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Oilseed Trade Flows: A Gravity Model Approach to Transportation Impacts

Ying Xia[a①], Jack Houston[b], Cesar Escalante[c] and James Epperson[d]

[a] *Former Graduate Research Assistant, Department of Agricultural and Applied Economics, University of Georgia, Athens, GA, 30602 USA,* yingxiaga@gmail.com

[b] *Professor, Department of Agricultural and Applied Economics, University of Georgia, Athens, GA, 30602 USA Email* jhouston@uga.edu

[c] *Associate Professor, Department of Agricultural and Applied Economics, University of Georgia, Athens, GA, 30602 USA Email* cescalan@uga.edu

[d] *Professor, Department of Agricultural and Applied Economics, University of Georgia, Athens, GA, 30602 USA*
Email: epperson@uga.edu
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Abstract

Oilseeds and oilseed products are vital commodities in international trade, and production has been rapidly expanded in recent years under the yield growth and demand characteristics linked to more income-elastic products. Of the global production for major oilseeds, which reached 395.2 million metric tons in 2009, three major producers – the United States, Brazil and China – account for almost 50 percent. This paper develops a broad trade framework to estimate the impacts of transportation costs on international oilseeds trade using gravity models. We describe export and import markets of oilseeds and derived vegetable oils. A Baier and Berstrand gravity model method (2009), using a Taylor-series expansion, reveals a theoretical relationship between incomes, trade flows and trading costs through a reduced-form gravity specification. Distance between two countries and border trade barriers have significant and substantive impacts on the trade value of oilseeds and oilseeds oils.

Keywords: oilseeds trade, gravity models, transportation costs

Introduction

The international oilseeds trade sector exhibits relatively complex flows, as oilseeds can be processed to use as edible food products or crushed to produce vegetable oils and feed meals, providing multiple final uses in the food, feed and associated industries. Five major oilseeds are produced world-wide: soybeans, cottonseeds, rapeseeds/canola, peanuts and sunflower seeds. Oilseeds production has rapidly expanded in recent years under the yield growth and demand characteristics linked to the more income-elastic products, reaching 395.2 million metric tons in 2009, with three major producers: United States, Brazil and China. This study constructs a simplified but comprehensive trade framework of oilseeds and oilseeds oils. The impacts of transportation costs and border barriers on internationally traded oilseeds and derived oils are then estimated using gravity models.

WORLD OILSEEDS PRODUCTION AND CONSUMPTION PATTERNS

Production of the five major oilseeds crops rose from 159.4 million hectares (m ha) in 1996 to peak at 198.7 m ha in 2006 before declining to 192.8 m ha in 2007. The United States (USA) has long been the leader in oilseeds production (USDA/FAS). China, second before 2002, was replaced by Brazil in order of production, and is currently followed by Argentina, India, the EU-27 and Canada. The USA, Brazil and China accounted for 64% of this world production in 2008. Oilseeds consumption includes two parts: oilseed oils and oilseed meals. China is the world's largest consumer of major oilseed oils, with its total oil consumption reaching 24.55 million tons and accounting for about 19% of total world consumption in 2008. The EU-27 trailed only China in consumption of major oilseed oils, estimated to be 23.23 million tons in 2009 (USDA, 04/2009). After EU-27, the major countries of oilseed oil consumption are India, the USA, Indonesia, Malaysia, Brazil, Japan, Mexico and Argentina. The EU-27 total protein meal consumption reached 52.13 million tons and accounted for about 23% of world total consumption in 2008. China trailed only the EU-27 in consumption of major protein meals at 49.53 million tons in 2008. After China, the major countries for consumption of protein meals are the USA, Brazil, India, Japan and Mexico. S Soybean meal consumption is far the largest of the protein meals. It is generally the highest in protein quality and highest in overall nutrient content of the commonly used plant proteins. Soybean meal has become a staple in poultry diets, and in the USA, the poultry industry is the biggest user of soybean meal, consuming about 54 percent of all USA soybean meal.

WORLD OILSEED EXPORTS/IMPORTS

With the increased production and consumption noted, oilseeds and oilseeds products have become one of the largest sectors in international trade. The amount of soybeans exported is the largest of the five major oilseed exports, increasing from 45.55 million tons in 1999 to 79.52 million tons in 2009. Exports of rapeseed, cottonseed, peanut and sunflower seed have been relatively stable between 1999 and 2008. The export of rapeseed was the second largest export in the world market, with lows of 4.11 million tons in 2002 and with the high export at 11.91 million tons in 2008 ("Oilseeds: World Markets and Trade", FAS, USDA).

The USA has been the premier exporter of oilseeds over the past several years, followed by Brazil, Canada and Argentina. Despite substantial production growth in the past 25 years and recent gains in export volume, the USA share of global exports has steadily decreased. The USA dominated world trade in unprocessed oilseeds in the mid to late 1970s, with a global market share of more than 70%. Recently, however, it has fallen below 50% (USDA, 2010). The main export markets for the USA are China, Mexico, Canada and Japan.

GRAVITY MODELS, DATA AND SPECIFICATIONS

Anderson (1979) first proposed and derived a gravity model by taking into account the effect of price. Helpman (1987) applied the gravity model framework and gave it an alternative characterization on the role of size of different countries, and he tested the model on several OECD countries. Bergstrand (1985) generalized the microeconomic foundations of the gravity model, and later, he extended them to introduce relative factor endowment differences and non-homothetic tastes (Bergstrand, 1989). Baier and Bergstrand (2001) estimated the effects of income convergence, income growth, transportation cost reductions and tariff declines on bilateral trade flows in OECD countries.
McCallum (1995) estimated the gravity equation:

$$\ln x_{ij} = a_1 + a_2 \ln y_i + a_3 \ln y_j + a_4 \ln d_{ij} + a_5 \delta_{ij} + \varepsilon_{ij} \quad (1)$$

where are exports from country i to country j; and are gross domestic production in country i and j; is the distance between country i and j; and is a dummy variable equal to one for inter-provincial trade and zero for state-province trade. The significant implication of this theoretical gravity model is that trade between countries is determined by relative trade barriers. Three general-equilibrium comparative implications found include: trade barriers reduce trade volume between large countries more than between small countries; trade barriers increase trade volume within small countries more than within large countries; and, trade barriers increase the ratio of trade within country 1 relative to size-adjusted trade volume between countries 1 and 2 by more the smaller is country 1 and the larger is country 2 (McCallum, 1995).

A second approach uses estimated border effects to measure price effects. Anderson and van Wincoop (2003) found that estimated gravity models do not have a sound theoretical foundation, suffering from omitted variables bias and comparative statics analysis. In order to resolve such problems, they developed a method that efficiently and consistently estimated a theoretical gravity equation, and they used an estimated general equilibrium gravity model to conduct comparative statics and to resolve the border puzzle. The drawback of using the method of Anderson and van Wincoop (A-vW) is the custom programming requirement to obtain standard errors. Their strategy used fixed effects to take account of the unobserved price indexes.

Baier and Bergstrand (2009) suggest a method for "approximating" the Multiple Resistance (MR) terms based on theoretically approximating international trade-cost effects. Using a Taylor-series expansion, they reveal a relationship between income, trade flows and trade cost by a reduced-form gravity equation, which is based on the model of A-vW (2009). While the A-vW model solves the demand for trade from country i to country j by maximizing the utility function subject to budget constraint, Baier and Berstrand (B-B) apply a first-order, log-linear Taylor-series expansion to equations of and to obtain a reduced-form gravity equation. They then use OLS to estimate the reduced-form equation. To confirm their theory, coefficient estimates for lnDIS and MRDIS are restricted to have identical but oppositely-signed coefficient values (Baier and Bergstrand, 2009).

Trade value data on oilseeds for 2009 were obtained from United Nations Commodity Trade Statistics Database (UN comtrade) http://comtrade.un.org/db/. Standard International Trade Classification (SITC) continues to be used by many countries and organizations, and for this study, we used SITC Revision 3 in the category oilseeds.

To compare the different specifications, we focus on trade patterns for a set of 22 countries for 2009. There are potentially 22*21=462 individual trade flows between the 22 countries of origin (exporters) and the 22 countries of destination (importers). We use oilseed trade value expressed in USA dollars as an indicator of the bilateral trade volume, such that each pair of countries yields two observations, each country being both an exporter and an importer. We use reported exports rather than reported imports, as the former provides a better coverage (Burger et al., 2009). The primary trade countries are USA, Canada, China, Argentina, Brazil, the EU-27, India, Japan, Mexico Australia, Colombia, Egypt, Indonesia, Malaysia, New Zealand, Pakistan, Russian Federation, Singapore, South Africa, Spain, Thailand and Turkey.

Despite the rapid growth in world trade of oilseeds, barriers of physical distance, institutional frameworks, culture and economic policy still generate considerable costs to international trade (Anderson and van Wincoop, 2004). Gross Domestic Product (GDP) data were obtained from the IMF 2010 List of Countries. Since transportation costs include shipping price, packing prices for international trade are almost impossible to obtain consistently. We use the distance between two countries to estimate the transportation cost. Data on distance directly to destination (minimum distance between two ports) were obtained from the website http://www.freemaptools.com/how-far-is-it-between.htm.

We specified five gravity model systems to estimate coefficients and compare the results, three of which we discuss here. First, we used a McCallum Gravity Equation proposed in 1995. According to our trade patterns, we revised this model and removed the dummy variable term that equals to one for interprovincial trade and zero for state-province trade, such that:

$$\ln X_{ij} = a_1 + a_2 \ln GDP_i + a_3 \ln GDP_j + a_4 DIS_{ij} + \varepsilon_{ij} \quad (2)$$

The following gravity model specifications, proposed by Baier and Bergstrand (B-B models) in 2009, are used for comparison:

$$\ln x_{ij} = \beta_0' - \rho(\sigma-1)\ln DIS_{ij} - \alpha(\sigma-1)BORDER_{ij} + \rho(\sigma-1)MRDIS_{ij} + \alpha(\sigma-1)MRBORDER_{ij} + \varepsilon_{ij} \quad (3)$$

where,

$$MRDIS_{ij} = \left[\left(\sum_{k=1}^{N} \theta_k \ln DIS_{ik}\right) + \left(\sum_{m=1}^{N} \theta_m \ln DIS_{mj}\right) - \left(\sum_{k=1}^{N}\sum_{m=1}^{N} \theta_k \theta_m \ln DIS_{km}\right) \right]$$

$$MRBORDER_{ij} = \left[(\sum_{k=1}^{N} \theta_k BORDER_{ik}) + (\sum_{m=1}^{N} \theta_m BORDER_{mj}) - (\sum_{k=1}^{N} \sum_{m=1}^{N} \theta_k \theta_m BORDER_{km}) \right]$$

$$x_{ij} = X_{ij} / GDP_i GDP_j \quad \text{or} \quad \ln x_{ij} = \ln X_{ij} - \ln GDP_i - \ln GDP_j$$

In this gravity model specification, coefficient estimates for and MRDIS, BORDER and MRBORDER are first restricted to have identical but oppositely signed coefficient values. For comparing among alternative gravity models, we estimated this equation with and without MRDIS and MRBORDER terms; then we estimated this equation with and without restrictions.

Results and Conclusions

In this section, we discuss a McCallum model without a dummy variable term. Estimated coefficients of the McCallum model are presented in table 1. The coefficient estimate of Geographical Distance (ln) in the McCallum model is -2.501. All variables for the McCallum Model specification have the expected signs and the estimated coefficients are significant. The results of coefficient estimates of the McCallum model are also very close to those of a naive model in which we replaced zero-valued oilseed trades by one (a small, non-negative amount).

Next, we show results for the Baier and Bergstrand model with and without MR terms or restrictions in table 2. The coefficient estimate of Geographical Distance (ln) for column of the first B-B gravity model without MR terms, ignoring multilateral resistance terms, is significantly different from zero at the 1% level. However, the coefficient estimate of the Border dummy variable is not significant. Column (2) of Table 2 represents the results of B-B gravity model with MR terms and without restrictions that lnDIS and MRDIS, BORDER and MRBORDER are constrained to have identical but oppositely signed coefficient values. The coefficient estimate of Geographical Distance (ln) is significant at the 1% level, but the coefficient of the border dummy variable has no statistical significance. The coefficient estimates of MRDIS and MRBORDER are significantly different from zero at the 1% level, indicating their contribution to explain trade in terms of transportation costs and/or relationships with neighbors. Column (3) represents the estimated B-B gravity model with restrictions. The coefficient estimate of the border dummy is statistically significant at the 1% level in this specification.

The application of various specifications of previously used gravity models exhibit considerable differences in coefficient estimates. Without MRDIS and MRBORDER terms, our B-B model finds only one term of geographical distance has the expected sign and is significant. After we added both MR terms, but no restriction that and MRDIS, BORDER and MRBORDER be limited to have identical but oppositely-signed coefficient values and examined the B-B model with MR terms and restrictions, coefficient estimates of both the geographical distance and border sharing have the expected signs. An increase in geographical distance by 1% leads to a decrease in the volume of trade in oilseeds by 0.9%, which is much smaller than in other gravity model specifications. Contingent countries have greater trade volumes of oilseeds than non-contingent countries.

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Tables

Table 1. Estimated McCallum Gravity Model for Oilseeds Trade (2009).

Variable	Parameter Estimate	Standard Error	t-Value	Pr> |t|
Intercept	-11.544	5.657	-2.040	0.0419*
Geographical Distance (ln)	-2.501	0.450	-5.560	<.0001**
GDP for Export Country (ln)	1.762	0.211	8.370	.0001**
GDP for Import Country (ln)	1.315	0.211	6.250	<.0001**

*p<0.05, **p<0.01; N=462

Table 2. Estimated Baier and Bergstrand Gravity Models for Oilseeds Trade (2009)

Parameter	(1) B-Bw/o MR terms	(2) B-B w/o restrictions	(3) B-B with MR terms
Geographical Distance (ln)	-2.521	-2.638	-0.009
	(<.0001)**	(<.0001)**	(0.968)
Border dummy	-0.081	-0.381	4.180
	(0.954)	(0.791)	(0.0003)**
MRDIS		-0.786	0.009
		(0.002)**	(0.968)
MRBORDER		-6.212	-4.180
		(0.0007)**	(0.0003)**

*p<0.05, **p<0.01

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