Detailed Representation of the Agricultural Sector in a Partial-General Equilibrium Trade Modelling Framework

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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 (Narayanan et al., 2010)
  • 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

• This suggests the need for a PE-GE, nested modeling framework to support trade policy analysis
Objective

- Develop PE-GE data base and model to advance trade policy analysis with focus on agriculture
  - Disaggregate two sectors in the GTAP data base
    - vegetables, fruit and nuts (v_f)
    - dairy products (mil)
  - Develop **integrated** PE-GE data base to remove inconsistencies in bilateral trade, trade policies and production which inevitably arise when conducting independent GE and PE analyses
  - Build PE-GE modeling framework that allows to quantify impacts of trade policies at the detailed commodity level, as well as other sectors and economy-wide impacts
  - Illustrate the value of this approach
PE-GE model

• GTAP-PE model (Aguiar et al. 2019)
  • Original concept developed in Narayanan et al. (2010)
  • Uses GTAP model version 7 (Corong et al. 2017)

• 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

• PE model is nested within the GTAP GE model and captures output, domestic consumption and trade at the HS6 level by using
  • CET and CES structures
  • Market clearing conditions
  • Price linkages
Quantity linkages in the PE-GE 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 $d$
Price linkages in the PE-GE model

Basic price of domestically supplied HS6 commodity $k$ within $v_f$ in region $s$

FOB price of HS6 commodity $k$ exported from region $s$ to region $d$

Price including cost of insurance and freight of HS6 commodity $k$ imported from $s$ to $d$

Basic price of HS6 commodity $k$ imported from region $s$ in domestic market in region $d$

Basic price of the imported GTAP commodity $v_f$ in region $d$

Basic price of domestically supplied GTAP commodity $v_f$ in region $s$

Destination-generic and destination specific export taxes in region $s$

Cost of international transport of the HS6 commodity $k$ imported from $s$ to $d$

Source-generic and source-specific import taxes in region $d$

Basic price of the imported HS6 commodity $k$ in domestic market in region $d$, aggregated across all sources $s$
PE-GE data base

- GTAP 10p2 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, 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 PE-GE data base
  - GE part: 20 regions and 28 sectors, including v_f and mil
  - PE part: trade and domestic use of 79 commodities within GTAP sector “vegetables, fruit and nuts” and 9 commodities within GTAP sector “dairy products”
Policy scenarios

• In March 2018, U.S. has implemented tariffs of 25% on steel and 10% on aluminum imports from most countries

• Affected trade partners initiated retaliatory tariffs, extended well beyond these two commodities, including many agricultural imports from U.S.

• 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

• Scenarios
  1. Increase in tariffs on U.S. vegetables, fruit and nuts only
  2. All tariffs
Structure of U.S. output of vegetables, fruit and nuts sector

- 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 vegetables, fruit and nuts before tariffs

- Total exports 16 billion USD
- 17 (20%) commodities represent 80% of exports
Export values vs. retaliatory tariffs imposed on U.S. vegetables, fruit and nuts

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

U.S. exports of vegetables, fruit and nuts by commodity and destination

mill 2014 USD

- Other countries
- AgExp
- India
- Mexico
- China
- EU
- Canada

Commodities listed include:
- Almonds
- Walnuts
- Apples
- Pistachios
- Grapes
- Veggies other
- Oranges
- Beans dry
- Lettuce
- Strawberries
- Cherries
- Cabbages
- Nuts other
- Potatoes
- Peas dry
- Raspberries
- Other 62...
Scenario 1: Change in U.S. exports of vegetables, fruit and nuts due to retaliatory tariffs (top 17 commodities by value)

- almonds: -20 billion USD
- walnuts: -15 billion USD
- apples: -10 billion USD
- pistachios: -5 billion USD
- grapes: 0 billion USD
- vegetables: 0.7 billion USD
- oranges: 0.6 billion USD
- beans dry: 0.5 billion USD
- lettuce: 0.5 billion USD
- strawberries: 0.5 billion USD
- cherries: 0.5 billion USD
- cabbages: 0.3 billion USD
- nuts dry: 0.3 billion USD
- potatoes: 0.2 billion USD
- pears: 0.2 billion USD
- peas dry: 0.2 billion USD

% change in exports: almonds -20%, walnuts -15%, apples -10%, pistachios -5%, grapes 0%, vegetables 0.7%, oranges 0.6%, beans dry 0.5%, lettuce 0.5%, strawberries 0.5%, cherries 0.5%, cabbages 0.3%, nuts dry 0.3%, potatoes 0.2%, pears 0.2%, peas dry 0.2%
Scenario 1: Contribution to change in U.S. total exports of vegetables, fruit and nuts due to retaliatory tariffs (top 10 largest contributors)

-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
%  
U.S. total exports of vegetables, fruit and nuts are reduced by 5.2%
Scenario 1: Change in U.S. aggregate v_f exports and output: PE-GE vs GE

<table>
<thead>
<tr>
<th>Model</th>
<th>v_f output, %</th>
<th>v_f exports, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-GE</td>
<td>-1.6</td>
<td>-5.2</td>
</tr>
<tr>
<td>GE</td>
<td>-2.2</td>
<td>-7.1</td>
</tr>
</tbody>
</table>
## Scenario 2

<table>
<thead>
<tr>
<th>No</th>
<th>Component</th>
<th>U.S. trade partners</th>
<th>U.S. tariffs on foreign goods</th>
<th>Foreign tariffs on U.S. goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>North American trade frictions</td>
<td>Canada, Mexico</td>
<td>steel and aluminum</td>
<td>• Reciprocal tariffs on steel and aluminum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Mexica’s tariffs on apples, meat and other food</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Canada’s tariffs on yoghurt, meat and other food</td>
</tr>
<tr>
<td>2</td>
<td>U.S.-China trade frictions</td>
<td>China</td>
<td>• Steel and aluminum</td>
<td>• Tariffs in $3 bn round:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• All tariffs in $200 bn</td>
<td>No v_f targeted in this round</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Round 1: Tariff increases</td>
<td>• First wave of $50 bn round:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on 71 HS6 within v_f</td>
<td>tariff increases on 49 HS6 v_f</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(uniform 10% increase)</td>
<td>(uniform 15% increase)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Round 2 is not included</td>
<td>Second wave of $50 billion round:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tariff increases on 100 HS6 v_f</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(uniform 25% increase)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not included: Tariffs in $60 billion round</td>
</tr>
<tr>
<td>3</td>
<td>U.S. and the ROW</td>
<td>Other countries</td>
<td>steel and aluminum</td>
<td>Retaliatory tariffs by EU, India and Turkey</td>
</tr>
</tbody>
</table>
## Scenario 2: Change in the U.S. exports of vegetables, fruit and nuts

<table>
<thead>
<tr>
<th>Region</th>
<th>Reference value, mill USD</th>
<th>Change, %</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>North American trade frictions</td>
<td>U.S.-China trade frictions</td>
<td>ALL</td>
<td></td>
</tr>
<tr>
<td>Oceania</td>
<td>353.0</td>
<td>0.2</td>
<td>3.2</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>1196.9</td>
<td>0.3</td>
<td>-53.9</td>
<td>-53.7</td>
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</tr>
<tr>
<td>Japan</td>
<td>906.6</td>
<td>0.2</td>
<td>2.4</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>AgImp</td>
<td>1527.5</td>
<td>0.3</td>
<td>-3.9</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td>139.5</td>
<td>0.2</td>
<td>4.9</td>
<td>5.4</td>
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</tr>
<tr>
<td>Indonesia</td>
<td>122.8</td>
<td>0.2</td>
<td>2.8</td>
<td>3.1</td>
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<tr>
<td>AgExp</td>
<td>1020.0</td>
<td>0.2</td>
<td>3.4</td>
<td>0.7</td>
<td></td>
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<tr>
<td>India</td>
<td>811.5</td>
<td>0.1</td>
<td>3.2</td>
<td>-9.1</td>
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</tr>
<tr>
<td>Canada</td>
<td>4267.2</td>
<td>0.6</td>
<td>1.7</td>
<td>1.7</td>
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<tr>
<td>Mexico</td>
<td>1269.4</td>
<td>-3.2</td>
<td>-0.9</td>
<td>-0.8</td>
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<tr>
<td>SouAm</td>
<td>468.4</td>
<td>0.2</td>
<td>4.9</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>Argentina</td>
<td>11.7</td>
<td>0.4</td>
<td>6.0</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>42.7</td>
<td>0.4</td>
<td>6.0</td>
<td>6.4</td>
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<tr>
<td>EU</td>
<td>3132.4</td>
<td>0.3</td>
<td>3.7</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>51.6</td>
<td>0.4</td>
<td>4.9</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>86.0</td>
<td>0.2</td>
<td>3.1</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>MENA</td>
<td>343.4</td>
<td>0.3</td>
<td>4.8</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>ECOWAS</td>
<td>10.4</td>
<td>0.3</td>
<td>5.8</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>50.8</td>
<td>0.3</td>
<td>5.7</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Total U.S. exports</td>
<td>15811.8</td>
<td>0.1</td>
<td>-1.6</td>
<td>-2.6</td>
<td></td>
</tr>
</tbody>
</table>
### Scenario 2: Change in regional welfare, mill 2014 USD

<table>
<thead>
<tr>
<th>Regions\Scenarios</th>
<th>North American trade frictions</th>
<th>U.S.-China trade frictions</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceania</td>
<td>72.2</td>
<td>951.3</td>
<td>1068.6</td>
</tr>
<tr>
<td>China</td>
<td>1423.6</td>
<td>-47166.3</td>
<td>-45602.3</td>
</tr>
<tr>
<td>Japan</td>
<td>408.8</td>
<td>4348.0</td>
<td>4412.6</td>
</tr>
<tr>
<td>AgImp</td>
<td>344.2</td>
<td>3862.6</td>
<td>3691.7</td>
</tr>
<tr>
<td>Asia</td>
<td>16.9</td>
<td>1240.6</td>
<td>1220.0</td>
</tr>
<tr>
<td>Indonesia</td>
<td>33.6</td>
<td>446.3</td>
<td>462.8</td>
</tr>
<tr>
<td>AgExp</td>
<td>185.0</td>
<td>3217.7</td>
<td>2645.2</td>
</tr>
<tr>
<td>India</td>
<td>164.8</td>
<td>1381.9</td>
<td>1534.2</td>
</tr>
<tr>
<td>Canada</td>
<td>-2676.8</td>
<td>2656.5</td>
<td>3352.3</td>
</tr>
<tr>
<td>USA</td>
<td>-1494.0</td>
<td>-24340.8</td>
<td>-26976.1</td>
</tr>
<tr>
<td>Mexico</td>
<td>-131.8</td>
<td>4274.2</td>
<td>4778.2</td>
</tr>
<tr>
<td>SouAm</td>
<td>129.6</td>
<td>1620.2</td>
<td>1465.4</td>
</tr>
<tr>
<td>Argentina</td>
<td>28.1</td>
<td>588.5</td>
<td>610.4</td>
</tr>
<tr>
<td>Brazil</td>
<td>114.8</td>
<td>3073.9</td>
<td>3234.7</td>
</tr>
<tr>
<td>EU</td>
<td>1411.9</td>
<td>12057.3</td>
<td>12177.4</td>
</tr>
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<td>Europe</td>
<td>11.4</td>
<td>278.6</td>
<td>245.4</td>
</tr>
<tr>
<td>Russia</td>
<td>-75.8</td>
<td>172.6</td>
<td>205.9</td>
</tr>
<tr>
<td>MENA</td>
<td>-4.5</td>
<td>523.6</td>
<td>360.8</td>
</tr>
<tr>
<td>ECOWAS</td>
<td>-6.5</td>
<td>394.6</td>
<td>364.8</td>
</tr>
<tr>
<td>Africa</td>
<td>-9.0</td>
<td>397.1</td>
<td>367.4</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td>-53.7</td>
<td>-30021.4</td>
<td>-30380.4</td>
</tr>
</tbody>
</table>
Conclusions

• Developed PE-GE data base and model to advance trade policy analysis with focus on agriculture
• Quantified impacts of the recently introduced trade frictions between U.S. and trading partners
  • Vegetables, fruit and nuts exports by commodity and total, and by trading partner
  • Welfare impacts
• When comparing PE-GE with GE results, we find that GE overstates impacts on aggregate sector output and trade
• On aggregate level, U.S. and China suffer the most, while other regions gain
  • Canada and Mexico are loosing due to trade frictions within NAFTA, but gain due to U.S.-China trade war
• While aggregate U.S. exports of v_f decrease by 2.6% (scenario 2), impacts are highly heterogeneous across individual commodities
  • U.S. exports of some of the v_f commodities are reduced by more than 15%
  • For many of the v_f commodities, U.S. exports to China are reduced by more than 50%
Next steps

• Incorporate tariff-rate quotas (dairy products)
• Sensitivity analysis
  • Substitution elasticities
• Expand PE-GE data base to cover more agricultural and food sectors
• Include use by agent at the HS6 level (household, intermediate use by production activities, government, investment) in the PE-GE framework
  • Data (completed)
    • Food Balance Sheets (FAO)
    • Assumptions
  • Model
• Associate production of commodities with the specific U.S. states and explore regional impacts
Thank you!