Putting U.S. Agricultural R&D and Productivity Developments in Perspective

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- Jason Beddow, U. Minnesota
- Steven Dehmer and Connie Chan-Kang, U. Minnesota
Outline

- U.S. and World Agricultural Productivity Patterns
  - Partial Productivity Measures
  - Multifactor Productivity
  - A Productivity Slowdown?

- Linking Agricultural R&D to Productivity
  - Attribution Problems (R&D Lags, Spillovers-spatial, fields of science, etc)

- R&D Spending Patterns
  - United States vs Global
  - All Science vs Agriculture
  - Sources and Forms of Funding
U.S. and World Productivity Patterns in Agriculture
### U.S. Commodity Yields, 1866 - 2008

#### Annual Yield Growth Rate

<table>
<thead>
<tr>
<th>Commodity</th>
<th>1950-1989</th>
<th>post-1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1.45%</td>
<td>2.85%</td>
</tr>
<tr>
<td>Rice</td>
<td>1.19%</td>
<td>2.27%</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.71%</td>
<td>1.75%</td>
</tr>
</tbody>
</table>

#### Graph

- **Corn**
- **Rice**
- **Wheat**
U.S. Labor, Land, and Multi-Factor Productivity, 1911-2002

Index (1911=100)

- Labor Productivity: 1.69% growth, 4.01% overall
- Land Productivity: 1.77% growth, 1.85% overall
- Multi-Factor Productivity: 2.01% growth

Average Annual Growth (Percentage)

- 1950-1989
- post-1990

Graph showing trends in Labor, Land, and Multi-Factor Productivity from 1911 to 2002.

Land Productivity Growth Rate

- Developed
- Developing w/o China
- World w/o China

Labor Productivity Growth Rate

- Developed
- Developing w/o China
- World w/o China
Causes of Slower Productivity Growth

- **Some Possibilities**
  - Bad weather?
  - Other factors?
    - Changing regulatory environment?
    - Degradation of natural resource base?

- **Research Related Factors**

- **Reduced support for farm productivity R&D?**
  - Slower growth in total agricultural R&D investments
  - Changing composition of “agricultural research”
    (e.g., shrinking share for farm productivity)

- **Other aspects of R&D?**
  - Shifting structure of U.S. general public R&D?
  - Changing private sector roles?
  - Reduced spillins from other countries and CGIAR?
R&D – Productivity Relationships

- Research spending to productivity lags are long (matters of decades not years)
- Research results “spillover” affecting locales beyond where the research was performed.
- Significant research required to maintain not just increase yields/productivity

Hybrid and Biotech Share of US Corn Acreage

- 19 yrs
- 13 yrs
R&D Spending Patterns

Overall trends

Global and all science comparisons

Sources and forms of funding

1981
$14.84 billion
(2000 intl dollars)

- United States: 18%
- Other Developed: 28%
- China: 4%
- Other Developing: 37%

2000
$20.30 billion
(2000 intl dollars)

- United States: 19%
- Other Developing: 23%
- China: 9%
- Other Developed: 41%
- Japan: 8%

Rich country ag share all R&D (year 2000) 1.8%
Developing country ag share of all R&D (year 2000) 8.2%
U.S. R&D Spending by Performing Sector, 2006

All R&D
$340.4 billion

Agricultural R&D
$9.24 billion

Billions of dollars, 2000 prices

Dept. of Defense (DOD)

Other

Dept. of Health and Human Services (DHHS)

Dept. of Agriculture (USDA)
**Funding Channels for U.S. Public Sector Agricultural R&D, 2007**

**Public Funding Sources**

- **State governments** $1,364.7
- **Federal funds from USDA** $1,959.9
  - For SAES research
    - CSREES administered
      - Formula funds $258.4
      - Competitive funds $101.7
      - USDA grants and contracts $145.4
      - Other grants and contracts $183.9
      - Total $689.5
    - For intramural USDA research
      - Regular in-house (block grants) $1,213.1
      - Contract $5.1
      - Other $52.2
      - Total $1,270.4
- **Non-USDA federal funds** $706
  - For SAES research $666.0
  - For USDA research $40.0

**Research Performers**

- **SAESs and related institutions**
  - SAESs $2,861.4
  - Veterinary medicine schools $335.3
  - Forestry schools $168.8
  - 1890 institutions $60.4
  - Other Cooperating inst. $52.6
  - Total $3,478.6

- **USDA intramural**
  - Agricultural Research Service $1,116.0
  - U.S. Forest Service $205.5
  - Economic Research Service $32.9
  - Total $1,354.4

**Total public (federal and state)** $4,833.0

**Other Funding Sources**

- **Self-generated funds** $228.3
- **Industry grants & contracts** $261.5
- **Other non-federal funds**
  - For SAES research $268.7
  - For intramural USDA research $11.1
Total and Public Spending on Ag R&D, 1950-2007

- **Total Ag R&D**
  - Average Annual Real Growth (Percentage)
    - 1951-1969: 1.0%
    - post-1970: 3.8%
    - post-1990: 4.7%

- **Public Ag R&D**
  - Average Annual Real Growth (Percentage)
    - 1951-1969: 1.5%
    - post-1970: 1.1%
    - post-1990: 1.9%

- **Private Ag R&D**
  - Average Annual Real Growth (Percentage)
    - 1951-1969: 1.1%
    - post-1970: 1.9%
    - post-1990: 4.7%
Private Shares of R&D, 1950s vs 2000s

Private R&D as share of total R&D (all industries)

Private R&D as share of total R&D (food and ag)

Private food and ag R&D as share of total private R&D for all industries

1966-1958 average
2004-2006 average
Commodity Orientation of U.S. Public Agricultural R&D

1975
- Other (including non-commodity specific) crops 32%
- Other crops 27%
- Specialty crops 15%
- Livestock 26%

$2.19 billion (2000 prices)

2007
- Other (including non-commodity specific) crops 34%
- Other crops 26%
- Specialty crops 14%
- Livestock 26%

$3.01 billion (2000 prices)
Farm Productivity Orientation of U.S. Public Agricultural R&D

Percentage

Distribution of SAES Research Intensities

Ratio represents SAES research spending relative to state value of agricultural production
Federal and USDA Roles in Funding SAES Research

- Federal share of SAES*
- USDA share of total federal
- CSREES share of total federal
- CSREES share of SAES*
USDA Funding of SAES Research (by form of funding)

- Formula funding (of Total USDA)
- Formula funding (of Total Federal)
- Special (Earmarked) grants
- Competitive grants

Percentage

Concluding Remarks

- Significant slowdown in US ag productivity growth since early 1990s

- Preceded by
  - slowdown in rate of ag R&D spending growth
  - Redirection of ag R&D away from maintaining or enhancing productivity

- Major shifts in the sources and forms of funding for public ag R&D
  - Very substantial decline in share from formula funding
  - Shift of federal funding away from USDA
  - Comparatively small share disbursed as competitive grants
  - Rise in share of funding via special (earmarked) grants
Thanks!

www.instepp.umn.edu

www.apec.umn.edu

www.HarvestChoice.org
Out-of-Sample Projections of MFP

Index (1949=100)

Spending Grows at 1950-2002 Average Rate
Spending Grows at 1991-2002 Average Rate

MFP Growth Rate
Converges to 1.2%

MFP Growth Rate
Converges to 0.5%
Predicting the Future

The New York Times

Monsanto Seeks Big Increase in Crop Yields

Monsanto, the leader in agricultural biotechnology, pledged Wednesday to develop seeds that would double the yields of corn, soybeans and cotton by 2030 and would require 30 percent less water, land and energy to grow.

By Andrew Pollack
June 2008

DuPont Leader Discusses Agricultural Productivity at USDA Agricultural Outlook Forum

“We expect the traits and technologies in our product pipeline to help meet that demand by doubling the rate of genetic gain – targeting a 40 percent yield increase in our corn and soybean products over the next 10 years.”

By Paul Schickler
February 2008

US Maize Yields

Since 1961, 10 year global maize yield growth has never exceeded 3.4%
The Tyranny of the Red Queen

- Biological 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
### Global Average Yields – Annual Percent Change (8 year moving average)

#### Average Annual Yield Growth Rate, by period

<table>
<thead>
<tr>
<th>Period</th>
<th>Maize</th>
<th>Wheat</th>
<th>Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961-1989</td>
<td>2.22%</td>
<td>2.78%</td>
<td>2.19%</td>
</tr>
<tr>
<td>1990-2007</td>
<td>1.77%</td>
<td>0.51%</td>
<td>0.96%</td>
</tr>
</tbody>
</table>
A Slowdown in Crop Yield Growth

Percentage of countries for which the rate of yield growth during 1990-2007 was less than the rate during 1961-1989

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<th>Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Countries included in “All Countries”</td>
<td>146</td>
<td>106</td>
<td>110</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Countries</td>
<td>58</td>
<td>75</td>
<td>55</td>
</tr>
<tr>
<td>Top 10 Producing Counties</td>
<td>50</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Top 25 Producing Counties</td>
<td>60</td>
<td>80</td>
<td>52</td>
</tr>
</tbody>
</table>

Average yield growth reflects the changing location of production around the world as well as the changing country-specific yields.