What can gravity tell us about Africa's export performance?

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Gravity models are a workhorse employed by economists to analyse trade flows between countries. Based on the Newtonian concept, they seek to describe patterns of trade between two countries in terms of their size and the distance between them. Some worry that Africa does not export enough because its policies make trade hard (difficult). The gravity framework can be used to estimate the impact of a variable of interest, for example tariffs or trade infrastructure, on trade. The framework can also be used to see whether Africa exports a lot or a little relative to its peers.

After introducing the gravity model, this note selectively discusses some issues that may impede exports from Africa. It shows that after one has accounted for the basic elements of the gravity model, namely that Africa has a low GDP and far from attractive markets, an African country does not export less than any other country. Showing this will hopefully illuminate the utility of this basic model in examining Africa's trade levels. However, this article concludes with a brief discussion of gravity models, cautioning that they do not tell us about trade performance.

Since Tinbergen (1962), economists have studied international trade patterns using so-called gravity models. Fifty years is a long time in economics, but, of course, the Newtonian origins go back much further. Those who did secondary-school physics may recall that the gravitational pull between two objects is proportional to their mass and inversely proportional to the (squared) distance between them. Instead of mass, think of country size as the value of its goods and services. Instead of measuring gravitational pull in Newtons, think of the trade between those two countries in monetary terms. For the time being, distance is in kilometres.

This forms the basis for a theory to explain the size of export flows. A simple gravity model for exports from country 1 to country 2 would then be expressed as follows:

$$Exports_{12} = \beta_0+\beta_1*GDP_1 + \beta_2*GDP_2 -\gamma*distance +u_{12} \quad \text{(equation 1)}$$

All variables are in logs. Gross Domestic Product (GDP) measures country size and u_{12} is an 'error' term, which captures all other potential factors influencing exports from country 1 to country 2. Economists are typically interested in estimating the coefficients given by the Greek letters using statistical methods ('econometrics'). To do this, they take data on those variables for every country pair[1] and apply an 'estimator', which is a rule used to determine how to calculate the coefficients. A common method, 'ordinary least squares', uses linear algebra to find those values that minimise the unexplained variation in exports across all countries.

Figure 1 gives the output representative of what an econometrics package would produce when asked to do this.[2]

[1] For example, if there are 100 countries and everyone trades with everyone else, there would be 100*(100-1) = 9,900 observations.

[2] The export data are from the IMF's *Direction of Trade Statistics* while the GDP figures are from the World Bank's *World Development Indicators*.

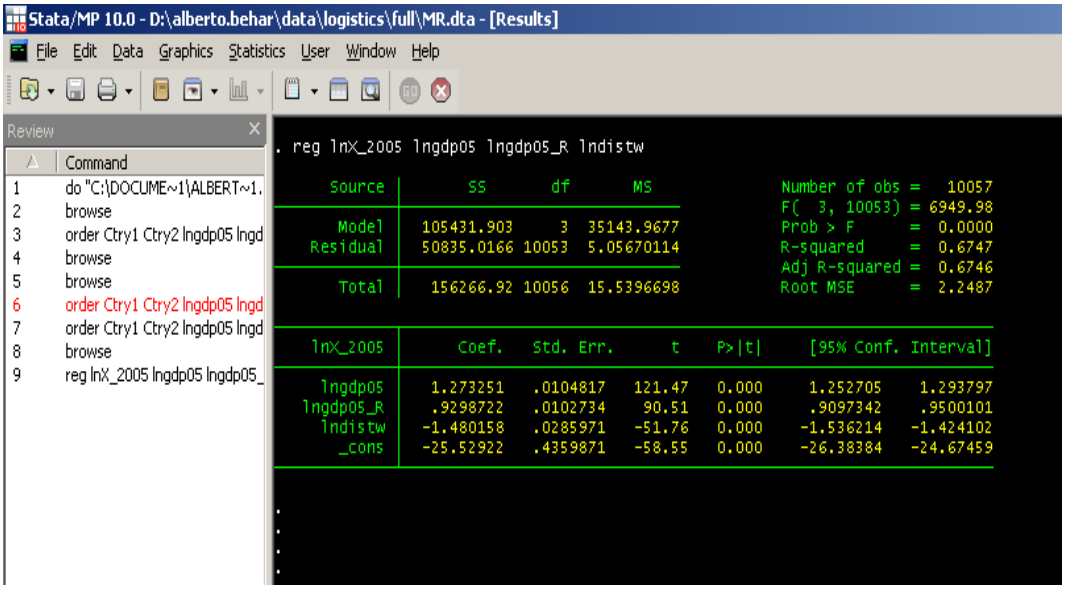

Figure 1: Computer output of an estimate of a gravity model (equation 1). lngdp05 is the exporter's GDP, lngdp05_R is the importer's GDP and lndistw is the distance between them. All variables are in logs. The results suggest trade flows are higher if GDP is higher and the distance between two countries is lower. Alberto Behar (2009).

Substituting in the values from the figure into equation 1, we can predict values for exports as:

$$Exports_{12}^{predicted} = -25 + 1.27*GDP_1 + 0.93*GDP_2 - 1.48*distance \quad \text{(equation 2)}$$

The statistics back up the theory; we see exports between two countries are bigger if (i) the exporter is bigger, (ii) the importer is bigger or (iii) the distance between them is smaller. For example, the coefficient on distance implies that a pair of countries that are 10% closer will tend to trade 14.8% more.

What about Africa? The World Bank (2006) documents that Africa's share of world trade has fallen from more than 6% in 1980 to barely 2% in 2002 (it has subsequently stabilised). Many worry that this drop in world trade participation is bad and seek to find explanations for it.

Gravity models are often employed as an aid. Distance need not only refer to physical distance; the actual time and difficulty inherent in transporting goods depends on other geographical aspects. Limão & Venables calculate that landlocked countries export less because transport costs are 55% higher. Gallup, Sachs & Mellinger (1999) suggest such countries are particularly vulnerable because their coastal neighbours may have military or economic incentives to impose costs on them deliberately. As emphasised by Collier (2007), this is particularly relevant for Africa because it has a disproportionately high number of landlocked countries.

In a practical sense, distance can also be a function of man-made technological features, like the quality of roads, ports or general trade logistics (Behar, Manners & Nelson, 2009). However, it is no good having a shiny new road if it means you spend longer waiting to load your goods on to a ship because the customs clearance office is on its tea break. The ability to clear goods across bureaucratic hurdles can also facilitate exports. Djankov et al (2006)

contrast Denmark – it takes two signatures, three documents and five days to get goods from the factory gate onto a ship – with Burundi, where it takes 29 signatures, 11 documents and 67 days.

Empirical work typically uses gravity models to measure the impact of the phenomena discussed on exports. Variables to capture all these features have been added to specifications such as equation 1 and have been shown to influence trade levels. However, what we will see next is that the basic elements of the gravity model can already tell us a great deal.

Africa's GDP is a small share of world GDP. In 2004, sub-Saharan Africa's trade to GDP ratio (66%) was actually above the world average of 52% (Behar & Manners, 2009). Furthermore, Sub-Saharan Africa is distant from the big/rich markets and is close to small/poor markets (including other African countries). Contrast this with North Africa or Eastern Europe, which are both close to big Western European markets.

Given the typical African country is small and remote, can that explain its low export values? We add one variable to equation 1 and re-estimate the model to get:

$$Exports_{12}^{predicted} = -25+1.27*GDP_1 + 0.93*GDP_2 - 1.48*distance - 0.03*Africa \quad \text{(equation 3)}$$

Africa is a dummy variable[3] which equals 1 if the exporter is in Africa and 0 otherwise. The coefficient is close to zero (and is indistinguishable from zero in a statistical sense). Were we to find a large negative coefficient, then we would conclude that Africa trades relatively little. Then one could investigate further and point to the candidates indicated above. However, the result in equation 3 implies that, once we control for GDP and distance, Africa does not typically export less than other countries.

The analysis may be informative but it not entirely satisfactory. We have seen that gravity can be used to benchmark Africa against the rest of the world and that the coefficient of zero implies it is on a par. Does that mean it is performing well? Should it be trying to match its peers in the first place? Furthermore, it is not clear what a strong positive coefficient on the Africa dummy would imply. Would it mean that Africa is 'outperforming' the rest of the world or would it mean that it is exporting 'too much'? We don't know because gravity models do not tell us what the optimal level of trade is. This is because the theoretical foundations are not designed to tell us why exports (or trade in general) are good. People often fret about trade performance because they think it affects GDP growth. In fact, many studies on the determinants of GDP growth have trade measures as an explanatory variable. In other words, GDP and trade measures would swap places in the equations, which raises the question of cause and effect.

Controlling for GDP and distance may establish that poor trade policies are not necessarily to blame, but attributing low African exports to its low GDP does not mean we shouldn't worry about it. That would be akin to dismissing malnutrition as a problem because its cause is low GDP. The statement 'African malnutrition is not so bad given how poor it is' is a statement that most would find both crass and unproductive. (One might then want to address the issue of whether malnutrition should be addressed directly or through general improvements in GDP.)

[3] It is often joked that "Economists like to do it with dummies". St Anne's economics students will know that this particular economist likes to use the Ribena dummy in tutorials.

We may want to consider this analogue for exports, but we would be getting ahead of ourselves. Some may first want to discuss why free trade is good. Now is not the time to explain why but it is the time to summarise what has been said. The gravity model seeks to account for trade flows (or just exports) between countries in terms of their size and the distance between them. Gravity can tell us Africa is exporting as much as everyone else, given its low GDP and distance from places with high GDPs. However, gravity cannot tell us what the optimum level of trade is and hence cannot be used to evaluate Africa's export performance.

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