Harvesting Prosperity: Technology and Productivity Growth in Agriculture

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World Bank Productivity Project

The Productivity Project: www.worldbank.org/productivity
What’s at stake?
Agricultural Productivity: Central to Growth, Poverty Reduction, Equity Agendas, AND Environmental Sustainability

- **Extreme Poor**: 2/3 work in farming
- **Poverty**: Productivity growth in agric. has greatest impact of any sector
- **Global undernourishment**: remains significant and is on the rise
- **Climate change**: will hit agric. hardest where largest numbers of poor live
- **Convergence**: impeded by slow agric. productivity growth in poorest countries

Source: Ivanic & Martin (2018)
What drives agricultural growth?
Ag. growth is increasingly productivity-dependent
But... TFP growth slow in key high-poverty regions.

Average Annual TFP Growth Rate, 1971-2015

Source: USDA-ERS  On-line database
What impedes productivity growth?
Decomposing Growth and Total Factor Productivity (TFP)

Key policy drivers:
- Research & development
- Enabling environment for innovation and technology adoption
- Factor market reforms
- Nonfarm employment growth

- Price policies and incentives
- Credit policies
- Market infrastructure
- Irrigation investment
- Land policies
- Trade policies
- Exchange rates

Input intensification
- Reallocation to more productive farms
- Productivity growth on existing farms
- Entry/exit of farms

Terms of trade and price effects

Irrigation expansion

Area growth

Value growth
Real output growth
Yield growth
TFP growth
Revisiting an old debate: where should policies to raise productivity focus?

Dynamic sector with growth & poverty reduction potential

- Raising agricultural productivity is key to stimulating inclusive economic growth
- Farmers are resource efficient – “poor but efficient” – optimizing subject to constraints they face
- Need public investment in new technology for growth

Misallocation of resources

- Smallholder agricultural is a drag on development
- Too much labor is tied up in low-productivity farming
- Imperfect factor markets prevent resource reallocation (labor out of agric.; land to most efficient farmers)
Labor Misallocation? Ag/Non-Ag gap in labor productivity is not large when measured correctly.

In fact average productivity is a *faux amis*: Need to look at *Marginal not Average Productivity* - we find wages broadly equated in India.
Land Misallocation? Rapid Productivity growth observed in large and small farms

Labor Productivity vs. Farm Size

Source: Rada and Fuglie 2019.

Note: TFP = total factor productivity. The lines compare productivity among farms of different sizes, and how those productivity differences have evolved over time, within a country. However, the lines should not be interpreted as comparing TFP across countries (they do not compare agricultural TFP between Bangladesh and Brazil, for example).
Supply Side: Investment in Knowledge generation and diffusion – The key driver of productivity

The Research Investment Gap

- High Rates of return to R&D= 30-40%
- R&D/worker: 50X higher in ACs than DCs.
- R&D/GDP: 6X higher in ACs than DCs.
  - Rising in LA, Asia, (China, South Asia)
  - Falling in Africa, Southeast Asia
  - R&D falling in half of African countries

Focus on invention, adaptation and dissemination of new technologies

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Agricultural research intensity</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>R&amp;D/GDP (%)</td>
<td>Trend</td>
<td>R&amp;D/Land ($/Ha)</td>
<td>R&amp;D/Ag labor ($/worker)</td>
</tr>
<tr>
<td>Public agricultural R&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAC</td>
<td>1.06</td>
<td>↑</td>
<td>25</td>
<td>107</td>
</tr>
<tr>
<td>Brazil</td>
<td>1.65</td>
<td>↑</td>
<td>31</td>
<td>174</td>
</tr>
<tr>
<td>W Asia/N Africa</td>
<td>0.49</td>
<td>↑</td>
<td>27</td>
<td>80</td>
</tr>
<tr>
<td>China</td>
<td>0.73</td>
<td>↑</td>
<td>47</td>
<td>40</td>
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<tr>
<td>SE Asia</td>
<td>0.34</td>
<td>↓</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>South Asia</td>
<td>0.30</td>
<td>↑</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>SSA</td>
<td>0.38</td>
<td>↓</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Developing countries</td>
<td>0.52</td>
<td>↑</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>Developed countries</td>
<td>3.25</td>
<td>↓</td>
<td>5</td>
<td>1,311</td>
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<tr>
<td>Private agricultural R&amp;D</td>
<td>0.25</td>
<td>↑</td>
<td>8</td>
<td>14</td>
</tr>
</tbody>
</table>
Increasing R&D: New opportunities, but new challenges

### Strengthening the Public sector
- Increase, stabilize & diversify funding
- Incentivize scientists and strengthen U’s and PRIs
- Align priorities with user needs
- Partner with foreign & intern’l research

<table>
<thead>
<tr>
<th>Country</th>
<th>Total ag R&amp;D spending (mil $)</th>
<th>Private sector share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>272</td>
<td>19</td>
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<tr>
<td>Brazil</td>
<td>2,719</td>
<td>14</td>
</tr>
<tr>
<td>China</td>
<td>5,730</td>
<td>25</td>
</tr>
<tr>
<td>India</td>
<td>1,140</td>
<td>25</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>80</td>
<td>26</td>
</tr>
<tr>
<td>Kenya, Senegal, Tanzania &amp; Zambia</td>
<td>159</td>
<td>8</td>
</tr>
<tr>
<td>USA</td>
<td>9,960</td>
<td>59</td>
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</tbody>
</table>

### Mobilizing the Private Sector
- Market Liberalization
- Regulatory reform
- Intellectual Property Rights
- Catalytic & Complementary Public R&D
The technology adoption paradox: why don’t farmers adopt new technologies if returns are so high?

Agricultural Input Use in 2015

- Fertilizer
- Irrigation
- Tractors

Region:
- East Asia
- South Asia
- West Asia & North Africa
- Latin America
- Sub-Saharan Africa
The Demand side: Multiple constraints restrict small farmers in adopting new and profitable technologies

Enabling Environment
- Remove policy biases against agriculture
- Secure land tenure rights
- Improve agricultural advisory services
  - Digital extension
- Help farmers manage risk
  - Weather index insurance?
- Improve access to finance
- Improve access to markets
  - Reduce marketing margins
  - Rural roads; competitive market services

Human Capital - Capabilities
- Literacy and numeracy - basic
- Managerial: technical, financial and risk management; marketing and negotiation skills

Digital technologies offer cheaper, more ubiquitous ways of achieving these goals.

But...require capabilities and coordination that are a challenge for many countries
Government’s need to work on multiple fronts

Government Oversight and Resolution of Market Failures

SUPPLY

EDUCATION AND TRAINING SYSTEM

AVAILABLE LAND, IMPORTED OR DOMESTICALLY PRODUCED INPUTS

RESEARCH AND INNOVATION SYSTEM

NATIONAL

INTERNATIONAL

PUBLIC/PRIVATE

QUALITY AND STANDARDS

ACCUMULATION/ALLOCATION

H Human capital

K Land, physical capital, and inputs

A Knowledge

BARRIERS

LAND AND LABOR MARKET RIGIDITIES

INFORMATION BARRIERS

LACK OF FINANCE AND RISK DIFFUSION MARKETS/INSTRUMENTS

BUSINESS/REGULATORY CLIMATE

CONTRACTING ENVIRONMENT, LAND RIGHTS

INFRASTRUCTURE

INNOVATION AND SELF- DISCOVERY EXTERNALITIES, INTELLECTUAL PROPERTY RIGHTS

DEMAND

The farm/Lead firm in the value chain

INCENTIVES TO ACCUMULATE FACTORS OF PRODUCTION

MACRO CONTEXT/VOLATILITY

COMPETITIVE STRUCTURE

ACCESS TO MARKETS, TRADE REGIME, AND INTERNATIONAL NETWORKS

FDI REGULATIONS

FARMER CAPABILITIES

CORE COMPETENCIES (MANAGEMENT)

HIGHER-ORDER TECHNOLOGY CAPABILITIES
With limited capabilities, what are the options?

- Reduce the dimensionality of the problem
  - Identify truly binding constraints in local contexts
  - E.g.: in rainfed environments, risk management is priority
- Experiment, evaluate, learn, innovate
- Employ incentives to involve private sector
  - Not enough public resources
  - Reduces demands on public capabilities and coordination
Promise of GVCs: help open markets and resolve market failures

- Structural changes in food & agric. markets
  - Rise of supermarkets; consumer demand for diverse, quality foods
  - Private quality standards, scale economies, global sourcing

- Value chains can help overcome market failures
  - Lead coordinating firm can provide access to markets and sources of credit, insurance, information
  - High transactions costs dealing with smallholder farmers
  - Again, policy/enabling environment matters
    - Contract enforcement, conflict resolution mechanisms
    - Barriers to entry, competition and bargaining power
Fortune favors the prepared - Pasteur

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