Global Trade Analysis Project

Climate change impacts on the production factor land and implications for growth

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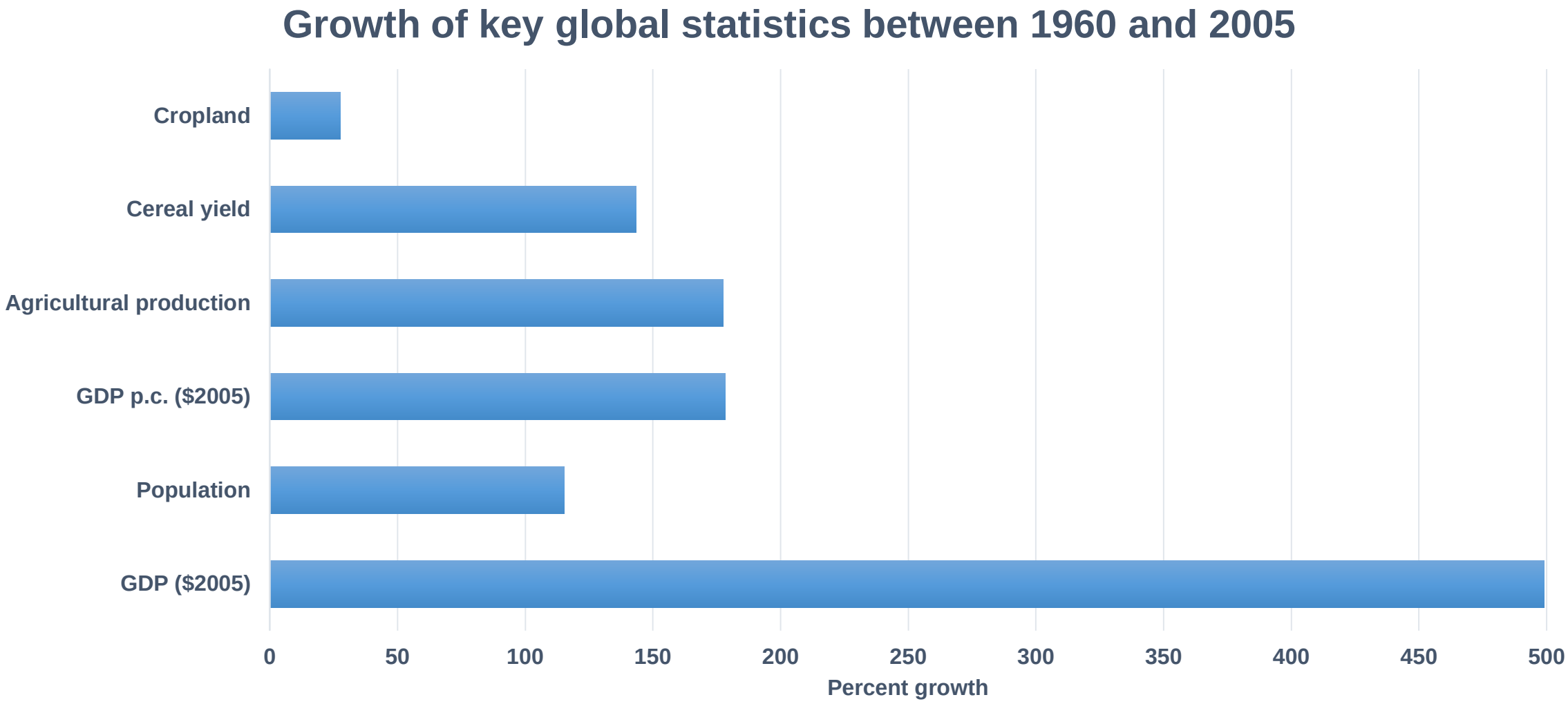
Outline

- Motivation
- Overview of historical projections
- AgMIP summary
- Analytical framework
- Monte Carlo simulations with SIMPLE
- Conclusion

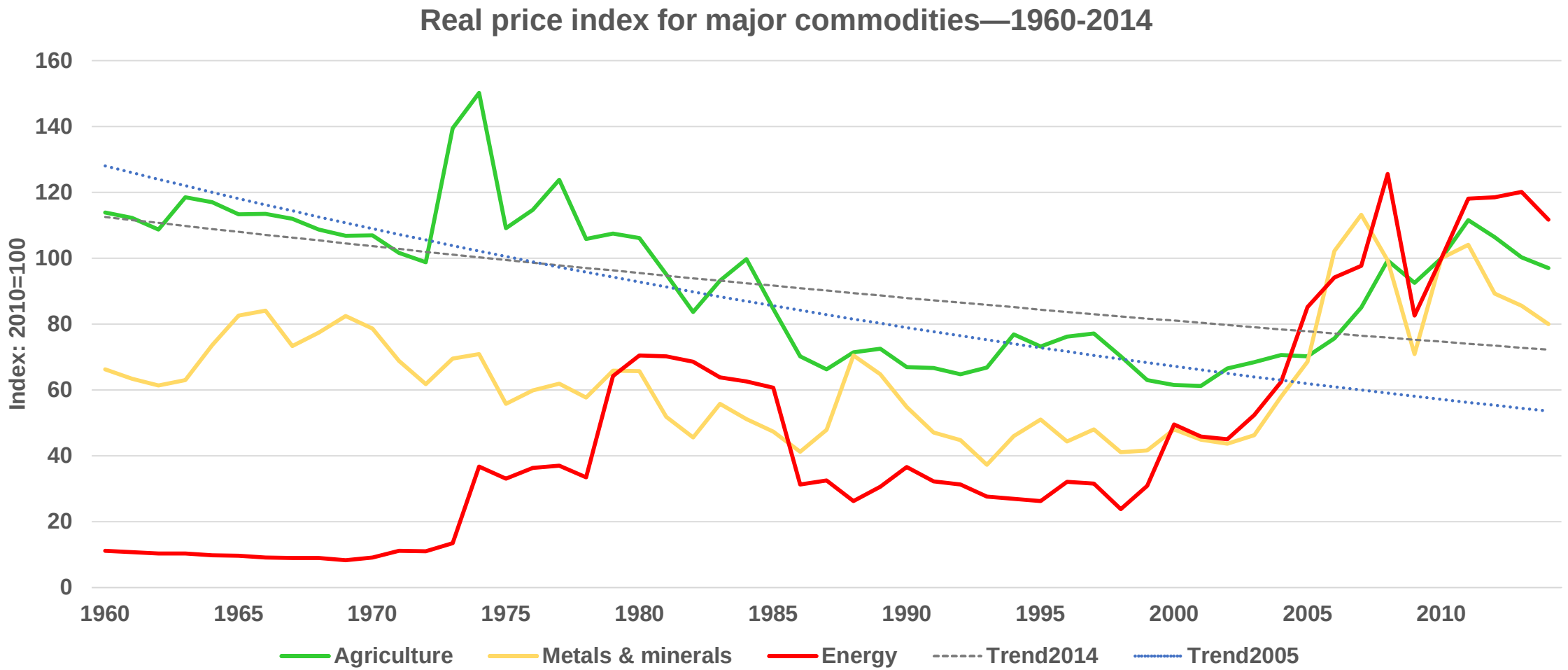
Motivation

Historically rapid growth in drivers—population & GDP



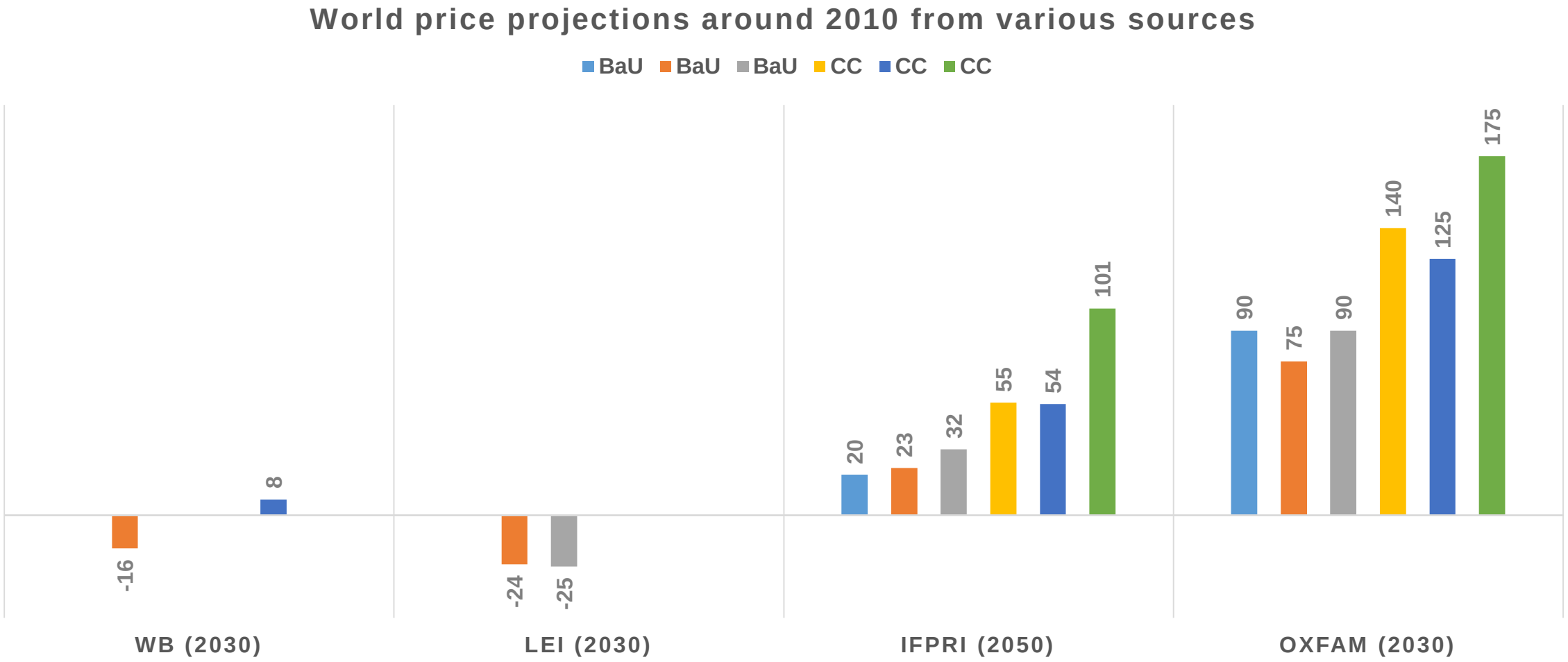
Source: Alexandratos & Bruinsma (2012) (http://www.fao.org/docrep/016/ap106e/ap106e.pdf).

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.

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	152	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

Characterization of the static equilibrium

$q_O^* = \frac{-\left(\Delta_O^D + \Delta_L^S - \Delta_L^D\right)}{\varepsilon^{S,I}/\varepsilon^D + \varepsilon^{S,E}/\varepsilon^D + 1} + \Delta_O^D = -\varepsilon^D \frac{\Delta}{\eta} + \Delta_O^D$	Output
$p_O^* = \frac{\Delta_O^D + \Delta_L^S - \Delta_L^D}{\varepsilon^{S,I} + \varepsilon^{S,E} + \varepsilon} = \frac{\Delta}{\eta}$	Output price
$q_L^* = \varepsilon^{S,E} \frac{\Delta_O^D + \Delta_L^S - \Delta_L^D}{\varepsilon^{S,I} + \varepsilon^{S,E} + \varepsilon^D} - \Delta_L^S = \varepsilon^{S,E} \frac{\Delta}{\eta} - \Delta_L^S$	Land supply response
$\varepsilon^{S,E} = \nu_L / \theta_L$	The extensive margin of supply response (area elasticity wrt commodity price)
$\varepsilon^{S,I} = \sigma\left(\theta_L^{-1} - 1\right)$	The intensive margin of supply response (yield elasticity wrt commodity price)
$\Delta = \Delta_O^D + \Delta_L^S - \Delta_L^D$	Aggregate exogenous shock
$\eta = \varepsilon^{S,I} + \varepsilon^{S,E} + \varepsilon^D$	Aggregate model responsiveness

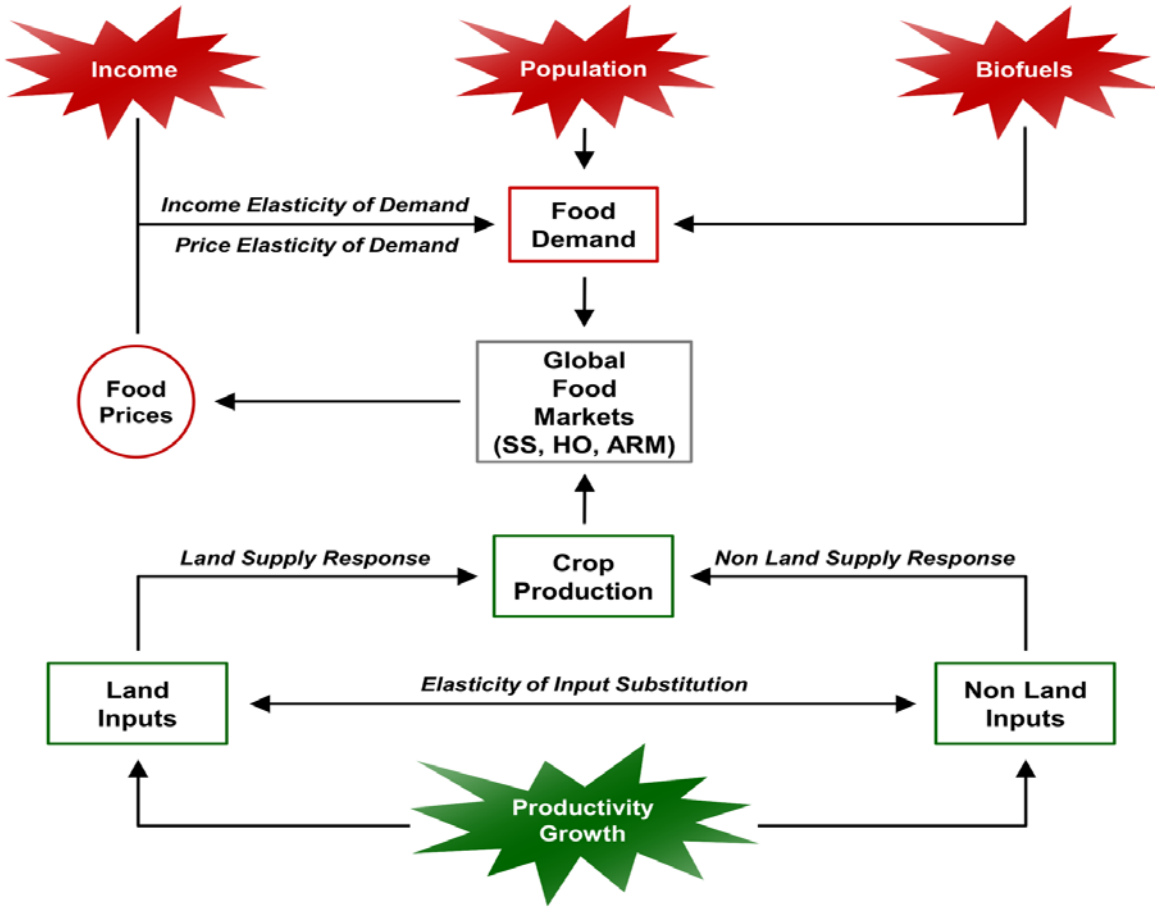
Implied Global Demand and Supply Elasticities for the AgMIP Global Economic Models

Model	Total	Demand	Extensive	Intensive
Partial equilibrium models				
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
MAgPIE[b]	0.36	0	0.18	0.18
General equilibrium models				
AIM	0.85	0.10	0.92	-0.17
ENVISAGE	3.22	0.47	1.57	1.18
FARM	1.33	0.07	1.30	-0.04
GTEM	0.96	0.07	0.52	0.36
MAGNET	0.93	-0.04	1.23	-0.26

Monte Carlo Simulations with SIMPLE

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

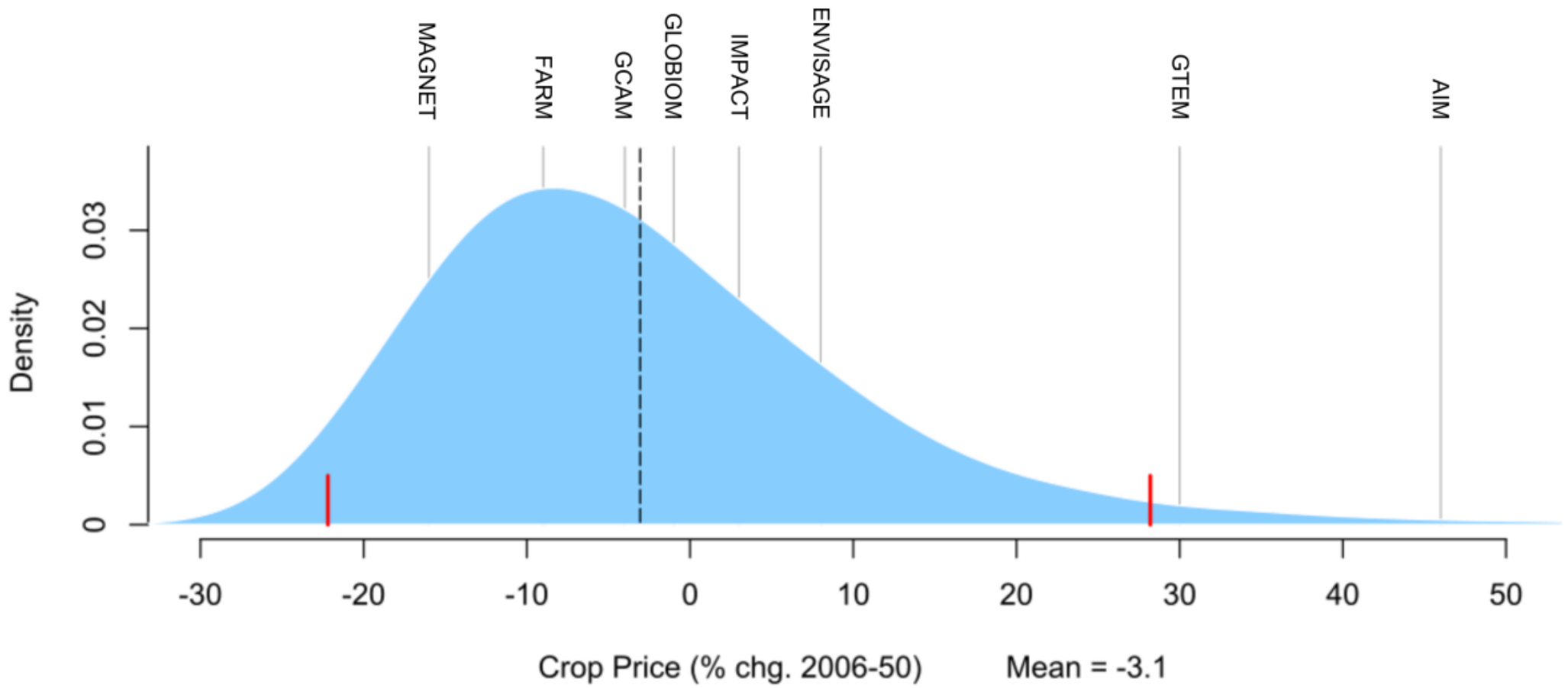
Emulator implements PE framework for 15 regions across globe: Monte Carlo analysis varies parameters and shocks over full range of possible values: Use TFP productivity shocks



Exogenous Shocks (p.a. rates)	Mode	Max	Min
Population	0.78	1.02	0.56
Per capita income	1.9	2.8	0.73
Biofuels	3.88	4.72	3.04
Total Factor Productivity			
Crops	0.94	1.14	0.5
Livestock	2.11	2.49	0.78
Processed Foods	0.89	1.05	0.33
Parameters	Mode	Max	Min
Demand Elasticities			
Future Price Elasticities			
Crops	-0.10	-0.02	-0.31
Livestock	-0.34	-0.29	-0.5
Processed Foods	-0.38	-0.29	-0.65
Future Income Elasticities			
Crops	-0.06	0.26	-0.17
Livestock	0.2	0.49	0.1
Processed Foods	0.21	0.55	0.1
Land supply response	0.28	0.56	0.11
Non-land supply response	1.34	2.68	0.49
Elasticity of substitution: Crop	3	4.5	0.24
Elasticity of substitution: Livestock	1.16	1.51	0.81
Elasticity of Transformation: Local and Global Markets	3	3.9	2.1

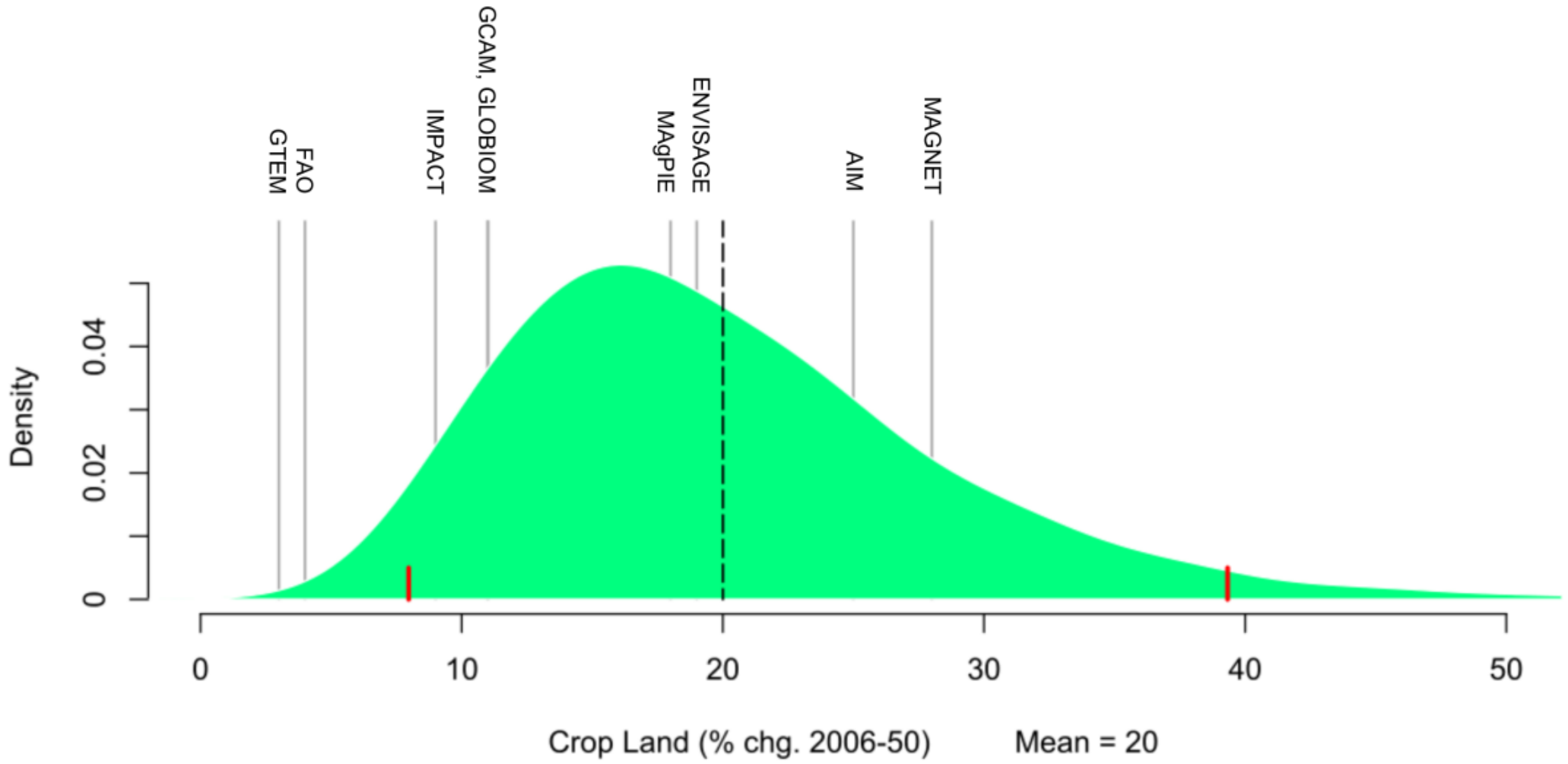
Monte Carlo results for 2050 crop prices

Dotted line denotes mean outcome, red bars represent 95% CI.

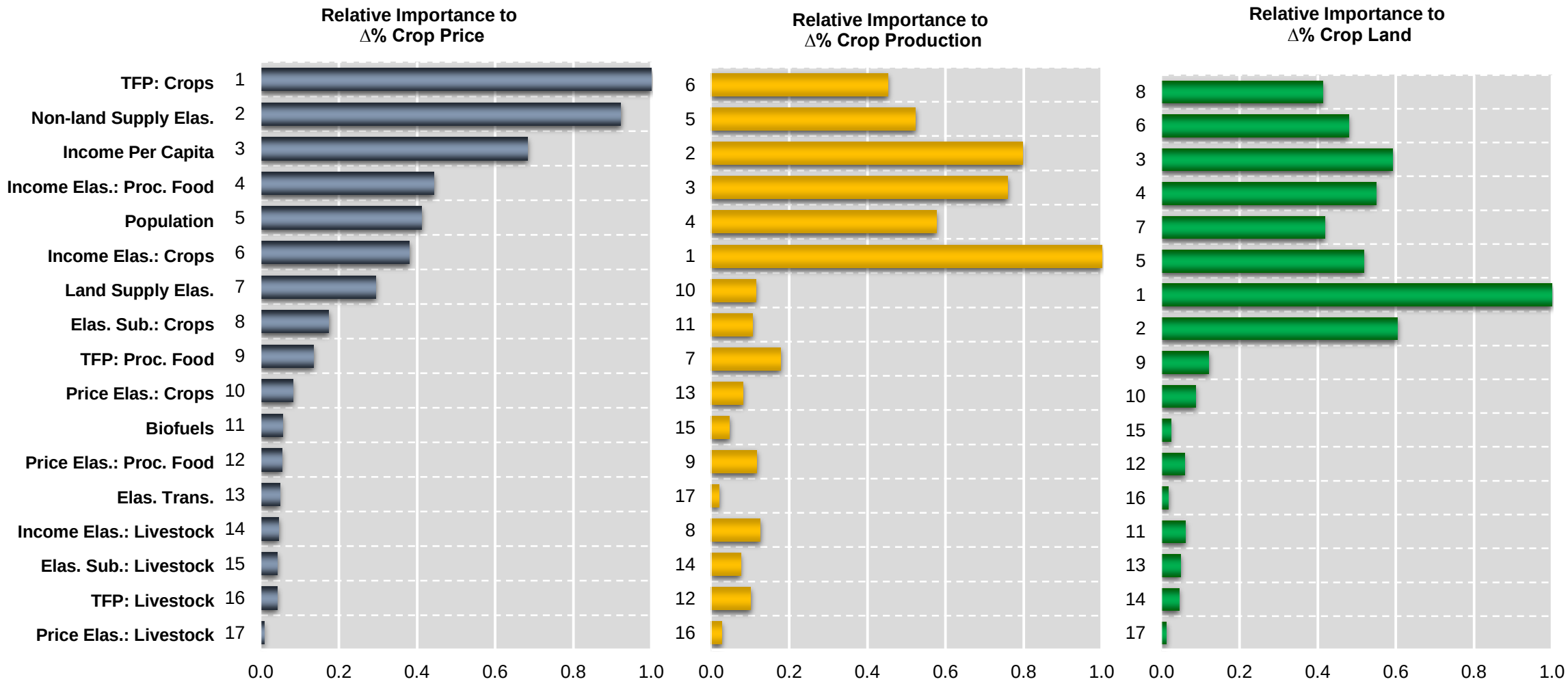


Monte Carlo results for 2050 land-use

Dotted line denotes mean outcome, red bars represent 95% CI.



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.