Trade Costs and the Gains from Trade in Crop Agriculture

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Introduction

World crop markets are often highly insulated, prospering for further trade liberalization are uncertain. Since countries are often quite hesitant to make concessions in exchange for trade liberalization in other countries, it may help to illuminate basic facts about the world crop sector, and get new perspectives on the size and distribution of the gains from trade, by country.

In this study, we develop a new global simulation model of crop agriculture to address these questions. The model is partial-equilibrium and designed around the salient features of world crop markets: yield variability and high trade costs, the latter of which are caused by policy as well as geography. The resulting framework provides economic evidence about trade costs, and it is a simulation model – can be used to examine the types of questions that have been the domain of partial-equilibrium and comparable general equilibrium models.

A new model for crops trade

The simulation model we propose for crop agriculture is based on the classical Ricardian trade models developed by Elyas and Kannan (Econometrica, 2022). Unlike the textbook Ricardian model, in which two countries each specialize in one of two goods, the goods sector is modeled as a continuum, with multiple countries specializing in sections of this continuum according to competitive advantage.

In our adaptation, specialization is determined by random productivity, land endowments, and the bilateral costs of trade. Productivity is determined through a random draw from country-specific crop yield distributions. Each country has a chance of being a low-cost supplier depending on whether it has a bumper crop or crop failure in a given year.

A country’s ability to trade is hampered by bilateral trade costs, however, which are estimated from a structural gravity model that is personalized by the model.

Comparison to other models

The framework provides an alternative to computable general equilibrium (CGE) models. As with them, the model can be used to simulate the effects of trade policy changes or other types of shocks once it is parameterized. The characterization of the global trading equilibrium differs in important ways from CGE models; however. For example, countries specialize in a subset of homogeneous crops as determined by their productivity distributions and the costs of trading with foreign markets. By contrast, most CGE models invoke specialization through differentiation by country. Relative to that approach, our model has greater flexibility in the extent to which trade patterns adjust in response to shocks to the system.

In this way, the framework is more like a spatial equilibrium model, which allocates trade flows on the basis of lowest possible transportation cost. Unlike spatial equilibrium models, however, bilateral trade is predicted by a gravity model, which is generally superior at replicating actual trade flows.

Our gravity model is different from most in the literature, in turn, in that it is derived from the trade model used for the simulation analysis. It incorporates structural parameters from the yield distributions that govern specialization. Furthermore, gravity studies tend to focus only on what gets traded. We allow the size of the sector to be endogenous and account for the amount of trade relative to overall consumption, that is, the extent of “home bias” in consumption.

Parameterization of model

Data to estimate model parameters are primarily from the Food and Agricultural Organization (FAO) and the Global Trade Analysis Project (GTAP). The model corresponds to the following crops: paddy rice, wheat, oilseeds, and cereal grains are clearly classified.

Nearly every model parameter is systematically estimated. Bilateral trade costs are calculated as an ad valorem tax equivalent and are estimated using the structural gravity equation predicted by the model. Parameters of the crop-yield distributions are estimated by three alternative approaches: Approach I is a Generalized Linear Method of Moments technique applied directly to the crop yield distributions. Approach II proceeds in similar fashion but involves Maximum Likelihood Estimation. Approach III starts with a different equation within the model and makes use of Ordinary Least Squares.

The choice of technique affects the overall parameterization of the model since certain remaining parameters are a function of the parameters of the crop yield distributions. A comparison of the three parameterizations to external criteria provides evidence in favor of Approaches I and III. We base our subsequent simulation results on both approaches.

Crop markets are thin

With the model fully parametrized, we consider six counterfactual simulations. The first two are not meant to emulate actual policy changes or other types of shocks but to illustrate basic points about the world trading system. We compare global trade volumes that are observed with those that would occur under hypothetical (a) free-trade and (b) autarkic (infinite bound tariffs in agriculture are roughly double those in other sectors).

With compared against these extremes, the international crops market is surprisingly close to the extreme of autarky. For example, observed trade volumes are only fifteen-fifteenth of the flow that would occur under autarky costs.

Another way to interpret this result is that there is far less trade than one might expect given how much countries differ in terms of their (a) crop prices, (b) land endowments and rental rates, and (c) crop yields. The severity of barriers to international trade costs – whether caused by policy or geography – is also revealed by the sensitivity of trade flows to them. A mere 1% reduction in aggregate trade costs would increase world trade volumes by approximately 2.5%.

In the third and fourth simulations we distinguish trade costs that are in principle reducible, such as tariffs, from those that are difficult to reduce, such as transportation costs. The two simulations differ in terms of whether land is fixed within the crop sector. We find that a modest degree of liberalization – such that each country has a level of openness similar to the current U.S. level – leads to big welfare gains in most countries, mainly because crop prices for consumers can fall a great deal. Selected results are below.

Transportation costs matter

The fifth and sixth counterfactual simulations simulate how changes in supply to one country affect the welfare of other countries. Distance in particular can greatly reduce the benefit by which an event in one country is transmitted to others. The following scatterplot shows what happens if there would be an expansion of supply in Brazil, due, say, to an expansion of cropland area onto former rainforest. The offer to which prices fall in other countries is correlated strongly with their physical distance to Brazil.

Systematic differences between rich and poor countries

Many of the results differ systematically by countries’ level of economic development, as proxied by per capita income. Countries with high average productivity are more likely to be found on the high end of the global income distribution. Countries with high import trade costs, by contrast, are more likely (though not always) found on the low end of the global income distribution.

The insulation associated with high import costs may shield countries somewhat from adverse changes in other countries. However, it also means they may gain less when other countries are able to increase their supply. Regardless of these tendencies, it appears that all countries are very far from reaping the potential gains from trade in international crop markets. The framework offers a means for future researchers to determine the gains from trade from new policy directions.

For further information

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