

Analysis of trade policies with CAT linked livestock-crop model
in the context of the ERS USDA International Baseline

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Abstract

The objective of this work is to develop a modeling tool for policymakers interested in how trade policies and potential conflict scenarios around the world could impact the United States' agricultural production and trade in the context of the USDA Economic Research Service's International Baseline projections. The modeling tool is based on the recursively dynamic, global, partial equilibrium model of world crop and livestock products trade developed at the Center for Agricultural Trade at Virginia Tech. The model is applied to analyze a potential EU-Mercosur Free Trade Agreement modeled as a counterfactual scenario and evaluated relative to USDA's baseline.

Introduction

Baseline projections play a key role in agricultural decision-making and policies. Economic Research Service (ERS) at the United States Department of Agriculture (USDA) in collaboration with the World Agricultural Outlook Board (WAOB) produces annual 10-year International Baseline projections that indicate the possible long-term supply, demand, and trade balances for agricultural commodities in major exporting and importing countries and regions.¹ The International Baseline is constructed using models of agricultural sectors in major exporting and importing countries and regions (Hjort et al. 2018, Maples et al. 2022). Critical long-term assumptions are made about macroeconomic conditions, agricultural and trade policies, and growth rates of agricultural productivity. However, the projections only include policies and events that are already in place. Thus, the projections represent anticipated outcomes based on underlying trends, rather than a forecast.

The objective of this work is to develop and illustrate a new modeling tool for policymakers (e.g. Office of the Chief Economist, USDA) interested in how trade policies and potential conflict scenarios around the world could impact the United States' agricultural production and trade in the context of ERS USDA's International Baseline projections. The modeling tool is based on the recursively dynamic, global, partial equilibrium (PE) model of world crop and livestock products trade developed at the Center for Agricultural Trade (CAT) at Virginia Tech (Peterson 2020).² The model baseline is calibrated annually to match the ERS USDA International Baseline over a ten-year projection period. We illustrate the features of this

¹ <https://www.ers.usda.gov/data-products/international-baseline-data/documentation/>

² The model and the calibration procedure share many features with CAT livestock products model (Peterson et al. 2017).

model by analyzing a potential EU-Mercosur Free Trade Agreement (FTA) (EU, Argentina, Brazil Paraguay, and Uruguay) modeled as a counterfactual scenario and evaluated relative to USDA's baseline. The model is implemented in GEMPACK (Horridge et al. 2018). The calibration of the model baseline and policy scenario are implemented using RunDynam software.³

Model

Regions in the PE model produce, use for food and/or feed, stock, and trade seven globally important crops (barley, corn, cotton, rice, sorghum, soy, wheat) and four livestock commodities (beef, pork, poultry, other livestock). Soybeans can be traded or demanded by domestic industries for crushing to produce soy meal and soy oil which are also traded and used for feed, food, and industrial use. Regional aggregation of the global economy is represented by 26 regions: 20 large agricultural producing and consuming countries, and 6 composite geographical regions.

Final demand in each region is determined by the preferences of a single representative consumer using a two-level utility structure. At the top level modeled with the Constant Difference of Elasticities (CDE) demand system, the representative consumer can substitute among composite crops, composite livestock commodities, and an "outside" good, which is an aggregate of all other goods and services consumed and included to complete the demand system and account for changes in overall price levels (Peterson et al. 2017)⁴. The lower nest is modeled

³ <https://www.copmodels.com/gprdyn.htm>

⁴ Consumer expenditure on the outside aggregate good is equal to regional income minus total consumer expenditure on all commodities explicitly modeled in the PE framework.

with Constant Elasticity of Substitution (CES) Armington style structure where within each composite good, consumers can substitute between domestic good and imported composite. For each commodity, a national agent in each region decides on the composition of the imported composite using the CES function.

Commodities produced for domestic and export markets are differentiated, as well as commodities exported to different destinations. To represent this heterogeneous supply of output, the production of each commodity is modeled with a two-level nested Constant Elasticity of Transformation (CET) production possibilities frontier. At the top level, firms can shift supply between the domestic or export markets as relative prices change. At the bottom level, firms can shift exports between destinations as relative prices in the destination markets change. The location of the production possibilities frontier is determined by the supply of sector-specific aggregate factors (Peterson et al. 2017). Supply of the aggregate factor is assumed to be a linear function of the composite producer price of this sector in each region.

Market clearing conditions for each commodity guarantee that supply to the domestic market is equal to domestic demand, imported quantity is equal to the demand for imports, and export from a source region to a destination region is equal to the respective import flow. Prices and quantities of all commodities are determined endogenously in the model, except for the outside good that follows the ERS USDA macroeconomic baseline.

Data

The starting point in the data construction for this project is ERS USDA's International Baseline which contains projections of country/region levels of production, imports, exports, consumption (food, feed, crush), and stocks. Calibration of the CAT linked livestock-crop model to this

international baseline and setting the initial equilibrium is a multi-step process (Peterson 2020). First, the projections are aggregated into 26 model regions. USDA ERS's feed grains database and FAOSTAT livestock production data (milk, beef, eggs, etc.) are used to compute estimates of grain and high protein consuming animal units to allocate feed from cropping activities such as corn, wheat, and soymeal across livestock sectors. Additional data sources and assumptions are used to incorporate industrial uses of corn and soybean oil, allocate beginning and ending changes in stocks to domestic and import sources, and split consumption categories into domestic and imported products based on historical shares. The resulting projections are used to calibrate the PE model baseline.

ERS USDA International Baseline does not contain bilateral trade information, whereas bilateral trade is a critical feature of the model. To incorporate bilateral trade into the initial equilibrium, the RAS procedure is applied to bilateral trade quantity data from Trade Data Monitor (TDM) to match export and import quantity data for the first year of the projections developed above. Information on producer prices from OECD's AgLink Cosimo model and FAOSTAT, TDM bilateral data in monetary terms, and Market Access Maps (MAcMaps) applied bilateral tariffs are used to assign values for the various prices required by the partial equilibrium model. Various checks are implemented through the data construction process to produce a balanced database.

CDE substitution and expansion parameters are calibrated to replicate GTAP compensated own-price and income elasticities. Armington parameters are taken from USDA's recent multi-institutional study on trade elasticities (Grant et al., forthcoming). Values for all other parameters are from Peterson (2020). All data construction steps described above are

implemented using GEMPACK software (Horridge et al. 2019), except for the calibration of the CDE that was implemented in GAMS⁵.

Calibration of the model baseline

Exogenous population, national income, and price of the outside good are incorporated in the model baseline.⁶ Preference and technology variables are calibrated by forcing the PE model to “match” as closely as possible to the ERS USDA International Baseline described above. In the model, consumer demand equations are equipped with preference shifters, while technology shifters are incorporated into the supply of output and input demand functions. Under the standard model closure, quantity variables are typically endogenous, while variables representing changes in technology and preference are typically exogenous. In the calibration, quantity variables are swapped with the technology or preference parameters and shocked to follow the ERS USDA projections. Variables targeted in the calibration include household demand, supplies to domestic and export markets, livestock demand for feed, and demand for soy from the soybean crush industry.

Policy scenario

To illustrate the model and how future trade policies, conflict scenarios, or shocks to global food systems may cause significant deviations from ERS USDA baseline projections for key economic variables, we analyze the potential European Union and Mercosur FTA. While the two regions reached a political agreement on 28 June 2019 for an ambitious, balanced, and

⁵ <https://www.gams.com/>

⁶ Regional income and price of the outside good are exogenous variables in the PE model. GDP and GDP deflator projections are used to represent regional income and the price of the outside good, respectively. The projections of these variables and population are obtained from ERS International Macroeconomic Data Set available at <https://www.ers.usda.gov/data-products/international-macroeconomic-data-set/>.

comprehensive trade agreement (European Commission), the agreement has yet to be ratified by the EU. The agreement covers 23% of the world GDP and 9% of the world population (Ngavozafy et al. 2022). Among many goals of the agreement are increased bilateral trade and lower tariff and non-tariff trade barriers. Mercosur tariff reductions will benefit EU exports of beef and ethanol, while Mercosur states will gain greater access to the EU agricultural markets that the EU offers through tariff-rate quotas (TRQs) and elimination of in-quota tariff rates. However, because EU producers are worried about increased competition, the EU tries to limit its openness through limited enlargements of import quotas, or new quotas openings (Mitaritonna et al. 2023). EU is also concerned that the agreement will increase deforestation in Brazil.

The CAT recursively dynamic PE model is applied to analyze the EU-Mercosur FTA focusing on the agreement's impact on wheat, soy, beef, pork, and poultry markets. Specifically, we conduct the baseline simulation which projects income and population growth while respecting the projected ERS USDA baseline projections. In the policy scenario, we then model the potential impacts of the EU-Mercosur FTA on U.S. and non-members' agricultural market outcomes over the 10-year policy simulation according to the FTA's agreed (in principle) upon tariff elimination schedules.⁷ The results are reported as policy deviations from the baseline simulation (see Dixon et al. 2013). Almost all Mercosur trade liberalization commitments are specified as reductions in Most Favored Nation (MFN) tariffs on imports from the EU (i.e., preferential rates), with many falling to zero over a 5- to 10-year phase-in period. Most EU trade

⁷ https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/mercotur/eu-mercotur-agreement/text-agreement_en

liberalization falls under TRQs. Some EU TRQs will be expanded over a phase-in period and some TRQs will feature cuts to in-quota tariffs (or both).

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