An Augmented Gravity Model of South Africa's Exports of Transport Equipments and Machineries

Moses Sichei[1]

Jean Luc Erero[2]

Tedros Gebreselassie[3]

Paper Prepared for the Biennial Conference of the Economic Society of South Africa at the Durban, Kwazulu Natal, 7th –9th September 2005

Abstract

The study applies an "augmented" gravity equation to exports of transport equipment (SIC29 and SIC30) to a number of countries. The study uses a methodology applied in Cheng and Wall (2005), which entails two-stages. In the first stage a fixed effects panel data model is estimated. The estimated fixed effects are then regressed on a set of variables that are constant over the sample period (1994-2003) such as distance, language etc. The study utilises moving block bootstrap to check the validity of first-order asymptotic theory results. Using exports data for 77 countries (SIC 29) and 54 countries (SIC30), the study finds that, a number of variables, namely, importer income, population, exchange rate, distance, English language and are important determinants of bilateral trade flows. The estimated model is useful for forecasting (potential trade) trade flows and policy simulations.

JEL Codes: E33, E52

Key words: Gravity equation, panel data, block bootstrap transport equipment,

[1] and [3] are lecturer and postgraduate student, respectively, Department of Economics, University of Pretoria

[2] The Director of Statistical Analysis and Modelling, the Department of Trade and Industry (DTI), South Africa

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 and 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. Gauteng is home to BMW, Nissan, Fiat, and Ford (assembly of Mazda, Volvo and Land Rover). Toyota is located in KwaZulu Natal while Volkswagen SA, Daimler Chrysler SA, and Delta Motor (to be changed to General Motors) Corporation are located in the Eastern Cape.

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 can be used 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 decreasing with the cost of transportation between them, proxied by the distance between their economic centres. The gravity model of trade has been used for policy simulation including regional trading groups, currency unions, political blocs etc.

The standard approach is to model these events and policies as deviations from the volume of trade predicted by a baseline gravity model. This means that the critical policy issues in the transport sector in South Africa can be analysed using the gravity model. In this context, the gravity can predict the trade flows (within-sample) given certain conditions and provide policy simulations, which can be useful for MIDC's and DTI's transport export promotion strategies.

2. Theoretical foundations of the gravity equation

The gravity model, with foundations in the physical sciences, has consistently proved to be a useful tool for the analysis of bilateral trade flows. Isaac Newton originally devised the model to explain gravitational force in the universe, theorising that the gravitational pull between two celestial bodies is positively related to the product of their masses and inversely related to their distance apart. Similarly, in its simplest form, the gravity model as applied to trade, predicts that the amount of trade between two economies will be positively related to the product of their outputs (a measure of size or mass), and negatively related to the distance between them.

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 theoretical, albeit plausible, empirical models.

Despite the widespread empirical and policy use, the theoretical foundation has been controversial. Many theories have been developed to support the gravity model. Table 1 in Oguledo and Macphee (1994:108-110) present the results from different gravity models.

The first theoretical justification for the gravity model emanates from gravitational forces in physics. Newton's law states that all objects attract each other with a force of gravitational attraction. This force of gravitational attraction is directly dependent upon the masses of both objects and inversely proportional to the square of the distance, which separates their centres. This law can be stated symbolically as;

$$F_{grav} = \frac{G * M_1 * M_2}{d^2} \qquad (1)$$

Where F_{grav} represents the force of gravity between two objects and G represents universal gravitational constant. M_1 and M_2 represent the mass of object 1 and 2 respectively while d represents the distance separating the two objects' centres.

According to this approach, the flow of goods from one country (object 1) to another (object 2) equals the product of the potential trade capacities of the two countries divided by a resistance or distance factor. Isard and Peck (1954) and Beckerman (1956) used this framework and found that distance played a significant role in trade flows.

The second approach has its roots in the Walrasian general equilibrium model. In this model, each country has its own supply and demand functions for all goods but aggregate income is proxied by importing country demand and exporting country supply. Using this approach, the gravity model is a reduced-form equation for trade volume in which prices do not appear because they are endogenous. Transport costs are proxied by geographic distance, which in line with Newton's law, drive a wedge between demand and supply. This approach was used by, among others, Tinbergen (1962), Pöyhönen, (1963). They found that incomes of the trading partners and the distances between them are statistically significant and have the expected positive and negative signs respectively. Other studies such as Bergstrand (1985, 1989) include size.

The third explanation for the gravity equation is based on the probability model. This model assumes that customers are assigned to suppliers in a random manner. Sattinger (1978) predicts trade flows between countries, where trade flows are treated as stochastic events.

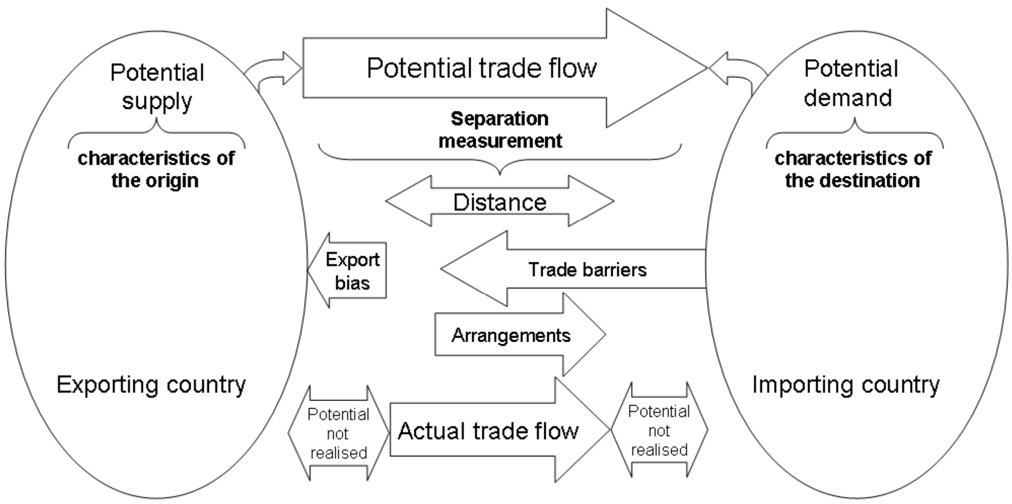
The fourth approach is based on micro-foundations and postulates that the assumption of perfect product substitutability of the standard gravity model is flawed since empirical evidence support product differentiation on the basis of place of origin. Consequently excluding price variables results to misspecification of the gravity equation (Oguledo and MacPhee, 1994: 112). This means that price variables should be included. Oguledo and MacPhee (1994) develop the following fully blown gravity model;

$$M_{ij} = \frac{\gamma}{K} Y_i^{\alpha_1} N_i^{\alpha_2} P_i^{\alpha_3} Y_j^{\beta_1} N_j^{\beta_2} P_j^{\beta_3} TC_{ij}^{\varepsilon_1} t_j^{\varepsilon_2} d_{ij}^{\varepsilon_3} U_{ij} \qquad (2)$$

Where M_{ij} is the foreign price value (e.g. US dollars) of imports of goods by country *i* from country j, Y_i and Y_j are the importer and exporter income respectively, N_i and N_j are importer and exporter population respectively, P_i and P_j are the price levels respectively, TC_{ij} is the distance between the trading partners, d_{ij} are the preferential dummy variables and U_{ij} is a log-normal white noise error term.

Figure 1 provides a graphical representation of the gravity equation. It shows that potential supply and demand are determined by the sizes of the economies and these predict the potential trade flows between the countries. This flow is subject to certain trade resistance factors that are mitigated by trade arrangements.

Figure 1: The gravity model



2.4 Model specification

The study follows the approach of Oguledo and MacPhee (1994) and Cheng and Wall (2005) and specifies a generalised gravity panel model as follows;

$$\ln X_{ijt} = C_0 + \beta_1 \ln EX_{jt} + \beta_2 \ln GDP_{jt} + \beta_3 \ln GDPSA_{it} + \beta_4 \ln Pop_{jt} + \beta_5 \ln PopSA_t + \beta_6 \ln oil + \varepsilon_{ijt} \qquad (3)$$

Where X_{ijt} refers to South Africa's exports to country j, EX_{jt} is exchange rate between South Africa and country j (Rand/foreign currency). 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.

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.

2.5 Estimation and statistical inference methodology

2.5.1 Estimation

In line with Cheng and Wall (2005), the gravity equation is estimated in two steps. In the first stage, equation 3 is estimated for two transport sectors (motor vehicles, parts & Accessories and other transport). 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 distance, dummies for language, FTA agreements etc (Equation 4);

$$\hat{\mu}_{ij} = \alpha_0 + \alpha_1 Dis_j + \alpha_2 Lang_j + \alpha_3 EU_j + \alpha_4 AFR_j + \alpha_5 NAFTA_j + \alpha_6 MERC_j + u_i \quad (4)$$

Where $\hat{\mu}_{ij}$ are the estimated country-specific effects from Equation 3, Dis_j is the distance in KM between Pretoria and trading partner capital city, $Lang_j$ is English language dummy. Trading partners, whose official language is English are coded 1 and 0 otherwise. EU_j is European Union dummy (EU members coded 1 and 0 otherwise), AFR_j is African dummy (African countries coded 1 and 0 otherwise), $NAFTA_j$ is North Atlantic Free Trade Agreement dummy (NAFTA members coded 1 and 0 otherwise), $MERC_j$ is MERCOSUR FTA dummy (MERCOSUR members coded 1 and 0 otherwise).

The second step is predicated on the fact that in a fixed effects model, it is not possible to directly estimate variables that do not change over time because the inherent WITHIN estimation transformation (demeaning variables) wipes out such variables. Additionally, using the least squares dummy variable (LSDV) method, the variables will be perfectly collinear with dummy variables used in the fixed effects.

2.5.1 Statistical inference using moving block bootstrap

Bootstrap methodology, introduced by Efron (1979), is used because it provides a more reliable estimator of the true Type I critical values than the approximation of first-order asymptotic theory (Horowitz and Savin, 2000, Horowitz, 2001). According to Mooney and Duval (1993: 1), bootstrapping uses the analogy between the sample and the population from which the sample was drawn.

The bootstrap allows inferences to be made without making strong distributional assumptions about the statistics. Instead of imposing a shape on $\hat{\beta}$'s sampling distribution by assumption, bootstrapping entails empirically estimating its entire sampling distribution (i.e. the empirical distribution function) by examining the variation of the statistic in the bootstrap sample.

Bootstrap tests cannot be relied upon if there is serial correlation in the residuals. If the bootstrap is to work well, we need to generate bootstrap error terms that display the same sort of serial correlation as the real ones. This is done by block bootstrap. We use the moving block bootstrap (MBB), presented by, Künsch (1989) and Politis and Romano (1994), and Mackinnon (2002). The procedure entails the following. First, a block b length is selected ($b < n$). Second, n blocks of b residuals are formed, which overlap. Third, bootstrap errors are generated by resampling the blocks with replacement. Fourth, a response variable (bootstrapped exports) is constructed by adding the residuals on the fitted values. Fifth, the bootstrap response function is regressed on the regressors in equation 3 and estimated coefficients stored. The process from step one to step five is repeated 3000 times. Sixth, percentile method is used to construct confidence intervals.

3. The data

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.

4. Panel unit roots

The test for panel unit roots can be classified into two groups. The first class of tests assumes that the autoregressive parameters are common across countries. The Levin, Lin, and Chu (2002), Breitung (2000), and Hadri (2000) tests all employ this assumption. The first two tests employ 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. The Im, Pesaran, and Shin (1995,2003), and the Fisher-ADF and PP tests (Maddala and Wu (1999) and Choi (2001) all allow for individual unit root processes. The tests are all constructed by combining individual unit root tests to derive a panel-specific result.

The unit root tests results are presented in Tables 7 and 8. All the variables except South Africa's GDP are stationary. Consequently, this variable is excluded in the subsequent regressions.

5. Estimation results

5.1 Motor vehicles, parts & accessories (SIC 29)

Table 1 reports estimation results for the first-order asymptotic theory and block bootstrap. The first-order asymptotic theory results are straightforward but the bootstrap results need some clarification. A variable is significant if zero is not contained in the confidence intervals. The last column is standardised bias computed as follows;

$$Bias = \frac{\left(\hat{\beta} - \hat{\beta}^{*}\right)}{S_{\hat{\beta}^{*}}} \qquad (5)$$

Where $\hat{\beta}$ is the first-order asymptotic theory estimate, $\hat{\beta}^{*}$ is the bootstrap coefficient and $S_{\hat{\beta}^{*}}$ is the bootstrap standard error. If the standard deviation is much greater than the bias, the latter can be disregarded since the random error will overwhelm it. Efron (1982:8) suggests that when the ratio of the estimated bias to the standard error is less than 0.25, the bias of $\hat{\beta}$ is not a serious problem. The results show that exchange rate coefficient is biased. Mooney and Duval (1993:33) warn against subtracting the bootstrap estimate of the bias from the sample $\hat{\beta}$ in an attempt to achieve an unbiased estimate of β.

The model explains a significant variation in South Africa's exports of motor vehicles, parts and accessories as shown by the high adjusted R^2. The Durbin-Watson statistic shows presence serial correlation problem in the model and this motivates the use of block bootstrap. Although the Hausman test suggests a random effects model (REM), FEM model is preferred since it provides useful policy information. The redundant fixed effects test shows that the country-specific effects are important. The empirical distribution functions (EDF) in Figure 2 show that in all variables asymptotic normality assumption is not valid. Consequently, our analysis relies on the block bootstrap results.

The importer income is significantly positive as expected positive sign. This means that a rise in income, given a relatively high marginal propensity to import, will lead to an increase in imports (Ceteris Paribus). Income elasticities are close to unity as predicted by theory.

The importer population is negative but not significant. South Africa's population has a significant positive effect on transport exports. This means that the large population implies large domestic market, which creates opportunities for exports of differentiated transport equipment.

The oil price has a negative but insignificant effect on exports. The exchange rate has a significant positive effect on exports. This implies that a depreciation of the rand against foreign currencies by 1 per cent leads to a 0.05 per cent rise in exports of manufactured transport.

The estimates for country-specific effects from first-order asymptotic theory block bootstrap are presented in the appendix (Table 4 and 5). The last column shows that the fixed effects coefficients for Cameroon, Côte d'Ivore, Mali and Saudi Arabia are biased (shaded). The country-specific effects are all the factors that are unique to each country but not included in the gravity model. On one hand the results show that there are unobservable unique characteristics of each country that enhance South Africa's exports of motor vehicle, parts & accessories to Angola, Australia, Belgium, D.R Congo, Ghana, Kenya, Madagascar, Malawi, Mozambique, Netherlands, Uganda, Tanzania, Zambia and Zimbabwe. 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, Oman, Peru, Poland, Saudi Arabia.

The second stage regression tries to determine some of the factors that explain the fixed effects. Table 3 reports the results in which the country-fixed effects in Tables 4 and 5 are regressed on distance, English language dummy etc. The high R^2 means that the variables included are the main determinants of the country-specific effects.

Table 1: WITHIN FEM Estimation for motor vehicles, parts & accessories (SIC 29)

	First-order asymptotic theory results			Block bootstrap results (3000 replications)				
Variables	**Estimate**	**Standard error**	**t-value**	**Estimate**	**Standard error**	**Confidence Interval (Percentile method)**	**%**	**Standardised bias**
Intercept	-106.48***	11.117	-9.58	-107.63***	27.95	[-180.07, -41.88]	99	0.04
Importer GDP	0.93***	0.179	5.17	0.94***	0.25	[0.26, 1.37]	99	-0.04
Importer population	-1.17	0.937	-1.25	-1.02	1.74	[-3.82, 1.98]	90	-0.09
Population for South Africa	6.71***	0.80	8.38	6.62***	6.62	[4.25, 9.08]	99	0.01
Crude oil prices (US/barrel)	-0.26*	0.14	-1.90	-0.26	0.28	[-0.78, 0.17]	90	0.00
Exchange rate (Foreign/Rand)	0.06**	0.03	2.01	0.05***	0.02	[0.004, 0.109]	99	0.50
Weighted diagnostic statistics								
$\bar{R}^2$	0.99533							
Durbin-Watson	1.4669							
Redundant fixed effects	1124.66(0.0000)							
Hausman test	5.7567(0.3306)							

Notes: (i) Country-specific effects are reported in Tables 4 and 5

(ii) ***, ** and * refer to significance at 1%, 5% and 10% respectively

(iii) Estimation done with cross-section weights

Table 2: WITHIN FEM Estimation for other transport (SIC 30)

	First-order asymptotic results			Block bootstrap results (3000 replications)				
Variables	**Estimate**	**Standard error**	**t-value**	**Estimate**	**Standard error**	**Confidence interval (Percentile method)**	**%**	**Standardised bias**
Intercept	-18.99	17.481	-1.09	-19.54	30.65	[-70.19, 31.03]	90	0.04
Importer GDP	1.26***	0.281	4.48	1.34***	0.296	[0.48, 2.02]	99	-0.04
Importer population	-5.08***	1.902	-2.67	-5.25***	1.121	[-7.92, -2.35]	99	-0.09
Population for South Africa	4.92***	1.581	3.11	4.99**	2.04	[0.99, 9.14]	95	0.01
Crude oil prices (US/barrel)	-0.44**	0.218	-2.00	-0.43	0.42	[-1.19, 0.25]	90	0.00
Exchange rate (Foreign/Rand)	0.09*	0.053	1.78	0.09**	0.04	[0.01, 0.16]	95	0.5
Weighted diagnostic statistics								
$\overline{R}^2$	0.9887							
Durbin-Watson	1.922							
Redundant fixed effects	29.506(0.000)							
Hausman test	19.701(0.0014)							

Notes: (i) Country-specific effects are reported in Table 6

(ii) ***, ** and * refer to significance at 1%, 5% and 10% respectively

(iii) Estimation done with cross-section weights

Table 3: Second stage regression of FE on dummies

	Motor vehicles, parts & accessories (SIC 29)		Other transport (SIC 30)	
Variable	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Intercept	-1.23***	-15.55	-6.15***	-11.96
Distance (KM)	-3.94e-05***	-3.44	0.00***	6.75
English language dummy	1.35***	17.51	2.89***	15.29
EU member state dummy	1.46***	11.97	1.11***	3.44
African member state dummy	2.42***	27.43	4.80***	2.84
NAFTA member state dummy	1.45***	9.18	5.79***	4.88
MERCOSUR member state dummy	1.09***	6.69	2.15***	6.40
Weighted diagnostic statistics				
$\overline{R}^2$	0.98027		0.862	

Notes: (i) ***, ** Refer to significance at 1% and 5% respectively

(ii) Estimation done with cross-section weights

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

First, the distance has the expected negative sign implying that countries, which are further a way from South Africa would tend to have country-specific effects that are inimical to exports. Second, South Africa tends to export more to English speaking countries. This has implication on the language policy in South Africa. Third, South Africa exports more to EU, Africa, NAFTA and MERCOSUR member states.

5.2 Other transport (SIC 30)

Table 2 reports the results of the gravity for other transport equipment. The model explains a significant variation in the exports of other transport as shown by the high adjusted R^2. The Durbin-Watson statistic shows that there is no problem of serial correlation in the model. The Hausman test suggests a FEM while redundant fixed effects test shows that the country-specific effects are important. The EDFs of most variables (Figure 3) are not normally distributed implying that first-order asymptotic theory results not be appropriate. Consequently, the analysis is done using bootstrap results. The coefficients for all the variables are unbiased.

The importer income has the expected significant positive sign. This means that an increase in trading partner income leads to an increase in South Africa's exports of other equipment. The income elasticity is close to unity as predicted by theory.

The importer population has a negative 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 transport equipment. South Africa's population has a significant positive effect on transport exports. This means that the large population implies large domestic market, which creates division of labour and thus opportunities for a wide variety of transport equipment exports.

The oil price has a negative but insignificant effect on exports. The exchange rate has a significant positive effect on exports. This implies that a depreciation of the exchange rate by 1 per cent rise leads to a 0.05 per cent rise in exports of manufactured transport.

The first-order asymptotic theory as well as bootstrap country-specific effects coefficients are presented in Table 6. The last column shows that the fixed effects coefficients for Australia, Belgium, Cameroon, D.R.Congo, Greece, Hong Kong, India, Madagascar, Malaysia, Norway, and Tanzania are biased (shaded).

The results show that there are unobservable unique characteristics of each country that enhance South Africa's exports of other transport to Angola, Cameroon, Canada, China, D.R Congo, France, Germany, Ghana, India, Iran, Italy, Japan, Kenya, Madagascar, Malawi, Malaysia, Mozambique, Nigeria, Pakistan, Spain, Sudan, Tanzania, United Kingdom, United States, Zambia and Zimbabwe.

There are also unobservable country characteristics that tend to inhibit South Africa's exports of other transport to Austria, Belgium, Chile, Comoros, Congo, Czech republic, Denmark, Gabon, Greece, Hong Kong, Ireland, Israel, Mauritius, Norway, New Zealand, Portugal, Sierra Leone, Singapore, Sweden, Switzerland.

Table 3 shows the results for the second stage regression, which are quite similar to those for the motor vehicle, parts and accessories (SIC 29). First, the distance has the expected negative sign implying that countries, which are further a way from South Africa would tend to discourage exports. Second, South Africa tends to export more to English speaking countries. Third, South Africa exports more to EU, Africa, NAFTA and MERCOSUR member states.

6. Conclusion

This paper attempts to apply an augmented gravity model to annual bilateral exports between South Africa and her trading partners in transport equipment (SIC 29 and SIC 30). The paper utilises the methodology used in Cheng and Wall (2005), which aims to estimate fixed effects and variables that are constant over the sample size. The paper employs moving block bootstrap with a view to estimating appropriate Type I error critical values. A number of conclusions emerge from the study.

First, importer income has the expected positive influence on bilateral trade flows for transport. The income elasticities are close to unity as expected by theory. Second, trading partner population has negative effect for other transport (SIC 30) implying that South Africa exports more to smaller countries. South Africa,s population has a positive relationship with exports. Third, transport costs tend to hamper South Africa's exports of transport equipment. Fourth, South Africa tends to export more to English speaking countries than non-English-speaking countries. Fifth, there are some country-specific factors that are inimical to South Africa's exports of transport equipment to some countries. The estimated model can be useful for forecasting (potential) trade flows and policy simulations.

References

Anderson, J.E. (1979), "A Theoretical Foundation of the Gravity Equation". *American Economic Review*, 69, 106-116.

Beckerman, W. (1956), "Distance and Pattern of Intra-European Trade". *The Review of Economics and Statistics*, 38 (1), 31-40.

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.

Breitung, J. (2000), The Local Power of Some Unit Root Tests for Panel Data. In: Baltagi, B. (eds.) *Advances in Econometrics: Nonstationary Panels, Panel Cointegration, and Dynamic Panels*, *15:161*-178. Amsterdam: JAI Press.

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.

Choi, I. (2001), "Unit Root Tests for Panel Data". *Journal of International Money and Finance*, 20:249-272.

Efron, B. (1979), "Bootstrap Methods: Another Look at the Jacknife". *Annals of Statistics*, 7:1-26.

Efron, B. (1982), *The Jacknife, the Bootstrap and Other Resampling Plans*. Philadelphia: Society for industrial and applied Statistics.

Isard, W., (1954), "Location Theory and International and Interregional Trade". *Quarterly Journal of Economics*, 68, 97–114.

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

Horowitz, J.L. and Savin, N.E. (2000), "Empirically Relevant Critical Values for Hypothesis Tests: A Bootstrap Approach". *Journal of Econometrics*, 95:375-389.

Horowitz, J.L. (2001), "The Bootstrap and Hypothesis Tests in Econometrics". *Journal of Econometrics*, 100:37-40.

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

Isard, W. and Peck, M.J. (1954), "Location Theory and International and Interregional Trade Theory", *The Quarterly Journal of Economics*, 68(1), 97-114.

Künsch, H.R. (1989), "The Jacknife and the Bootstrap for General Stationary Observations". *Annals of Statistics*, 17, 1217-1241.

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.

Maddala, G. S. and Wu, S. (1999), A Comparative Study of Unit Root Tests With Panel Data and a New Simple Test". *Oxford Bulletin of Economics and Statistics*, 61:631-52.

Mackinnon, J.G. (2002), "Bootstrap Inference in Econometrics". [Online] Available from: http://qed.econ.queensu.ca/pub/faculty/mackinnon/papers/cea-presadd-2002.pdf [Accessed: 2004-10-12].

Mooney, C.Z. and Duval, R.D. (1993), "Bootstrapping: A nonparametric Approach to Statistical Inference". Sage University Paper Series on Quantitative Applications in the Social Sciences, 07-095. London: Sage Publications.

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

Politis, D.N. and Romano, J.P. (1994), “Large Sample Confidence Regions Based on Subsamples Under Minimal Assumptions”. *Journal of the American Statistical Association,* 22:2031-50.

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

Table 4: Fixed effects for motor vehicle, parts and accessories (SIC 29)

	First-Order Asymptotic Theory Results	Block Bootstrap Results(3000 Replications)				
Country	Estimate	Estimate	Standard Error	Confidence Interval	%	Standardised bias
Angola	2.89	2.92	0.49	[1.74, 4.27]***	1	-0.05
Argentina	-0.51	-0.70	1.24	[-2.78, 1.31]	10	0.15
Australia	2.43	2.37	0.58	[0.81, 3.74]***	1	0.11
Austria	-3.22	-3.21	1.46	[-5.53, -0.71]*	10	-0.01
Belgium	1.91	1.87	1.09	[0.19 3.75]*	10	0.03
Brazil	2.39	1.87	3.79	[-4.55, 8.01]	10	0.14
Burundi	-0.52	-0.23	1.44	[-2.61, 2.14]	10	-0.20
Cameroon	0.39	0.62	0.80	[-0.81, 1.79]	10	-0.28
Canada	-0.72	-0.88	0.99	[-2.56, 0.76]	10	0.16
Chile	-1.73	-1.78	0.31	[-2.47, -0.93]***	1	0.17
China	5.00	4.13	7.22	[-8.18, 15.82]	10	0.12
Colombia	-0.98	-1.12	1.65	[-3.87, 1.58]	10	0.09
Comoros	-3.34	-2.79	5.42	[-11.52, 6.38]	10	-0.10
Congo	-0.67	-0.30	2.51	[-4.43, 3.89]	10	-0.15
Côte d'Ivoire	0.28	0.50	0.53	[-0.36,1.37]	10	-0.41
Cyprus	-3.59	-3.22	5.13	[-11.31, 5.69]	10	-0.07
Czech Republic	-2.75	-2.89	0.95	[-4.89, -0.36]***	1	0.15
D.R.Congo	4.09	3.94	2.23	[0.10, 7.54]*	10	0.07
Denmark	-3.63	-3.46	2.13	[-6.91, 0.12]	10	-0.08
Egypt	0.63	0.42	2.31	[-3.55, 4.14]	10	0.09
Ethiopia	0.38	0.27	2.63	[-4.23, 4.36]	10	0.04
Fiji	-5.55	-5.00	4.95	[-12,96, 3.46]	10	-0.11
Finland	-4.44	-4.33	2.12	[-7.63, -0.64]*	10	-0.05
France	0.60	0.29	1.98	[-3.03, 3.53]	10	0.16
Gabon	-1.98	-1.61	4.31	[-8.55, 5.64]	10	-0.09
Germany	3.95	3.63	2.53	[-0.69, 7.73]	10	0.13
Ghana	2.34	2.44	0.90	[0.53, 4.05]**	5	-0.11
Greece	-1.06	-1.01	0.89	[-2.42, 0.49]	10	-0.05
Hong Kong(China)	-0.42	-0.39	1.83	[-3.36, 2.68]	10	-0.02
India	4.08	3.43	6.89	[-8.48, 14.44]	10	0.09
Indonesia	0.35	0.03	4.33	[-7.37, 7.11]	10	0.07
Iran	-1.92	-2.07	2.34	[-6.04, 1.74]	10	0.06
Ireland	-2.82	-2.61	2.61	[-6.80, 1.86]	10	-0.08
Israel	-1.62	-1.44	1.82	[-4.26, 1.65]	10	-0.10
Italy	1.12	0.85	1.98	[-2.44, 4.07]	10	0.14
Japan	1.63	1.13	3.22	[-4.34, 6.27]	10	0.16

Notes: (i) Shaded cells in column 2 refer to significant negative fixed effects
(ii) Shaded cells in last column refer to biased coefficients (standardised bias greater than 0.25)
(iii) *, ** and *** refer to 10%, 5% and 1% significance respectively

Table 5:Fixed effects for motor vehicle, parts and accessories(SIC 29)-Continued

	First-Order Asymptotic Theory Results	Block Bootstrap Results(3000 Replications)				
Country	Estimate	Estimate	Standard Error	Confidence Interval	%	Standardised bias
Kenya	4.35	4.30	1.28	[0.94, 7.26]***	1	0.04
Madagascar	1.75	1.78	0.62	[0.23, 3.41]***	1	-0.05
Malawi	5.68	5.74	0.86	[3.69, 8.29]***	1	-0.06
Malaysia	0.91	0.91	0.57	[-0.04, 1.83]	10	0.01
Mali	0.52	0.76	0.87	[-0.66,2.20]	10	-0.27
Malta	-5.14	-4.53	6.19	[-14,38, 6.03]	10	-0.10
Mauritius	0.84	1.22	4.30	[-5.65, 8.64]	10	-0.09
Mexico	-0.35	-0.75	2.92	[-5.75, 3.96]	10	0.14
Morocco	-0.91	-0.97	1.07	[-2.83, 0.71]	10	0.05
Mozambique	5.85	5.87	0.77	[3.89, 7.67]***	1	-0.02
Netherlands	1.53	1.45	0.58	[0.03, 3.04]***	1	0.13
New Zealand	-0.15	0.00	2.55	[-4.09, 4.42]	10	-0.06
Nigeria	2.71	2.45	3.56	[-3.68, 8.07]	10	0.07
Oman	-6.58	-6.33	3.29	[-11.52, -0.57]*	10	-0.08
Pakistan	-1.14	-1.56	3.70	[-7.78, 4.29]	10	0.11
Peru	-3.66	-3.85	0.84	[-5.92, -1.83]***	1	0.23
Philippines	-2.15	-2.28	2.73	[-6.92, 2.02]	10	0.05
Poland	-3.61	-3.93	1.64	[-8.36, -0.12]***	1	0.19
Portugal	-0.85	-0.85	0.97	[-2.34, 0.86]	10	0.00
Republic of Korea	0.26	0.09	1.63	[-2.62, 2.74]	10	0.10
Russian Federation	-1.93	-2.47	3.67	[-8.70, 3.36]	10	0.15
Rwanda	-0.71	-0.43	1.30	[-2.63, 1.70]	10	-0.21
Sao Tome and Principe	-3.20	-2.40	7.53	[-14, 10.44]	10	-0.11
Saudi Arabia	-1.82	-1.98	0.53	[-3.55, -0.70]*	10	0.30
Seychelles	-2.38	-1.49	8.75	[-15.46, 13.58]	10	-0.10
Sierra Leone	-0.29	-0.03	1.96	[-4.60, 5.11]	1	-0.13
Singapore	0.61	0.79	2.56	[-3.35, 5.11]	10	-0.07
Spain	1.22	0.94	1.42	[-1.41, 3.27]	10	0.20
Sri Lanka	0.31	0.31	0.54	[-0.59, 1.23]	10	0.00
Sweden	-1.95	-1.83	1.41	[-4.20, 0.48]	10	-0.09
Switzerland	-3.17	-3.21	1.79	[-5.96, 0.16]	10	0.02
Thailand	1.13	1.08	2.23	[-2.96 4.56]	10	0.02
Turkey	-0.90	-1.10	2.29	[-5.04, 2.59]	10	0.08
Uganda	2.41	2.45	0.97	[0.31, 4.16]**	5	-0.04
United Arab Emirates	-1.46	-1.22	2.98	[-5.97, 3.93]	10	-0.08
United Kingdom	3.25	2.95	2.00	[-0.48, 6.14]	10	0.15
United Republic of Tan	3.92	3.81	1.50	[0.69, 6.56]**	5	0.07
United States	3.47	2.89	4.45	[-4.56, 10.12]	10	0.13
Venezuela	-3.12	-3.23	0.65	[-5.01, -1.85]***	1	0.17
Zambia	4.97	5.07	0.85	[3.12, 7.39]***	1	-0.13
Zimbabwe	5.45	5.49	0.59	[4.09, 7.16]***	1	-0.07

Notes: (i) Shaded cells in column 2 refer to significant negative fixed effects
(ii) Shaded cells in last column refer to biased coefficients (standardised bias greater than 0.25)
(iii) *, ** and *** refer to 10%, 5% and 1% significance respectively

Table 6:Fixed effects for other transport (SIC 30)

	First-Order Asymptotic Theory Results	Block Bootstrap Results(3000 Replications)				
Country	Estimate	Estimate	Standard Error	Confidence Interval	%	Standardised bias
Angola	3.24	3.36	0.60	[1.54, 4.75]***	1	-0.20
Argentina	0.34	0.25	0.93	[-1.24, 1.84]	10	0.10
Australia	0.22	0.07	0.56	[-0.80, 1.08]	10	0.26
Austria	-7.21	-7.32	1.20	[-10.32, -4.35]***	1	0.09
Belgium	-2.86	-3.10	0.81	[-5.02, -0.96]***	1	0.28
Cameroon	1.20	1.60	0.86	[0.03, 2.89]*	10	-0.46
Canada	2.52	2.47	0.92	[0.48, 4.97]***	1	0.05
Côte d'Ivoire	-0.89	-0.76	0.75	[-1.96, 0.51]	10	-0.17
China	16.72	17.30	4.61	[5.31, 28.99]***	1	-0.12
Chile	-1.45	-1.41	0.26	[-2.05, -0.76]***	1	-0.15
Comoros	-12.78	-12.89	3.55	[-21.76, -4.14]***	1	0.03
Congo	-6.08	-6.04	1.85	[-10.96, -1.63]***	1	-0.02
Czech Republic	-6.95	-6.90	0.67	[-8.29, -5.13]***	1	-0.08
Denmark	-8.79	-9.08	1.51	[-12.82, -5.19]***	1	0.19
D.R congo	9.56	9.97	1.64	[5.71, 13.76]***	1	-0.25
Egypt	2.28	2.44	1.73	[-0.39, 5.23]	10	-0.09
France	5.41	5.47	1.46	[2.02, 9.25]***	1	-0.04
Gabon	-11.02	-11.06	2.85	[-18.31, -3.78]***	1	0.01
Germany	6.21	6.20	1.75	[1.84, 10.61]***	1	0.00
Ghana	3.33	3.80	0.81	[1.40, 5.64***	1	-0.57
Greece	-4.46	-4.76	0.72	[-6.45, -2.91]***	1	0.41
Hong Kong(China)	-6.30	-6.76	1.27	[-9.82, -3.58]***	1	0.37
India	16.31	16.63	4.32	[5.52, 27.04]***	1	-0.08
Iran	3.80	3.93	1.62	[0.80, 7.03]**	5	-0.08
Ireland	-8.43	-8.71	1.67	[-12.85, -4.50]***	1	0.17
Israel	-4.84	-5.04	1.18	[-7.85, -1.83]***	1	0.17
Italy	3.36	3.14	1.45	[0.48, 6.12]***	1	0.15
Japan	3.87	3.88	2.19	[0.36, 7.62]**	5	0.00
Kenya	7.14	7.36	0.92	[4.89, 9.43]*	10	-0.24
Madagascar	2.67	2.90	0.78	[0.68, 4.71]***	1	-0.29
Malawi	2.69	2.87	0.97	[0.02, 5.09]***	1	-0.19
Malaysia	2.00	2.19	0.54	[0.98, 3.53]***	1	-0.37
Mauritius	-9.30	-9.56	2.81	[-16.61, -2.41]***	1	0.09
Morocco	-0.65	-0.59	0.95	[-2.19, 0.94]	10	-0.07
Mozambique	4.86	5.05	0.85	[2.69, 7.08]***	1	-0.22
Netherlands	0.41	0.43	0.85	[-0.95, 1.86]	10	-0.03
Nigeria	9.56	9.86	2.34	[3.55, 15.03]***	1	-0.13
Norway	-9.45	-9.97	1.96	[-14.66, -5.02]***	1	0.26
New Zealand	-7.77	-8.00	1.65	[-12.03, -3.77]***	1	0.14
Pakistan	8.52	8.75	2.50	[2.08, 14.71]***	1	-0.09
Portugal	-4.39	-4.53	0.64	[-6.03, -2.74]***	1	0.22
Seychelles	-20.63	-21.14	5.60	[35.26, -6.72]***	1	0.09
Sierra Leone	-5.06	-4.78	1.49	[-8.82, -1.35]***	1	-0.19
Singapore	-6.25	-6.55	1.65	[-10.59, -2.21]***	1	0.18
Spain	2.96	2.84	1.06	[0.45, 5.74]***	1	0.11
Sri Lanka	-0.11	-0.17	0.50	[-0.99, 0.65]	10	0.13
Sudan	5.16	5.15	1.25	[1.76, 7.95]***	1	0.00
Sweden	-4.65	-4.88	1.11	[7.55, -2.01]***	1	0.21
Switzerland	-4.82	-5.07	1.20	[-7.79, -1.81]***	1	0.21
Tanzania	6.46	6.84	1.08	[3.94, 9.34]***	1	-0.35
United Kingdom	6.00	5.91	1.52	[2.40, 9.98]***	1	0.06
United States	12.90	12.94	3.00	[5.66, 20.56]***	1	-0.01
Zambia	2.38	2.52	0.89	[0.06, 4.43]***	1	-0.15
Zimbabwe	3.31	3.44	0.60	[1.75, 4.75]***	1	-0.22

Notes: (i) Shaded cells in column 2 refer to significant negative fixed effects

(ii) Shaded cells in last column refer to biased coefficients (standardised bias greater than 0.25)

(iii) *, ** and *** refer to 10%, 5% and 1% significance respectively

Figure 2:Empirical distribution functions (EDF) for SIC 29

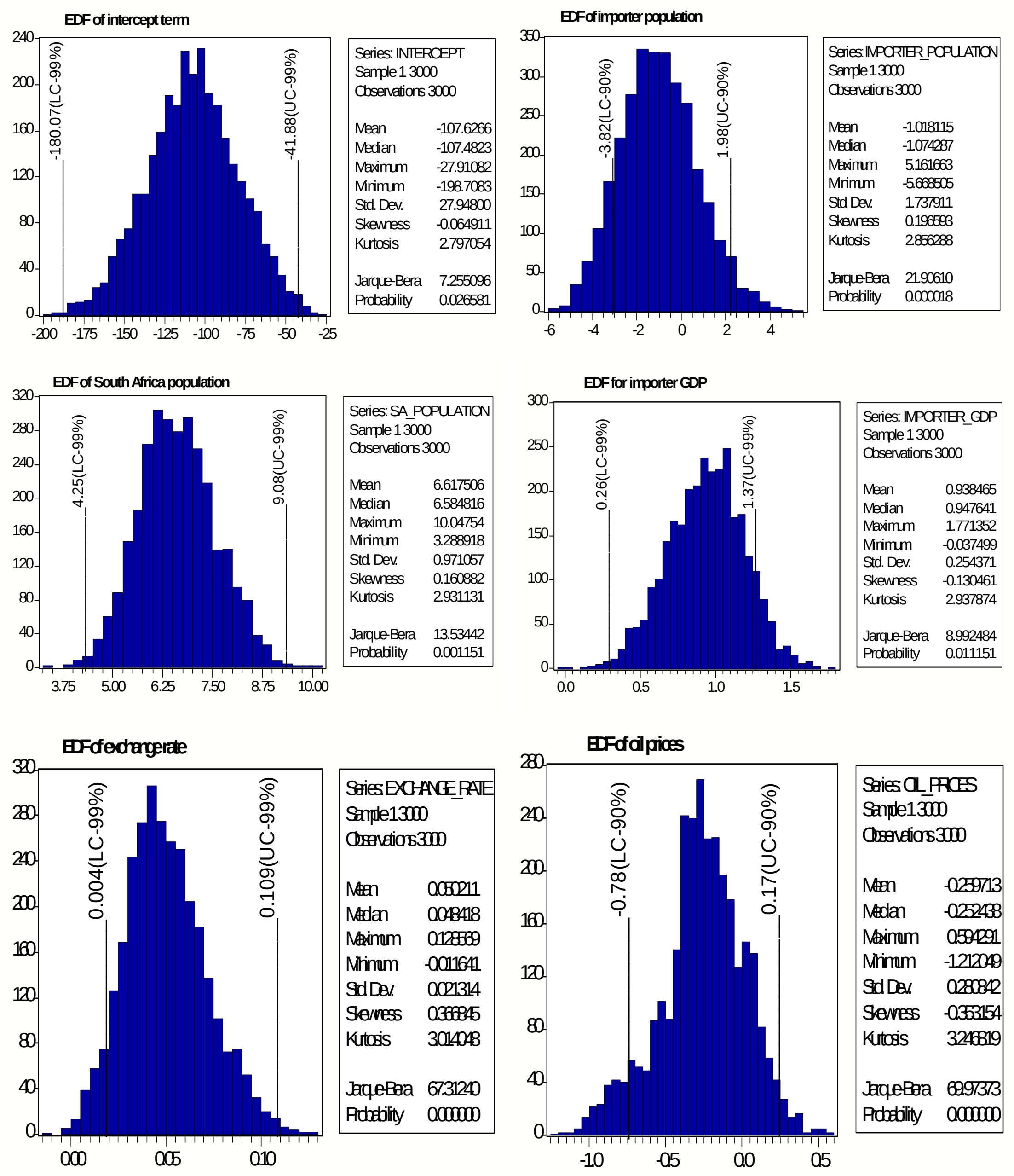


Figure 3:Empirical distribution functions (EDF) for SIC 30

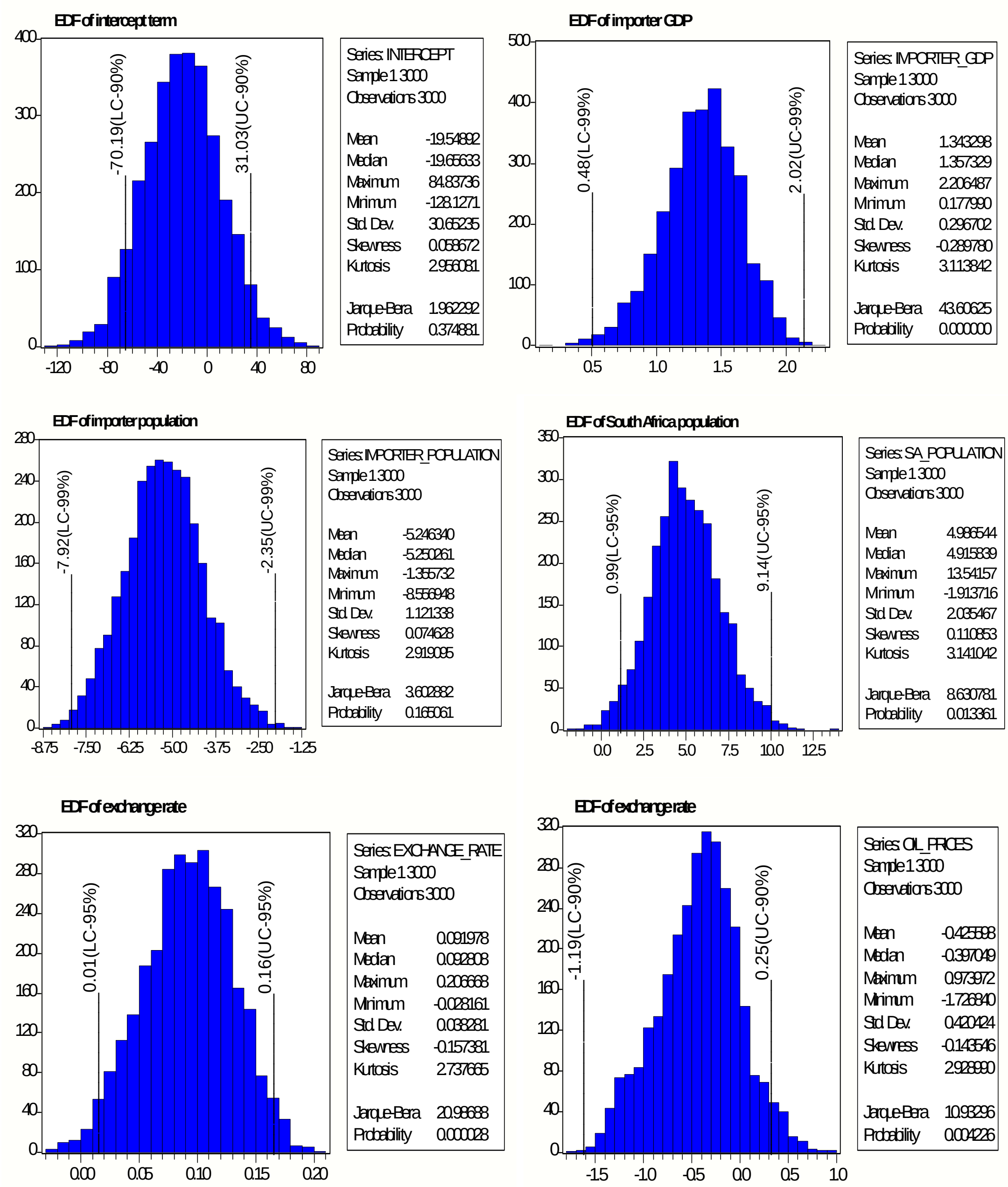


Table 7: Summary of panel unit root tests (Sic 29)

	Null: Unit root (Homogeneous)		Null: Unit root (heterogeneous)			Null: No unit root (homogenous)
Variable	*LLC t-stat*	*Breitung t-stat*	*IPS w-stat*	*ADF-Fisher chi square*	*PP- Fisher chi square*	*Hadri z-test*
$X29$	-36.808** (0.000)	-1.206 (0.114)	-5.076** (0.000)	419.239** (0.000)	569.675* (0.000)	31.143** (0.000)
GDP_{jt}	-14.363** (0.000)	4.241 (1.000)	0.480 (0.684)	261.961 (0.137)	343.791** (0.000)	19.873** (0.000)
$GDPSA_{it}$	19.619 (1.000)	52.741 (1.000)	-1.089 (0.138)	249.337 (0.294)	7.898 (1.000)	53.190** (0.000)
POP_{jt}	-8.594** (0.000)	-6.712** (0.000)	0.756 (0.775)	362.371 (0.000)	508.338 (0.000)	21.114** (0.000)
$POPSA_{it}$	23.628 (1.000)	-13.668** (0.000)	-3.477** (0.000)	414.700** (0.000)	0.087 (1.000)	34.674** (0.000)
XR_{jt}	-13.366** (0.000)	4.456 (1.000)	-3.601** (0.000)	430.671** (0.000)	564.851* (0.000)	23.356** (0.000)

Notes:

1.* and ** denotes rejection of null at 5% and 1% significance levels.
2. Sample: 77 cross-sections, period 1994-2003
3. Probabilities for Fisher tests are computed using asymptotic chi-square distribution. The other tests assume asymptotic normality
4. Exogenous variables include individual effects, individual linear trends.

Table 8: Summary of panel unit root tests (Sic 30)

	Null: Unit root (Homogeneous)		Null: Unit root (heterogeneous)			Null: No unit root (homogenous)
Variable	*LLC t-stat*	*Breitung t-stat*	*IPS w-stat*	*ADF-Fisher chi square*	*PP- Fisher chi square*	*Hadri z-test*
$X30$	-21.116** (0.000)	4.743 (0.114)	-6.041** (0.000)	390.970** (0.000)	529.221* (0.000)	22.745** (0.000)
GDP_{jt}	-12.342** (0.000)	6.124 (1.000)	0.563 (0.713)	183.369 (0.416)	235.474** (0.003)	17.445** (0.000)
$GDPSA_{it}$	17.156 (1.000)	46.121 (1.000)	-0.952 (0.170)	190.669 (0.315)	6.039 (1.000)	46.514** (0.000)
POP_{jt}	-8.612** (0.000)	-5.673** (0.000)	0.595 (0.724)	276.991 (0.000)	373.793 (0.000)	19.139** (0.000)
$POPSA_{it}$	20.663 (1.000)	-11.952** (0.000)	-3.041** (0.001)	317.123** (0.000)	0.067 (1.000)	30.322** (0.000)
XR_{jt}	-12.528 (0.000)**	3.569 (0.999)	-3.372** (0.000)	340.362** (0.000)	456.858 (0.000)*	20.932 (0.000)**
Oil_t	-23.764** (0.000)	-0.284 (0.388)	-1.497 (0.067)	238.845 (0.003)*	142.102 (0.987)	98.927 (0.000)

Notes:

1.* and ** denotes rejection of null at 5% and 1% significance levels.
2. Sample: 54 countries, period 1994-2003

3. Probabilities for Fisher tests are computed using asymptotic chi-square distribution. The other tests assume asymptotic normality
4. Exogenous variables include individual effects, individual linear trends.