Rethinking Realizing Value from Genetic Resources

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**Genebank Benefits vs Costs**

Estimating the marginal benefits of conserving each type of genebank accession is an important, but particularly difficult, task.

In part because attributing an appropriate part of the agronomic improvement in a plant to the use of conserved germplasm is a daunting, if not intractable, inferential challenge.

- Cost data are estimable, at least in principle, from historical data relevant to existing genebank operations.
- If the total and marginal costs of the genebank operations are judged to be less than any reasonable lower-bound estimate of the corresponding benefits, then it may not be necessary to confront the challenge of precisely estimating the latter to establish the economic justification of the genebank operation.
The Value in Genes

Existence Value

- Benefits from knowing a particular environmental resource, endangered species, or seed variety **exist**
  
  *Quantification: Willingness to pay*

Use Value

- The economic (and other, often related, e.g. environmental or health) benefits from using a **variety/gene** (trait discovery, breeding, etc)
  
  *Quantification: R&D evaluation evidence (with attribution issues)*

Option Value

- The benefit derived from using a **variety/gene sometime in the future**
  
  *Quantification: R&D evaluation evidence (with attribution issues)*
Genetic Resources—Existence and Options Value

Time Inconsistencies

Conservation costs being borne now

Option values being realized sometime in the future

USD 34 million a year to fund a global system for the conservation of crop diversity.
Attributing Value/Benefits (Benefit Sharing)

Pioneer 2375 (MN 1989, hard red spring wheat)
Almost one-quarter of the 133 documented nodes in this pedigree developed or discovered prior to 1920 (60 years before release)

- Half the nodes predate 1960
- Agglomeration of material from distant nodes (5.3% from Minnesota)

**Pioneer 2375** (MN 1989, hard red spring wheat)
The CGIAR provides 80% of the germplasm exchanged globally by the public sector in the frame of the International Treaty on Plant Genetic Resources on Food and Agriculture.

Over 80% of these samples went to developing countries and countries with economies in transition.

Prime facie evidence of use value, but........
Genetic Resources—Use Value

- 3,426 rate-of-return estimates
- 492 published studies
- Period, 1958 and 2015
- Nearly three quarters published since 1990

<table>
<thead>
<tr>
<th>Category</th>
<th>Yield enhancement, Pest and Disease management</th>
<th>Other technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other crops</td>
<td>50.9%</td>
<td>49.1%</td>
</tr>
<tr>
<td>Wheat</td>
<td>51.6%</td>
<td>48.4%</td>
</tr>
<tr>
<td>Maize</td>
<td>59.5%</td>
<td>40.5%</td>
</tr>
<tr>
<td>Oil crops, fodder, pulses</td>
<td>63.0%</td>
<td>37.0%</td>
</tr>
<tr>
<td>Millet &amp; sorghum</td>
<td>58.7%</td>
<td>41.3%</td>
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<tr>
<td>Rice</td>
<td>44.1%</td>
<td>55.9%</td>
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<tr>
<td>Fruits, veg. &amp; nuts</td>
<td>44.8%</td>
<td>55.2%</td>
</tr>
<tr>
<td>Roots &amp; tubers</td>
<td>36.1%</td>
<td>63.9%</td>
</tr>
</tbody>
</table>
Genetic Resources—Use Value

The returns on investment are large
- IRR (Internal rate of return) mean of 63.2 percent per year
- MIRR (Modified internal rate of return) mean of 14.3 percent per year
- BCR (Benefit cost ratio) mean of 27:1

Time structure of the returns to R&D
- The returns to contemporary R&D investments are as high as ever (no signs of a reduction in the returns to ag R&D over time)

Developed vs developing country returns
- Median reported IRR for developing countries (41.1%py) is greater than the median for developed countries (34.0%py).
- This difference must be taken with a grain of salt because of substantial developing- versus developed-country differences in the composition of the evaluation evidence such as who performed the evaluation, how it was performed and what was evaluated.
The Shifting (or Shifted!) Structure of Global Food & Agricultural R&D

Agricultural R&D is on the move

Big shifts in where research and development in food and agriculture is carried out will shape future food production, write Philip G. Pardey and colleagues in Nature...
Public Agricultural R&D Spending Worldwide, 1961 & 2011

Source: Pardey et al. (2016).
Spending Slices of the Global Ag & Food R&D Pie, 2011

**Public**
- Asia excl. China and India, 7.4%
- SSA, 6.1%
- ROW, 84.8%

**Total**
- CGIAR, 1.0%
- Asia excl. China and India, 5.2%
- SSA, 3.8%
- ROW, 90.0%

**Private**
- Asia excl. China and India, 2.5%
- SSA, 1.1%
- ROW, 96.5%

**Total**
- CGIAR, 1.7%
- Asia excl. China and India, 5.2%
- SSA, 3.8%

**Public**
$38.8$ bil.

**Private**
$31.1$ bil.

**Total**
$69.9$ bil.

Source: Pardey et al. (2016).
Rising Private Sector Participation

Source: Pardey et al. (2016).
Private R&D to the (low-income country) Rescue?

<table>
<thead>
<tr>
<th>Year</th>
<th>High income</th>
<th>Middle income</th>
<th>Low income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td></td>
<td></td>
<td>12.9%</td>
</tr>
<tr>
<td>1985</td>
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<td></td>
<td></td>
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<td>1990</td>
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<td>2000</td>
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<td></td>
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<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>52.5%</td>
<td>36.8%</td>
<td>12.9%</td>
</tr>
</tbody>
</table>
Private R&D to the (low-income country) Rescue?

- R&D spending highly concentrated geographically, 2011
  - Top 10 countries – public 60.5% (total 69.6%)
  - Bottom 100 countries – public 12.2% (total 9.2%)
Rethinking the Value Proposition

From Genebank Accessions to Genes to Traits

DARTseq: A generic genotyping by sequencing platform routinely applied to hundreds of crops species as well as animals and microbes

>5,000 sweet potato accessions (CIP)

>30,000 maize accessions (CIMMYT)

>60,000 maize accessions (CIMMYT)

>4,000 cassava accessions (CIAT)

Most of WorldFish’s organisms
Rethinking the Value Proposition

Genetic Value Chains

- **Accelerate** gene/trait discovery

- **Expand the scope** of gene/trait discovery
  - Yield enhancing
  - Yield preserving (biotic and abiotic stresses)
  - Quality improving

- Better **targeting** of technology deployment
Rethinking the Value Proposition

Genetic Value Chains

- Requires an **INTEGRATED** and **informatics-enabled** approach to genetic curation, gene sequencing, gene discovery, and gene deployment

- **For the first time in history**, the technical capabilities are now available, but need to be deployed, along with
  
  - Institutional innovations
    - Genetic value chains
      - Breakdown the genebank-breeding divides
      - Leverage public-private opportunities
    - Geographical spillovers
  
  - Investment innovations—aligning incentives, benefits and costs
    - Programmatic approaches
    - Pre-commercial public-private R&D
Thanks

www.instepp.umn.edu