From Micro to Macro: Land Institutions, Agricultural Productivity, and Structural Transformation

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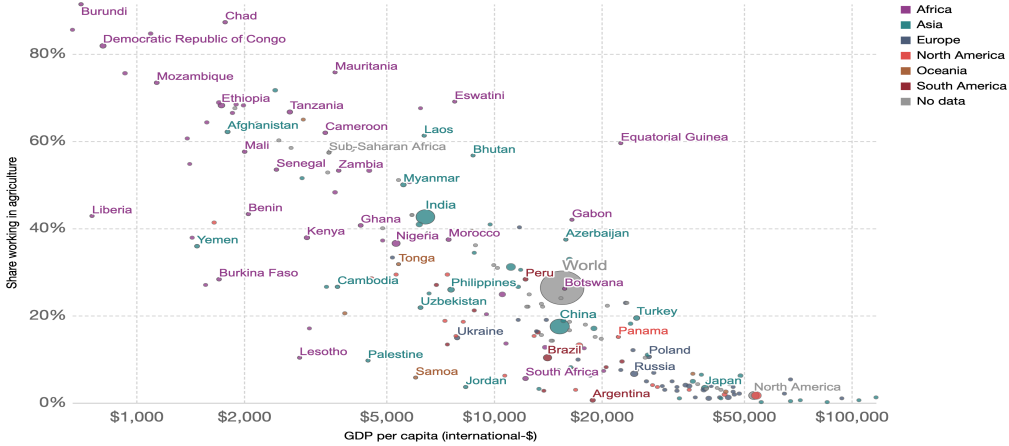
Employment in agriculture vs GDP per capita, 2017

Share of persons of working age who were engaged in any activity to produce goods or provide services for pay or profit in the agriculture sector (agriculture, hunting, forestry and fishing).

Our World in Data



Source: World Bank

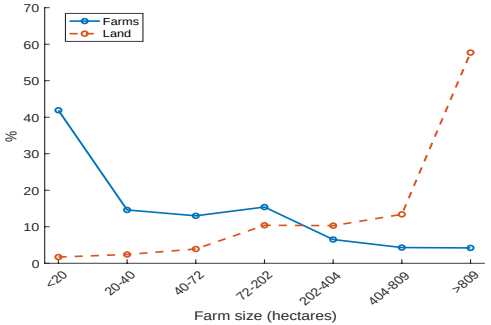
OurWorldInData.org/employment-in-agriculture • CC BY

Motivation

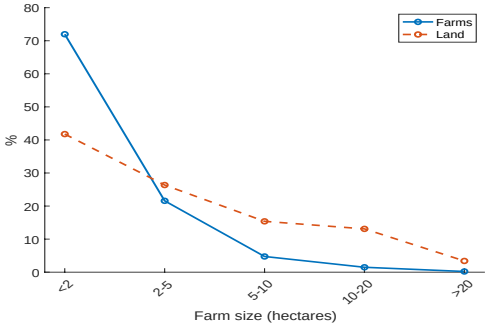
- Agriculture important in accounting for rich/poor income per capita disparity (Gollin, Parente, and Rogerson 2002; Restuccia, Yang, and Zhu 2008)
- Poor countries feature much lower agricultural productivity relative to non-agriculture compared to developed countries, and allocate much of their employment to agriculture
- What factors are key in holding back agricultural productivity in poor countries?
- Many relevant factors, I focus on factor misallocation across farms arising from restrictive land institutions

Size Distribution of Farms and Land

(a) United States



(b) Poorest quintile



- Land distribution skewed towards small farms in poor countries, suggesting misallocation (Adamopoulos and Restuccia, 2014)

Outline

- Land institutions in developing countries, evidence of land misallocation in agriculture
- Develop a two-sector general equilibrium model of structural transformation, featuring distorted land markets in agriculture
- Calibrate benchmark distorted economy to aggregate and micro data for Ethiopia
- Quantify the aggregate and distributional effects of a land rental-market reform

Why Ethiopia?

- Very poor country in Africa, GDP per capita about 3% of US
- Agriculture dominant sector, represents 70% of total employment
- Interesting land institution
- Detailed household-level micro data
  - LSMS-ISA data from the World Bank
  - Information on farm-level inputs and output in physical units
  - Useful in constructing measures of farm productivity and distortions

Land institution—Ethiopia

- Current institution shaped by historical events, prevailing characteristic state control over allocation and use of land
- Imperial period (mid 19th century to 1974):
  - Land ownership allocation to political supporters regardless of occupation or use in farming, resulted in powerful landlords
- Communist regime (1975 to 1991) "Land to the Tiller"
  - Land expropriated, uniformly redistributed, adjusting for soil quality and family size, among all rural households in the form of use rights
  - Redistributions frequent to achieve equitable allocation of use rights at the local level
  - Prohibited land transactions
- Market-oriented government (1991–) largely maintained policies related to land
  - Certification reform (since early 2000s) to promote tenure security
  - Restrictive land rentals only channel allowing reallocation of farms' operational scale

Evidence of misallocation—framework

- Standard model of heterogeneous production units and input allocation (Lucas 1978; Hopenhayn 1992; Adamopoulos and Restuccia 2014)
- Heterogeneous farms producing single homogeneous good,

$$y_i = A z_i^{1-\gamma} \ell_i^{\gamma}$$

- Efficient allocation (max output given resources L)

$$\ell_i^e = \frac{z_i}{\sum z_i} L$$

- Efficient allocation equates input productivity across farms

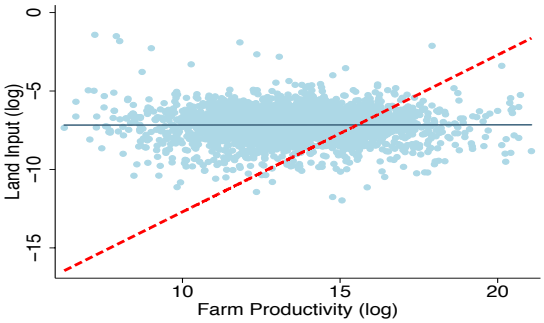
$$y_i^e / \ell_i^e = A \left(\sum z_i \right)^{1-\gamma} L^{\gamma-1}$$

Evidence of misallocation—Ethiopia

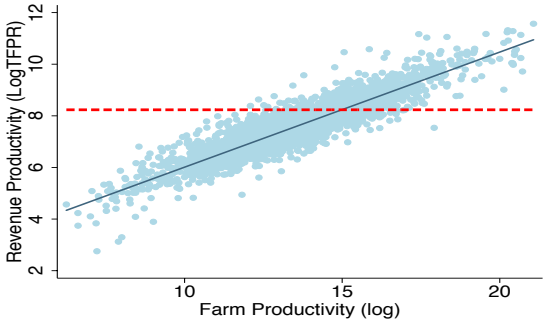
- Panel data from Chen, Restuccia, and Santaeulalia (2017)
- Focus on the household farm as unit of analysis
- Data on outputs (physical units), labor (days), capital, intermediate inputs, operated land, control for land quality and weather shocks
- Measure farm TFP as residual from farm production function
- Abstract from transitory variation by estimating household-farm fixed effect from panel data, focus on within-zone variation

Evidence of misallocation—Ethiopia

(a) Operated land



(b) Measured distortions



- Within zones (counties): STD(log farm TFP)=0.65, STD(log farm TFPR)=0.74, CORR(logTFP,logTFPR)=0.90
- Percentage of farms not renting land 68%

Interpreting evidence of misallocation

- Efficient benchmark
  - Evidence of strong positive relationship between farm size and productivity in developed countries, both across farms and over time
- Mismeasurement
  - Gollin and Udry (2021) attribute a large role for mismeasurement using plot-level data
  - At face value, correcting for mismeasurement does not change lack of positive relationship between land input and productivity (Aragon, Restuccia, and Rud 2021)
  - Key distinction with previous evidence: farm vs plot-level analysis
  - Mismeasurement not quantitatively as important at the farm level using Bils, Klenow, and Ruane (2017) method exploiting panel data

A model of distorted land markets

- Two sector GE model of structural transformation of agriculture and non-agriculture (Gollin et al. 2002; Restuccia et al. 2008)
- Production heterogeneity in agriculture, distorted land rental markets, land endowment (Adamopoulos and Restuccia 2014; Deininger and Nagarajan 2010; Bolhuis, Rachapalli, and Restuccia 2020)
- Ability heterogeneity across sectors (Lagakos and Waugh 2013; Adamopoulos, Brandt, Leight, and Restuccia 2017)

Preferences and endowments

- Closed local economy (county or village)
- Preferences over agricultural and non-agricultural goods

$$U_i = a \log (c_{ai} - \bar{a}) + (1 - a) \log(c_{ni})$$

  where $\bar{a}$ minimum subsistence consumption of agricultural good

- Heterogeneous abilities in agriculture and non-agriculture, (z_{ai}, z_{ni}) drawn from a bivariate distribution of skills with cdf $F(z_{ai}, z_{ni})$, variance-covariance matrix given by,

$$\Sigma = \begin{pmatrix} \sigma_a^2 & \sigma_{an} \\ \sigma_{an} & \sigma_n^2 \end{pmatrix}$$

- Individuals in agriculture are endowed with an equal amount of land $\bar{\ell}$

Production in non-agriculture

- Constant returns technology in efficiency units of labor,

$$Y_n = A_n Z_n$$

where

- Y_n is real non-agricultural output
- A_n is productivity in non-agriculture
- $Z_n = \int_{i \in H_n} z_{n_i} dFi$ is effective labor input from workers in non-agriculture

Production in agriculture

- The production unit in the agricultural sector is a farm
- A farm is a technology that requires the inputs of a farm operator with ability z_a as well as land, which also defines the size of the farm
- The farm technology exhibits decreasing returns to scale,

$$y_{ai} = A_a z_{ai}^{1-\gamma} \ell_i^{\gamma},$$

where y_a is farm output, ℓ is the land input, and A_a is an agriculture-specific TFP parameter, common across all farms

Competitive distorted markets

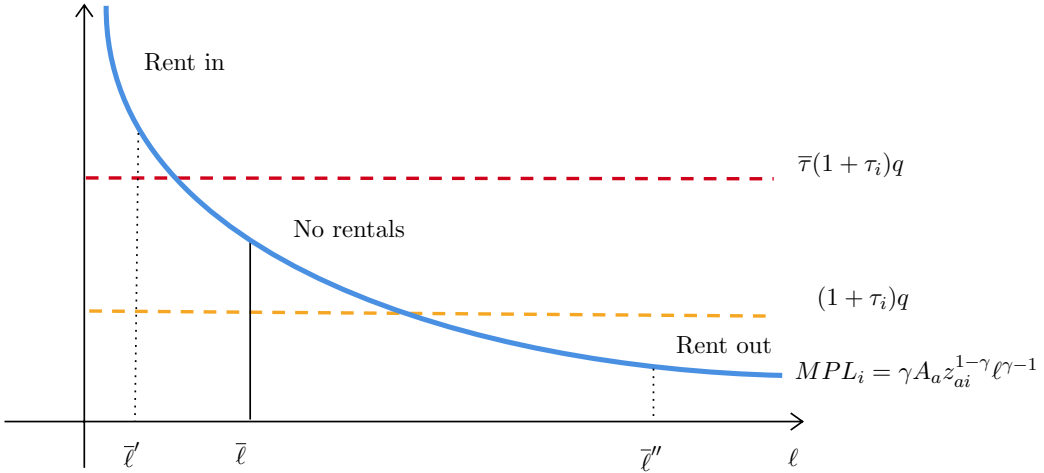
- Denote relative price of agriculture p_a and rental price of land q
- Endowed land ($\bar{\ell}$) cannot be sold, land reallocation through rentals (e.g. communal land institution)
- Farmers can rent land to (l_i^{out}) or from (l_i^{in}) other farmers, but face farm-specific transaction costs represented as wedges denoted as τ_i^{in} and τ_i^{out}
- Assume $(1+\tau_i^{in}) = \bar{\tau}(1+\tau_i^{out})$, where $\bar{\tau} \geq 1$ wedge between renting in and out (common across farmers); and $(1+\tau_i^{out}) = (1+\tau_i)$ farm-specific distortion
- Assume $\log(1+\tau_i) = \theta \log z_{ai} + \epsilon_i$, where $\epsilon_i \sim N(0, \sigma_\epsilon^2)$, *i.i.d.* across farms
- Land distortions characterized by $\bar{\tau}$, θ, and σ_ϵ

Farm problem

- Given z_{ai}, $\bar{\ell}$, prices and wedges, a farm chooses operated land ℓ_i, to maximize profits:

$$\max_{\{\ell_i, \ell_i^{out}, \ell_i^{in} \geq 0\}} \pi_i \equiv p_a A_a z_{ai}^{1-\gamma} \ell_i^{\gamma} - q(1+\tau_i)\left(\bar{\tau}\ell_i^{in} - \ell_i^{out}\right),$$

subject to $\ell_i = \bar{\ell} + \ell_i^{in} - \ell_i^{out}$


Rent in
$\overline{\tau}(1+\tau_i)q$
No rentals
$(1+\tau_i)q$
Rent out
$MPL_i = \gamma A_a z_{ai}^{1-\gamma} \ell^{\gamma-1}$
$\overline{\ell}'$
$\overline{\ell}$
$\overline{\ell}''$
ℓ

Occupational choice

- Income in agriculture is determined by profits from farm operation, $I_{ai} = \pi_{ai}(z_{ai}, \tau_i, \bar{\ell})$
- Income in non-agriculture is $I_{ni} = w_n z_{ni}$
- Individual i's income is given by $I_i = \max\{I_{ai}, I_{ni}\}$
- Denote the occupational choice by an indicator function $o(z_{ai}, \tau_i, z_{ni})$ which equals 1 if $I_{ai} \geq I_{ni}$ and 0 otherwise

Calibration

- Calibrate benchmark distorted economy to Ethiopia
- Parameters selected without solving the model: $a = 0.01$, $A_a = A_n = 1$ (normalization), decreasing returns in farm production $\gamma = 0.54$, correlation of sectoral abilities $\rho_{an} = 0.35$
- Common land endowment in agriculture $\bar{\ell}$ set to match average farm size (1.3 ha)
- Land per capita L/N is average farm size times the target for the share of employment in agriculture

Calibration

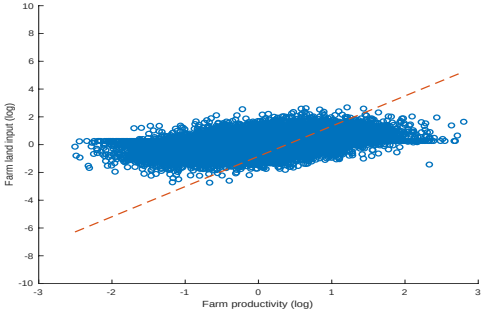
- Parameters selected to match targeted moments
- Select $\bar{a}$ to match share of employment in agriculture $N_a = 0.70$
- Calibrate ability distribution (σ_a, σ_n) to dispersion in log sectoral incomes
- Distortions θ, σ_ϵ, and $\bar{\tau}$ to match: correlation log distortions (TFPR) and log TFP across farms, dispersion of distortions, and share of farms not renting

Calibrated parameters and moments

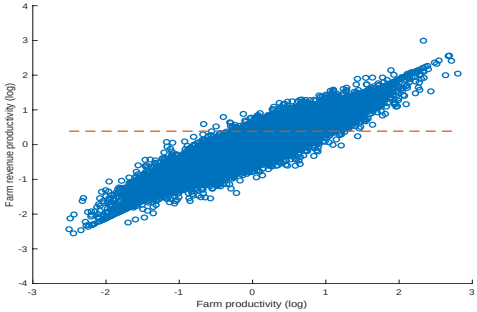
Parameter	Value	Moment	Data	Model
$\bar{a}$	1.06	Share of employment in agriculture (N_a)	0.70	0.70
$\bar{\ell}$	1.30	Average farm size (AFS)	1.30	1.30
L/N	0.91	AFS$\times N_a$	0.91	0.91
ρ_{an}	0.35	Baseline value	0.35	0.35
σ_n	1.30	STD of log non-agricultural income	0.88	0.88
σ_a	1.42	STD of log agricultural TFP (TFP$_a$)	0.65	0.65
σ_ϵ	0.60	STD log TFPR	0.74	0.74
θ	0.80	CORR(log TFP$_a$, log TFPR)	0.90	0.90
$\bar{\tau}$	2.15	Share of farms not renting	0.68	0.68

Land allocations and distortions across farms

(a) Operational land



(b) Measured distortions



- Parsimonious parameterization of distortions captures well the patterns of operational farm scales and measured distortions

Quantitative experiment

- Land rental-market reform experiment
- Maintain land endowment, allowing perfectly competitive rental markets
- Set $\bar{\tau} = 1$ and $\tau_i = 0$ for all i (i.e., $\theta = \sigma_\epsilon = 0$)
- Farm operational scales and occupational choices independent of the land endowment
- Reform delinks land rights from land use via rental markets

The effects of land rental-market reform

Statistic	Benchmark (BE)	Land Reform
Aggregate statistics		
Agricultural labor productivity (Y_a/N_a)	1.00	3.85
Fraction of employment in agriculture (N_a)	0.70	0.19
TFP in agriculture (TFP_a)	1.00	1.88
TFP in agriculture, BE farms	1.00	1.26
Average ability in agriculture (Z_a/N_a)	1.00	2.41
Average ability in non-agriculture (Z_n/N_n)	1.00	0.48
Real GDP per capita (Y/N)	1.00	1.19
Conditional micro-level statistics		
STD of log–farm TFP	0.65	0.54
STD of log–farm TFPR	0.74	0.00
CORR of log–(farm TFP, farm TFPR)	0.90	0.00

- A 26% increase in agricultural TFP due to reduced misallocation translates into a 285% increase in agricultural labor productivity

Discussion of results

- Increase in agricultural labor productivity (almost 4-fold) still leaves large residual productivity gap with developed countries
- With reform average farm size increases from 1.3 ha to 4.8 ha, still far from developed countries with similar land endowment $\approx$ 16 ha
- Not considered are additional complementary effects:
  - Separation of land rights from land use on reallocation across space
  - Increased farm size on mechanization and technology adoption in agriculture

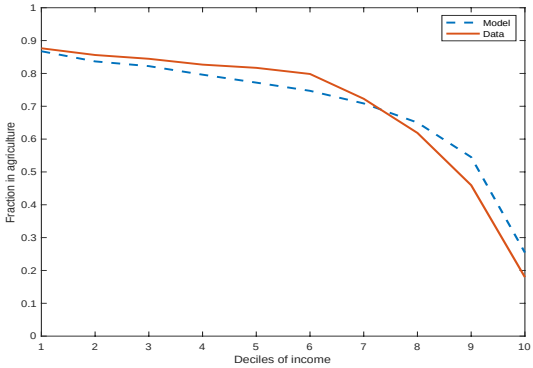
Other results

- Importance of systematic component of land distortions ($\approx 80\%$ of agricultural productivity) and intensive margin of land rental markets

Statistic	BE	Land Reform	$\bar{\tau} = 1$ $\theta = 0$	$\theta = 0$
Ag. labor productivity (Y_a/N_a)	1.00	3.85	3.04	2.41
Fraction emp. in agriculture (N_a)	0.70	0.19	0.23	0.29
Fraction farms not renting	0.68	0.00	0.00	0.44
Fraction land rented in	0.07	0.77	0.75	0.61

Distributional implications

Agriculture and income



- Despite uniform distribution of land input, substantial dispersion in income in BE: p90/p10 income ratio 6.8-fold

Reform with rental income

- Medium term effect on income: same N_a but efficient rental markets to disassociate land rights from land use
- Counterfactual income: CF $I_a = p_a y_a(\ell^e) + q^e(\bar{\ell} - \ell^e)$, compare with BE I_a

	p90	p10	Ratio
CF I_a	4.99	1.78	2.80
BE I_a	4.59	0.88	5.22
Ratio	1.09	2.04	0.54

- Rental markets more effective in equalizing incomes, substantial reduction in poverty

Reform with rental income

- Long term effect on income inequality:

p90/p10	BE	Reform
Total income	6.8	7.7
Rural income	5.2	5.9

- Dispersion in income increases, but mostly from larger dispersion in non-agriculture

Conclusions

- Restrictive land markets substantially depress agricultural productivity
- An egalitarian distribution of ownership rights can be consistent with efficient distribution of farm operational scales via rental markets, dissipating distributional concerns
- Productivity gains can unravel substantial process of structural transformation and growth (modernization of agriculture)
- This process also requires free flow of resources across sectors and space, separating land use from land rights aids in this process (de Janvry et al. 2015)
- Challenge is developing and fostering decentralized arrangements (markets) that improve resource allocation and productivity growth