

The Size Distribution of Farms and International Productivity Differences

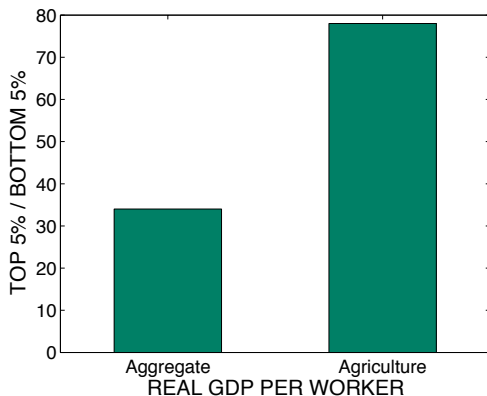
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Agricultural Labor Productivity

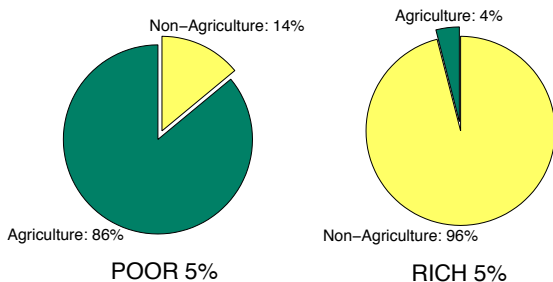
- Poor countries are particularly unproductive in agriculture ...



Source: PWT, FAO

Agricultural Employment Shares

- ... and poor countries devote most of their labor to agriculture.



Source: FAO

Our Idea

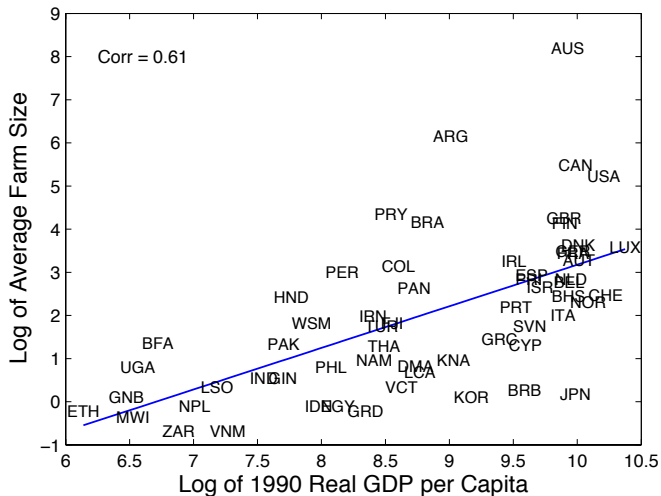
misallocation of resources across farms of different sizes
⇒ low agricultural productivity

(low agricultural productivity + subsistence constraint
⇒ high share of employment in agriculture)

Why study this channel?

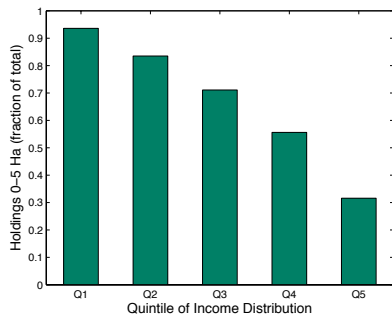
- 1 Poor countries have many small farms, compared to rich.
- 2 Larger farms tend to have higher labor productivity.
- 3 Poor countries have a lot of policies/institutions that encourage “smallness” in agriculture.

Average Farm Size Across Countries

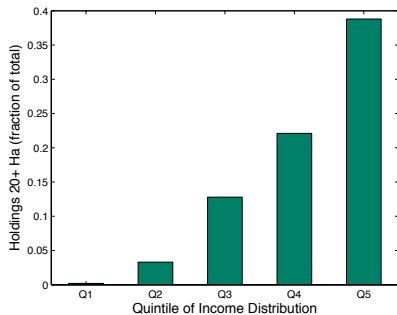


Size Distribution of Farms

Small (≤ 5 Ha)



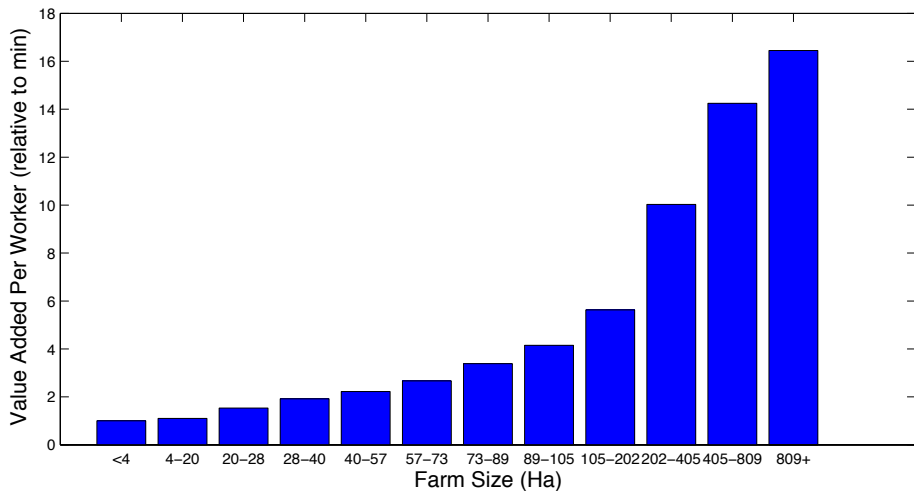
Large (> 20 Ha)



Why study this channel?

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Labor Productivity, U.S. Census of Agriculture



Why study this channel?

- 1 Poor countries have many small farms, compared to rich.
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Farm-Size Distortions

- Land reforms that cap size (e.g., Philippines, Bangladesh).
- Progressive land taxes (e.g., Pakistan, Brazil).
- Input subsidies to smallholders (e.g., Kenya, Malawi).
- Land sales restrictions (e.g., Ethiopia, Japan).
- Land rental restrictions (e.g., India, Korea).
- Output quotas (e.g., Puerto Rico).
- Subsidized credit to smallholders (e.g., Philippines).
- Inheritance norms (e.g., India, Bulgaria).
- Subdivision restrictions (e.g., Indonesia, Zimbabwe).

What We Do

- 1 Develop a two-sector model of agriculture – non-agriculture that features a non-degenerate distribution of farms, which we calibrate to U.S. farm-level data.
- 2 Use this framework to assess the quantitative importance of:
 - (a) aggregate factors (aggregate TFP, capital, land)
 - (b) farm-size distortions
- 3 Study quantitatively two specific farm-size distortions,
 - (a) 1988 land reform in the Philippines
 - (b) 1976 progressive land tax in Pakistan

Economic Environment

- General equilibrium two-sector model of agriculture and non-agriculture.
- Sectoral reallocations driven by subsistence constraint for food.
- Embed Lucas (1978) span-of-control model of firm size in agriculture \implies non-degenerate distribution of farms.

Production – Non-Agriculture

Representative firm in non-agriculture produces according to constant returns to scale technology,

$$Y_n = AK_n^\alpha N_n^{1-\alpha}$$

- A = economy-wide productivity (TFP)
- K_n = non-agricultural capital
- N_n = non-agricultural labor

Production - Agriculture

- Production unit is a farm.
- Farm: a technology that requires the input of an operator (farmer) with managerial skills s , land input (ℓ) which defines its size, and capital (k).
- Farmer of ability s produces according to decreasing returns to scale technology,

$$y_a = A\kappa [\theta k^\rho + (1 - \theta)(s\ell)^\rho]^{\frac{\gamma}{\rho}}$$

- κ = sector-specific agricultural productivity
- γ = span-of-control parameter
- $1/(1 - \rho)$ = capital-land elasticity of substitution

Stand-in Household

- Non-homothetic preferences over two goods (c_a, c_n) ,

$$u(c_a, c_n) = \{\phi \cdot \log(c_a - \bar{a}) + (1 - \phi) \cdot \log(c_n)\}$$

- Endowments, supplied inelastically to the market:
 - capital stock K
 - arable land L
 - one unit of time per member
- Household members are heterogeneous in managerial ability in farming, $s \sim F(s)$ with support in $S = [\underline{s}, \bar{s}]$.
- Workers in non-agriculture are homogeneous in ability.

Discussion

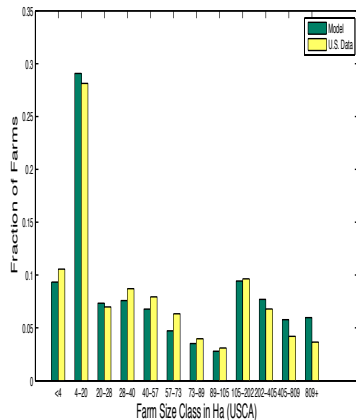
- Share of employment in agriculture mainly determined by subsistence relative to agricultural productivity.
- Low productivity in agriculture is driven by low economy-wide productivity A , low endowment of land L , and low sector level productivity, which may be driven by misallocation of factors across heterogeneous farms.
- Other factors may amplify these effects: selection into agriculture, farmer's managerial investment, and accumulation of human capital.

Calibration

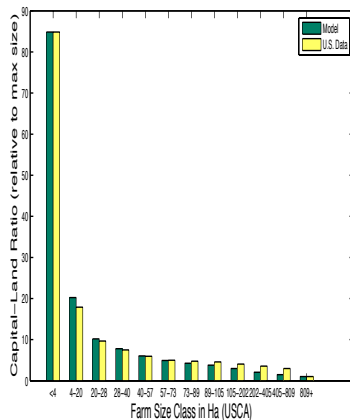
- Strategy: Calibrate benchmark economy (BE) to U.S. farm level and aggregate observations.
- Distribution of farmer ability $F(s)$ approximated by a log-normal distribution, with mean μ and variance σ .
- Normalize A and κ to 1, most other parameters calibrated to usual targets in sectoral analyses.
- Solve the model for (\bar{a}, ρ, θ) to match three targets:
 - (1) Share of employment in agriculture of 2.5%.
 - (2) Agricultural land income share of 18% (Herrendorf and Valentinyi, 2008).
 - (3) Disparity of capital-land ratio between minimum and maximum farm sizes of 84.8.
- Resulting $\rho = 0.24$ implies more substitution than Cobb-Douglas.

Calibrated Variables by Farm Size

Size Distribution

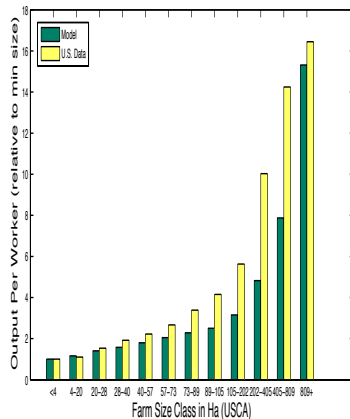


Capital-Land Ratio

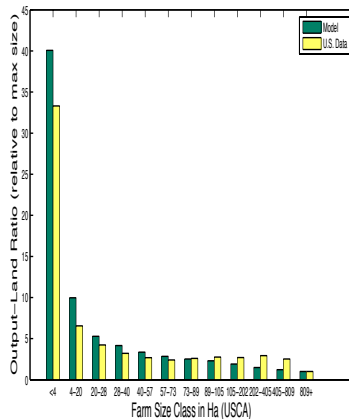


Other Variables by Farm Size

Labor Productivity



Output per Hectare



Aggregate Factors

- How important are aggregate factors (L , A , K) in accounting for farm size and productivity in poor countries?
- We measure rich-poor gaps in:
 - ▶ L to match farmland per person gaps: 1.3-fold.
 - ▶ A and K to match non-agricultural real GDP per worker gaps: 6.8-fold and capital-output ratio gaps: 2.9-fold.

Aggregate Factors - Results

	B.E.	Land	+ (TFP, Capital)	Data
Size Distribution (%):				
Farms < 5 Ha	13.3	16.3	58.1	93.6
Farms > 20 Ha	61.4	56.6	20.5	0.2
Share of Land (%):				
Farms < 5 Ha	0.2	0.3	4.7	68.1
Farms > 20 Ha	99.1	97.3	84.1	3.4
N_a (%)	2.5	2.6	16.6	65.0
Ratio B.E./Poor:				
Average Farm Size	1	1.3	8.6	34
Labor Prod. in Ag.	1	1	11.2	46.7
Aggregate Labor Prod.	1	1	7.6	19.2

All aggregate factors together account for roughly 1/4 of the disparities in the variables of interest.

Farm-Size Distortions

- Follow approach in Restuccia and Rogerson (2008).
- Each farmer faces a farm-specific output tax τ_s (idiosyncratic distortions).
- Parameterize taxes according to the following function:

$$\tau_s = P(s) = 1 - \frac{1}{\exp(\psi s)}.$$

- Taxes as “catch-all” distortions, functional form motivated by features of farm-size distortions.
- Calibrate ψ to match average farm size in poor countries.

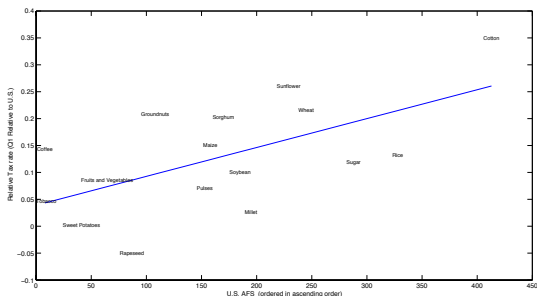
Farm-Size Distortions - Results

	Aggregate Factors	+Farm-Size Distortions	Data
Size Distribution (%):			
Farms < 5 Ha	58.1	76.8	93.6
Farms > 20 Ha	20.5	13.4	0.2
Share of Land (%):			
Farms < 5 Ha	4.7	2.0	68.1
Farms > 20 Ha	84.1	72.5	3.4
N_a (%)	16.6	65.2	65.0
Ratio B.E./Poor:			
Average Farm Size	8.6	34	34
Labor Prod in Ag	11.2	46.5	46.7
Agg Labor Prod	7.6	17.0	19.2

Farm-size distortions can potentially account for the disparities between rich and poor countries.

Empirical Farm-Size Distortions

- Measure of distortions from internationally comparable database.
- Nominal rates of assistance (NRAs) from World Bank. Available at the aggregate and crop categories across countries (Kruger, Schiff, and Valdes extended by Anderson and Valenzuela 2008).
- Measure of distortions to farmer prices induced by domestic policy: taxes/subsidies to farmers and price wedges (farm gate vs. world).
- To uncover distortions by productivity level (size) we assume product level size in the United States.



Empirical Farm-Size Distortions

- Negative NRA is a tax on producers, we focus on mean, std and correlation with U.S. size as key statistics.
- We find high mean relative taxes (rich to poor) of 2.6 fold, normalizing rich to zero, then taxes in poor = 0.62.
- Std of 0.33 (crop-specific NRAs) and correlation with U.S. size of 0.6.
- Parameterize taxes according to the following generalized function:

$$\tau_s = P(s) = 1 - \frac{\psi_0}{\exp(\psi_1 s)}.$$

- Calibrate (ψ_0, ψ_1) to match summary statistics on empirical measures of nominal rates of assistance: mean, std, and correlation with U.S. size.

Empirical Farm-Size Distortions

	Aggregate Factors	+Farm-Size Distortions	Data
Size Distribution (%):			
Farms < 5 Ha	58.1	47.6	93.6
Farms > 20 Ha	20.5	22.7	0.2
Share of Land (%)			
Farms < 5 Ha	4.7	3.9	68.1
Farms > 20 Ha	84.1	59.3	3.4
N_a (%)	16.6	33.8	65.0
Ratio B.E./Poor:			
Average Farm Size	8.6	17.6	34
Labor Prod in Ag	11.2	23.9	46.7
Agg Labor Prod	7.6	9.5	19.2

Aggregate factors and farm size distortions account equally for more than 50% in the disparities between rich and poor countries.

Specific Policies

● Land Reforms

- ▶ 1988 land reform in the Philippines (ceiling of 5 Ha)
- ▶ Redistributed 64% of the country's farmland
- ▶ Pre-reform AFS = 2.85 Ha, post-reform AFS = 2.01 Ha \implies AFS dropped by 29.6%
- ▶ Calibrate model to Philippines prior to reform, add explicit size restriction.
- ▶ On impact agricultural productivity falls by 7%, over time aggregate factors can mask negative effects of ceiling.

● Progressive land taxes

- ▶ West Pakistan Land Revenue Act of 1967, tax rates not differentiated on size.
- ▶ 1976 Amendment introduces steep progressive taxes, AFS dropped 28.7%.
- ▶ In the model progressive taxes as in reform in Pakistan reduces both size and productivity (about 3%).
- ▶ Over time aggregate factors can amplify/mitigate these effects.

Conclusions

- Farm-size policies that distort size are harmful for productivity.
- Farm structure matters, to the extent generated by these policies.
- Not all problems lie within agriculture: aggregate factors still account for 1/4.
- What specific policies/institutions are most damaging for size and productivity in agriculture?