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
  - Export supply and import demand
- GTAP-HS CGE model
  - Modified to take advantage of export supply elasticity estimates
- GTAP-HS data base
- Evaluate impacts of retaliatory tariffs imposed on U.S. vegetables, fruit and nuts (VFN) sectors
- Explore how uncertainties in the trade elasticities contribute to the estimates of changes in trade, output, prices and macro variables

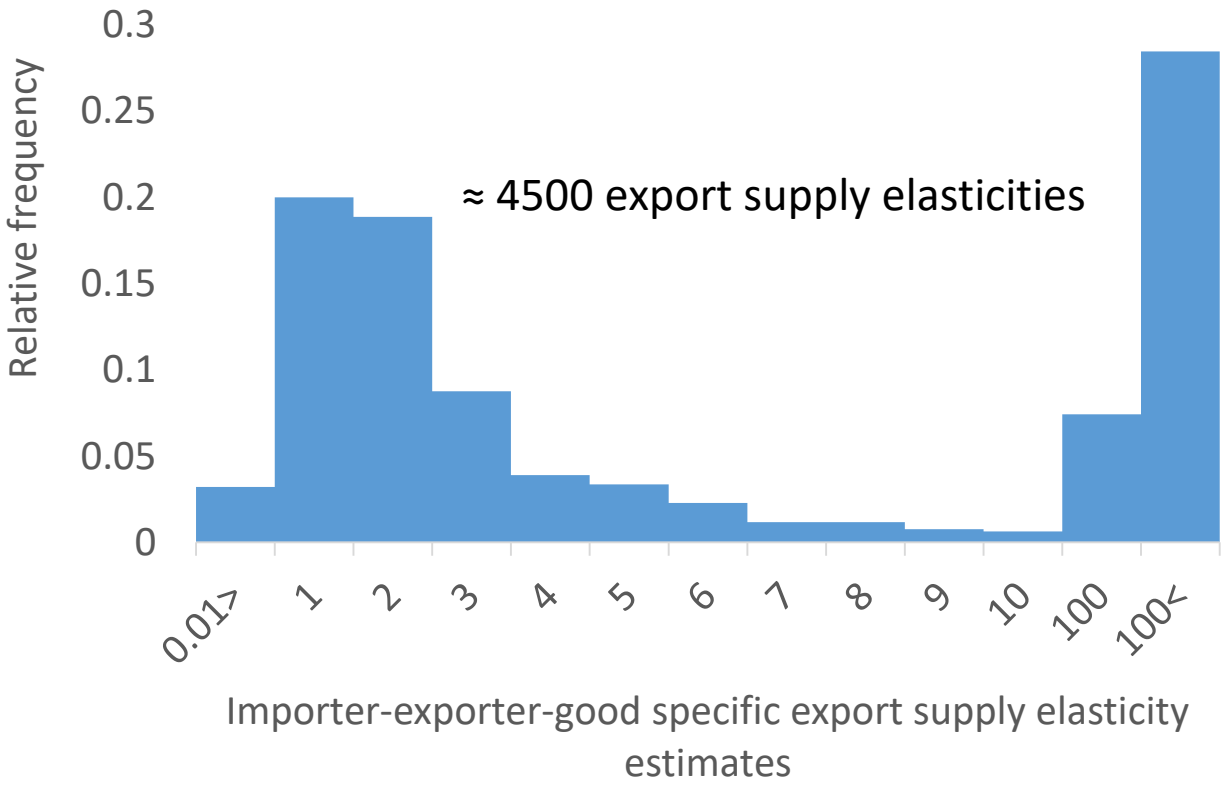
Trade elasticities

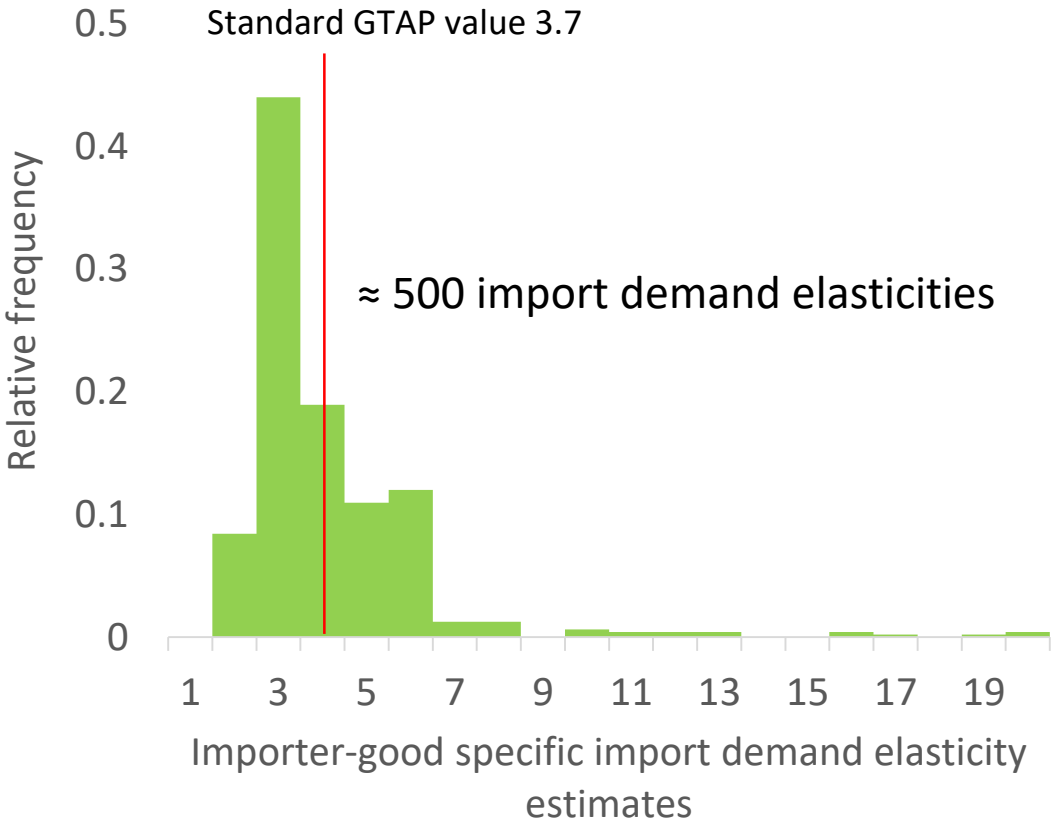
- The Armington parameters currently available in the GTAP data base package (Hertel et al. 2007)
  - Estimated more than a decade ago and do not employ time series data
  - Do not reflect the structural changes in the global agricultural production and food consumption during the past two decades
- Fontagné et al. (2019)
  - Estimate 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) use these estimates to parametrize Armington structure in GTAP-HS
- Soderbery (2018)
  - Estimate export supply and import demand elasticities at HS 4-digit product level
  - Used in this analysis to parametrize both supply of exports and demand for imports in GTAP-HS model

Soderbery (2018) trade elasticities

- Exploit price and quantity variation over time for the same good across export and import markets to identify heterogenous elasticities
- Develop a structural estimator
  - Estimate export supply and import demand elasticities simultaneously
  - Does not rely on instrumental variables
- Use Comtrade data
  - bilateral trade flows from 1991 to 2007
  - 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, assume small countries in the same region have identical supply technologies
  - 20 trading regions (10 of 20 are large individual countries)
    - For example, 43 African countries within AFR region have the same destination-good export supply elasticities
  - Estimate ≈ 1.2 million export supply and ≈ 125,000 import demand elasticities

HS4 vegetables, fruit and nuts trade elasticities





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

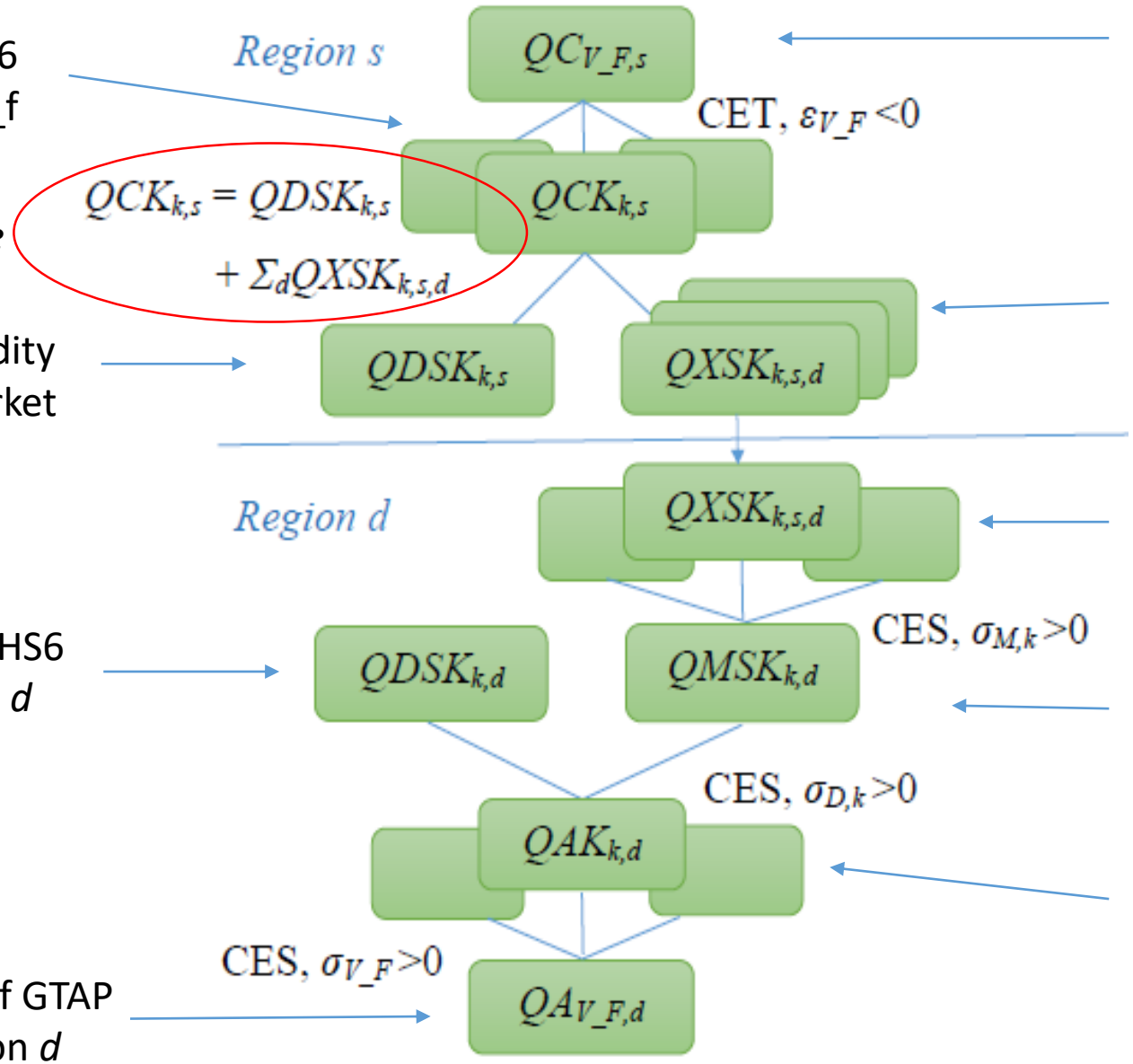
GTAP-HS model

- History of model development
  - Original concept was developed in Grant, Hertel, and Rutherford (2007)
  - Implemented in 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 products
  - Production sector definition follows the CGE model aggregation
  - Produced commodities and trade are defined at the HS6 level
    - In some cases, a more aggregate commodity categories (relative to the HS6 level) are used due to data limitations
- Output, domestic consumption and trade are represented at the HS6 level within the GTAP CGE model
  - In production, an activity produces multiple commodities
  - In consumption, substitution among disaggregated commodities within aggregated commodity
  - Market clearing conditions
  - Price linkages

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

- GTAP 10p1 data base, reference year 2014
- 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
- In the final GTAP-HS data base
  - CGE level aggregation: 20 regions and 28 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”

Quantity linkages in the GTAP-HS model



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

Supply of HS6 commodity *k* for the domestic market in region *s*

Demand for domestic HS6 commodity *k* in region *d*

Domestic absorption of GTAP commodity v_f in region *d*

Domestic supply of GTAP commodity v_f in region *s*

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

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

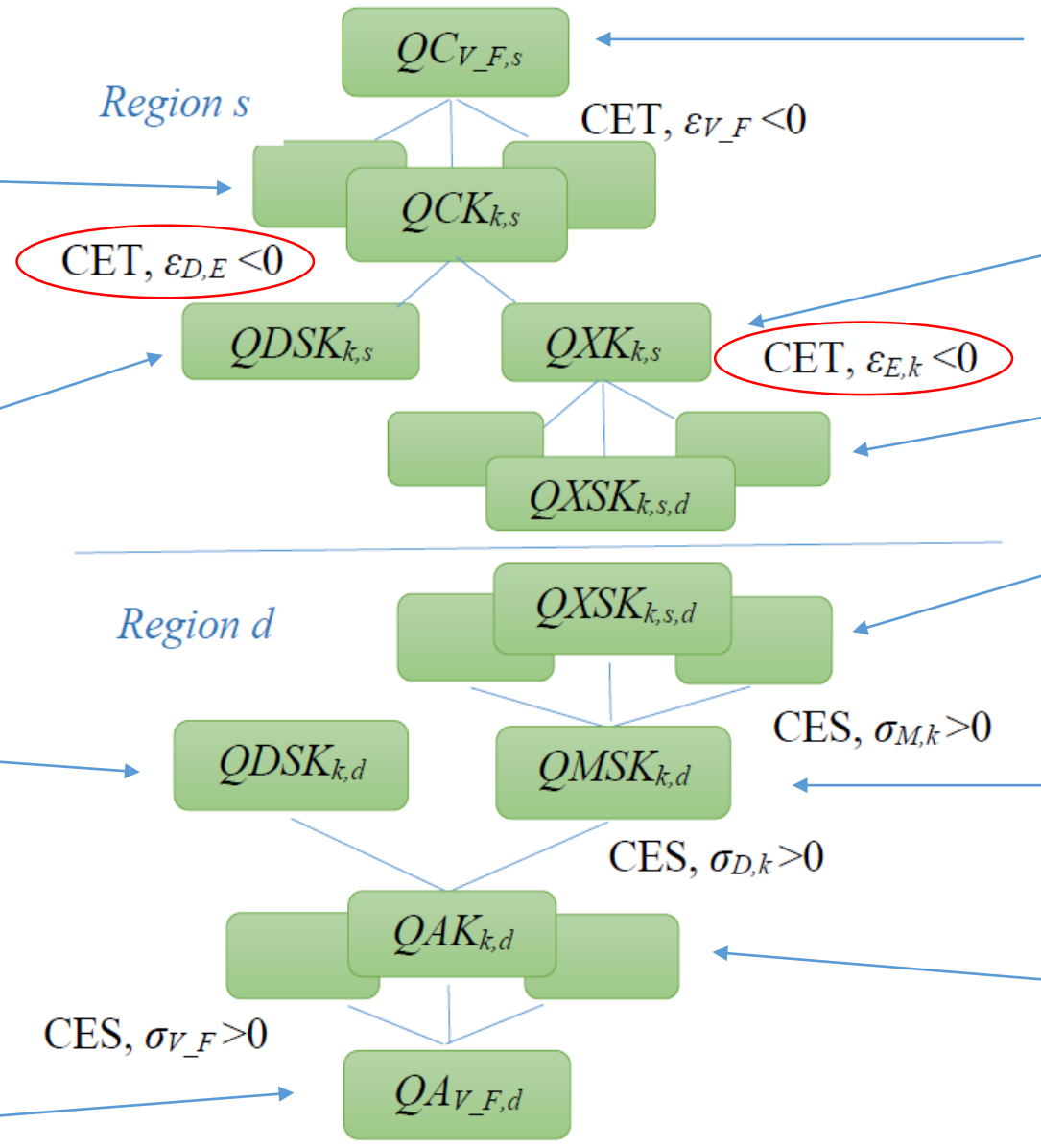
Demand for imported HS6 commodity *k* aggregated across sources *s*

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

GTAP-HS with CET specification for the allocation of domestic output

- 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)
- We modify GTAP-HS by incorporating heterogeneous output supply with a double-nested constant elasticity of transformation (CET) structure (van der Mensbrugghe 2018)
  - 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 CET specification reduces the ease with which countries can re-allocate their output to maximize their gains
- In previous studies, a drawback of the CET specification was the lack of econometric estimates to inform settings of the transformation parameters

Quantity linkages in the GTAP-HS with CET specification for the allocation of domestic output



Domestic supply of GTAP commodity v_f in region *s*

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

Supply of HS6 commodity *k* from region *s* to export markets

Supply of HS6 commodity *k* for the domestic market in region *s*

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

Domestic absorption of GTAP commodity v_f in region *d*

Implementation in the model

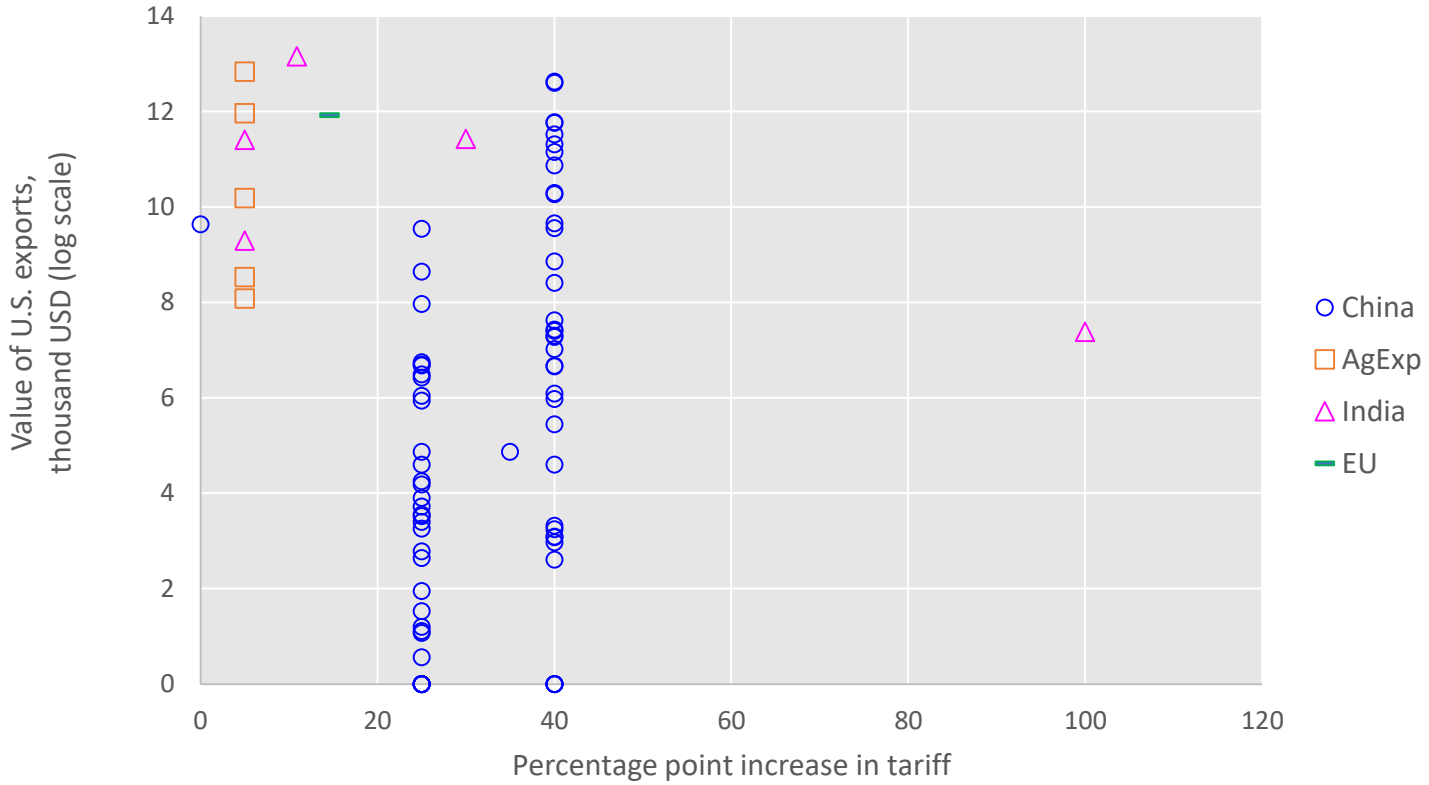
```
Equation E_qdsk
# allocation of domestic supply of HS6 commodity k to domestic market #
(all,k,SSECT_COMM)(all,r,REG)
0 = IF[abs(ETRASK(k,r)) lt 100, - qdsk(k,r) + qck(k,r) - ETRASK(k,r) * [pdsk(k,r) - pck(k,r)]]
  + IF[abs(ETRASK(k,r)) gt 100, pdsk(k,r) - pck(k,r)]
  + tradslackk(k,r);
Equation E_qxk
# allocation of domestic supply of HS6 commodity k to export market #
(all,k,SSECT_COMM)(all,r,REG)
0 = IF[abs(ETRASK(k,r)) lt 100, - qxk(k,r) + qck(k,r) - ETRASK(k,r) * [pxk(k,r) - pck(k,r)]]
  + IF[abs(ETRASK(k,r)) gt 100, pxk(k,r) - pck(k,r)]
  + tradslackk(k,r);
Equation E_pck
# HS6 commodity k supply price in region r #
(all,k,SSECT_COMM)(all,r,REG)
0 = IF[abs(ETRASK(k,r)) lt 100, - pck(k,r) + DBKSHR(k,r) * pdsk(k,r) + EXBKSHR(k,r) * pxk(k,r)]
  + IF[abs(ETRASK(k,r)) gt 100, - qck(k,r) + DBKSHR(k,r) * qdsk(k,r) + EXBKSHR(k,r) * qxk(k,r)];

Equation E_qxsk
# export sales of HS6 commodity k from source s to destination d #
(all,k,SSECT_COMM)(all,s,REG)(all,d,REG)
0 = IF[abs(ETRAXK(k,s)) lt 100, - qxsk(k,s,d) + qxk(k,s) - ETRAXK(k,s) * [pxsk(k,s,d) - pxk(k,s)]]
  + IF[abs(ETRAXK(k,s)) gt 100,  pxsk(k,s,d) - pxk(k,s)];

Equation E_pxk
# price of aggregate exports of HS6 commodity k #
(all,k,SSECT_COMM)(all,s,REG)
0 = IF[abs(ETRAXK(k,s)) lt 100, - pxk(k,s) + sum(d,REG, XSBKSHR(k,s,d) * pxsk(k,s,d))]
  + IF[abs(ETRAXK(k,s)) gt 100, - qxk(k,s) + sum(d,REG, XSBKSHR(k,s,d) * qxsk(k,s,d))];
```

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, including many agricultural imports from U.S.
- 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.

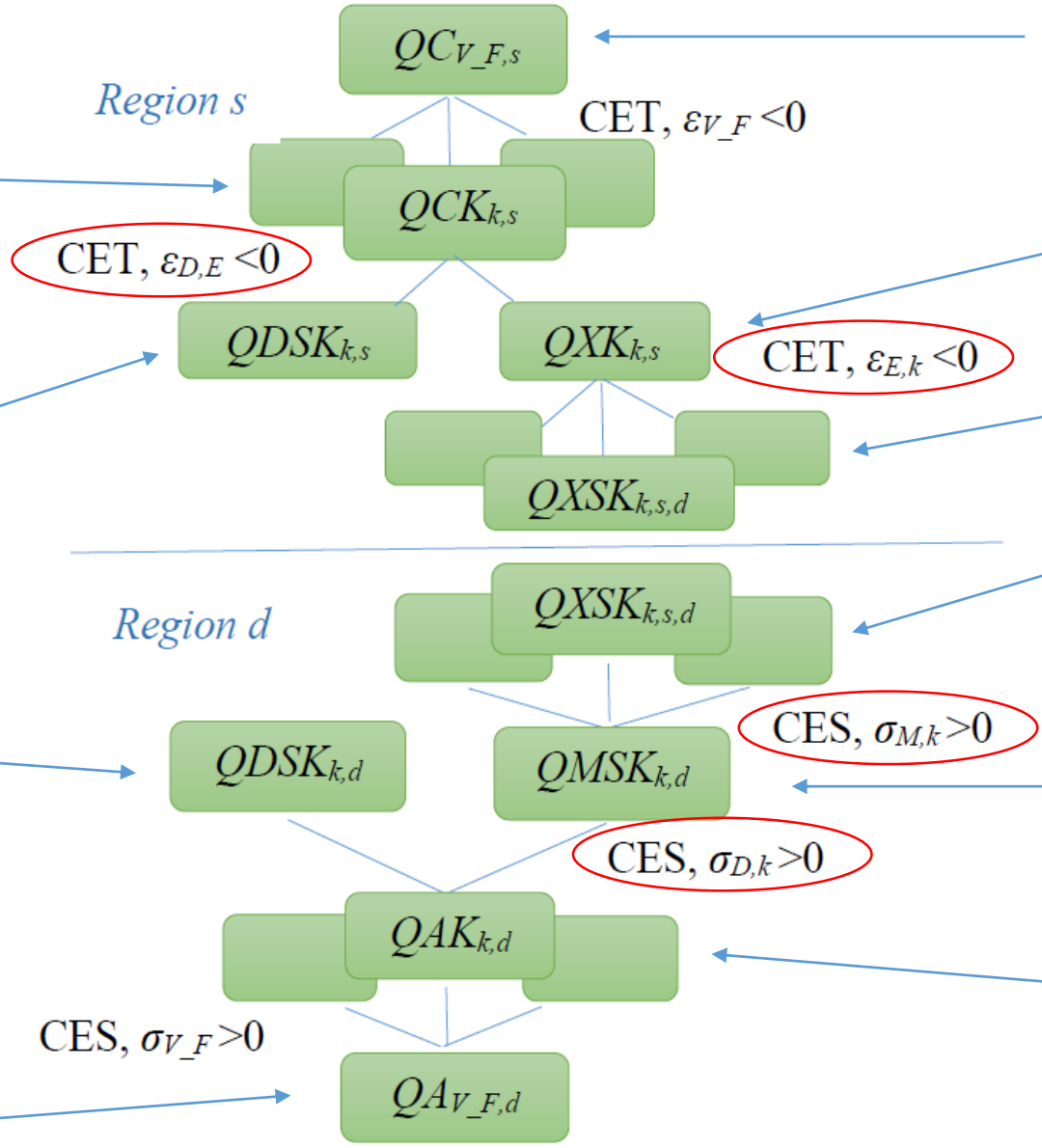
Source: Developed in Chepeliev et al (2019)using Li (2018), UN (2018).

Law-of-one-price vs. CET allocation of domestic output

- 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	CET
Change in U.S. exports of grapes to China, %	-65	-44
Change in U.S. export of VFN, %	-1.24	-2.6
Change in price of U.S. exports of VFN, %	-0.21	-1.01
EV U.S., mill 2014 $	-177	-263
EV China, mill 2014 $	-283	-135

Parameters to calibrate using Soderbery (2018) estimates



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Next steps

- Calibrate trade elasticities using Soderbery (2018) estimates and incorporate into GTAP-HS with CET specification for the allocation of domestic output
- Investigate role of these parameters in key trade policy modelling uncertainties using one of these methods:
  - Monte-Carlo simulation with Latin Hypercube Sampling
  - Systematic Sensitivity Analysis
  - Morris method

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