Agricultural R&D, Food Prices, Poverty and Malnutrition Redux

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Presented at the Festschrift conference on
New Directions in Fight Against Hunger and Malnutrition
held in honor of Per Pinstrup-Andersen
Cornell University
December 12–14, 2013
**The Issue**

- **Problem #1**
  - Very high marginal social returns to agricultural R&D
  - Slowing farm productivity growth and rising food commodity prices
    - Paradox
      - Evidence calls for a significant increase in funding
      - We observe reduced agricultural research investments by high-income countries
    - Conundrum
      - Do policymakers not understand the evidence and its implications?
      - Are money metric (economic surplus) measures not effectively meaningful?

- **Problem #2**
  - Many of the world’s poor remain undernourished
  - High and rising rates of obesity and overweight
    - Policy Conundrum
      - Implications for agricultural research priorities?
        - To what extent has agricultural R&D contributed to increasing obesity while reducing poverty?
        - Should priorities emphasize poor farmers in marginal areas or more nutritious food?
      - What about Problem #1?
      - What about opportunity cost?
Who saved a billion lives?

Norman Borlaug has already saved more lives than any other person who ever lived . . . . The form of agriculture that Borlaug preaches may have prevented a billion deaths.


What was the benefit-cost ratio?
Alternatives to money metric Measures?

Norman Borlaug recording data in wheat breeding plots at Obregon, Mexico, around 1964. At that time, a legend started spreading that he could “talk” with each plant, selected the best breeding materials.
A slowdown in productivity growth: cereals
Gains from agricultural TFP growth in 2009
(by income group of countries)

<table>
<thead>
<tr>
<th>Income Group</th>
<th>TFP in 2009 1961=100</th>
<th>AgGDP 2005 billion PPP$</th>
<th>Population million</th>
<th>GDP per capita 2005 PPP$</th>
<th>Benefits 2005 billion PPP$</th>
<th>Per capita benefits billion PPP$</th>
<th>Benefits as % of GDP (all countries) percent</th>
<th>Benefits as % of GDP (TFP growth) percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>225</td>
<td>3,658</td>
<td>6,796</td>
<td>9,317</td>
<td>1,809</td>
<td>266</td>
<td>2.9</td>
<td>4.0</td>
</tr>
<tr>
<td>High income</td>
<td>235</td>
<td>510</td>
<td>1,082</td>
<td>32,442</td>
<td>293</td>
<td>271</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Upper-middle income</td>
<td>228</td>
<td>1,648</td>
<td>2,575</td>
<td>7,913</td>
<td>924</td>
<td>359</td>
<td>4.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Lower-middle income</td>
<td>175</td>
<td>1,266</td>
<td>2,369</td>
<td>2,982</td>
<td>541</td>
<td>228</td>
<td>7.7</td>
<td>5.9</td>
</tr>
<tr>
<td>Low-income</td>
<td>127</td>
<td>234</td>
<td>770</td>
<td>1,017</td>
<td>50</td>
<td>65</td>
<td>6.4</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Source: TFP from Keith Fuglie. Benefits computed as B = AgGDP*(TFP – 100)/TFP
## Gains from agricultural TFP growth in 2009 (by region)

<table>
<thead>
<tr>
<th>Region</th>
<th>TFP in 2009 1961=100</th>
<th>AgGDP</th>
<th>Population</th>
<th>GDP per capita</th>
<th>Benefits</th>
<th>Per capita benefits</th>
<th>Benefits as % of GDP (all countries)</th>
<th>Benefits as % of GDP (positive TFP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>225</td>
<td>3,658</td>
<td>6,796</td>
<td>9,317</td>
<td>1,809</td>
<td>266</td>
<td>2.9</td>
<td>4.0</td>
</tr>
<tr>
<td>High Income</td>
<td>246</td>
<td>472</td>
<td>1,018</td>
<td>33,355</td>
<td>280</td>
<td>275</td>
<td>0.8</td>
<td>1.0</td>
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<tr>
<td>EE &amp; FSU</td>
<td>148</td>
<td>251</td>
<td>406</td>
<td>11,239</td>
<td>82</td>
<td>201</td>
<td>1.8</td>
<td>2.9</td>
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<tr>
<td>LAC</td>
<td>211</td>
<td>317</td>
<td>582</td>
<td>9,301</td>
<td>167</td>
<td>286</td>
<td>3.1</td>
<td>4.0</td>
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<tr>
<td>MENA</td>
<td>233</td>
<td>305</td>
<td>390</td>
<td>7,593</td>
<td>174</td>
<td>447</td>
<td>5.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Asia &amp; Pacific</td>
<td>211</td>
<td>1,978</td>
<td>3,557</td>
<td>4,171</td>
<td>1,042</td>
<td>293</td>
<td>7.0</td>
<td>7.8</td>
</tr>
<tr>
<td>SSA</td>
<td>124</td>
<td>335</td>
<td>843</td>
<td>1,899</td>
<td>64</td>
<td>76</td>
<td>4.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>
What’s agricultural productivity worth?

Output gain per capita (2005 PPP$)

GDP per capita (2005 PPP$ per person)
Gains from agricultural TFP growth in 2009

Output gain as percent of GDP, log scale

GDP per capita (2005 PPP$ per person), log scale

Asia&Pacific
EE&FSU
High Income
LAC
MENA
SSA
“... a naïve targeting of research resources on poor producers based only on direct benefits may produce quite misleading results on overall poverty alleviation effects.”

– Byerlee (2000) Food Policy, p. 442

Direct Effects
– benefits to poor farmers who adopt

Indirect Effects: (a) Induced Output Price Changes
– benefits to consumers
– reduced benefits to farmers who adopt
– cost to farmers who do not adopt
– net benefits to farmer household depend on whether they adopt and whether the household is a net surplus or deficit producer

Indirect Effects: (b) Employment and Wage Effects
– in agriculture
– in other sectors

Where will the world’s poor be found in 2030? 2050?
• On subsistence farms?
• In cities?

Will poverty be reduced more effectively by providing
• technologies targeted towards poor subsistence farmers?
• technologies that result in more abundant, cheaper food?

“As the world population is becoming increasingly urbanized, the role of technological change in reducing aggregate poverty correspondingly evolves from direct to indirect effects.”

Distribution of an additional 1$ of income across 144 countries, broad categories
Marginal propensity to consume food

Marginal share of food, bev. and tobacco

Asia&Pacific
EE&FSU
High Income
LAC
MENA
SSA

Marginal share on medical and health

Marginal propensity to consume food
Agriculture, food and health—anthropomometric angles
Average life expectancy at birth by world region, 1870–2012
Death caused by nutrition related diseases and by age category, 2008

High and upper middle income

Low and lower middle income

- Diabetes
- Hypertensive heart disease
- Ischaemic heart disease
- Cerebrovascular disease

- Prematurity and low birth weight
- Nutritional deficiencies
- Diarrhoeal disease
Number of deaths by disease, income group and age group in 2008

Cancer

Cardiovascular and diabetes

HIV, TB and Malaria

Maternal, perinatal, nutritional and diarrhoeal
Agricultural policies, household resource allocation and nutrition

**HOUSEHOLD RESOURCES**

- **FIXED CAPITAL**
  - Land
  - Animals
  - Physical Capital
  - Education
  - Experience

- **LABOR (TIME ALLOCATION: ENERGY USE)**
  - Own-farm production
  - Off-farm production
  - Leisure
  - Household chores (including child care and food preparation)

**TOTAL HOUSEHOLD INCOME**

- **INVESTMENT AND CONSUMPTION EXPENDITURES**
  - Own-farm production and income
  - Off-farm income
  - Other goods and services
  - Housing
  - Health and sanitation
  - Food

**ENDOGENOUS TO HOUSEHOLD DECISIONMAKING PROCESS**

- **INTRAHOUSEHOLD FOOD DISTRIBUTION**
- **INDIVIDUAL NUTRITIONAL STATUS**
- **MORBIDITY**

**COMMUNITY HEALTH AND SANITATION**

**EXOGENOUS IN THE SHORT RUN**

- **AGRICULTURAL PRICE POLICIES**
  - Food imports(exports)
  - Storage/buffer stocks
  - Price controls
  - Credit Programs
  - Input subsidies

- **AGRICULTURAL INVESTMENT POLICIES**
  - Research and extension
  - Irrigation
  - Roads and other infrastructure

- **FOOD PRICES AND WAGES**

- **Lagged effect**
### How to spend $1 billion?????

<table>
<thead>
<tr>
<th>Policy Objective</th>
<th>Maximum Economic Surplus</th>
<th>Incomes of farm &amp; nonfarm poor</th>
<th>Incomes of poor farmers</th>
<th>Nutrition of the poor</th>
<th>Reduced obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infrastructure</strong></td>
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<tr>
<td>(roads, water supply, markets)</td>
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<td><strong>Education</strong></td>
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<td><strong>Public health</strong></td>
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<tr>
<td>(clean water, sewerage, immunization deworming)</td>
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<tr>
<td><strong>Nutrition subsidies</strong></td>
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<tr>
<td>(food subsidies, supplements)</td>
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<tr>
<td><strong>Nutrition research</strong></td>
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<tr>
<td><strong>Medical research</strong></td>
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<tr>
<td><strong>Agricultural research</strong></td>
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</tbody>
</table>

**Effective?**

- Positive entry

**Efficient?**

- Cost effective relative to alternatives
A Trade-off of Equity and Efficiency

Equity (V)

Equity (V)

Efficiency (E)

IC$_1$

BTC*

BTC$_R$

V**

V$_{max}$

V*

V$_{min}$

0

E$_{min}$

E*

E**

E$_{max}$

V*

V$_{max}$

V**

V$_{min}$

0

E$_{min}$

E*

E**

E$_{max}$
Agricultural R&D as Obesity Policy?

- Parks, Alston and Okrent (2013)
  - $166.2 billion in additional health-care expenses attributable to obesity
  - 15.2% of U.S. public medical expenditures in 2009
  - DWL (c.f. BMI* = 25) of $148.2 billion
  - Marginal excess burden is $27 per year per additional unit of adult BMI
  - $3.06 per year per additional pound of adult body weight

- Alston, Okrent and Parks (2013) use these to compute benefits from hypothetical changes in U.S. public agricultural R&D taking into account effects on
  - Prices of food commodities =>
  - U.S. food consumption =>
  - Obesity patterns
  - Public health-care costs
Projected Changes in Calorie Consumption & Body Weight from Changes in Public Research Spending

<table>
<thead>
<tr>
<th>Change in consumption (kcal/day)</th>
<th>10%, all commodities</th>
<th>10% specialty crops</th>
<th>Revert to 1980 knowledge Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13.70</td>
<td>-5.81</td>
<td>-85.19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change in body weight (lb/U.S. adult)</th>
<th>One year</th>
<th>Steady state</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.05</td>
<td>1.75</td>
</tr>
<tr>
<td>Change in consumption (kcal/day)</td>
<td>-0.45</td>
<td>-0.74</td>
</tr>
<tr>
<td>Change in body weight (lb/U.S. adult)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One year</td>
<td>-6.53</td>
<td></td>
</tr>
<tr>
<td>Steady state</td>
<td>-10.90</td>
<td></td>
</tr>
</tbody>
</table>

Source: Alston, Okrent, and Parks (2013).
### Projected Changes in Social Welfare

<table>
<thead>
<tr>
<th></th>
<th>↑10%, all commodities</th>
<th>↑10%, specialty crops</th>
<th>↓10%, all others</th>
<th>Revert to 1980 knowledge Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Change in Steady-State Body Weight for US Adults</strong> (lb per capita)</td>
<td>1.75</td>
<td>-0.74</td>
<td></td>
<td>-10.90</td>
</tr>
<tr>
<td><strong>Change in Public Health-Care Costs (ΔH)</strong> (millions of $ per year)</td>
<td>3,849</td>
<td>-1,634</td>
<td></td>
<td>-23,940</td>
</tr>
<tr>
<td><strong>Change in Social Welfare</strong> (millions of $ per year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excluding ΔH</td>
<td>28,739</td>
<td>-15,063</td>
<td></td>
<td>-223,890</td>
</tr>
<tr>
<td>Including ΔH</td>
<td>24,890</td>
<td>-13,429</td>
<td></td>
<td>-199,950</td>
</tr>
<tr>
<td><strong>Cost per Pound Decrease in Body Weight</strong> ($ per lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excluding ΔH</td>
<td>73.33</td>
<td>90.53</td>
<td>91.84</td>
<td></td>
</tr>
<tr>
<td>Including ΔH</td>
<td>63.51</td>
<td>80.71</td>
<td>82.02</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Alston, Okrent, and Parks (2013).*
Implications

- Agricultural R&D is likely to be
  - *comparatively ineffective* as an instrument of obesity policy
    - it takes a very long time to take effect
  - *economically inefficient*
    - R&D yields a very high social payoff
    - we are already investing much too little
    - high opportunity cost
  - $\Rightarrow$ high net social cost: over $60/\text{lb}$ reduction in adult weight!

- If you want to use high prices to reduce obesity, more economic to tax food according to its caloric content (Okrent and Alston, 2012):
  - calorie tax ($0.163/1,000$ calories): $\$1.77/\text{lb}$ net benefit
  - sugar tax ($2.64/\text{kg}$): $\$1.73/\text{lb}$ net benefit
  - food tax (4.97% ad valorem): $\$1.54/\text{lb}$ net benefit
  - fat tax ($5.00/\text{kg}$): $\$1.31/\text{lb}$ net benefit

- Net benefit (negative net social cost per pound) from introducing food taxes compared with net cost from reducing R&D to reduce obesity
Strange synthesis, second-best solutions

• **First-best solution**—R&D as an instrument of science policy to correct for market failures in R&D

• **Second-best solution**—modified R&D policy, correcting for market failures in R&D with allowance for implications for reducing other distortions

• **Third-best solution**—recognizing institutional failure
  
  – Given gross underinvestment in it, R&D may be a least-cost (or, at least, pretty good) instrument for other objectives (related to the environment, health, income distribution)

  – What is the relevant counterfactual alternative? Less R&D?

  – An increase in R&D spent “sub-optimally” may be better than a continuing decline in total resources?
Equity and Efficiency: Win-Win!
Main Points

- **Agricultural R&D has paid handsome dividends**
  - Favorable BCRs
  - Increased availability of food and much lower prices
  - Important engine for poverty reduction and growth

- **Current concerns**
  - Underinvestment in agricultural R&D
  - Slowdown in spending, especially in high-income countries
  - Diversion of funds away from farm productivity enhancement
  - Slowdown in agricultural productivity growth in many places
Main Points

- **Targeted research?** (e.g., poor, resource-poor farmers on marginal lands)
  - Will targeted research be effective?
  - Will it yield (much) smaller total benefits?
  - Will it yield larger or smaller impacts on poverty reduction?
  - Is it the least-cost way of achieving the income distribution goal?

- **Doing well by doing good (Derek Tribe)**
  - VS
  
  Doing good by doing well

- Can justify (and perhaps achieve) an increase in R&D funding based on its impact on social objectives, and attain significant net benefits

- It will often be best (for equity as well as efficiency objectives) to spend given R&D resources where the total payoff is highest