The role of trade elasticities in shaping uncertainty in CGE policy outcomes

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Computable general equilibrium (CGE) models have become a widespread method to assess economy-wide and sectoral impacts of trade policies. While the results of simulations with these models depend on a number of inputs, trade elasticities are of particular interest because of their significant impact on modeled trade patterns, welfare and factor returns (Hillberry and Hummels, 2013). For example, trade elasticities play a central role in determining the effects of preferential trade agreements, with small trade elasticities generating large terms of trade effects and relatively modest efficiency gains, whereas large trade elasticities lead to the opposite result (Hertel et al., 2007). Trade elasticities are also a critical piece of trade dispute cases litigated at the World Trade Organization (e.g. WTO, 2019). Given their importance, trade elasticities should be accurate and up-to-date to support trade policy analysis.

Our objective is to implement and evaluate, within the context of a CGE model, an up-to-date set of trade elasticities, and investigate the role of these parameters in key trade policy modelling uncertainties. The analysis is based on an extension of the GTAP model, called GTAP-HS (Aguiar et al., 2019b; Narayanan et al., 2010), which allows for the incorporation of detailed trade data and analysis of trade policies at the level of the Harmonized System's "tariff line". In GTAP-HS, the general idea is that sectors of interest produce multiple commodities. These commodities are consumed domestically and traded internationally. Demands for these goods by an aggregate domestic user are modeled in a two-stage process: the disaggregated commodities at the HS6 level (e.g. "apples") first substitute for one another within the aggregate GTAP consumption category (e.g. various vegetables, fruit and nuts are substitutes within aggregate GTAP consumption category "vegetables, fruit, and nuts"). To model international trade, the Armington assumption is employed in a way similar to the standard GTAP model (Corong et al., 2017; Hertel, 1997): the disaggregated commodity (e.g. apples) that enters the aggregate GTAP consumption category is a composite of a domestic good and an imported composite, where the imported composite consists of goods from various trading partners.

In this paper we use a special version of the GTAP-HS data base with focus on the GTAP data base sector "v_f" (vegetables, fruit and nuts). Output, domestic absorption and trade flows of this sector are disaggregated into 79 separate commodities within the standard GTAP data base (see Chepeliev et al. (2019) for description of the data base construction process). The data is consistent with version 10 of the GTAP data base with reference year 2014 (Aguiar et al., 2019a), and is constructed at the GTAP disaggregated level to allow user specific aggregations.

The Armington parameters currently available in the GTAP data base package were estimated in Hertel et al. (2007) using cross-section data in Hummels (1999). These elasticities may not adequately reflect the structural changes that have affected the global agricultural production and food consumption landscape during the past two decades, nor do they leverage the wealth of time series data that has become available over the last decade. Recent estimates of trade elasticities include estimates of import demand elasticities (Fontagné et al., 2019) and estimates of both export supply and import demand elasticities (Soderbery, 2018). In this paper we employ elasticities and methodology from Soderbery (2018) in order to investigate allocation of domestic output across destination markets.

Soderbery (2018) develops a structural estimator of supply and demand that does not rely on instrumental variables and can identify variety by market specific heterogeneity in the elasticities. Using only COMTRADE trade flows associated with country pairs across 192 importing and exporting countries and 1243 goods at the HS4 level data from 1991 to 2007, Soderbery (2018) estimates good-importer specific elasticities of substitution within composite imported good and importer-exporter-good specific export supply elasticities.

To take advantage of both export supply and import demand elasticity estimates, we modify the GTAP-HS model by replacing the homogenous supply of domestically produced goods to domestic and export markets with a differentiated products specification. We implement heterogeneous output supply with a nested constant elasticity of transformation (CET) structure, as in van der Mensbrugghe (2019). The domestic supply of each commodity is supplied to the domestic market and an aggregate export bundle using a top-level CET function. The latter is allocated across regions of destination using a second-level CET function. The implementation allows for the possibility of homogeneity, as is standard in the GTAP model; and also allows for a single-nested CET by assuming uniformity of the elasticities of transformation for both the first and second level nests.

The GTAP-HS model equipped with new set of trade elasticities is used to evaluate impacts of retaliatory tariffs imposed on U.S. vegetables, fruit and nuts sectors. Sectoral aggregation of the GTAP-HS data base follows the one in Chepeliev et al. (2019), while regional aggregation follows Soderbery (2018). In the model, output and trade flows of the disaggregated vegetables, fruit and nuts sectors are represented at the HS6 level, while Soderbery (2018) elasticities are estimated for goods at the HS4 level.[1] We map HS4 elasticities to HS6 vegetables, fruit and nuts commodities within the same HS4 code. Soderbery (2018) estimates of good-importer specific elasticity of substitution within composite imported good serve as CES parameters in the lower nest of import demand functions in the model, with upper nest parameter set at half of the lower nest parameter. Response of exports in our model depends on an exporter-good specific component of the export supply elasticities. We implement a calibration procedure in order to extract the model relevant component of export supply. To do so, we calculate the transformation parameter in the second-level of the CET function for each importer, exporter and good combination using information on domestic and export shares of output, export shares within aggregate export bundle, and the export supply elasticities. In the calibration, we assume that transformation parameter in the top-level is half the parameter in the second-level. Then, the exporter-good specific CET parameters in the second-level are calculated as weighted sums of the respective transformation parameters, with importer-exporter-good trade flows serving as weights. The exporter-good specific CET parameters are used in the model experiments.

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[1] Due to data limitations, of the 79 disaggregated vegetables, fruit and nuts sectors, 70 sectors represent individual commodities at the HS6 level and 9 sectors represent groups of several commodities at the HS6 level. See Chepeliev et al. (2019) for details.

To explore how uncertainties in the trade elasticities contribute to the estimates of changes in trade, output, prices and macro variables we will employ Monte-Carlo simulation with Latin Hypercube Sampling (McKoy et al. 1979) to reduce number of runs with the model. We will also attempt to implement Morris method (Morris, 1991) that requires larger number of model runs. With this method, drivers and economic parameters are perturbed individually across their full distribution to elicit the impact of elementary effects of each model input, allowing identification and ranking of critical model variables (Hertel, Baldos and van der Mensbrugghe, 2016). This will allow to determine relative importance of each uncertain model input, including trade elasticities and other parameters, for each model output.

References

Aguiar, A., Chepeliev, M., Corong, E., McDougall, R., & van der Mensbrugghe, D. (2019a). The GTAP Data Base: Version 10. Journal of Global Economic Analysis, 4(1), 1-27.

Aguiar, A., Corong, E., & van der Mensbrugghe, D. (2019b). Updating the Partial Equilibrium Module to GTAP 7 Model (Presented at the 22nd Annual Conference on Global Economic Analysis, Warsaw, Poland). Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

Chepeliev, M., Golub, A., Hertel, T., & Saeed, W. (2019). U. S. Trade Policies and Their Impact on Domestic Vegetables, Fruits and Nuts Sector: a Detailed Tariff Line Analysis. Paper presented at the 2019 Agricultural & Applied Economics Association Annual Meeting, Atlanta, GA, July 21-23. https://ageconsearch.umn.edu/record/291075?ln=en

Corong, E., Hertel, T., McDougall, R., & Tsigas, M., & van der Mensbrugghe, D. (2017). The Standard GTAP Model, Version 7. Journal of Global Economic Analysis, 2(1), 1-119.

Fontagné, L., Guimbard, H., & Orefice, G. (2019). Product-Level Trade Elasticities. CEPII Working Paper No 2019-17 - December. http://www.cepii.fr/PDF_PUB/wp/2019/wp2019-17.pdfHertel, T. (1997). Global Trade Analysis Modeling and Applications. Cambridge University Press.

Hertel, T., Baldos, U.L.C., & van der Mensbrugghe, D. (2016). Predicting Long-Term Food Demand, Cropland Use, and Prices. Annual. Rev. Resour. Econ. 8:417-441.

Hertel, T., Hummels, D., Ivanic, M., & Keeney, R. (2007). How confident can we be of CGE-based assessments of Free Trade Agreements? Economic Modelling, Volume 24, Issue 4, Pages 611-635.

Hillberry, R., & Hummels, D. (2013). Trade Elasticity Parameters for a Computable General Equilibrium Model. Chapter 18 in Handbook of Computable General Equilibrium Modeling, 2013, vol. 1, p.1213-1269, Elsevier.

Hummels, D. (1999). Towards a Geography of Trade Costs, GTAP Working Paper No. 17, Center for Global Trade Analysis, Purdue University, West Lafayette, IN.

McKay, M., Beckman, R., & Conover, W. (1979). "A Comparison of Three Methods for Selecting Values of Input Variables in the Analysis of Output from a Computer Code". Technometrics 21 (2): 239–245.

Morris, M. (1991). Factorial sampling plans for preliminary computational experiments. Technometrics 33(2):161–74.

Narayanan, B., Hertel, T., & Horridge, M. (2010). Linking Partial and General Equilibrium Models: A GTAP Application Using TASTE. GTAP Technical Paper 29, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Soderbery, A. (2018). Trade elasticities, heterogeneity, and optimal tariffs. Journal of International Economics 114: 44-62.

van der Mensbrugghe, D. (2019). The Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model, Version 10.01. The Center for Global Trade Analysis, Purdue University.

WTO (2019). United States -- anti-dumping and countervailing measures on large residential washers from Korea. https://www.wto.org/english/tratop_e/dispu_e/464arb_e.pdf