Estimating Protectionism through Residuals from the Gravity Model

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Introduction

Countries do all sorts of things to distort trade. For instance, most rich countries place barriers to trade in textiles and agricultural goods. Although this protectionism hurts consumers inside rich countries, it also harms the poor countries which are natural exporters of these goods. Nevertheless, most of the damage done by distorted trade is done not *to* poor countries but *by* poor countries. In this short section, we estimate the effect of trade barriers on trade in the developing world, including the effects of *all* trade-distorting barriers.

Protectionism lowers trade. The question is: how much? In principle, we would like to see how much lower trade actually is a result of protectionism than it would be otherwise. In other words we need to model international trade and compare the model's predicted output to actual trade. If most trade is unrestricted and the result of forces which naturally drive trade, then a finding that a country's trade is consistently lower than predicted by the model is consistent with the idea (and probably implies) that the country's barriers to trade are responsible for the underperformance. So we need an empirical model of international trade.

The Gravity Model of International Trade

The "gravity" model is a very simple empirical model that explains the size of bilateral international trade between countries. The model has a lineage that stretches back to Jan Tinbergen, the co-winner of the first Nobel Prize in economics. It models the flow of international trade between a pair of countries as being proportional to their economic "mass" (read "national income") and inversely proportional to the distance between them (literally interpreted). The gravity equation acquired its name since a similar function describes the force of gravity in Newtonian physics.

The gravity model of international trade has a remarkably consistent (and thus, for economics, unusual) history of success as an empirical tool. The elasticities of trade with respect to both income and distance are consistently signed correctly, economically large, and statistically significant in an equation that explains a reasonable proportion of the cross-country variation in trade. Indeed in their recent survey on the empirics of international trade in *The Handbook of International Economics*, Leamer and Levinsohn (1995, p. 1384) describe the gravity model as having provided "… some of the clearest and most robust empirical findings in economics."

If it works in practice, can it work in theory? Yes. While originally an entirely empirical model, the gravity model can now claim theoretical foundations. In fact, numerous theoretical aspirants have claimed the singular empirical success of the gravity model. These include: the 'Armington' model of nationally differentiated goods; models with increasing returns and monopolistic competition; models with national technological differences; 'reciprocal dumping' models of homogeneous goods; and models with internationally varying factor endowments.

Which particular theoretical model best describes the empirical findings of the gravity model is a matter of some dispute. But that is irrelevant here. All one needs to know is that the gravity model stands proudly on both theoretical and empirical legs.

The gravity model used below is augmented in that the standard gravity model only includes (the natural logarithms of) income and distance variables. In order to account for as many other factors as possible, the equation adds a host of extra conditioning variables which might affect trade. These account for potentially important cultural phenomena (e.g., whether the countries share a common language), the geographic nature of the countries (e.g., whether none, one or both are landlocked), and the historical nature of the relationship between the countries (e.g., whether one colonized the other). The idea is to control for as many important effects on trade as possible, so that whatever is left over is mostly the result of artificial barriers to trade.

The exact specification of the gravity model we use is:

$$\ln(X_{ijt}) = \beta_0 + \beta_1 \ln D_{ij} + \beta_2 \ln(Y_i Y_j)_t + \beta_3 \ln(Y_i Y_j / Pop_i Pop_j)_t + \beta_4 Lang_{ij} + \beta_5 Cont_{ij}$$
$$+ \beta_6 Landl_{ij} + \beta_7 Island_{ij} + \beta_8 \ln(Area_i Area_j) + \beta_9 ComCol_{ij} + \beta_{10} CurCol_{ijt}$$
$$+ \beta_{11} Colony_{ij} + \beta_{12} ComNatij + \beta_{13} CU_{ijt} + \Sigma_k \beta_{14,k} FTA_{ijt,k} + \Sigma_t \phi_t T_t + \varepsilon_{ijt}$$

where i and j denotes countries, t denotes time, and the variables are defined as:

- X_{ijt} denotes the average value of real bilateral trade between i and j at time t,
- Y is real GDP,
- Pop is population,
- D is the distance between i and j,
- Lang is a binary variable which is unity if i and j have a common language,

- Cont is a binary variable which is unity if i and j share a land border,
- Landl is the number of landlocked countries in the country-pair (0, 1, or 2).
- Island is the number of island nations in the pair (0, 1, or 2),
- Area is the land mass of the country,
- ComCol is a binary variable which is unity if i and j were ever colonies after 1945 with the same colonizer,
- CurCol is a binary variable which is unity if i and j are colonies at time t,
- Colony is a binary variable which is unity if i ever colonized j or *vice versa*,
- ComNat is a binary variable which is unity if i and j remained part of the same nation during the sample (e.g., France and Guadeloupe, or the UK and Bermuda),
- CU is a binary variable which is unity if i and j use the same currency at time t,
- FTA_k is a binary variable which is unity if i and j both belong to regional trade agreement k,
- $\{T_t\}$ is a comprehensive set of time fixed effects,
- β and ϕ are vectors of nuisance coefficients, and
- ε_{ij} represents the myriad other influences on bilateral exports, assumed to be well behaved.

Data Set and Methodology

The data set we use relies on the IMF's "Direction of Trade". The data set covers bilateral trade between over 230 trading partners between 1948 and 1999 (with gaps). Not all of the areas covered are countries in the conventional sense of the word; colonies, dependencies, territories, overseas departments, and so forth are all included. Bilateral trade on FOB exports and CIF imports is recorded in American dollars; we deflate trade by the American CPI. We create the dependent variable by taking the natural logarithm of the average value of bilateral trade between a pair of countries.

We add population and real GDP data (in constant dollars) from standard sources: the Penn World Table, the World Bank's *World Development Indicators*, and the IMF's

International Financial Statistics. We exploit the CIA's *World Factbook* for a number of country-specific variables. These include: latitude and longitude, land area, landlocked and island status, physically contiguous neighbors, language, colonizers, and dates of independence. We use these to create great-circle distance and our other controls. We obtain data from the World Trade Organization to create an indicator of regional trade agreements, and include: ASEAN, EEC/EC/EU; US-Israel FTA; NAFTA; CARICOM; PATCRA; ANZCERTA; CACM, SPARTECA, and Mercosur. Finally, we add information on whether the pair of countries was involved in a currency union.

We follow a simple two-step empirical strategy. *First*, we estimate the gravity model (using least squares with time-specific "fixed" effects, and computing standard errors which are robust to clustering by country-pairs). *Second*, we average the estimated residuals for various countries to measure protectionism for six different regions of the developing world. We perform extensive robustness checks to confirm that the results are not only sensible but insensitive to the exact econometric methodology.

More details on the data set, as well as the data set itself (and the regression output discussed below) are available at http://faculty.haas.berkeley.edu/arose.

Results

Estimates of the gravity model appear in the top panel of Table 1. The results are presented in three columns which add successively more controls to the gravity equation to account for more potential causes of international trade. Unsurprisingly, the standard features work well. The smaller the distance between two countries and the higher their combined GDPs, the higher their trade. Both coefficients are not only economically reasonable but highly

statistically significant. Countries with higher real GDP per capita trade more. Sharing a land border, a language, a currency, or a regional trade agreement also increase trade by economically and statistically significant amounts. Land-locked and physically large countries trade less, while islands trade slightly more. Ex- and/or current colonies trade more with their colonizers, as do countries with the same colonizer. The equations fit the data relatively well, explaining around three-fifths of the variation in bilateral trade.

--- Table 1 about here ---

Still, the gravity model is not of intrinsic interest to us; it is merely the benchmark we use to compare with actual trade. The bottom panel of Table 1 averages the residuals from the estimated equation for six different geographic regions in the developing world: Sub-Saharan Africa; East Asia; South Asia; the Caribbean; Latin America; and the Middle-East and North Africa. The *sign* of the average residual indicates whether the countries in the region typically trade more (+) or less (-) than the rest of the world; since the gravity model of trade accounts for so many "natural" causes of trade, we associate the remaining with trade policy. The *size* of the average residual quantifies this effect. Thus, the last entry at the left of Table 1, indicates that the log of trade is .24 (≈24%) *lower* when at least one of the trading partners is from the Middle East or North Africa trades. That is, countries from the Middle East and North Africa trade about a third less than otherwise identical countries. While there is considerable variation within the group (the standard deviation is in fact 2.14), there are so many observations (37,245 actually) that the mean residual is lower than average at any conventional level of statistical significance (hence we omit standard errors).

What do the results indicate? Two regions of the world – Sub-Saharan Africa and East Asia – trade more than would be predicted from the augmented gravity model, while the other four regions – South Asia, the Caribbean, Latin America, and the Middle East/North Africa – trade less. These effects are intuitive, economically large, statistically significant, and robust to the exact specification of the gravity model. Trade that involves at least one country from Sub-Saharan Africa is around twelve percent higher than it would be for otherwise identical countries outside Sub-Saharan Africa; trade involving at least one East Asian country is even higher (around seventeen percent) above average. But trade involving countries from the Caribbean or South Asia is almost half its predicted level, while trade from Latin America, the Middle East and North Africa is almost a quarter below average trade. This is strong *prima facie* evidence of strong protectionism in the Americas, the Middle East, North Africa, and South Asia.

Results from most econometric investigations are notoriously sensitive to the exact methodology. However, that is not true in this case. Table 2 contains results from a default model, and six perturbation of the basic methodology. The default model – at the extreme left of the table – is the equation listed above (also the equation tabulated at the right-hand side of Table 1, but allowing for different coefficients for each of the ten different regional free trade arrangements). Next to it, we show the results when we drop all data from before 1980, re-estimate the gravity equation, and average the new residuals. While this clearly lowers the number of observations available, the results do not seem very sensitive to the exact time period used.

--- Table 2 about here ---

In successive columns, we add extra controls which might explain why trade in certain regions differs from that in others. First we add controls for the number of primary non-fuel commodity and fuel exporters.[1] Next we add controls for the specialization/concentration of both total exports and manufacturing exports.[2] Then we add controls for trade structure, in an attempt to account for whether trade is mostly intra- or inter-industry in nature.[3] But despite the addition of these extra controls (with resulting changes in the sample from missing data), the results remain robust.

At the right-hand side of the table are two final sensitivity checks. First, we model year-effects as random; second, we move from the annual frequency to taking non-overlapping five-year averages of the data. Again, the results are not much affected by these robustness experiments.

We conclude that the results are not only economically and statistically significant but also insensitive to the exact nature of the econometric methodology.

Given the size of the effects, it is interesting to probe further. In Table 3, we investigate whether the apparently strong signs of protectionism are mostly the signs of reduced trade within the region or between countries inside and outside the region. Usually the effects on trade of both countries being in the same region are larger than if only one of the countries is from the region. For instance, if one of the trading partners is from Sub-Saharan Africa, trade is ten

[1] That is, we add two dummy variables: the first is one if one of the countries was a non-fuel primary commodity exporter, two if both countries were, and zero otherwise; the second dummy variable is the analogue for fuel exporters. A country is classified as a primary non-fuel commodity exporter if at least half its exports came from SITC codes 1,2,4, and 68 using the UNCOMTRADE data set, which exists from 1970 on. A country is classified as a fuel exporter if at least half its exports came from SITC code 3.

[2] In particular, we add the natural logarithm of the product of the two countries' Herfindahl-Hirschmann trade concentration indices (one each for total trade and manufacturing trade). These data again come from UNCOMTRADE.

[3] In particular, we add the natural logarithm of the product of the two countries' Grubel-Lloyd intra-industry trade indices (one each for total trade and manufacturing trade). These data again come from UNCOMTRADE.

percent (.10) higher than predicted by the gravity model; if both countries are from the region, trade is higher by 28%. The only exception is the Caribbean, where trade is only sixteen percent lower than expected if both countries are from the region, but 45% lower if both countries are. Aside from this, there is only weak evidence of any inter- vs. intra-regional trade bias.

--- Table 3 about here ---

Finally, in Table 4, we ask whether there are trends in regional protectionism. To do this we add to the default gravity equation six intercepts (1 for each region, as before), and six trend terms (again, one for each region). It is often difficult to disentangle level from trend effects, so the estimates in Table 4 should be interpreted cautiously. Still, it is striking that all six of the trend coefficients are negative, most significantly so. The exception is East Asia, for which there is no significant evidence of low trade and hence protectionism. South Asia is also unusual in that both the level and trend effects are negative, providing strong evidence of protectionism. In the latter case, trade involving at least one country from South Asia is not only 27% below average but tending to fall at the rate of 1.3% annually. Since the level effect from Latin America is insignificantly different from zero, only the negative trend effect of falling trade is of relevance. The evidence from the three other regions (Sub-Saharan Africa, the Caribbean, and the Middle East and North Africa) is more difficult to understand since the positive level effect offsets some or all of the negative trend effect.

To summarize, deviations from the gravity model of seem to be a sensible way of estimating the effects of protectionist barriers to international trade. The results indicate that Sub-Saharan Africa and (especially) East Asia trade disproportionately more than expected from

the gravity model. On the other hand, South Asia, the Caribbean, Latin America, and the Middle East and North Africa trade much less than expected. Since the gravity model accounts for most of the natural barriers to trade, it is reasonable to associate this trade-underperformance with trade barriers. These have an economically significant effect on trade, lowering trade by almost half in South Asia and the Caribbean, and almost a quarter in the other two regions. The effects are statistically as well economically significant, and relatively insensitive. There is little evidence of intra-regional trade bias, but some worrying evidence indicating that trade is shrinking over time.

Conclusion

While most economists believe that protectionism reduces income, growth, and welfare, this view is by no means universally shared. Extending the effects from trade to these other phenomena is beyond the scope of this note. Still, the gravity model shows a strong and robust conclusion; much, though not all of the developing world, has substantially lower trade. Since the pattern of this reduced trade accords with anecdotal evidence, it seems clear that trade barriers substantially and harmfully lower the trade of developing countries.

Table 1: Estimates of the Gravity Equation and Implied Protection from Residuals

Log Distance	-1.17 (.02)	-1.16 (.02)	-1.10 (.02)
Log Product Real GDPs	.93 (.01)	.92 (.01)	.93 (.01)
Log Product Real GDP/capita	.37 (.01)	.40 (.01)	.39 (.01)
Common Language	.60 (.04)	.36 (.04)	.33 (.04)
Common Land Border	.49 (.12)	.47 (.12)	.46 (.11)
Number Landlocked	-.22 (.03)	-.21 (.03)	-.20 (.03)
Number Islands	.09 (.04)	.07 (.04)	.06 (.04)
Log Product Land Areas	-.10 (.01)	-.09 (.01)	-.09 (.01)
Common Colonizer		.58 (.07)	.46 (.07)
Current Colony		1.32 (.26)	.86 (.25)
Ever Colony		1.36 (.13)	1.32 (.13)
Same Nation		-.23 (1.11)	-.16 (1.01)
Currency Union			1.25 (.13)
Regional Trade Agreement			.90 (.12)
R^2	.63	.64	.64
RMSE	2.029	2.014	2.006

Average Residual when at least one country is:

Sub-Sahara African	.12	.11	.11
East Asian	.16	.18	.17
South Asian	-.44	-.47	-.46
Caribbean	-.43	-.41	-.43
Latin American	-.23	-.21	-.23
Middle-Eastern or North African	-.24	-.23	-.19

Intercept and year controls not recorded.
Regressand is log real trade. Sample size = 234,597. OLS estimation.
Standard errors robust to country-pair clustering recorded in parentheses.
Annual data for 178 "countries" 1948-1999.

Table 2: Estimates of Protectionism from Residuals of the Gravity Equation

	Default	1980s and 1990s only	Add Controls for Commodity Exporters	Add Controls for Export Specialization	Add Controls for Trade Structure	Random Year Effects	Five-Year Averages
Sub-Sahara Africa	.12	.08	.14	.20	.19	.10	.15
East Asian	.14	.21	.25	.25	.22	.12	.13
South Asian	-.46	-.51	-.52	-.45	-.52	-.46	-.45
Caribbean	-.43	-.46	-.42	-.38	-.47	-.44	-.44
Latin American	-.25	-.23	-.26	-.23	-.21	-.23	-.27
Middle-Eastern or North African	-.19	-.31	-.11	-.13	-.16	-.20	-.17
Observations	234,597	134,929	141,463	115,757	123,672	234,597	46,742

Average residuals from default gravity regression.
Annual data for 178 "countries" 1948-1999.

Table 3: Estimates of Protectionism from Residuals of the Default Gravity Equation

How much is trade affected when one or both countries are from the region?

	One	Both
Sub-Saharan Africa	.10	.28
East Asian	.11	.66
South Asian	-.45	-.99
Caribbean	-.45	-.16
Latin American	-.24	-.36
Middle-Eastern and North African	-.15	-.79

Average residuals from regression of log trade in gravity regression.
Annual data for 178 "countries" 1948-1999.

Table 4: Adding Trends and Regional Effects to the Default Gravity Equation

	Level Effect	Trend Effect
Sub-Saharan Africa	1.03 (.11)	-.032 (.003)
East Asian	.04 (.11)	-.004 (.003)
South Asian	-.27 (.13)	-.013 (.003)
Caribbean	.62 (.12)	-.042 (.003)
Latin American	.10 (.10)	-.020 (.002)
Middle-Eastern and North African	.35 (.10)	-.021 (.002)

Intercept, year and other controls not recorded.
Regressand is log real trade.
Standard errors robust to country-pair clustering recorded in parentheses.
Annual data for 178 "countries" 1948-1999.