Technological schange in long run IPCC scenarios: The impact of methodological choices

Hans van Meijl, Andrzej Tabeau LEI Wageningen UR
research with co-authors Sherman Robinson (IFPR), Dirk Willenbockel (IDS, Uni Sussex) and many others

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LEI WAGENINGEN UR

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This analyses is part of

- **Comparing CGE and PE Supply-Side Specifications in Models of the Global Food System**
- Lead Authors:
- Sherman Robinson, IFPRI
- Hans van Meijl, LEI, Wageningen UR
- Hugo Valin, IIASA
- Dirk Willenbockel, IDS, University of Sussex
- And many other contributors

Contents

- Background
- AgMIP Global Model comparison
- Impact of labour saving tech change assumptions on prices
- conclusions

Long-term trends in agricultural markets

- Scenarios as a tool to provide alternative views of the future
- Scenarios as a tool to test policy strategies
- Scenarios published over the past several years give fundamentally different, even contradictive views of future agricultural markets
- Also in the crucial variables for food security: food supply, food prices, non-food prices and household income

Key scenario results in the literature

- FAO:, “World Agriculture: Towards 2030/2050 - The 2012 Revision” (Alexandratos and Bruinsma)
- IFPRI: “Food Security, Farming, and Climate Change to 2050” (Nelson et al, 2010)
- INRA-CIRAD 2009. “Agrimonde – Scenarios and Challenges for Feeding the World in 2050”
- International Assessment of Agricultural Science and Technology for Development (IAASTD): “Agriculture at a Crossroads” (Rosegrant et al, 2009)
- IWMI: “Looking Ahead to 2050” (de Freiture et al, 2007).
- UN Millennium Ecosystem Assessment (Carpenter et al (eds), 2005).
- UNEP: “GEO4 – “The Future Today” (Rothman et al, 2007)
- Van der Mensbrugghe, et al, 2011. “Macroeconomic Environment and Commodity Markets: A Longer-Term Outlook”

Work agenda for teams in policy modelling

- Studies are of little comparability, results difficult to use for guidance in decision making
- Need for a structured analysis of comparable, well-designed scenarios across different approaches

→Long-term trends in agricultural markets: A comparative analysis / **AgMIP** (synergy effects with **WP7 of FoodSecure**)

- Agricultural model intercomparison project (AgMIP, Jerry Nelson)
- Work agenda by OECD secretariat (Martin von Lampe)
- Contributions from FOODSECURE teams (LEI-WUR, IIASA, IFPRI, PBL)

Participation: 10 global economic models that have agricultural representation

Economy-wide models		Agriculture sector models	
Host	*Model*	Host	*Model*
ABARES	*GTEM*	IIASA	GLOBIOM
FAO/World Bank	*ENVISAGE*	IFPRI	IMPACT
LEI Wageningen UR	MAGNET	PNNL	*GCAM*
MIT	*EPPA*	PIK	*MAgPIE*
NIES	*AIM*		
USDA	*FARM*		

Notes
(a) MAGNET, GLOBIOM, IMPACT form the FOODSECURE toolbox for long term modelling, with the IMAGE model of PBL and MIRAGE model of IFPRI/INRA
(b) Agriculture sector including forestry

Methods: Scenarios analyzed (1)

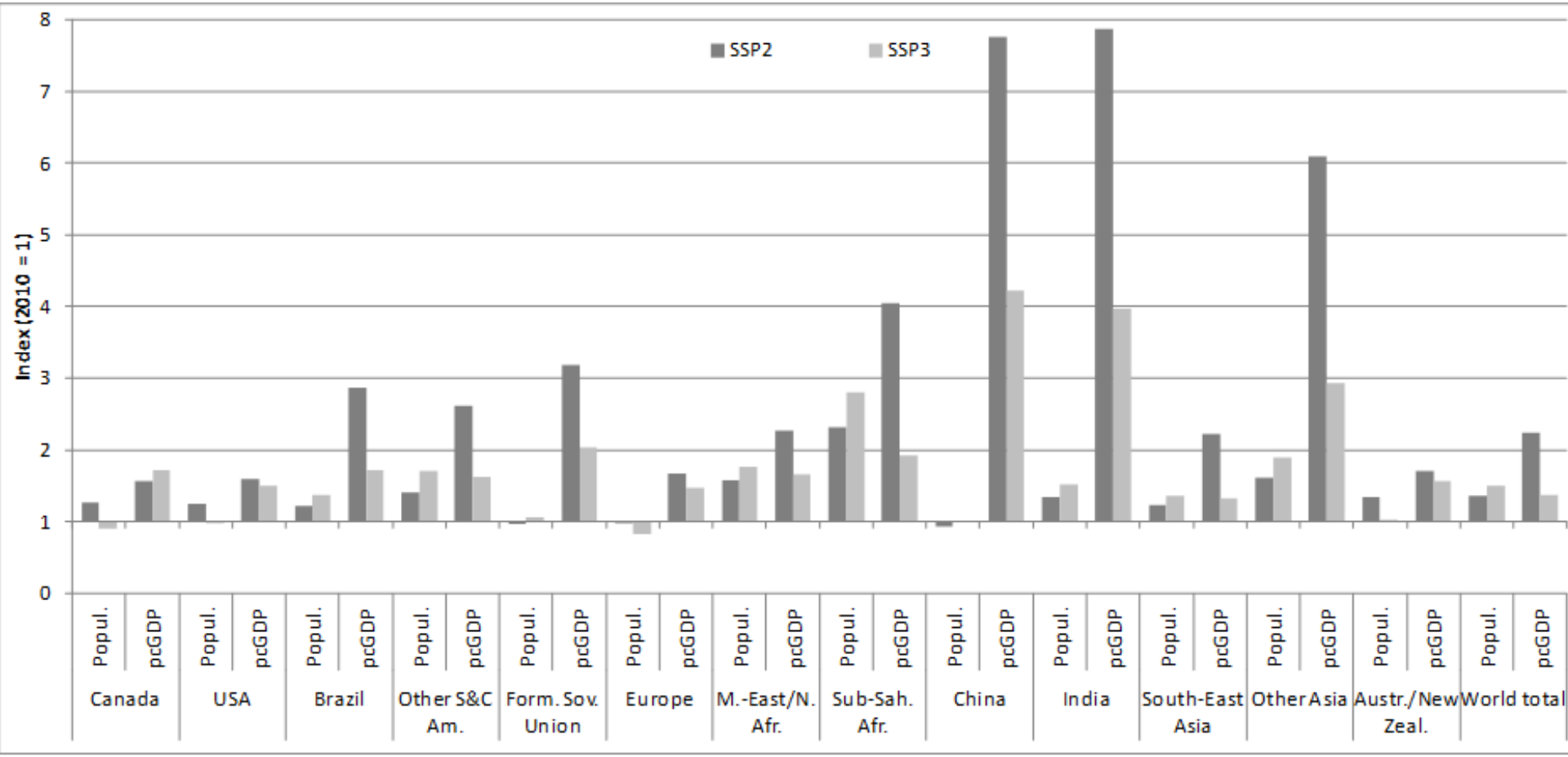
- Guiding principle is **not** probability / plausibililty
- Reference plus 7 orthogonal scenarios along three dimensions
- Harmonized assumptions on key drivers

- Reference scenario (SSP2):
  - Population and GDP growth as in SSP2 (new IPCC scenario)
  - Land productivity as from IMPACT (based on crop models)
  - Present-day climate
  - Constant oil price

Methods: Scenarios analyzed (2)

- Socio-economic scenario:
  - Population and GDP growth as in SSP3 (new IPCC scenario)
  - Other drivers as in reference
- Climate change scenarios:
  - Alternative sets of land productivity shifters, derived (via Global Circulation Model (GCM) and Crop Model (CM) from high concentration assumption RCP8p5 (i.e., 8.5 W/m^2)
- Bioenergy scenarios:
  - Based on harmonized reference: high energy output (+108 EJ in 2050)

Population and per capita GDP growth to 2050 by region, SSP2 and SSP3



Source: Von Lampe, Willenbockel et al., under review

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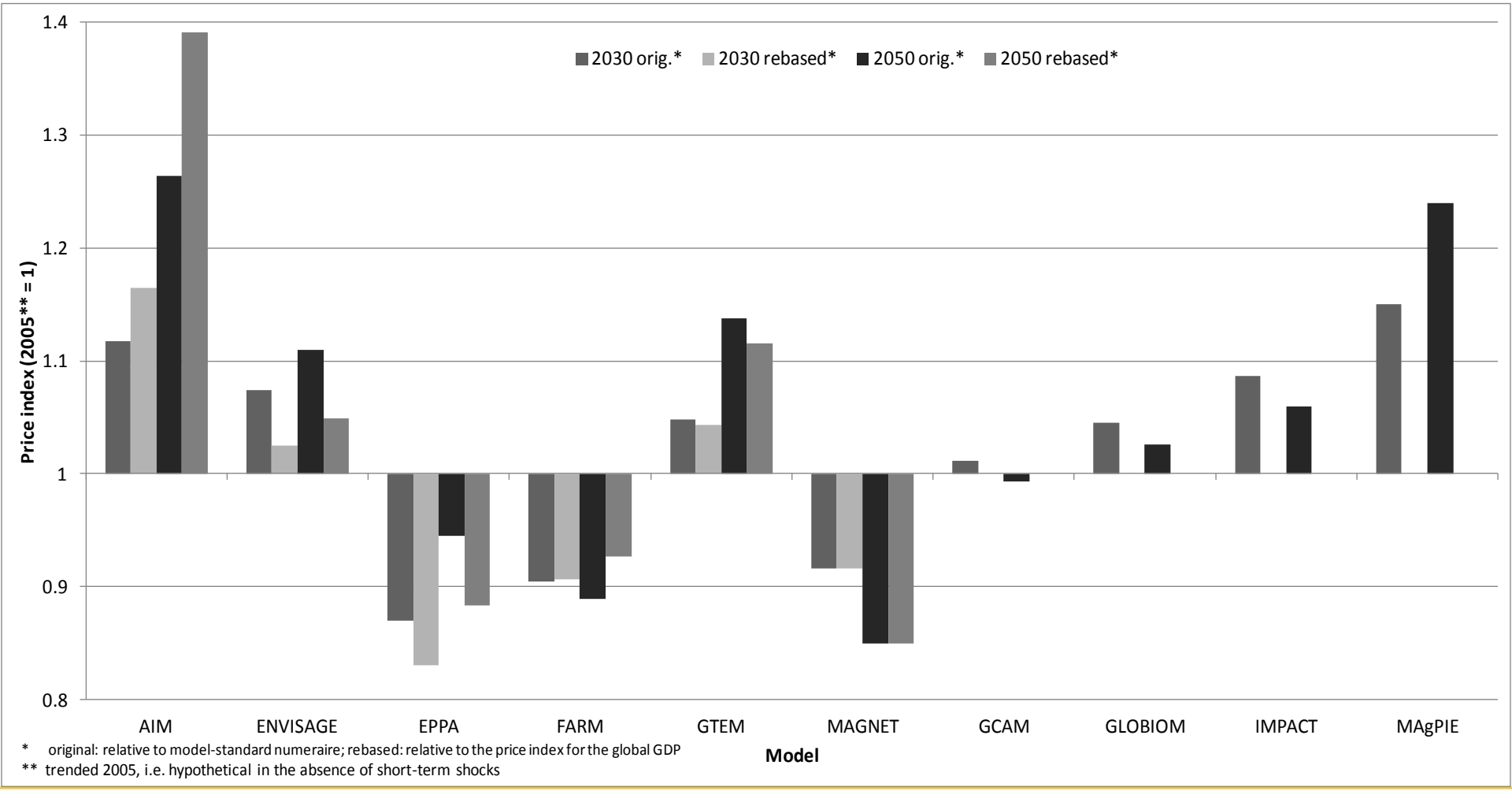
Price projections for the agricultural aggregate, 2005** - 2050



* original: relative to model-standard numeraire; rebased: relative to the price index for the global GDP
** trended 2005, i.e. hypothetical in the absence of short-term shocks

Source: Von Lampe, Willenbockel et al., under review

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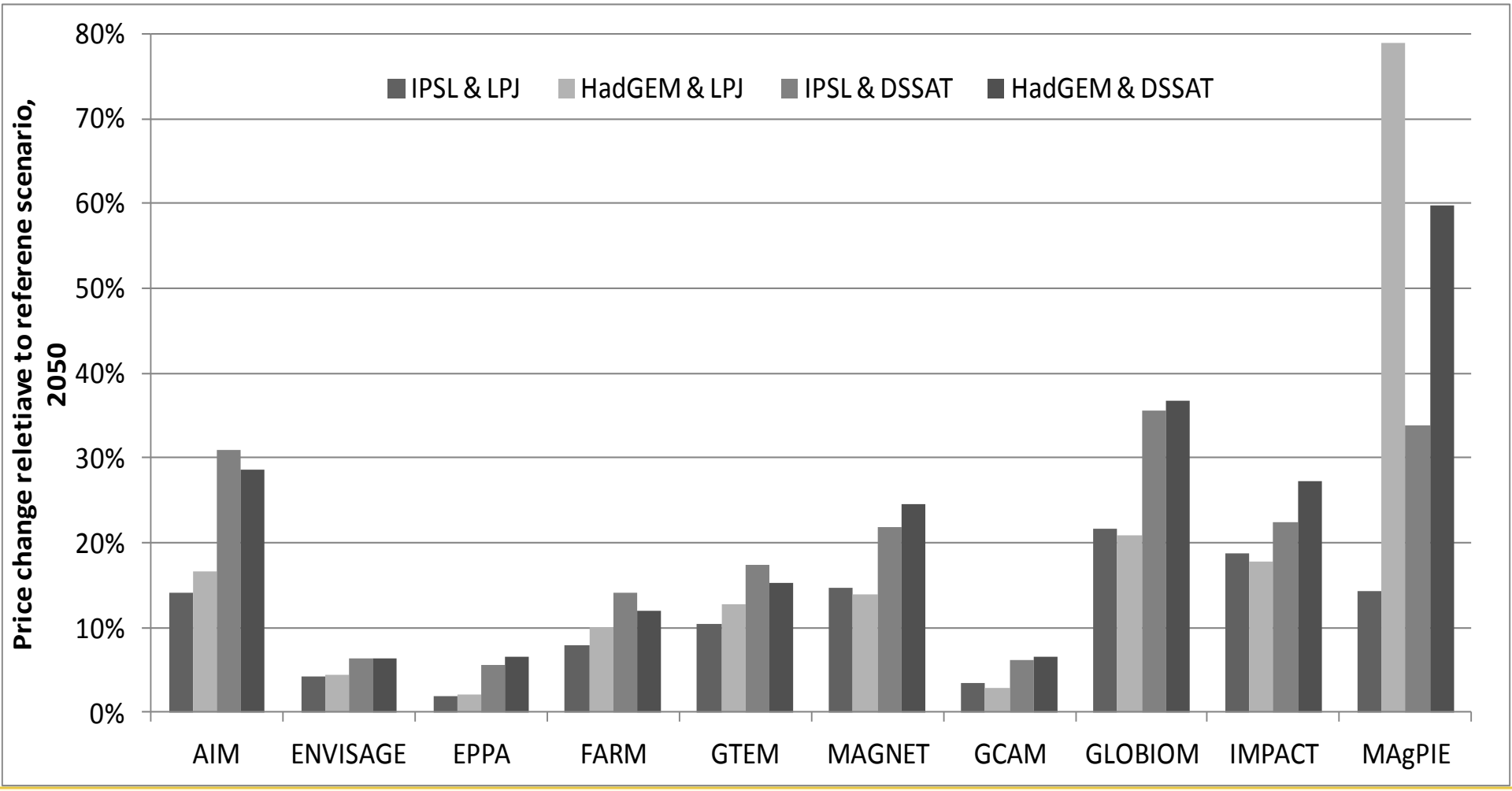
Changes in world average producer prices for five main crops (CR5) in 2050 due to climate change



Source: Von Lampe, Willenbockel et al., under review

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Intro to the key findings

- Results continue to differ across models, despite significant efforts on harmonization
  - Ag Price index up 40% to down 15% relative to global GDP deflator in S1
  - Range is narrower than earlier comparison
  - Comparison process helped to improve models
  - Some convergence through alignment?
  - Several key results common across models

Source: Von Lampe, Willenbockel et al., under review

Technological change is one of the key determinants of economic growth and global prices

- Modeling technical change is however still largely considered as black box or Solow residual, despite developments in the new trade and growth theories (Krugman, 1990, Romer, 1990).

- Empirical evidence is still weak and not persuasive enough to tell us how to realistically endogenize technological change within CGE models.

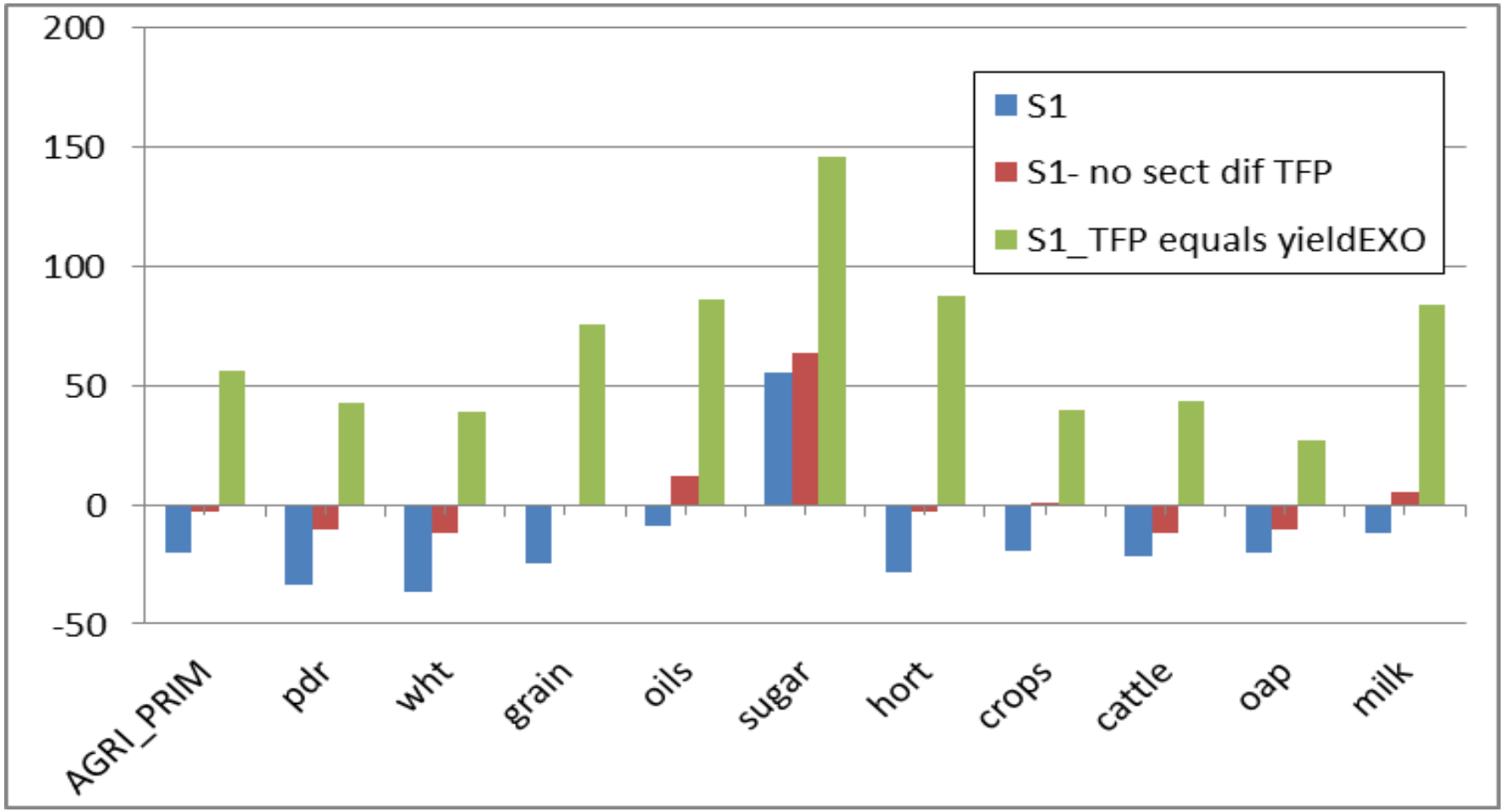
Technological change is one of the key determinants of economic growth and global

- Focus on conceptual issues arising from the need to calibrate the paths for sectoral “factor embodied” technical change in CGE models residually in order to replicate the given GDP growth path and shows that different ways to do this can affect empirical results.
- Focus on the treatment of sectoral labor embodied technical change in a stylized PE and CGE models and the impact on agricultural world prices, trade and production. All scenarios are quantified with the MAGNET model.

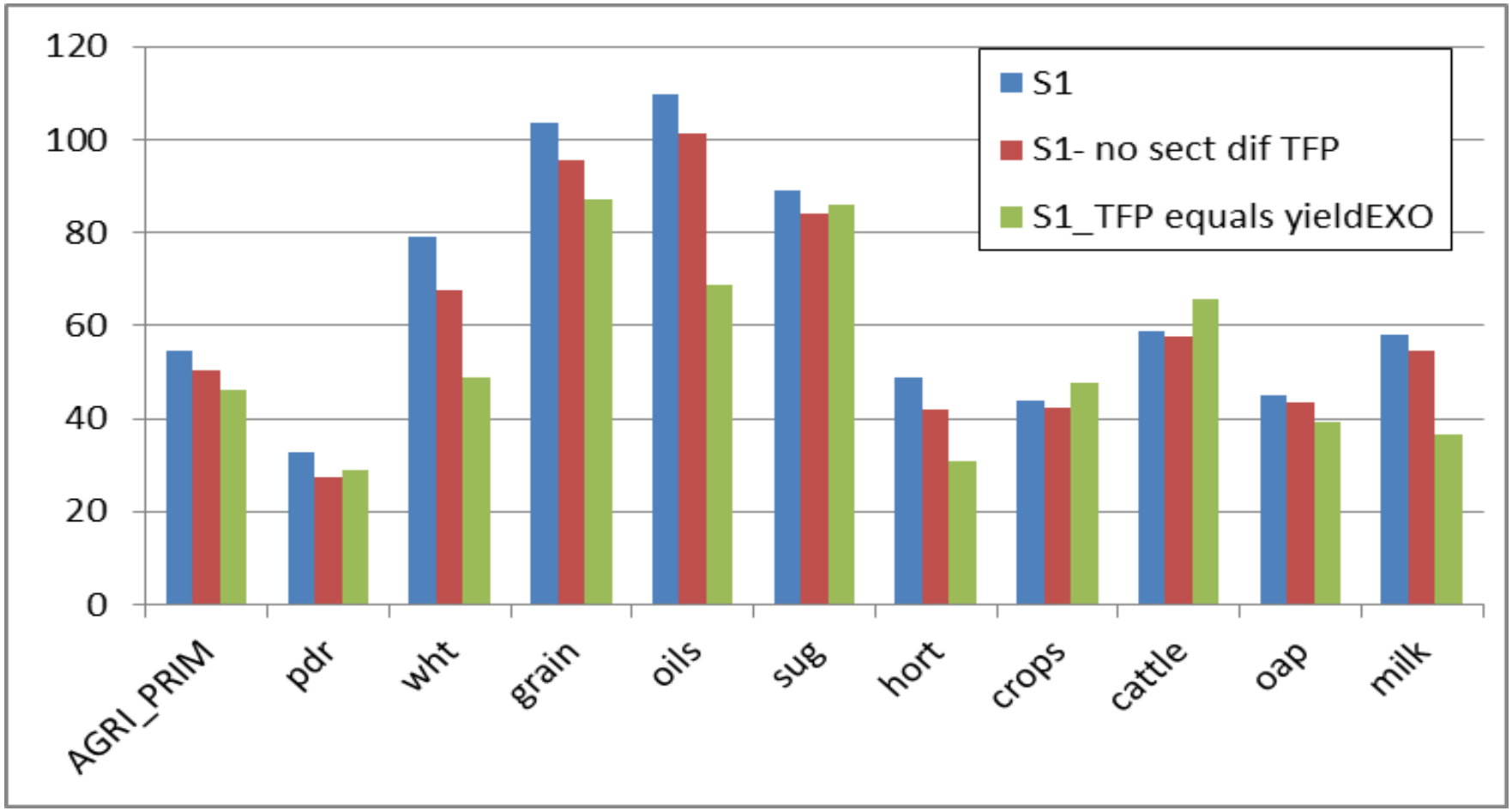
Reference scenario: Sensitivity scenarios with regard to different sectoral TFP assumptions

Scenario name	Description
S1	AgMIP S1 scenario on SSP2 with different sectoral technological change (**Agriculture higher TFP growth than other sectors** (Kets and Lejour 2003, Dollar and Wolff, 1993 lejouras implemented in MAGNET)
S1- no sect dif TFP	as S1 except: no sectoral biased technological change, all sectors within **economy identical** labor saving technological change
S1_TFP equal YieldEXO	As S1 except: exogenous **yield shocks** delivered by IMPACT not only implemented to land **but also implemented to labor**

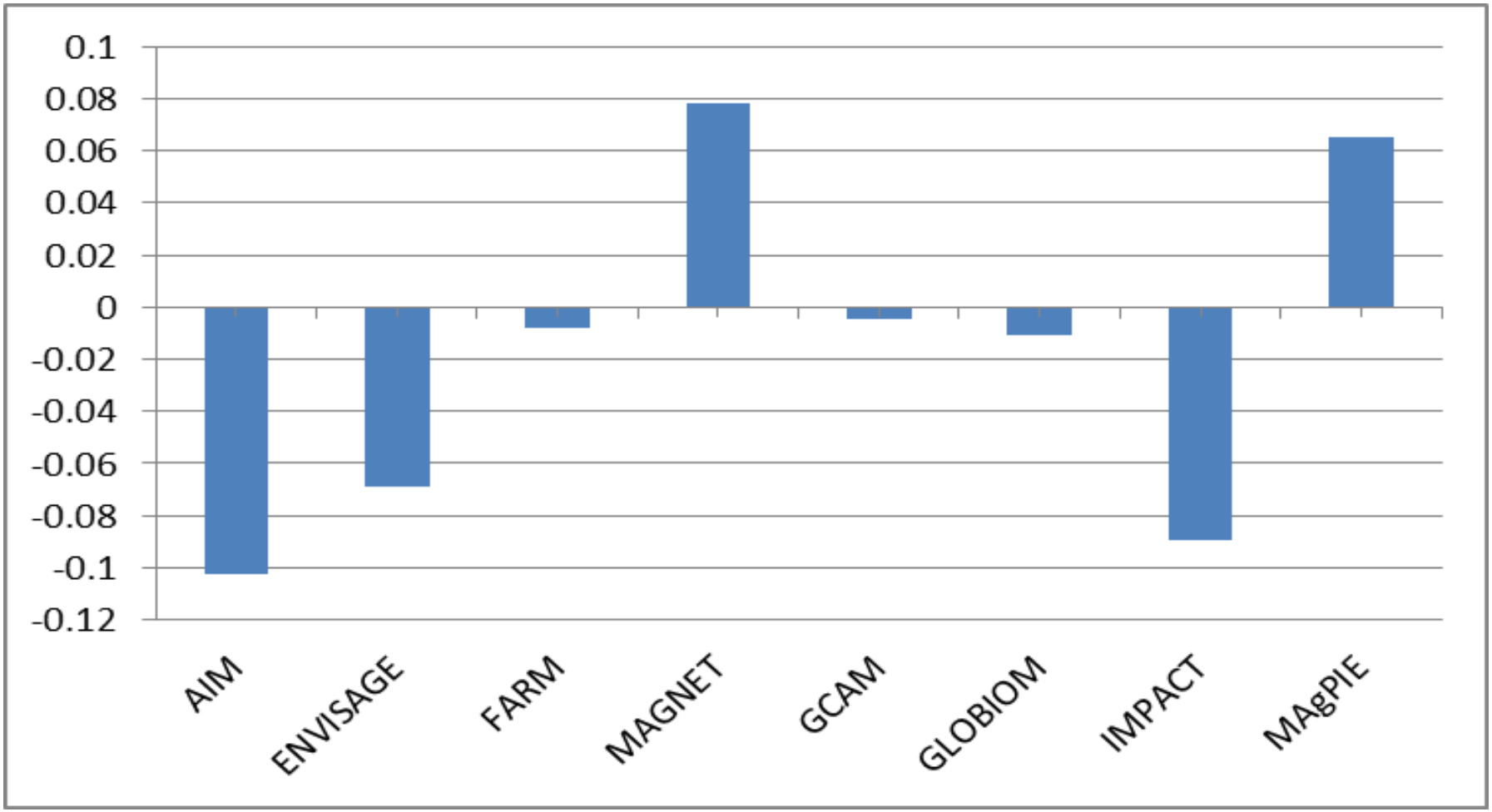
World market prices under different sectoral TFP assumptions, 2010-2050 growth rates (%)



World production with different sectoral TFP assumptions, 2010-2050 growth rates



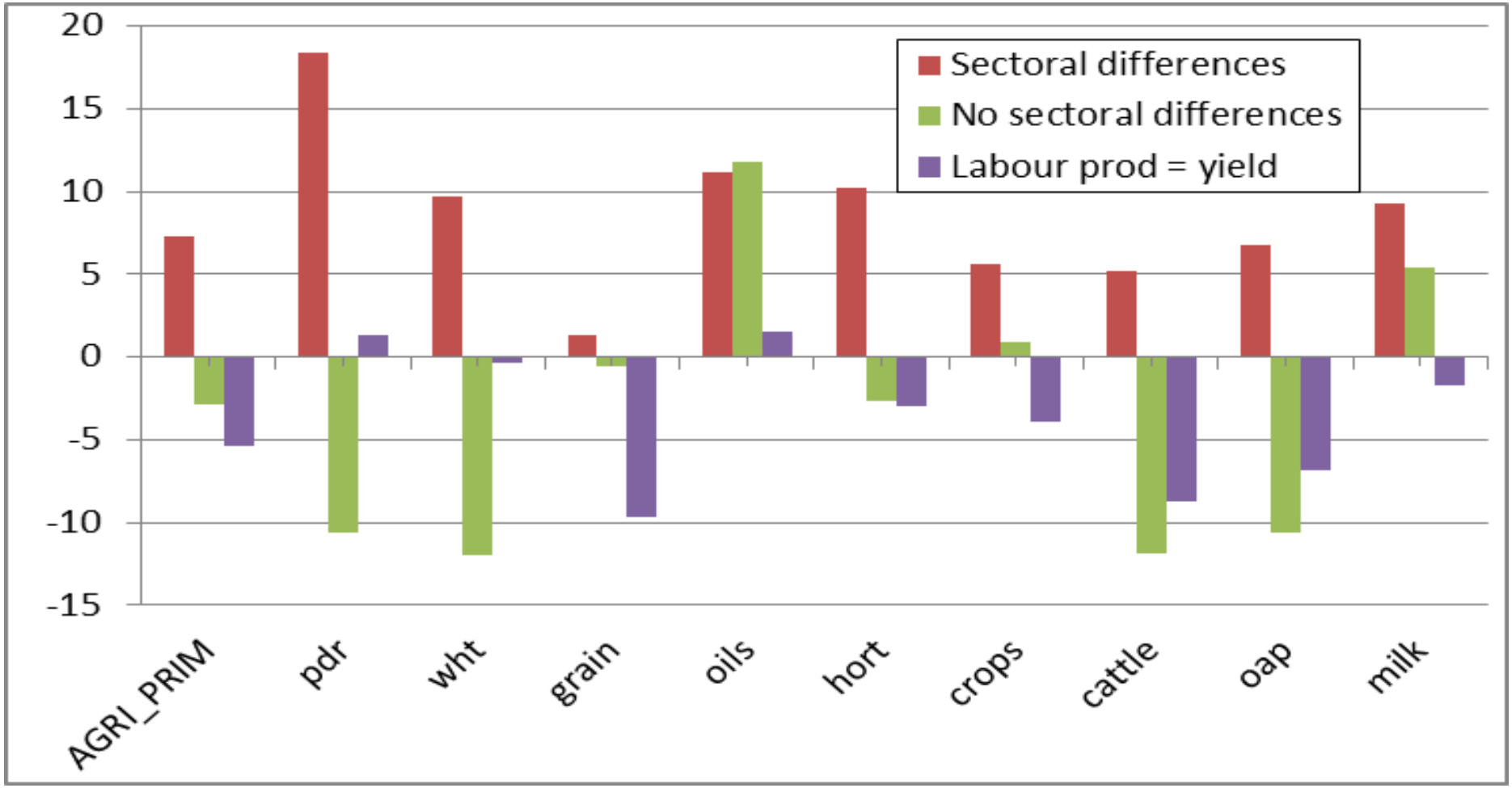
Changes in prices of agricultural products, SSP3 relative to SSP2, 2050



Different socio-economic scenarios: Sensitivity scenario's with regard to different labor productivity assumptions

Scenario name	Description
Sectoral differences	AgMIP S1 scenario on SSP2 with different sectoral technological change (agriculture higher than other sectors)
No sectoral differences	as S1 except: no sectoral biased tech change, all sectors within economy identical labor saving tech change
Labor productivity = yield	As S1 except: exogenous yield shocks delivered by IMPACT not only implemented to land but also implemented to labor

World market prices and difference of socio-economic scenarios (S2 relative to S1) under different labor productivity assumptions, 2010-2015 growth rates (%)



Conclusions

- Sectoral labor productivity paths have major impact on price developments.
- The degree of factor bias within agriculture and the degree of sectoral bias between agriculture and the rest of economy are important determinants of price developments.
- Also a main driver of whether prices increase or decrease from the SSP3 to the SSP2 scenario.

Conclusions

- More empirical research is needed to open the black box of macro and sectoral technical change which is crucial for price results.
- Given the variety of different approaches to modeling technological change, there is need for model testing and validation: Which of these approaches best fits the data?
- Back casting might be a method as a kind of validation (Dixon and Rimmer, 2002). It is only through such systematic research that we will be able to eliminate the least promising approaches and focus on those that are worthy of further attention.