Disaggregating the Vegetables, Fruit and Nuts Sector to the Tariff Line in the GTAP-HS Framework

Maksym Chepeliev[a]
Alla Golub[a]
Thomas Hertel[a]
Wajiha Saeed[a]
Jayson Beckman[b]

[a] Center for Global Trade Analysis, Department for Agricultural Economics, Purdue University.
[b] Economic Research Service of the United States Department of Agriculture

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Introduction

- When evaluating trade policies, policy makers want to know impact on GDP, trade balance, employment and output by sector, for which **general equilibrium model** is needed
  - CGE model factors in all sectors in the economy, for which aggregation of sectors and commodities is required
  - In CGE analysis based on the GTAP data base, maximum 65 sectors (v.10) and no more than 20 for agricultural and food products
- As negotiations over specific trade policy proceed, policy makers want to know impact on a few sensitive commodities, for which **partial equilibrium model** is needed
  - PE model allows to represent policies and trade relationships at the detailed commodity level
  - However, PE may not incorporate all the relevant linkages and policy detail across key sectors and regions of the world, and cannot capture economy-wide changes in welfare

Introduction

- Level of aggregation in CGE models leads to a variety of problems for evaluation of the economic impacts of trade policy changes
  - Some sectors aggregate large number of commodities, while there exist huge variations in protection levels and characteristics across tariff lines for many commodities
  - Aggregation of sectors may result in false competition
  - Trade negotiations are conducted at highly disaggregated tariff lines
- Hybrid framework to overcome these limitations
  - GTAPinGAMS GE model linked with a PE model to analyze dairy trade (Grant et al. 2007)
  - GTAP GE model with disaggregated automotive trade (Narayanan et al. 2010)
  - GTAP-HS framework (Aguiar et al. 2019) generalizes data processing approach in Narayanan et al. (2010) and resyncs code with the GTAP v7 model (Corong et al. 2017)

GTAP-HS

- 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
    - In some cases, a more aggregate commodity categories are used due to data limitations
  - Domestic absorptions at the HS6 level compete within the aggregate CGE model consumption category
- Implementation
  - Disaggregated bilateral trade flows, protection rates, domestic output and absorption
  - Model structure
    - CET and CES structures
    - Market clearing conditions
    - Price linkages

Objectives

- Construct GTAP-HS data base by disaggregating two GTAP sectors
  - Vegetables, fruit and nuts (v_f)
  - Dairy products (mil)
- Introduce HS6 elasticities of substitution among different import sources (Fontagné et al., 2019)
- Analyze trade frictions between the United States and its trading partners with a specific focus on **VFN** (vegetables, fruits and nuts)
  - Compare GTAP and GTAP-HS results

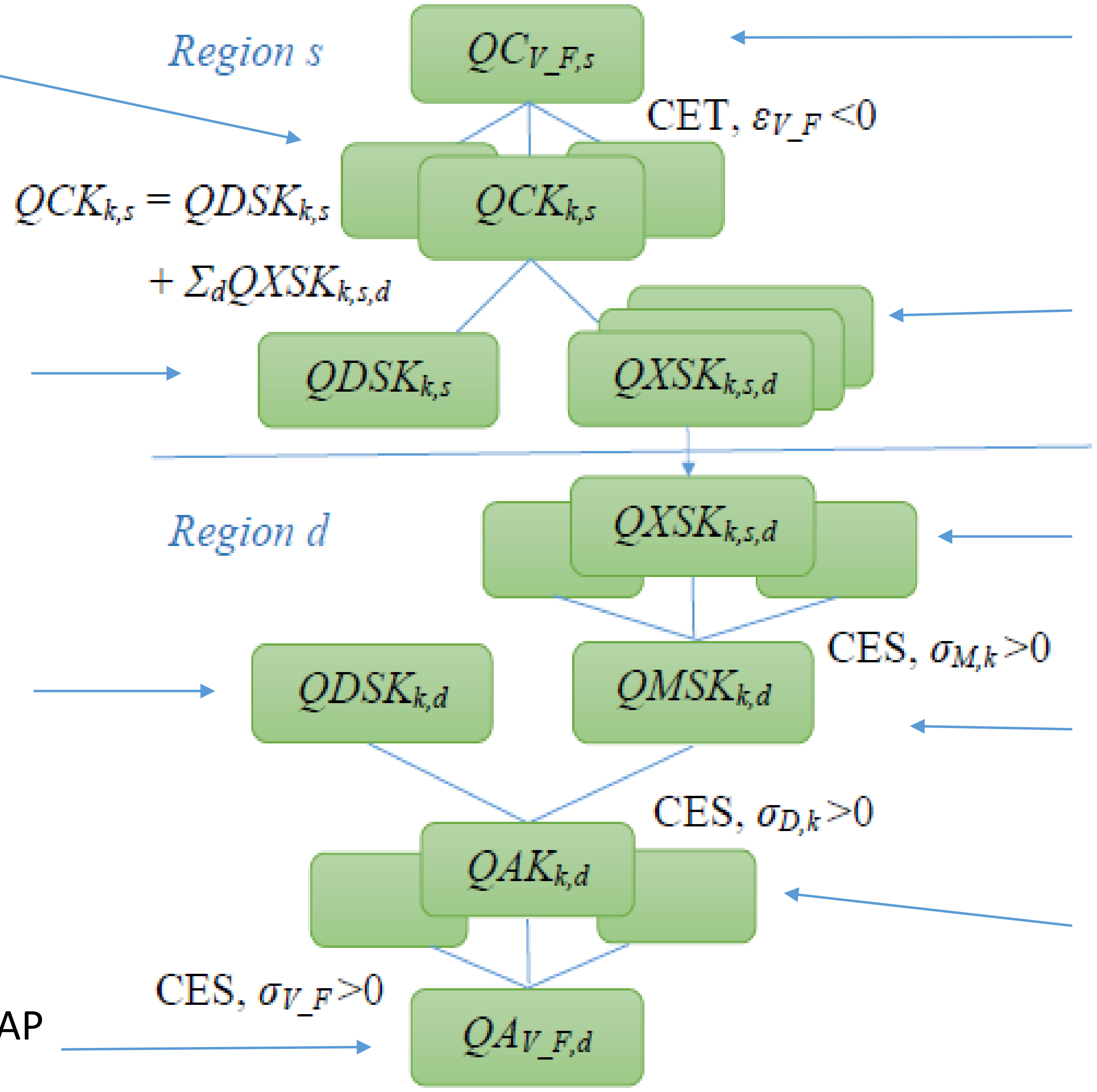
Quantity linkages in the GTAP-HS model

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 database: motivation

- Data requirements (HS6 level):
  - Bilateral imports -> UN COMTRADE
  - Protection rates -> MACMAP
  - Domestic production and demand -> ***different assumptions***

Constrained optimization to minimize deviations at the aggregate level (e.g. Grant et al., 2007)

Assume the same ratio of the domestic consumption to imports within the disaggregate sector (e.g. Narayanan et al., 2010)

Ad hoc assumptions regarding domestic consumptions and production at the HS6 level

Potentially critical in the case of heterogenous commodities

GTAP-HS database: key features

- GTAP 10 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 trade data and FAO production data use different classification systems (HS 2012 and CPC 2.1) => use intersection => reconcile to match GTAP at the sectoral level
- In the final GTAP-HS data base
  - Trade and domestic use of 79 commodities within GTAP sector “vegetables, fruit and nuts” and 9 commodities within GTAP sector “dairy products”

Data processing steps

(1) Mapping of the agricultural output values and quantities	• ***Data:*** FAOSTAT values and quantities of agricultural output (FAO, 2018): 217 countries, 93 commodities, 2014 reference year. Mapping to the GTAP Data Base countries.
(2) Price estimates	• ***Data:*** FAOSTAT commodity prices, agricultural export and import values and quantities, agricultural commodity output values and quantities; OECD commodity prices. • Estimation of country and commodity specific prices; world average agricultural commodity price estimates.
(3) Gap-filling of the agricultural output and export values	• ***Data:*** Agricultural output and exports quantities and prices. • Agricultural output and exports value gap-filling, mapping to GTAP Data Base countries.
(4) Reconciliation of trade, production and consumption data	• ***Data:*** MACMAP trade data, GTAP Data Base, data from step (3). • MACMAP and FAO data are merged and reconciled to match the GTAP data.
(5) Estimation of the HHs consumption shares	• ***Data:*** FAO Food Balance Sheets (FAO, 2018). • Estimation of the households' shares in the aggregate domestic absorption by commodities and GTAP Data Base countries.
(6) Mapping to the regional aggregation	• ***Data:*** Output and exports value from step (4). • Mapping to the designed regional aggregation.

Substitution at the disaggregate commodity (HS6) level

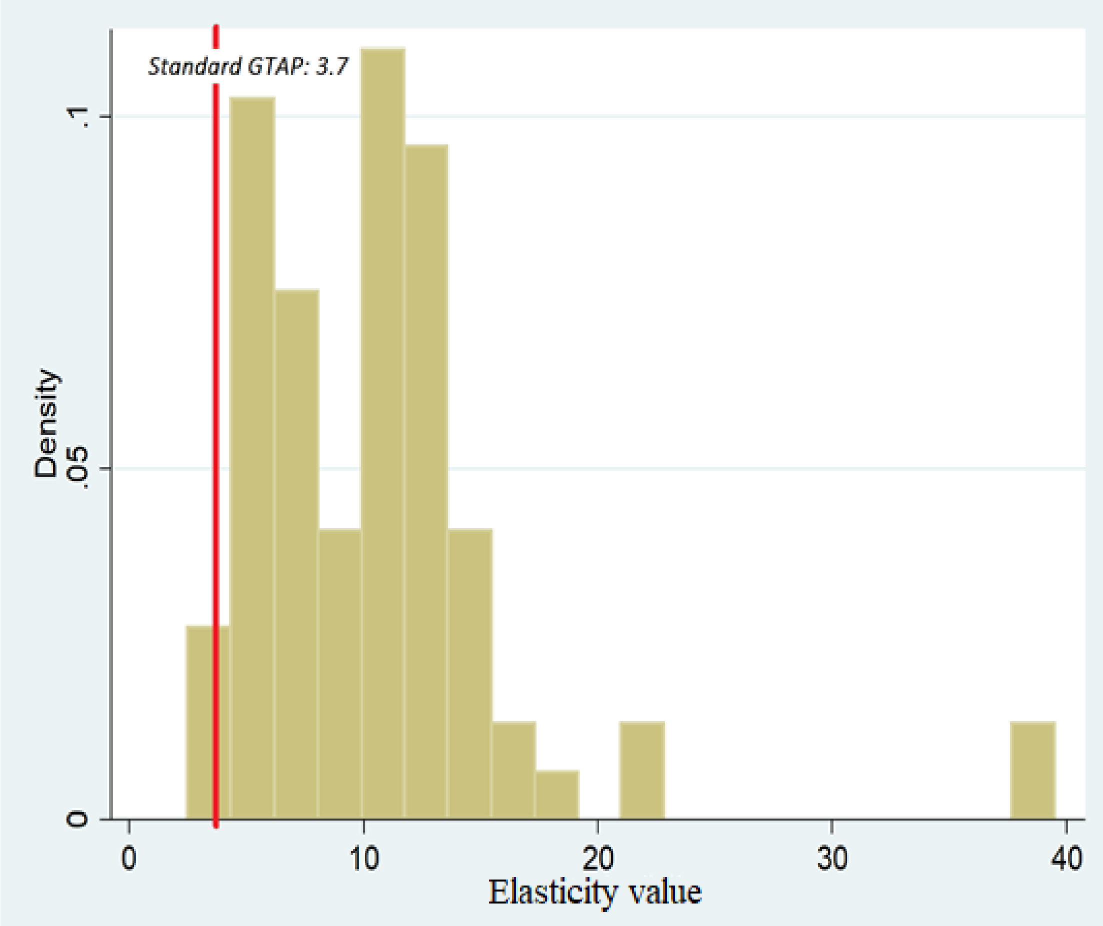
- GTAP-HS model requires provision of selected elasticities at the detailed commodity level:
  - Elasticity of **transformation between disaggregated commodities** (apples, pears, plums, etc.) supplied by an aggregate sector (vegetables, fruit and nuts) (ε_{VFN})

    –> Is set to "-2".
  - **Substitution between import suppliers** at the disaggregate level (e.g. bananas imported to U.S. from Ecuador, Costa Rica, Colombia, etc.) ($\sigma_{M,k}$)

    – > HS6 elasticity estimated in Fontagné et al. (2019) from CEPII. Trade weighted to match the commodity classification of the GTAP-HS model.
  - **Substitution between domestic and imported commodities** at the disaggregate level (e.g. domestic apples vs imported apples) ($\sigma_{D,k}$).

    –> Half of the $\sigma_{M,k}$ value ("rule of two").
  - **Substitution among different VFN commodities** within the domestic absorption (σ_{VFN}).

    –> Is set to "0.5".



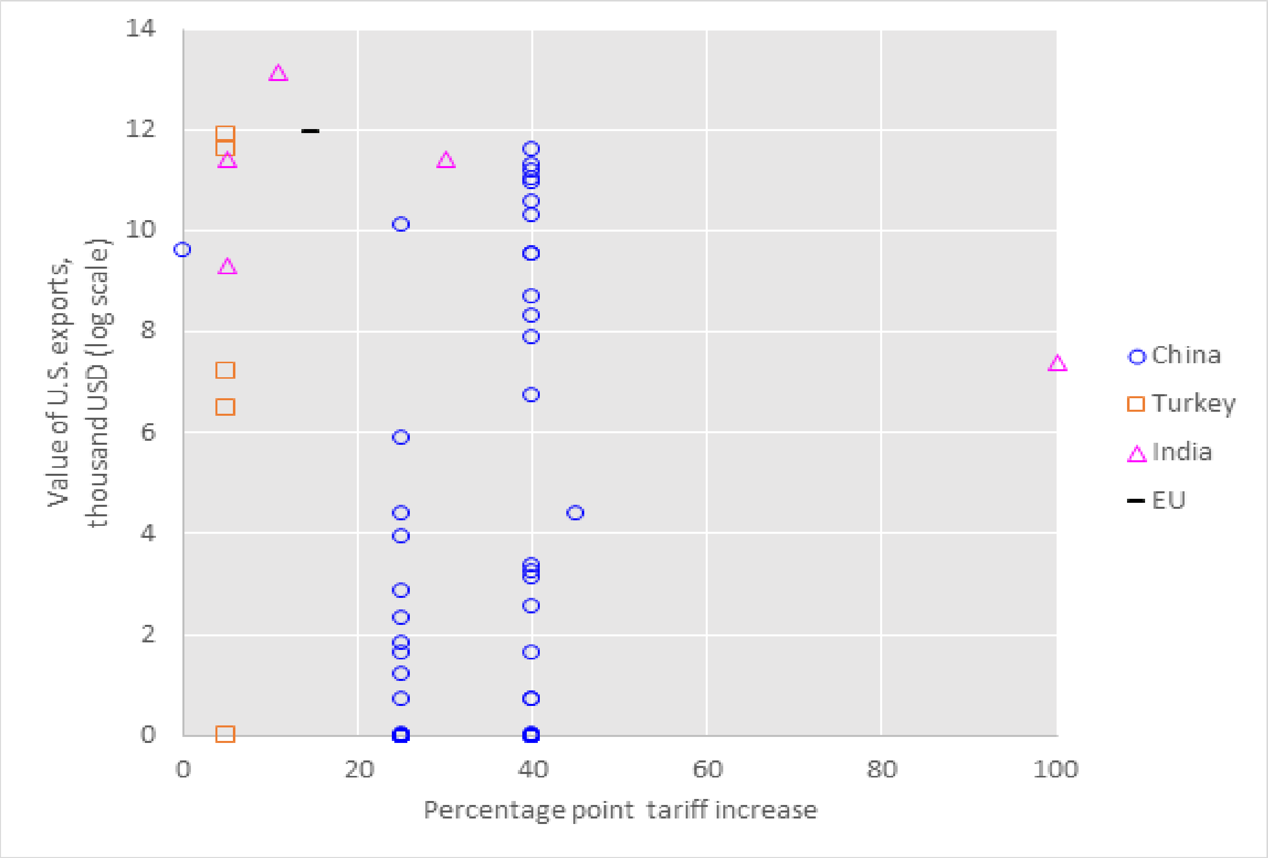
Frequency density of disaggregated VFN trade elasticities:

Note: Commodity-specific elasticities are reported.

Source: Estimated based on Fontagné et al. (2019).

Increase in tariffs on U.S. VFN

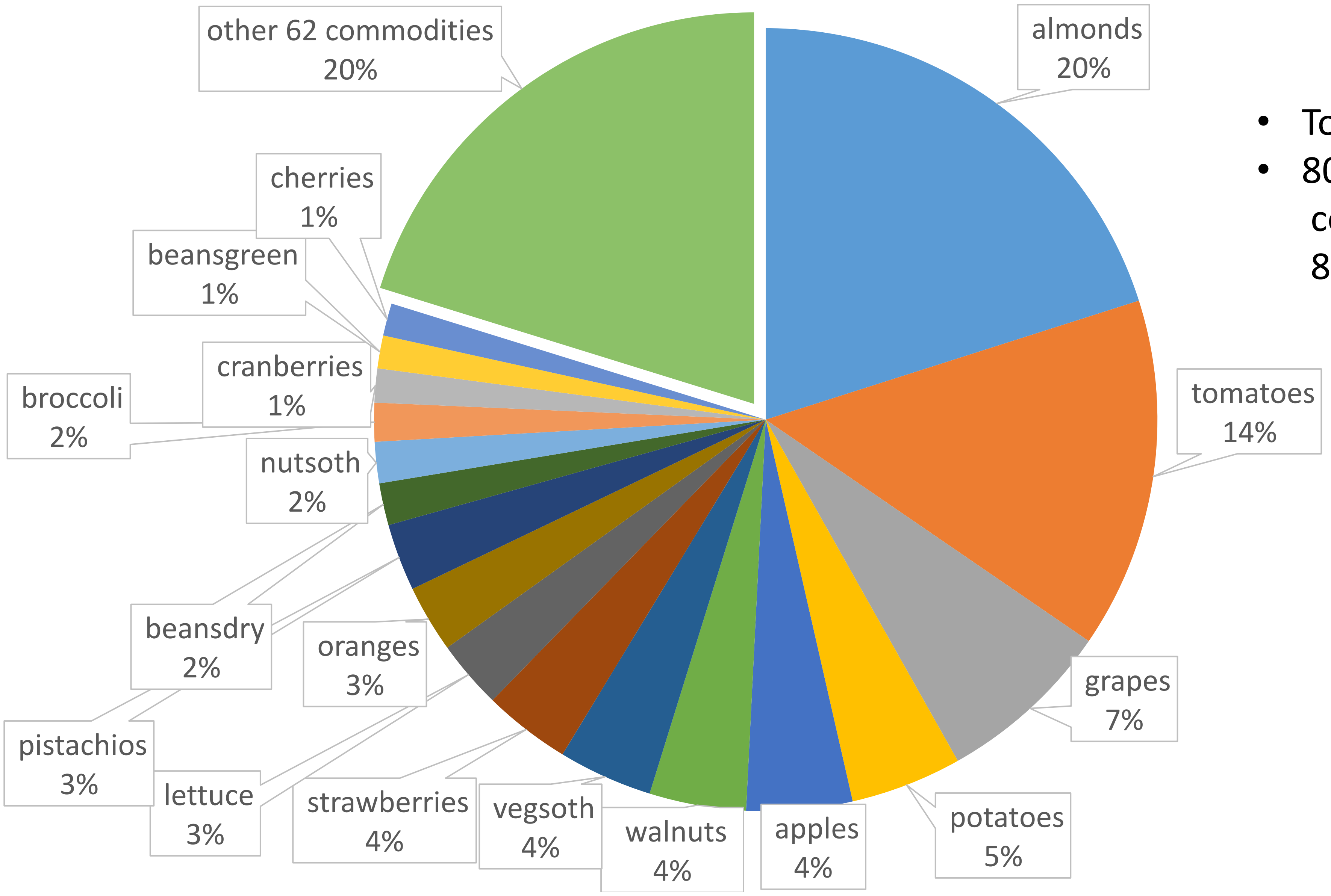
- In March 2018, U.S. has implemented tariffs on steel and aluminum imports from most countries
- Affected trade partners initiated retaliatory tariffs, extended well beyond these two commodities
- U.S.-China trade war
- One of the targeted U.S. agricultural sectors is vegetables, fruit and nuts
  -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



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

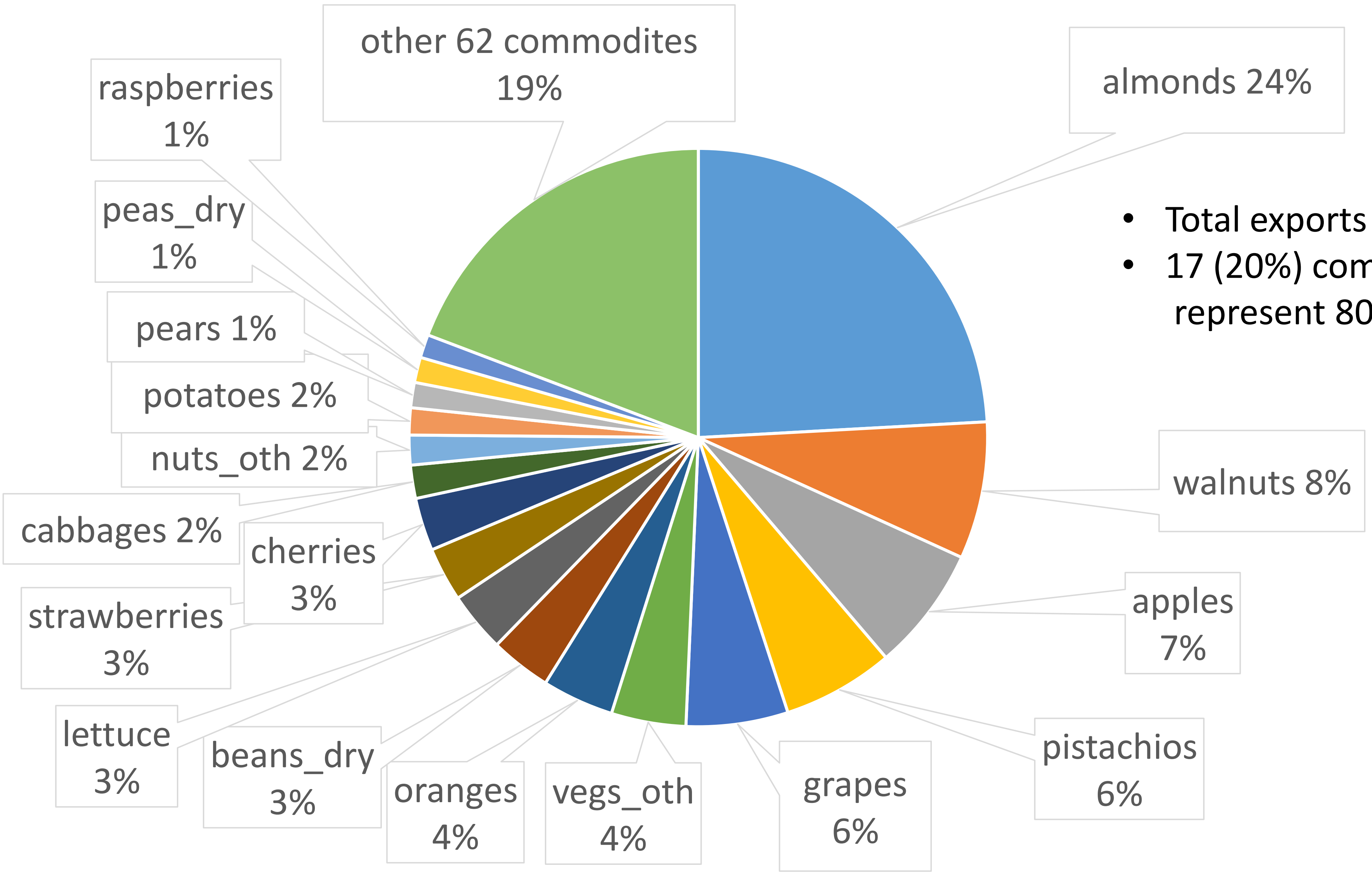
Source: Developed in Chepeliev et al (2019) using Li (2018).

Structure of U.S. output of VFN



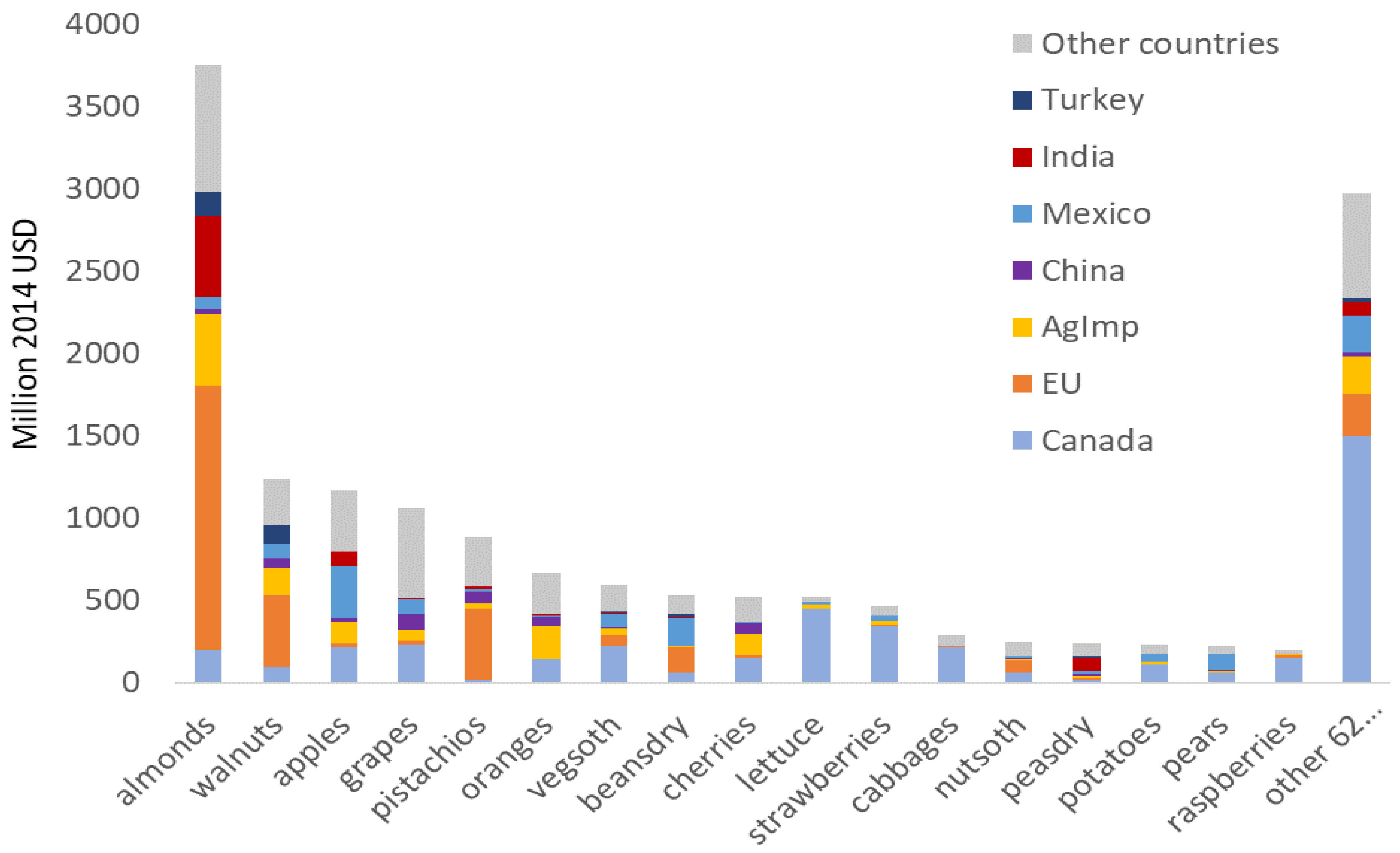
- Total output 46 billion USD
- 80/20 rule: of 79, 17 (20%) commodities represent 80% of output by value

Structure of U.S. exports of VFN before tariffs



- Total exports 16 billion USD
- 17 (20%) commodities represent 80% of exports

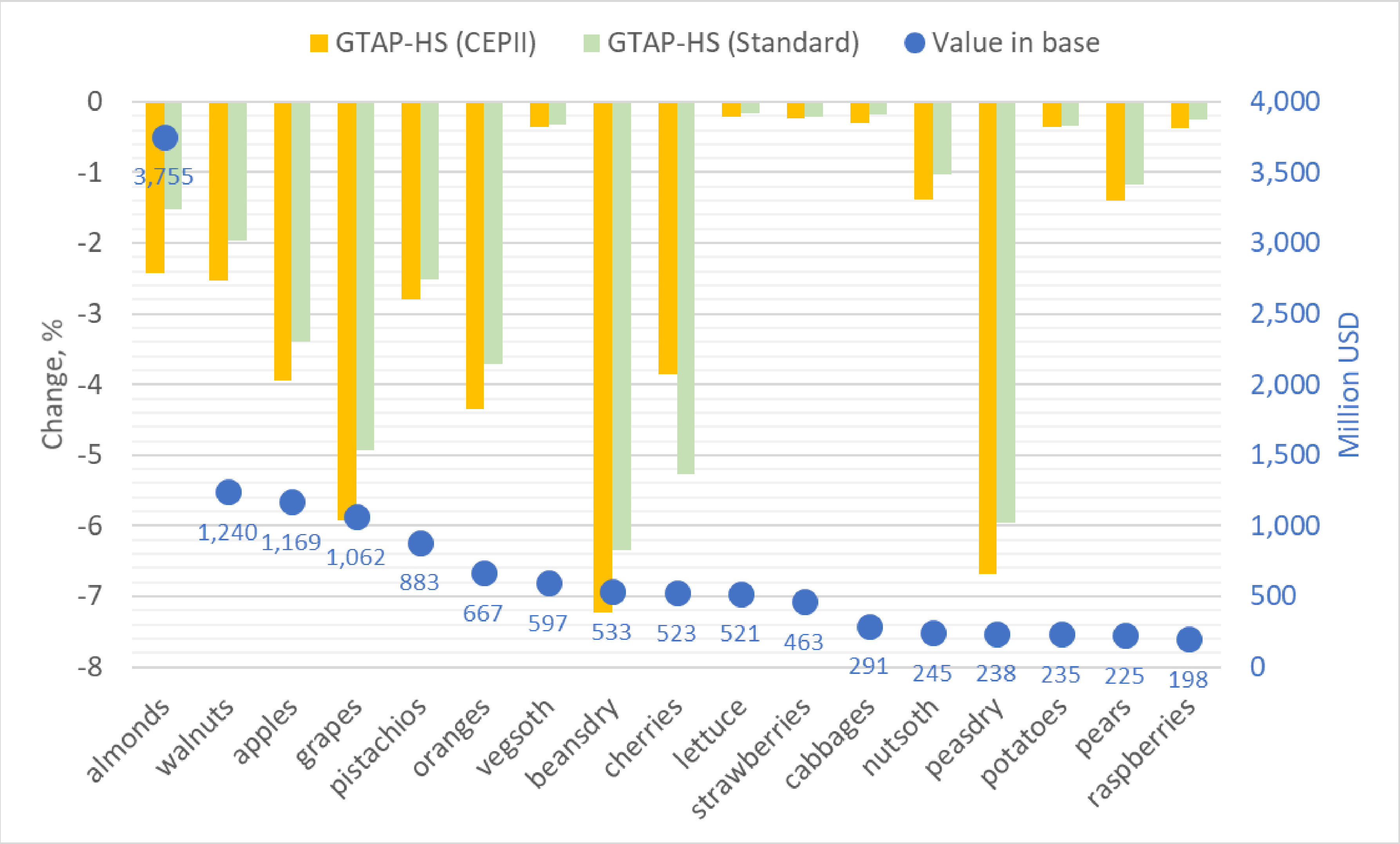
U.S. exports of VFN by commodity and destination



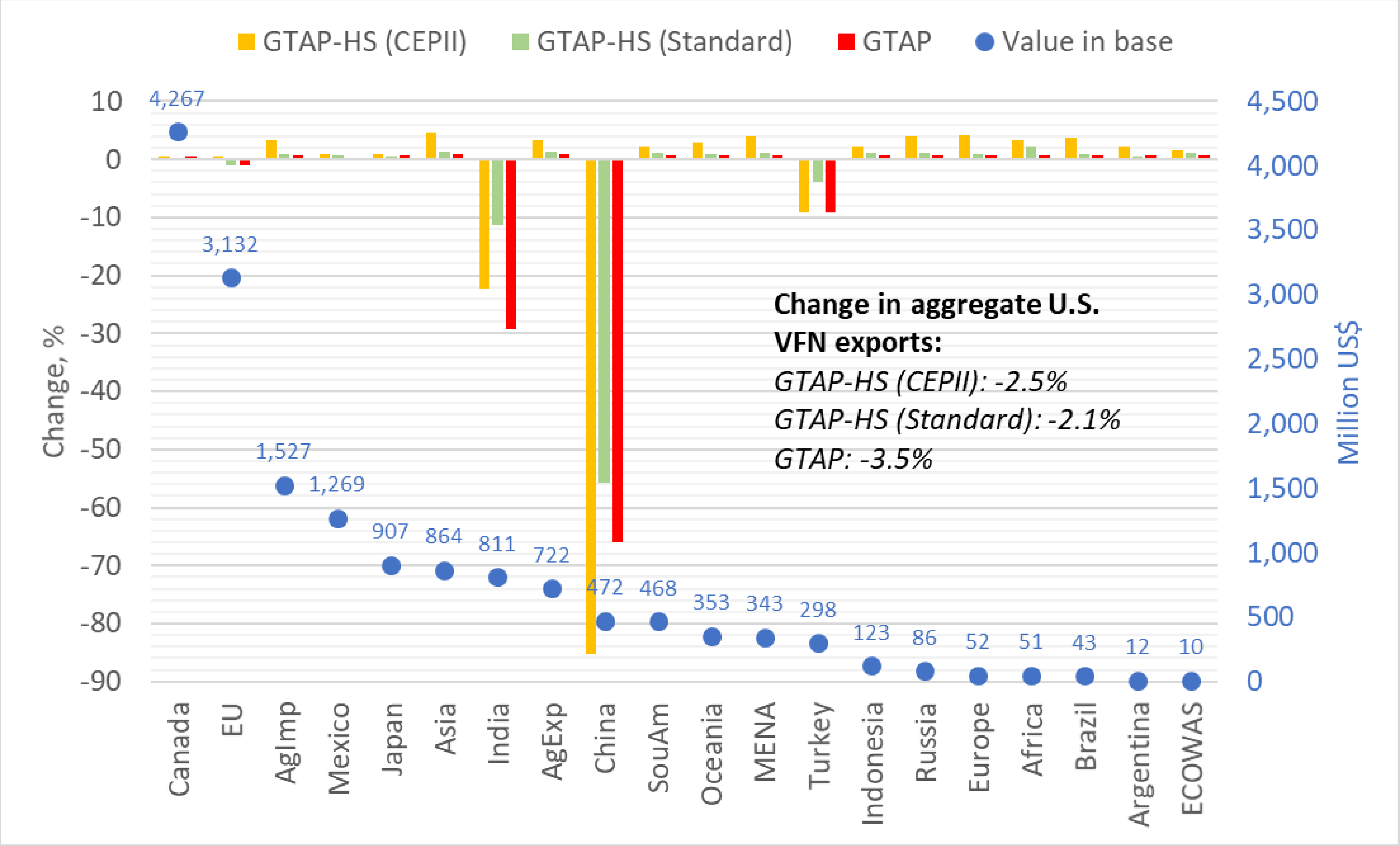
Scenarios

<table>
<tr><th>No.</th><th>Scenario</th><th>Countries engaged</th><th>US tariffs on foreign goods included in scenario</th><th>Foreign tariffs on US goods included in scenario</th></tr>
<tr><td>1.</td><td>VFN retaliations</td><td>All countries that have imposed retaliatory tariffs on US VFN exports, as of August 2019</td><td>None</td><td>All tariffs imposed on US vegetables, fruits and nuts exports</td></tr>
<tr><td rowspan="5">2.</td><td rowspan="5">US-China trade frictions</td><td rowspan="5">China</td><td>Steel & aluminum tariffs on China</td><td rowspan="2">China's tariffs in $3 bn round:
➢ No fruit & veg. commodities targeted in this round</td></tr>
<tr><td rowspan="2">All tariffs in $200 bn Round 1:
➢ Tariff increases on 71 fruit & veg. HS6 commodities (uniform 10% increase)</td></tr>
<tr><td>First wave of $50 bn round:
➢ Tariff increases on 49 fruit & veg. HS6 commodities (uniform 15% increase)</td></tr>
<tr><td rowspan="2">All tariffs in $200 bn Round 2:
➢ Additional 15% point increase on VFN commodities</td><td>Second wave of $50 billion round:
➢ Tariff increases on 100 fruit & veg. HS6 commodities (uniform 25% increase)</td></tr>
<tr><td>China's $60 billion rounds: tariffs on various other sectors</td></tr>
<tr><td>3.</td><td>All trade frictions</td><td>All countries affected by US steel and aluminum tariffs</td><td>Steel and aluminum tariffs on all countries; US-China trade frictions from Scenario 2</td><td>All tariffs from Scenario 1 and other retaliatory tariffs by EU, India, and Turkey; China's tariffs from Scenario 2</td></tr>
</table>

Scenario 1: Change in U.S. exports of VFN under different elasticity assumptions (top 17 commodities by value)



Scenario 1: Change in U.S. bilateral and total exports of aggregate VFN by region



Change in regional welfare (mill 2014 USD)

Model->	GTAP	GTAP-HS (Standard)		GTAP-HS (CEPII)	
Region\Scenario	Scenario 1: Retaliatory tariffs on US VFN only			Scenario 2: US-China trade frictions	Scenario 3: All trade frictions
Oceania	6.4	9.0	16.5	1124.9	1210.5
China	-137.7	-143.9	-123.7	-68407.2	-67279.6
Japan	11.5	7.3	9.8	5135.9	5173.4
AgImp	0.9	2.0	13.1	4599.6	4313.3
Asia	9.0	-0.1	2.5	2299.2	2254.1
Indonesia	2.1	1.2	1.4	536.0	507.7
Turkey	0.2	-3.0	-10.6	350.3	-92.2
AgExp	38.8	24.3	22.3	3810.0	3628.8
India	-20.9	17.6	11.9	1464.3	1600.7
Canada	34.1	17.4	18.7	7969.2	8726.2
USA	-161.8	-102.6	-121.4	-34880.8	-36463.2
Mexico	5.6	14.2	14.9	6411.8	6953.8
SouAm	7.2	7.0	8.3	2012.9	1836.8
Argentina	0.4	1.0	0.6	652.1	668.6
Brazil	-1.1	-0.8	-1.4	3410.8	3559.5
EU	30.3	18.4	27.5	13615.9	13571.7
Europe	-1.8	-1.5	-0.5	392.5	340.4
Russia	-6.9	-5.5	-3.5	560.5	559.4
MENA	-4.9	-4.5	-2.4	817.6	640.0
ECOWAS	1.3	-2.1	-1.4	616.9	575.1
Africa	-0.2	-1.1	-0.2	636.2	602.5
World	-187.4	-145.5	-117.9	-46871.4	-47112.3

Limitations

- No explicit representation of the production structure of each of the disaggregated VFN commodities; instead, the output of the aggregate VFN sector is allocated across different commodities using the CET function
  - Single CET parameter determines changes in output of all VFN
  - Cost structure of the VFN production sector is independent of the composition of output
    - In the initial data base, the cost structure of the aggregate VFN sector is representative of the cost structure mix of 79 sectors the aggregated VFN produces
    - However, after a policy shock, the cost structure of the aggregate VFN sector will not be perfectly reflecting cost structure mix in the new equilibrium
    - This limitation is of a lesser importance given the large number of the disaggregated VFN commodities

Conclusions

- Developed a new modeling framework to analyze trade policies implemented at the tariff line in VFN sectors
  - Value of output and domestic absorption data at the disaggregated commodity level are based on FAOSTAT
  - Output, trade and domestic absorption data from different data sets are reconciled
  - Trade elasticities estimated at the HS6 level (Fontagne et al. 2019)
- Analyzed trade frictions between U.S. and its trading partners
  - GTAP-HS vs. GTAP: GTAP overstates impacts on aggregate sector output and trade; magnitudes of these differences depend on Armington elasticities
  - Larger Armington elasticities translate to larger reductions in U.S. exports
  - Impacts of policies implemented in other sectors on disaggregated sectors of interest, and vice versa

Future work

- Split aggregate VFN sector into annuals and perennials with specification of distinct production structures for each of these sectors
  - Distinguish between general purpose and sector-specific capital (Dixon et al. 2011)
  - The responsiveness of perennial crops to changes in trade policy will differ dramatically from that of annual crops
- Refine values of substitution and transformation elasticities
- Expand GTAP-HS data base to cover more agricultural and food sectors
- Associate production of commodities with the specific U.S. states and explore regional impacts

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Thank you!