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Applying the Gravity Model to Trade Flows in a Country Under Sanctions: Case of Zimbabwe (1998-2006)

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ABSTRACT

The research looks at the trade flows between Zimbabwe and its major trading partners over the period 1998 to 2006 with the intention of evaluating whether or not the sanctions imposed by the United States and the European Union had effect on depressing economic interaction. The methodology applies the gravity model on data obtained from fifteen countries considered to be Zimbabwe's major trading partners. The sanctions dummy generally indicates that the so-called 'targeted sanctions' in fact significantly diminished the volume of trade between Zimbabwe and its foes. The researcher proposes a reintegration into the global economy in order to enjoy the full welfare gains from trade.

1. OVERVIEW OF THE STUDY

Gravity models are a group of econometric models derived from Newton's laws of gravity. Newton's law of gravity states that the gravitational attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square

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of the distance between them⁶. Gravity models have been popular in the last few decades in explaining the patterns of trade between countries. In the context of trade, the gravity model proposes that the volume of trade is positively influenced by the product of the national incomes of trading partners, and negatively related to the distance between them.

Zimbabwe has in the last eight years (2000-2007) experienced high rates of inflation, dwindling export receipts, depletion of foreign exchange reserves, amid a *de facto* economic sanctions regime. The combined effect of these and other factors has been to generate negative economic growth rates. The isolation of Zimbabwe can probably be traced back to the late 1990s when the country adopted the massive land reform, allowing in the process lawlessness and threats to private property rights. Having originally agreed to compensate displaced white commercial farmers, the government later changed its position in the light of failure of the Donors' Conference in 1998. The immediate result of such policies was the sharp decline in agricultural output, generating ripple effects across the economy. The United Kingdom, United States and most European countries then took a retaliatory stance, inviting large scale investor and donor boycotts. It is thus important to view the sanctions imposed on Zimbabwe not in direct context of any other sanctions preventing the country from importing or exporting commodities. The inability of the country to import commodities follows directly from the inability to generate enough foreign currency to meet obligations to foreign suppliers. If such foreign currency were available the country would be at almost full liberty to import commodities from the western countries. The sanctions are

⁶ Fitzsimons E. , Neary J. P. and Hogan V. "Explaining the Volume of North-South Trade in Ireland: A Gravity Model Approach", *The Economic and Social Review*, Vol. 30, No. 4, October, 1999, pp. 381-401.

explicitly declared as "targeted at selected individuals" and to a certain extent trade in specified military hardware. It sounds like quite an unusual punishment package. The intention is thus to whip the regime into reforming the governance practices. But how does a weapon as lethal as sanctions spare the innocent people? Even this paper will not be able to provide an answer or even a guess in that direction!

The import and export figures in relation to bilateral trade with the European and other sanctions-initiating countries point towards shrinking volumes, but there has not been any rigorous study to evaluate whether or not such trends are directly related to the sanctions.

Table 1: Export and Import Figures for Zimbabwe in relation to Some Countries

Year	US		UK		Germany	
	Imp(US\$M)	Exp(US\$M)	Imp(US\$M)	Exp(US\$M)	Imp(US\$M)	Exp(US\$M)
1998	145.518	116.466	171.607	184.269	92.518	134.646
1999	101.306	109.876	142.394	181.891	113.357	149.975
2000	107.790	103.462	86.618	159.903	55.042	142.305
2001	48.431	61.464	55.014	130.248	47.650	155.753
2002	66.857	83.392	67.516	157.831	74.622	151.047
2003	9.883	34.656	15.352	124.964	13.328	181.258
2004	40.438	40.064	81.419	128.232	36.646	75.392
2005	29.706	96.769	34.184	73.384	46.684	28.708
2006	138.314	98.284	59.082	11.669	28.750	8.342

Source: IMF online Database

An important fact that can be identified from the statistics in the above table is that Zimbabwe's UK destined exports which in 1998 were US\$184.269 had dropped to as low US\$11.669 in 2006, with a

generally visible downward trend over the period. Well, it could be just coincidence! But that would be a rare coincidence given that the imports also display a similar trend. Although the table is only a snap view depicting alienation of the country from trade relations with America and the west, it may not represent the global picture with respect to overall isolation from the rest of the world. However such trends should immediately pose a worry which is worth investigation.

To date no study has evaluated the validity of the gravity model on Zimbabwe. In this paper I attempt to document the trade flows of Zimbabwe in the context of the gravity model, which is otherwise borrowed from physics.

In pursuing such an investigation, I explicitly state the following as the key objectives:

To evaluate significance of sanctions on the volumes of bilateral trade with Zimbabwe.

To check the validity of the gravity model in analysing the trade flows of a country reeling under sanctions.

2. LITERATURE REVIEW

Although Zimbabwe has been lagging behind in literature on the application of gravity models to trade, a number of related studies have been conducted in other countries. Balistreri and Hillberry (2003) performed an evaluation of the gravity model *viz a viz* its ability to replace traditional models of international trade on policy analysis. The researchers evaluated the effects of the size of the transport sector on trade volume; the distance and border related costs on price; and the extent of spatial variation in retail prices as it

affects direction of trade. The researchers conclude that the gravity model is at variance with the practical realities on the welfare implication of trade. Transport costs may have a significant influence on the volumes of trade between countries (Balistreri and Hillberry, 2003). Using the standard gravity model, they found that iceberg melt⁷ were quite significant, which in their conclusion could lead to differences in the cost of living between Canada and United States.

A related study of the trade flows between Northern Ireland and Southern Ireland concluded that the volume of trade between the two countries was in compliance with the predictions of the gravity model, thus providing a strong case for its applicability to trade policy (Fitzsimons *et al*, 1999).

A study of the trade flows in a panel of Latin American countries found that there was, in a number of cases, evidence of validity of the gravity-related influences on trade volumes (Carrillo and Carmen, 2002). There is however evidence that the gravity models may not be directly compatible with traditional comparative advantage arguments for trade (Helpman and Krugman, 1985). They use the gravity model to provide evidence that there may be a bi-directional movement of similar but quite differentiated goods across countries with similar levels of income. Trade of such nature has been observed to be quite significant. Their findings also tend to diminish the long held strength of the factor endowments theories of international trade.

⁷ Iceberg melt is defined as the cost of transporting a commodity that consumes a certain fraction of the commodity itself.

3. RESEARCH METHODOLOGY

This research uses a pooled panel consisting of fifteen countries, which based on trade volumes are considered to be Zimbabwe's major trading partners⁸. The period of study spans from 1998 to 2006, providing a total of 135 observations. The data is stacked, with the countries assuming the role of the cross-sectional identifiers. This makes the data set compatible with the E-Views econometric package for purposes of estimation.

The paper adopts the gravity model as the core of its methodology. The original gravity model of Newton has been widely applied to other situations in natural sciences, social sciences, as well as economics (Bergstrand, 1985; Bergstrand, 1989; Deardorff, 1998; Evenett *et al*, 1998; Feenstra, 2001). In international trade the model predicts bilateral trade flows based on the economic sizes of (often measured using GDP in a common currency) and distance between two countries. The basic theoretical form of the gravity model for trade between two countries (*i* and *j*) is:

$$T_{ij} = A \left(\frac{E_i E_j}{d_{ij}} \right)$$

Where: *T* is the trade flow, *E* is the economic mass (usually proxied by GDP) of each country, *d* is the distance between the two countries and *A* is a constant. Applying natural logs to linearise the expression gives an econometric version of the form:

⁸ The full list of countries used in the research include United Kingdom, South Africa, Botswana, Mozambique, Zambia, Namibia, France, Germany, Switzerland, Malawi, China, United States, Netherlands, DRC and Japan.

$$\ln T_{ij} = \beta_0 + \beta_1 \ln E_i + \beta_2 \ln E_j + \beta_3 \ln d_{ij} + \mu$$

where: the constant *A* becomes part of β_0

μ is an error term.

Some variations of the above model often include variables such as price levels for the countries, common language relationships, common regional block, sanctions (whether country *1* is adopting a policy of trade isolation against country *2* or *vice versa*) and colonial history (whether Country *1* ever colonised Country *2* or *vice versa*). The gravity model can also be used in international relations to evaluate the impact of pacts, treaties and alliances on trade. The model provides a rather spatial or geographic perspective of trade.

In this study, a variant of the above model is adopted and will cater for the effect of sanctions as follows:

$$T_{ij} = \beta_0 + \beta_1 E_i E_j + \beta_2 \text{DIS}_{ij} + \beta_3 \text{RGD} + \beta_4 \text{SD} + \mu$$

For purposes of estimation, the natural logarithmic version of the model will be applied as:

$$\ln T_{ij} = \beta_0 + \beta_1 \ln E_i E_j + \beta_2 \ln \text{DIS}_{ij} + \beta_3 \text{RGD} + \beta_4 \text{SD} + \mu$$

The trade flow between countries (*T*) is proxied by the sum of imports and exports at current prices, all denominated in United States Dollar terms. This variable is the dependent in the gravity model to be estimated. The IMF online data bases provided the relevant information on exports and imports. The economic mass of

a country shall be represented by its Gross Domestic Product at current US dollars. The product of the GDPs of the two trading partners ($E_i E_j$) becomes the variable of interest in the estimation of the gravity model. Such data was obtained from the World Bank online data base. Distance (DIS) between countries is often considered to have an influence on the volume of trade flows between countries as it has bearing on transportation costs and associated costs. This study follows the common practice of using the great circle distance between capital cities to represent the estimated spatial separation between any two countries (Carrillo and Carmen, 2002). There are however strong arguments that also dispute the adoption of the great circle distance in the gravity models on the basis of the fact that such a proxy may underestimate the transport cost imposed by distance especially considering the realities of the alternative transportation modes and routes.⁹

The regional block dummy (RGD) is constructed on the basis of whether or not the trading partner is a member of the Southern African Development Community (SADC), and thus shares the preferential trade arrangements with Zimbabwe. The variable takes the value of one if the trading partner is a member and zero, otherwise. The effect of sanctions is expected to be catered for through the sanctions dummy (SD), which takes the value of zero if the country did not conspire to impose sanctions on Zimbabwe and one if, in the post year 2000, the country was part to the conspiracy. A value of zero is thus universally applicable on all countries in the period 1998 to 2000.¹⁰

⁹ Limao, N. and A. Venables, (2001), "Infrastructure, Geographical Disadvantage, Transport Costs, and Trade", in *The World Bank Economic Review*, Vol. 15, No.3, pp. 451 – 479.

¹⁰ This is based on the well-motivated notion that the sanctions imposed on Zimbabwe were driven by the policies adopted by its government at the

4. RESULTS PRESENTATION AND INTERPRETATION

Having estimated the gravity model using the E-Views package, this section represents the findings as well as the associated interpretations. It is important to recall that the panel is balanced as it relates to fifteen countries over a nine year period.

Table 2: Estimated Gravity Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.23669	2.067127	6.403422	0.0000
LNEE	-0.030438	0.055789	-0.545595	0.5863
RGD	-1.934973	0.390194	-4.958997	0.0000
SD	-0.544655	0.127043	-4.287156	0.0000
LNDIS	-0.444438	0.109420	-4.061780	0.0001

Weighted Statistics

R-squared	0.832887		
Adjusted R-squared	0.827745	S.D. dependent var	2.684697
S.E. of regression	1.114246	Sum squared resid	161.4007
F-statistic	161.9792	Durbin-Watson stat	1.839655
Prob(F-statistic)	0.000000		

The results generally represent a case of strong model, with the adjusted R^2 of almost 83%. All coefficients (except that of LNEE) are highly significant. The estimation method factored in the White Heteroskedasticity-Consistent Standard Errors & Covariance. Caution should however be thrown that when applying this to panel data, this variance estimator is robust to heteroskedasticity within each cross-section, but does not account for the possibility of contemporaneous correlation across cross-sections.

changeover of the millennium. Activating the sanctions dummy in year 2001 allows a reasonable one year policy response lag.

The coefficients for all variables with the natural logarithm are interpreted as elasticities of the volume of trade with respect to the relevant variable. The regional trade dummy (RGD) is negative and at variance with the theoretical expectations. The dummy variable is constructed under the presumption that the Southern African Development Community (SADC) is a trade enhancing economic grouping, membership of which should be expected to attract larger trade volumes. As such there are strong arguments for a positive *a priori* sign. The negative sign could possibly be due to the practical lack of capacity by SADC to influence the trade volumes. Such a result is not surprising given that SADC has not been successful in any circles socio-political or economic.

The coefficient for the distance between Zimbabwe and its relevant trading partners (LNDIS) is negative. This supposes that the more geographically intimate the trading partners, the larger also is the volume of trade between them. Distance imposes several cost-related restrictions to commodity flows and overall acts as a hindrance to international economic interaction. Neighbouring countries are thus likely to have stronger economic and trade ties than those that are geographically detached, which of course is the basic thrust of the gravity model. Transactions in the global financial sector are probably the only segment that has managed to significantly minimise the distance barrier. Not only is such a finding logical, but it is also consistent with the theoretical motivation of the gravity model as well as the empirical backing thereof (Fitzsimons *et al.*, 1999; Deardorff, 1998).

The sanctions dummy (SD) is negative and significant, a clear and quite compelling indication that the sanctions imposed by the European countries and the United States indeed acted as a deterrent to trade between Zimbabwe and such countries. This also confirms the logical, theoretical and empirical expectations of the base model.

The inclusion of the sanctions dummy variable in the variant of the gravity model used in this paper is thus vindicated.

5. CONCLUSIONS AND RECOMMENDATIONS

There is clear evidence from the findings that distance and sanctions are hindrances to trade enhancement. The gravity model is largely applicable to the sanctions-ridden Zimbabwe. There is a striking resemblance with the behaviour of magnetic forces in Newton's laws. A non-metallic object placed between two magnets tends to interfere with the magnetic forces, thus reducing the extent of attraction between the opposite poles of the two magnets. Similarly, in trade, sanctions diminish the volumes of trade between the isolated country and those initiating the sanctions. The sanctions thus interfere with what should otherwise be the natural flow of commodities across international boundaries. This paper thus advocates for the adoption of policies that are acceptable to the global political and economic order in order to be spared from the detrimental sanctions. The sanctions dummy fitted relatively well in the gravity model, providing an opportunity for future studies to open a new and exciting front that may be of immediate interest to Zimbabwe and other countries in similar circumstances.

The regional economic grouping, SADC, should promote greater trade opportunities between its member countries so that membership has visible benefits on the volumes of bilateral trade and ultimately the general well being of the people.

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