Discussion on Mark Rosegrant’s “Global Perspectives on Food Security and Environmental Sustainability”

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The starting point

IMPACT: A fascinating journey in integrated model building

• 1995: first IMPACT model, only policy and economic component (IFPRI Vision 2020)
• 2002: integration with a water model accounting for CC
• 2009: integration with a crop model accounting for CC
• 2010: major revision to reflect results from the next generation climate models
• 2014: the role of Agr R&D and adoption of innovations on long-term food security and environmental sustainability
The starting point

IMPACT: A fascinating journey in integrated model building

Model Inputs and Scenario Definitions

- Urban growth & changes in food habits (demand elasticities)
- Income growth projections
- Population growth projections
- Supply, demand, and trade data from FAOSTAT, IFPRI, UN, World Bank, and others
- Area elasticities w.r.t. crop prices
- Yield elasticities w.r.t. crop, labor, and capital prices
- Area and yield annual growth rates

Water Simulation

- Water Demand
  - Irrigation
  - Livestock
  - Domestic
  - Industry
  - Environment
- Water Supply
  - Renewable H2O
  - Effective H2O for Irrigated and Rainfed Crops
- Climate Scenarios
  - Rainfall, Runoff, Potential ET

Model Calculations (Food)

- Demand Projection
- Supply Projection
- Net Trade exports - imports
- World Trade Balance
- Imports = Exports
- Malnutrition
- Hunger

Adjust World Price

Iteration for World Market Clearing

Source: Rosegrant and IMPACT Devt Team, 2012
My discussion

• not focusing on model’s projections
• focus on the rationale, hypotheses and implications
  - what is in there?
  - what is not in there?
  - what may be in there?
What is in there?

(basic) IMPACT: policy and trade simulations
- **partial equilibrium** global agricultural sector model: world market prices for all commodities that satisfy market-clearing conditions
- **multi-commodity**: 46 crops and livestock commodities
- **multi-country**: 115 countries/regions, linked to the rest of the world through trade

IWSM: water systems and water stress
- **water scenarios**: downscaled and calibrated to GCMs (future climates in the different IPCC SRES scenarios)
- **food producing units**: 281 combination of 126 water basins with 115 country/regions
What is in there?

**DSSAT**: process-based crop model
- **crop modeling suite**: simulate the responses of crops to changing biophysical conditions
- **technology adoption**: adoption pathways, link between IMPACT and DSSAT

**Outputs**
- **demand**: function of prices, income, and population growth
- **crop production**: determined by crop and input prices, the rate of productivity growth, and water availability
- **projections**: global food supply, demand, trade, and prices
What is in there?

Rationale

- rising resource scarcity (water, land) $\rightarrow$ constraints on food production growth
- increasing bioenergy demand $\rightarrow$ increased food-fuel competition for land and water
- greater food production from higher productivity rather than from a net increase in cropland area
- role of agricultural R&D activities and technology adoption
## What is in there?

<table>
<thead>
<tr>
<th>Model (References)</th>
<th>Institution</th>
<th>Type</th>
<th>Economy coverage</th>
<th>Agric. sectors</th>
<th>Regions</th>
<th>Agric. policies</th>
<th>Agric. supply</th>
<th>Final demand</th>
<th>Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIM (Fujimori et al., 2012)</td>
<td>NIES, Japan</td>
<td>CGE</td>
<td>Full economy</td>
<td>8/1</td>
<td>89/17</td>
<td>Implicitly assumed unchanged</td>
<td>Nested CES</td>
<td>LES utility</td>
<td>Nonspatial; Armington gross-trade Armington spatial equilibrium</td>
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<tr>
<td>ENVISAGE (van der Mens-brugghe, 2013)</td>
<td>FAO/World Bank</td>
<td>CGE</td>
<td>Full economy</td>
<td>10/5</td>
<td>11/9§</td>
<td>Price wedges (based on GTAP)</td>
<td>Nested CES</td>
<td>LES utility (w/ dynamic shifters)</td>
<td>Armington spatial equilibrium</td>
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<tr>
<td>EPPA (Paltsev et al., 2005)</td>
<td>MIT, USA</td>
<td>CGE</td>
<td>Full economy</td>
<td>2/0</td>
<td>7/9</td>
<td>Subsidies, taxes, tariff equivalents</td>
<td>Nested CES</td>
<td>Nested CES utility</td>
<td>Armington spatial equilibrium</td>
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<td>CGE</td>
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<td>5/8§</td>
<td>Price wedges (based on GTAP)</td>
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<td>LES utility</td>
<td>Armington spatial equilibrium</td>
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<tr>
<td>GTEM (Pant, 2007)</td>
<td>ABARES, Australia</td>
<td>CGE</td>
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<td>7/7</td>
<td>5/8§</td>
<td>implicitly assumed unchanged Price wedges (based on GTAP)</td>
<td>Nested Leontief and CES</td>
<td>Nested CES</td>
<td>CDE utility</td>
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<tr>
<td>MAGNET (Woltjer et al., 2011)</td>
<td>LEI-WUR, The Netherlands</td>
<td>CGE</td>
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<td>10/9</td>
<td>29/16</td>
<td>Price wedges (adjusted from GTAP); milk quotas</td>
<td>Nested Leontief and CES</td>
<td>Nested CES</td>
<td>CDE private demand and Cobb-Douglas utility</td>
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<td>Leontief</td>
<td>Iso-elastic</td>
<td>Heckscher-Ohlin nonspatial, net-trade Enke-Samuelson-Takayama-Judge spatial equilibrium</td>
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<td>Iso-elastic</td>
<td>Heckscher-Ohlin nonspatial, net-trade</td>
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<td>Leontief</td>
<td>exogenous</td>
<td>Based on historical self-sufficiency rates</td>
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</table>

Source: von Lampe et al., 2014
What is in there?

• **comparative advantage**: analysis of global agricultural production along with detailed regional disaggregation

• **objective**: providing long-term projections (i.e. model simulations, not predictions of the future), “to address a lack of long-term vision and consensus among policy-makers and researchers” → looking for trends/estimates not necessarily accuracy

• Questions
  - Q1: baseline based on reasonably assumptions, but how robust is it and what are the most sensitive assumptions?
  - Q2: how robust are the results obtained wrt technology adoption?
What is in there?

**IMPACT** projections close to the average of models’

Crop vs. ruminant prices in 2050

Source: von Lampe et al., 2014: Figure 4
What is in there?

**IMPACT** projections close to the average of models’

Agr area expansion vs. avg agr prices in 2050

Source: von Lampe et al., 2014: Figure 5
What is in there?

**IMPACT** projections close to the average of models’

Global consumption vs. avg agr prices in 2050

Source: von Lampe et al., 2014: Figure 6
What is in there?

• agreements:
  - relative importance of productivity progress as compared to area expansions
  - hotspots for future growth in agricultural demand (e.g. SSA, MENA) and production (e.g. SSA, LAC)
  - increasingly important role for international trade (e.g. import SSA, MENA, veg exp NAM, OCE, an exp BRA)

• disagreements:
  - estimating future demand over a long-term horizon (small differences in income elasticities add to substantial differences in projected food consumption)
  - accounting for technical progress in agriculture: assumptions about yield growth, but also factor deepening
  - bioenergy: endogenous vs exogenous, 1\textsuperscript{st} vs. 2\textsuperscript{nd} gener.
What is not in there?

• CGE vs. PE
  - prices: CGE models usually smoother price path
  - institutions: CGE agents’ behavioral rules, income distribution

Q3: is there any chance to incorporate some of these features through empirical relations/components feeding into the PE model?

• Land dynamics

Q4: is it already in DSSAT? Or is an additional module (e.g. LPJmL) needed?

Q5: only land use switching or also new land conversion to agriculture
What may be in there?

- Improvements:
  - more economic research and better economic data
  - more bio-physical research and better linkage to the economic module

Q6: what are the most promising research areas in the short, medium and longer run?
A couple of concluding remarks on policy implications

• Differences in results across regions and within regions:
  – diversified policy packages
  – prioritization

• Many technology options:
  – single vs. multiple technology packages
  – sequencing of technology adoptions