Global Trade Analysis Project

Lessons from the Agricultural Model Intercomparison Project (AgMIP)

Thomas Hertel, Uris Baldos and **Dominique van der Mensbrugghe**
Center for Global Trade Analysis
Purdue University

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Center for Global Trade Analysis
Department of Agricultural Economics, Purdue University
403 West State Street, West Lafayette, IN 47907-2056 USA

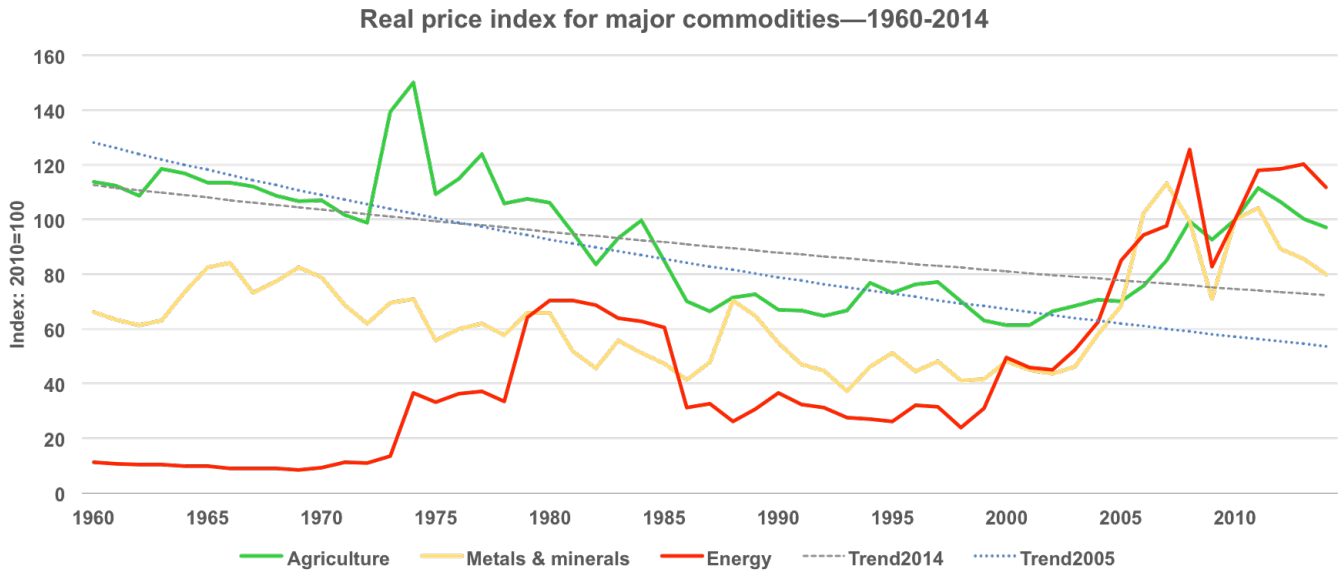
contactgtap@purdue.edu
http://www.gtap.agecon.purdue.edu

Outline

- Motivation
- AgMIP Phase 1 projections
- Analytical framework
- Monte Carlo simulations with SIMPLE
- Conclusion

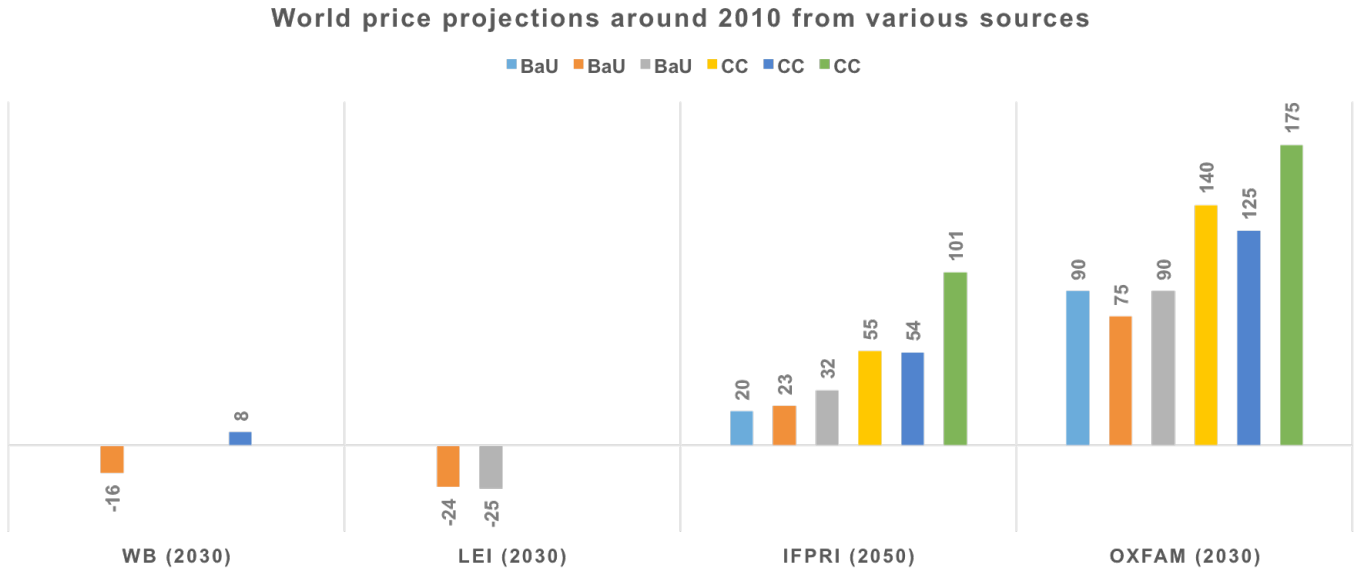
Motivation

Yet long-term downward slope for agricultural prices



Source: World Bank Pink Sheet, Nov. 2015, accessed 14-Nov-2015 (http://go.worldbank.org/4ROCCIEQ50).
Note: Trend2005 is the exponential regression of the agricultural price series between 1960 and 2005. The other trend line is the exponential trend line for the entire period. The trend growth rate is -1.6 p.p.a for the former and -0.8 p.p.a. for the latter.

Are price trends changing? Is there consensus?



Sources: World Bank 2009, Prins et al. 2011, Nelson et al. 2010, Oxfam 2011.
Notes: (1) End-year in parenthesis. (2) World Bank price index reflects all agriculture with baseline yields and with slower yield growth. (3) LEI results reflect baseline for temperate cereals and maize. (4) IFPRI and Oxfam results represent baseline yields and climate change-impacted scenarios.

Agricultural Model Intercomparison and Improvement Project (AgMIP)

List of participating models

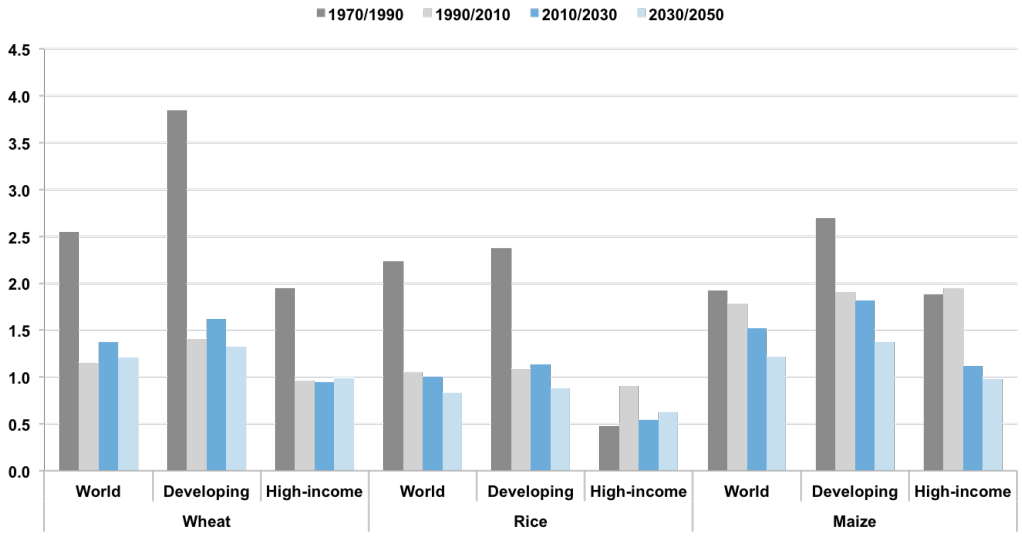
Model	Institution	Type	Base year
AIM	NIES	CGE	2005
ENVISAGE	FAO/World Bank	CGE	2007
EPPA	MIT	CGE	2004
FARM	ERS/USDA	CGE	2004
GTEM*	ABARES	CGE	2004
MAGNET*	LEI	CGE	2001
GCAM	PNNL	PE	2005
GLOBIOM	IIASA	PE	2000
IMPACT	IFPRI	PE	2000
MAgPIE	PIK	PE	2005

Note: CGE models marked with a '*' are based on the core GTAP model. All other CGE models are GAMS based using the GTAP database.

Scenario protocols

- **Harmonized population and GDP projections from 2010 through 2030 and 2050**
  - Use of newly developed shared socio-economic pathways (SSPs) developed by the Integrated Assessment Modeling (IAM) community to replace the SRES scenarios for AR5
  - SSP2 ('*middle of the road*') chosen as reference scenario using OECD GDP projections. Global population more or less in line with UN population projections (2010 revision)
- **So-called intrinsic productivity growth rates from IFPRI (for crops only)**
- **No harmonization of biofuels, trade and agricultural support policies**
- **Climate shocks: 2 x 2 (IPSL-CM5A & HadGEM2-ES x LPJmL & DSSAT)**

History vs. projected yield growth, percent per annum



Source: 1970/2010 FAOSTAT (accessed 22-Jul-2013), IFPRI's IPRs and own calculations

Note: Slight differences in regional aggregations between history and projections. Maize yield projections equivalent to coarse grain definition in GTAP.

Summary 2050 results from AgMIP Phase 1 study (2005=100)

	Production			Crop	Crop
	Cereals	CR5	Crop	Price	Land
AIM	169	182	157	146	125
ENVISAGE	164	191	216	108	119
FARM	169	193	183	91	94
GCAM	159	195	182	96	111
GLOBIOM	164	197	198	99	111
GTEM	164	175	NA	130	103
IMPACT	157	193	185	103	109
MAGNET	186	192	177	84	128
MAgPIE	168	208	157	NA	118
SIMPLE*	NA	NA	179	86	119
SIMPLE**	NA	NA	161	126	132
FAO	147	NA	NA	NA	105

Sources: von Lampe et al (2014) and Schmitz et al (2014) including supplemental materials. SIMPLE results are based on the authors' calculations SIMPLE * corresponds to the case of both land and non-land augmenting technical change, whereas SIMPLE** only has land-augmenting technical change.

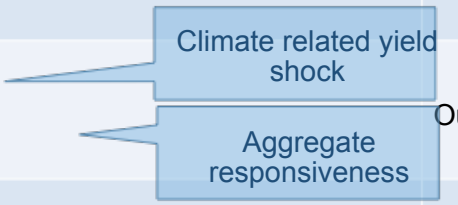
Analytical Framework

The basic analytical framework for global production

	Demand for agricultural output
	Zero profit condition
	Demand for non-land inputs
	Demand for land
	Supply of non-land inputs (infinite elasticity)
	Supply of land to agriculture
	Agricultural output, non-land and land inputs and their respective prices
	Output augmenting and input-specific augmenting technical change, and cost shares
	Key elasticities: price elasticity of demand, substitution across inputs, land supply
	Exogenous shifters in agricultural demand, land demand and land supply

CES with subst. s

Characterization of the static equilibrium



	Output
	Output price
	Land supply response
	The extensive margin of supply response (area elasticity wrt commodity price)
	The intensive margin of supply response (yield elasticity wrt commodity price)
	Aggregate exogenous shock
	Aggregate model responsiveness

Backing out responsiveness elasticities from PE models

	Total responsiveness is the (negative) ratio of the yield shock to the price change
	Demand elasticity can be derived from output equation (given the aggregate responsiveness)
	Extensive margin of supply response can be derived from area response function
	The intensive margin of supply response can be derived from aggregate responsiveness identity

Backing out responsiveness elasticities from GE models

	Price is a function of the productivity of land from which we can derive the parameter b.
	Output is related to price from which it is possible to derive the demand elasticity (given b).
	Land supply response function can be used to derive extensive margin
	Land supply response is derived by definition
	The aggregate response is derived from b and nL
	The intensive margin is derived from the aggregate response function.

‘Implicit’ aggregate responsiveness

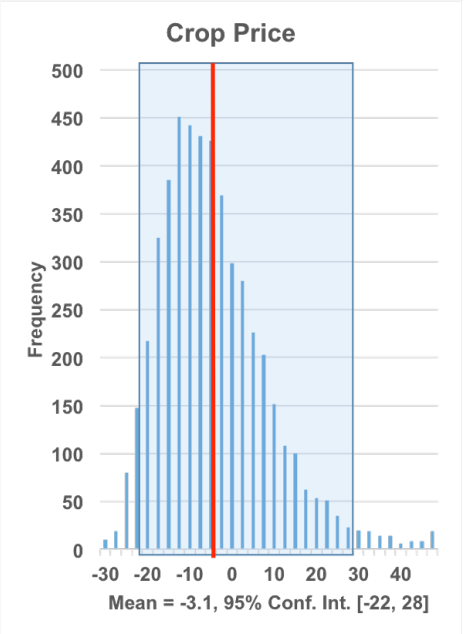
Model	Total	Demand	Extensive	Intensive
Partial Equilibrium Modelsa				
IMPACT	0.58	0.24	0.37	-0.03
GCAM	2.80	0.63	2.52	-0.36
GLOBIOM	0.49	0.28	0.08	0.13
MAgPIEb	0.36	0.00	0.18	0.18
General Equilibrium Modelsa				
AIM	0.85	0.10	0.92	-0.17
ENVISAGE	3.22	0.47	1.57	1.18
FARMb	1.33	0.07	1.30	-0.04
GTEMb	0.96	0.07	0.52	0.36
MAGNET	0.93	-0.04	1.23	-0.26
Comparison Modela				
SIMPLE	1.16	0.29	0.36	0.51

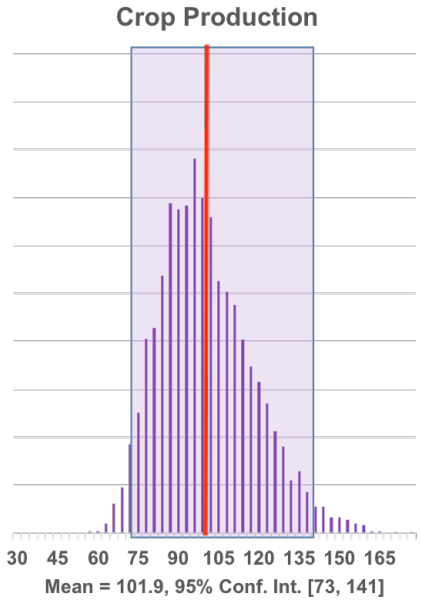
Notes: a) Elasticities for the PE models are computed by supply shifter approach using model results for 2050 changes in grains and oilseeds output, land use and prices, based on four different yield shocks, thereupon taking the average of these four elasticity estimates. Results for the CGE models are based on production function approach. SIMPLE elasticities are obtained via model simulation. b) denotes case where global shock is taken from IMPACT calculations.

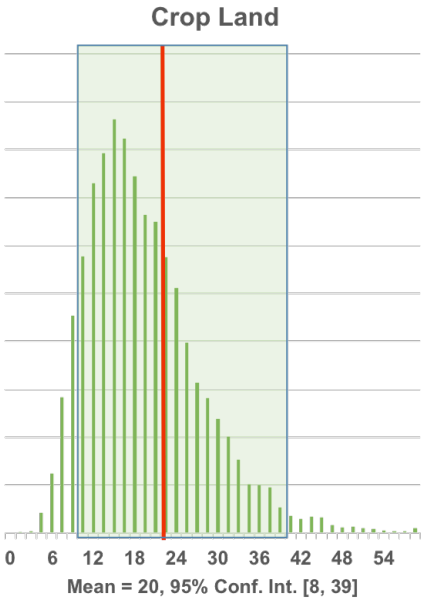
Monte Carlo Simulations with SIMPLE

- Simplified International Model of agricultural Prices, Land use and the Environment),

Monte Carlo outcomes for 2050 (% change, 2006-2050)

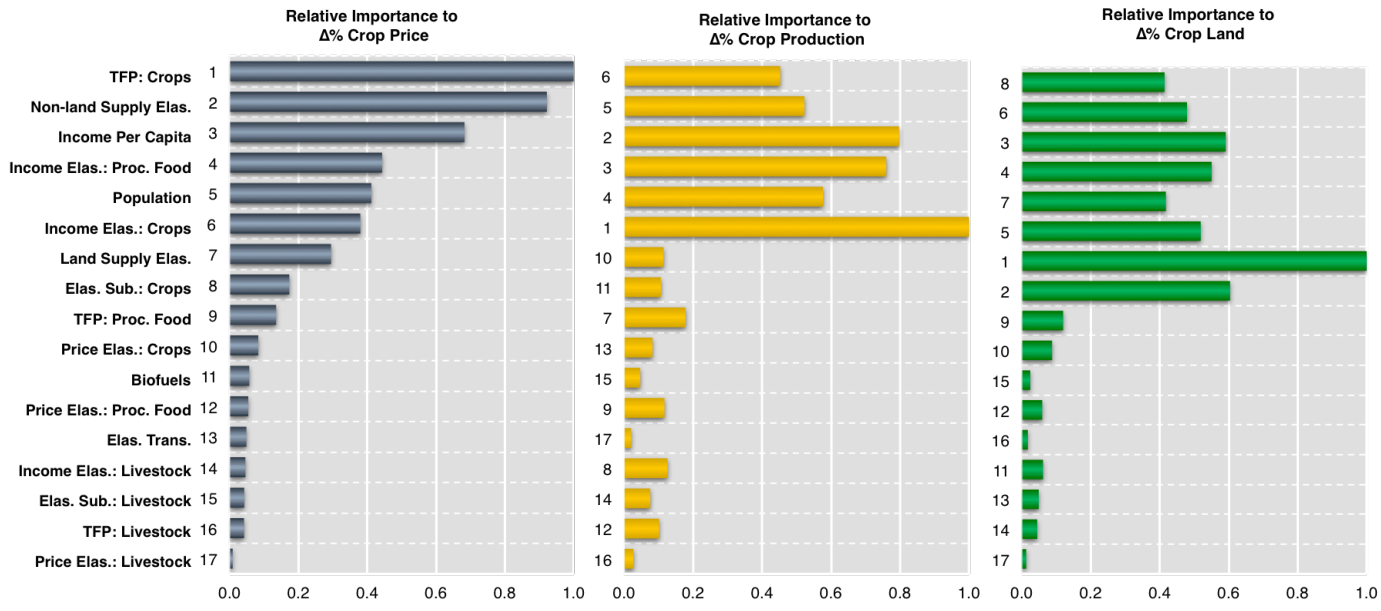






Source: SIMPLE model simulations.
Note: Solid red bar represents mean value of sampled model output, rectangle represents 95% confidence interval.

Relative importance of model inputs for future projections based on the Morris Method under segmented markets



Take-away messages

- Historical debate between Malthus and Ricardo continues.
- AgMIP harmonization has helped narrow differences across a suite of diverse models, but their projections vary widely due to differences in the underlying supply and demand responses, as well as their treatment of technical change.
- The Monte Carlo simulations with SIMPLE result in rightward-skewed outcomes such that the expected values are all higher than the point estimates obtained by simply using the most likely input values for the underlying drivers and economic response parameters.
- Crop prices are expected to be at roughly the same level in 2050 as in 2006, while overall crop production is expected to double and cropland conversion is expected to continue at roughly the same rate as for 1961-2006.

Looking ahead…

- Improvement in future predictions will benefit from greater attention to TFP projections.
- Global economic modelers must also give more thought to the way they incorporate productivity growth into their framework, since this is an important source of difference across model projections.
- Future research should focus on the relatively neglected topic of labor and capital supply to agriculture, as this is a key parameter governing the long run evolution of the crops sector.