Agricultural R&D, Technological Change, and Food Security

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Effects of Agricultural R&D

For sure
- more abundant, cheaper food
- less poverty
- a decrease in the number of people going hungry
- a (perhaps smaller) decrease in the proportion of people going hungry

And perhaps
- more specialized and more intensive production on individual farms (and, for some, a greater risk of crop failure)
- a greater use of purchased inputs (and, for some, a greater risk of financial ruin)
- a faster rate of consumption of natural resource stocks
- less biological diversity and an increased risk of widespread famine
## Annual Growth in Agricultural Production, 1961-1997

<table>
<thead>
<tr>
<th>Region</th>
<th>Crop (percentage)</th>
<th>Livestock (percentage)</th>
<th>Total (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latin America and the Caribbean</td>
<td>2.61</td>
<td>2.85</td>
<td>2.71</td>
</tr>
<tr>
<td>Asia</td>
<td>3.01</td>
<td>4.93</td>
<td>3.50</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>2.09</td>
<td>2.35</td>
<td>2.16</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>2.97</td>
<td>4.07</td>
<td>3.29</td>
</tr>
<tr>
<td>United States</td>
<td>1.98</td>
<td>1.23</td>
<td>1.61</td>
</tr>
<tr>
<td>Western Europe</td>
<td>1.08</td>
<td>1.43</td>
<td>1.27</td>
</tr>
<tr>
<td>Developed Countries</td>
<td>1.20</td>
<td>1.33</td>
<td>1.27</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td><strong>2.23</strong></td>
<td><strong>2.28</strong></td>
<td><strong>2.25</strong></td>
</tr>
</tbody>
</table>
## Agricultural Productivity Growth in South China, 1976-1995

<table>
<thead>
<tr>
<th>Crop</th>
<th>Total MFP Growth</th>
<th>MFP Growth Due to R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>1.78</td>
<td>1.38</td>
</tr>
<tr>
<td>Wheat</td>
<td>4.54</td>
<td>2.82</td>
</tr>
<tr>
<td>Other Grain</td>
<td>4.29</td>
<td>3.58</td>
</tr>
<tr>
<td>Cash Crops</td>
<td>9.27</td>
<td>7.26</td>
</tr>
</tbody>
</table>
U.S. Wheat and Rice Yields, 1800-1996
World Wheat Yields, 1960-1996

![Graph showing the trend of world wheat yields from 1960 to 1996. The graph indicates a general increase in wheat yields over the years, with fluctuations and upward trends.]
World Wheat Production, 1960-1996
U.S. Real Wheat and Rice Prices, 1899-1996
(1994 US$)
Real World Food Price Index, 1959=100
World Food Price and per Capita Food Production

Index (1961=100)

- Food Price
- Food/capita

Effects of Eliminating Past R&D on Current Grain Production and Prices

- Past Patterns--over 35 years
  - \( q = \frac{d\ln Q}{d\ln Q} = 100\% \)
  - \( p = \frac{d\ln P}{d\ln P} = -50\% \)
  - \( g = q - \varepsilon p = 150\% \) (\( \varepsilon = 1 \))

- Assume \( \eta = -0.2 \) and \( \frac{2}{3}g = 100\% \) increase in supply due to research, relative to 1960

- Eliminate past growth in supply from R&D (reduce supply by 50\% relative to 1995)
  - \( q = \frac{-\eta(-50\%)}{(\varepsilon-\eta)} = -8\% \) (-16\% of 1960)
  - \( p = \frac{-(-50\%)}{(\varepsilon-\eta)} = 42\% \) (25\% of 1960)
Distributional Considerations

\[ B_i = -P_i C_i \ln P_i + (k_i + \ln P_i) P_i Q_i > 0? \]

- **consumers:** \(- P_i C_i \ln P_i > 0\)
- **producers:** \((k_i + \ln P_i) P_i Q > 0?\)

\[ B_i = k_i P_i Q_i + (P_i Q_i - P_i C_i) \ln P_i > 0? \]

- **adopters:** \(k_i P_i Q_i > 0\)
- **deficit households:** \((P_i Q_i - P_i C_i) \ln P_i > 0\)
- **surplus households:** \((P_i Q_i - P_i C_i) \ln P_i < 0\)

Households who produce a surplus and cannot adopt are the only sure losers
Agricultural R&D and Household Income Distributions

![Graph showing frequency vs annual income with a poverty line]
IFPRI Projections: 1995-2020

- World population will increase by 32% to 7.5 billion, mostly in cities in developing countries.
- Per capita incomes will increase in all regions.
- 85% of total food demand growth will come from developing countries.
- Demand for meat (and for grain for feeding livestock) in developing world will double.
- World grain production will have to increase 40 percent (through yield improvement).
- Food prices will remain steady or fall slightly.
Agricultural Research Investments: 1971 to 1991

- Global public ag. R&D increased from $7.3 billion to $15 billion
- In developing countries: from $3 billion to $8 billion
- In developed countries: from $4.3 billion to $7 billion
- ARIs in developed countries increased from $1.38 to $2.39 per $100 of output
- ARIs in developing countries increased from $0.38 to $0.50 per $100 of output
- Slower growth in the 1980s than the 1970s
- Spending in IARCs grew rapidly in the 1970s, stalled in the 1990s
- Relatively rapid growth of private agricultural research, in developed countries, in particular areas
Public Agricultural R&D Spending: Global Perspectives, 1971 and 1991

1971: 7.28 billion 1985 international dollars

- Australia, Netherlands, New Zealand, United Kingdom, & USA: 32%
- Other developed countries: 27%
- Developing countries: 41%

1991: 14.95 billion 1985 international dollars

- Australia, Netherlands, New Zealand, United Kingdom, & USA: 26%
- Other developed countries: 20%
- Developing countries: 54%
Public vs. Private R&D in OECD Countries (1981-93 growth rates)

- **Public Growth Rates**
  - Greece: -1.8% pa
  - New Zealand: -2.0% pa
  - Belgium: -3.0% pa
  - Ireland: -2.0% pa
  - Canada: -2.0% pa
  - United Kingdom: 1.0% pa
  - Australia: 1.8% pa
  - Germany: 5.0% pa
  - Austria: 5.0% pa
  - France: 5.0% pa
  - Netherlands: 5.0% pa
  - Average: 5.0% pa

- **Private Growth Rates**
  - Greece: 4.0% pa
  - New Zealand: 4.0% pa
  - Belgium: 6.0% pa
  - Ireland: 8.0% pa
  - Canada: 8.0% pa
  - United Kingdom: 10.0% pa
  - Australia: 8.0% pa
  - Germany: 12.0% pa
  - Austria: 10.0% pa
  - France: 12.0% pa
  - Netherlands: 14.0% pa
  - Average: 10.0% pa
  - United States: 16.0% pa
  - Sweden: 16.0% pa
  - Denmark: 14.0% pa
  - Finland: 12.0% pa
  - Norway: 12.0% pa
  - Italy: 14.0% pa
  - Portugal: 12.0% pa
  - Spain: 16.0% pa
  - Iceland: 16.0% pa

**Note:** Continues to 32.0% pa.
Policy Issues

- How much total R&D?
- Which types of R&D?
- Who should pay for it?
- Who should do it?
- What institutional arrangements?
- What incentive mechanisms?
A Supply and Demand Model

MSC = MPC

MSC

MSB

MPB

$R_0 \leq R \leq R_1 \leq R_2$

Food Security

FS_0 < FS_1 < FS_2

Research (R)

0 \leq R \leq R_2
A Trade-off of Equity and Efficiency Using Research Policy Alone

Equity (V)

V_{\text{MAX}}

V^*

V_{\text{MIN}}

0

Efficiency (E)

E^*

E_{\text{MAX}}

BTC_R

IC_0

a

b

E^*

c
A Trade-off of Equity and Efficiency Using the Least-Cost Policy Combination

Equity (V)

BTC*
BTC_R
V**
V*
V_MIN

BTC*
IC_1
IC_0

E*
E**
E_MAX
Efficiency (E)
Targeted versus Traditional Research

- Will “targeted” research be effective?
- Will it yield smaller total benefits?
- Will it yield greater food security (or other distributional) benefits?
- Is “targeted” research the least-cost way of achieving the food security (or other distributional) objective?
- Need a better understanding of technological possibilities and consequences for different types of research.
Conclusion: Main Points

- Agricultural R&D has increased total availability of food, and enhanced access by the poor

- Important effects: Without past 35 years of growth in grain supply from R&D quantity would be 8% lower, price 42% higher

- Projections imply grain yields “have to” increase 40% by 2020 through productivity increases

- Funds for public R&D
  - Is the current rate of investment adequate?
  - Will “targeted” R&D be effective?
  - Is it the best instrument for distributional objectives?

- Information is lacking on implications of targeting for
  - Total benefits
  - Distributional outcomes