Global and U.S. Trends in Agricultural R&D in a Global Food Security Setting

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OECD Conference on

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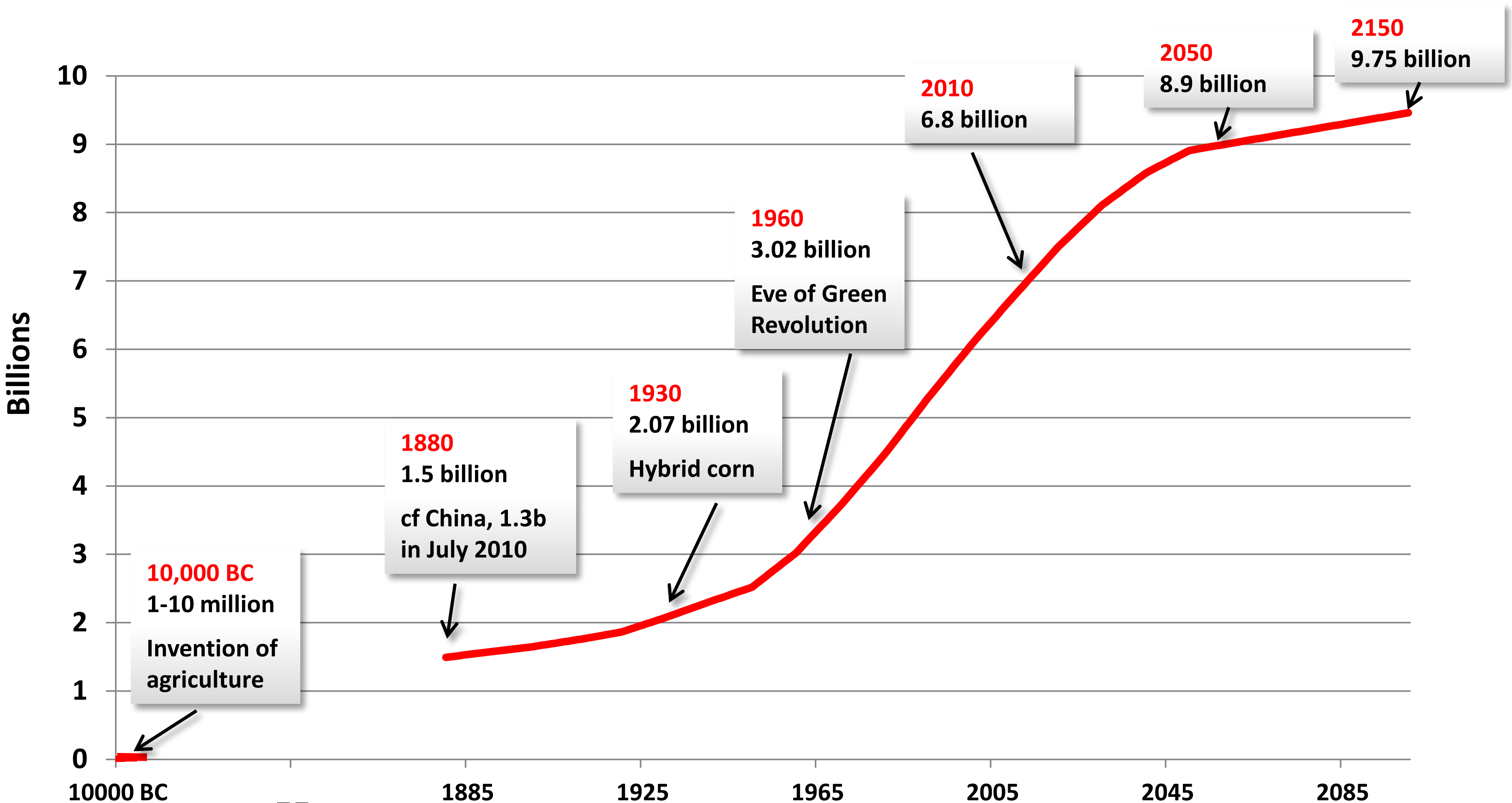
University of California
Agricultural Issues Center

Department of Agricultural and Resource Economics

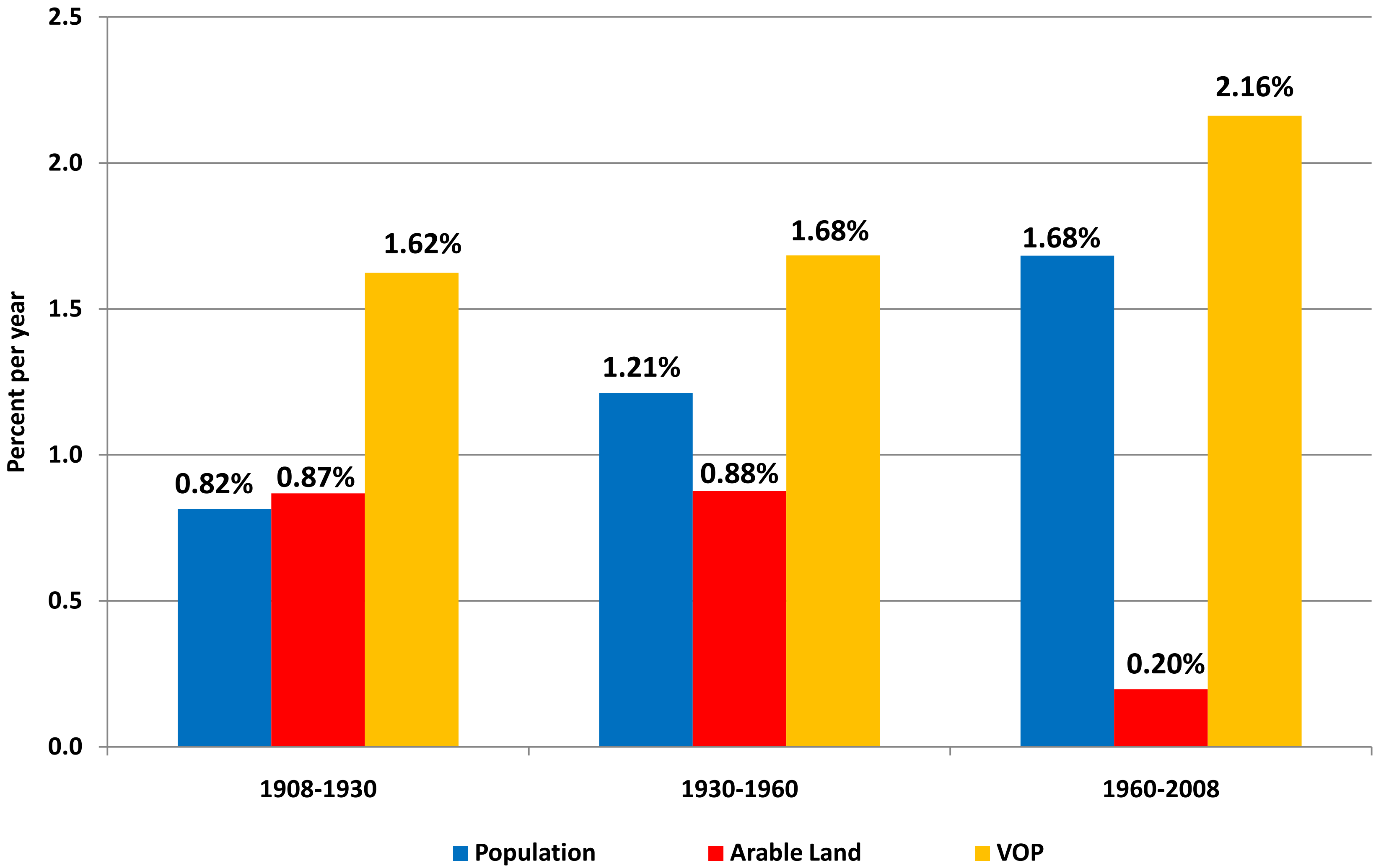
Long-run historical perspectives

Long-term World Population – 10,000 BC to 2150



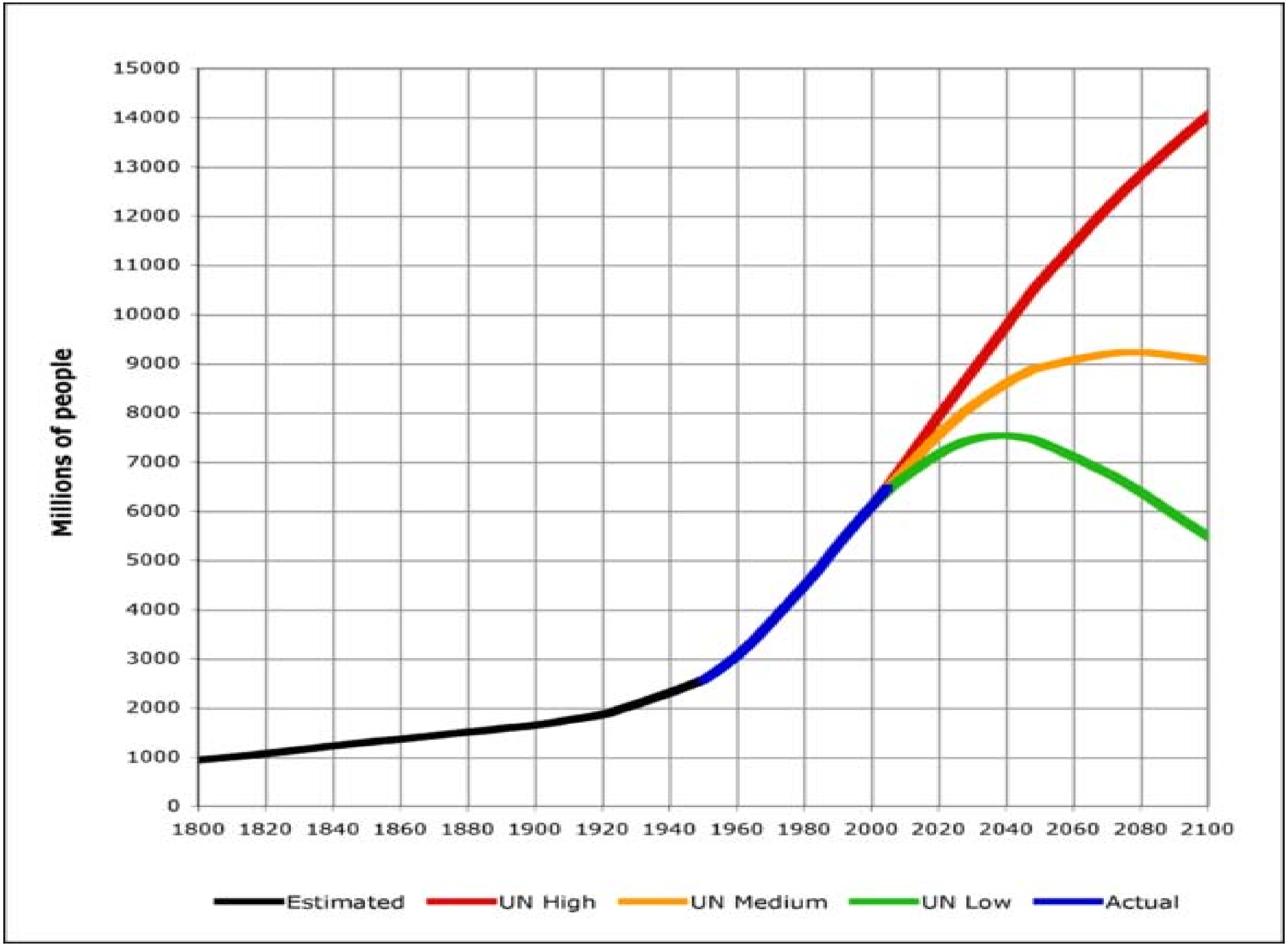
Source: Pardey (2011) and United Nations (n.d. and 2004)

Growth Rates of Global Population, Agricultural Land Area, and Value of Agricultural Production, 1908-2008



Source: Pardey (2011)

World Population Projections to 2100



The Supply-Side Challenge

- **Farm Productivity**
  - **To increase agricultural productivity fast enough to feed 9-10 billion people within the next 40 years, in the face of**
    - competing demands for land and water
    - competing demands for biofuels
    - changing climate
    - co-evolving pests and diseases

- **Agricultural R&D**
  - **To conduct enough of the right types of agricultural R&D and get the resulting innovations adopted soon enough to meet the farm productivity challenge**

Today’s issues: investing in R&D and productivity

Key Points

1. **High rates of return to agricultural R&D**
   - **Implies persistent underinvestment—why is it so?**

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2. **Shifting patterns of public support for R&D**
   - **High-income countries**
     - Slowdown in spending growth
     - Diminishing share for on-farm productivity enhancement
   - **A different pattern in Brazil and China**

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3. **Shifting productivity patterns**
   - **Productivity slowdown in high-income countries**
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Key Points

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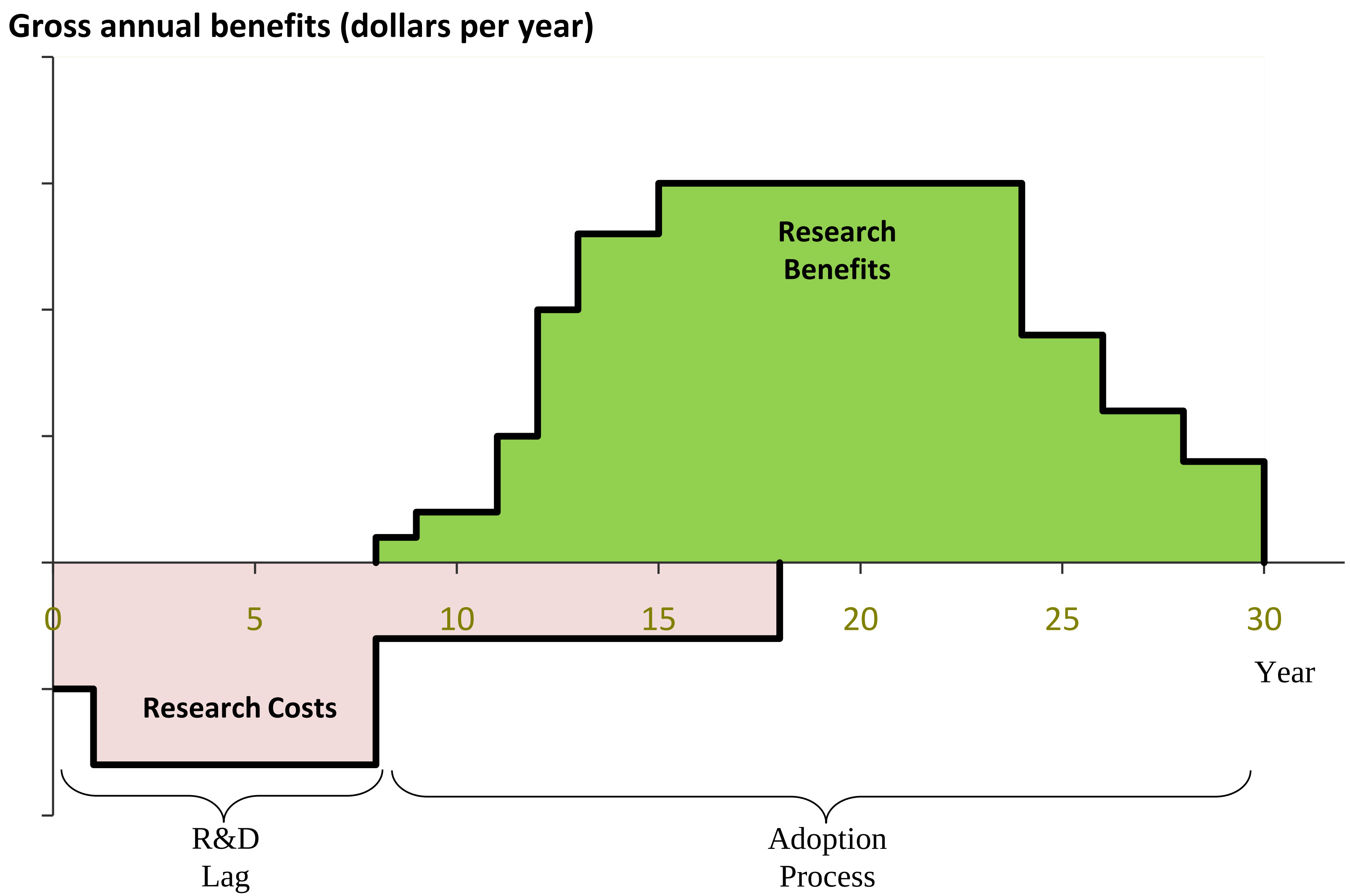
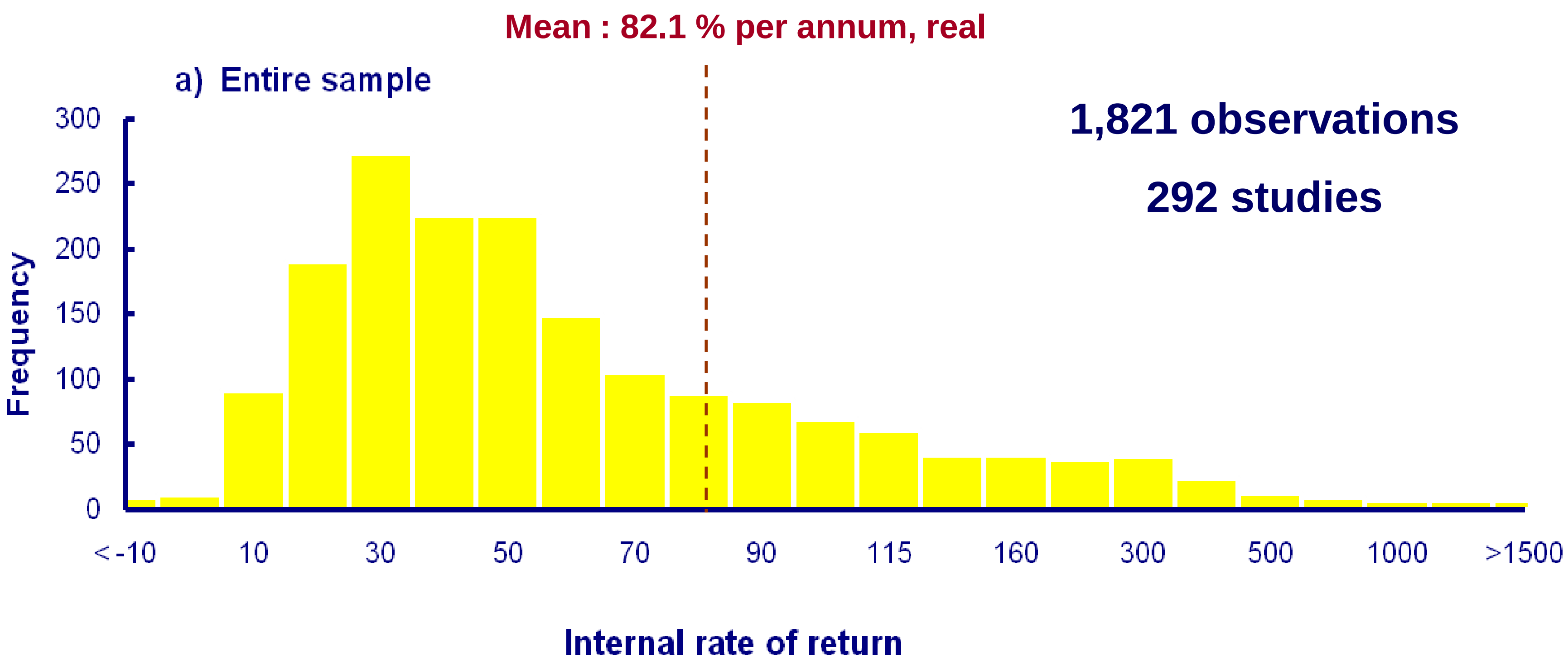
   - **A different pattern in Brazil and China**
3. **Shifting productivity patterns**
   - **Productivity slowdown in high-income countries**
   - **A different pattern in Brazil and China**
4. **Implications—institutional reform required?**
   - **Enhance rates of research investment, restore productivity growth, reduce pressure on natural resource stocks**

Rates of return to agricultural R&D

Stylized Representation of Research Benefits and Costs



Meta Evidence from Literature Prior to 2000



Source. Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey, and T J Wyatt. *A Meta-Analysis of the Rates of Return to Agricultural R&D: Ex Pede Herculem*. IFPRI Research Report No. 113, 2000.

Key Points from the Meta-Analysis

- **Challenge:**
  - Which research, conducted by whom, and when was responsible for observed productivity growth?

- **Attribution Issues**
  - Long time lags in knowledge creation and adoption
  - Spatial spillovers among states and countries
  - What is the relevant counterfactual alternative?

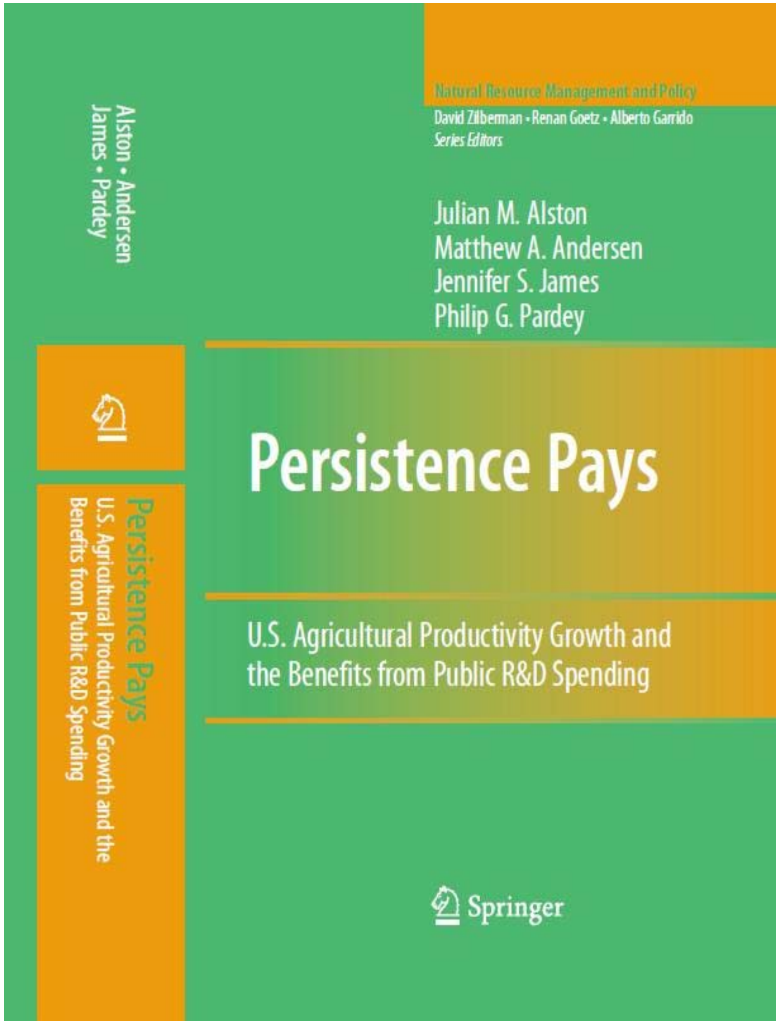
- **Studies have tended to overstate rates of return as a result of attribution biases . . . but true returns are still very large**

New Evidence

***Persistence Pays: U.S. Agricultural Productivity Growth and the Benefits from Public R&D Spending*.**

J.M. Alston, M.A. Andersen, J.S. James, and P.G. Pardey

Springer, January 2010



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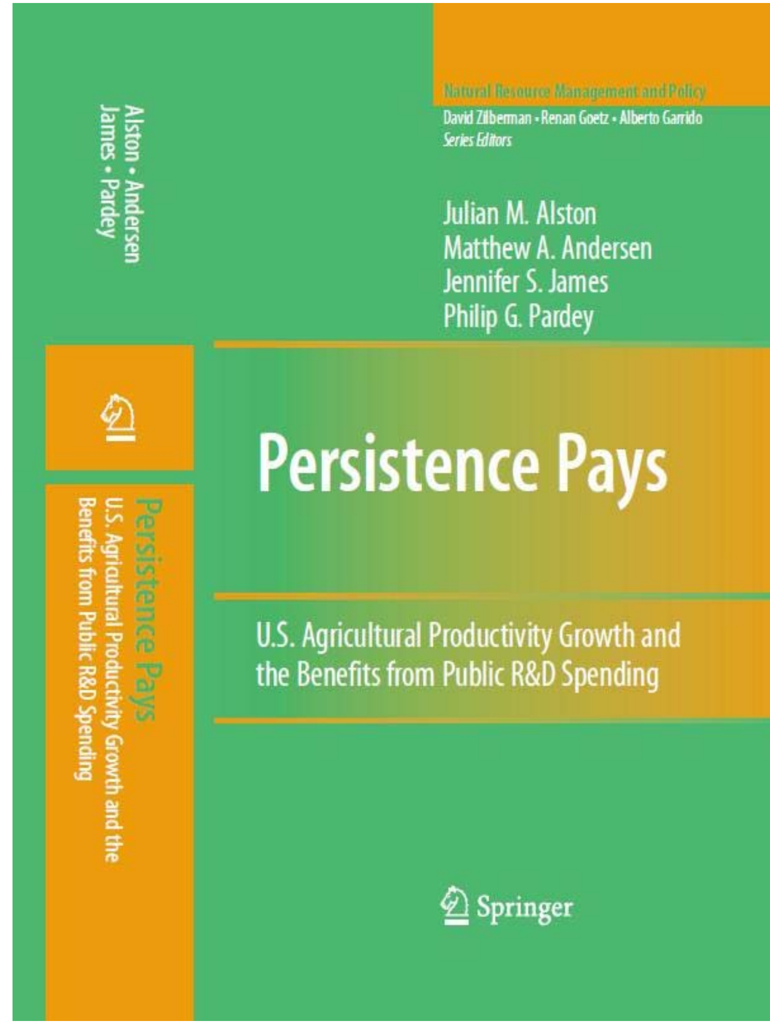
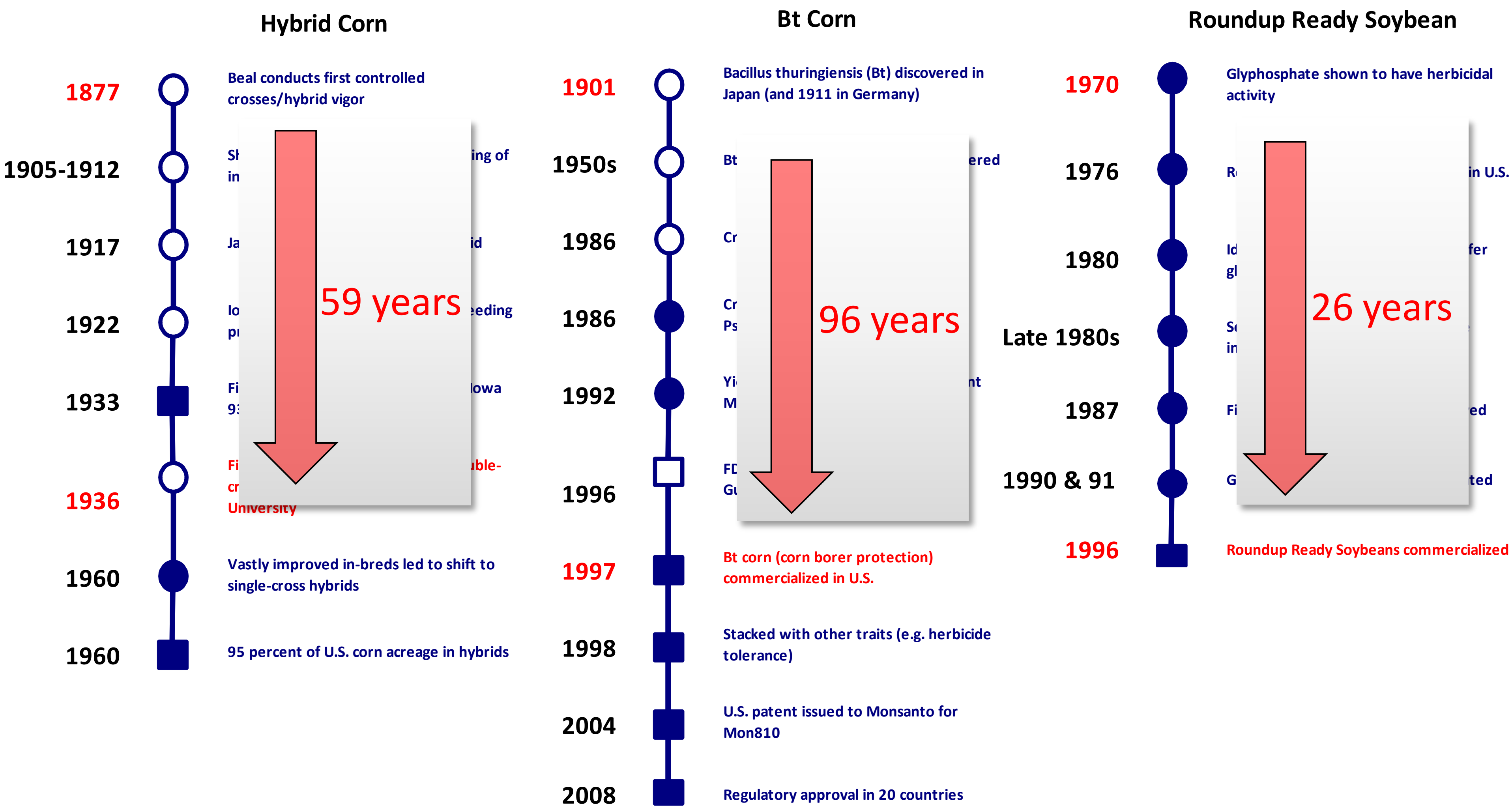


Challenges

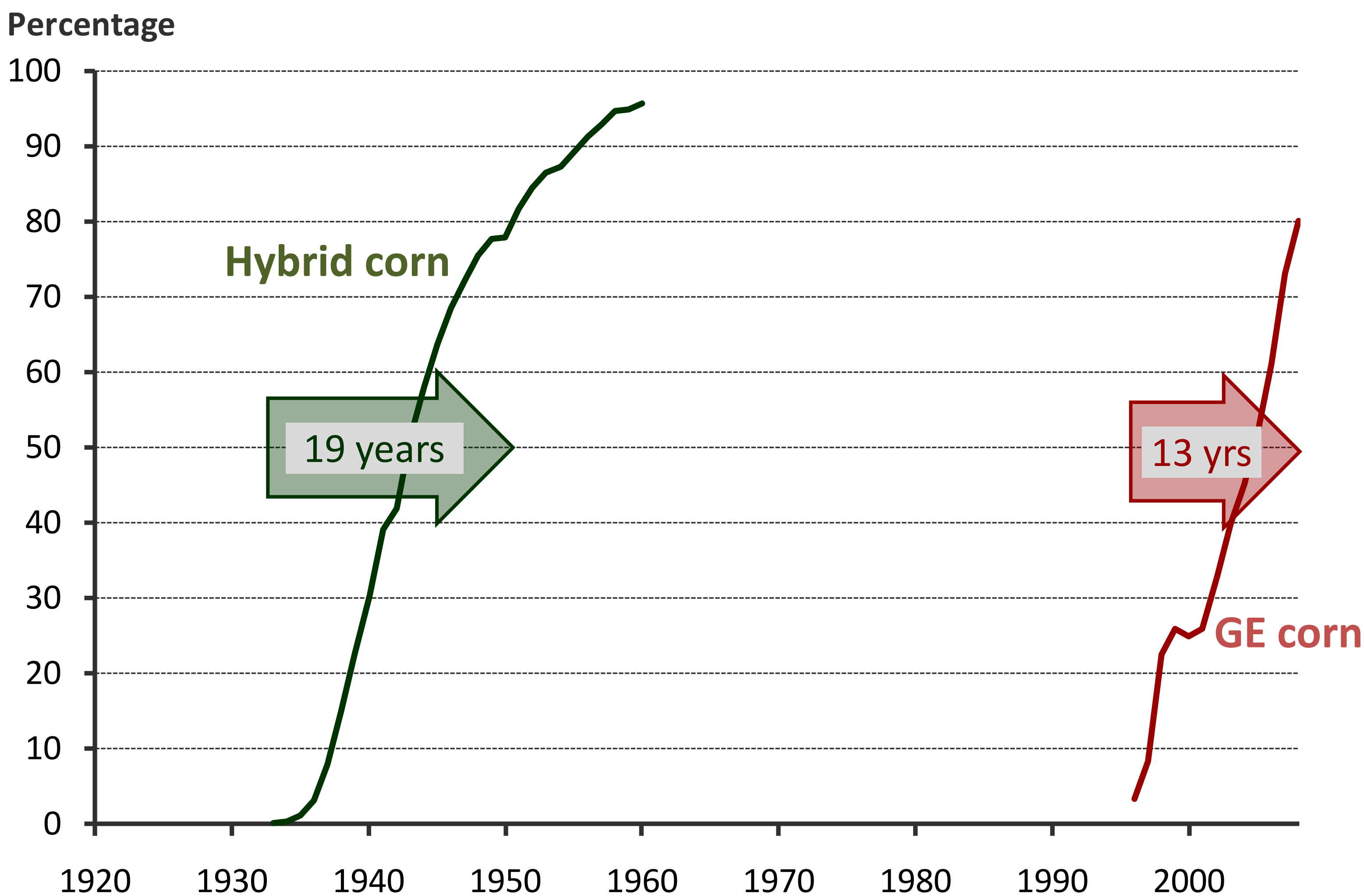
- Spillovers
- Long R&D Lags
- Role of maintenance research

Illustrative Technology Development Lags

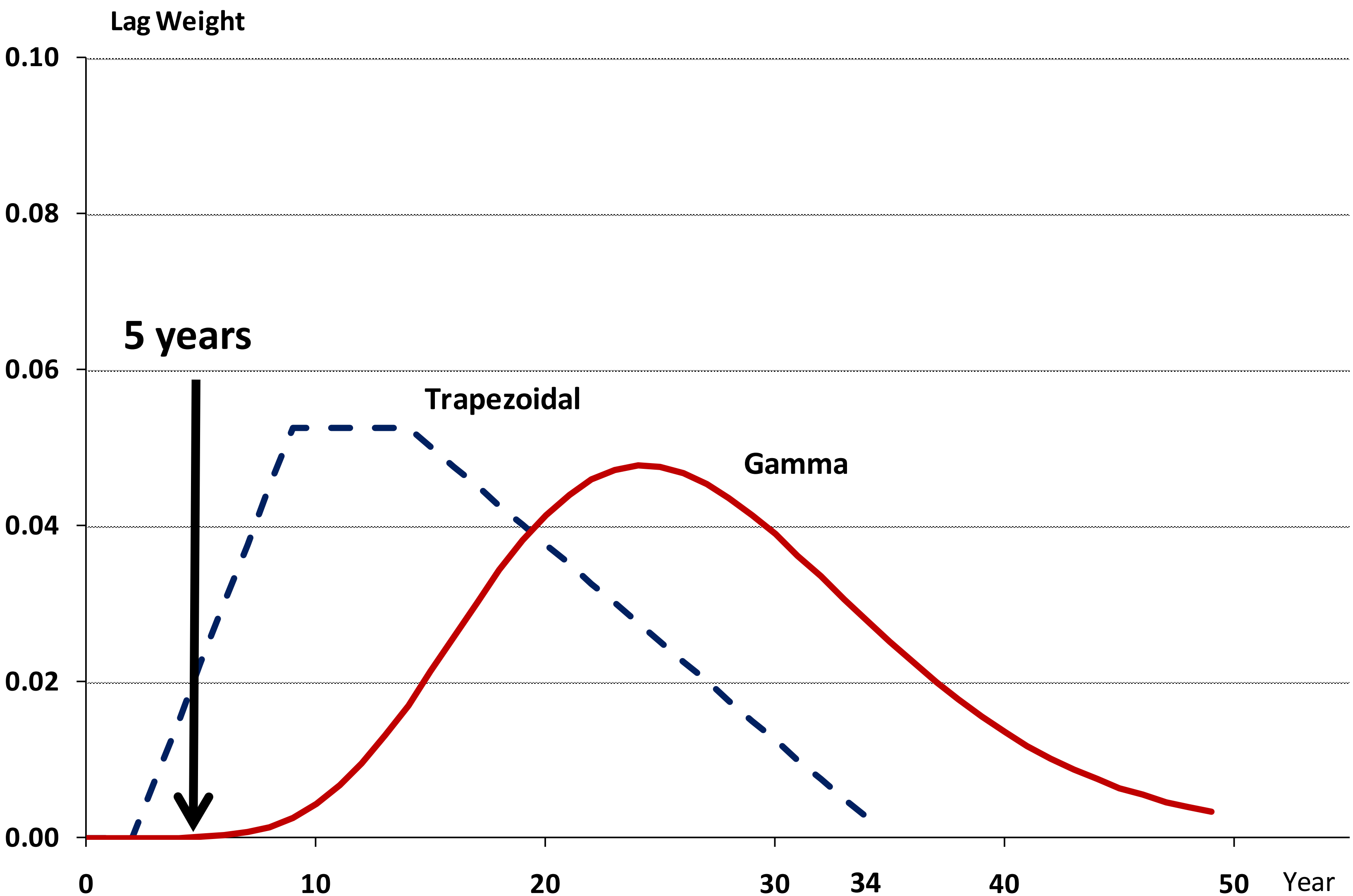


Source: Alston, Pardey and Ruttan (2008) and Alston et al. (2010)

Share of acreage planted to different types of corn varieties—years to reach 80 % adoption



Aggregate R&D-Productivity Lag



Source: Alston, Pardey and Ruttan (2008) ; and Alston et al. (2010)

The Tyranny of the Red Queen

- Crop varietal innovations masked by
  - Changing location of production => adaptive research
  - Co-evolving pests and diseases => maintenance research
    - The “Red Queen” effect

"Well, in our country," said Alice, still panting a little, "you'd generally get to somewhere else — if you run very fast for a long time, as we've been doing.“

"A slow sort of country!" said the Queen. "Now, here, you see, **it takes all the running you can do, to keep in the same place**. If you want to get somewhere else, you must run at least twice as fast as that!"

– ***Through the Looking Glass***

Marginal Returns to U.S. Public Agricultural R&E

Returns to	Benefit-Cost Ratio (3% real discount rate)	
	Own-State	National
	ratio	
State R&E		
48-State Average	**21.0**	**32.1**
48-State Minimum	2.4	9.9
48-State Maximum	57.8	69.2
USDA Research		**17.5**

Benefit cost ratios seem very big . . .

Marginal Returns to U.S. Public Agricultural R&E

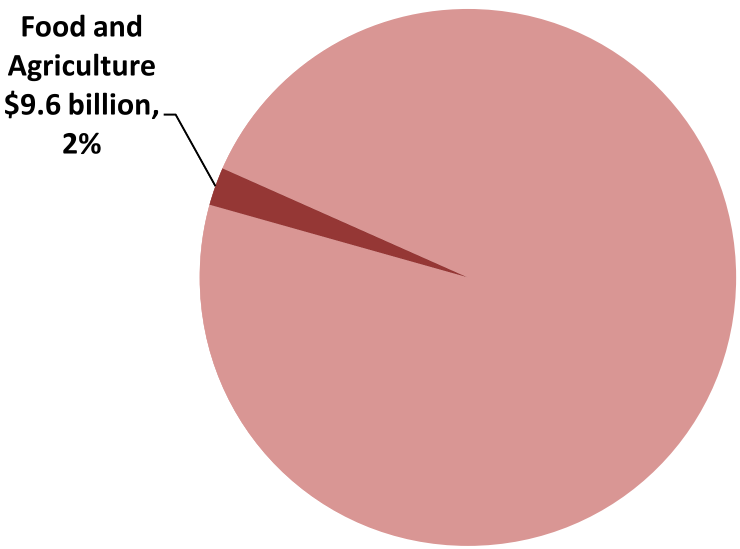
Returns to	Benefit-Cost Ratio (3% real discount rate)		Conventional Real Internal Rate of Return	
	Own-State	National	Own-State	National
	ratio		*percent per year*	
State R&E				
48-State Average	21.0	32.1	18.9	22.7
48-State Minimum	2.4	9.9	7.4	15.3
48-State Maximum	57.8	69.2	27.6	29.1
USDA Research		17.5		18.7

Benefit cost ratios seem very big . . . but the implied IRRs are comparatively modest reflecting the very long lags and other modeling details (improvements)

U.S. science spending

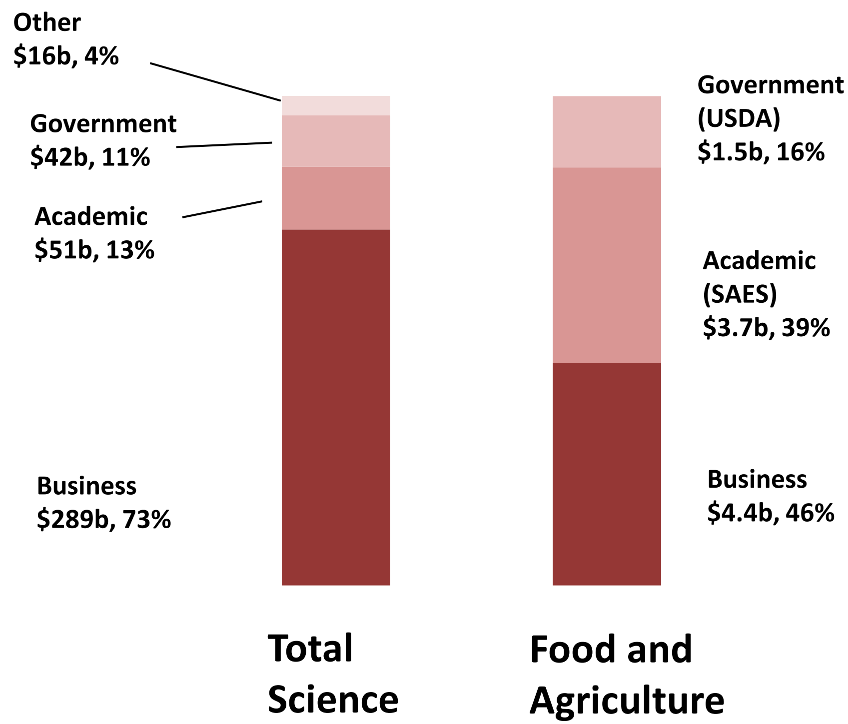
U.S. Science Spending, 2008

Total Science



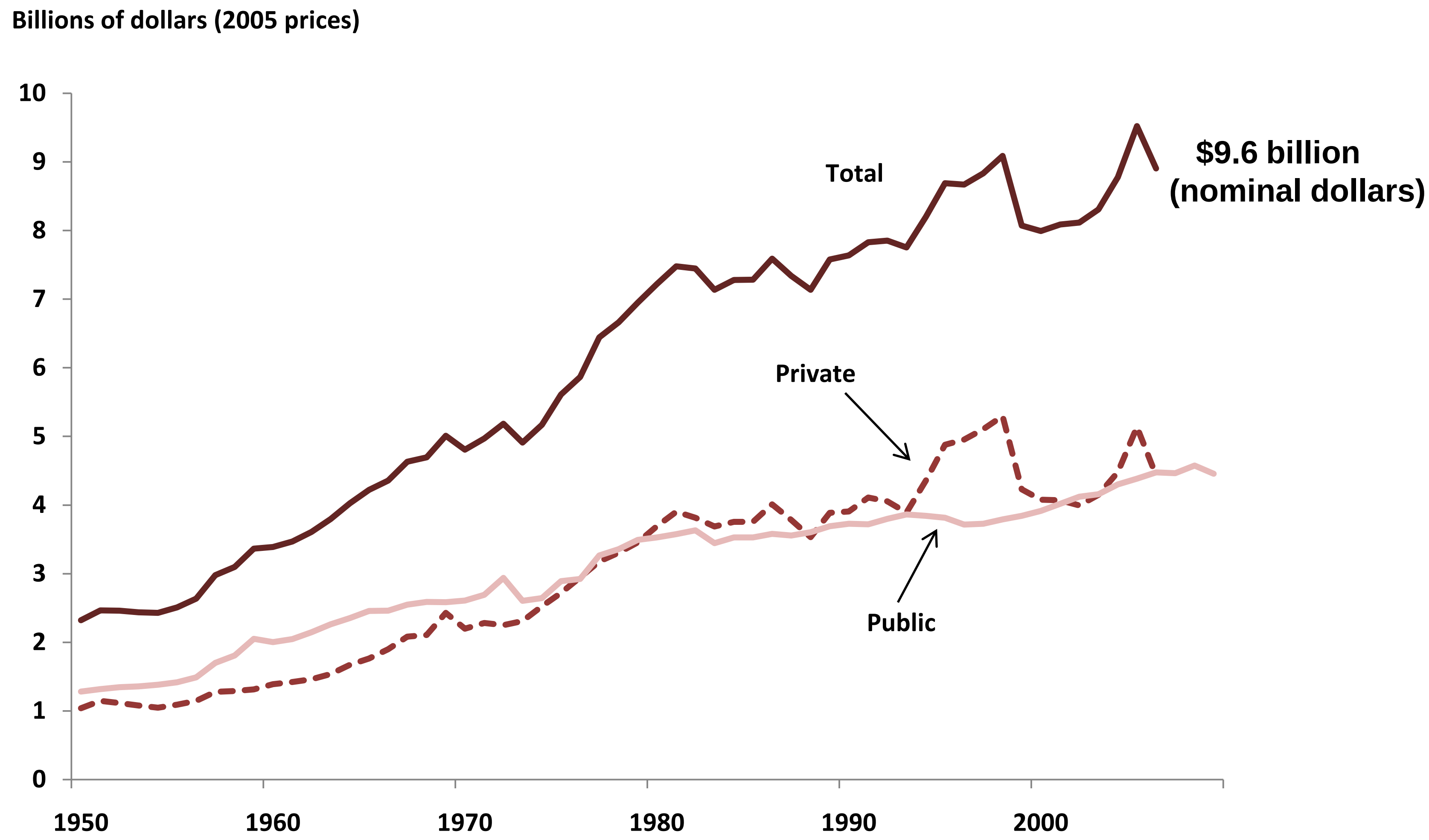
$398 billion

By Performer



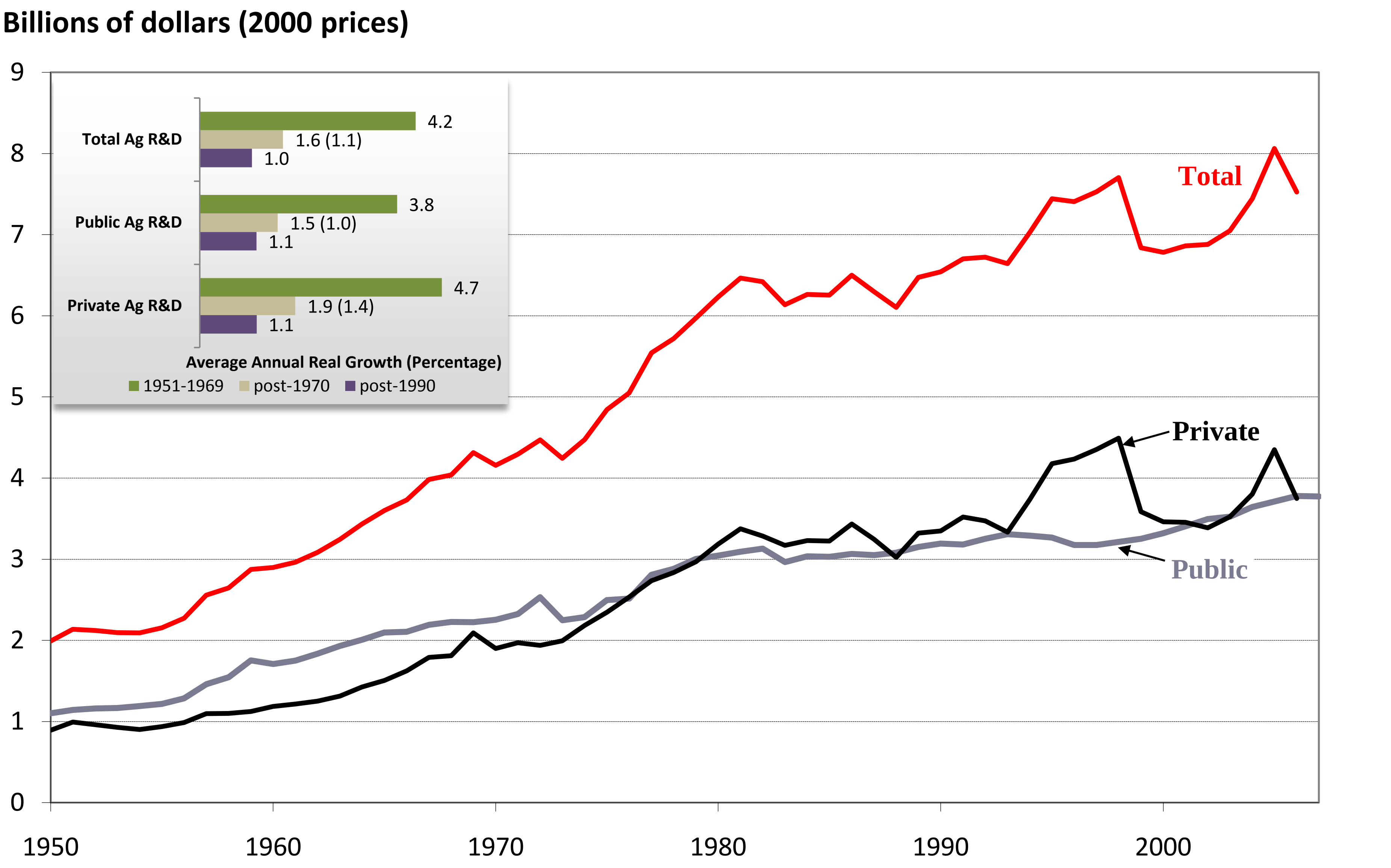
Source: Dehmer and Pardey (2011); Pardey and Chan-Kang (2011)

U.S. Agricultural R&D, 1950–2009

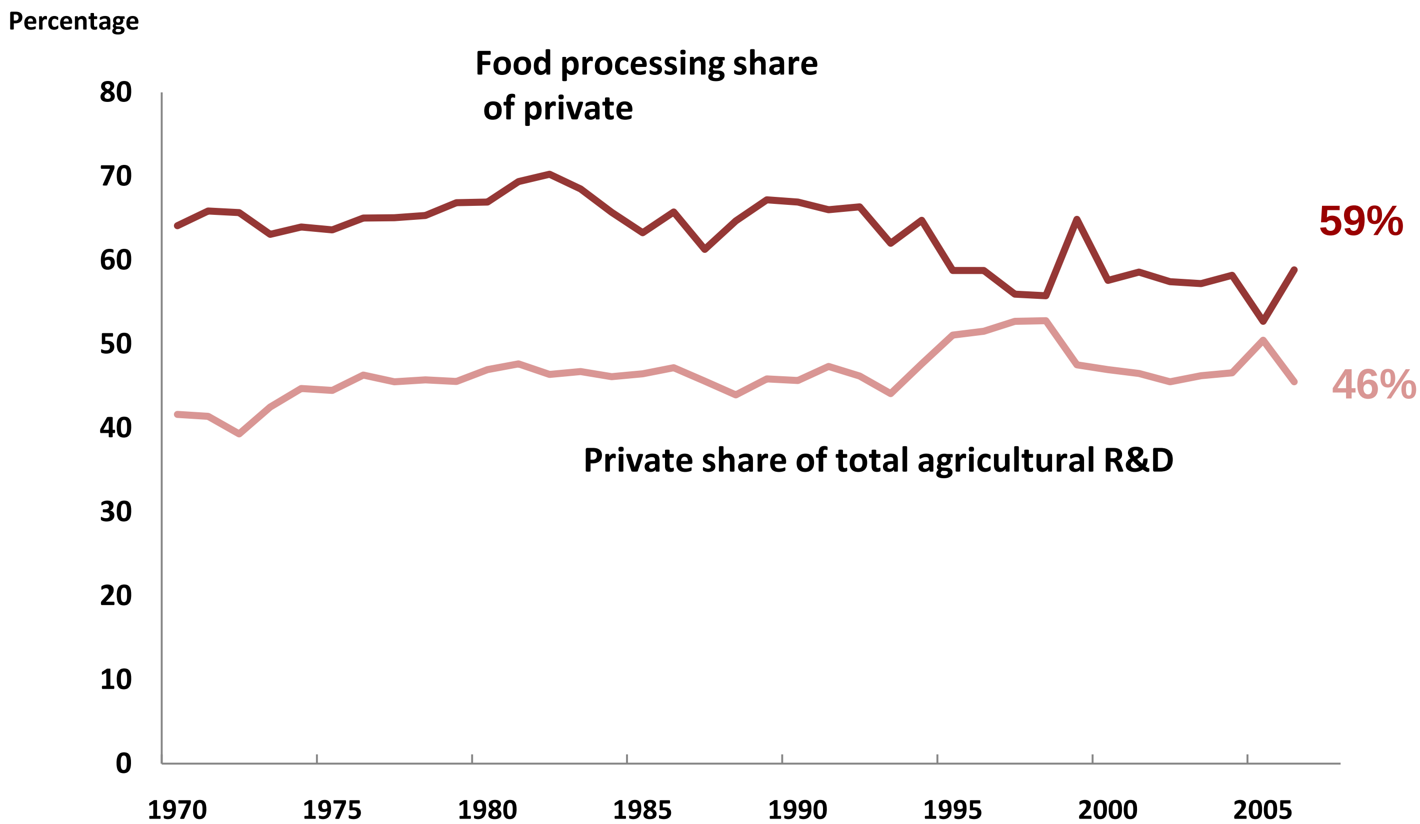


Source: Dehmer and Pardey (2011)

Agricultural R&D Expenditures, 1950-2007

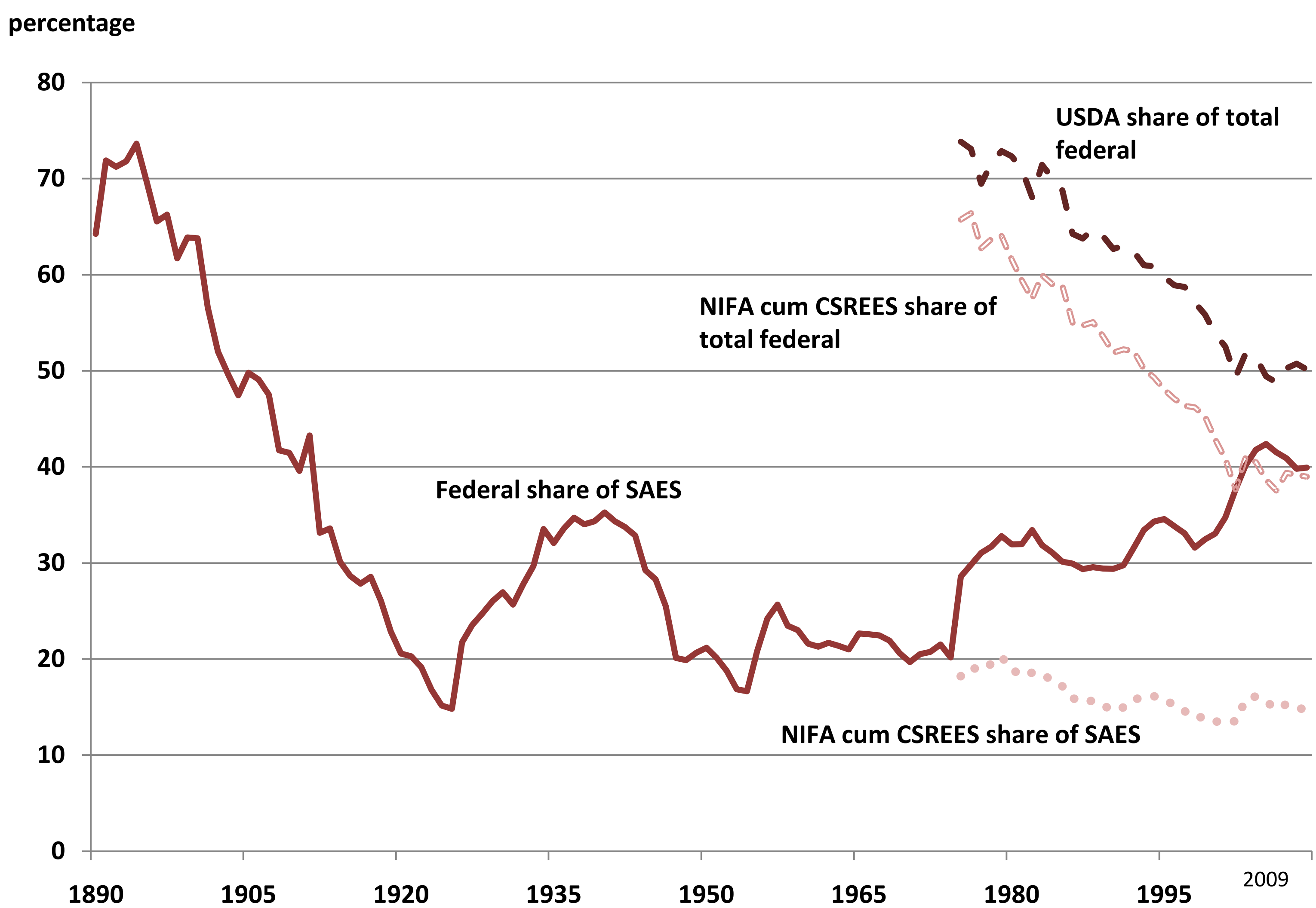


U.S. Private Agricultural R&D, 1950–2009



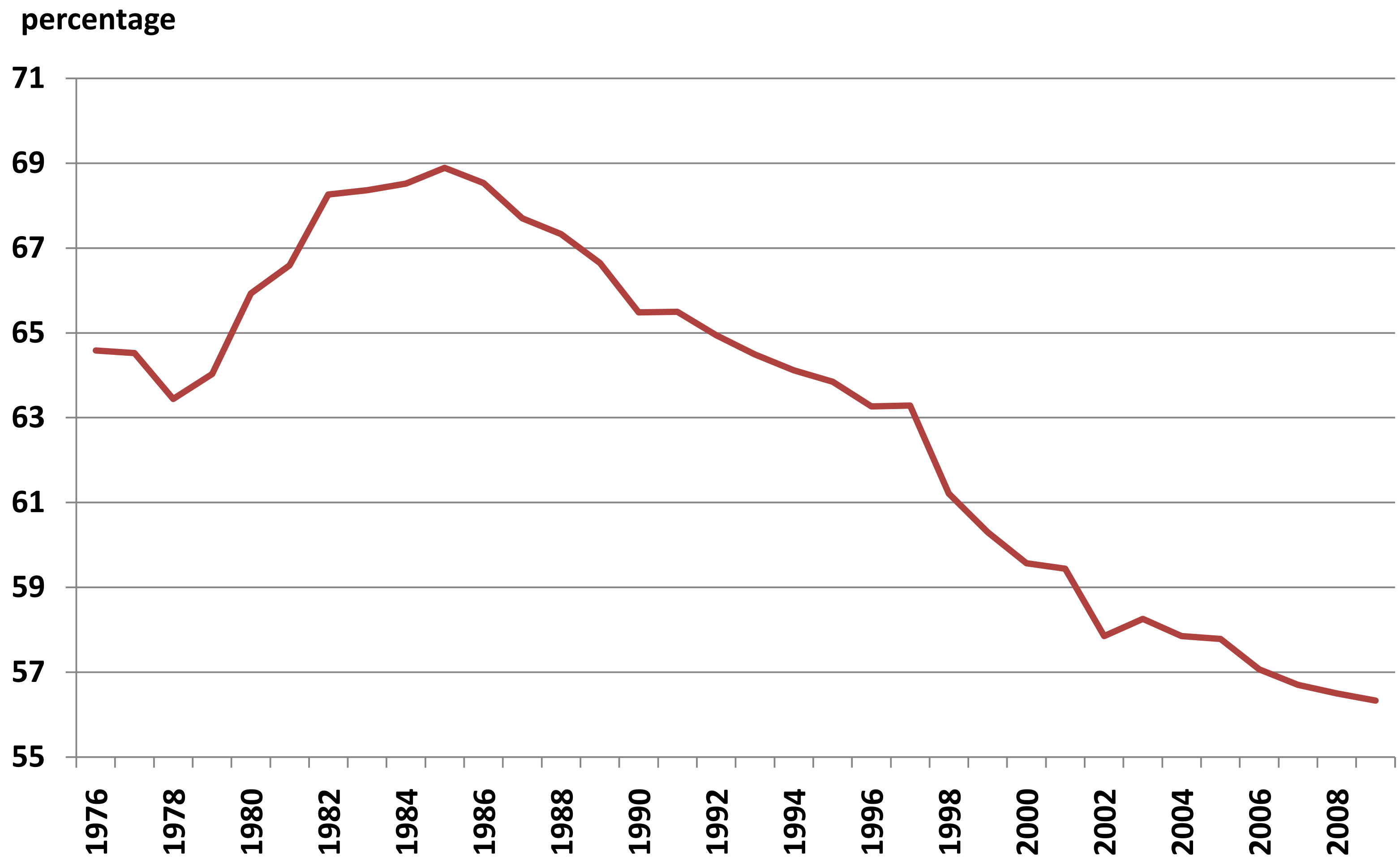
Source: Dehmer and Pardey (2011)

USDA Role in Funding SAES Research



Source: Pardey et al. (2011) with data from USDA, CRIS (various years)

Farm Productivity Share of SAES Research

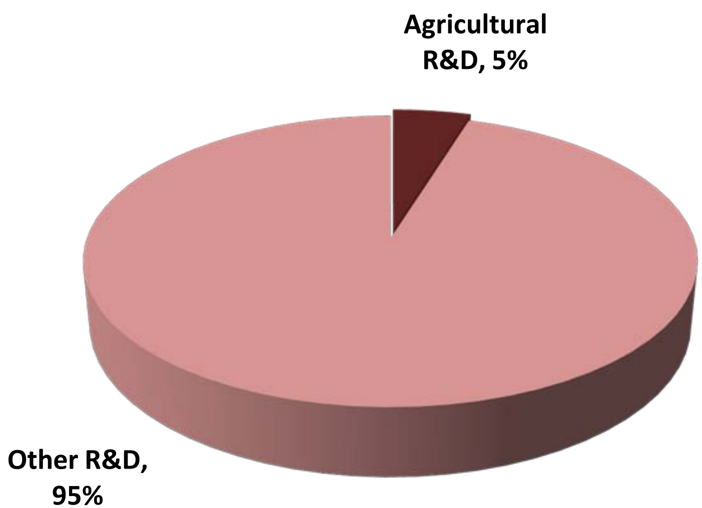


Source: Pardey et al. (2011) with data from USDA, CRIS (various years)

Global science spending

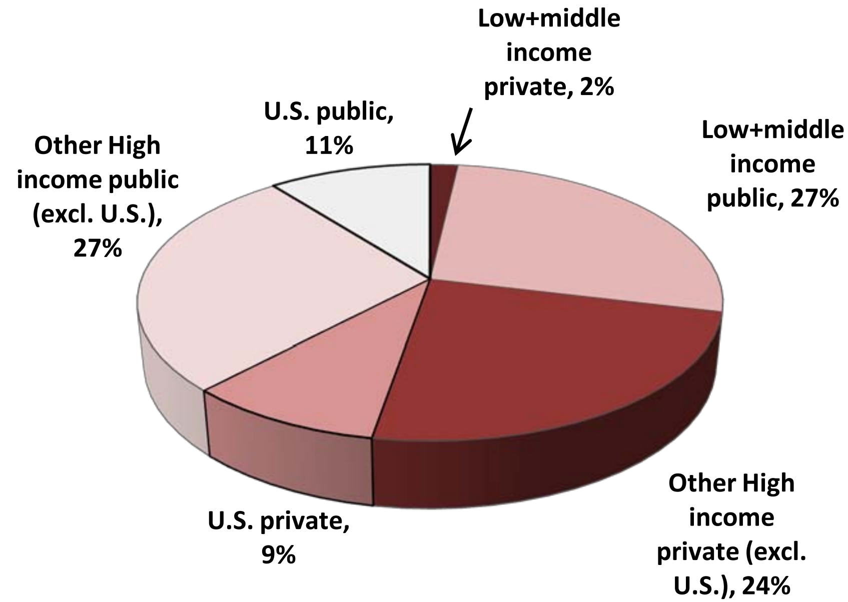
Global Science Spending Landscape, 2000

Total Science



$782.7 billion

Food & Agricultural R&D

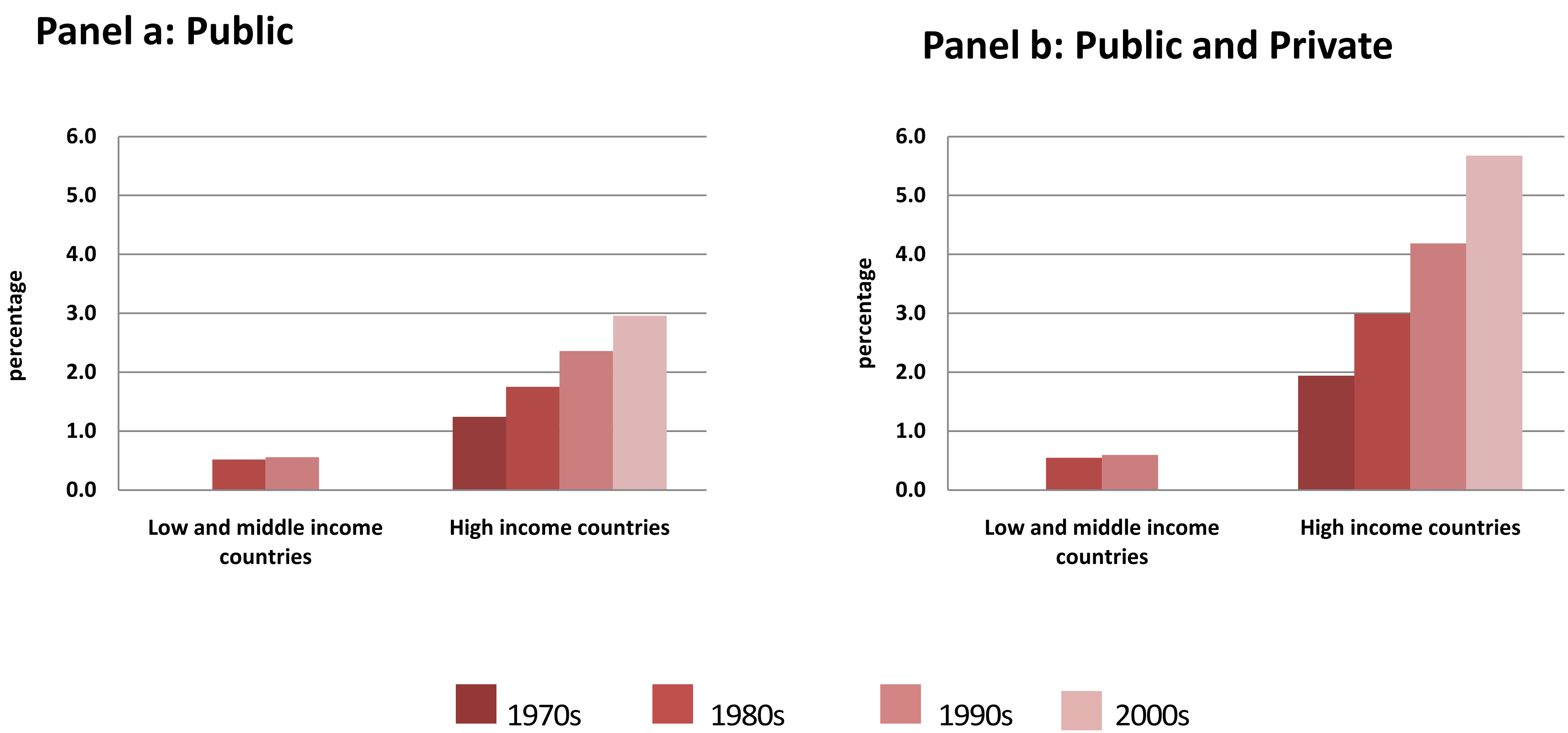


$37.5 billion

Note: Spending in 2005 prices

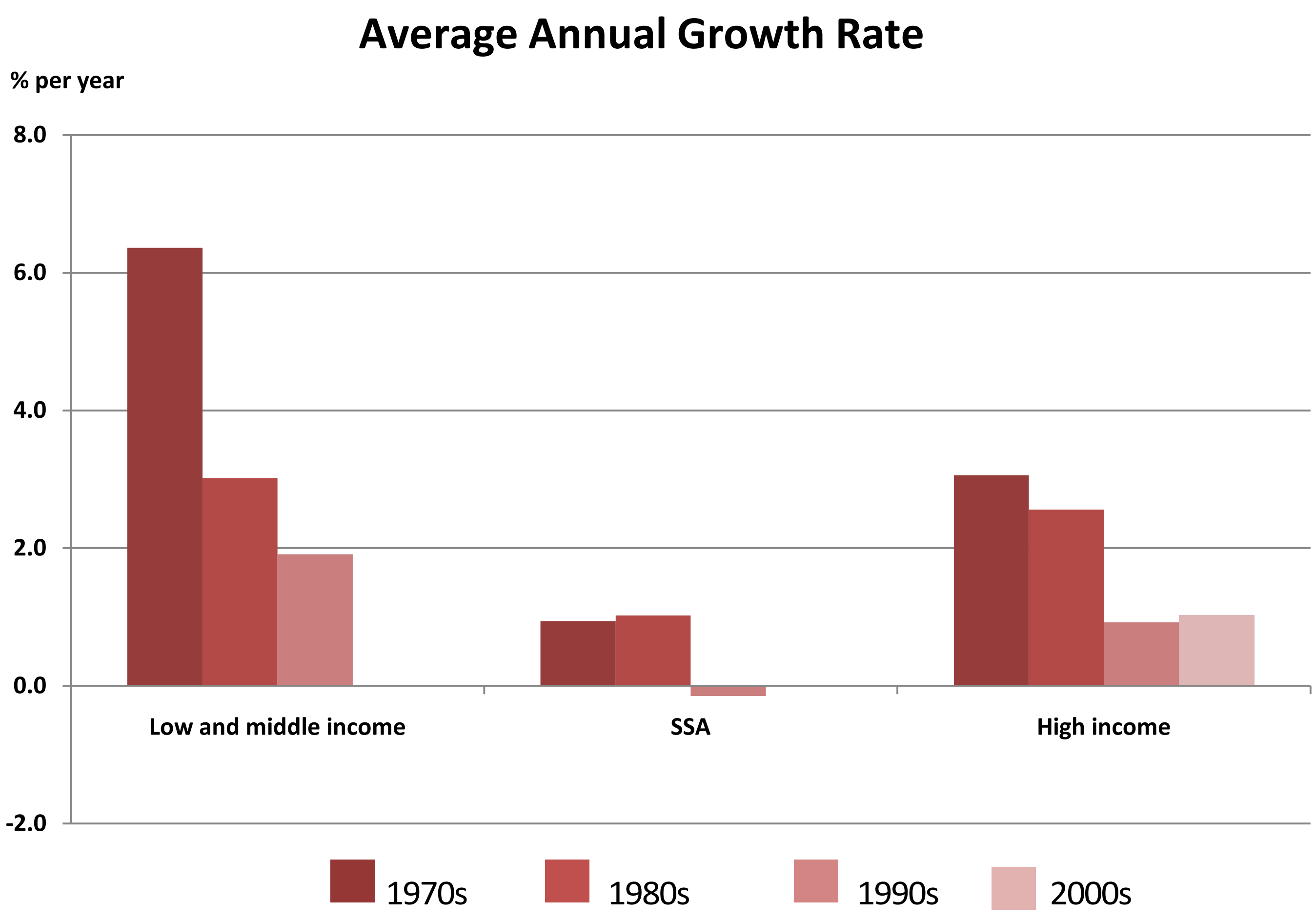
Source: Dehmer and Pardey (2011); Pardey and Chan-Kang (2011))

Food and Agricultural Research Intensity Ratios



Source: Pardey and Pingali (2010).

Public Food and Agricultural Research Expenditures



Source: Pardey and Pingali (2010).

Farm productivity patterns

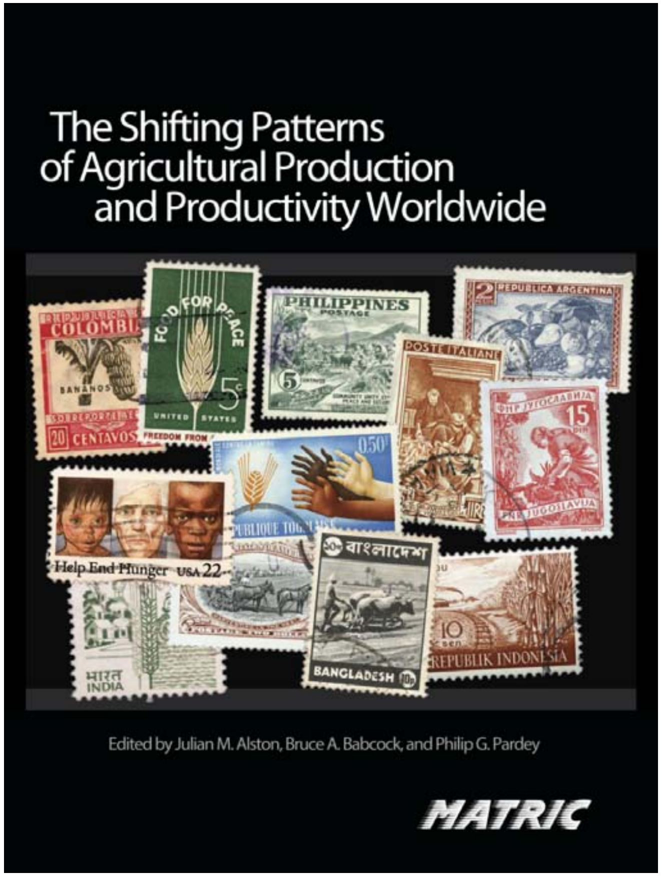
Sources . . .

The Shifting Patterns of Agricultural Production and Productivity Worldwide

March 2010 (CARD, Iowa State University, MATRIC e-book)

Julian Alston, Bruce Babcock, and Philip Pardey (editors)

- **23 authors, 15 chapters**
- **5 chapters => global overview, general issues**
- **10 country-specific chapters**
  - Argentina
  - Australia and New Zealand
  - Canada
  - China
  - India
  - Indonesia
  - Former Soviet Union and Eastern Europe
  - South Africa
  - United Kingdom
  - United States



Sources . . .

Diverging Agricultural Productivity Paths—International Competitiveness and Food Security in the Long Run

(theme in *Choices*, Fall 2009)

Julian Alston and Philip Pardey (theme editors)

Six articles:

- Theme overview
- Global patterns
- Canada
- China
- Former Soviet Union and Eastern Europe
- United States

Main points

- **Evidence of a significant pervasive slowdown in agricultural productivity growth since 1990 or thereabouts**
- **China is an important exception with faster growth reflecting institutional change and other factors**
- **The converse applies for FSU and Central European countries**
- **Similar patterns emerge using various measures**
  - **Commodity prices**
  - **Crop yields**
  - **Production per unit of land or labor**
  - **Multifactor productivity measures where available**
    - Australia, Canada, United States, United Kingdom

Global Crop Yield Growth Rates, 1961-2007

	Maize		Wheat		Rice		Soybeans	
Group	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07
				(percent per year)				
World	2.20	1.77	2.95	0.52	2.19	0.96	1.79	1.08

Source: Alston, Beddow and Pardey (2010).

Global Crop Yield Growth Rates, 1961-2007

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Group	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07
				(percent per year)				
World	2.20	1.77	2.95	0.52	2.19	0.96	1.79	1.08
High Income	2.34	1.48	2.47	0.06	1.07	0.54	1.14	0.02

Source: Alston, Beddow and Pardey (2010).

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Group	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07
				(percent per year)				
World	2.20	1.77	2.95	0.52	2.19	0.96	1.79	1.08
High Income	2.34	1.48	2.47	0.06	1.07	0.54	1.14	0.02
Middle Income	2.41	2.12	3.23	0.85	2.54	0.81	3.21	2.08
Low Income	1.07	0.65	1.32	2.15	1.46	2.16	2.63	0.00

Source: Alston, Beddow and Pardey (2010).

Growth in Agricultural Land and Labor Productivity, 1961-2005

Group	Land Productivity		Labor Productivity	
	1961-90	1990-05	1961-90	1990-05
World	2.03	1.82	1.12	1.36
excl. China	1.90	1.19	1.21	0.42
excl. China & USSR	1.91	1.57	1.13	0.73

Source: Alston, Beddow and Pardey (2010).

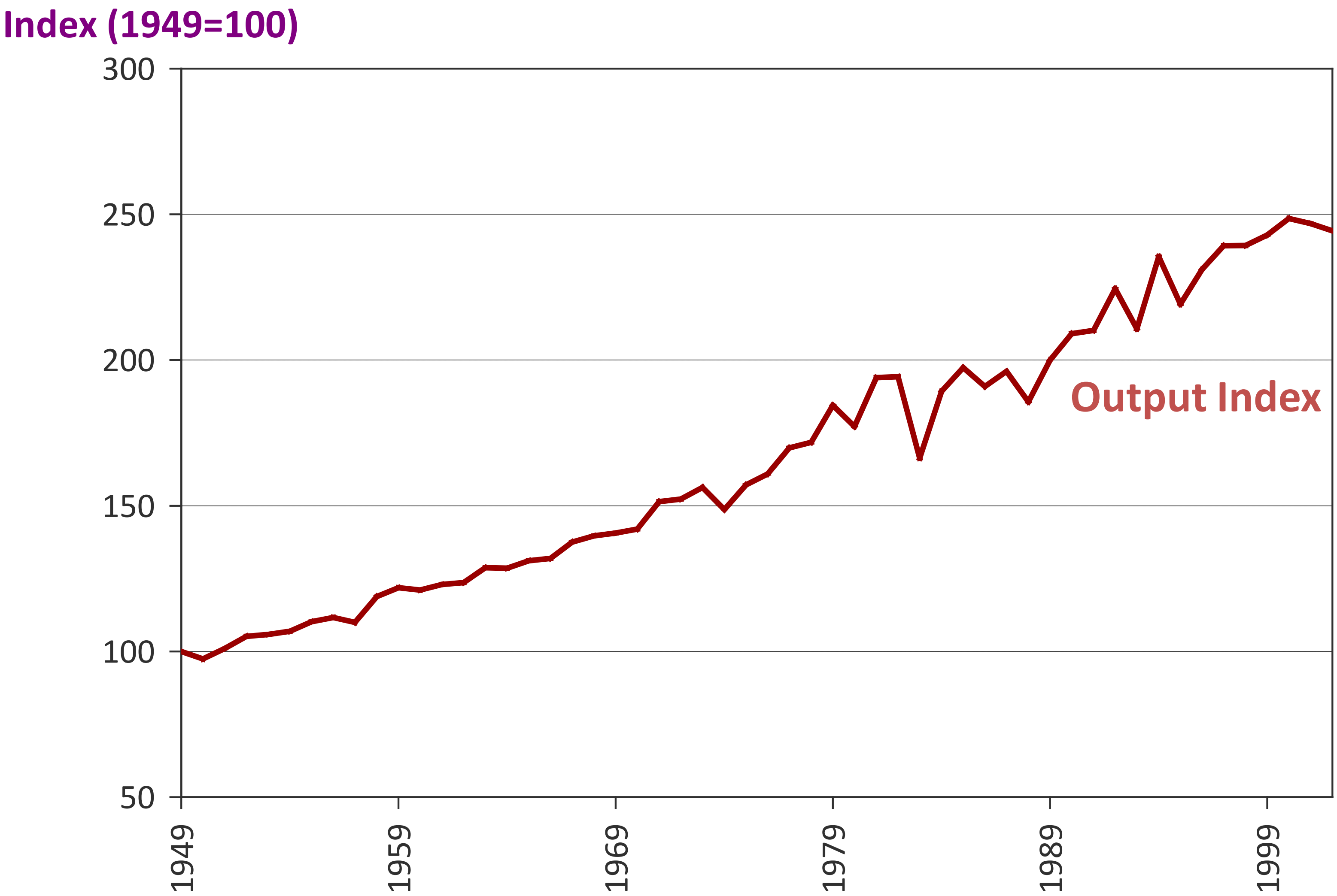
U.S. agricultural productivity data

- Long-term project led by Phil Pardey
  - detailed state-specific data on
    - 74 categories of outputs
    - 58 categories of inputs
  - 48 contiguous states
  - long series (1949-2002)
  - soon to be released
- Currently updating to 2007

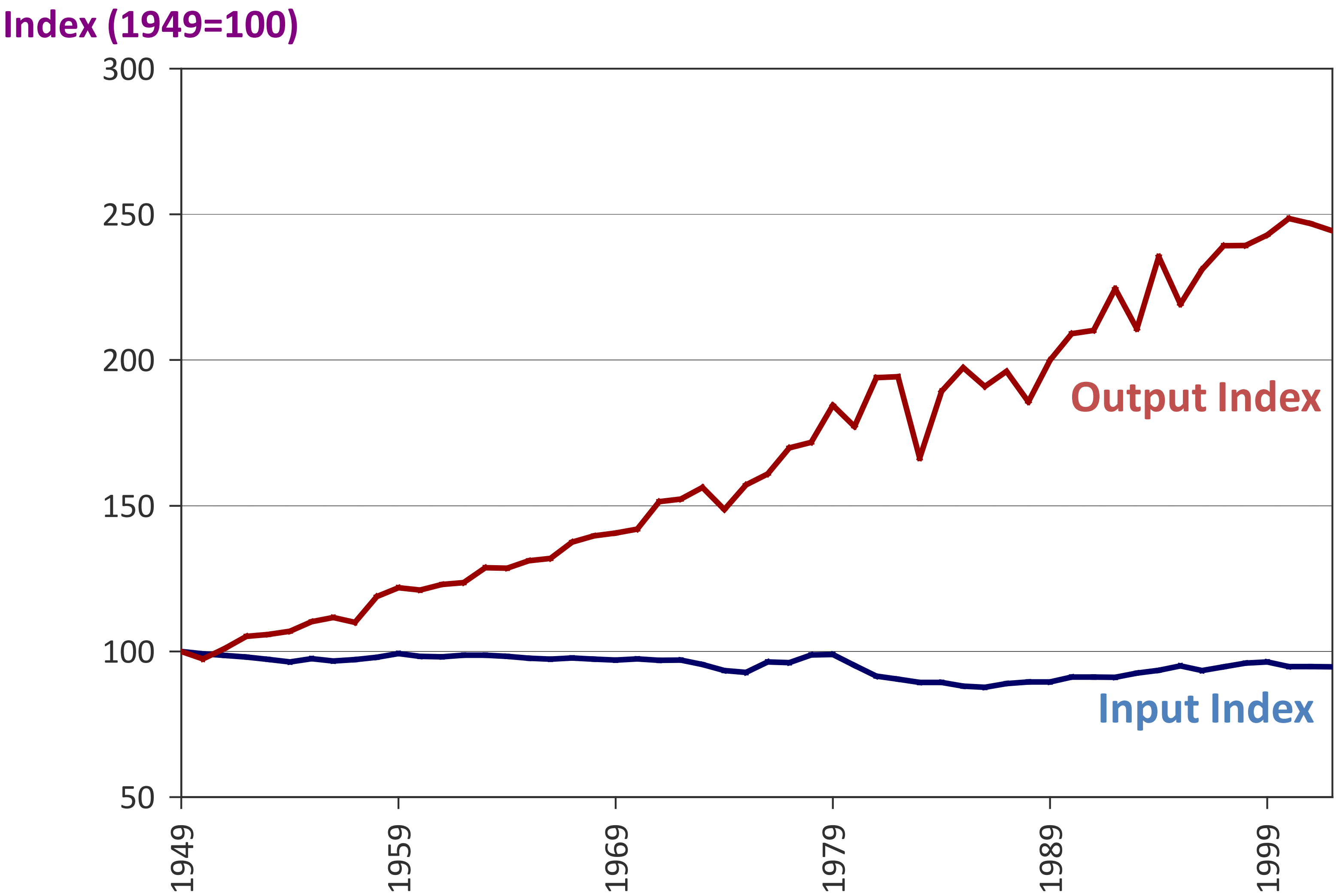
- MFP = Total Output / Total Input

INSTEPP
INTERNATIONAL
SCIENCE & TECHNOLOGY PRACTICE & POLICY

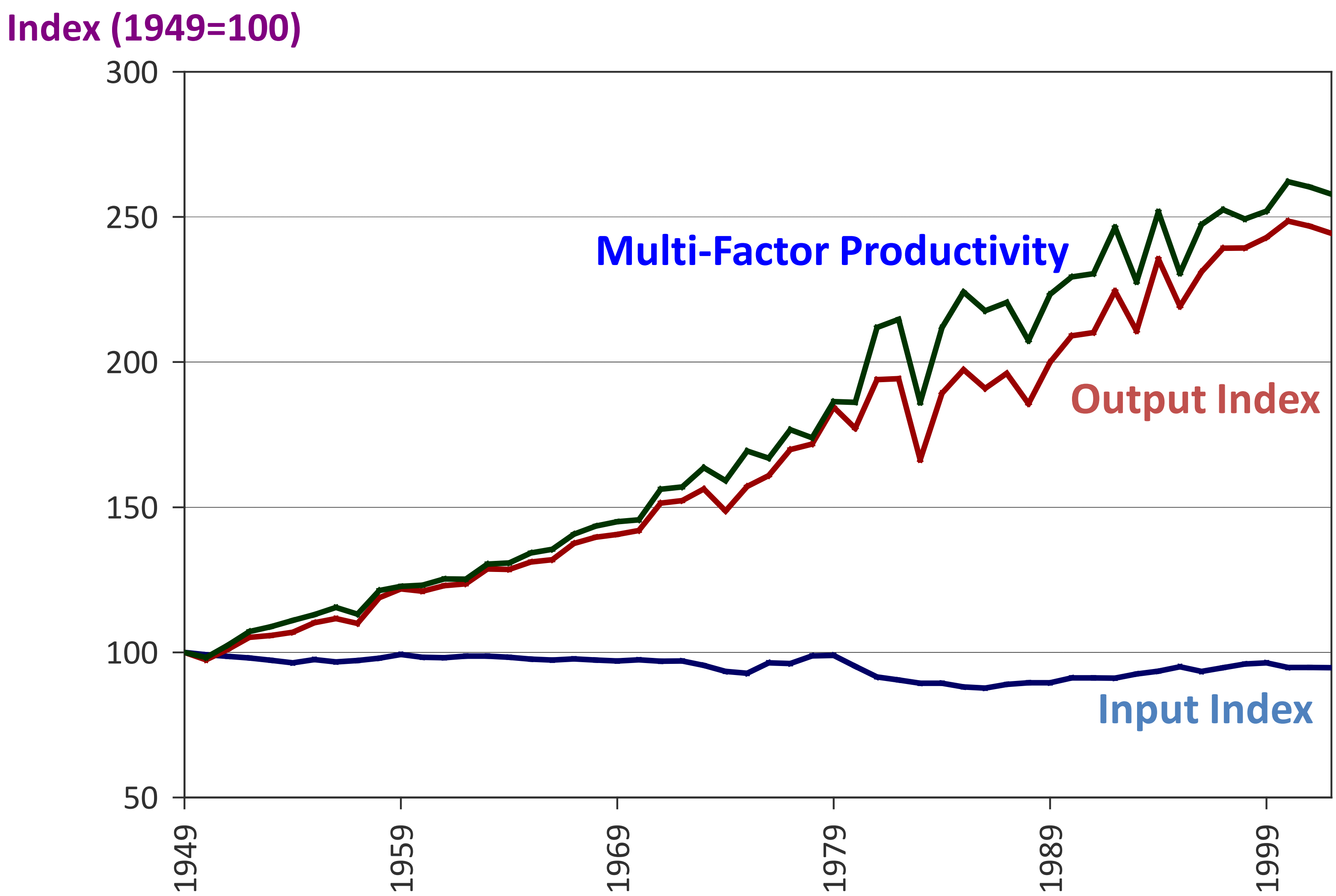
U.S. Agricultural Productivity, 1949-2002



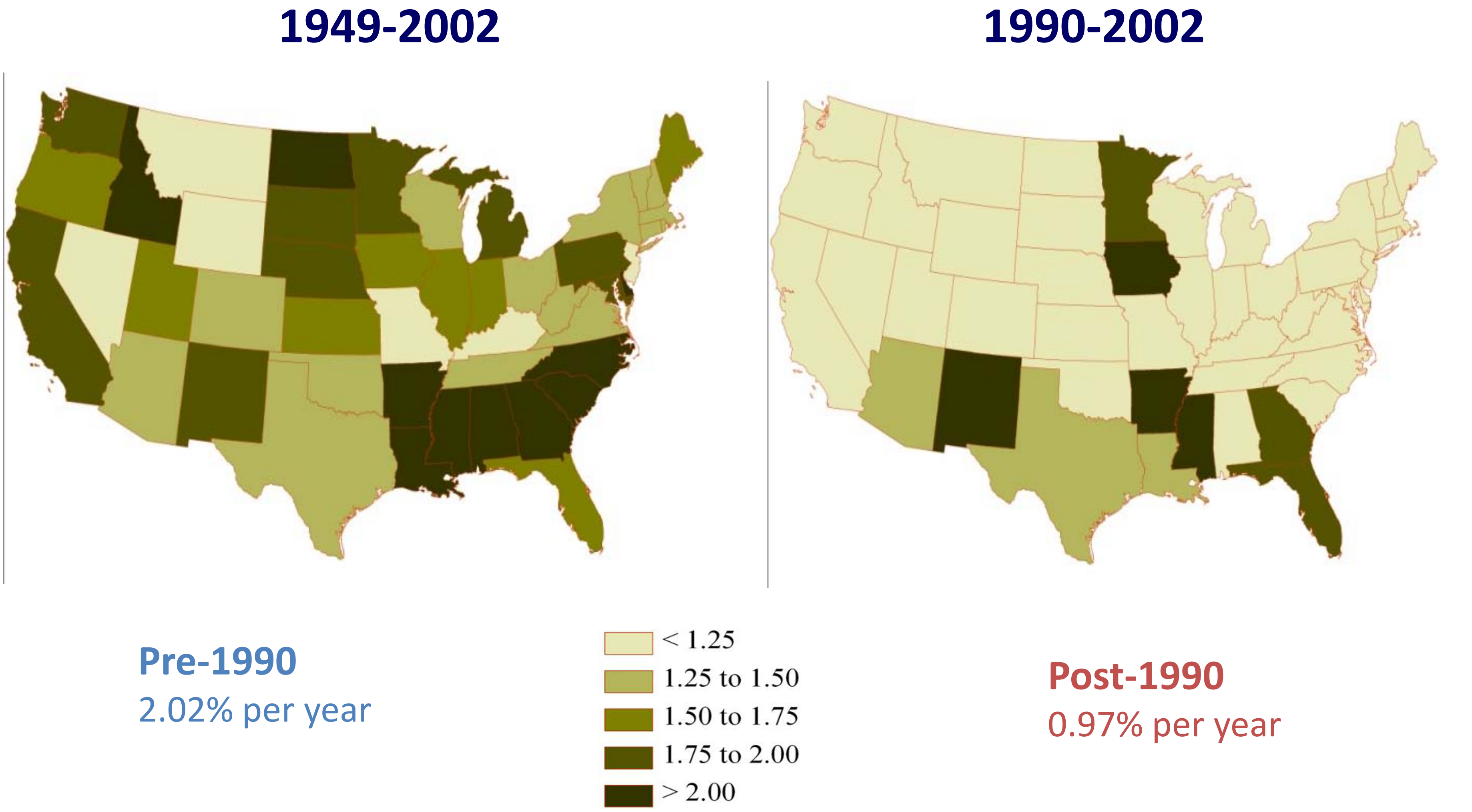
U.S. Agricultural Productivity, 1949-2002



U.S. Agricultural Productivity, 1949-2002



MFP Growth Rates, 1949-2002 and 1990-2002

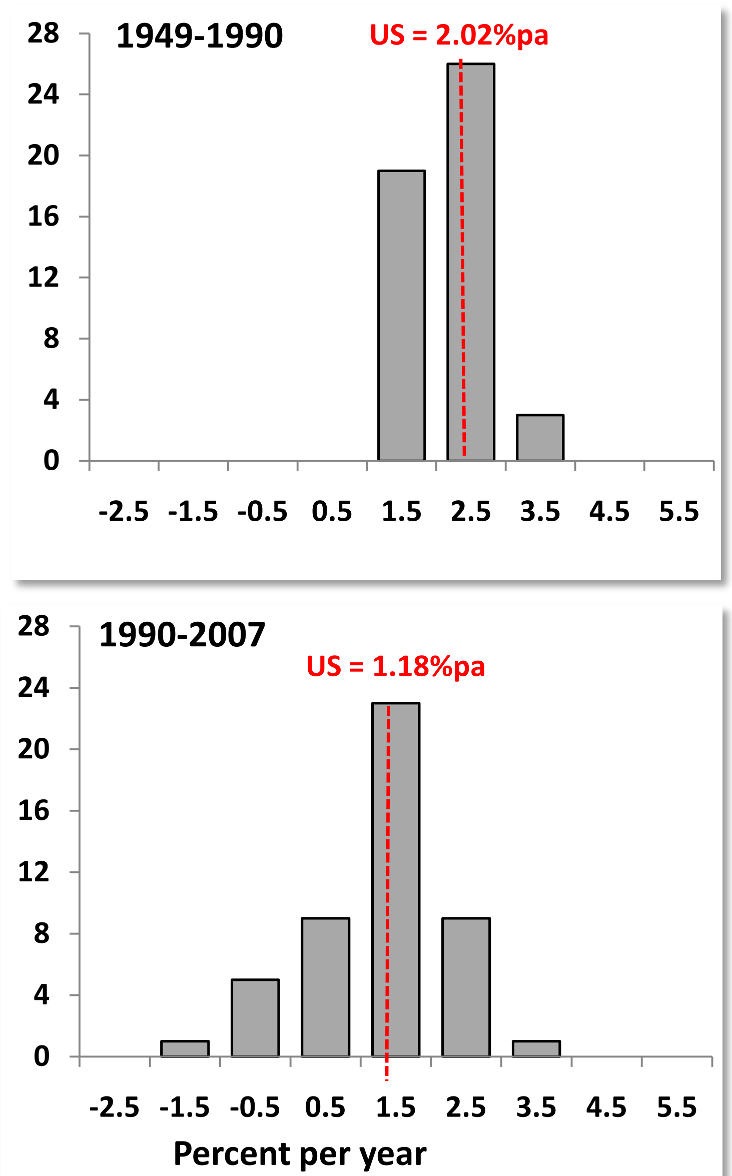


Pre-1990
2.02% per year

Post-1990
0.97% per year

U.S. Multifactor Productivity, 1910-2007

State MFP Growth Distributions



InStePP Production Accounts

Outputs

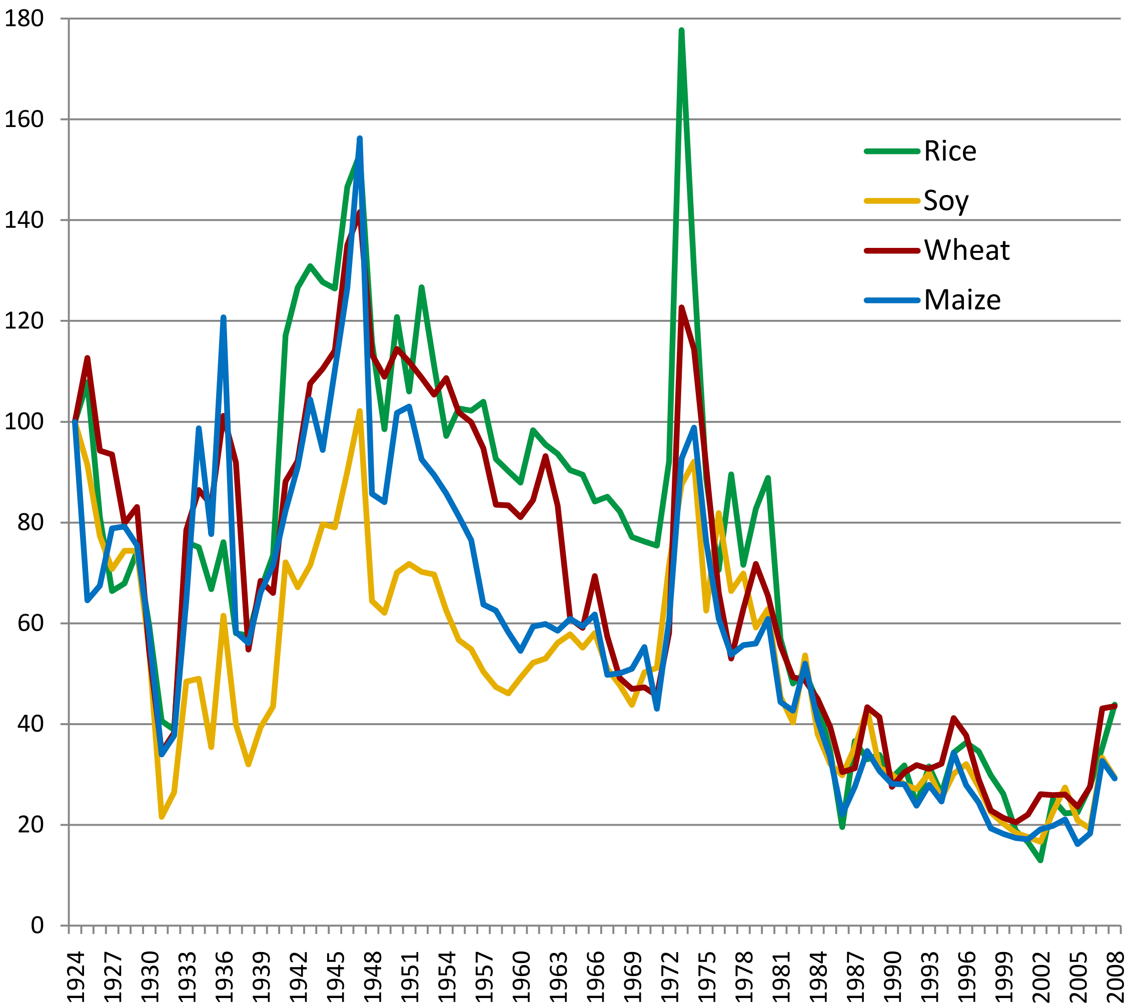
- Crops 61
- Livestock (9)
- Miscellaneous (4)

Inputs

- Land (3)
  - Cropland, irrigated cropland, pasture and grassland
- Labor (32)
  - Family labor
  - Hired labor
  - Operator labor (30)
    - Education: 0–7 years, 8 years, 1–3 years of high school, 4 years of high school, 1–3 years of college, 4 years or more of college
    - Age: 25–34, 35–44, 45–54, 55–64, or 65 or more years of age
- Capital (12)
  - Machinery (6)
    - Automobiles, combines, mowers and conditioners, pickers and balers, tractors, trucks
  - Biological capital (5)
    - Breeding cows, chickens, ewes, milking cows, sows
  - Buildings
- Materials (11)
  - Electricity, purchased feed, fuel, hired machines, pesticides, nitrogen, phosphorous, potash, repairs, seeds, miscellaneous purchases

Real U.S. Commodity Prices, 1924-2008 (Deflator = CPI-U)

Index = 100 in 1924



Growth Rates, Percent per Year

Period	Commodity			
	Maize	Wheat	Rice	Soybean
1924-2005	-1.08	-0.73	-1.53	-1.17
1950-2005	-2.61	-2.16	-2.51	-1.56
1975-2005	-3.93	-3.30	-3.68	-2.59
1975-1990	-4.45	-3.59	-4.84	-2.89
1990-2005	-3.22	-0.63	-1.96	-2.28
2000-2005	-2.04	1.59	1.10	1.31

60 percent decline since mid 1970s!

What will commodity prices do over the next 40 years?

A return to the rapid real declines of the 1970s and 1980s?

A continuation of the recent pattern?

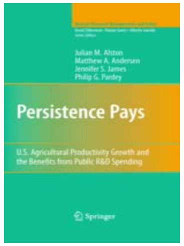
What are the key determinants?

Alston, Beddow, and Pardey (2009). *Mendel versus Malthus: Research, Productivity and Food Prices in the Long Run*

Policy Options

- **Do nothing**
  - **Wasted opportunity (high rates of return)**
  - **Declining competitiveness (for most developed countries)**
  - **Worsening world food supply and demand balance**
    - from the perspective of the world's poor
    - in terms of implications for natural resource stocks
- **Reinvigorate public investments in agricultural R&D**
  - **Enhance government commitment to agriculture**
  - **Shift priorities within the agriculture budget (e.g., R&D vs subsidies)**
- **Encourage private investments in agricultural R&D**
  - **Enhance IPRs (e.g., end-point royalties)**
  - **Strengthen co-financing arrangements and institutions (e.g., RDCs)**

Selected Sources



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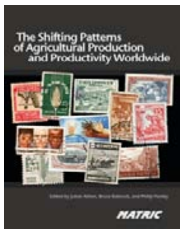

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Pardey, P.G. and J.M. Alston. ***U.S. Agricultural Research in a Global Food Security Setting***. A Report of the CSIS Task Force on Food Security. Washington D.C.: Center for Strategic International Studies, January 2010.

Pardey , P.G. and P.L. Pingali. "**Reassessing International Agricultural Research for Food and Agriculture.**" Report prepared for the Global Conference on Agricultural Research for Development (GCARD), Montpellier, France, 28-31 March 2010 .

- **Thank You!**

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