij} are sets of time-invariant factors that promote or discourage trade in Equation 2.

The error term, ε_{jt}, is decomposed as a one-way error component model i.e. $\varepsilon_{jt} = \mu_j + \nu_{ijt}$. Where μ_j are the country-specific effects while ν_{ijt} is a white noise residual. The country-specific effects (μ_j) are time-invariant characteristics of the different countries. These include all the factors that are unique to each country but not included in the gravity model.

However, the model in Equation 3 is based on the assumption that at any time period, exporters exchange the products and that an exact zero trade balance between countries exist. However, countries generally have either a trade deficit or surplus because the equilibrium exports are never achieved instantaneously at time period t. For instance, exporters in South Africa have to bear sunk costs to set up distribution and service networks in the partner countries, which generates inertia in bilateral trade flows. Additionally, trade relationship between countries are affected are affected by past investments in exported-facilitating infrastructure, accumulation of invisible assets such political, cultural and geographical factors characterising the area. This implies that if South Africa exported products to particular countries at time $t-1$, it will normally tend to keep doing so at time t.

Despite the importance of this inertia effect, quite few studies based on panel estimation of gravity equations have introduced dynamism (e.g. De Grauwe and Skudelny, 2000).

The "persistence effects" can be incorporated in a dynamic choice problem. Thus the assumption of zero trade balance is relaxed by adapting a partial adjustment mechanism so that exports have the form;

$$\left(\ln X_{ijt} - \ln X_{ijt-1}\right) = \delta\left(\ln X_{ijt}^{*} - \ln X_{ijt-1}\right) + \psi_{ijt} \qquad (4)$$

Inserting this in Equation 3 and rearranging generates;

$$\ln X_{ijt} = \delta C_0 + (1-\delta)\ln X_{ijt-1} + \delta\beta_1 \ln EX_{jt} + \delta\beta_2 \ln GDP_{jt} + \delta\beta_3 \ln GDPSA_{it} + \delta\beta_4 \ln Pop_{jt} + \delta\beta_5 \ln PopSA_t + \delta\beta_6 \ln oil_t + \delta\beta_7 Z_{ij} + \varepsilon^*_{ijt} \quad (5)$$

This can be re-written as;

$$\ln X_{ijt} = C_0^* + \delta^* \ln X_{ijt-1} + \beta_1^* \ln EX_{jt} + \beta_2^* \ln GDP_{jt} + \beta_3^* \ln GDPSA_{it} + \beta_4^* \ln Pop_{jt} + \beta_5^* \ln PopSA_t + \beta_6^* \ln oil_t + \beta_7^* Z_{ij} + \varepsilon^*_{ijt} \quad (6)$$

This is a partial adjustment gravity model. In this model, the variables with asterisks in Equation 6 represent the short-run effects while the $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ and β_7 in Equation 5 represent the long-run effects. The coefficient δ represents the speed of adjustment ($0 < |\delta| < 1$) and should be equal to 1 for full adjustment in a one-time period.

3 Estimation Strategy

There are two critical issues in the estimation process. First, the presence of lagged dependent variable among the regressors leads to biased and inconsistent estimates (Nickell, 1981). As far as the gravity model is concerned, use of first difference GMM estimators attributed to Arrellano and Bond (1991) and orthogonal forward deviation transformation of Arrellano and Bover (1995) removes fixed effects and time-invariant regressors in Equation 2. These regressors are of interest for policy purposes. Consequently, the study adopts a two-stage least squares (2SLS) model as used in Baltagi and Levin (1986, 1992).

Second, trying to simultaneously estimate country-specific effects and time-invariant regressors leads to perfect multicollinearity. In line with Cheng and Wall (2005), the gravity equation is estimated in two steps. In the first stage, Equation 6 is estimated without time-invariant regressors. A fixed effects model (FEM) is used since interest is on estimating trade flows between *ex ante* predetermined selection of nations. In the second step, the estimated fixed effects are regressed on the variables in Equation 2;

$$\hat{\mu}_{ij} = \alpha_0 + \alpha_1 Dis_j + \alpha_2 Lang_j + \alpha_3 EU_j + \alpha_4 AFR_j + \alpha_5 NAFTA_j + \alpha_6 MERC_j \\ \alpha_7 Asia + \alpha_8 Midest + u_i \qquad (7)$$

Where $\hat{\mu}_{ij}$ are the estimated country-specific effects from Equation 6. The rest of the variables are as given in Equation 2.

4. Nonstationarity Issues

The estimation commences with univariate exploratory data analysis of the variables. This entails descriptive analyses[3] and panel unit root tests. Panel unit root tests are classified into two groups. The first class of tests assumes that the autoregressive parameters are common across countries. The Levin, Lin, and Chu (2002) hereafter LLC, and Hadri (2000) tests all employ this assumption. The first test employs a null hypothesis of a unit root while the Hadri test uses a null of no unit root.

The second class of tests allows the autoregressive parameters to vary across countries. The Im, Pesaran, and Shin (2003) hereafter IPS, allow for individual unit root processes. These tests are constructed by combining individual unit root tests to derive a panel-specific result.

[3] These statistics are not presented to minimise on the size of the paper.

The unit root tests results are presented in Table 3 (in the appendix). The study uses rejection of unit root by at least one test to return a verdict of stationarity. On the basis of this, panel unit root is rejected at 5 percent level. Consequently panel cointegration is not pursued.

5. Estimation results

Table 1 presents the estimation results for different models over the period 1994 to 2003. The first estimation results are those from a static pooled panel data model, which includes all the variables in Equation 3. This model suffers from two major pitfalls. First, it does not allow for heterogeneity of countries i.e. no country-specific effects are estimated. Second, the model does not take into consideration the "persistence effects" in trade flows. In other words, it assumes that if there is a trade potential South African exporters take advantage of this opportunity within one year. Indeed, the existence of the "persistence effects are evident from the low Durbin-Watson statistic

The second model is the static fixed effects model, which introduces heterogeneity by estimating country-specific effects (not presented in Table 1). However, the model still suffers from "persistence effects" as evident from low Durbin-Watson statistic. The Hausman specification test shows that the fixed effects are correlated with the remainder error term implying that the fixed effects model (FEM) employed is appropriate.

The final model is the dynamic FEM estimated using 2SLS. This model allows for heterogeneity among the countries as well as exporters' inertia in response to export opportunities. The appropriateness of the model with regard to "persistence effects" is evident from the high Durbin-Watson statistic. The Hausman specification test, however, shows that the country-specific fixed effects are not correlated with the remainder error term. This implies that the appropriate model is one with random effects. However, for trade policy purposes, FEM model is preferred to random effects model.

There are two parameter estimates for the 2SLS dynamic fixed effects model (long-run and short-run). The speed of adjustment (δ in Equation 4) is 0.76, which means that if there is an export opportunity of motor vehicle, parts & accessories in any of the trading partners, exporters in South Africa are likely to adjust to meet 76 percent of the export contract within one year leaving the other 24 percent to be met the next year. In other words, it takes about 16 months for exporters to take advantage of export opportunities[4]. The null hypothesis that $\delta = 1$ or $\delta^{*} = 0$ or full adjustment of trade occurs in one year is rejected at 10 per cent level.

Generally, the long-run coefficients are slightly higher than the short-run coefficients. This makes economic sense since exporters have more time to adjust to a shock in the long-run as compared to the short-run. In the short-run, a 1 per cent increase in importer income leads to 1.21 per cent increase in South Africa's exports of motor vehicles, parts & accessories. However, in the long-run a 1 per cent increase in importer income leads to 1.59 per cent increase in exports.

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[4] $\frac{1}{0.76} \times 12 months = 15.789 months \cong 16 months$

South Africa's GDP has the expected positive and significant effect on trade both in the short-run and long-run. In the short-run, a 1 per cent increase in South Africa's GDP leads to 2.65 per cent increase in South Africa's exports of motor vehicles, parts & accessories. However, in the long-run the response rises significantly to 3.49 per cent.

The importer population has a negative and significant effect on exports. This can be rationalised by the fact that a large population may indicate a large resource endowments, self-sufficiency and less reliance on South African motor vehicles, parts & accessories.

The oil price has a negative but insignificant effect on exports. This means that high crude oil prices may not have a serious effect on South Africa's exports of motor vehicle, parts & accessories. The exchange rate has a significant positive effect on exports. Thus a depreciation of the rand against the US dollar by 1 per cent leads to a 3.64 per cent rise in exports of motor vehicles, parts & accessories in the short-run. In the long-run the response increases substantially to 4.79 per cent.

The estimates for country-specific effects are presented in Table 4. The country-specific effects are all the factors that are unique to each country but not included in the gravity model. In other words, the country-specific effects highlight the fact that the bilateral trade in motor vehicle, parts & accessories between South Africa and its trading partners differs from country to country i.e. each country is unique.

On one hand the results show that there are unique characteristics in some countries that enhance South Africa’s exports of motor vehicle, parts & accessories to Angola, Australia, Argentina, D.R Congo, Ghana, Kenya, Madagascar, Malawi, Mozambique, etc. On the other hand, there are unobservable country characteristics that tend to inhibit South Africa’s exports of motor vehicles, parts & accessories to Austria, Chile, Czech republic, Finland, Peru, Poland, Saudi Arabia etc.

The second stage regression tries to determine some of the factors that may explain the fixed effects in Table 4. For instance what are the factors that contribute to the negative country-specific effects in Greece but positive country-specific effects in Kenya? Table 2 reports the results and it is evident from the high adjusted R^2 that the variables included in the regression model are the main determinants of the country-specific effects.

First, the distance has a positive sign contrary to expectation. The coefficient is however, quite small. Second, contrary to expectation, South Africa tends to export more of motor vehicles, parts & accessories to non-English speaking countries. Third, membership to EU, Africa, NAFTA, Asia, Middle East and MERCOSUR tends to enhance South Africa’s exports.

From a policy perspective, it is imperative to conduct a survey on motor vehicle exporters to determine the other factors that may be hampering trade to the countries that have negative country-specific effects (shaded cells in Table 4).

Table 1: Estimation for motor vehicles, parts & accessories (SIC 381-383)

	Static pooled panel data model		*Static fixed-effects model*		*2SLS Dynamic fixed effects model*		
Variables	**Estimate**	**t-value**	**Estimate**	**t-value**	**LR Estimate**	**SR Estimate**	**t-value**
Intercept	-117.56	-1.33	-142.54	-2.87	261.16*	198.48*	1.65
Exports(-1)					0.76*	0.24*	1.75
Importer GDP	1.38***	26.46	0.83***	4.31	1.59***	1.21***	2.95
South Africa GDP	0.98	0.79	0.20	0.28	3.49**	2.65**	2.01
Importer population	-0.58***	-13.43	-0.71	-0.79	-6.24***	-4.74***	-3.74
Population for South Africa	4.87	0.72	8.20**	2.18	-15.86	-12.05	-1.37
Crude oil prices (US/barrel)	-0.47*	-1.82	-0.29**	-2.07	-0.58	-0.44	-1.44
Exchange rate (rand/US $)	0.48	0.34	-0.24	-0.31	4.79**	3.64**	2.00
Distance	-0.001***	-16.24					
English language	1.06***	9.22					
African continent	1.53***	7.68					
NAFTA member state	2.36***	7.74					
EU member state	0.51***	2.79					
Asian member state	1.56***	7.84					
Middle East member state	-1.10***	-4.35					
MERCOSUR member state	0.61**	3.15					
Adjusted R-Squared	0.976		0.9948		0.9943		
Durbin-Watson	0.6721		1.44465		2.1614		
Hausman test	2.8264(0.8303)		0.0000(1.000)		36.4119(0.000)		

Notes: (i) Country-specific effects from the third model are reported in Tables 4 and 5 (ii) ***, ** and * refer to significance at 1%, 5% and 10% respectively (iii) The speed of adjustment under 2SLS estimator is $1-\delta = 1-0.24 = 0.76$. The long-run coefficients are computed by dividing the short-run coefficient by 0.76 (iv) Estimation done with cross-section weights

Table 2: Second stage regression of FE on dummies Motor vehicles, parts & accessories (SIC 381-383)

Variable	Coefficient	t-value
Intercept	-7.56***	-32.49
Distance (KM)	3.08e-04***	15.81
English language dummy	0.77***	-8.73
EU member state dummy	3.69***	19.18
African member state dummy	8.71***	42.88
NAFTA member state dummy	8.69***	29.36
MERCOSUR member state dummy	6.76***	17.88
Asia dummy	10.39***	66.62
$\overline{R}^2$	0.9682	

Notes: (i) *** refer to significance at 1%

(ii) Estimation done with cross-section weights

(iii) Durbin-Watson statistic cannot be computed since the variables are time invariant

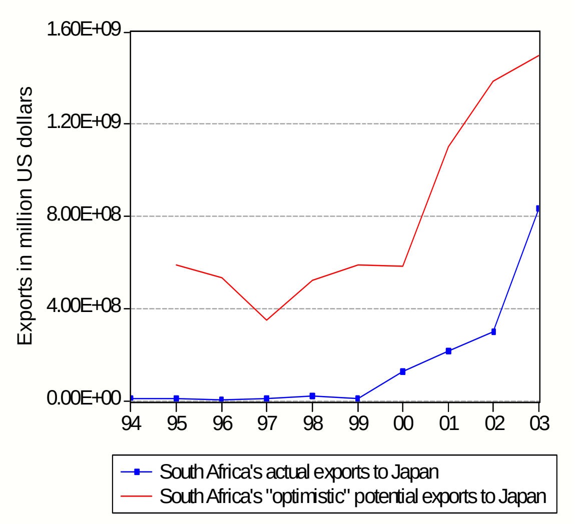
6. "Optimistic", "Pessimistic" and "Average" Potential Exports

The estimated model in Equation 6 is solved stochastically to determine *within-sample* "pessimistic", "optimistic" and "average" potential exports of motor vehicles, parts & accessories. The potential exports are then compared with actual exports to see if there is unexploited trade potential. A number of stylised facts emerge from Figure 1 on the results for Japan[5]. Figure 1(a) shows that South Africa's actual exports to Japan are well below the "optimistic" potential exports. On the contrary, Figure 1(b) shows that South Africa's exports of motor vehicles, parts & accessories to Japan were more than the "pessimistic" potential exports.

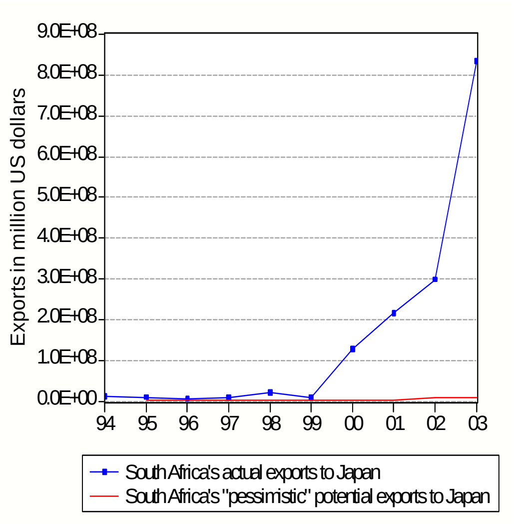
[5] The results for all the other 75 countries are available from the authors' on request.

Figure 1: Comparison of South Africa's Actual Exports with "Optimistic", "Pessimistic" and "Average" Potential Exports to Japan

(a) South Africa's Actual Exports Vs "Optimistic" Potential Exports to Japan



(b) South Africa's Actual Exports Vs "Pessimistic" Potential Exports to Japan



(c) South Africa's Actual Exports Vs "Average" Potential Exports to Japan

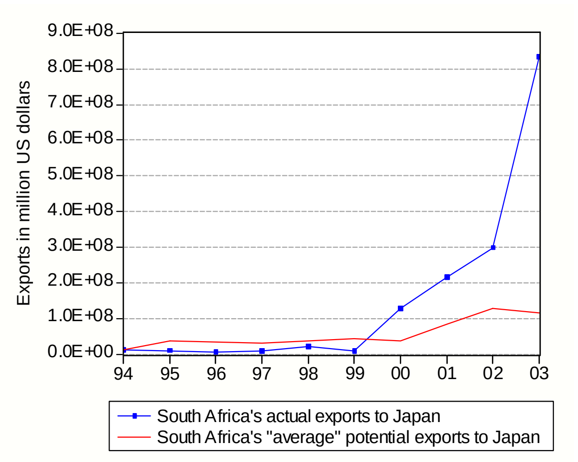


Figure 1 (c) shows that South Africa's actual exports to Japan was below the "average" potential exports before 1999 i.e. there was unexploited trade potential. Thereafter, this trade potential has been exhausted.

The study shows existence of unexploited trade in Portugal, Mozambique, Zambia and Zimbabwe, among others, especially from 1999.

7. Variability of "Average" Potential Trade

Stability of export flows in motor vehicles, parts & accessories is important for South Africa since it provides reliability in terms of jobs, tax revenue etc. The study uses coefficient of variation (CV) computed from the stochastically solved model. The percentage CV is computed as follows;

$$\%CV = 100 * \left(\frac{Standard \quad deviation}{Mean} \right) \tag{8}$$

The percentage CV is sorted to determine South Africa's export destinations that are stable (low CV) and those that are very unstable.

Figure 2: % CV of South Africa's 12 Most Reliable Trading Partners for Motor Vehicle, Parts & Accessories

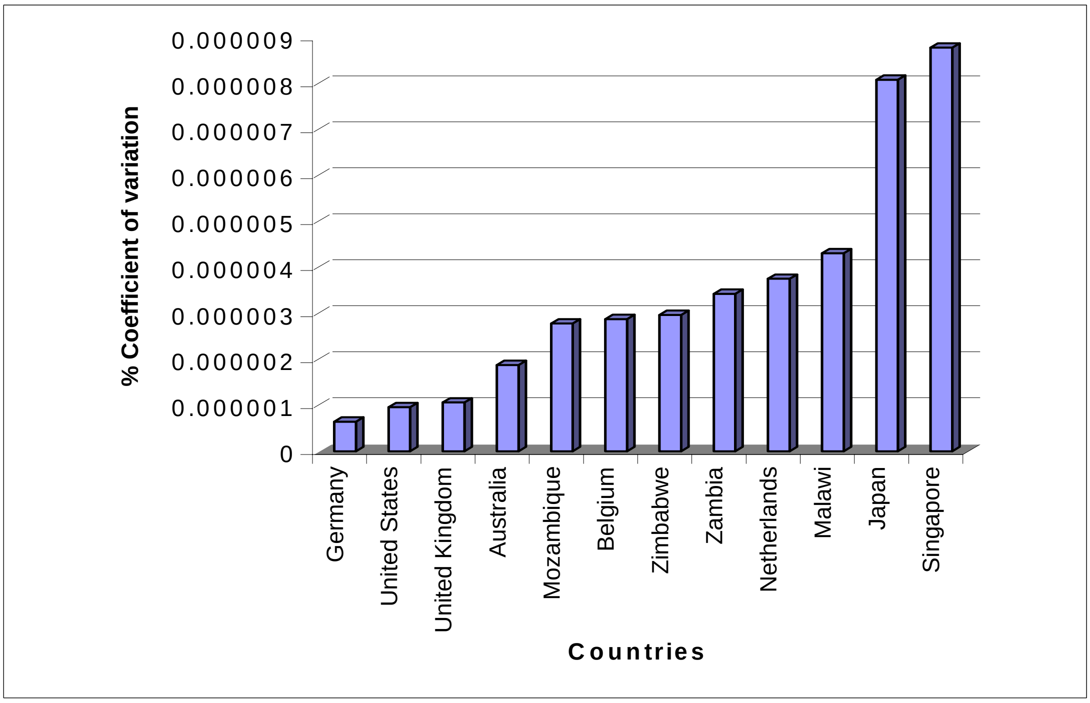
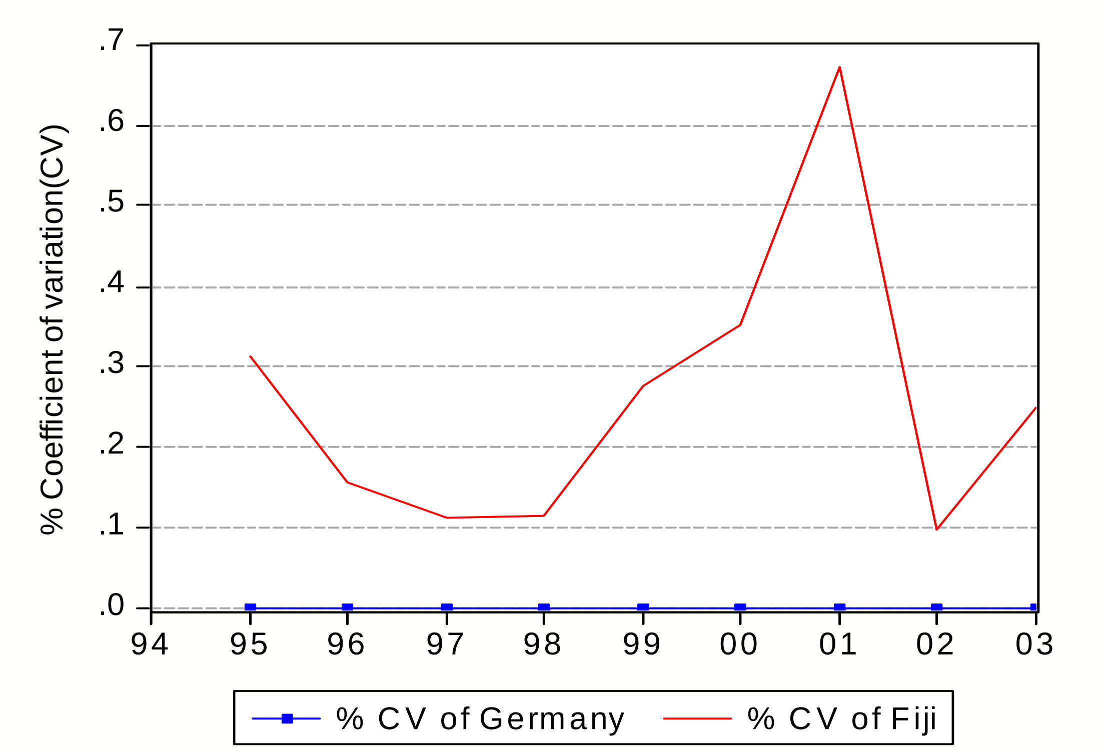


Figure 2 shows South Africa's 12 most reliable export destination of motor vehicles, accessories & parts. The CV for Fiji, Poland, Pakistan and Sao Tome and Principe are quite high implying that they are among the most unreliable trading partners.

Figure 3 shows the evolution of the percentage CV for Germany (the lowest CV) and Fiji (the highest CV). This means that proactive export promotion policies need to be pursued with a view to improving predictability of trade to countries like Fiji.

Figure 3: The Evolution of "Average" Potential Export Variability for Germany and Fiji



8. Conclusion

This study employs an "augmented" gravity model to South Africa's annual bilateral exports of motor vehicles, parts & accessories (SIC 381-383) to 76 of its trading partners over the period 1994 to 2003. A dynamic panel data model is utilised to estimate speed of adjustment, long-run and short-run coefficients.

First, the study finds that there is less than full adjustment in South Africa's exports of motor vehicles, parts & accessories. Specifically, is shown that it takes about 16 months for exporters to fully adjust. Second, South Africa's income and importer income have the expected positive influence on bilateral trade flows both in the short-run and long-run. Third, trading partner population has a negative effect implying that South Africa exports less to larger self-sufficient countries. Fourth, a depreciation of the rand stimulates exports. Fifth, South Africa tends to export less to English speaking countries. Finally, membership to EU, Africa, NAFTA, Asia, Middle East MERCOSUR (South America) promotes exports of motor vehicles, parts & accessories.

In line with Sattinger (1978), the study solves the baseline gravity model stochastically to determine "optimistic", "pessimistic" and "average" potential exports. This makes much sense in the uncertain exports market. On the basis of this, South Africa's actual exports are well below the "optimistic" potential exports but above the "pessimistic" potential exports. In terms of the "average" potential exports, there are countries where there is unexploited trade potential e.g. Portugal, Mozambique, Zambia and Zimbabwe. The study also determines the degree of variability of the "average" potential trade. On the basis of this, it is shown that Germany, the United States and the United Kingdom, among others, have low trade variability.

The gravity model used in the study can be used for policy analysis and out-of-sample forecast to determine “optimistic”, “pessimistic” and “average” exports.

References

Arrellano, M. and Bond, S. (1991), “Some Tests of Specification of Panel Data: Monte Carlo Evidence and Application to Employment Equations”, *Review of Economic Studies*, 58, 277-297.

Arrellano, M. and Bover, O. (1991), “Another Look at the Instrumental Variable Estimation of Error-Components Models, *Journal of Econometrics*, 68, 29-51.

Baltagi B.H. and Levin, D. (1986), “Estimating Dynamic Demand for Cigarettes Using Panel Data: The Effects of Bootlegging, Taxation and Advertising Reconsidered”, *The Review of Economics and Statistics*, 68(1), 148-155.

Baltagi B.H. and Levin, D. (1992), “Cigarette Taxation: Raising Revenues and Reducing Consumption”, *Structural Change and Economic Dynamics*, 3(2), 321-355.

Bergstrand, J.H. (1985), “The Gavity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence”. *The Review of Economics and Statistics*, 67, 474-481.

Bergstrand, J.H. (1989), “The Generalised Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade”. *The Review of Economics and Statistics*, 71(1), 143-153.

Brülhart M. and Kelly, M.J. (1999), “ Ireland’s Trading Potential With Central and Eastern European Countries: Agravity Study”, *Economic and Social Review*, 30(2), 159-174.

Jean-François Brun J.F et al. (2005), “ Has Distance Died? Evidence from a Panel Gravity Model”, World Bank Economic Review, Online, http://wber.oxfordjournals.org/cgi/content/short/lhi004v1 (Date accessed: 2005/10/31).

Cheng, H.I. and Wall, H.J. (2005), “Controlling for Heterogeneity in Gravity Models of Trade”. *Federal Reserve Bank of St. Louis Review*, 87(1), 49-63.

De Grauwe P. and Skudelny, F.(2000), “The Impact of EMU on Trade Flows”, *Weltwirtshaftliches Archiv*, 136, 381-402.

Hadri, K. (2000), “Testing for Stationarity in Heterogeneous Panel Data”. *Econometric Journal*, 3(2),148-161.

Im, K.S., Pesaran, M.H. and Shin, Y. (2003). Testing for Unit Roots in Heterogeneous Panels”. *Journal of Econometrics*, 115:53-74.

International Trade Centre (2003), “TradeSim: A gravity Model for the Calculation of Trade Potentials for Developing Countries and Economies in Transition”, *Technical Report*, UNCTAD-WTO.

Levin, A., Lin, C. F. and Chu, C. (2002), “Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties”. *Journal of Econometrics*, 108:1-24.

Nickell, S. (1981), “Biases in Dynamic Models with Fixed Effects”, *Econometrica*, 49, 1417-1426.

Nilsson, L. (2000), “ Trade Integration and the EU Economic Membership Criteria”, *European Journal of Political Economy*, 16, 807-827.

Oguledo, V.I. and Macphee, C.R. (1994), “Gravity Models: A Reformulation and Application to Discriminatory Trade Arrangements”. *Applied Economics*, 26, 107-120.

Pöyhönen, P. (1963), “A Tentative Model for the Volume of Trade Between Countries”, *Weltwirtschaftliches Archiv*, 90, 93-99.

Sattinger, M.(1978), “Trade Flows and Differences Between Countries”, *Atlantic Economic Journal*, 6, 20-22.

Tinbergen, J. (1962). *Shaping the World Economy: Suggestions for an International Economic Policy,* Twentieth Century Fund, New York.

APPENDICES

Data Sources

Exports data are collected from Quantec research (http://ts.easydata.co.za), distance data are collected from http://www.indo.com/distance/. GDP, population, oil and exchange rate are collected from IFS.

Table 3: Summary of Panel Unit Root Tests

	Null: Unit root (Homogeneous)	**Null: Unit root (heterogeneous)**	**Null: No Unit Root (Homogenous)**
Variable	*LLC t-stat*	*IPS w-stat*	*Hadri*
$X29_t$	-23.935*** (0.000)	-4.180*** (0.000)	19.313*** (0.000)
GDP_{jt}	-12.933*** (0.000)	0.279 (0.610)	15.349*** (0.000)
$GDPSA_{it}$	15.678 (1.000)	-0.871 (0.192)	42.507*** (0.000)
POP_{jt}	-6.151*** (0.000)	1.059 (0.855)	17.349*** (0.000)
$POPSA_{it}$	18.883 (1.000)	-2.779*** (0.003)	27.710*** (0.000)
XR_{jt}	8.152 (1.000)	-3.583*** (0.000)	90.407*** (0.000)
Oil_t	-21.717*** (0.000)	-1.368* (0.086)	90.407*** (0.000)

Notes:

(i) *, ** and *** denote rejection of null at 10%, 5% and 1% significance levels, respectively.
(ii) Sample: 76 cross-sections, period 1994-2003
(iii) Exogenous variables include individual effects, individual linear trends.

Table 4: Fixed Effects for Motor Vehicle, Parts and Accessories

Country	Fixed effects	Country	Fixed effects
1 Angola	1.7745	39 Kuwait	3.8430
2 Argentina	1.6560	40 Malaysia	1.5466
3 Australia	1.3467	41 Mali	0.5354
4 Austria	-6.3314	42 Malta	-17.4412
5 Belgium	-1.6881	43 Mauritius	-8.5536
6 Brazil	9.1728	44 Mexico	5.6086
7 Burundi	-1.7775	45 Morocco	1.5936
8 Cameroon	1.5431	46 Mozambique	6.0263
9 Canada	0.2141	47 Netherlands	-0.3772
10 Chile	-1.9571	48 New Zealand	-6.0215
11 China	18.2391	49 Nigeria	10.2455
12 Colombia	2.4548	50 Pakistan	6.5958
13 Comoros	-13.3240	51 Peru	-1.5832
14 Congo	-4.9521	52 Philippines	4.6818
15 Côte d'Ivoire	0.8980	53 Poland	-0.3868
16 Cyprus	-14.1982	54 Portugal	-3.3597
17 Czech Republic	-4.3857	55 Republic of Korea	3.1947
18 Democratic Republic of the Congo	8.2299	56 Russian Federation	5.6813
19 Denmark	-7.7527	57 Rwanda	-1.7012
20 Egypt	5.0084	58 Sao Tome and Principe	-17.3551
21 Ethiopia	6.4546	59 Saudi Arabia	-1.6678
22 Fiji	-15.0020	60 Seychelles	-20.3623
23 Finland	-8.7871	61 Sierra Leone	-2.6591
24 France	3.3355	62 Singapore	-5.4817
25 Gabon	-9.4563	63 Spain	2.8252
26 Germany	7.0116	64 Sri Lanka	1.1626
27 Ghana	4.0775	65 Sweden	-4.2596
28 Greece	-3.3136	66 Switzerland	-7.2922
29 Hong Kong Special Administrative Region of China	-4.6507	67 Thailand	5.7092
30 India	17.8394	68 Turkey	4.5143
31 Indonesia	9.5366	69 United Arab Emirates	-7.8134
32 Iran (Islamic Republic of)	3.7576	70 Uganda	4.4890
33 Ireland	-8.4791	71 United Kingdom	5.4615
34 Israel	-5.7920	72 United Republic of Tanzania	6.5776
35 Italy	3.5199	73 United States	10.6829
36 Japan	6.9817	74 Venezuela	-1.0570
37 Kenya	6.0961	75 Zambia	3.0552
38 Madagascar	2.5144	76 Zimbabwe	3.5277

Notes: Shaded cells refer to negative country-specific fixed effects