Global-Local-Global Analysis of Systems Sustainability

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Global Impacts of Agricultural Productivity Growth

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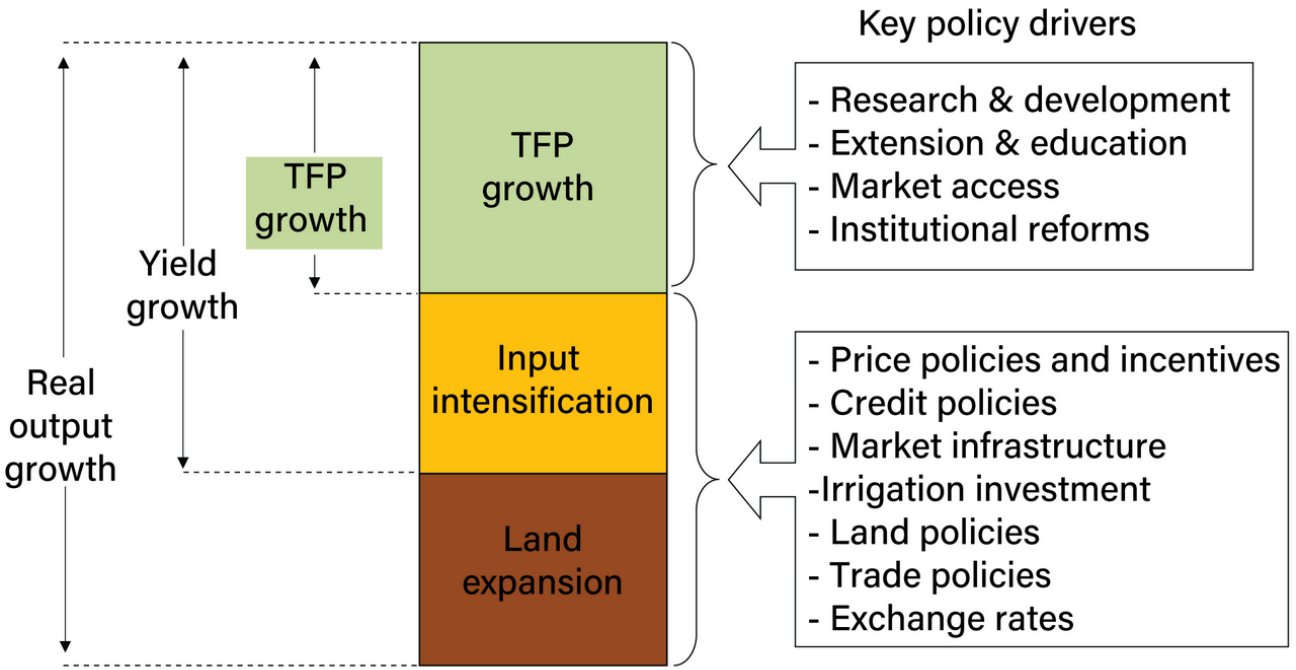
NIFA

NSF

Key Concept: ***Total Factor Productivity (TFP)***

TFP growth is equal to

Growth in all output(s) — Growth in all inputs



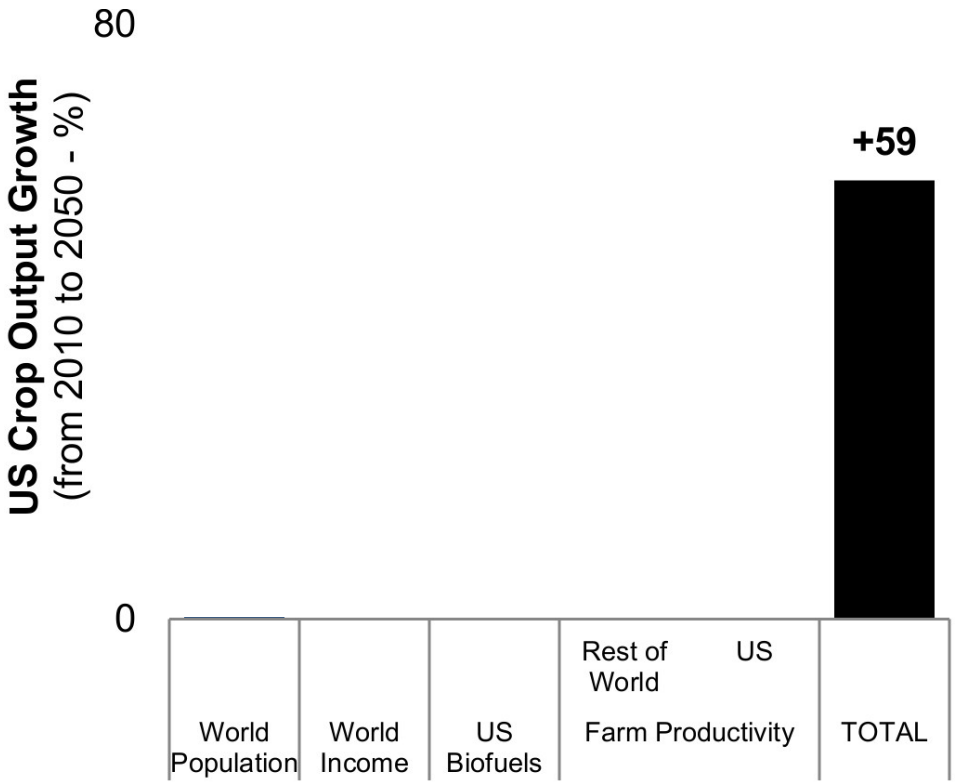
Source: USDA, Economic Research Service

TFP growth rates shape the global agricultural economy

- TFP growth drives *competitiveness* in world markets
- TFP growth drives *land use change*
- TFP growth can reduce overall *input usage*
- TFP growth can reduce *greenhouse gas emissions*
- TFP growth can improve *nutrition outcomes*

TFP growth drives competitiveness

Baseline
Productivity Growth
(+1.2 p.a. | 1981-10)



Projections from SIMPLE-G using Global Population, Income, US Biofuels as other drivers

TFP growth drives competitiveness

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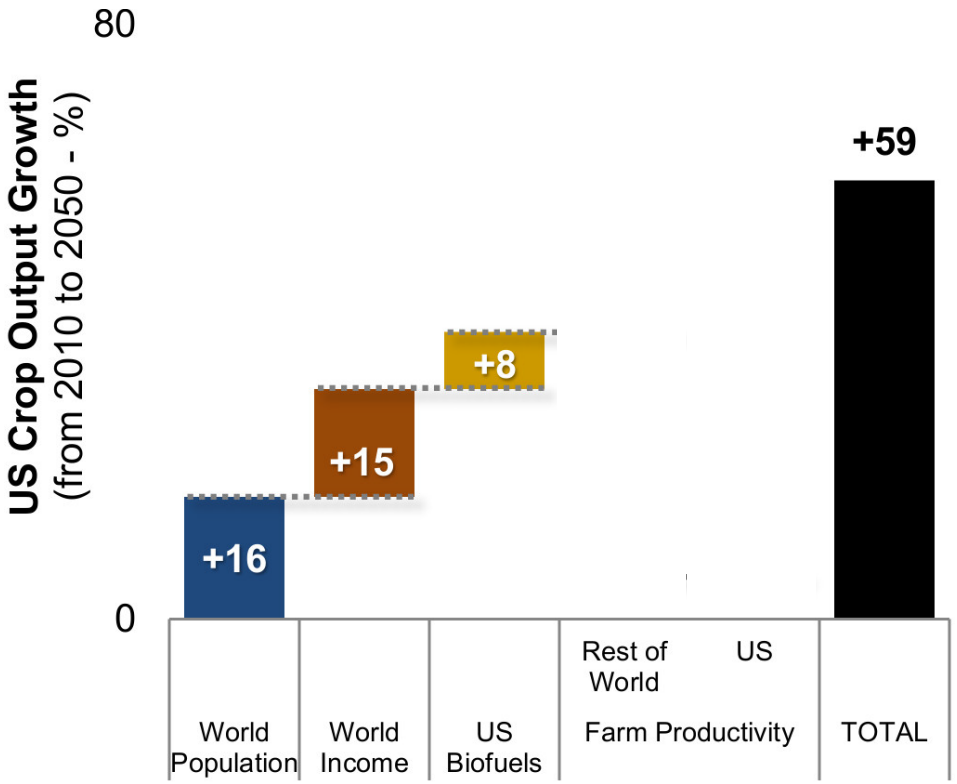

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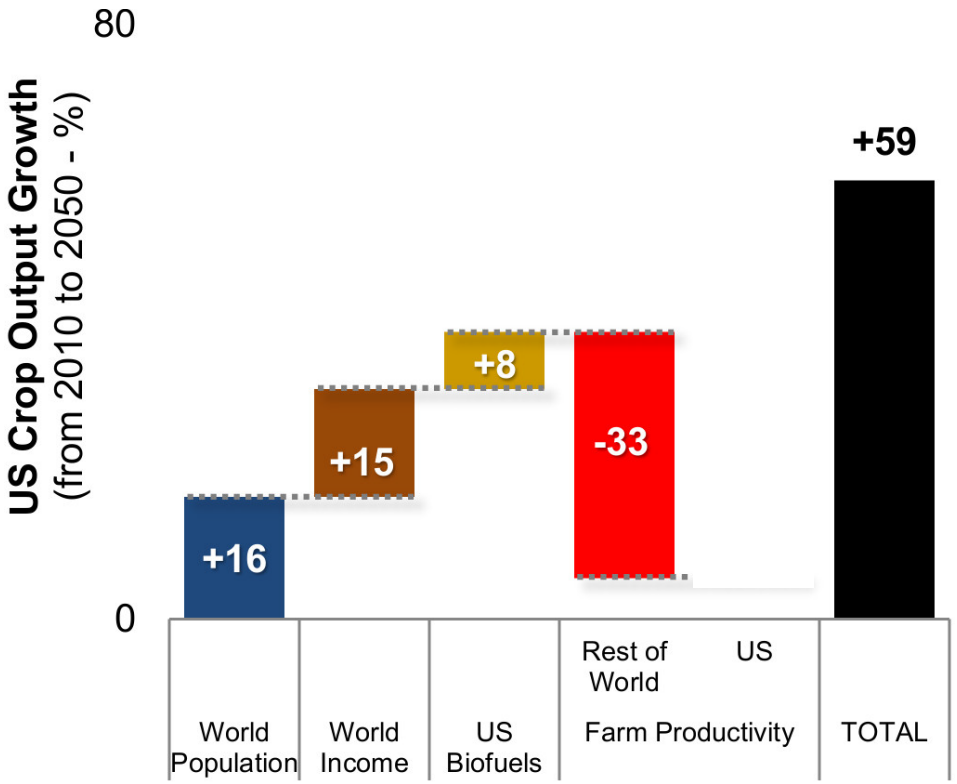

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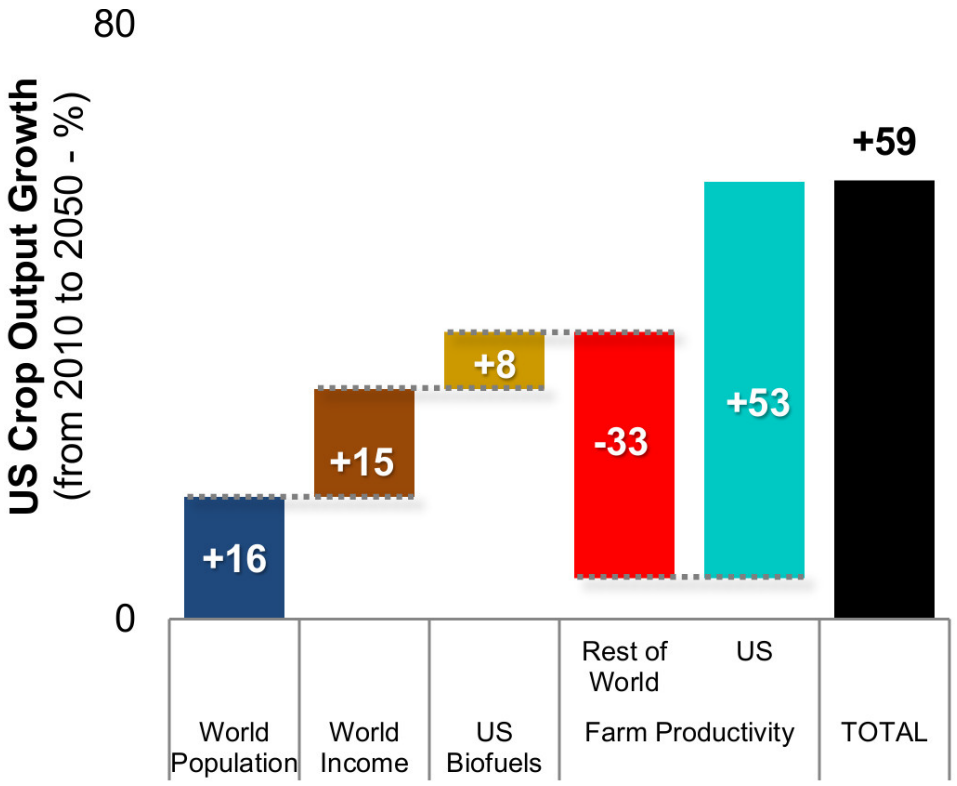
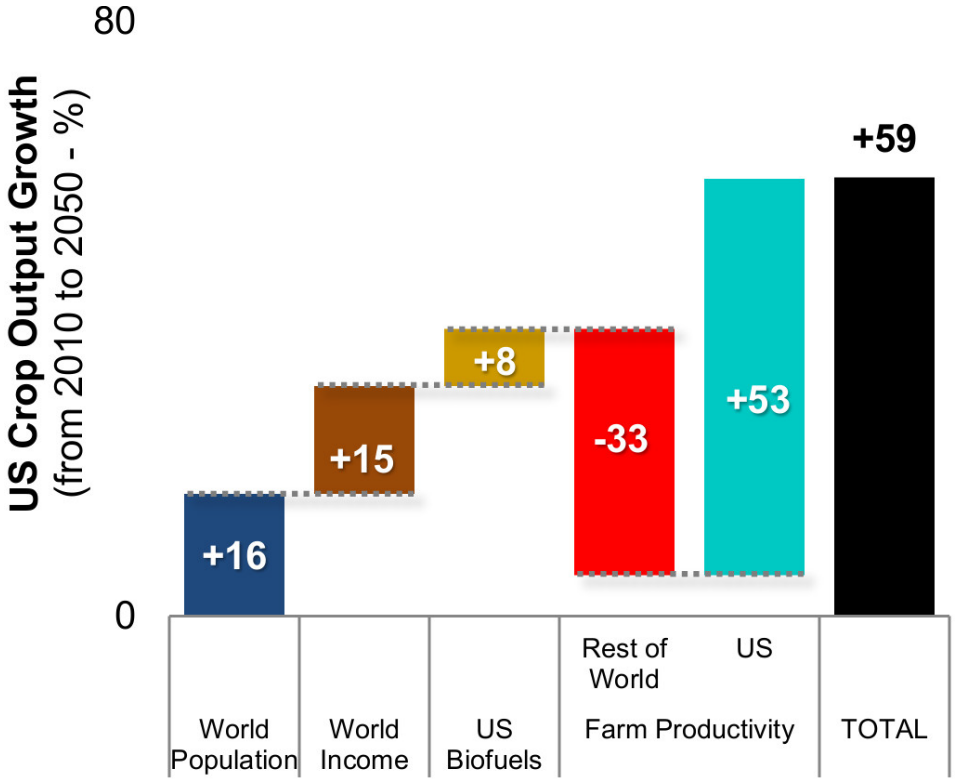


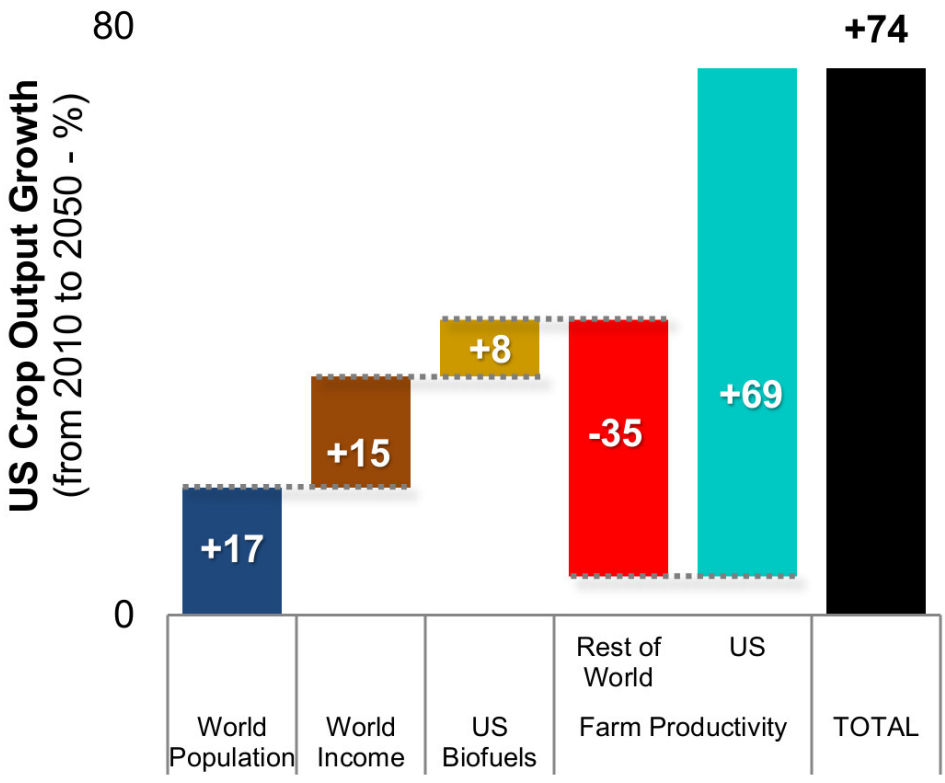
Baldos, Uris, and Thomas Hertel. 2018. "Productivity Growth Is Key to Achieving Long Run Agricultural Sustainability." *Purdue Policy Research Institute, Policy Brief* 4 (1).

Gains from R&D Spending: Future Projections

Baseline
Productivity Growth
(+1.2 p.a. | 1981-10)



Greater R&D Inv.
Productivity Growth
(+1.5 p.a. | +1.1 B USD / yr 2020-50)



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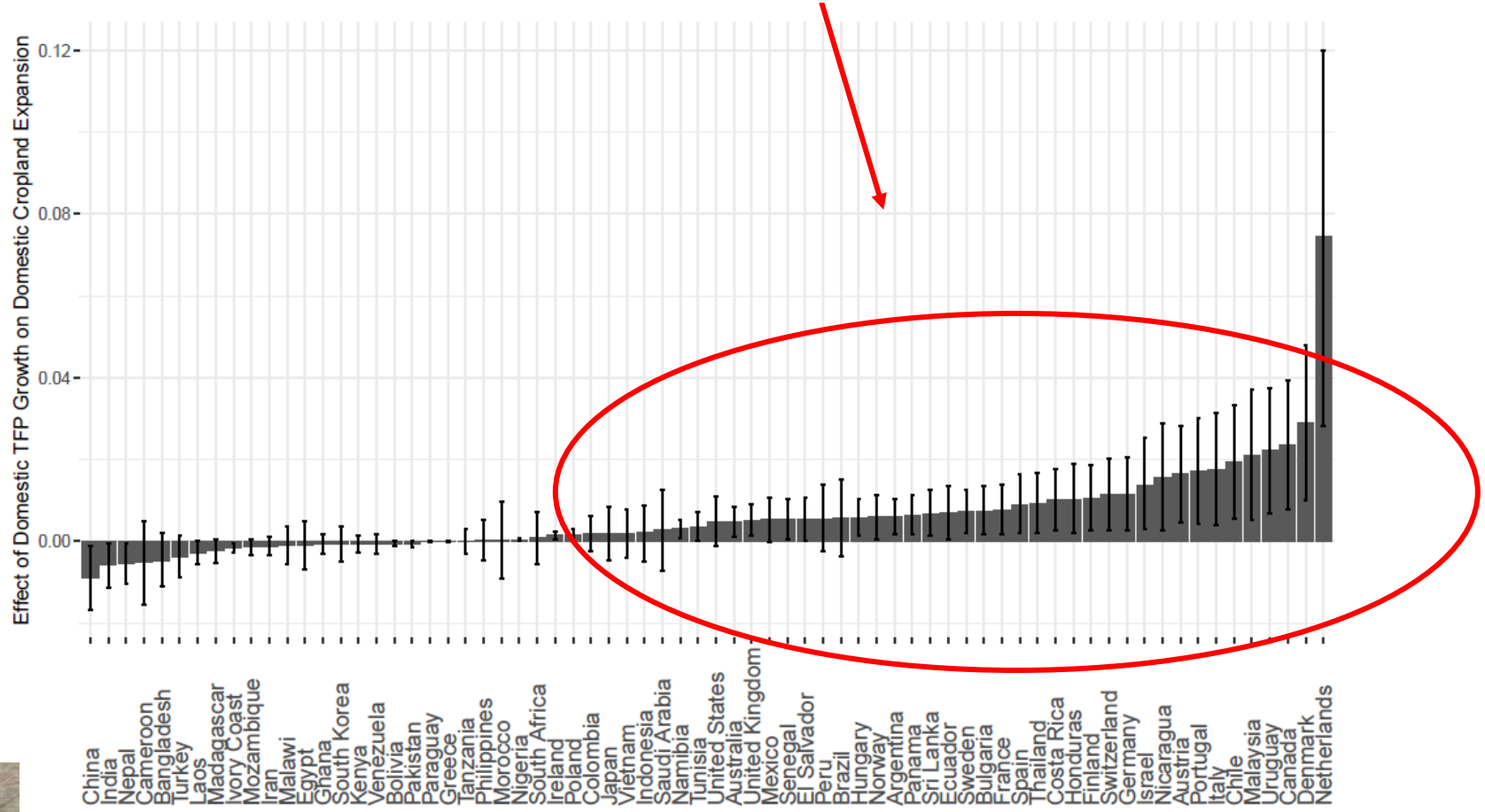
Regional patterns of TFP growth shape the global agricultural economy

- TFP growth drives competitiveness in world markets
- TFP growth drives land use change

Farmland use in the innovating region can contract (more efficient use of resources) or expand (owing to competitiveness effect). The outcome depends critically on openness to trade and whether the innovation is local or global in scope.

Effects of domestic TFP growth on domestic cropland expansion

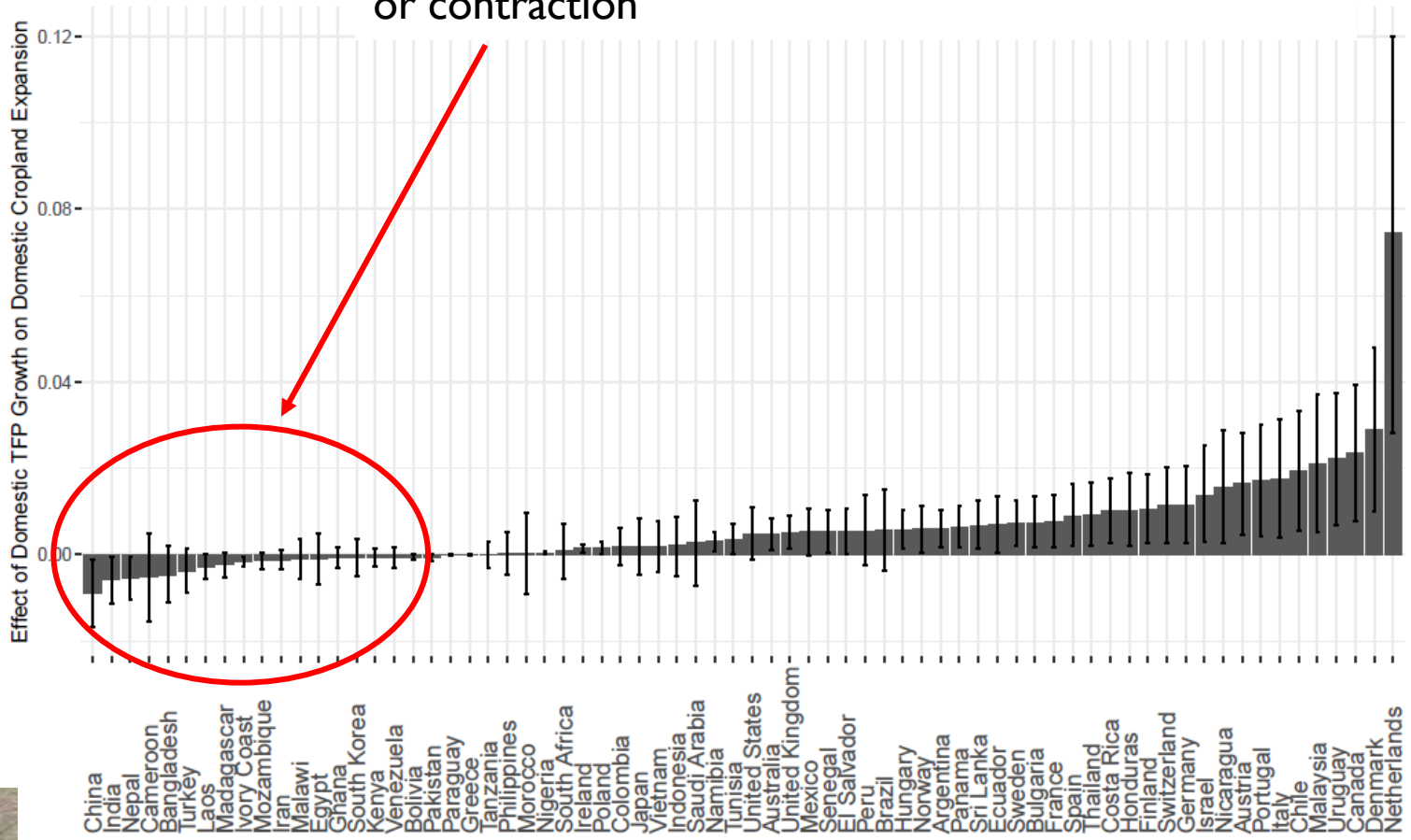
Local TFP growth can lead to cropland expansion….



Effects of Domestic TFP Growth on Domestic Cropland Expansion.

Effects of domestic TFP growth on domestic cropland expansion

Local TFP growth can lead to cropland expansion….
or contraction



Villoria, Nelson B. 2019. "Technology Spillovers and Land Use Change: Empirical Evidence from Global Agriculture." *American Journal of Agricultural Economics* 101 (3): 870–93.

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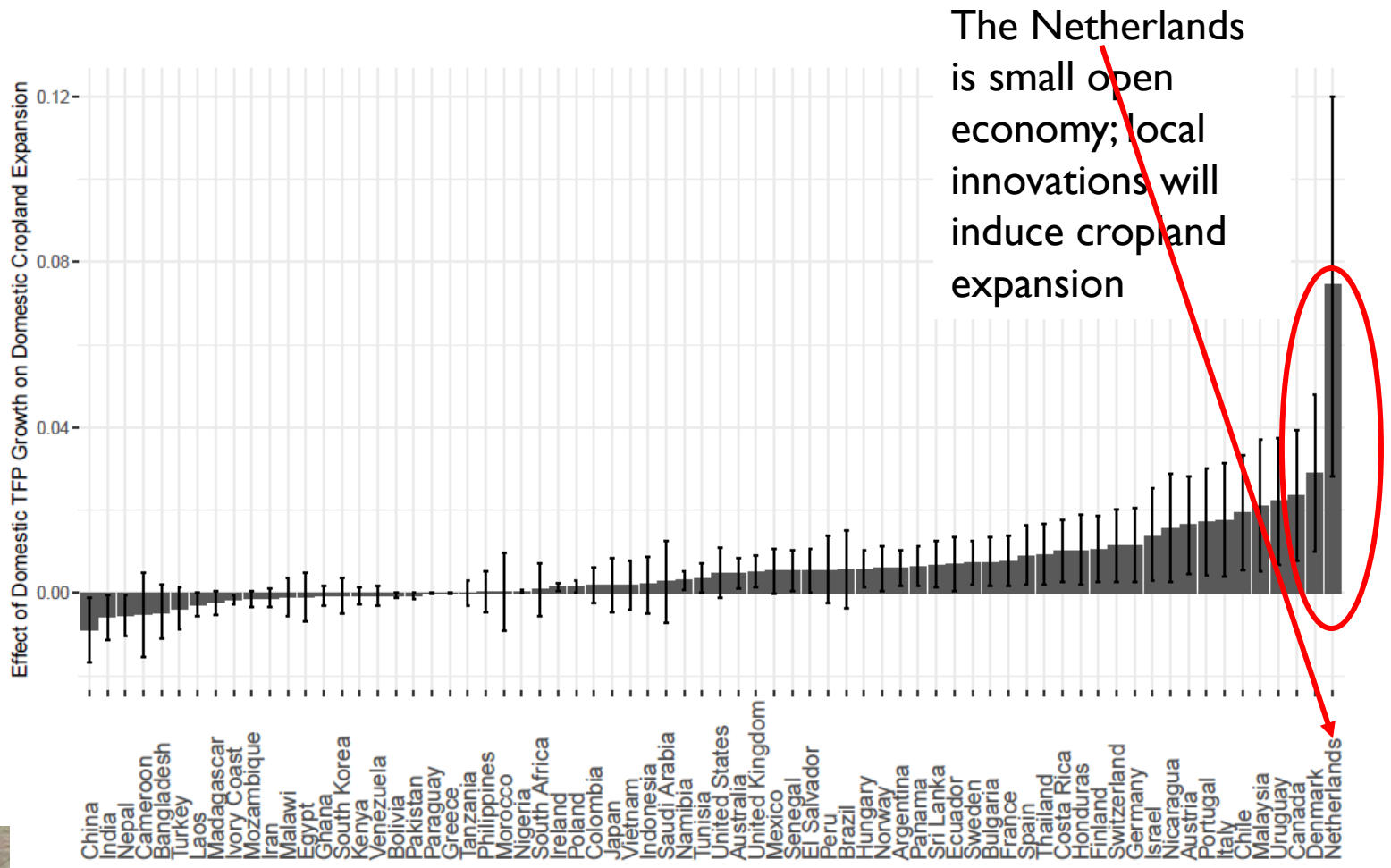
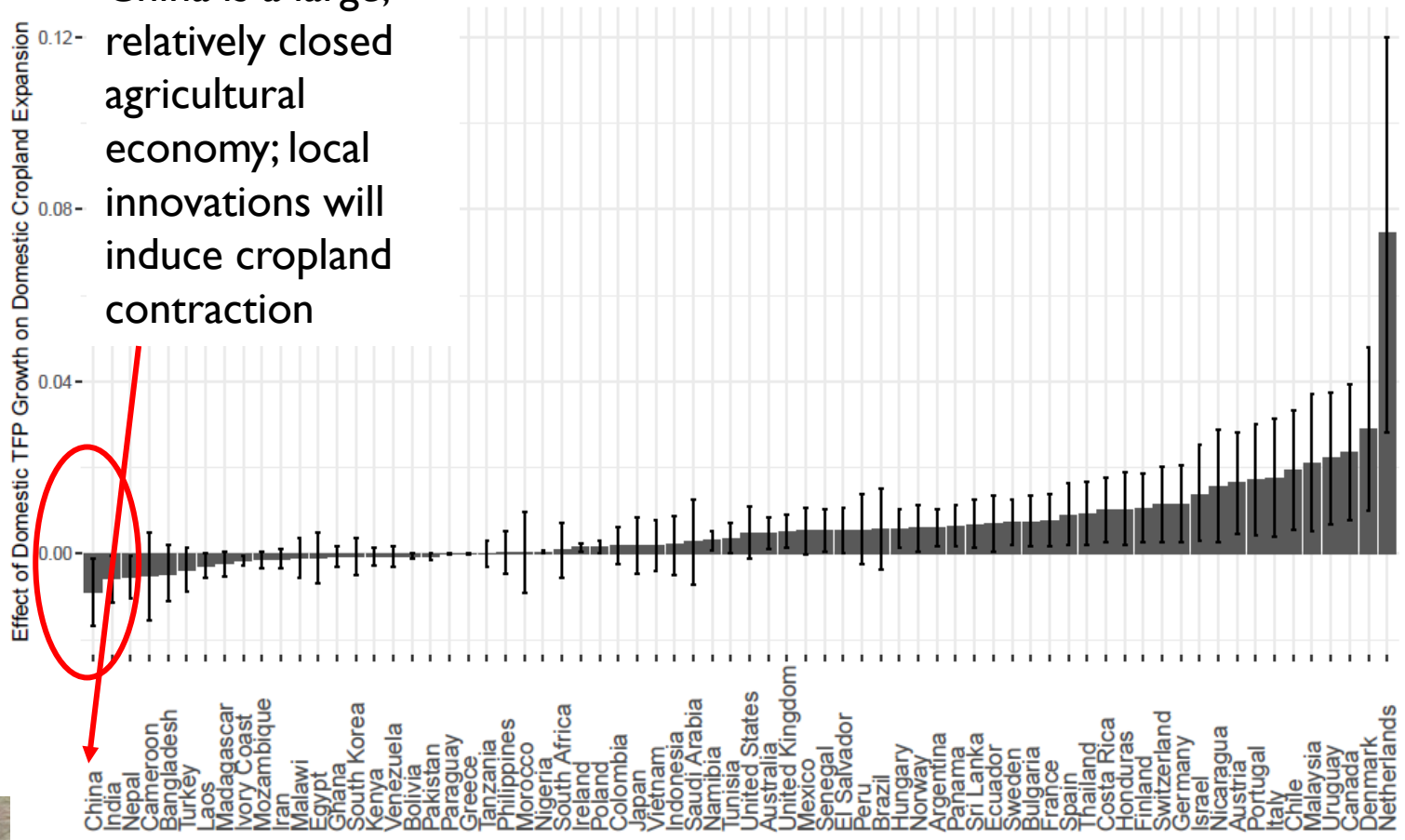


Villoria, Nelson B. 2019. "Technology Spillovers and Land Use Change: Empirical Evidence from Global Agriculture." *American Journal of Agricultural Economics* 101 (3): 870–93.

Effects of domestic TFP growth on domestic cropland expansion

China is a large, relatively closed agricultural economy; local innovations will induce cropland contraction



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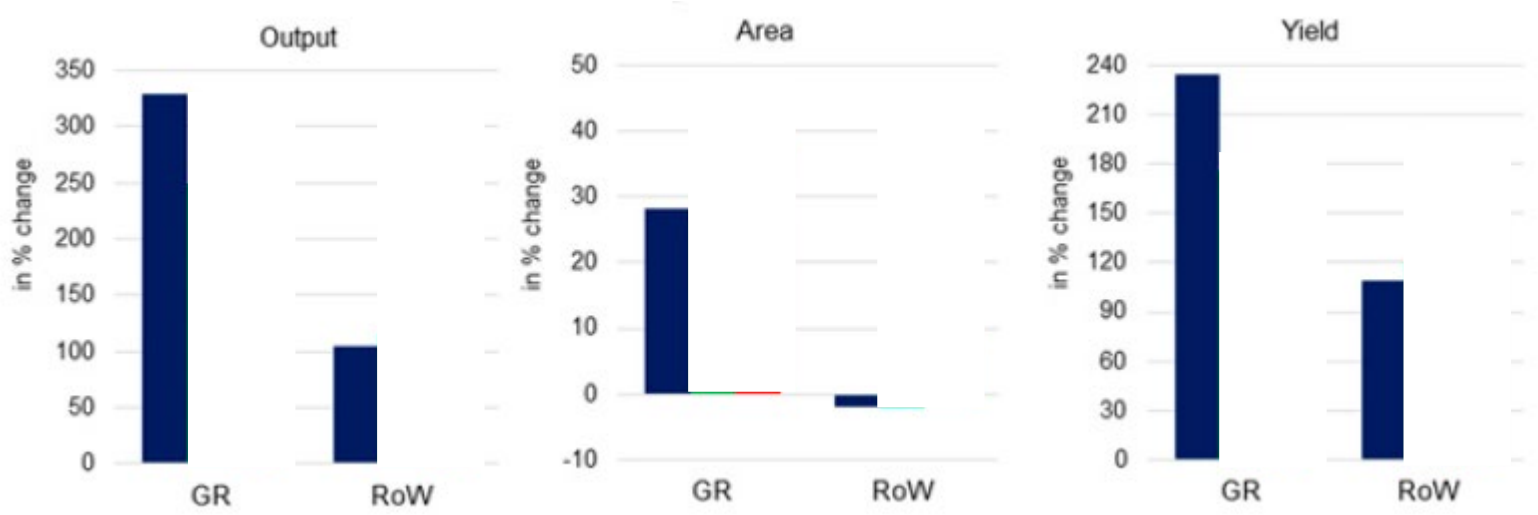
Let us move beyond the hypothetical and examine history. The challenge here is that we cannot rewrite history with a different rate of TFP growth – so we will need to use an economic model as our 'laboratory'.

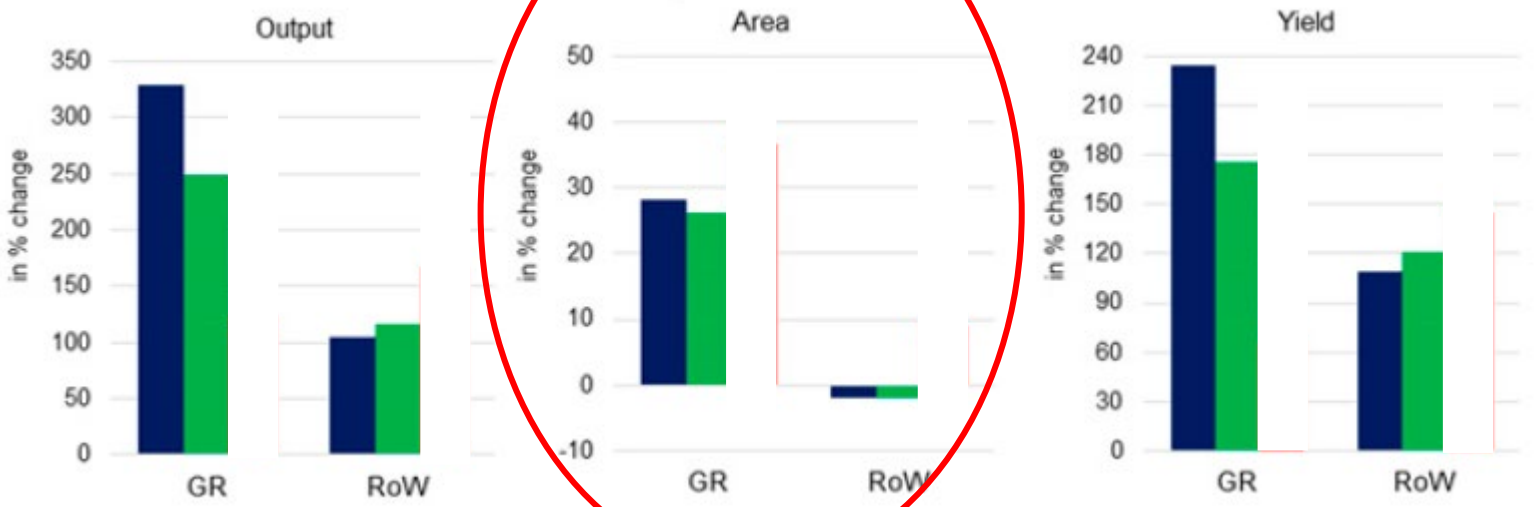
What if there had been no Green Revolution?



- Blue = Baseline: what actually happened: 1961-2006: GR = Green Revolution regions; RoW = Rest of World

What if there had been no Green Revolution?

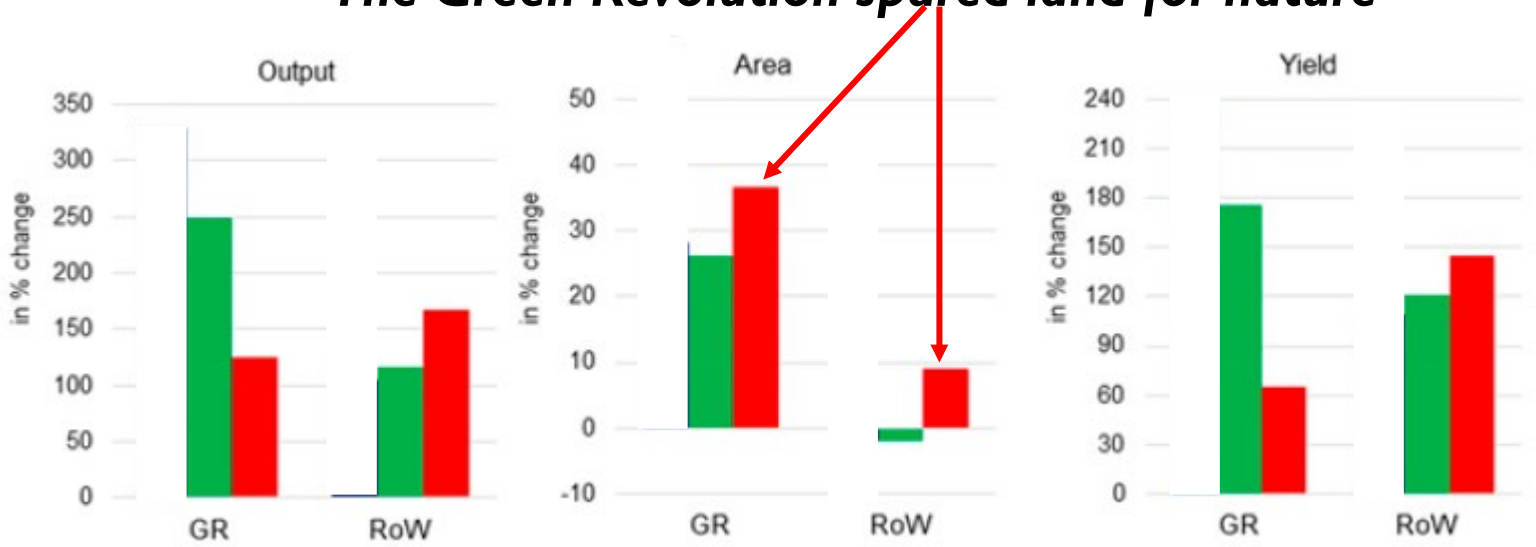
SIMPLE model used to simulate historical evolution of global agriculture



- Blue = Baseline: what actually happened: 1961-2006
- Green = Historical simulation using SIMPLE model: Provides a 'lab' to study alternative histories: What if?.....

What if there had been no Green Revolution? Rewriting history

The Green Revolution spared land for nature



- Green = Historical simulation using SIMPLE model: 1961-2006
- Red = Counterfactual simulation: Rewrite history using the model what would have happened if *No Green Revolution*

➡ ***The Green Revolution spared land for nature***

Hertel, T., W., N. Ramankutty and U.L.C. Baldos, (2014) "Global market integration increases likelihood that a future African Green Revolution could increase crop land use and CO2 emissions", *Proceedings of the National Academy of Sciences* 111(38):13799–13804

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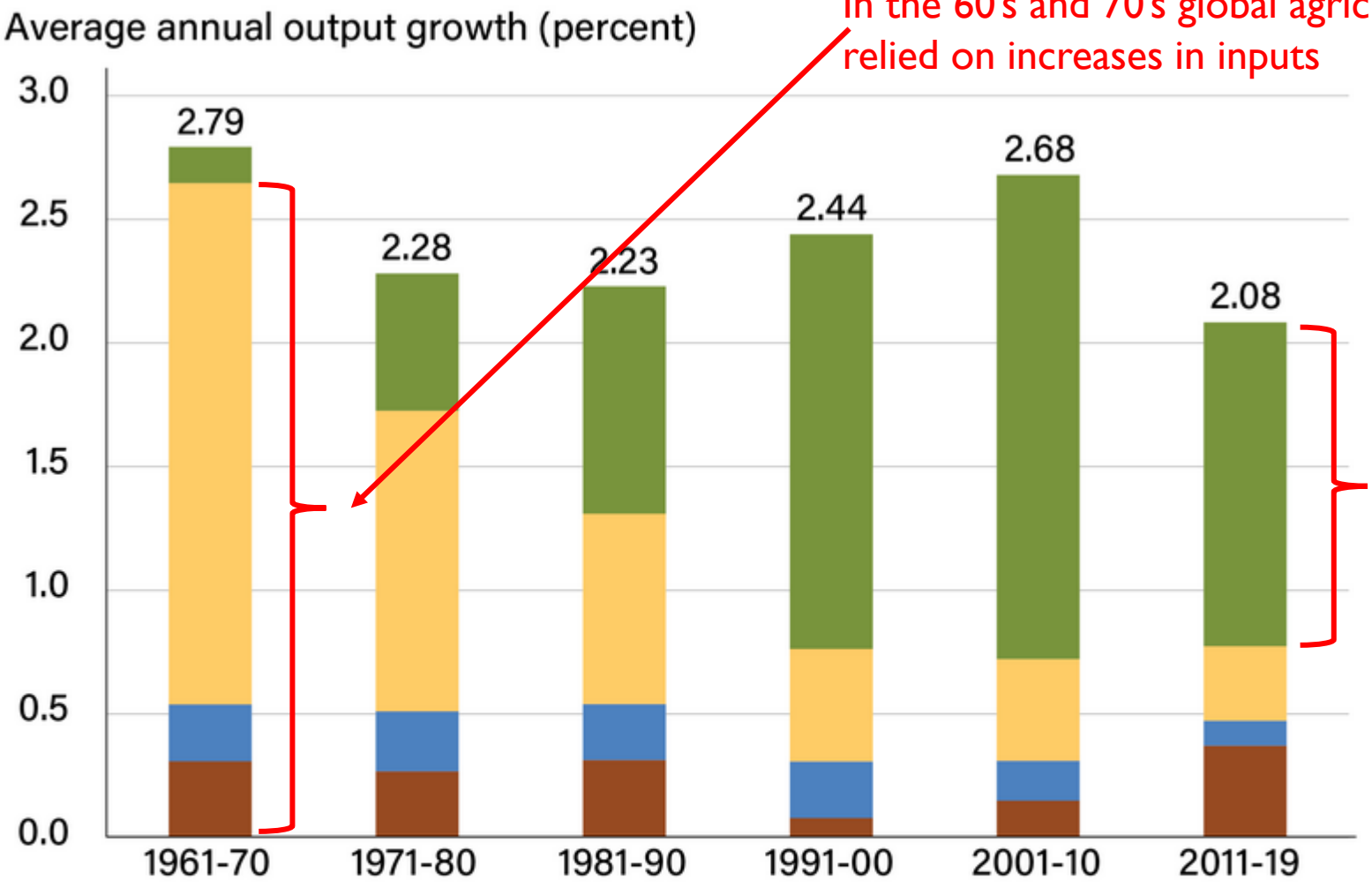
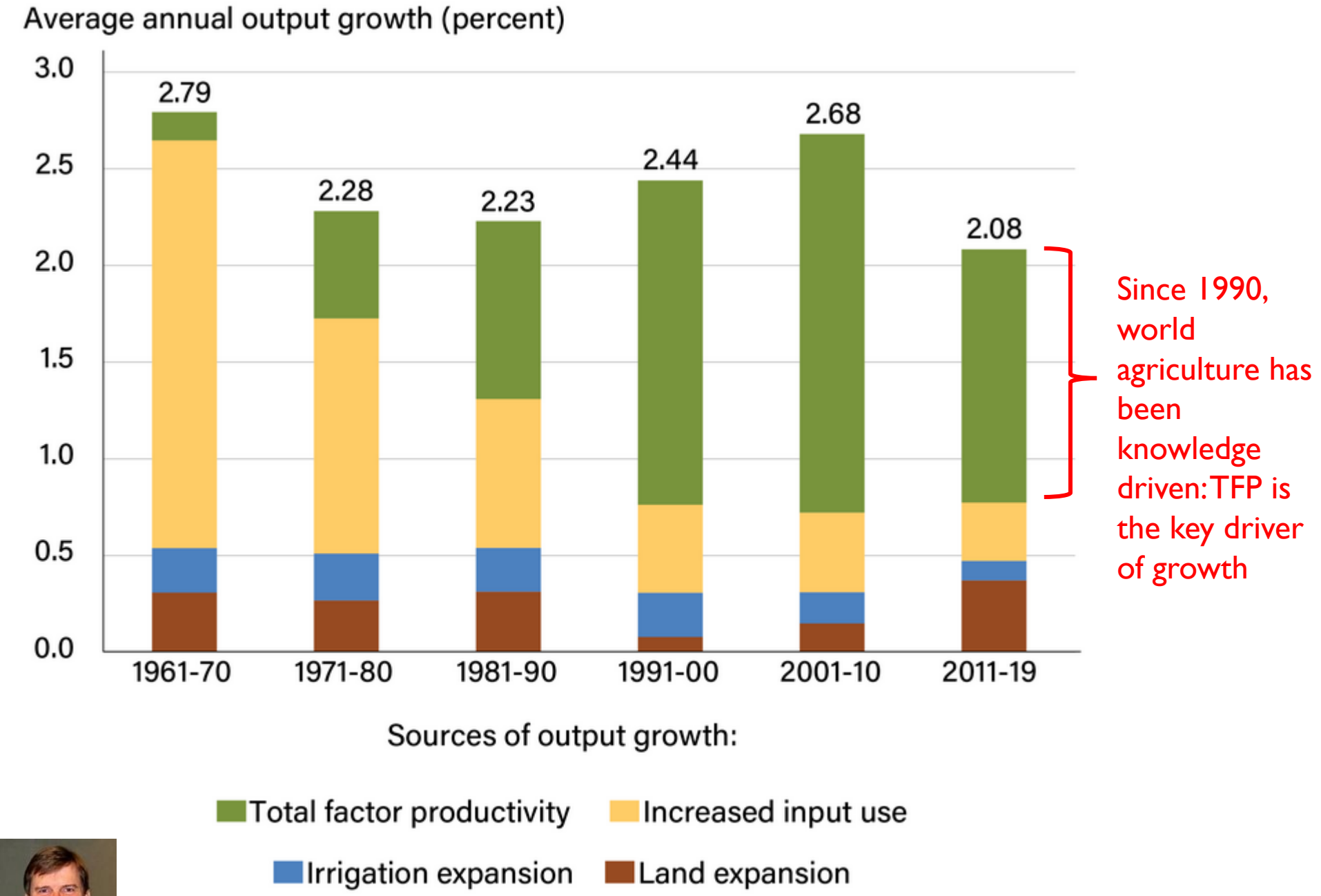
In the 60's and 70's global agricultural growth relied on increases in inputs



Feature: Farm Economy December 28, 2021

Slowing Productivity Reduces Growth in Global Agricultural Output

by Keith Fuglie, Jeremy Jelliffe, and Stephen Morgan



Since 1990, world agriculture has been knowledge driven: TFP is the key driver of growth

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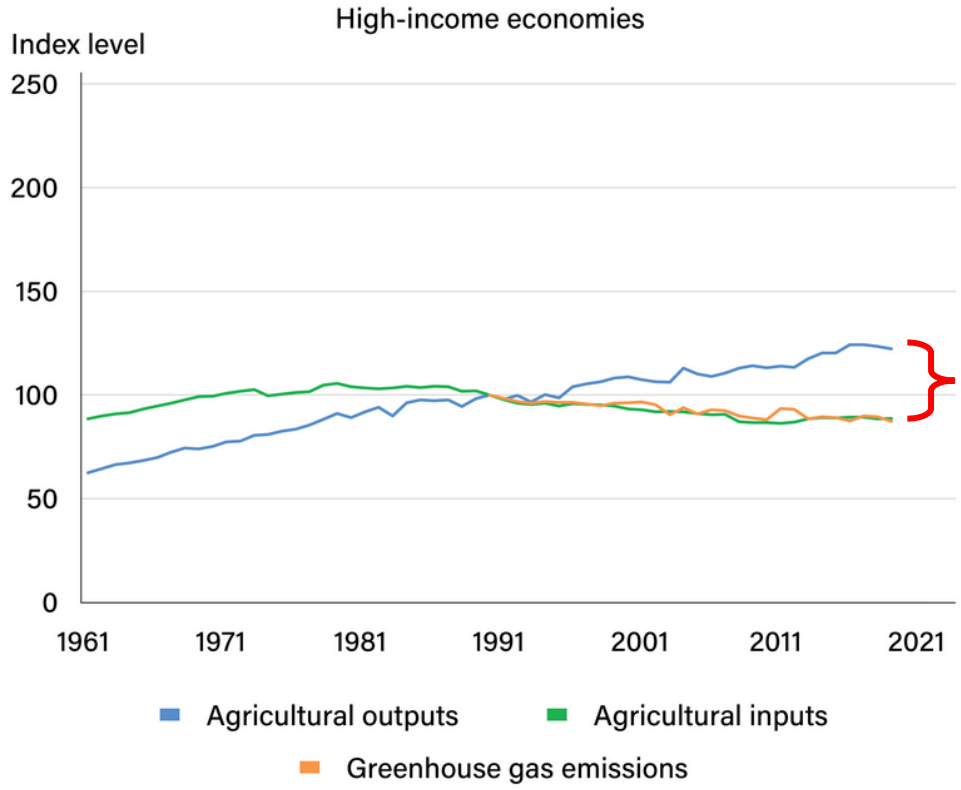

By permitting output to grow faster than input usage, TFP growth has dampened GHG emissions from agriculture in high income economies

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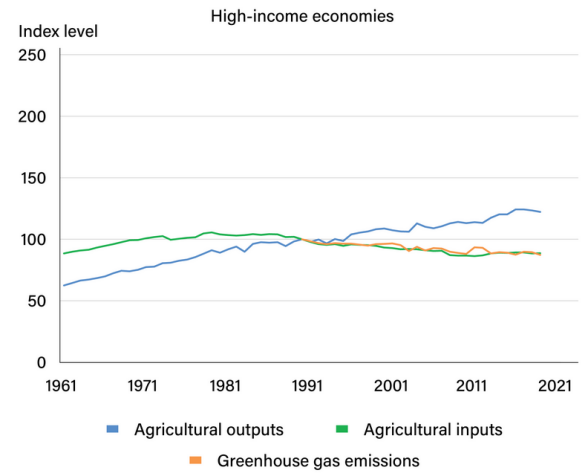

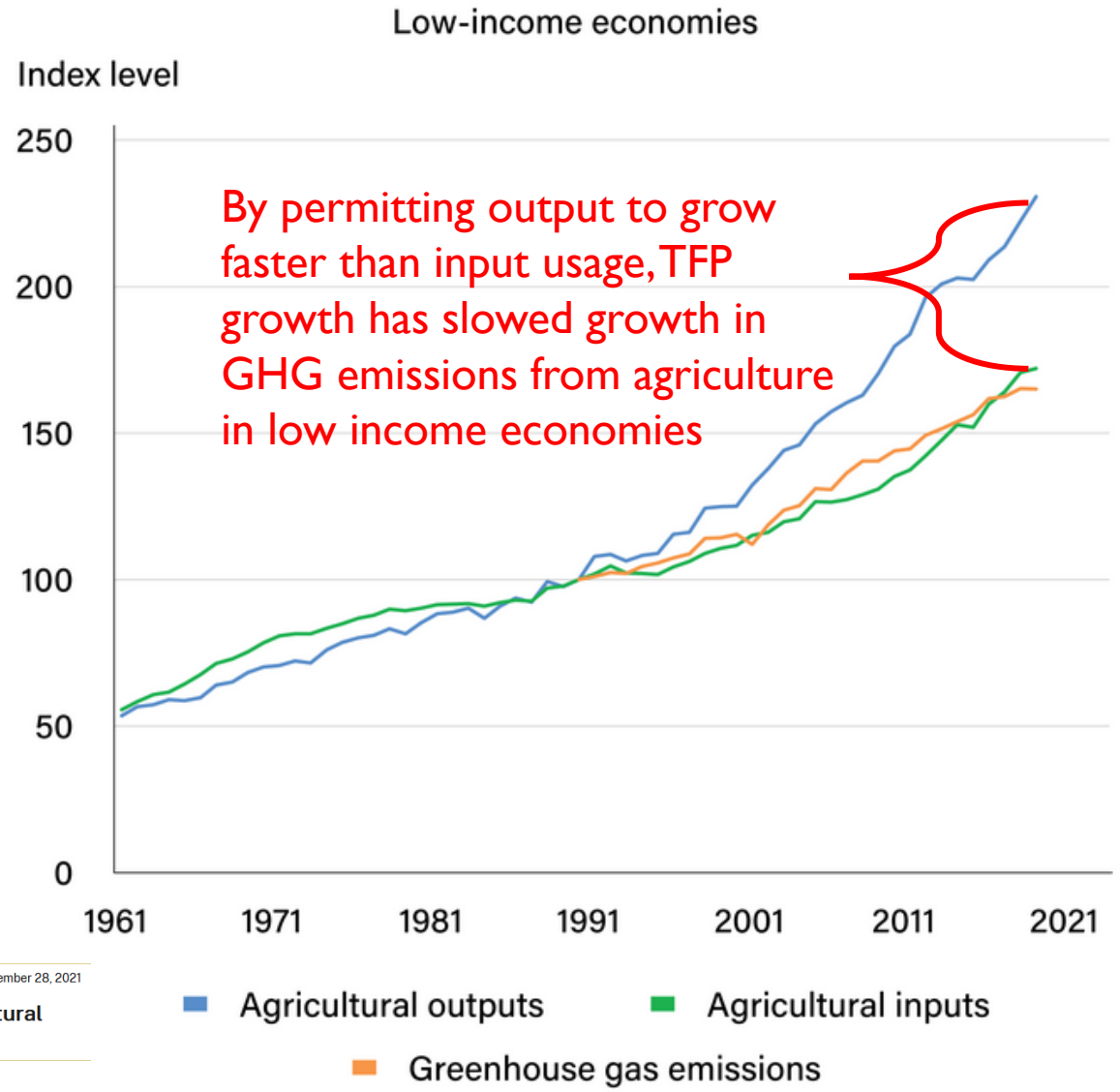

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Slowing Productivity Reduces Growth in Global Agricultural Output

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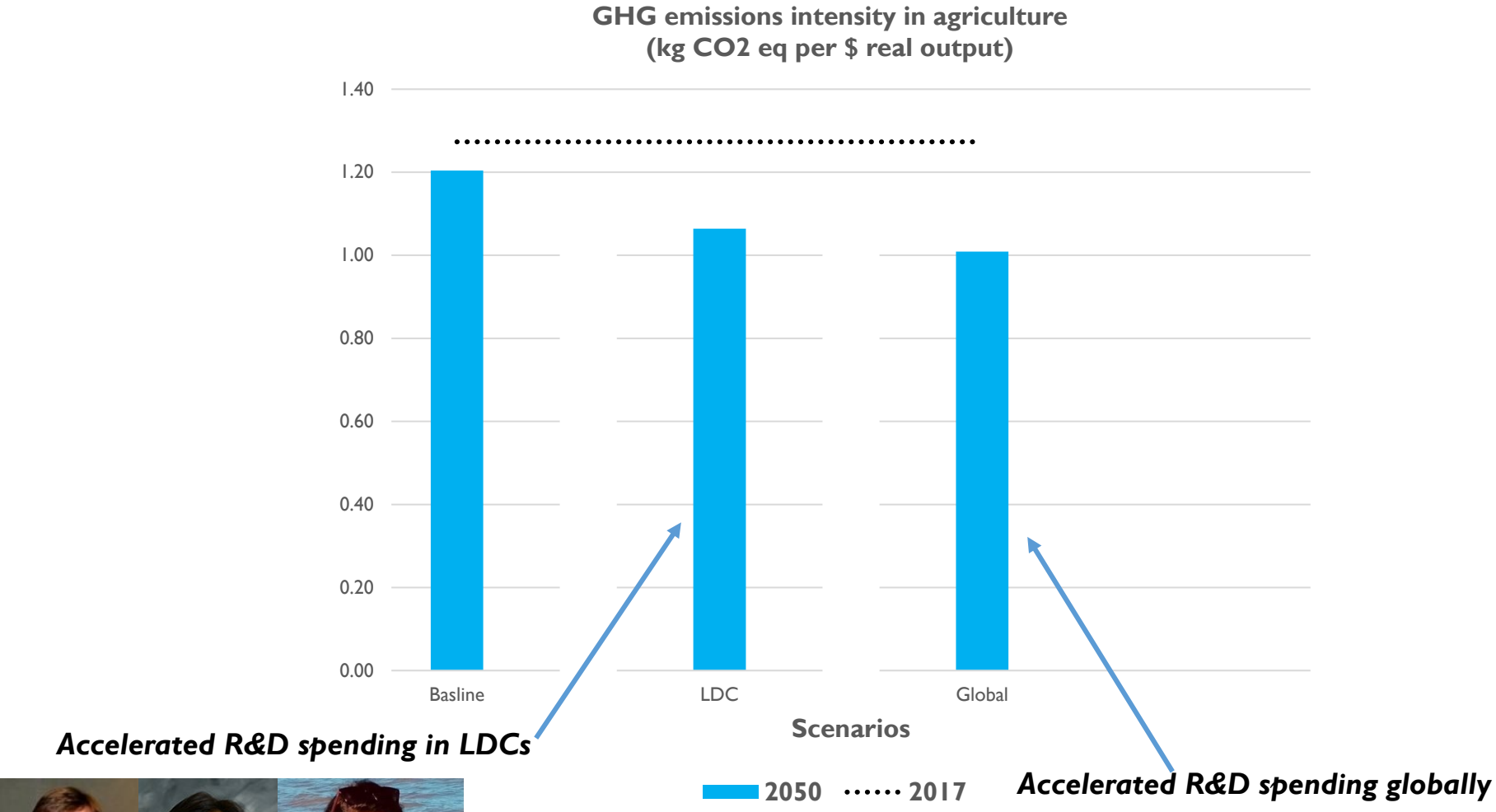
Accelerating public R&D spending would reduce GHG emissions intensity in 2050



Fuglie, K.O., U.L.C. Baldos, S. Ray and T.W. Hertel. (Forthcoming) "The R&D Cost of Climate Mitigation in Agriculture", *Applied Economic Perspectives and Policy.*

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Regions	Total change	Contribution of population	Contribution relative to population (Index = 100)	
			Per capita income	TFP
Malnutrition count (millions)				
Historical experiment: 1991–2001				
World	−150.7	266.5		
sub-Saharan Africa	44.6	73.7		

Over the decade 1991-2001, the malnutrition head count worldwide fell by 150M, while rising in SSA by 44.6M. Population growth alone would have increase malnutrition globally by 266.5M.

The Australian Journal of Agricultural and Resource Economics
Journal of the Australian Agricultural and Resource Economics Society
Australian Journal of Agricultural and Resource Economics, 58, pp. 1–18

Global food security in 2050: the role of agricultural productivity and climate change

Uris Lantz C. Baldos and Thomas W. Hertel†

Regions	Total change	Contribution of population	Contribution relative to population (Index = 100)			
			Per capita income		TFP	
Malnutrition count (millions)						
Historical experiment: 1991–2001						
World	−150.7	266.5	−47	–	−109	–
sub-Saharan Africa	44.6	73.7	25	–	−64	–

Globally, income growth and TFP growth allowed for the reduction in malnutrition
In SSA, per capita income declined, but global TFP growth mitigated the rise in undernourishment

The Australian Journal of Agricultural and Resource Economics
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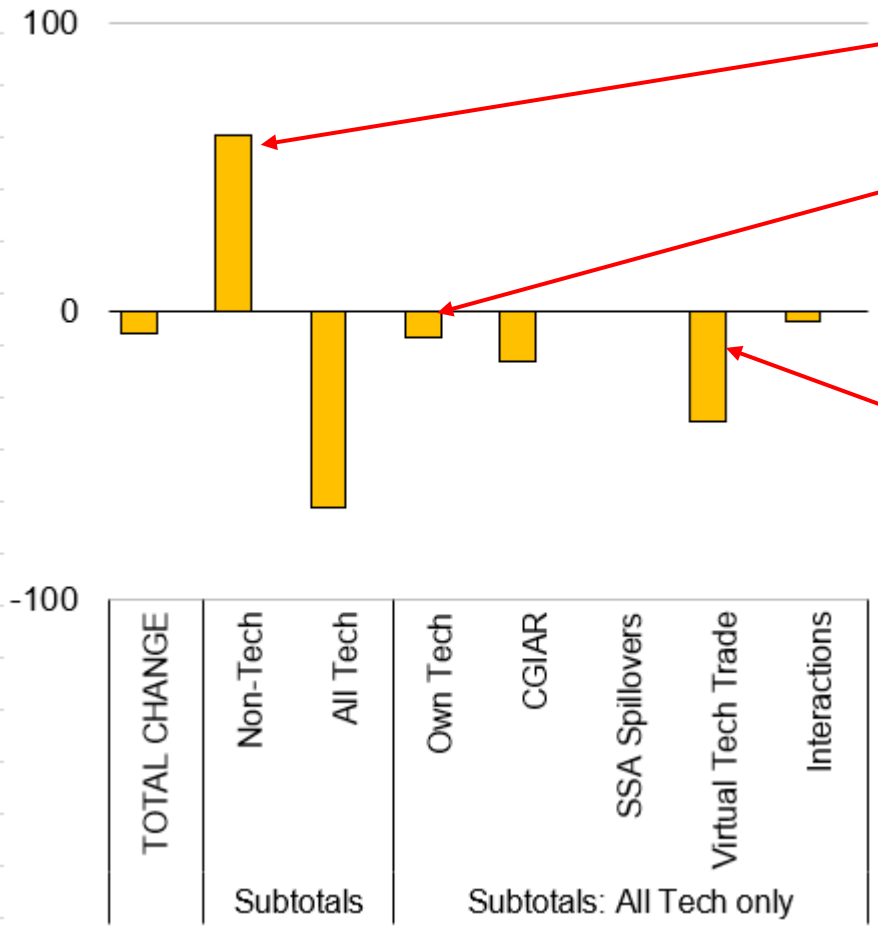
Global food security in 2050: the role of agricultural productivity and climate change

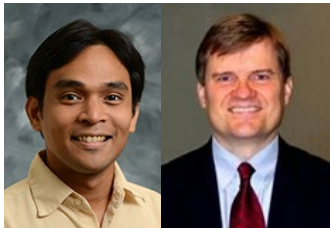
Uris Lantz C. Baldos and Thomas W. Hertel†

Future Drivers of Consumers' Crop Price in SSA: 2006-2050



- **Domestic *pop and income growth will drive up food prices in SSA***
- **Domestic R&D has limited impact; projected SSA R&D investments are very modest to 2050**
- **CGIAR investments to mid-century are important**
- **However, *virtual technology trade is the dominant driver of price reductions; SSA will depend on R&D investments in other regions to maintain stable food prices***

Hertel, T.W. and U.L.C. Baldos and K.O. Fuglie. (2020) "Trade in Technology: A Potential Solution to the Food Security Challenges of the 21st Century", *European Economic Review* 127(August):1-20.



Summary: TFP growth rates shape the global agricultural economy

- *Competitiveness* of the US in world markets hinges on domestic TFP growth – driven by public & private R&D
- Global TFP growth is critical to *dampening farmland expansion* – the primary source of biodiversity losses
- Mitigating *greenhouse gas emissions from agriculture* also hinges on increasing TFP growth rates
- TFP growth lowers food prices and *improves overall nutrition outcomes in developing countries*