

The State of the Global Crop Innovation System

Julian M. Alston
University of California, Davis

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University of California
Agricultural Issues Center



Department of Agricultural
and Resource Economics

Key Points

1. High rates of return to agricultural R&D

- Implies persistent underinvestment—why is it so?

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, China, and India

3. Shifting productivity patterns

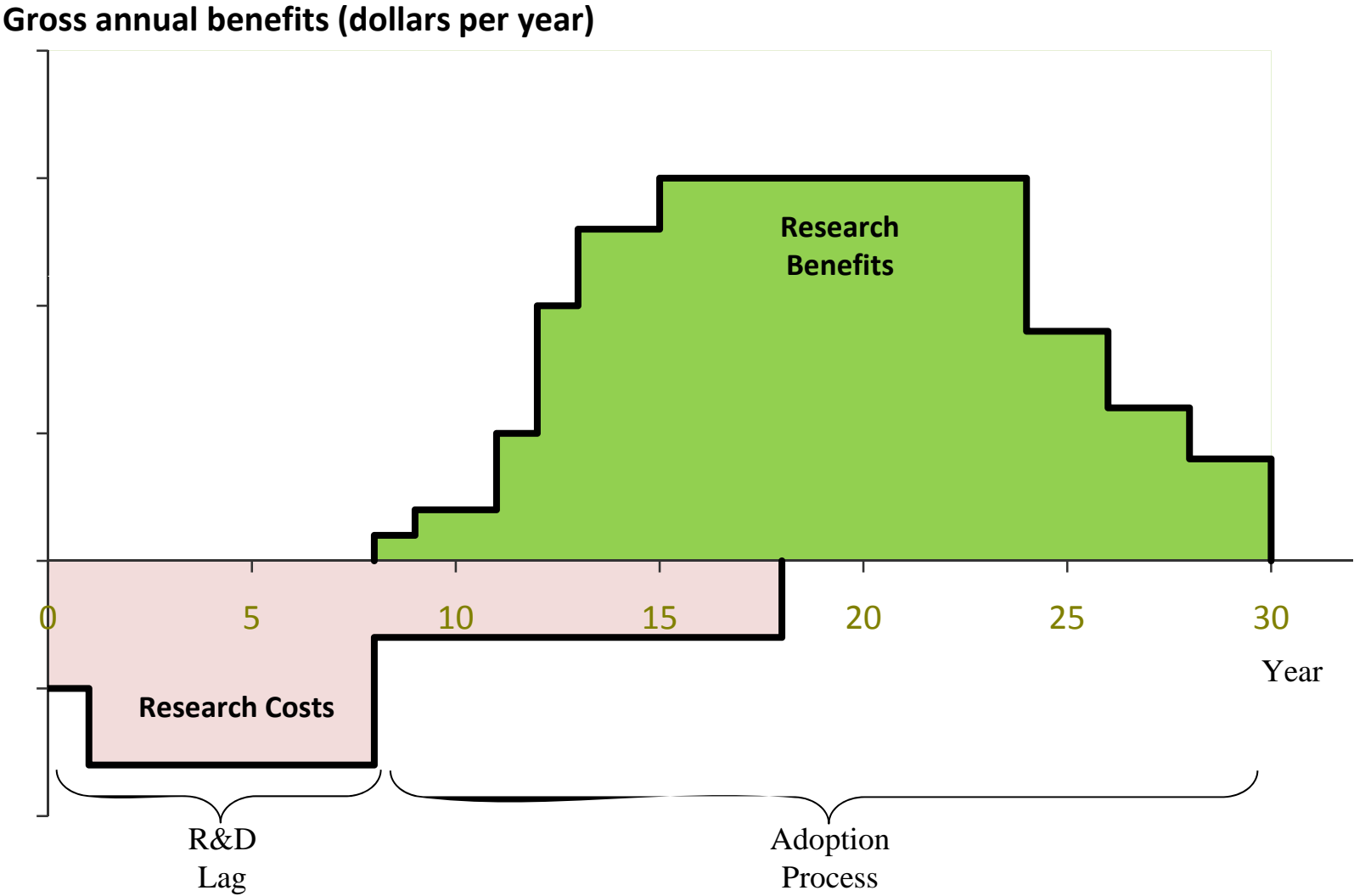
- Productivity slowdown in high-income countries
- A different pattern in Brazil, China, and India

4. Implications—institutional reform required?

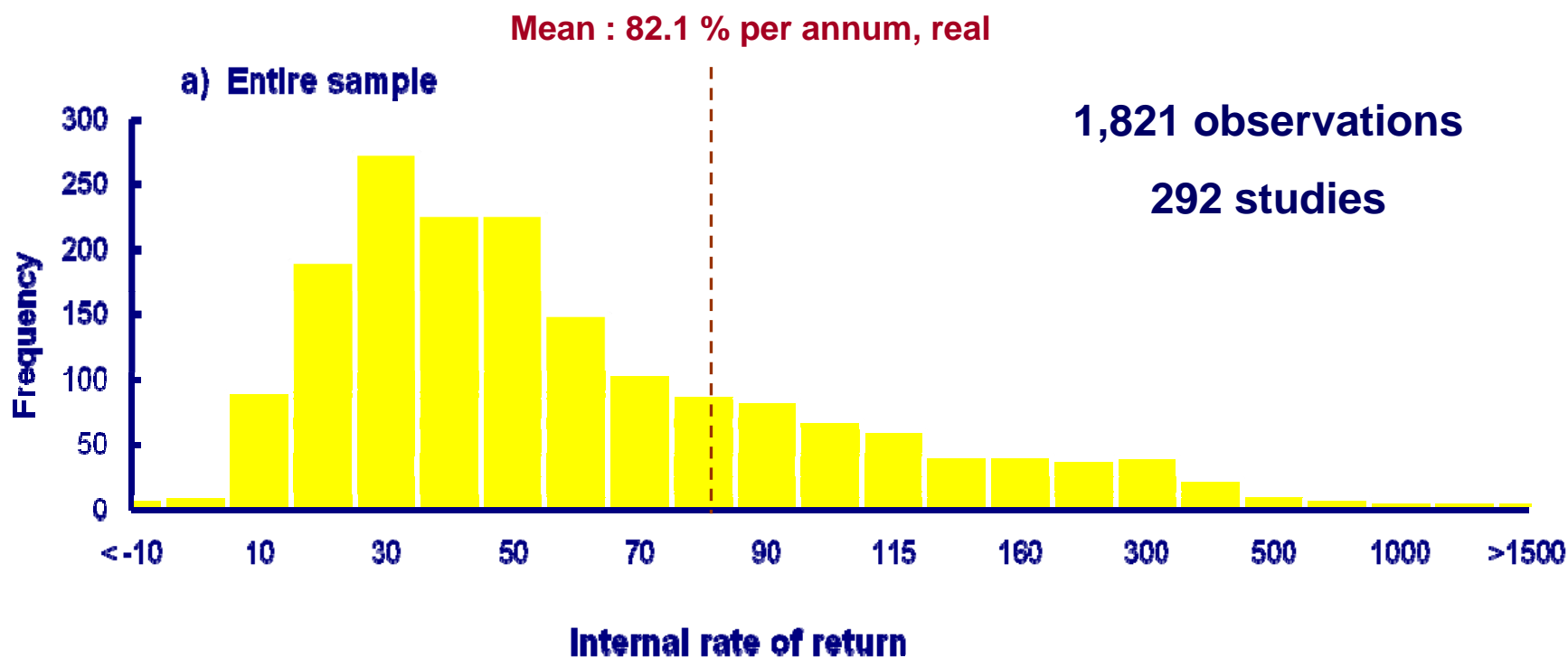
- Enhance rates of research investment, restore productivity growth, reduce pressure on natural resource stocks

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?

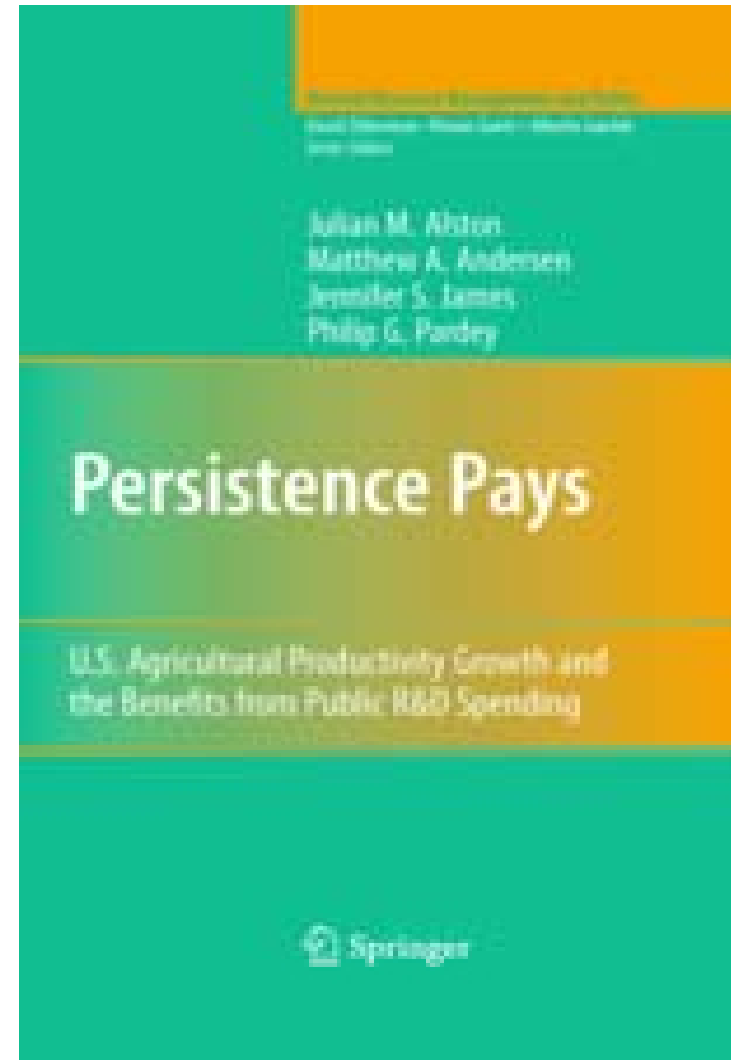
- **Studies have tended to overstate rates of return as a result of attribution biases . . . but true returns are still very large**

New Evidence

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

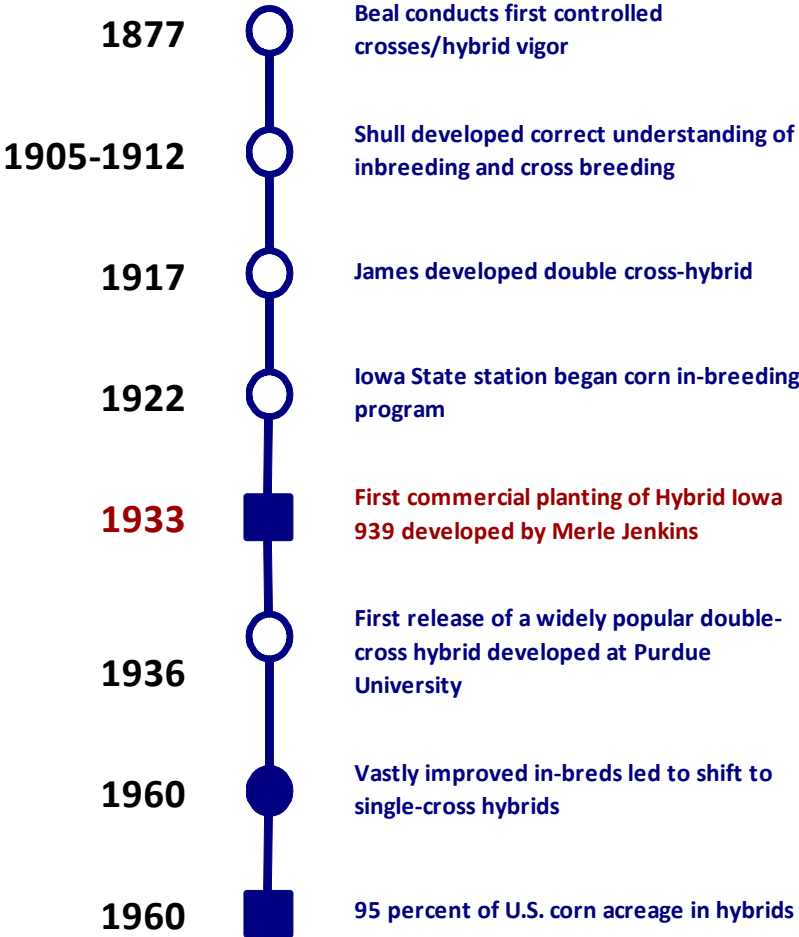
J.M. Alston, M.A. Andersen, J.S. James, and P.G. Pardey

Springer, January 2010

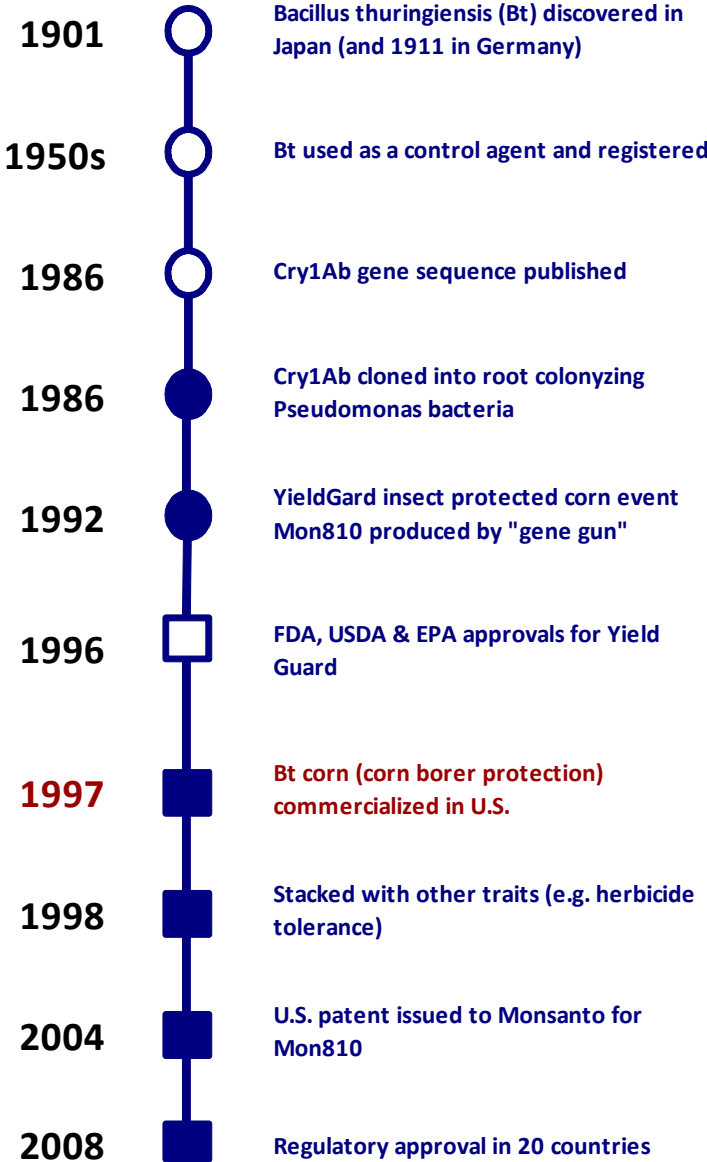


Agricultural Technology Timelines

Hybrid Corn

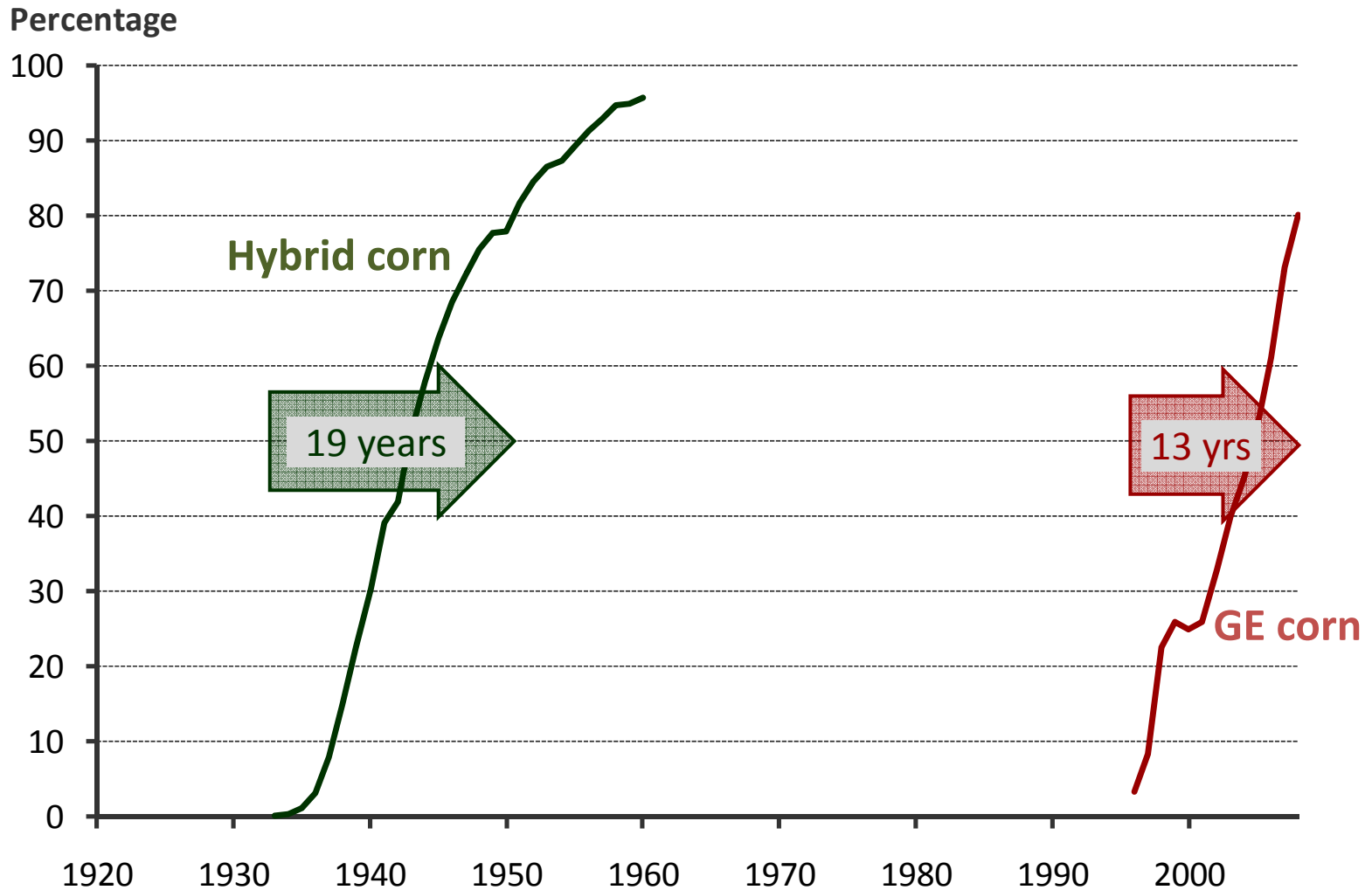


Bt Corn



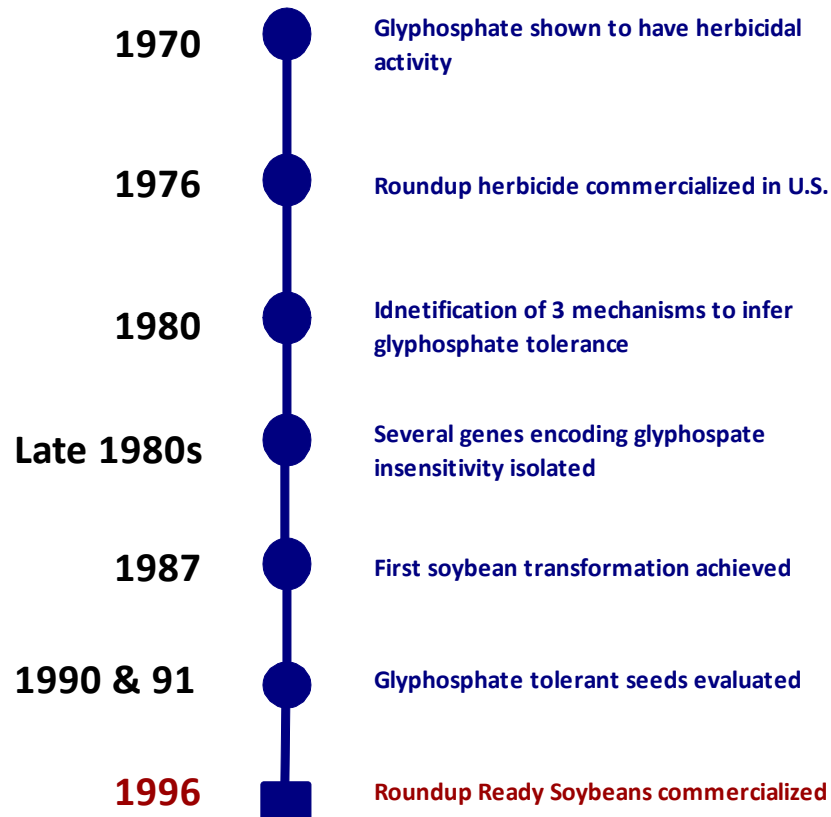
Source: Alston et al. (2010).

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

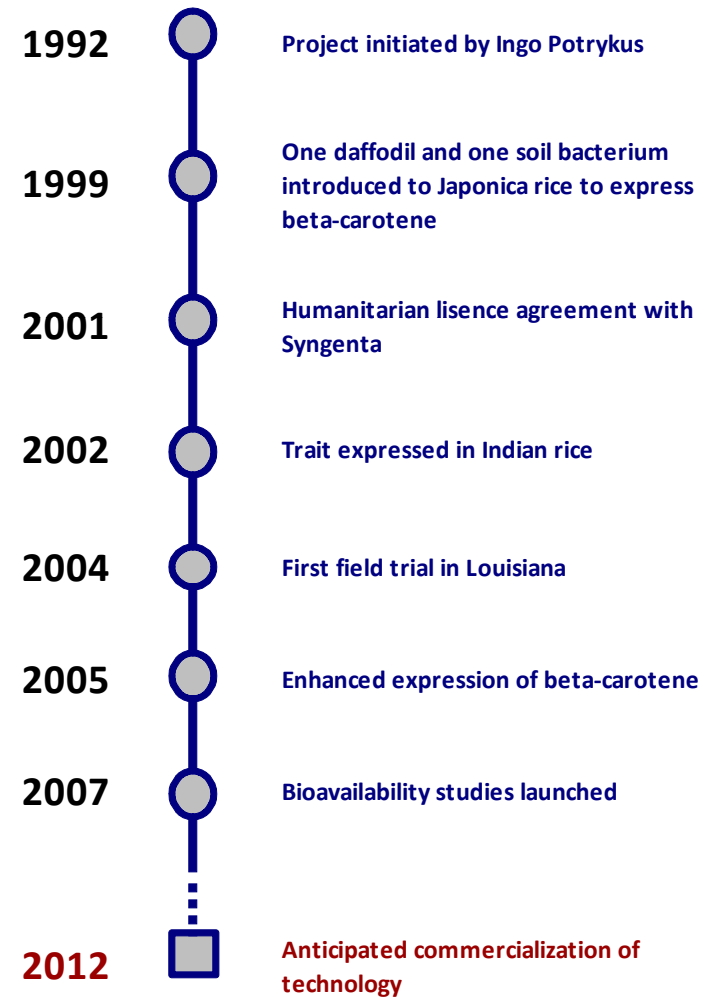


Agricultural Technology Timelines

Roundup Ready Soybean



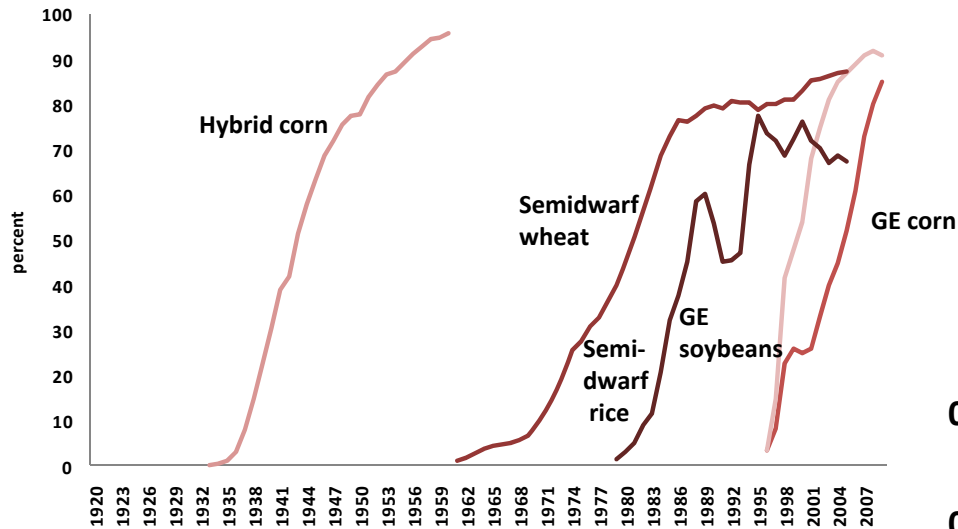
Golden Rice



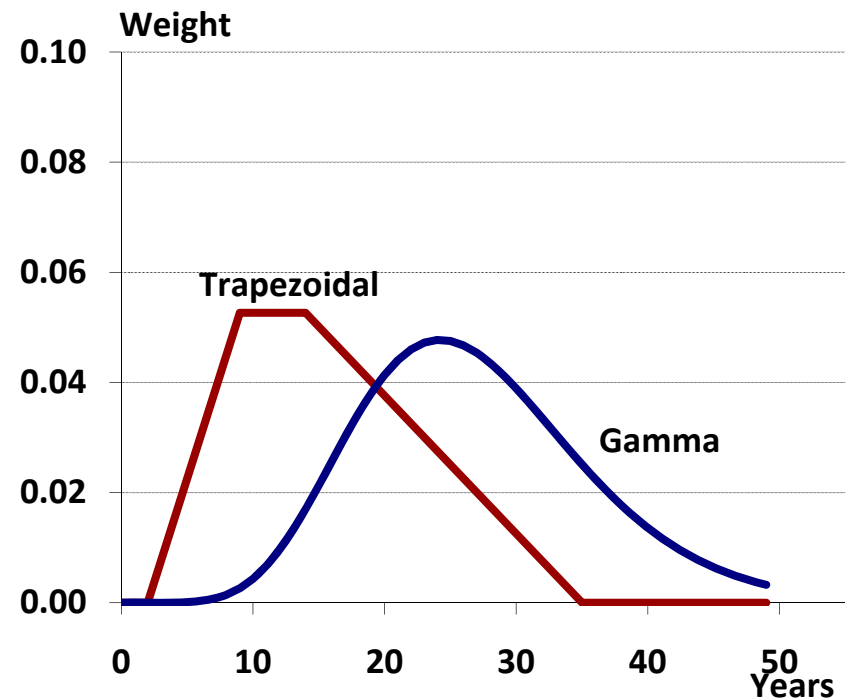
Source: Alston et al. (2010).

R&D Lags (United States)

Panel a: Varietal Adoption Lags



Panel b: Aggregate R&D-Productivity



Source: Pardey and Chan-Kang (2011) 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
<i>ratio</i>		
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

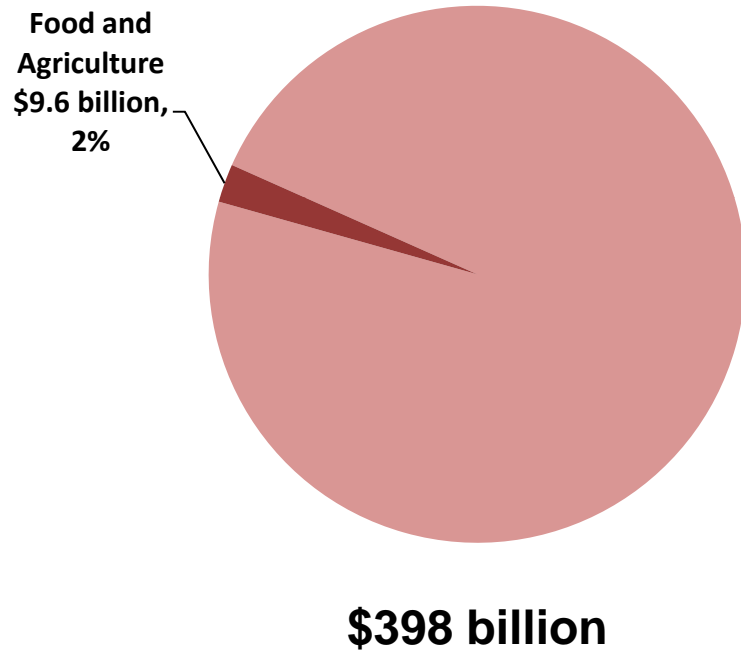
Returns to	Benefit-Cost Ratio (3% real discount rate)		Real Internal Rate of Return	
	Own-State	National	Own-State	National
	<i>ratio</i>		<i>percent per year</i>	
<i>State R&E</i>				
48-State Average	21.0	32.1	18.9	22.7
48-State Minimum	2.4	9.9	7.4	15.3
48-State Maximum	57.8	69.2	27.6	29.1
<i>USDA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

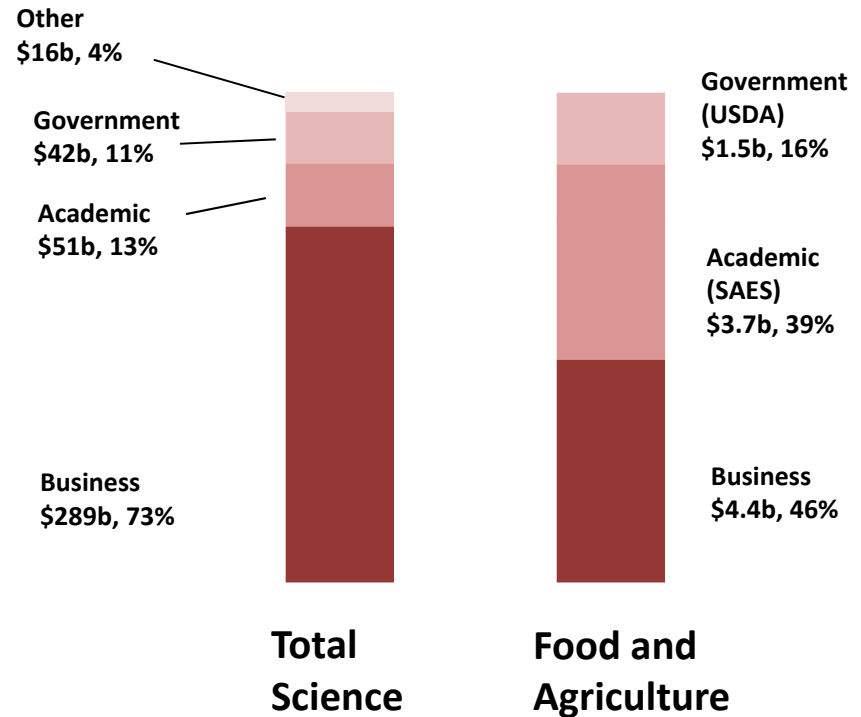
U.S. science spending

U.S. Science Spending, 2008

Total Science

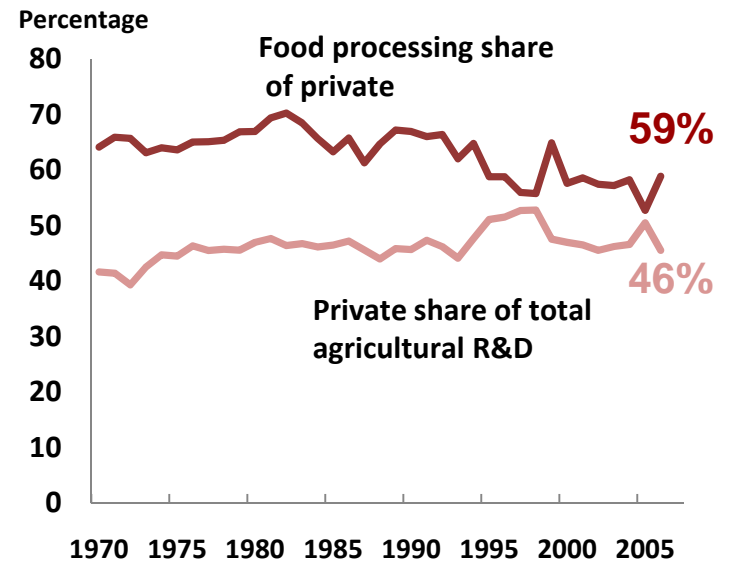
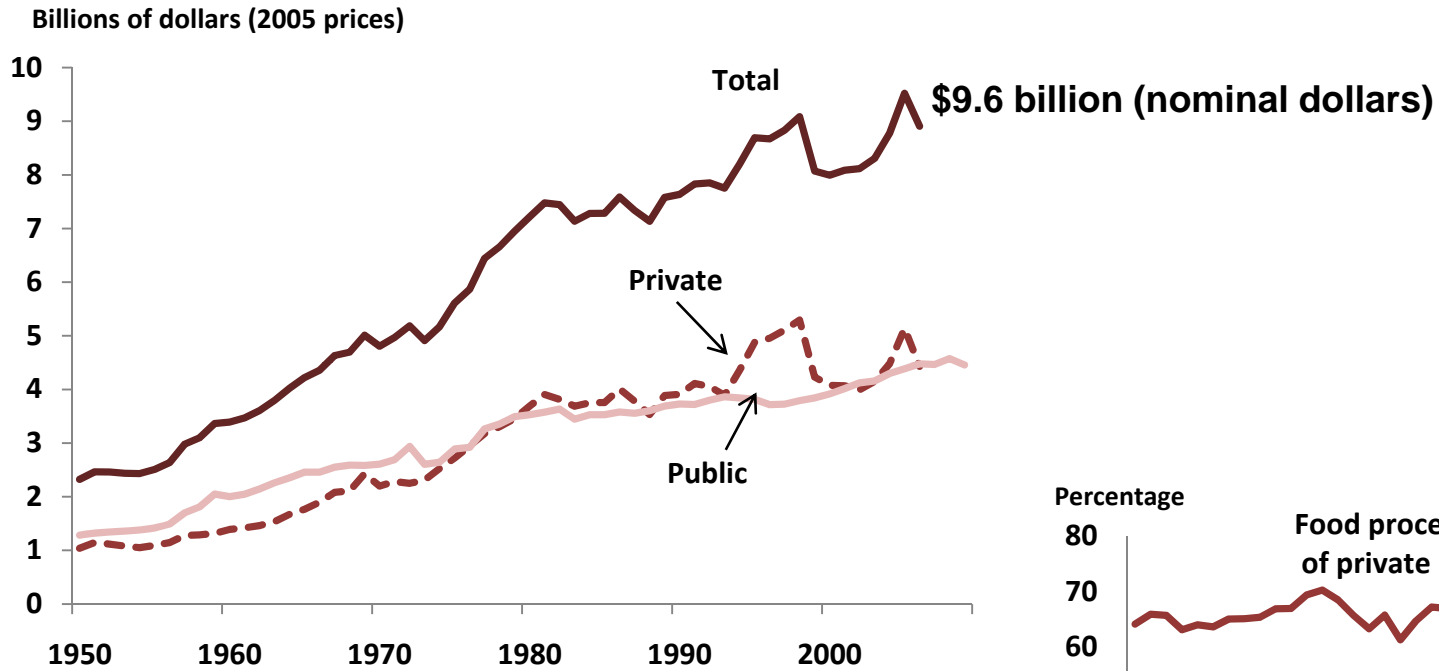


By Performer



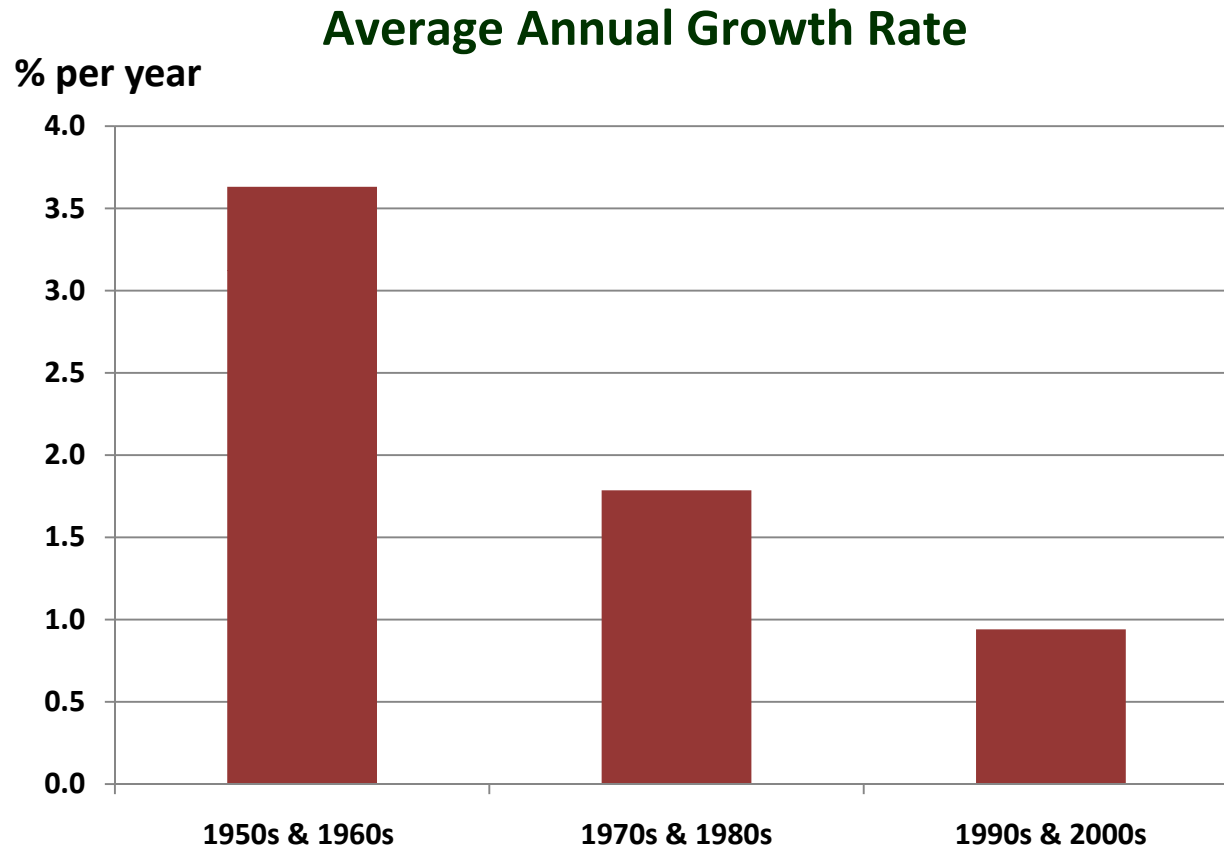
Source: NSB (2010), USDA, CRIS (various years), and Dehmer and Pardey (2011)

Public and Private Agricultural R&D, 1950–2009



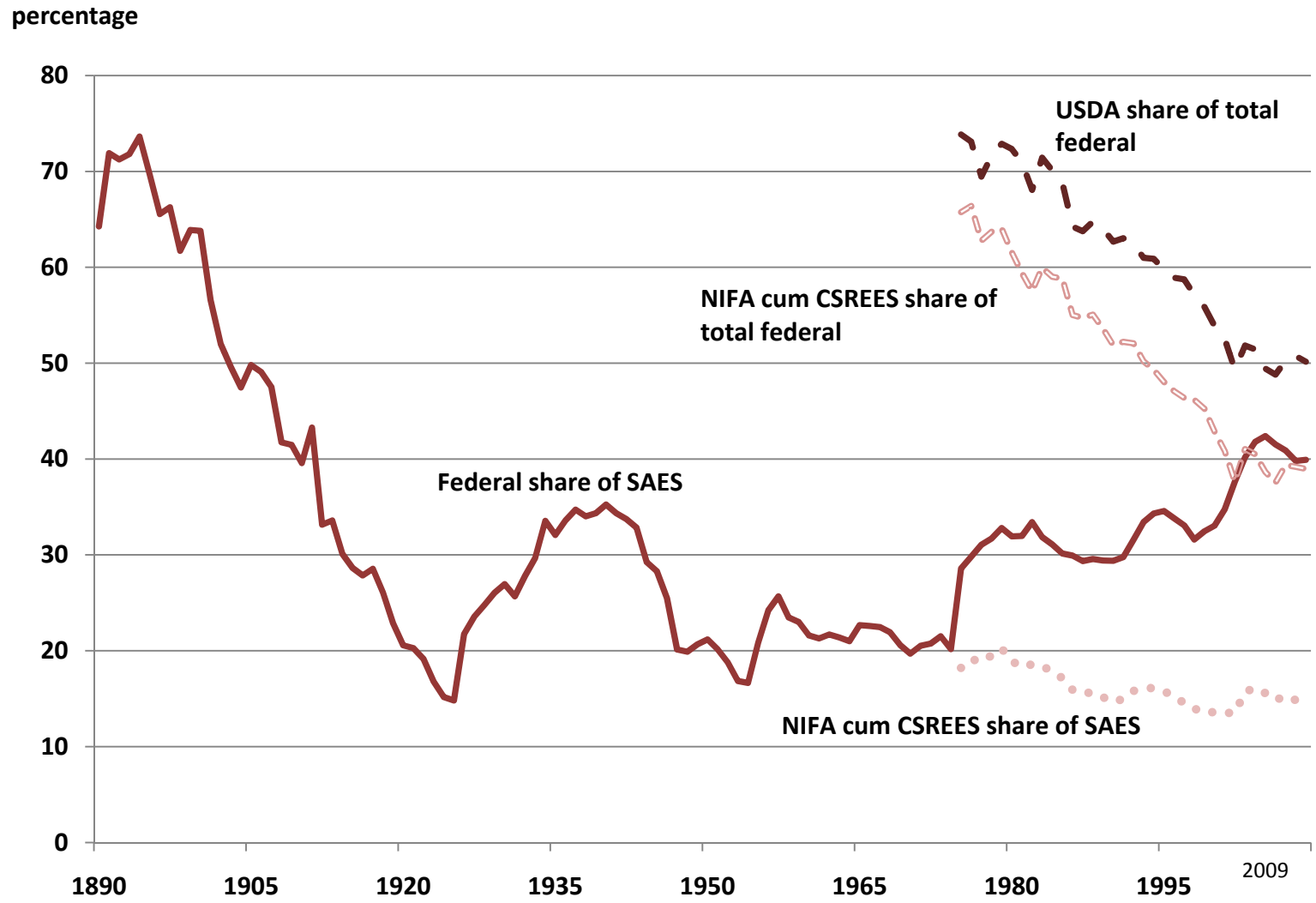
Source: Dehmer and Pardey (2011)

U.S. Agricultural Research Spending, 1950-2009



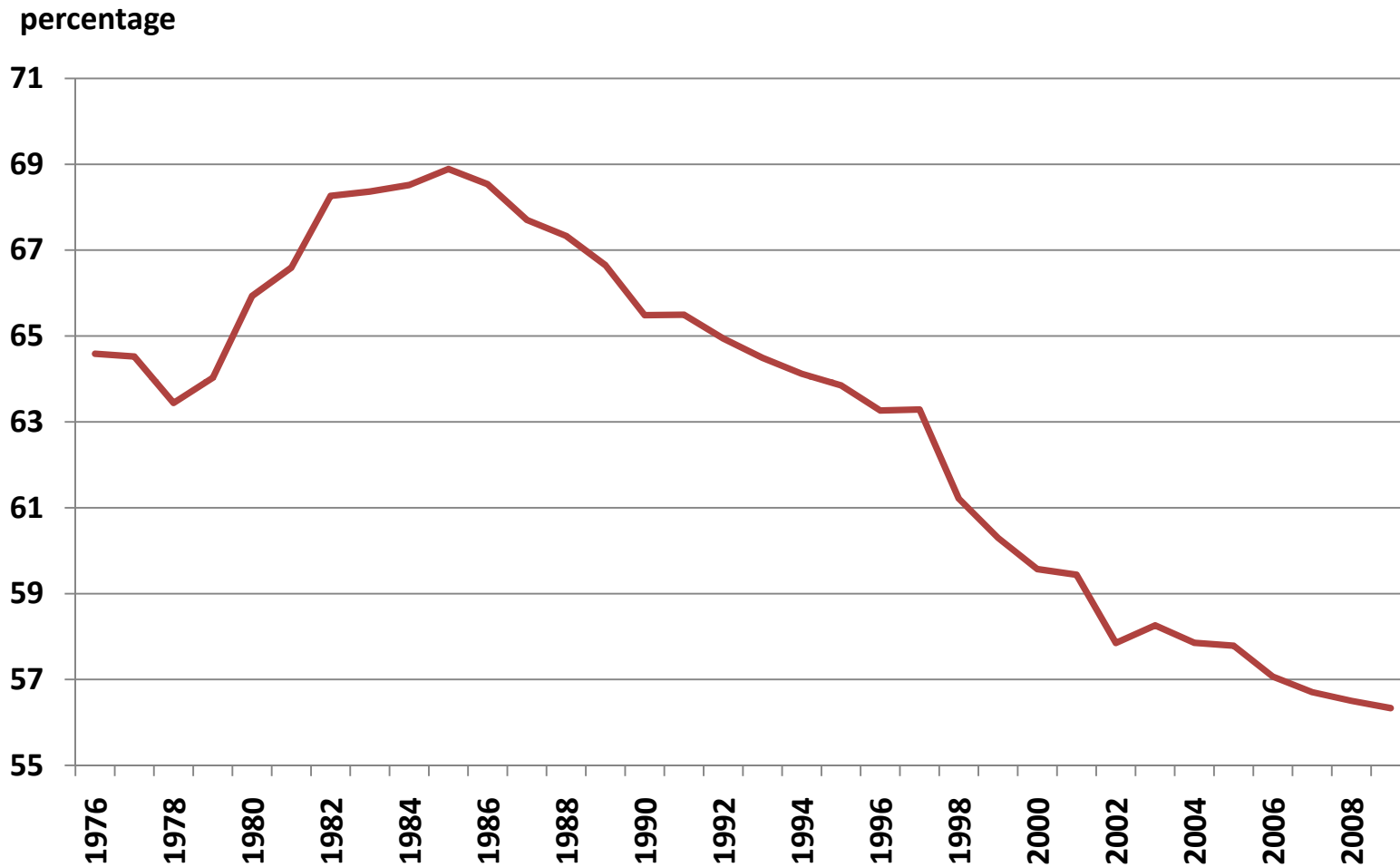
Source: Pardey et al. (2011) with data from USDA, CRIS (various years)

USDA Role in Funding SAES Research, 1970–2009



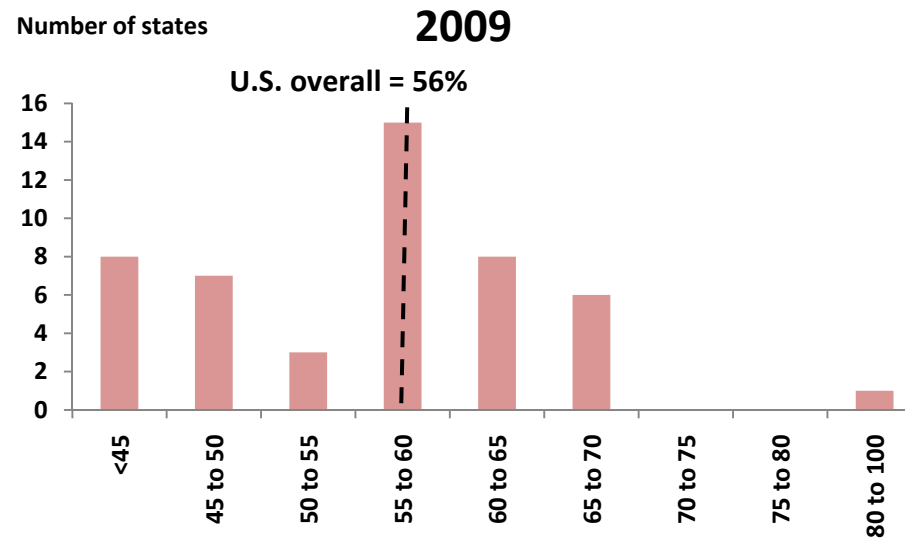
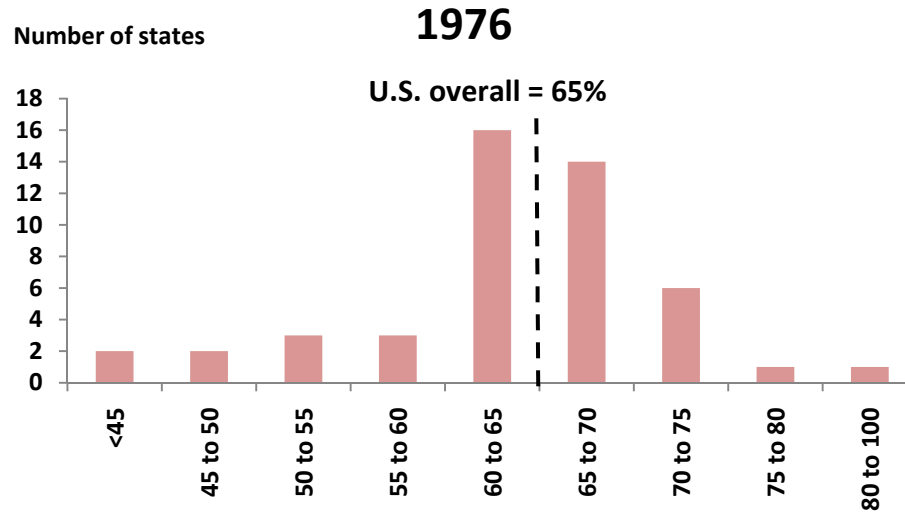
Source: Pardey et al. (2011) with data from USDA, CRIS (various years)

Farm Productivity Share of SAES Research, 1976-2009



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

Farm Productivity Share by State, 1976 and 2009

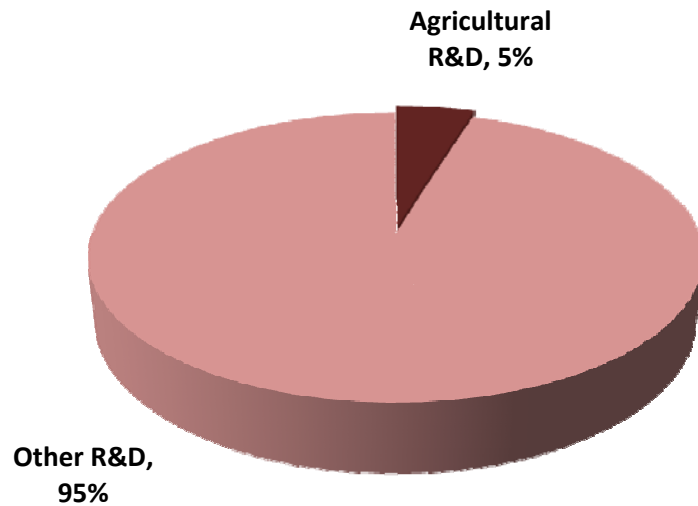


Source: Pardey et al. (2011) with data from USDA, CRIS (various years)

Global science spending

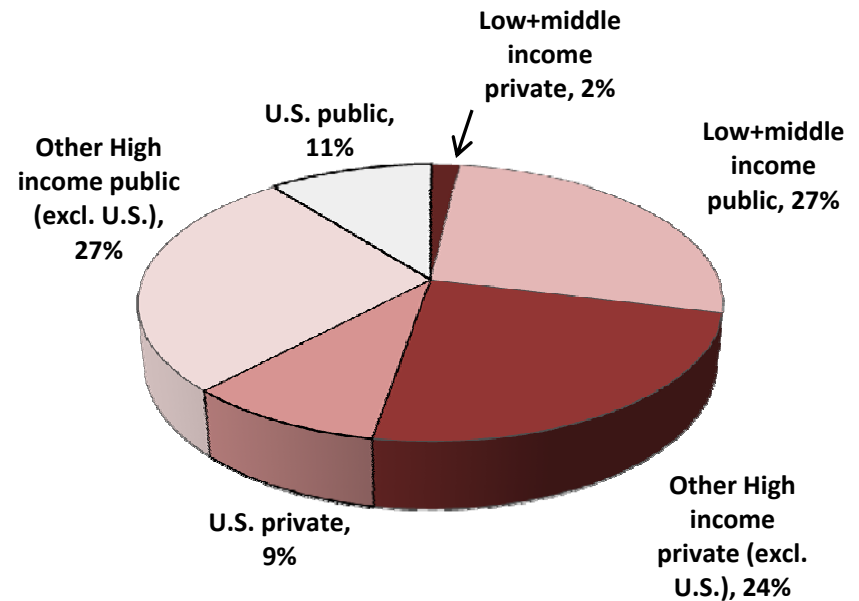
Global Science Spending Landscape, 2000

Total Science



\$782.7 billion

Food & Agricultural R&D



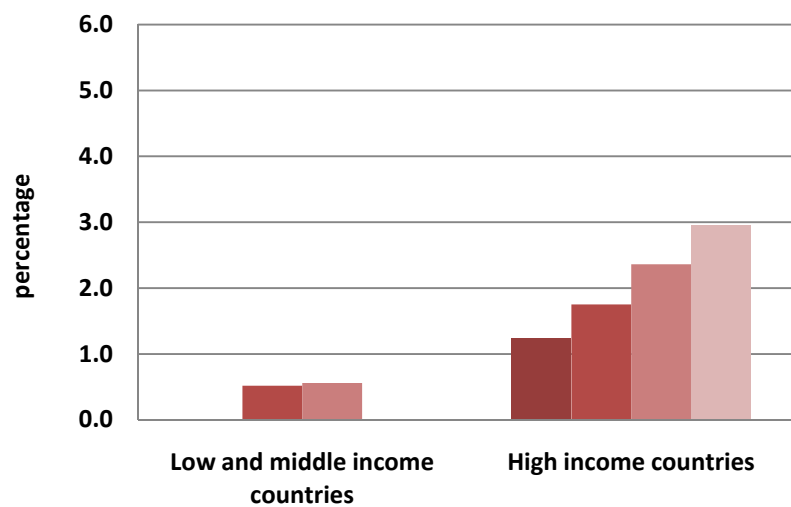
\$37.5 billion

Note: Spending in 2005 prices

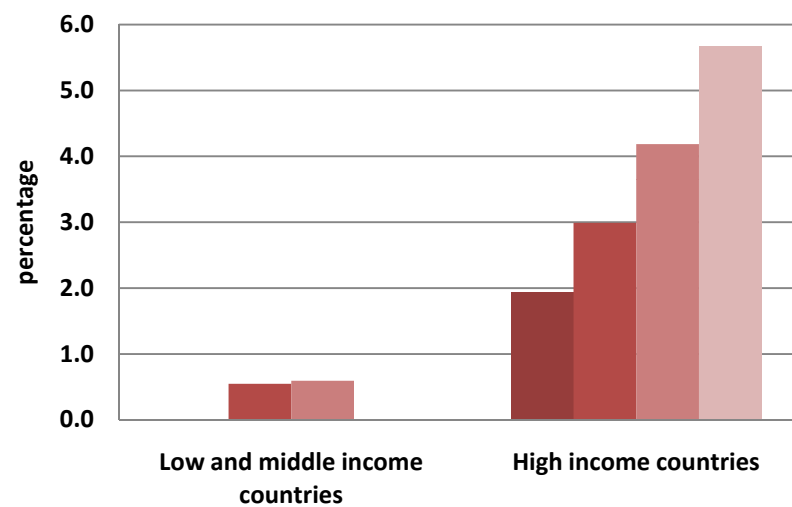
Source: NSB (2010), USDA, CRIS (various years), and Dehmer and Pardey (2011)

Food and Agricultural Research Intensity Ratios

Panel a: Public



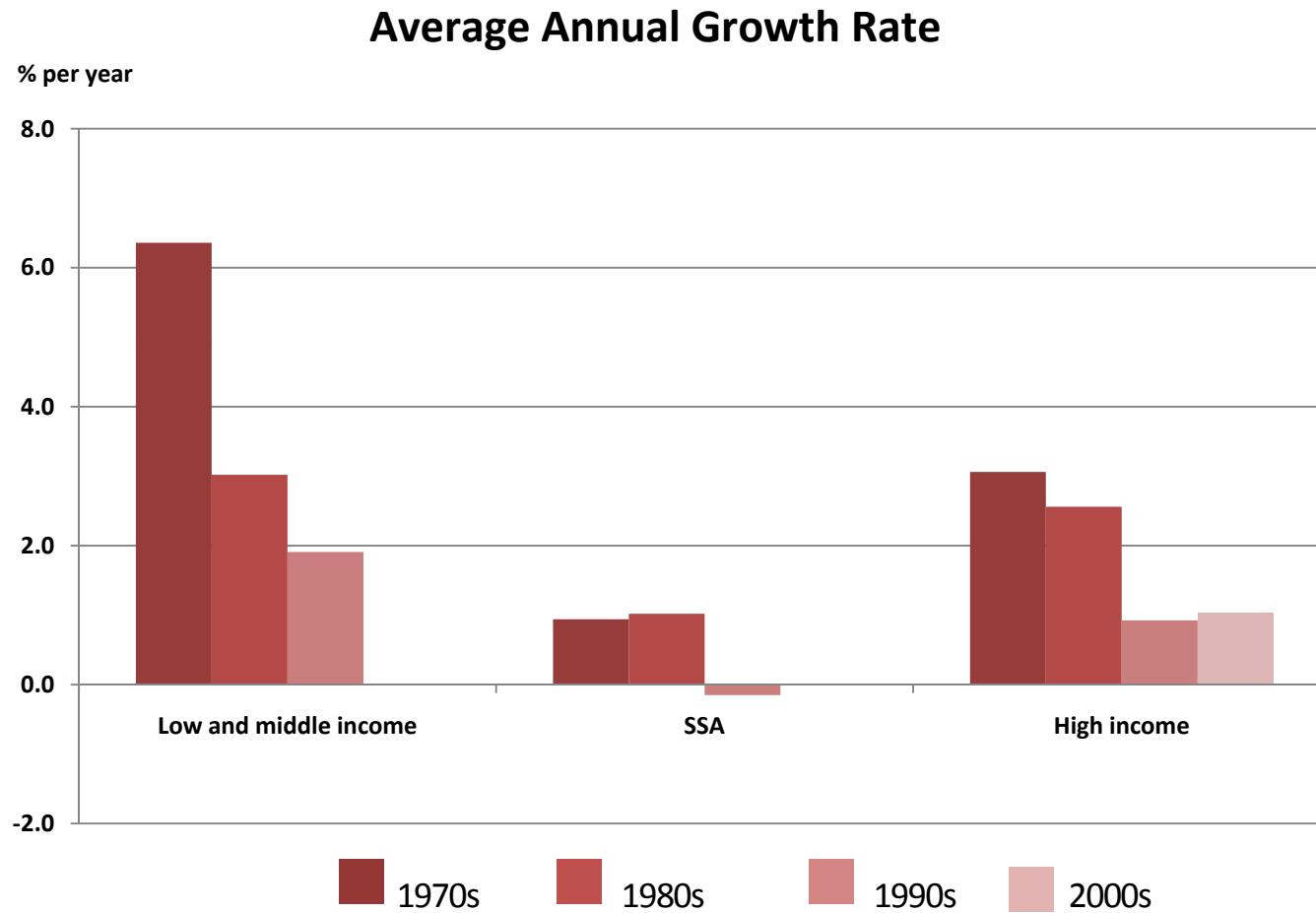
Panel b: Public and Private



1970s 1980s 1990s 2000s

Source: Pardey and Pingali (2010).

Public Food and Agricultural Research Expenditures



Source: Pardey and Pingali (2010).

Productivity patterns

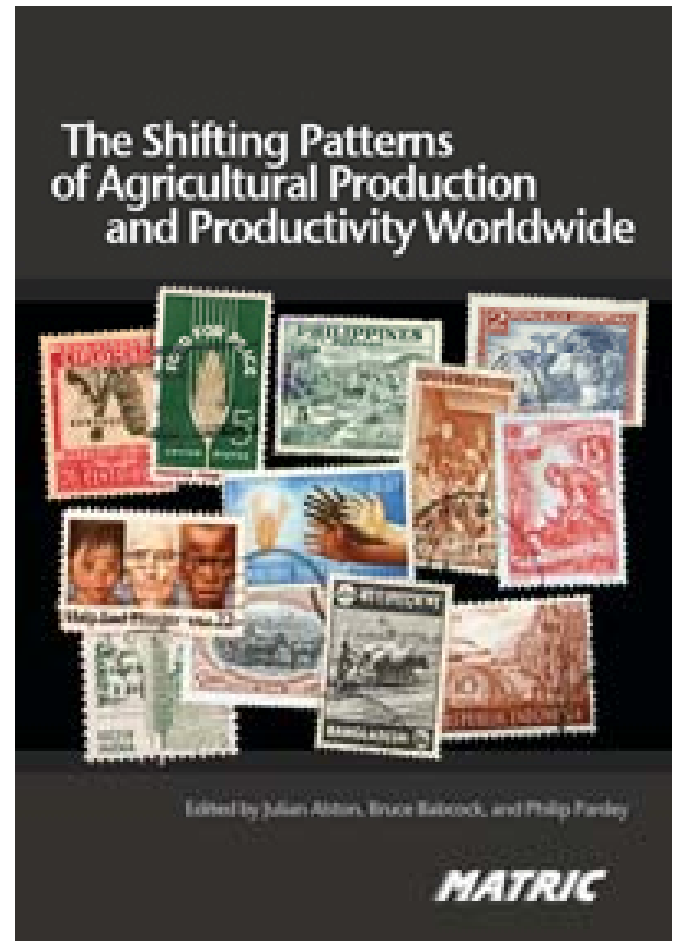
Sources . . .

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

Group	Maize		Wheat		Rice		Soybeans	
	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07	1961-90	1990-07
	<i>(percent per year)</i>							
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
Latin America	2.17	2.83	2.15	3.53
Asia	2.56	3.01	1.83	2.72
excl. China	2.45	1.83	1.69	1.24
China	2.81	4.50	2.29	4.45
Africa	2.18	2.21	0.68	0.90

Source: Alston, Beddow and Pardey (2010).

Growth in Agricultural Land and Labor Productivity, 1961-2005

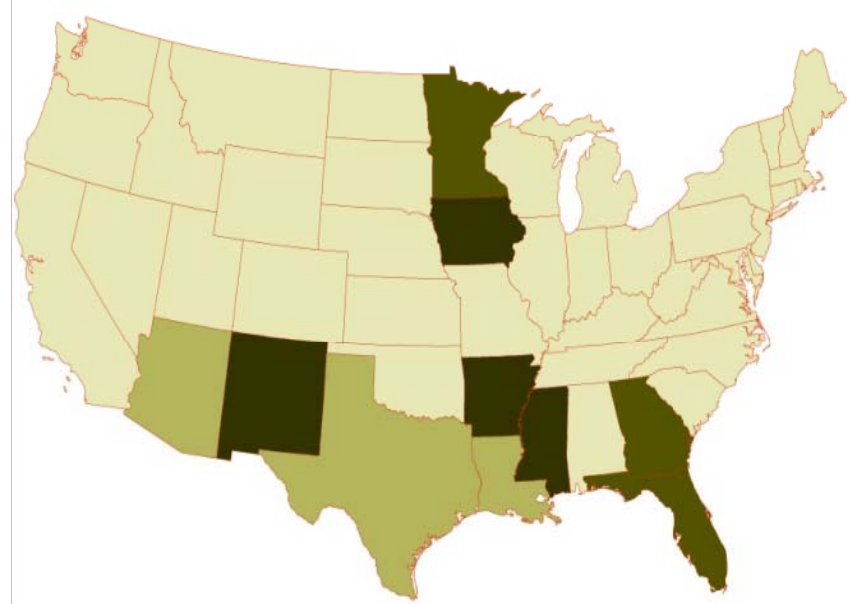
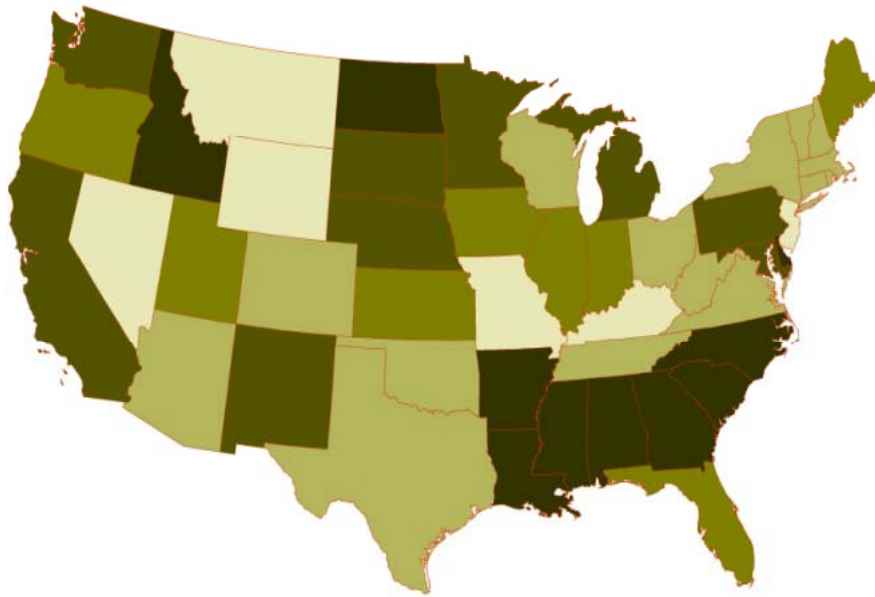
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China	2.81	4.50	2.29	4.45
Africa	2.18	2.21	0.68	0.90
Low Income Countries	2.00	2.39	0.46	1.03
Middle Income Countries	2.35	2.30	1.51	2.02
excl. China	2.18	1.37	0.39	0.81
High Income Countries	1.61	0.72	4.26	4.18
Top 20 Producers	2.11	2.16	1.17	1.77
excl. China	1.98	1.38	1.33	0.63
Other Producers	1.74	0.88	1.00	0.07

Source: Alston, Beddow and Pardey (2010).

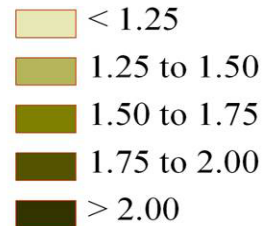
MFP Growth Rates, 1949-2002 and 1990-2002

1949-2002

1990-2002



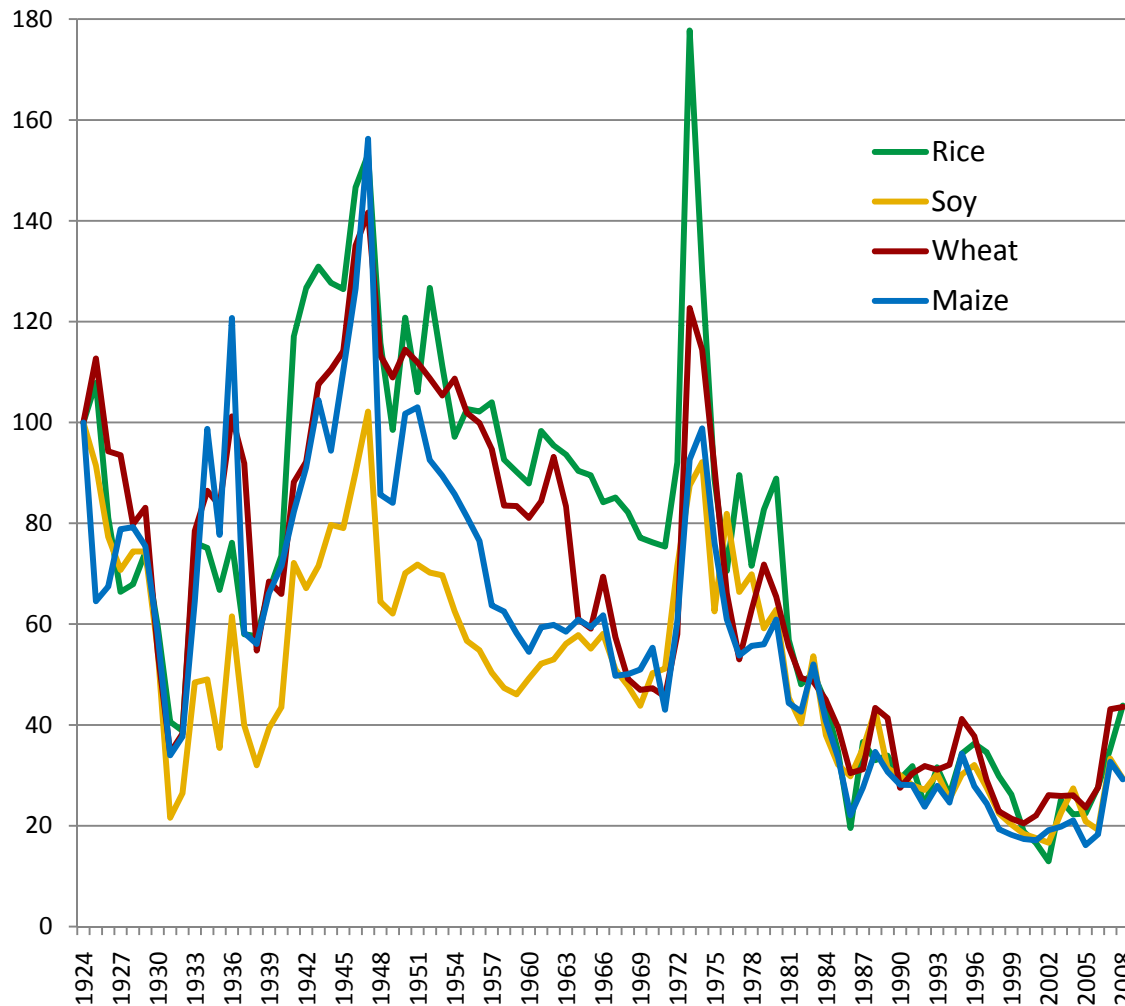
Pre-1990
2.02% per year



Post-1990
0.97% per year

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?

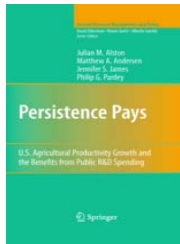
A continuation of the recent pattern?

What are the key determinants?

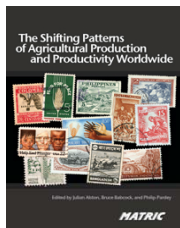
U.S. Policy Options

- **Reinvesting in agricultural R&D**
 - **Redirecting federal tax revenue to agricultural R&D**
 - **Priorities within the agricultural budget**
 - **nutrition vs farm subsidies vs R&D**
- **Co-financing arrangements**
 - **Research levy with a public match**
 - **Farmers , input suppliers, post-farm processors, bio-energy and other industries that benefit from R&D**
- **Similar ideas may be relevant for Canada**

Selected Sources



Alston, J.M., M.A. Andersen, J.S. James, and P.G. Pardey. ***Persistence Pays: U.S. Agricultural Productivity Growth and the Benefits from Public R&D Spending***. New York: Springer, 2010.



Alston, J.M., B.A. Babcock and P.G. Pardey. ***The Shifting Patterns of Agricultural Production and Productivity Worldwide***, Ames IA: Iowa State University, CARD-MATRIC e-book, 2010.



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!**

jmalston@ucdavis.edu

