THE OHIO STATE UNIVERSITY

"Agricultural productivity and the impact of GM crops: What do we know?"

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- **Growth in agricultural productivity has important implications for food security and food prices**
- **Net food importing countries have rapidly growing populations and growing food demand per capita, plus poorer land and water availability**
- **Significant yield gaps in Africa (Matthews, 2014)**
- **Investment in R&D could significantly increase production and productivity growth**
- **Brazil, India and China in top-5 producing countries, and account for 31% of public research**

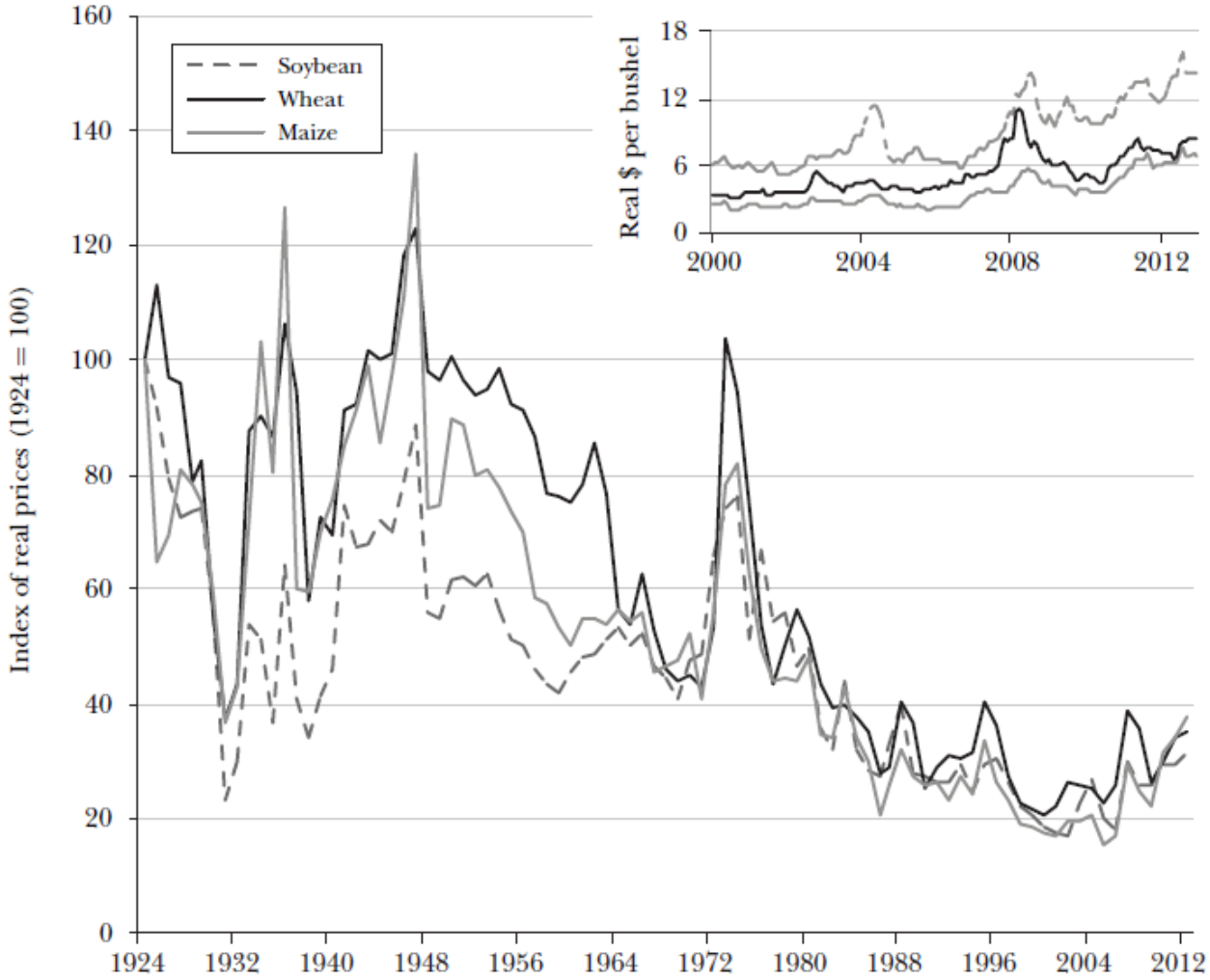
- **20th Century – growth in food supply outweighed growth in demand, driving down real food prices**
- **Recent price spikes are last step in slowing down in rate of decline in real food prices since 1970s**
- **Consistent with productivity slowdown - global average yields for key crops have fallen:**

Average annual yield growth rates (%)

Crop	1961-1990	1990-2011
Corn	2.33	1.77
Wheat	2.72	1.09
Rice	2.14	1.06
Soybeans	1.72	1.21

Source: Alston and Pardey (2014)

Real US Prices of Corn, Soybeans and Wheat, 1924-2012



Source: Alston and Pardey (2014)

- **Public expenditure on agricultural R&D declining in developed countries – US share in total dropped from 21% to 13% between 1960 and 2009**
- **Changes in patent law have provided incentives to private firms to invest in development of GM crops – corn, soybeans, cotton and rapeseed**
- **Private-sector spending on agricultural R&D estimated at $20-22 billion/year**
- **1.25 billion acres planted to GM crops since 1996**
- **What do we know about impact of first-generation GM crops on agricultural productivity?**

GM Area Harvested in 2010 (millions of acres)

Cotton		Soybeans	
India	23.2	US	72.6
US	10.1	Brazil	45.5
China	8.6	Argentina	44.5
Argentina	1.5	Paraguay	6.7
ROW	3.2	ROW	7.7

90% of area

92% of area

Corn		Rapeseed	
US	69.7	Canada	15.0
Brazil	18.5	US	1.2
Argentina	6.9	Australia	0.2
South Africa	4.7	ROW	0.0
ROW	4.7		

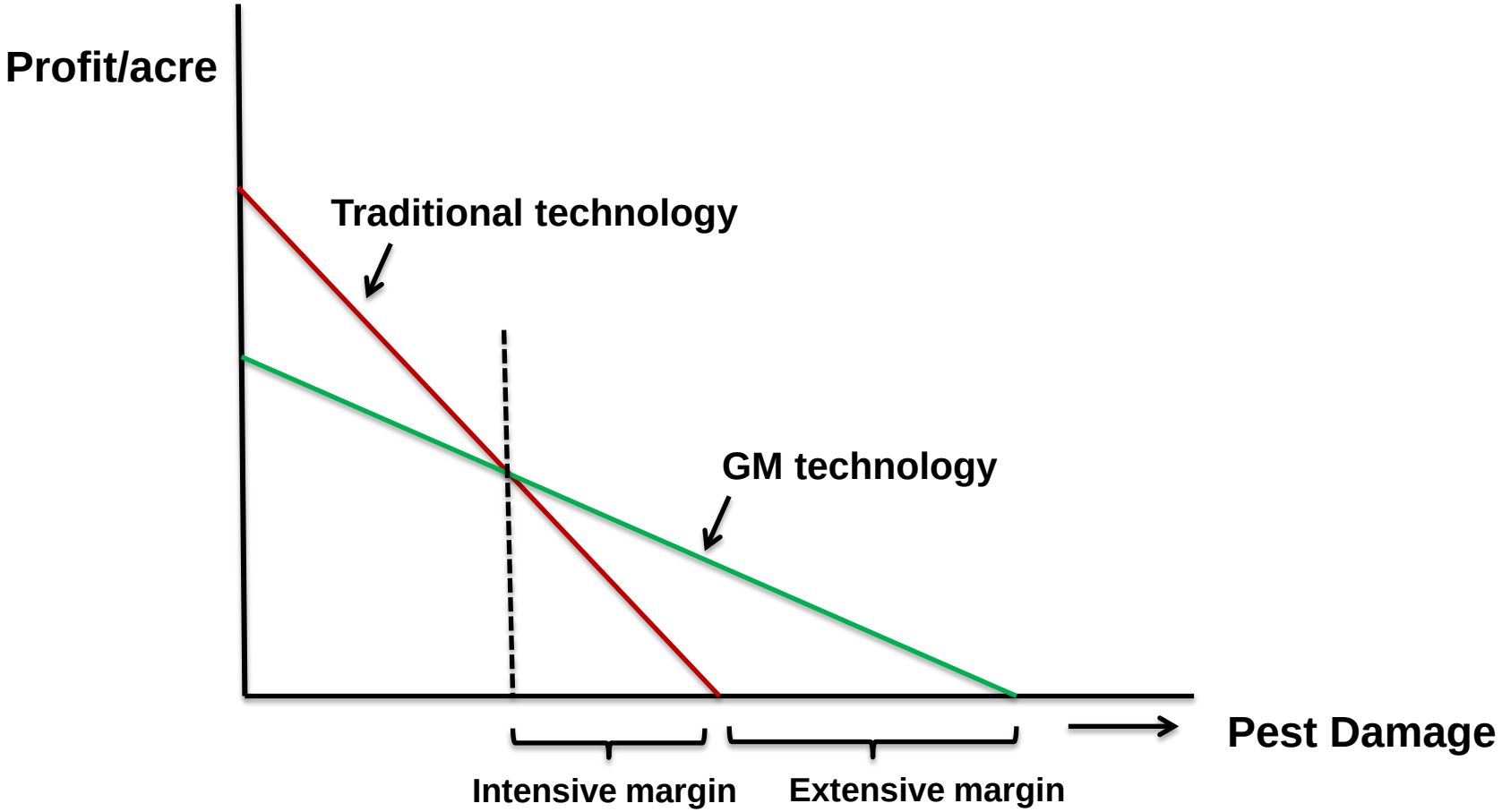
85% of area

85% of area

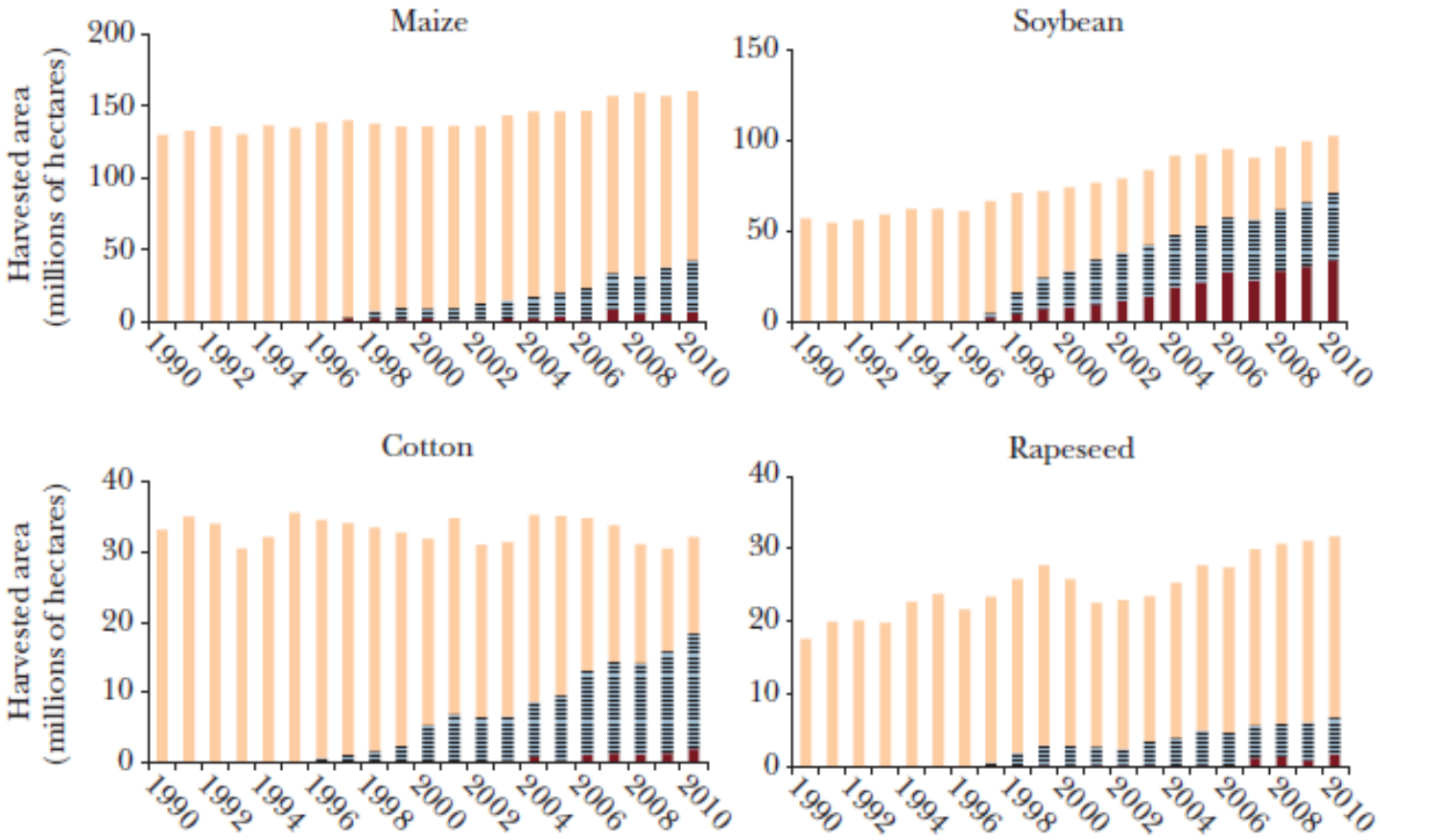
Source: Barrows *et al*. (2014)

- **Adoption of GM crops occurs along two margins:**
  - ***intensive margin*** **- conventional seed is replaced with GM variety**
  - ***extensive margin*** **- previously unused land recruited into production, switch from other crops, and double-cropping**
- **GM cotton, corn and rapeseed mostly adopted along intensive margin**
- **In contrast, adoption of GM soybeans adopted evenly along both margins – 50% increase in acreage mostly in Brazil and Argentina**

Adoption of GM Technology



World Area of Four Crops with GM Varieties (1 hectare = 2.47 acres)



Source: Barrows *et al*. (2014)

- **Potential for yield gains from GM technology likely greatest where pest pressure is high, i.e., in low income developing countries**
- **Most GM yield estimates based on randomized control tests – farmer behavior held constant, i.e., a pure "gene effect"**
- **Diminished crop damage increases marginal value of other inputs – generates extra yield gains**
- **Impact on extensive margin depends on whether additional production would have occurred in absence of GM crops**

- **Barrows *et al*. (2013) find yield effects at *intensive* and *extensive* margins over period 1990-2010:**
  - **2-14% to 9-19% increase in corn yields**
  - **0-25% to 5-29% increase in cotton yields**
  - **2-39% increase in soybean yields**
- **Adoption of GM corn, cotton and soybeans has lowered prices by 13%, 18% and 2-65% respectively (Barrows *et al*., 2013)**
- **Global net benefit to producers estimated at $65 billion over period 1996-2009, $30 billion accruing to US producers (Brookes and Barfoot, 2012)**

- **Adoption of first-generation GM crops has had positive impact on productivity, with associated impact on prices and land-use**
- **GM corn adoption limited to 30% of global acreage – affected by bans/regulatory restrictions in China, EU and Africa**
- **Currently - no commercial use of GM technology in key food grains rice and wheat**
- **Important to recognize calorie substitution between wheat, rice and corn (Wright, 2014)**

- **Public concern about safety of GM crops has slowed approval and release of GM rice and wheat**
  - **GM rice approved by China in 2009, but not fully commercialized**
  - **Monsanto dropped development of GM wheat in 2004**
- **China an interesting case: significant public funding of biotechnology R&D, and has approved feed-grains for import – *but* public "skepticism" about growing GM crops for human consumption**