Agriculture in Global Scenarios: New Multi-Model Economic Results

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Ten global economics modelling groups; many contributing authors

- Six general equilibrium models
  - AIM, NIES
  - ENVISAGE, FAO/World Bank
  - EPPA, MIT
  - FARM, USDA
  - GTEM, ABARES
  - MAGNET, LEI/Wageningen

- Four partial equilibrium models
  - GCAM, PNNL
  - GLOBIOM, IIASA
  - IMPACT, IFPRI
  - MAgPIE, PIK

Plus several crop modeling groups!!!
Key policy-relevant questions

• What is the future of agricultural prices?
  • No change or slight decline
  • Doubling

• How will agricultural production evolve?
  • Land expansion
  • Yield growth and intensification

• How will climate change alter ...
  • Prices
  • Land use
  • Trade
  • Undernourishment
Alternate perspectives on price scenarios 2004-2050, OECD comparison 2011 (no climate change)

IMPACT had substantially greater price increases than LEITAP or ENVISAGE (e.g. 80% increase in coarse grains)
Why do the results differ?

• Differing modeling approaches
  • CGE models more ‘flexible’ (?)
  • Functional forms determine outcomes (e.g., Armington assumption, demand system)
    • E.g., two CGE models have positive and rising income elasticities over time for staples. Several models have increasing price elasticities over time.

• Differing perspectives on future unknowns (and today’s values)
  • What maize yield growth rate will private sector research be able to achieve? Everywhere or only in developing countries?
  • How easy is it to convert Congolese rainforest to agricultural activities
  • What is the own price demand elasticity for non-ruminant meat in China today (-0.09 in AIM to -0.56 in GLOBIOM)
Scenario harmonization to identify sources of the differences among model results

- Three key drivers
  - Population from SSPs
  - GDP from SSPs (OECD values)
  - Exogenous component of agricultural yield growth (from IMPACT model)
  - Note: didn’t standardize biofuels/trade/ag policy assumptions

- Three ‘orthogonal’ comparisons
  - **Socioeconomics** – two scenarios (S1 and S2)
    - SSP2 – no climate change (S1)
    - SSP3 – no climate change (S2)
  - **Climate change** – six scenarios with most extreme AR5 emissions pathway – RCP8.5 (S3 – S6 + 2 additional for PNAS paper)
    - Two crop models (DSSAT and LPIJ) with no CO₂ fertilization
    - Two GCMs (Hadley and IPSL) with RCP8.5
  - **Bioenergy policies** – two scenarios (S7 – S8)
    - 2nd generation bioenergy (adjusted ref & high scenario)
Scenario drive characteristics, per capita income

Per capita incomes in 2010 and 2050 under 2 scenarios, $2007 per capita

[Bar chart showing per capita incomes for different regions and scenarios]
Results

The range of outcomes has narrowed
Price changes over time still differ across models, but range reduced

Price change, 2005-2050, major crops (scenario S1: has no climate change)

** General equilibrium ** Partial equilibrium

**"trended 2005, i.e. hypothetical in the absence of short-term shocks**
Results from the socioeconomic scenarios

Comparisons are between S1 and S2 in 2050
Model differ dramatically in their responses to a socioeconomic shock
Percent price change 2050, S2/S1
Results from the climate change scenarios

Comparisons are with respect to S1 (SSP2, no climate change) to climate change scenarios (SSP2, various climate change GCM and crop model combinations)
The climate modeling chain: From biophysical to socioeconomic

Nelson, et al., PNAS 2013
Climate change and economic responses

Model choices
- How much supply response?
  - Area
  - Yield
- How much demand response?
- Where does response take place?
- How much cross country (i.e., international trade) response?

Initial shortage caused by climate change

Initaial shortage results in big price increases

Final price

Price

Final quantity

Quantity

Supply

Demand
Climate change reduces 2050 yields. Producer, consumer, and trade responses partially compensate.

Nelson, et al., PNAS 2013
How do the model distribute their 2050 responses to price changes from climate change?
Implicit aggregate model elasticities (normalized to 1)

<table>
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<th>Demand</th>
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<th>Yield</th>
<th>Demand/Supply</th>
<th>Model Type</th>
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Mostly area
Mostly yield
Results from the bioenergy scenarios

Comparisons are between S1 and S2 in 2050
Bioenergy-induced change in world market prices in 2050 are relatively small
(S8 compared to S7. %)
Availability of ‘unmanaged’ land is crucial for small price increases
How ‘plausible’ are these results? Two views

• They are too pessimistic
  • GHG concentration pathway with the greatest forcing (RCP 8.5)
  • Crop models assumed CO₂ concentrations the same throughout the period

• They are not too bad
  • Field results from FACE experiments suggest CO₂ fertilization effect in the field is less than in the lab

• And then there is the Lamppost problem
What is missing in our climate change results? The Lamppost Problem

• The models used to analyze the effects of climate change don’t include effects of
  • Increasing ozone
  • Increasing extreme events
  • Increasing pest and disease pressure
• These could swamp the negative effects already quantified, making the challenges much more difficult
Conclusions

• Substance
  • The relatively extreme climate change shock will reduce yields and increase prices
  • Adaptation reduces some of those effects across the supply and demand side
  • Models allocate response differently between supply (area and yield) and demand

• Model structure matters; not model type
• Models differ dramatically in the extent to which endogenous supply or demand response is important