The Agricultural Productivity Gap in Developing Countries

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World Bank-GWU Conference on Urbanization and Poverty Reduction
Washington, DC
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Background

- In much of sub-Saharan Africa (and in many of the world’s poorest countries), large fractions of the population live in rural areas and work in quasi-subsistence agriculture.

- Productivity levels in this sector appear to be very low – both in absolute terms and relative to the non-agricultural sector.

- By contrast, in rich countries, productivity appears to be approximately equal across sectors.

- Ricardian comparative advantage suggests that countries should specialize in sectors that are relatively most productive, compared to the rest of the world.

- Why are so many people in poor countries working in a sector where they appear to be relatively so unproductive?
Does Mismeasurement Explain the Puzzle?

- One view is that we simply cannot believe the data.

- This paper attempts to measure the productivity gaps using the best available theory and data.

  - Are sectoral productivity differences merely illusory?

  - Can we improve measurement of productivity differences?

  - Do unexplained differences remain?
Agriculture Sector in Developing Countries

- Agriculture’s share of employment high

- Share of value added *systematically lower* than share of employment
Agriculture Sector in Developing Countries

Gollin, Lagakos, & Waugh (2013)
Agriculture Sector in Developing Countries

- Agriculture’s share of employment high

- Share of value added *systematically lower* than share of employment

- Implies that \( VA/L \) lower in agriculture than non-agricultural sector
The Agricultural Productivity Gap in Developing Countries

- We define the Agricultural Productivity Gap (APG) to be:

\[ APG \equiv \frac{VA_n/L_n}{VA_a/L_a}. \]

- Under some moderately restrictive assumptions, APG should be close to 1; this is a useful benchmark.

- Typical developing country has APG of 4. Some have 8 or more!

- But can we trust these highly aggregate numbers?
The Agricultural Productivity Gap in Developing Countries

- In a mechanical sense, the differences in sectoral productivity can “explain” a great deal of cross-country differences in GDP per worker. (Caselli, 2005; Restuccia et al, 2008; Vollrath, 2009)

- Taken at face value, gaps suggest misallocation.

- Policy debate: Encourage movement out of agriculture? Target agricultural sector for investments?

- This paper: refine the measurement of productivity gaps.
Possible Sources of Measurement Error

- Sector differences in hours worked per worker?
  Construct measures of hours worked by sector for 51 countries

- Sector differences in human capital per worker?
  Construct measures of human capital by sector for 98 countries

- Shortcomings of national accounts data?
  Use household income/expenditure surveys from 10+ countries
Possible Sources of Measurement Error

- Sector differences in hours worked per worker?
  
    Construct measures of hours worked by sector for 51 countries

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Preview of Results

- After adjustments, APG in average developing country reduced from 4 to 2.

- Gaps are present in micro data as well as macro aggregates.

- Needed: better understanding of why residual gaps so large.
Simple Two-Sector Model

- Technologies:
  \[ Y_a = A_a L_a^\theta K_a^{1-\theta} \] and \[ Y_n = A_n L_n^\theta K_n^{1-\theta} \]

- Households can supply labor to either sector.

- Competitive labor markets, i.e. workers paid their marginal product.

- Equilibrium: \( \text{APG} \equiv \frac{VA_n/L_n}{VA_a/L_a} = \frac{Y_n/L_n}{p_a Y_a/L_a} = 1. \)
Computing “Raw” Agricultural Productivity Gaps

- Measures of $VA_a$ and $VA_n$.
  
  Value added as defined in 1993 System of National Accounts (SNA).
  
  Source: World Bank, via country national accounts data.

- Measures of $L_a$ and $L_n$: "economically active population" by sector.
  
  Employed or unemployed persons who are working (or seeking work) in the production of some good or service recognized by the 1993 SNA.
  
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# Summary Statistics of Raw Agricultural Productivity Gaps

<table>
<thead>
<tr>
<th>Measure</th>
<th>Weighted</th>
<th>Unweighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th Percentile</td>
<td>1.7</td>
<td>1.1</td>
</tr>
<tr>
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<td>3.0</td>
</tr>
<tr>
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<td>3.6</td>
</tr>
<tr>
<td>95th Percentile</td>
<td>5.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Number of Countries</td>
<td>113</td>
<td>113</td>
</tr>
</tbody>
</table>
“Simple” Measurement Error in National Accounts Data?

- Understate agricultural VA by excluding output produced for own consumption?

  No in principle: it is included as per SNA.

  No in practice: output of particular crop = area planted x yield

- Overstate agricultural employment, by including all rural persons?

  No in principle: only economically active persons included per SNA.

  No in practice: national accounts consistent with household surveys.
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Gollin, Lagakos, & Waugh (2013)
Sector Differences in Hours Worked

- Average hours worked per worker might differ across sectors.

- We construct average hours worked per worker by sector for 51 countries.
  - Population census micro data or labor force surveys.
  - All employed or unemployed persons 15+ years old.
  - Industry of primary employment (employed); industry of previous employment or rural/urban status (unemployed).
  - Hours worked in reference period (usually one week).
Sector Differences in Hours Worked

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Agricultural Productivity Gap
WB-GWU Conference
Sector Differences in Hours Worked: Summary

- Explains on average a factor 1.2.
- Only a few countries above 1.5.
- Unlikely to be the main cause of APGs in developing countries.
Sector Differences in Human Capital

- Average human capital per worker could differ across sectors. (Caselli & Coleman, 2001; Vollrath, 2009)

- We construct human capital per worker by sector for 97 countries.
  - Years of schooling measured directly when available.
  - Impute years of schooling using educational attainment otherwise.
  - Baseline: assume 10% rate of return on year of schooling. (Psacharoplos & Patrinos 2002; Banerjee & Duflo, 2005)

\[ h_{j,i} = \exp(s_{j,i} \cdot 0.10) \]
Sector Differences in Human Capital

Gollin, Lagakos, & Waugh (2013)
Quality Differences in Schooling

- Rural schools often of lower quality than urban schools. (Williams, 2005; Zhang, 2006)

- Potentially *overestimate* human capital among agriculture workers.

- We use literacy data to adjust for schooling quality.
Uganda: Literacy by Years of Schooling Completed

![Graph showing literacy rate by years of schooling completed for non-ag workers and ag workers.]

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Measuring Quality Differences in Schooling

- Given literacy rates by years of schooling: \( \ell_n^i(s) \) and \( \ell_a^i(s) \) for \( s = 1, 2, ... \)

- Assume that each year in rural school is worth \( \gamma \) years in urban school

- For each country \( i \), solve for \( \gamma_i \) that solves

\[
\min \gamma \sum_{s=1}^{\bar{s}} \left( \tilde{\ell}_n^i(\gamma s) - \tilde{\ell}_a^i(s) \right)^2
\]

where \( \tilde{\ell}_n^i(\cdot) \), \( \tilde{\ell}_a^i(\cdot) \) are polynomial interpolations of \( \ell_n^i(\cdot) \), \( \ell_a^i(\cdot) \) for \( s \in [0, \bar{s}] \).
### Table 3: Rural-Urban Education Quality Differences

<table>
<thead>
<tr>
<th>Country</th>
<th>$\hat{\gamma}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>0.87</td>
</tr>
<tr>
<td>Bolivia</td>
<td>0.95</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.89</td>
</tr>
<tr>
<td>Chile</td>
<td>0.92</td>
</tr>
<tr>
<td>Ghana</td>
<td>0.90</td>
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<td>Guinea</td>
<td>0.62</td>
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<tr>
<td>Malaysia</td>
<td>0.93</td>
</tr>
<tr>
<td>Mali</td>
<td>0.89</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.77</td>
</tr>
<tr>
<td>Panama</td>
<td>0.87</td>
</tr>
<tr>
<td>Philippines</td>
<td>0.80</td>
</tr>
<tr>
<td>Rwanda</td>
<td>0.88</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1.25</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.90</td>
</tr>
<tr>
<td>Uganda</td>
<td>0.82</td>
</tr>
<tr>
<td>Venezuela</td>
<td>0.78</td>
</tr>
<tr>
<td>Vietnam</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>0.87</strong></td>
</tr>
</tbody>
</table>
Quality-Adjusted and Unadjusted Human Capital

Gollin, Lagakos, & Waugh (2013)
Agricultural Productivity Gap
WB-GWU Conference
Sectoral Differences in Quality-Adjusted Human Capital

Gollin, Lagakos, & Waugh (2013)

Agricultural Productivity Gap

WB-GWU Conference 26 / 40
Adjusting the Raw APG numbers

Recap:

- Differences in hours worked contribute a factor of 1.2.
- Differences in human capital contribute a factor of 1.4.

Now, put them all together and construct “adjusted” APGs.
### Adjusted Agricultural Productivity Gaps

<table>
<thead>
<tr>
<th>Measure</th>
<th>Complete Data</th>
<th>All Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th Percentile</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Median</td>
<td>2.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Mean</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>95th Percentile</td>
<td>3.9</td>
<td>3.9</td>
</tr>
<tr>
<td>Number of Countries</td>
<td>50</td>
<td>113</td>
</tr>
</tbody>
</table>
Agricultural Productivity Gap

Gollin, Lagakos, & Waugh (2013)
Comparing Macro and Micro Data on Sector Value Added

The idea:

- Cross check “macro” value added data (from national accounts) with “micro” data from household income/expenditure surveys.

The data:

- Use World Bank’s Living Standards Measurement Surveys (LSMS)
- Explicit goal of LSMS: household income and expenditure measures
Measuring Value Added from Micro Data

Agriculture:

\[ \text{VA}_a = \sum_{i} y_{SE,a} + \sum_{i} y_{L,a} + \sum_{i} y_{K,a}, \]

\[ y_{SE,a,i} = \sum_{j=1}^{J} p_j \left( x_{i,j}^{\text{home}} + x_{i,j}^{\text{market}} + x_{i,j}^{\text{invest}} \right) - \text{COSTS}_{a,i}, \]

Non-agriculture:

\[ \text{VA}_n = \sum_{i} y_{SE,n} + \sum_{i} y_{L,n} + \sum_{i} y_{K,n}, \]

\[ y_{SE,n,i} = \text{REV}_{n,i} - \text{COSTS}_{n,i}. \]

\[ i = \text{household} \quad \text{and} \quad j = \text{agriculture commodity}. \]
## Comparison of Macro and Micro APG

Agriculture Share of

<table>
<thead>
<tr>
<th>Country</th>
<th>Micro</th>
<th>Macro</th>
<th>Micro</th>
<th>Macro</th>
<th>Micro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia (1996)</td>
<td>34.2</td>
<td>36.8</td>
<td>32.8</td>
<td>0.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Bulgaria (2003)</td>
<td>14.1</td>
<td>11.7</td>
<td>18.4</td>
<td>1.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Cote d’Ivoire (1988)</td>
<td>74.3</td>
<td>32.0</td>
<td>42.1</td>
<td>4.7</td>
<td>4.0</td>
</tr>
<tr>
<td>Guatemala (2000)</td>
<td>40.2</td>
<td>15.1</td>
<td>18.7</td>
<td>3.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Ghana (1998)</td>
<td>53.9</td>
<td>36.0</td>
<td>33.3</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Kyrgyz Republic (1998)</td>
<td>56.9</td>
<td>39.5</td>
<td>39.3</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Pakistan (2001)</td>
<td>46.9</td>
<td>25.8</td>
<td>22.6</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Panama (2003)</td>
<td>27.0</td>
<td>7.8</td>
<td>11.8</td>
<td>4.4</td>
<td>2.7</td>
</tr>
<tr>
<td>South Africa (1993)</td>
<td>11.0</td>
<td>5.0</td>
<td>7.0</td>
<td>2.3</td>
<td>1.7</td>
</tr>
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</table>

Gollin, Lagakos, & Waugh (2013)
## Income and Expenditure Per Worker and APGs

<table>
<thead>
<tr>
<th>Country</th>
<th>APG Micro</th>
<th>Income per Worker Ratio</th>
<th>Expenditure per Worker Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia (1996)</td>
<td>1.1</td>
<td>0.7</td>
<td>0.9</td>
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<tr>
<td>Bulgaria (2003)</td>
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<td>1.4</td>
<td>1.2</td>
</tr>
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<td>Cote d’Ivoire (1988)</td>
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<td>3.5</td>
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<td>Tajikistan (2009)</td>
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</table>
Different Labor Shares Across Sectors?

Production functions with different labor shares

\[ Y_a = A_a L^\theta_a K^{1-\theta_a} \quad \text{and} \quad Y_n = A_n L^\theta_n K^{1-\theta_n} \]

In equilibrium

\[ APG = \frac{Y_n/L_n}{p_a Y_a/L_a} = \frac{\theta_a}{\theta_n} \]

Macro evidence on \( \theta_a, \theta_n \)

- Employment share of agriculture varies a lot across countries;
- Aggregate labor share of GDP doesn’t, Gollin (2002) \( \Rightarrow \) \( \theta_a \approx \theta_n \)

Micro evidence on \( \theta_a, \theta_n \)

- Sharecropping arrangements suggest \( \theta_a \approx 0.5 \)
- Econometric estimates: \( \theta_a \approx 0.5 - 0.6 \)

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Cost-of-Living Differences

Purchasing power of nominal wages could differ in urban and rural areas

- APG$>$1 could reflect lower cost of living in rural (agricultural) areas

Chen, Ravaliion and Sangraula (2009): urban-rural COL differentials

- Estimates of urban-rural COL for household earning $1 per day

Average country: urban-rural cost of living differential of 1.3.

- Not ideal for various reasons,
- But suggestive that this is not sufficient to close the gap.
Cost-of-Living Differences

Gollin, Lagakos, & Waugh (2013)
Conclusion

- Typical developing country has large agricultural productivity gap
- Better measurement reduces gap from around 4 to around 2
- Large gaps also present in household survey data
- Needed: better understanding of why residual gaps so large
Why are Residual Gaps So Large?

- Yet more measurement error – Herrendorf and Schoellman (2011)

- Selection of more productive workers out of agriculture
  – Lagakos and Waugh (2012)

- Risk of migrating?
  – Harris and Todaro (1971), Bryan, Mubarak, Chowdhury (2011), others

- Other disutility of urban areas (social alienation? crime? pollution? decline in relative social status?)
### Individual Hours Worked By Sector

<table>
<thead>
<tr>
<th>Country</th>
<th>Worker Classification</th>
<th>Sector of Hours Worked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Agriculture</td>
</tr>
<tr>
<td>Cote d'Ivoire (1988)</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
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</table>

**Note:** Workers are classified by sector according to their primary sector of employment. Hours are classified by sector of job for each of the workers' jobs.
Agriculture Sector in Developing Countries

Gollin, Lagakos, & Waugh (2013)