# The Role of Trade Elasticities in Shaping Uncertainty in CGE Model Outcomes

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# The role of trade elasticities in shaping uncertainty in CGE model outcomes

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# Motivation

- Trade elasticities in a computable general equilibrium (CGE) model
  - Affect model outcomes
    - Trade patterns
    - Factor returns
    - Welfare
      - Terms of trade effects vs. efficiency gains in preferential trade agreements
  - Critical piece of trade dispute cases litigated at the WTO
  - Given their importance, should be accurate and up-to-date

# Objective

- Implement and evaluate, within the context of a CGE model, an up-to-date set of trade elasticities
- Investigate role of these parameters in key trade policy modelling uncertainties

# Methodology

- Recent estimates of trade elasticities in Soderbery (2018)
  - Export supply and substitution among imports from different sources
- GTAP-HS CGE model
  - Modified to take advantage of export supply elasticity estimates
- GTAP-HS data base with focus on agriculture
- Policy: retaliatory tariffs imposed on U.S. vegetables, fruit and nuts (VFN) sectors
- Explore how uncertainties in the trade elasticities contribute to the uncertainties in CGE estimates of changes in trade, output, prices and macro variables
- While focused on agriculture in this project, the approach can be applied to other sectors
  - Version of GTAP-HS model focused on motor vehicles and parts (Aguiar et al. 2020)

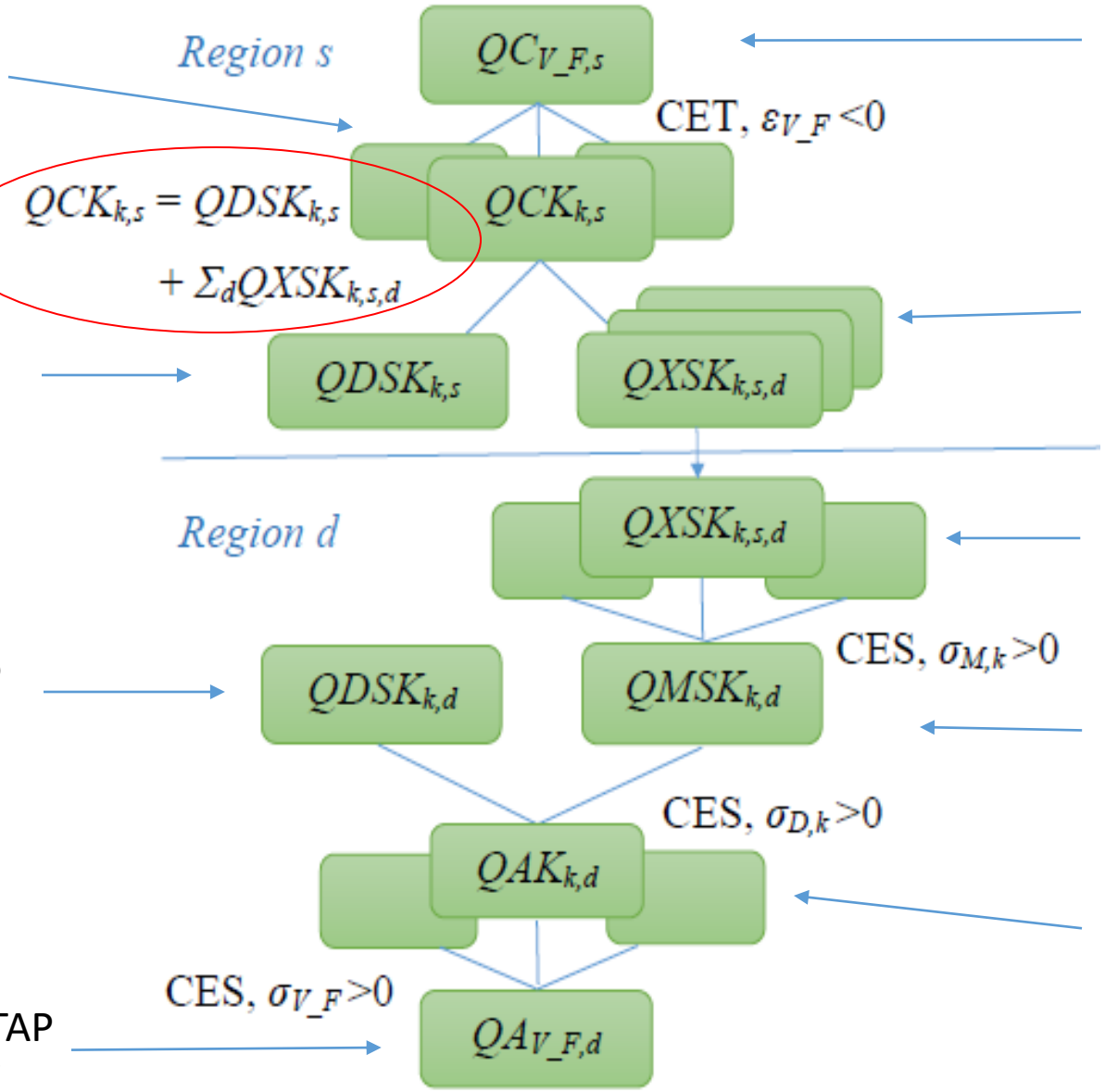
# Outline (focus on export supply elasticities)

- GTAP-HS model
  - Structure
  - Data base
- Allocation of domestic output across domestic and export markets
  - Law-of-one-price vs. Heterogeneous
  - Illustrative scenario
- Export supply elasticities in Soderbery (2018)
- Introduction of heterogeneous output supply into GTAP-HS model
- Next steps

# GTAP-HS model

- History of model development
  - Original concept was developed in Grant et al. (2007)
  - Implemented in the GTAP model (Narayanan et al. 2010)
  - Resynched with the latest code of the GTAP model (Aguiar et al. 2019)
- The general idea is that sectors of interest produce multiple commodities
  - Production sector definition follows the CGE model aggregation
  - Produced commodities, domestic absorption and trade are represented at the HS6 level
  - Domestic absorption at the HS6 level compete within the aggregate CGE model consumption category
- Implementation
  - CES and CET structures
  - Market clearing conditions
  - Price linkages

# Quantity linkages in the GTAP-HS model




Domestic supply of HS6 commodity *k* within v_f in region *s*

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Domestic absorption of GTAP commodity v_f in region *d*

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Supply of HS6 commodity *k* from region *s* to export market *d*

Demand for imported HS6 commodity *k* by source *s* in region *d*

Demand for imported HS6 commodity *k* aggregated across sources *s*

Domestic absorption of HS6 commodity *k* in region *d*

# Special version of GTAP-HS data base with focus on agriculture

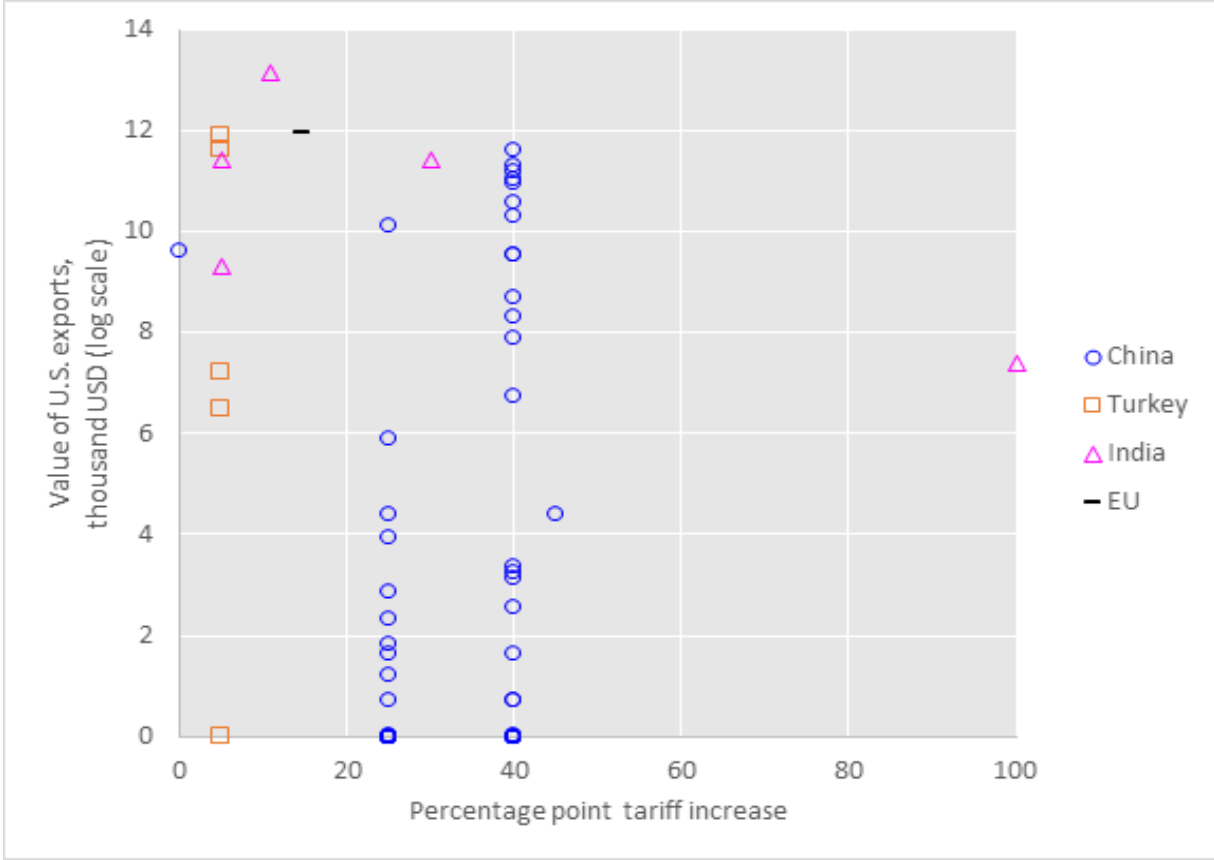
- Based on GTAP 10A data base, with agricultural production targeting, reference year 2014 (Chepeliev et al. 2020)
- Bilateral imports, protection rates, domestic production and demand for domestically produced commodities at the HS6 level within GTAP vegetables, fruit and nuts (v_f) and dairy products (mil) sectors
  - FAOSTAT data on production, total country exports and imports (quantities, prices and values) of 93 vegetables, fruits, nuts and 23 dairy commodities at the country level
    - Other data sets to fill gaps in FAO data (Euromonitor International, OECD-FAO Agricultural Outlook)
    - *Gap filling techniques*
  - MACMAP data on HS6 bilateral trade values (CIF prices) and import tariff rates
  - MACMAP trade data and FAO production data use different classification systems (HS 2012 and CPC 2.1) => use intersection
  - MACMAP and FAO data are reconciled to match the GTAP data at the sectoral level
- Aggregation for this analysis
  - CGE level aggregation: 21 regions and 24 sectors, including v_f and mil
  - HS6 level: trade and domestic use of 79 commodities within GTAP sector “vegetables, fruit and nuts”, and 9 commodities within GTAP sector “dairy products”

# Allocation of output across domestic and export markets

- GTAP-HS, as the standard GTAP model, assumes perfect transformation, i.e. law-of-one-price holds for all destination markets
- Many other models of international trade include a transformation function to allocate domestic output between domestic and export markets (WALRAS, LINKAGE, ENVISAGE)
  - In ENVISAGE (van der Mensbrugghe 2019), heterogeneous output supply with a double-nested constant elasticity of transformation (CET) structure
    - A first level nest allocates domestic output between domestic market and aggregate export bundle
    - A second CET nest allocates aggregate exports across destination markets
    - The implementation allows for the possibility of homogeneity, and also for a single-nested CET
- The transformation function reduces the ease with which countries can re-allocate their output and exports
- In previous studies, a drawback of the heterogeneous output specification was the lack of econometric estimates to inform settings of the transformation parameters

# Scenario: increase in tariffs on U.S. vegetables, fruit and nuts

- In March 2018, U.S. has implemented tariffs on steel and aluminum imports from most countries
- Affected trade partners initiated retaliatory tariffs, extended well beyond these two commodities
- U.S.-China trade war
- One of the targeted U.S. agricultural sectors is vegetables, fruit and nuts
  - Over hundred individual commodities
  - 21% of the U.S. agricultural exports




*Note:* Each point corresponds to the commodity at the HS6 level.

*Source:* Developed in Chepeliev et al (2019) using Li (2018).

# Law-of-one-price vs. heterogeneous output supply

- Increase in tariffs on U.S. VFN
  - For exposition purposes, uniform value of -2 for the first level CET elasticity, and a uniform value of -4 for the second level CET elasticity

| Variable | Law of one price | Heterogeneous |
|---|---|---|
| Change in U.S. exports of grapes to China, % | -65 | -44 |
| Change in price U.S. producers get for grapes exported to China, % | -0.5 | -14 |
| Change in price of U.S. exports of VFN, % | -0.21 | -1.01 |
| EV U.S., mill 2014 $ | -177 | -233 |

# Trade elasticity estimates

- Currently included in the GTAP data base
  - Export supply parameters are not included because of the law-of-one-price assumption
  - Import demand parameters (Armington) are from Hertel et al. (2007)
    - Estimated more than a decade ago
    - Do not reflect the structural changes in the global agricultural production and food consumption during the past two decades
- Recent estimates
  - Fontagné et al. (2019) estimated HS 6-digit product level specific elasticities between varieties exported by different countries by exploring the variation in bilateral applied tariffs for each product category for the universe of available country pairs
    - Chepeliev et al. (2019) used these estimates to parametrize Armington structure in GTAP-HS
  - Soderbery (2018) estimated both export supply and substitution among imports from different sources elasticities at the HS 4-digit product level
- We use elasticities estimated using Soderbery (2018) method to parametrize both supply of exports and demand for imports in the GTAP-HS model

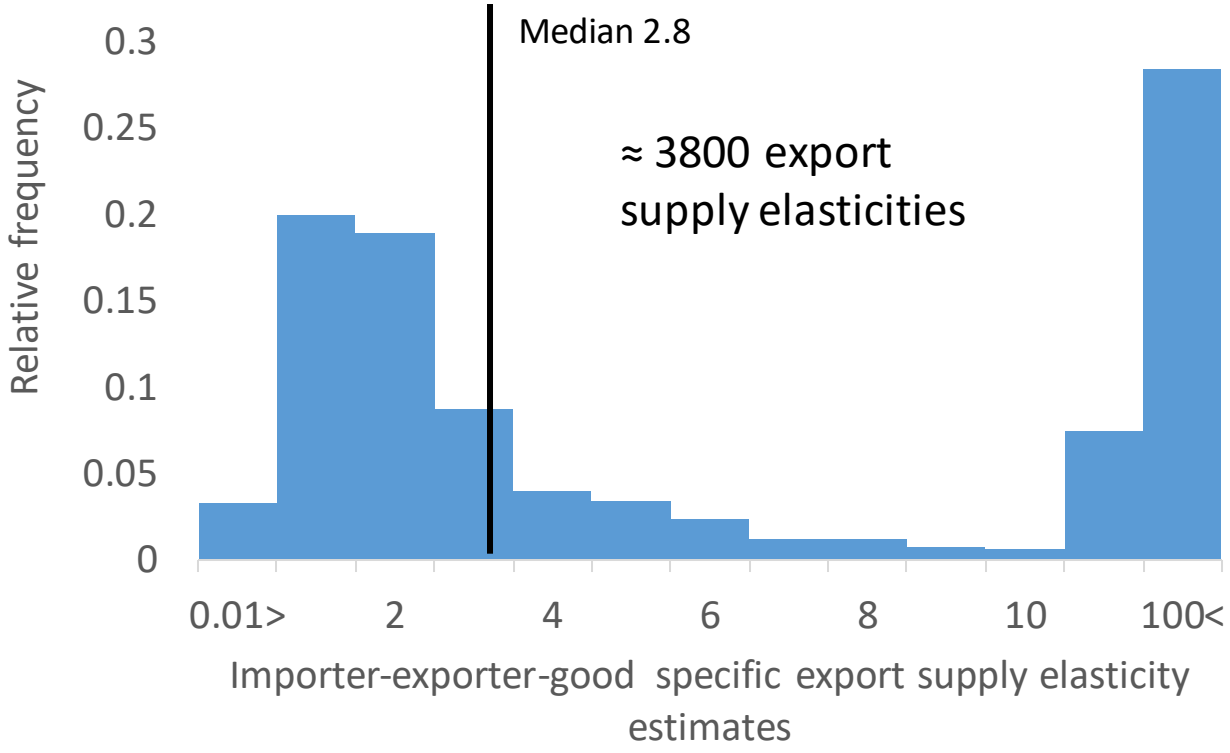
# Soderbery (2018) trade elasticities

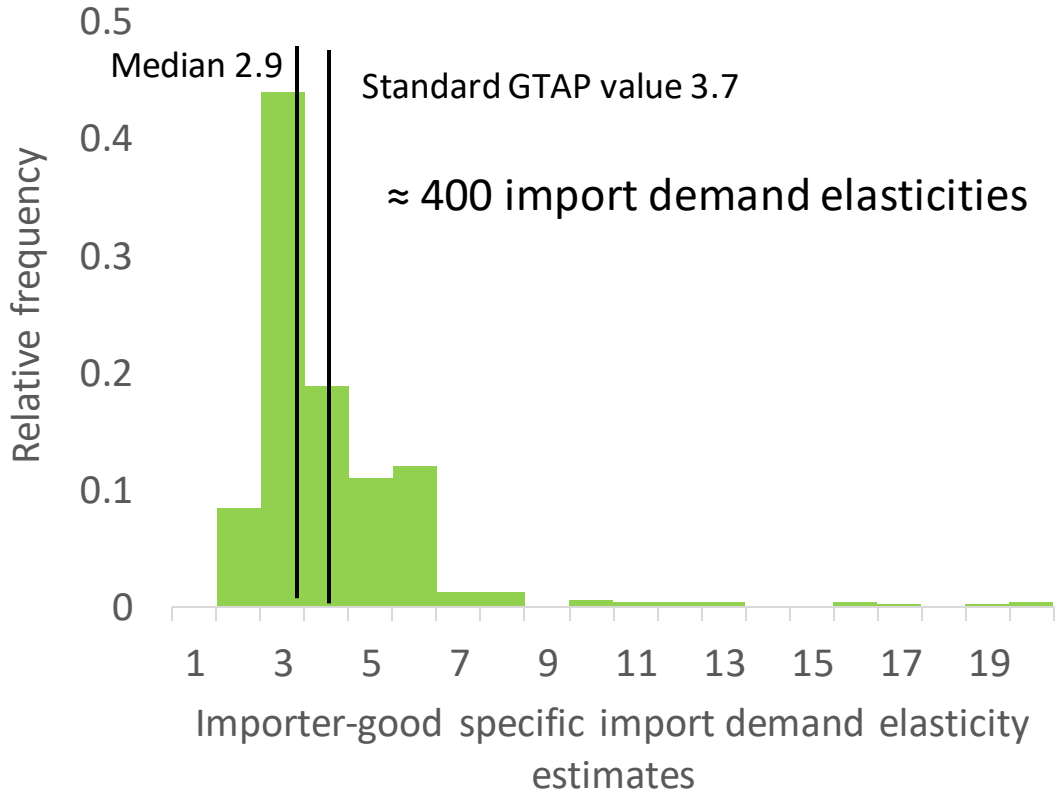
- Developed a structural estimator
  - Estimates export supply and import demand elasticities simultaneously
  - Does not rely on instrumental variables
  - Using only readily available bilateral trade data, leverages price and quantity variation over time for the same good across export and import markets to identify heterogenous elasticities

# Soderbery (2018) trade elasticities (cont.)

- Comtrade data
  - 1243 goods at HS4 level
  - 192 importing and exporting countries
- Not all countries trade all goods, but number of elasticities to estimate still is very large
  - ≈200,000 importer-good specific import demand elasticities
  - ≈3 million importer-exporter-good specific export supply elasticities
- To reduce parameter space, assumed small countries in the same region have identical supply technologies
  - 20 trading regions (7 of 20 are groups of countries)
    - For example, 43 African countries within AFR region have the same destination-good export supply elasticities
  - Estimated ≈ 1.2 million export supply and ≈ 125,000 import demand elasticities

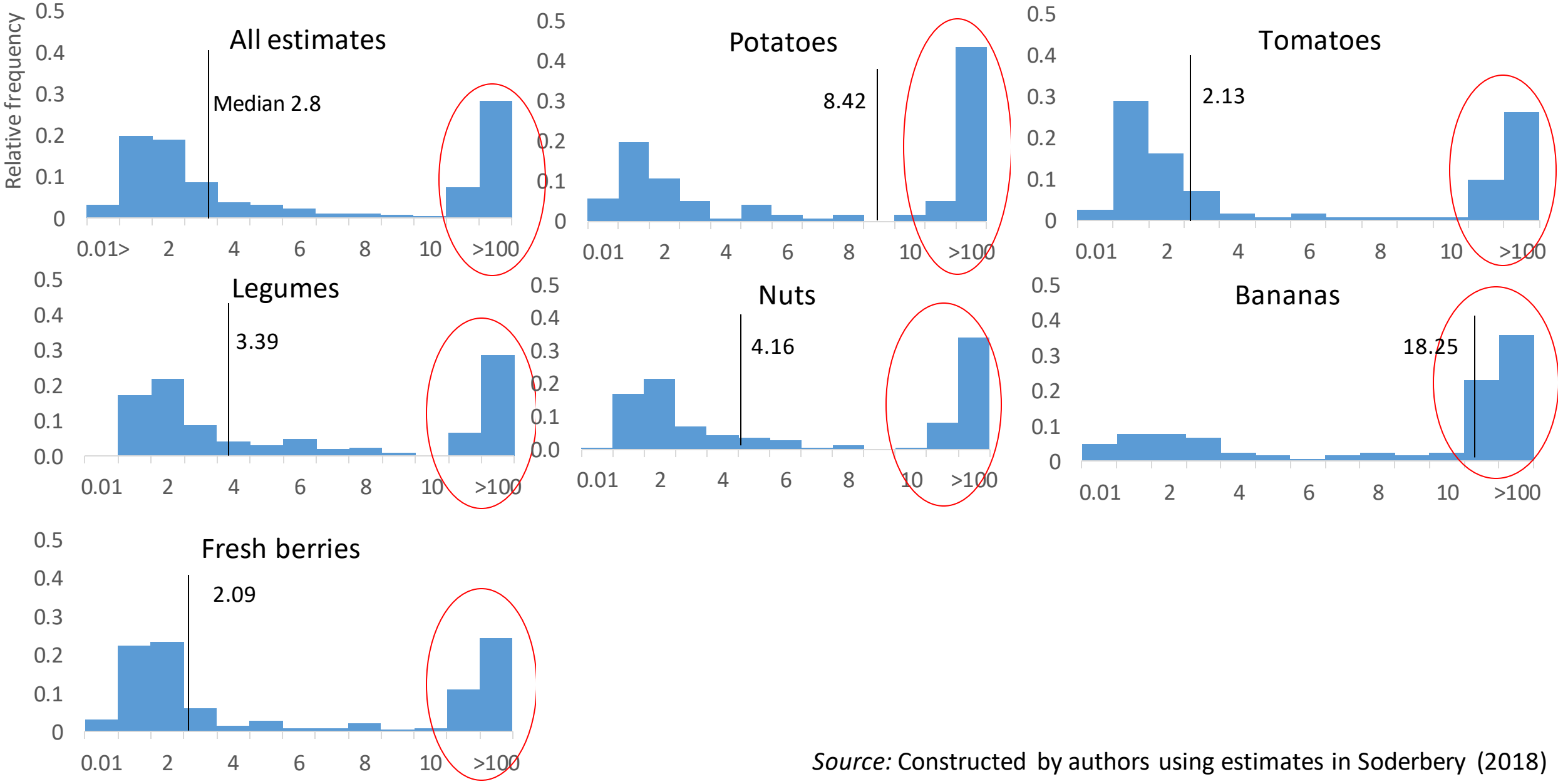
# HS4 VFN trade elasticities




*Source:* Constructed by authors using estimates in Soderbery (2018) for 0701-0709, 0713, 0714, 0801-0810, 1209 and 1212 HS4 codes.

# Importer-exporter-good specific export supply elasticities (some of the 23 HS4s)

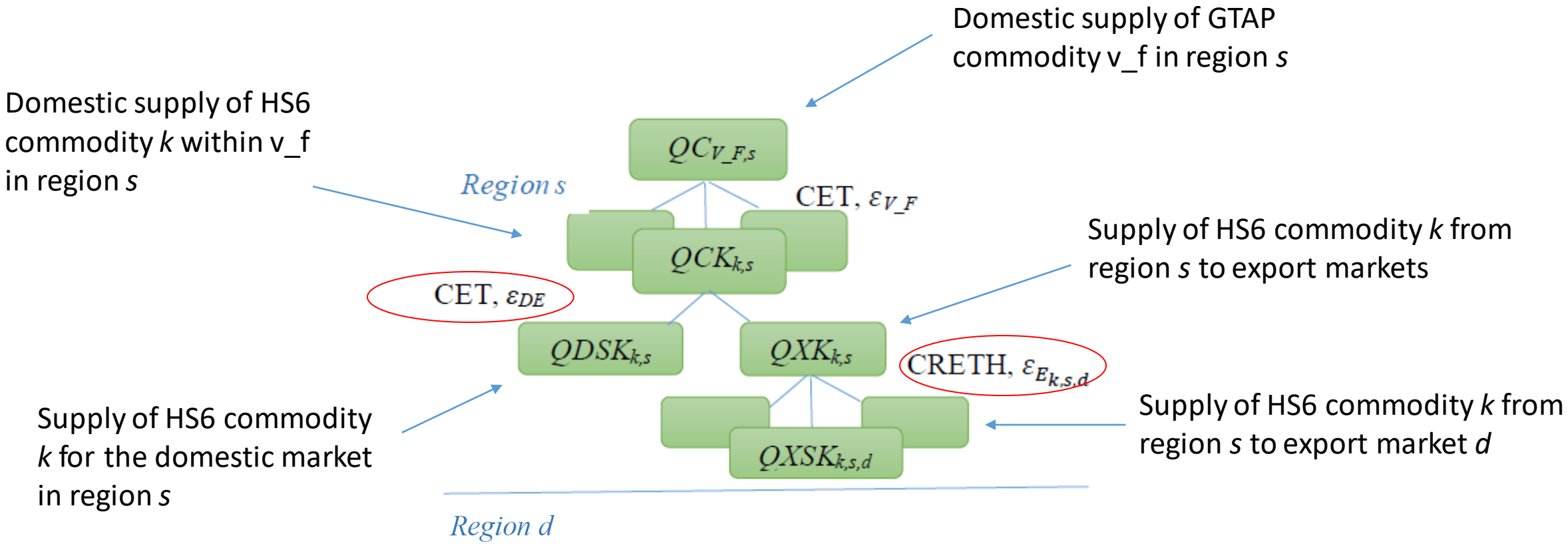



*Source:* Constructed by authors using estimates in Soderbery (2018)

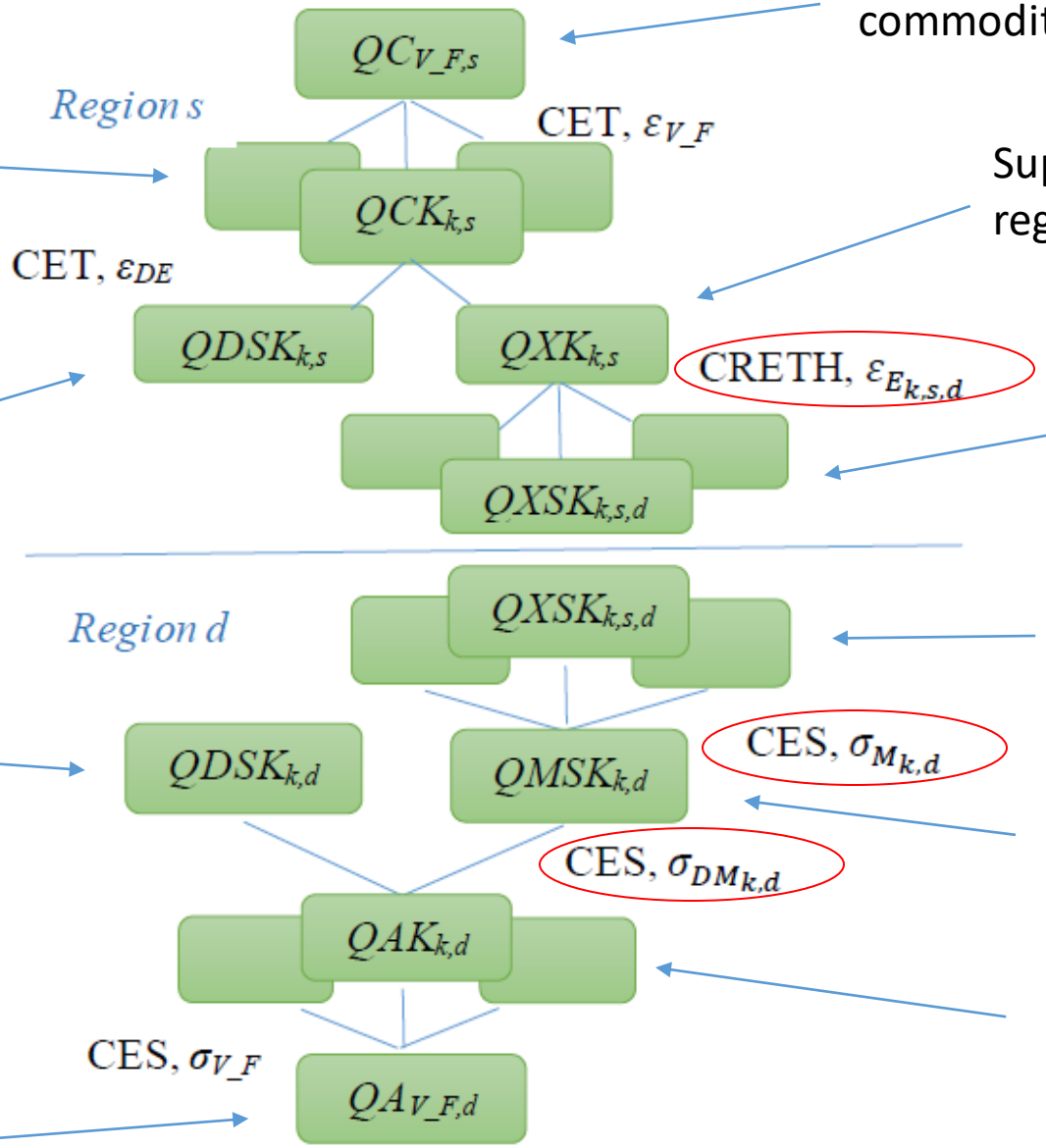
# How to incorporate heterogeneous output supply in a CGE model?

- Output is allocated, first, to domestic market and aggregate export bundle, and, then, aggregate exports are allocated across export destinations
- Which functional form to represent allocation across export destinations?
  - Constant elasticity of transformation (CET) allows only exporter-good specific, not importer-exporter-good specific transformation parameter
    - This means that for each exporter-good combination we have to calculate weighted average parameter across importers
    - Drawbacks
      - Lose heterogeneity across importers for a given exporter-good combination
      - If for a given exporter-good combination export supply elasticity for one of the destinations is very large (perfectly elastic supply), calibrated CET parameter will be also large => law-of-one-price
  - Constant ratios of elasticities of transformation, homothetic (CRETH) allows importer-exporter-good specific parameter

# Quantity linkages in the GTAP-HS with heterogeneous output supply



# Parameters to calibrate

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Domestic absorption of GTAP commodity v_f in region *d*

# Next steps

- Using Soderbery (2018) methodology, estimate elasticities of export supply and substitution among imports from different sources at the HS 6 level
  - 220 importing and exporting countries
  - Sample period 2007-2018
- Calibrate model parameters to the new estimates
- Explore how uncertainties in trade elasticities contribute to trade policy modelling uncertainties
  - Uncertainty analysis using a constrained Monte Carlo with Latin Hypercube sampling
  - Sensitivity analysis using Morris method
    - Relative importance of each uncertain model parameter in determination of model output

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Thank you!

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