Lecture 5: Agricultural Data
STEG's Course: Data in Macro-Development

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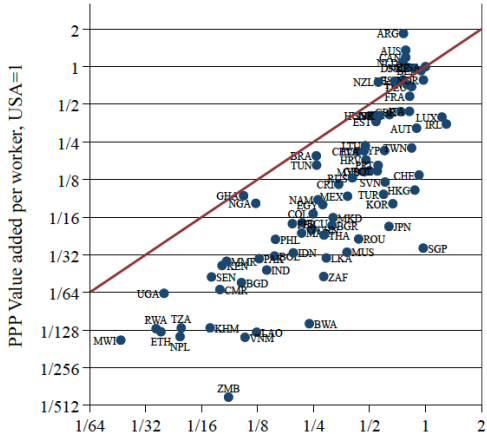
Why study Agriculture?

- A quarter of the world's population works in agriculture.
- Agriculture accounts for more than a third of the labor force in Africa and Asia.
  $\approx$ a fifth of the labor force in middle income countries.
- Process of economic development accompanied
  - Δ Production from own consumption towards market,
  - Labor reallocation out of agriculture into non-agriculture.
- Cross-country agriculture productivity differences largest among sectors. Caselli '05, Restuccia et.al. '08

Why study Agriculture?

productivity gaps are larger than elsewhere, Herrendorf et.al. '22

Productivity Gaps in Agriculture vs. Aggregate in 2017



Source: Productivity Level Database, 2023, GGDC

Main questions

What are the sources of cross-country agricultural productivity differences?

Are average disparities driven by heterogeneity within countries and misallocation?

Is agricultural productivity growth required for economic development?

Main questions

What are the sources of cross-country agricultural productivity differences?

Accounting

Are average disparities driven by heterogeneity within countries and misallocation?

Measurement challenges, drivers

Is agricultural productivity growth required for economic development?

Old and current debate: push and pull effects

Plan for today

From macro to micro, measurement and challenges

1. Cross-country agricultural productivity differences.
2. Sectorial Gaps.
3. The micro. Heterogeneity within agriculture.

Basic Data Sources

1. Across countries
   - Aggregate series: GGDC, FAOSTAT, USDA-ERS, World Census of Agriculture
   - Household surveys with rural coverage: DHS, LSMS, LSMS-ISA(Africa)
   - Sectorial investment and capital: KLEMS; Larson et.al. '00.; Caunedo-Keller, '21.
   - Geological/Climate data: EarthSTAT, Agro-Maps
   - Weather data: IMERG, GISTEMP

2. Country-specific
   - Representative: Agricultural Census.
   - Surveys w/rural coverage, e.g. ICRISAT (India/Bangladesh); MANY primary data collection efforts from micro-interventions.

Agricultural Productivity Accounting

$$\frac{Y_{it}}{N_{it}} = A_{it} \frac{1}{N_{it}^{1-\alpha_k-\alpha_n-\alpha_l}} \left(\frac{K_{it}}{N_{it}}\right)^{\alpha_k} \left(\frac{L_{it}}{N_{it}}\right)^{\alpha_l}.$$

country i time t

- Real output, PPP agricultural prices Prasada Rao, '93/FAOSTAT
- Factor shares, Fuglie '15/USDA-ERS/FAOSTAT
- Land L, cropland and permanent pasture Fuglie '15
- Labor N, salaried labor
- Average employment per farm Adamopolous & Restuccia, '14.
- Capital Fuglie '15 $\approx$ Larsson et al. '00/FAOSTAT; Caunedo& Keller 2021.

Biggest challenge $\rightarrow$ we don't have Penn World Tables!

Agricultural Productivity Accounting

Labor input

$$\frac{Y_{it}}{N_{it}} = A_{it} \frac{1}{N_{it}^{1-\alpha_k-\alpha_n-\alpha_l}} \left(\frac{K_{it}}{N_{it}}\right)^{\alpha_k} \left(\frac{L_i}{N_{it}}\right)^{\alpha_l}.$$

country i time t

Comments:

- very much available, GGDC, FAOSTAT, IPUMS
- can be linked to measures of human capital.

Challenges: how to properly account for self-employment?
key input in family-farming.

Gollin, '02

Agricultural Productivity Accounting

Capital input

$$\frac{Y_{it}}{N_{it}} = A_{it} \frac{1}{N_{it}^{1-\alpha_k-\alpha_n-\alpha_l}} \left(\frac{K_{it}}{N_{it}}\right)^{\alpha_k} \left(\frac{L_i}{N_{it}}\right)^{\alpha_l}.$$

country i time t

Comments:

- Larson et.al. '00. uses international prices, whereas FAOSTAT does not.
- Machinery series in FAO have been discontinued.

Challenges:

- Heterogeneity in the capital types,
- proper measurement of rental costs? asset values?
- how to properly account systematic disparities in quality, potentially large contributor to productivity differences, Caunedo-Keller, '21

Agricultural Productivity Accounting

Land input

$$\frac{Y_{it}}{N_{it}} = A_{it} \frac{1}{{N_{it}}^{1-\alpha_k-\alpha_n-\alpha_l}} \left(\frac{K_{it}}{N_{it}}\right)^{\alpha_k} \left(\frac{L_i}{N_{it}}\right)^{\alpha_l}.$$

country i time t

Comments:

- FAOSTAT offers standard measures of arable land.
- Fuglie '15 differentially aggregates pasture and cropland.
- Other quality adjustments can be obtained from Agro-Maps.

Challenges:

- Are potential yields ever realized? Adamopolous & Restuccia, '22 role of climate change
- proper measurement of rental costs? asset values?
- Do distortions in land markets affect returns and services? Adamopolous & Restuccia, '14

Agricultural Productivity Accounting

Factor Shares

$$\frac{Y_{it}}{N_{it}} = A_{it} \frac{1}{N_{it}^{1-\alpha_k-\alpha_n-\alpha_l}} \left(\frac{K_{it}}{N_{it}}\right)^{\alpha_k} \left(\frac{L_i}{N_{it}}\right)^{\alpha_l}.$$

country i time t

$$\alpha_k = \frac{r_k K}{Y} \qquad \alpha_l = \frac{r_l L}{Y} \qquad \alpha_n = \frac{WN}{Y}$$

Comments:

- estimates available in rich countries,KLEMS or via extrapolation Fuglie '15
- rental rates are key.

$$p_{it} = \frac{1}{R_t}[r_{it+1} + (1-\delta_i)p_{it+1}. \qquad \rightarrow r_i = p_{it}\left[R_t - (1-\delta_i)\frac{p_{it+1}}{p_{it}}\right]$$

Challenges:

- need more data on prices! particularly in poor countries

Development Accounting Accounting

	$\frac{(\frac{y}{n})^d_{US,2011-2014}}{(\frac{y}{n})^d_{c,2011-2014}}$	% AGRICULTURAL VA DIFFERENTIAL WRT US EXPLAINED BY:				
		$q_{\widehat{j}}$	$\frac{\tilde{k}}{n}$	$\frac{l}{n}$	n	SUM
Brazil	5.4	38.5%	1.9%	46.6%	13.1%	100.0%
China	30.3	49.6%	10.5%	40.3%	-6.2%	94.2%
India	64.5	19.6%	4.5%	31.2%	-1.8%	53.6%
Mexico	16.6	12.6%	6.0%	33.6%	9.3%	61.6%
Average		30.1%	5.7%	38.0%	3.6%	77.3%

Differences in value per worker to the US

- 12% and 50% from capital quality.
- 2% to 10% from capital-per-worker.
- 30%-47% from average farm size.*

*$\approx$ 50% in Adamopolous & Restuccia, '14

Development Accounting Accounting

- Value added accounting vs. Gross output accounting?
- Δ intermediate input usage $\rightarrow$ productivity differences,
  - in agriculture Donovan, '17
  - more generally Fadinger, et.al. '22
- Until today, best estimates available based on Prasada Rao '93.
  - dated.
  - handful of intermediates.

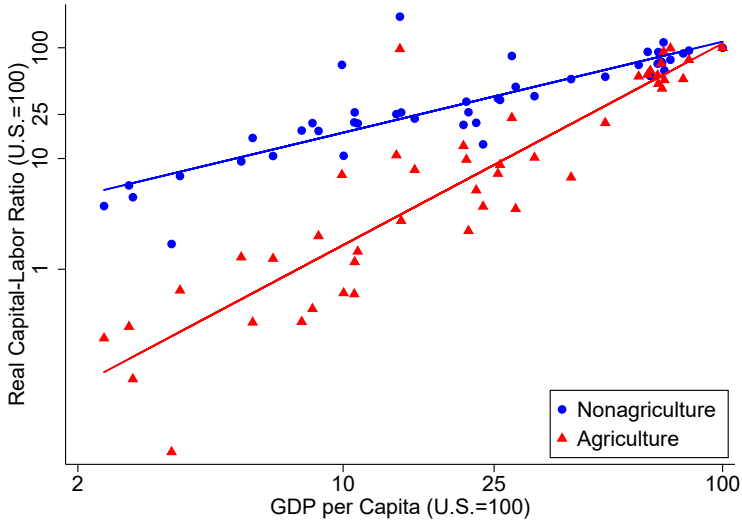
Technology in agriculture

Is a constant factor share technology adequate?

- In the US time-series, the evidence suggests capital and labor are substitutable in agriculture, Alvarez-Cuadrado & Poshcke, '11; Herrendorf et.al. '15.
- Across countries, the evidence also suggests capital intensification, Chen, '20 and substitutability, Boppart et.al. '23.
- Micro data, also suggests substitutability, Caunedo & Kala, '23.

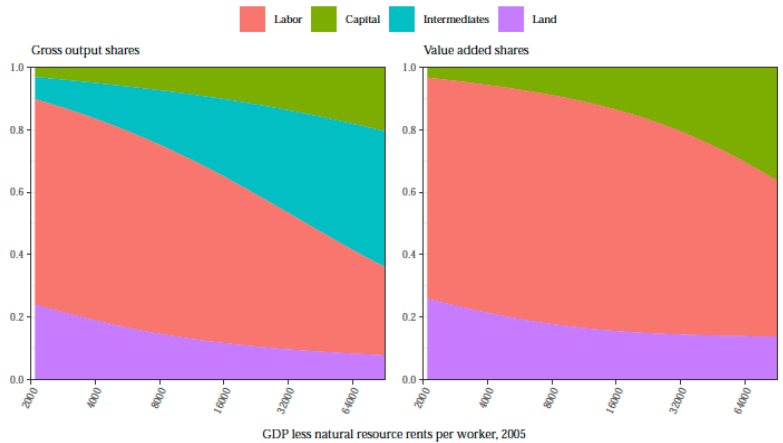
Capital-Labor ratios

Chen, '20



Technology agriculture,

Lower capital/intermediates share in poor countries, Boppart et.al. '23



Sectorial Productivity Gaps

Sectorial Productivity Gaps

- Output per worker gaps across countries are the largest in agriculture. $\rightarrow$

$$\frac{Y_{ag}}{N_{ag}} / \frac{Y_{nag}}{N_{nag}}_{poor} > \frac{Y_{ag}}{N_{ag}} / \frac{Y_{nag}}{N_{nag}}_{rich}$$

Caselli '05, Restuccia et.al. '08

Persists after adjusting for quality of labor and value added Gollin et.al. '14

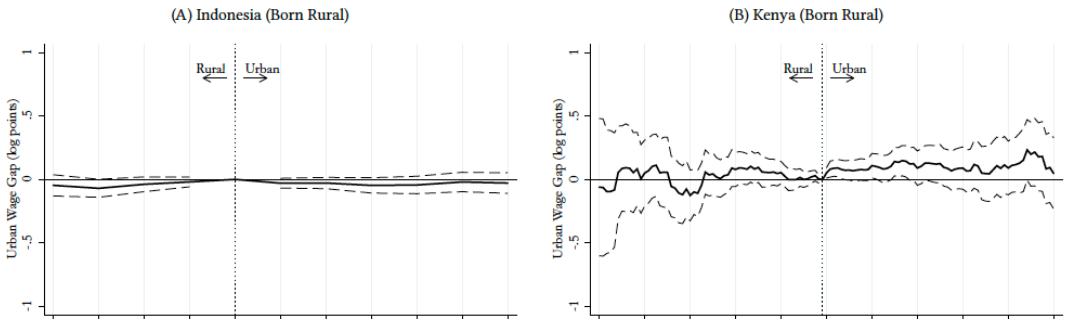
- *Does this imply misallocation?*
- Key distinction: Average labor productivity $\neq$ to marginal labor productivity. $\rightarrow$ hard to measure!
- Differential distortions, factor intensities and worker selection may drive average productivity gaps across sectors.

Sectorial Productivity Gaps

Little gaps in "marginals" from worker panels Hamory et.al., '21

Similar evidence in Alvarez, '20

Figure 4: Event Study of Urban Migration

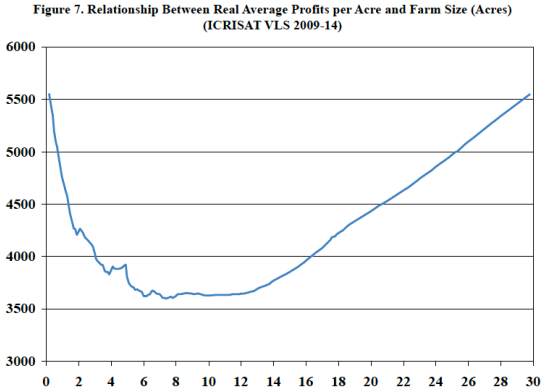


The Micro.

Heterogeneity

Productivity differences across farms

U-shape relationship in profits and output per worker, ICRISAT

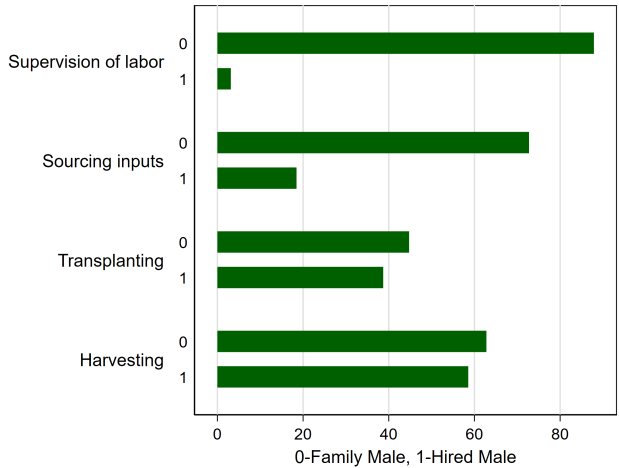


- Left tail: economies of scale
- Right tail: frictions (labor?)

Foster & Rosenzweig, '22

Moral hazard labor

Share of tasks performed by ...Caunedo & Kala, '23



Productivity differences across farms

Profitability

$$\pi_i = \text{revenue} - \text{costs}$$

- Which revenue? Home production?
- Which costs? variable costs? rents to fixed factors?

stay tuned for primary data collection module

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Productivity measures

- TFP measures (ideal). These are hard!
- Compromise: output per worker or revenue per worker/ per ha.
- Yields? aggregation? output prices?

Productivity differences across farms

- Measuring farm productivity

$$Y_{it} = \exp(z_{it}) K_{it}^{\alpha_{it}^k} N_{it}^{\alpha_{it}^n} L_{it}^{\alpha_{it}^l}$$

farm i at time t.

Restrictions on technology, α constant either along i or t or both.

- Estimate in logs

$$y_{it} = z_{it} + \alpha^k k_{it} + \alpha^n n_{it} + \alpha^l l_{it}$$

Key issue: TFP z_{it} is unobserved and inputs are correlated with it.

$\rightarrow$ randomized variation in inputs fails excludability restriction if technology shifts.

Caunedo & Kala, '23

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Caunedo & Kala, '23

- Standard Tools, useful data LSMS-ISA

Productivity differences across farms

- Why is TFP useful?
  Benchmark productivity gains in a wide-variety of models.

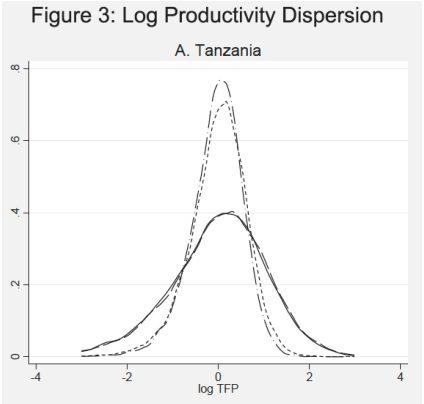
- If technologies are identical across farms (α) cost-minimization $\rightarrow$

$$l_{it} \approx n_{it} \approx k_{it} \approx \boldsymbol{z_{it}} \qquad \text{and} \qquad \frac{y_{it}}{n_{it}} = \frac{y_t}{n_t}$$

- So is dispersion a symptom of misallocation or measurement error?
  - Gollin & Udry, '21 argue measurement error
    Identification: household panel data $\rightarrow$ farmers produce the same crop in multiple plots.

Productivity measures vs. measurement error

little role for misallocation, Gollin & Udry, '21

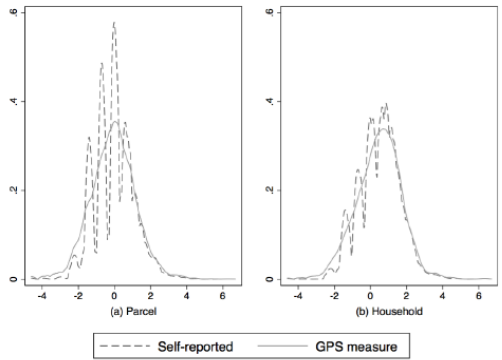


Less dispersion: TFP corrected from measurement error and risk.

Is it the plot or the farm the unit of analysis?

imputation to the plot level may induce measurement error, Aragon, '24

Figure 2: Self-reported and GPS-measured parcel and farm size



Ex-ante vs. Ex-post productivity

- Farming is risky:
  - Yields are sensitive to the timing of ag. activities, Caunedo et.al. '22
  - Weather shocks may shift ex-ante "optimal" outcomes.
    e.g. LSMS-ISA post-planting, post-harvest surveys

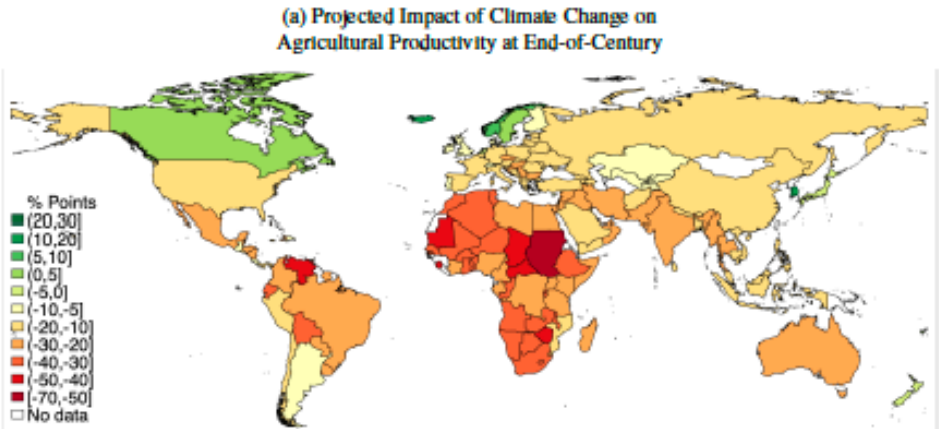
- Inability to insure against risk shifts
  - inputs decisions, Donovan, '17
  - technology choices, Mobarak & Rosenzweig, '13
  - value of irrigation and storage technologies?

- Complementarities: market access and infraestructure.

- Adaptation:
  - crops and technologies suitable in rich countries may fail in poor countries.
  - differential costs of climate change.

Differential costs of climate change

costs from extreme weather concentrated in ag sector/poor countries Nath, '23



Conclusion

- Hard to study the process of development without understanding agriculture.
- Measuring productivity is challenging but full of opportunities.
- Standard measures are good benchmarks, ... still room for improvement!
  - start-ups in poor countries are increasing data availability.
  - opportunities for harmonization of existing surveys.
  - links between climate and ag. outcomes.

Questions?