The Contribution and Value of Public Agricultural Research for Agricultural Productivity

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Research – Productivity Relationships 101

Basic Conceptual Constructs

1. Local and non-local R&D spending gives rise to stocks of research knowledge

2. Knowledge stocks give rise to technical changes that preserve past or promote new productivity growth

3. Productivity improvements generate economic value to producers and consumers
   - Consumers: Safer, more abundant (cheaper) food
   - Producers: Lower (than otherwise) unit costs of production
What Does the Returns to Ag. R&D Evidence Tell Us?

- Are the returns to agricultural R&D declining and development dependent?

- What would be the returns to global agricultural R&D if we all headed Griliches?

  or

- Is 60% per year really the returns to food and agricultural R&D?

- Is the returns-to-research evidence “representative” of the sector it purports to evaluate?
A Conundrum

Global Returns to Food and Ag R&D

InSTePP returns-to-research database (version 3.0) includes 2,829 evaluations (or 3,426 estimates) from 492 studies published from 1958 to 2015.

93% of the evaluations are IRRs

Mean IRR = 58.7 %py

Median IRR = 39.0%py

Global (Public) Spending on Food and Ag R&D

- 24% (9 of 24) rich countries spent less in 2011 than 1980
- 28 low and middle-income countries (mainly in SSA), also scaled back spending
- For the remaining 95 countries worldwide whose real spending has increased, 37% (35 out of 95) had lower growth rates in the 2000s than in both the 1990s and the 1980s.
Declining Returns Over Time?

“The widespread retreat from investing in public agricultural R&D is a policy choice that is consistent with returns to R&D that have declined over time, making public investments in agricultural R&D a (relatively) less attractive option in recent years compared with earlier decades.”

(Hurley et al. 2017)

“Some suggest that the rate of return to agricultural R&D ought to be expected to decline over time, owing to some loose notion of diminishing returns or the view that the easy problems have already been solved... On the other hand, others have said that new information and biotechnologies offer the potential for an unprecedented technological revolution.”

(Alston et al. 2000, p.7)
Trends in Reported IRR’s, at Face Value

Note: IRRs plotted by year ending of a 10-year moving average of the respective medians.
Changes in the Composition of IRR Studies Over Time
Developed vs Developing Country IRRs

On the One Hand
Relative to the size of their agricultural sectors, developed (high-income) countries invest more on agricultural R&D than developing (low- and middle-income) countries, so if diminishing returns prevail, one might expect the returns, ceteris paribus, to be lower in developed versus developing countries.

On the Other Hand!
The quality and structure of the resources devoted to R&D (e.g., in terms of the relative size of the research agencies, the training and work experience of the scientists, and so forth) would suggest the reverse relativity on developed- versus developing-country returns.

Median IRRs at Face Value

Developing country = 41.1%py
Developed country = 34.0%py
Development Differences in the Composition of IRR Studies

Bar charts showing the percentage of studies focusing on different commodities, the nature of R&D, institutional orientation, and spillover effects.
Frequency of IRR Estimates per Study

Number of studies

- Full sample
- Regression sample

IRRs per study

- 1
- 2
- 3
- 4
- 5
- 6-10
- Above 10

<table>
<thead>
<tr>
<th>IRRs per study</th>
<th>Full sample</th>
<th>Regression sample</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>185</td>
<td>115</td>
</tr>
<tr>
<td>2</td>
<td>67</td>
<td>46</td>
</tr>
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<td>3</td>
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<td>11</td>
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<tr>
<td>6-10</td>
<td>63</td>
<td>44</td>
</tr>
<tr>
<td>Above 10</td>
<td>60</td>
<td>46</td>
</tr>
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</table>
We deployed a hierarchical or mixed, random-intercept model (specifically we used a two-level, mixed-effect specification, i.e., both fixed and random effects)

Oaxaca decomposition used to discern developed vs developing country differences
Results

Declining Returns?

Our primary results find that neither the initiation year of R&D investment nor the publication date of the R&D evaluation study has a statistically significant association with the reported IRR estimate for developed countries, developing countries, or the pooled data.

- We conclude that the contemporary returns to agricultural R&D investments appear as high as ever.

Development Dependency?

There are differences in the estimated IRRs between developed and developing countries, but we cannot provide unqualified conclusions regarding the overall implications of these differences.

- Differences in study attributes, such as who, what and how the study was performed tend to result in higher IRR estimates in developed countries.

- Differences in the marginal effects of the attributes results in higher IRR estimates in developing countries.
The Conundrum Continued

Are the Reported Returns to R&D Believable?

“This will never do!” he protested. “No one will swallow these figures!” The report revealed that for every single dollar that had been spent for scientific research in the Department of Agriculture, the nation was reaping an annual increase of nearly a thousand dollars in new wealth.

“Cut it down to $500,” insisted Wilson. “That’s as much as we can expect the public, or Congress, to believe.”

(McMillen 1929, p.141 account of “Tama Jim” Wilson, then USDA Secretary)

With a return of 39.0% per year, the U.S.’s $4.1 billion investment in agricultural R&D in 2000 would generate $58 quadrillion ($10^{15}$) in net benefits by 2050—more than 390 times the projected world GDP in 2050.

(Hurley et al. 2014)
Recalibrating the Returns

Summary Statistic of Choice – IRR

\[ P_{VC} \text{ (IRR)} = P_{VB} \text{ (IRR)} \]

Griliches questioned the sensibility of using an IRR to represent the returns to hybrid corn research noting that his “…objection to this particular procedure is that it values a dollar spent in 1910 at $2,300 in 1933…I prefer to value the 1910 dollar at a reasonable rate of return on some alternative social investment.”

(Griliches 1958, p. 425)

An Alternative Summary Statistics – MIRR

\[ MIRR = \sqrt[T]{\frac{F_{VB}(\delta^r)}{P_{VC}(\delta^c)}} - 1 \]

where

\[ \delta^r = \text{reinvestment rate of benefits} \]

\[ \delta^c = \text{borrowing discount rate} \]
Imputing MIRRs (and BCRs)

**Step 1:** Used methodology in Hurley et al. (2014) to approximate MIRRs for the sub-set of 412 evaluations in the InSTePP database that reported both a BCR, an IRR, and the time-related information (i.e., $T^c$, $T^b$, and $T$).

**Step 2:** Deployed regression methods to identify the best-fitting relationship between the reported IRRs and the approximated MIRRs while accounting for differences in $T^c$, $T^b$, and $T$.

**Step 3:** Used regression results to project MIRRs for all reported IRR estimates that did not report sufficient information to approximate an MIRR using Step 1 and were within the support of the regression analysis.
# The Global Returns to Food and Ag R&D – The New Norm?

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Min</th>
<th>Median</th>
<th>Max</th>
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<tbody>
<tr>
<td>IRR</td>
<td>2,165</td>
<td>58.7</td>
<td>7.4</td>
<td><strong>38.98</strong></td>
<td>1,736</td>
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<tr>
<td>MIRR</td>
<td>2,165</td>
<td>17.9</td>
<td>9.09</td>
<td><strong>17.04</strong></td>
<td>51.62</td>
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<tr>
<td>BCR</td>
<td>2,165</td>
<td>51.3</td>
<td>0.89</td>
<td><strong>7.46</strong></td>
<td>15,173.0</td>
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\[ T^e = 30 \text{ and } \delta = 0.1 \, (10\%) \]
Representativeness of the Evidence
(Relative to R&D Spending)

- Public R&D is substantially over-represented, whereas private R&D is heavily under-represented.

- High and upper-middle income countries are slightly under-represented, whereas lower-middle and low income regions over represented.
  - A few countries are heavily over-represented in the evaluation evidence, notable the United States, Canada, Australia, New Zealand, and the United Kingdom.

- Three crop categories, wheat, corn and other cereals (including sorghum, millet, barley and oats), are over-represented, whereas rice, fruits, vegetables and nuts, and livestock (including poultry) are under represented.

- CGIAR centers account for about 10% of the evaluations (and around 18% of the studies) even though CGIAR spending ($14.3 billion from 1980 to 2011) accounted for just 1.01% of the corresponding CGIAR plus domestic public and private sector spending.
Talk Topics

- Are the returns to agricultural R&D declining, and development dependent? **No**

- What would be the returns to global agricultural R&D if we all headed Griliches? **Yes, but.....**
  
  \[\text{Median IRR} = 17\%py \text{ (vs } 39\%py)\]
  
  \[\text{Median BCR} = 7.5:1\]

- Is the existing evidence “representative” of the sector it purports to evaluate? **No, but.....**
<table>
<thead>
<tr>
<th>Output: Data set</th>
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<tbody>
<tr>
<td>CIMMYT maize</td>
</tr>
<tr>
<td>CIMMYT wheat</td>
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<tr>
<td>G2F maize</td>
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</table>

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<thead>
<tr>
<th>Location Series Trial Mgmt Condition Phenotype Socioeconomic Aggregate stats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global By Country By Series By Trial By Investigator By Seed Variety By Seed Source Germplasm Genotype Matrix Phenotype Socioeconomic Mousing</td>
</tr>
</tbody>
</table>

*Thanks*

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**Are Agricultural R&D Returns Declining and Development Dependent?** (2017)

**Recalibrating the Reported Returns to Agricultural R&D: What if We All Heeded Griliches?** (2017, forthcoming)

**Agricultural R&D is on the Move** (2016)

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[www.instepp.umn.edu](http://www.instepp.umn.edu)