The Gravity Model
Of Trade Applied To Africa

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ABSTRACT

The gravity model states that trade between any two countries is proportional, other things equal, to the product of the two countries' GDPs, and diminishes with the distance between the two countries. The logic is that larger economies tend to spend large amounts on imports and attract large share of other countries spending (exports) because they produce large quantity and variety of goods and services. Distance, on the other hand, tends to lessen trade between countries because of transportation costs and other intangible barriers, such as language, geography, and historic colonial relationships. The following specific hypotheses from the gravity model of trade are tested with respect to African countries alone: The amount of exports by one African country to another is inversely related to the distance between the two countries, The amount of exports by one African country to another reflects the GDP of the country to whom the exports are sent, The amount of exports directly reflects a country's own GDP, and Countries associated with the same colonial power experience greater trade. Each of these hypotheses is tested with logarithmic forms of the variables in the hypotheses. While the resulting logarithmic model works is statistically significant and bears the correct signs, it does not show colonial patterns to be a strong as those found in other studies that are focused on inter-continental trade relationships. The significance of colonization in other studies may be a surrogate for the degree of development of nations. Since trade grows less than proportionately both with respect to the GDP of the importing nation and with respect to the GDP of the exporter, this study shows a disappointing trade impact of growth in the developing world on the potential development of Africa through export growth.

Keywords: Gravity Model, Development, African economic growth,

INTRODUCTION

    *T*he gravity model of trade has empirically been quite successful, even if its underlying theoretical justification has been disputed (Deardorf, 1998 and Anderson and van Wincoop, 2003). Trade flows increase with the incomes of the trading partners and diminish with the distance between the partners (for a recent example, Rose, 2004). However, many of the empirical verification of these effects are based on samples that include both developed and developing nations. The economic differences among these nations are so great that income is likely to be a surrogate for differences in degree of development, not the ability of income growth to stimulate trade.

The purpose of our investigation is to choose nations that are quite close to each other in distance and development to find if the gravity effects still persist. By eliminating trade between the developed nations and focusing on just the exports from developing nations it is possible to test if gravity effects might help developing nations pull each other forward to greater growth. Furthermore, it will be possible to see if a developing nation's own growth positions it to become a larger exporter. Finally, by focusing on Africa it is also possible to test if trade patterns still reflect the legacy of the colonial past. In section I, the gravity model is presented. In section 2, it is tested for 52 countries and with 272 trade pairings.

SECTION 1. THE GRAVITY MODEL

The gravity model hypothesizes that trade between any two countries rises with the GDPs of the two countries, and diminishes with the distance between the two countries. Distance, on the other hand, tends to lessen trade between countries because of transportation costs and other intangible barriers, such as language and geography. Following would be an equation representing these relationships:

$$T_{ij} = A * C_{ij}^{\alpha} * Y_i^{\,B} * Y_j^{\,\gamma} * D_{ij}^{\,\delta}$$

Where T_{ij} is value of trade between country I and j, "A" is a constant, is a dummy variable reflecting a colonial relationship of the exporter (i) to the importer(j), Y_i is GDP of the exporting country i, Y_j is GDP of the exporting country j and D_{ij} is the distance between countries i and j. The elasticities (greek symbols), which are all posited to be positive except for the coefficient on distance ($\delta < 0$), show the percentage change in trade that responds to a percentage change in the determinant.

Data for the value of exports to different trading partners (T_{ij}) as well as the GDP of different countries is readily available from the U.S. Central Intelligence Agency factbook (https://www.cia.gov/library/publications/the-world-factbook/geos/ao.html) and distances of capitals of the different countries are taken from an internet site (for example the site, http://www.convertunits.com/distance/from/Madagascar/to/italy, can be used to find the distance between Madagascar and Italy). While there have been many alternative methods for measuring distances (e.g. Helliwell and Verdier, 2001), we were able to have success with the relatively straightforward and easily reproducible distance between capitals.

SECTION 2. THE TEST OF THE GRAVITY MODEL

To test the equation with linear regression, logarithms are taken of the above expression. The test of the model indicates that the gravity model produces statistically significant results. Following is the EXCEL spreadsheet testing the results of our equation:

Table 1: Regression Results for the Gravity Trade Model

Regression Statistics					
Multiple R	0.657319				
R Square	0.432068				
Adjusted R Square	0.423592				
Standard Error	1.416848				
Observations	273				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	409.2962	102.324	50.97193	7.01E-32
Residual	268	537.999	2.007459		
Total	272	947.2951			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	-1.90154	0.846114	-2.24738	0.025429	
LGDPimporter	0.244406	0.056596	4.318459	2.21E-05	
LGDPExporter	0.74369	0.061764	12.04084	5.59E-27	
Ldist	-0.38608	0.127626	-3.02512	0.002727	
Colonial Empire 1939	0.363352	0.199215	1.823918	0.069278	

The equation shows that 43% of the variation in African nation exports can be explained by the gravity model which is highly significant according to the F-statistic ($F_{4,268} = 51.0$). Each of the hypothesized relationships is confirmed. Both the income of the importer (LGDPimporter) and income of the exporter (LGDPExporter) are significantly and positively related to the logarithm of exports at better than a .00001 level of significance.

Particularly interesting is that the elasticities of export are below 1.0 for both imports and exports, but more so for imports! Exports rise by a much a smaller percentage (the elasticity coefficient is only .24) than the percentage rise in income of the importers. As countries become richer they may be importing from more developed countries, rather than the developing countries. Furthermore, exports do not grow proportionally with the GDP of African exporters. Exports rise by a smaller percentage (the elasticity coefficient is.74) than the percentage rise in income of the exporters. Both of these effects suggest that growth of African countries do not help trade with other African countries, but actually dampen its relative importance. These results contrast with those of Rose (2004) who actually finds the elasticity is close to 1.0 with an additional positive elasticity when per capita GDP rises-suggesting an acceleration of trade with respect to higher income. Since Rose includes the trade between the developed countries while this study does not, the difference between the two studies suggests that growth favors the developed countries, not the developing ones.

As expected, the logarithm of the distance (Ldist) is negatively related to the logarithm of exports. However, the negative impact diminishes as distance grows as indicated by the negative elasticity between 0 and -1.

The hypothesis that a former colony trades more (i.e. it is a one-tail hypothesis) with its colonial owner in 1939 is confirmed at a 95% confidence level (P-value= .0346), confirming the results of Grier (1999) and Acemoglu et. al. (2001). Although not reported here, weaker results were found if the dummy variable was defined for colonies as they existed in 1914, prior to the First World War, rather than prior to the Second World War.

While the hypotheses were all verified, the results reported in a sample focused on African nations alone are not as strong as those reported when a wider sample of developed nations are included. Rose (2004) achieves R-squared values as high as .70 in similarly specified models while Tomz et. al. (2007) reach .85. However, several additional variables accounting for the border and landlocked nature of a country, status with respect to the World Trade Organization and/or GATT, and other variables were included in both models. When the experience of the more developed countries are withdrawn from the sample, the gravity model becomes much weaker.

CONCLUSION

Examining gravity models within specific regions provides a potentially useful area of exploration. Such focused studies can isolate the tendency of developed countries to trade with each other. Furthermore, as developing countries emerge into developed countries, they are likely to reorient their trade to the developed countries, rather than continuing trade with those countries that have not emerged.

Nevertheless, in the gravity model applied to Africa the results suggest that developing countries can expect gravity effects to be at work if they are able to grow. Countries that grow can expect to export more. As trading partners grow, exports of a country will grow. Distance works in favor of trading partners from the same continent or region. Old trading relationships, such as historical colonial relationships, can still be perceived even seventy years later, but statistically these relationships appear only weakly.

AUTHOR INFORMATION

Dr. Michael Tansey is professor of Economics at Rockhurst University. He has done extensive economic analysis in consulting projects, particularly in telecommunications, banking, public utilities and health care. He has published studies of interest rate ceilings in real estate lending, fiscal impact analysis for local planning, protectionist policies in the steel industry, and the effects of price regulation. After his training at Harvard College (Class '70) he served as an intern in the Office of Emergency Preparedness (the predecessor to FEMA) where he did extensive work on disaster planning using input-output analysis and conducted a study on building codes. He then participated as an economic analyst in all four phases of the Nixon price control programs (71-74). His graduate work from the University of Wisconsin (Ph.D. '78) included a year (76-77) of study and research at the Brookings Institution. He has since served in acadaemia, developing an international curriculum for an Executive MBA program and an MBA program for medical students and physicians. For this latter work he received an honorary degree (03) from the Kansas City University of Medicine and Bioethics.

Alhagie Touray is a senior in the Rockhurst Honor's program. He received the Dean's Undergraduate Fellowship for Research. His project and careful research on Africa reflects his interest in and his experience with Gambia.

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