Misallocation and Productivity in Agriculture

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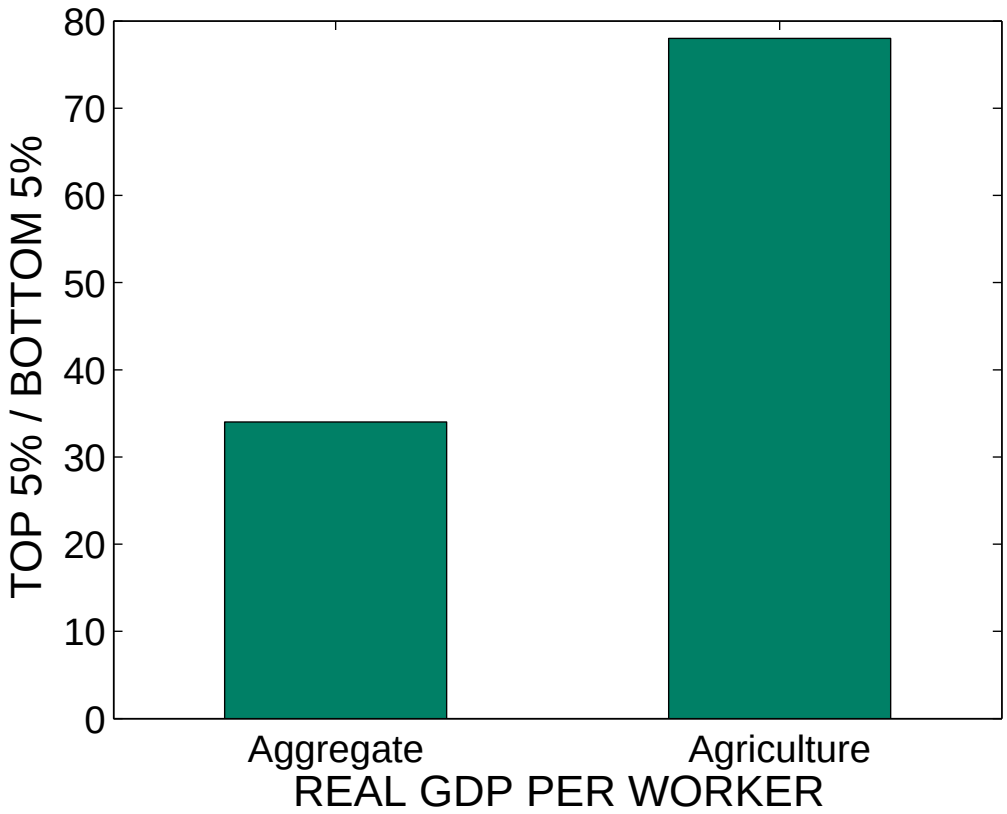
Motivation

- Large differences in GDP per capita between rich and poor countries mostly explained by differences in labor productivity and in particular total factor productivity
- Resource (mis)allocation across heterogeneous production units a key determinant of aggregate productivity
  - Restuccia and Rogerson (2008, RED), Hsieh and Klenow (2009, QJE)
- Key questions:
  - What specific policies/institutions/frictions cause misallocation?
  - How do they affect productivity at the industry level?
- Focus:
  - Industry $\rightarrow$ Agriculture
  - Specific Policy/Friction $\rightarrow$ Land reforms and imperfect land markets

Why agriculture?

Agricultural Labor Productivity

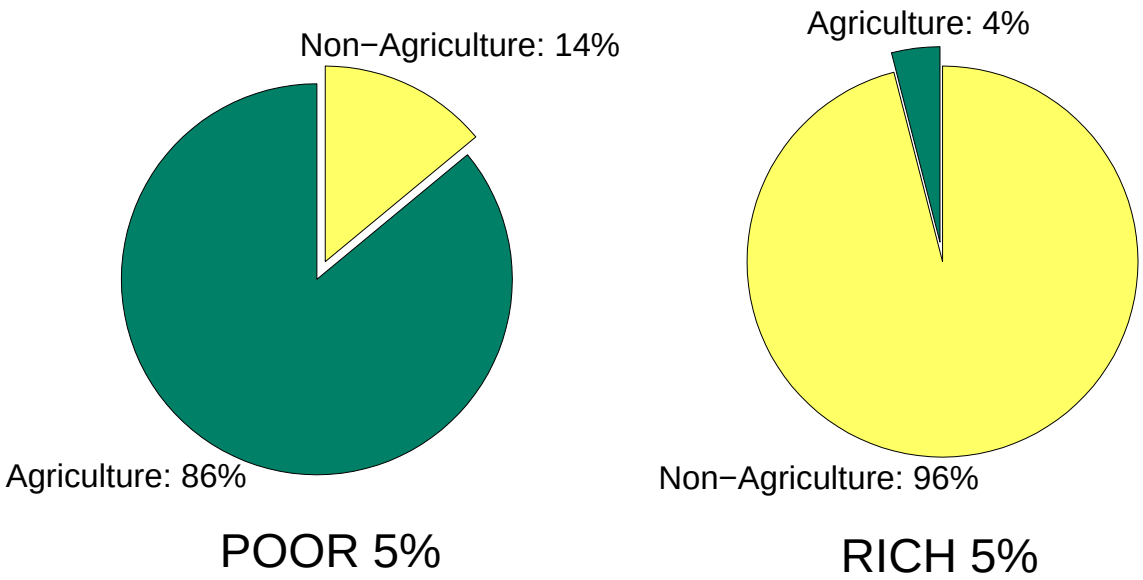
- Poor countries are particularly unproductive in agriculture ...



Source: Restuccia, Yang, and Zhu (2008, JME), PWT, FAO

Agricultural Employment Shares

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



Source: Restuccia, Yang, Zhu (2008, JME), FAO

Motivation

- Understanding labor productivity gap in agriculture is key. Several explanations ...

- Adamopoulos and Restuccia (forthcoming, AER)
  - Integrates literatures on misallocation and agricultural productivity differences
  - Poor countries characterized by institutions, market frictions, and policies creating misallocation in agriculture
  - These features manifest themselves through farm size
  - Can be quantitatively important in thinking about agricultural productivity

Two Specific Applications

(1) "Land Reform and Productivity: A Quantitative Analysis with Micro Data" (with Tasso Adamopoulos)

Land Reforms

- Typically involve redistribution of farm land above a given ceiling from land-rich to land-poor
- Often coupled with a "shutting down" of land sales and/or rental markets
- Prevalent in developing countries in the second half of the 20th century

Some Land Reforms

Country	Change in AFS (%)	Land Reform Period	Ceiling on Land Size (Ha)
Bangladesh	-49.1	1984	8
Ethiopia	-44.1	1975	10
India	-25.8	by early 1970s	by province: 4-53
Korea	-21.5	1950	3
Pakistan	-11.5	1972, 1977	61, 40
Sri Lanka	-26.2	1972	10-20
Philippines	-29.6	1988	5

- AFS drops after all these reforms against the tendency for AFS to increase over time

Research Questions

1. What are the effects of land reforms on farm size and agricultural productivity?
2. Through what channels do these effects manifest themselves?

Our Approach

- Focus on a particular land reform (Philippines)
- Use micro data to study the decisions of operators at the farm-level before and after the reform

What We Do

1. Develop an industry model that features a non-degenerate distribution of farms and a technology choice at the farm level
2. Calibrate the model to pre-reform farm-level data in the Philippines
3. Use the quantitative model to measure the effects of:
    - land reform alone
    - land reform alongside other changes

What We Find

1. The land reform reduces productivity by 17% and farm size by 34%, it also reduced the share of landless by 20%
2. These effects due to both misallocation and selection (distortion to occupational and technology choices)
3. How land redistribution takes place is key for magnitude of productivity drop
4. A market-based redistribution yields less than 1/3 of these effects
5. Other changes occurring alongside the reform can mask the effects of the reform

Land Reform in the Philippines

- 1988 land reform in the Philippines:
  Comprehensive Agrarian Reform Program (CARP)
- imposed ceiling of 5 Ha on all agricultural holdings
- severely restricted transferability of the redistributed farm lands
- targeted 80% of total farm land
- 80% of targeted farmland redistributed by mid-2000s
- Restrictiveness ratio $= \frac{ceiling}{pre-reform\ AFS} = 1.75$

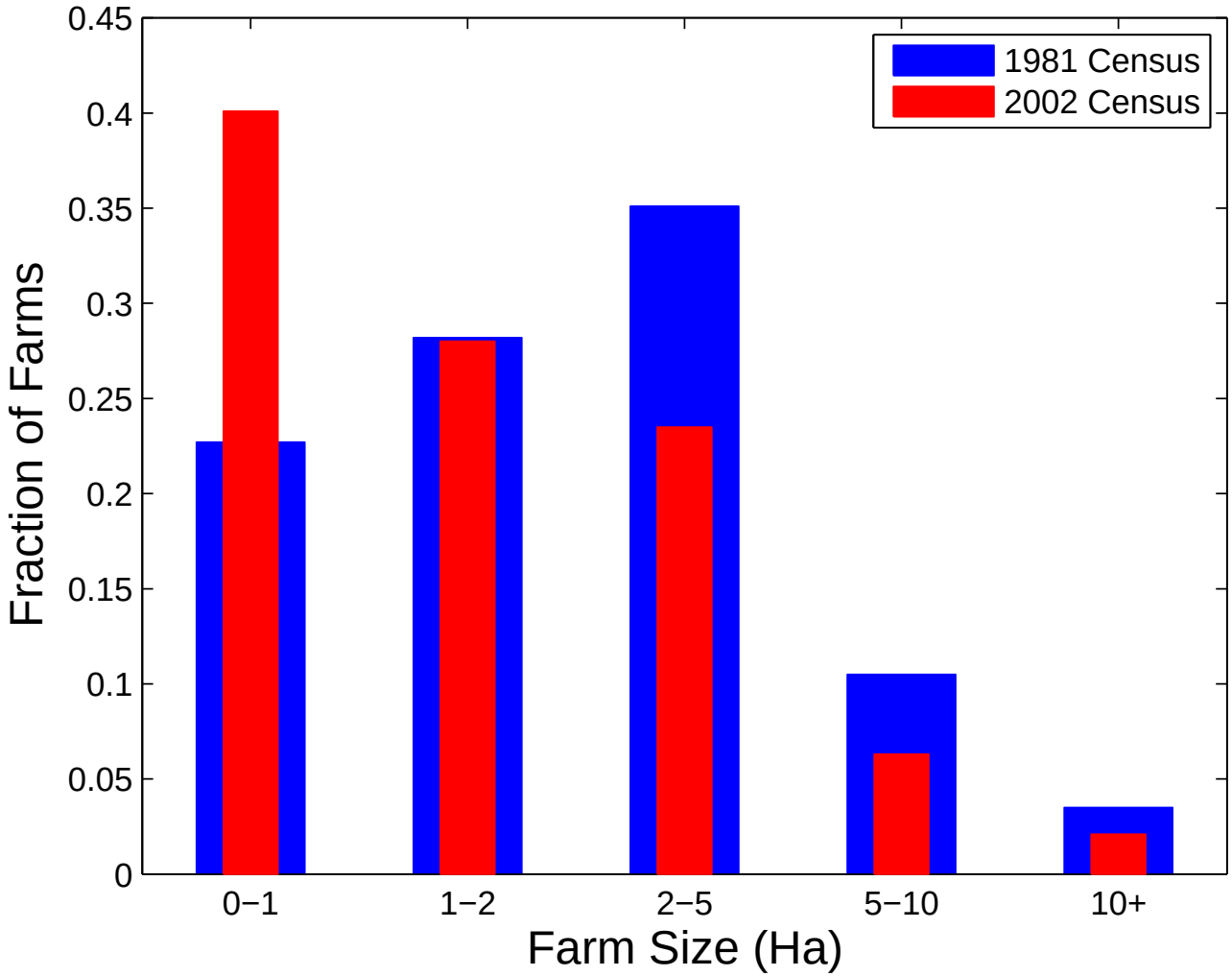
Micro Data - Philippines

1. Decennial Agricultural Censuses (1981, 2002)
   - Complete enumeration of farms
   - No outputs or inputs other than land, labor
2. Philippines Cash Cropping Project (1984, 2003), IFPRI
   - Survey data: Island of Mindanao, Bukidnon province
   - Can calculate productivity at the farm-level

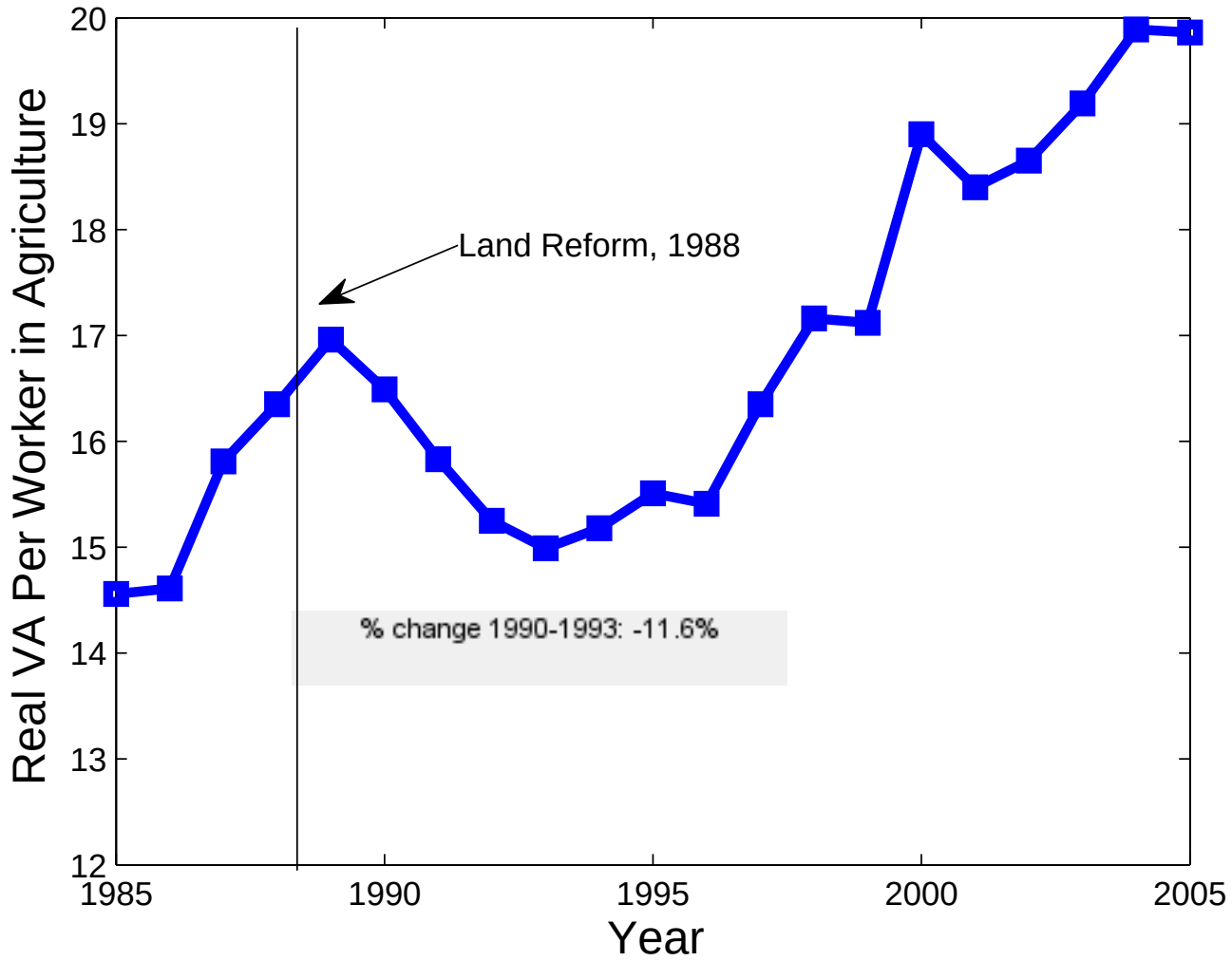
Average Farm Size - Census Data

- pre-reform (1981) AFS $= 2.85$ Ha
- post-reform (2002) AFS $= 2.01$ Ha
- AFS dropped by 29.6%

Changes in Size Distribution of Farms - Census Data



Agricultural Labor Productivity - Industry Accounts



Micro Data - IFPRI

- Household survey data
- 448 households interviewed in 4 round over 1984-85
- Original households and their children interviewed again in 5 rounds over 2003-04
- Precise and detailed measurement of inputs and outputs at the parcel and farm level
- Food crops: corn, rice; Cash crops: sugarcane (mainly), coconut, coffee, rubber

Size and Productivity By Crop - Panel

	1984-85	2003-04	% change
All Farms			
Average Farm Size	3.7	3.1	-17.6
Value Added Per Work Day	257.5	372.7	44.7
Cash Crop Farms			
Average Farm Size	4.6	3.7	-19.8
Value Added Per Work Day	298.2	386.1	29.5
Food Crop Farms			
Average Farm Size	2.1	1.3	-39.0
Value Added Per Work Day	101.2	201.0	98.7

- In 1984-85 cash crop farms are larger and more productive

Exiting and Continuing Farms

Average Farm Size and Productivity

	Exiting Farms	Continuing Farms
All		
Farm Size	2.3	3.5
Productivity	242.4	254.3
Top 10%		
Farm Size	5.2	6.7
Productivity	529.5	556.7

- Productivity drop not explained by most productive farmers leaving agriculture after reform

Economic Environment

- Industry model of agriculture - production side
- Build from Lucas (1978) span-of-control model of firm size $\Longrightarrow$ non-degenerate distribution of farms
- In addition, operators face a cropping technology choice (cash vs. food crop)

Production - Agriculture

- Production unit is a farm, that requires the input of an operator (farmer) with managerial skills s, land input (ℓ), and hired labor (n)
- There are two types of crops, cash crops (c) and food crops (f)
- Farmer of ability s produces crop $i \in \{c, f\}$ according to the decreasing returns to scale technology,

$$y_i = (A\kappa_i s)^{1-\gamma}(\ell^{\alpha} n^{1-\alpha})^{\gamma}$$

- $A =$ economy-wide productivity (TFP)
- $\kappa_i =$ crop-specific productivity parameter
- $\gamma =$ span-of-control parameter

Farmer Problem

- Farmer of ability s, operating technology $i \in \{c, f\}$ maximizes profits given prices (w, q, p_i),

$$\max_{\ell,n} \{p_i y_i - wn - ql - p_i C_i\}$$

- C_i = crop-specific fixed cost of operation
- p_i = price of crop $i \in \{c, f\}$ (fixed)

Farmer Problem

- Optimal scale of farm operation determined by farmer ability,

$$\ell_i(s) = \left(\frac{\alpha}{q}\right)^{\frac{1-\gamma(1-\alpha)}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{\gamma(1-\alpha)}{1-\gamma}} (\gamma p_i)^{\frac{1}{1-\gamma}} A\kappa_i s,$$

- Optimal land and hired labor demands $[\ell(s), n(s)]$ imply,

$$\frac{n(s)}{\ell(s)} = \frac{(1-\alpha)}{\alpha}\frac{q}{w},$$

- Given input demands and output functions profits are,

$$\pi_i(s) = (1-\gamma)p_i y_i(s) - p_i C_i.$$

Occupational Choice and Crop Choice

- Farmers are heterogeneous in their managerial ability, $s \sim F(s)$ with support in $S = [s_{min}, s_{max}]$
- There are two thresholds that determine the fraction of farmers being hired workers, cash crop farmers, and food crop farmers
- Denote occupational choice by $o_i(s)$, with $o_i(s) = 1$ if $\pi_i \geq \max\{\pi_{-i}(s), w\}$

Occupational Choice and Crop Choice: Example

Suppose that $C_c > C_f$ and $\kappa_c > \kappa_f$.

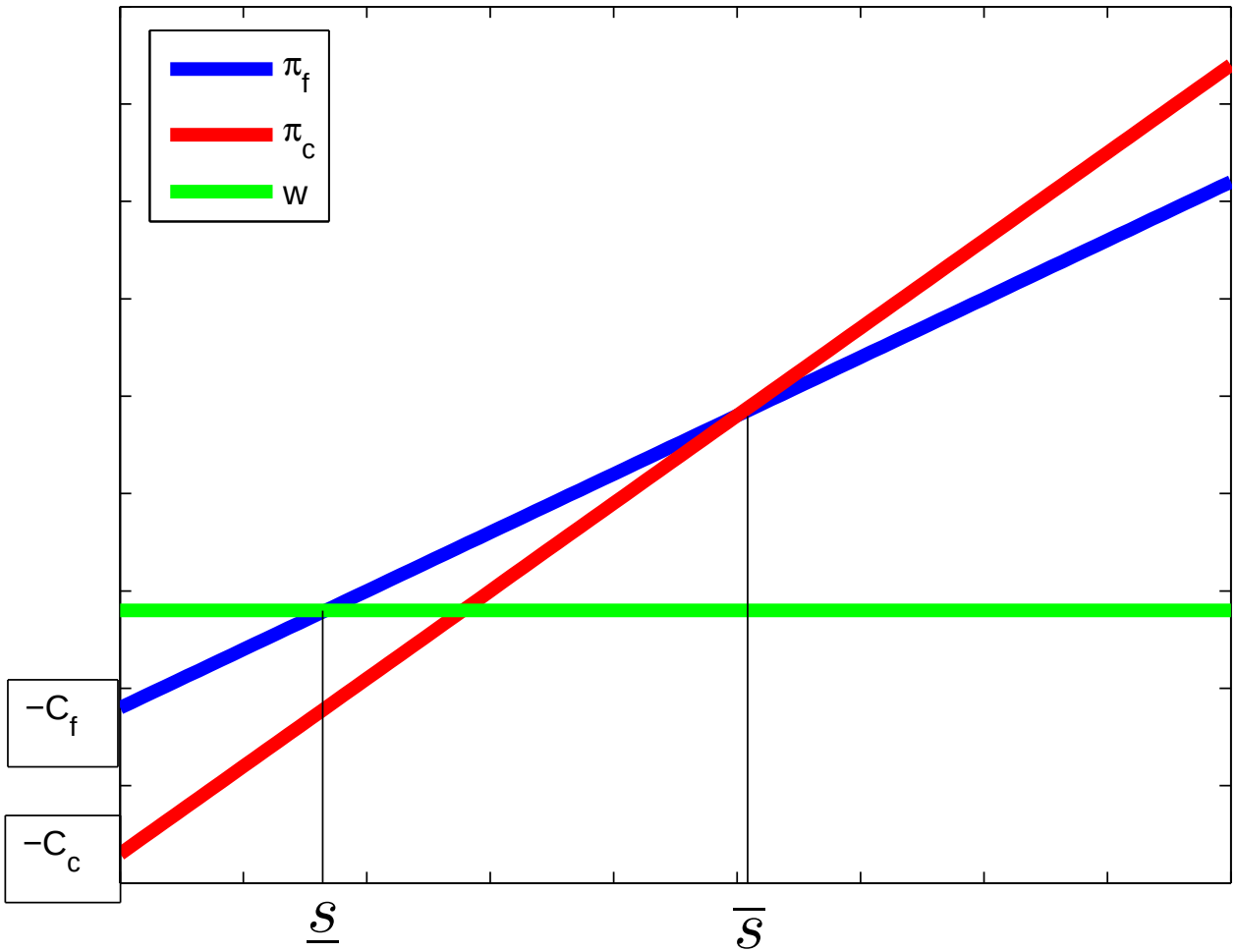
$\underline{s}$ is the cutoff for hired workers vs. operators

$$\pi_f(\underline{s}) = w$$

$\overline{s}$ is the cutoff for food crop vs. cash crop operators

$$\pi_f(\overline{s}) = \pi_c(\overline{s})$$

Illustration



Calibration I

- Strategy: Calibrate benchmark economy (BE) to pre-reform Philippines
- Distribution of farmer ability $F(s)$ approximated by a log-normal distribution, with mean μ and variance σ, chosen to match the distribution of farm sizes from the survey data

Calibration II

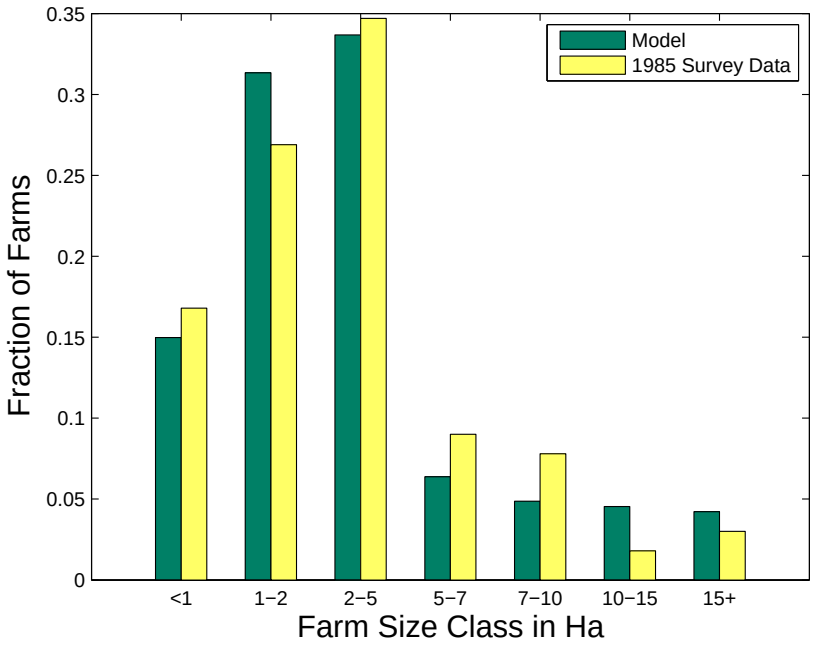
- Normalize the relative price of cash to food crops p_c/p_f to 1
- Normalize A and κ_f to 1
- Set span-of-control parameter to $\gamma = 0.7$
- Choose $\alpha = 0.3$ to match a land income share of 0.2
- Aggregate land endowment L chosen to match an average farm size of 3.7 Ha (survey data)

Calibration III

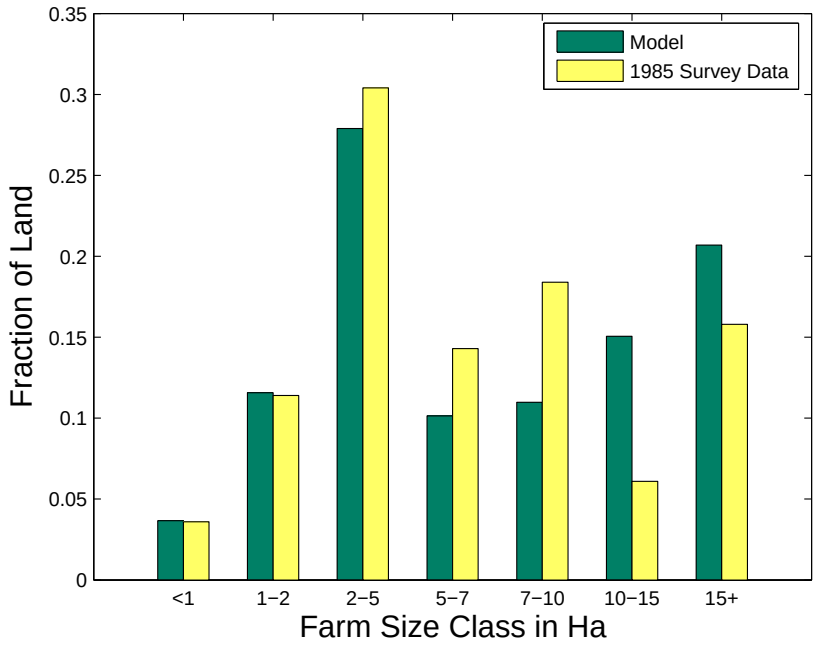
- Solve the model for (C_f, C_c, κ_c) to match three targets from the 1984-85 survey data:
  - (a) share of hired labor in total farm labor of 61.1%
  - (b) share of cash crop operators in total operators of 61.7%
  - (c) disparity of average output per worker between cash crops and food crops of 2.95

Model vs. 1984-85 Survey Data

Farm-size distribution

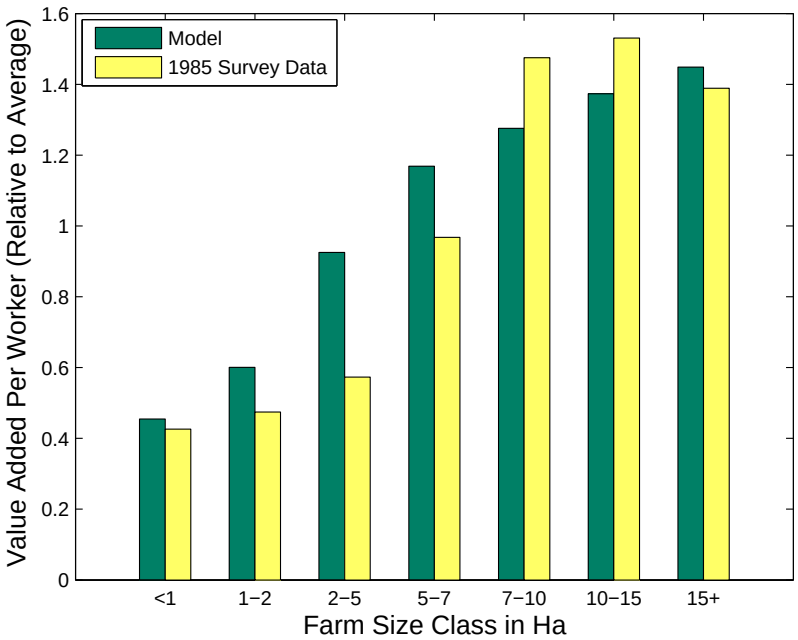


Share of land by size

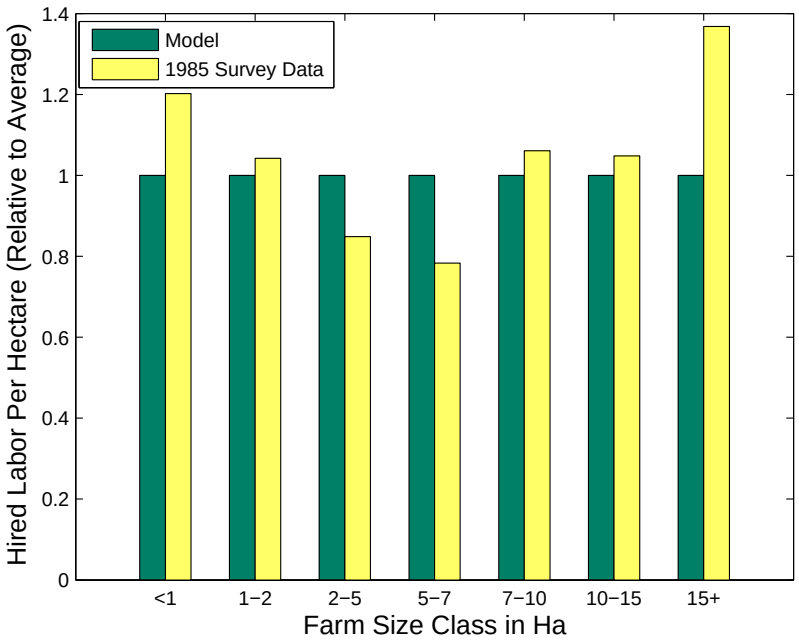


Model vs. 1984-85 Survey Data

Value added per worker by size



Hired labor per hectare by size



Land Reform I

- Model land reform as a government-mandated redistribution program.
- Farmland in excess of the effective ceiling is redistributed to the landless and smallholders.
- Land market is not operative.
- Redistributed land constitutes an endowment for each recipient (cannot be adjusted).

Land Reform II

Implement government-mandated redistribution using four parameters:

- legistlated land ceiling l_{max}.
- probability θ that farmers above the ceiling retain their previous farm size (enforcement).
- fraction of landless β that receive land
- fraction ψ of smallholders that receive land

These parameters fully determine the post-reform distribution of land (farms).

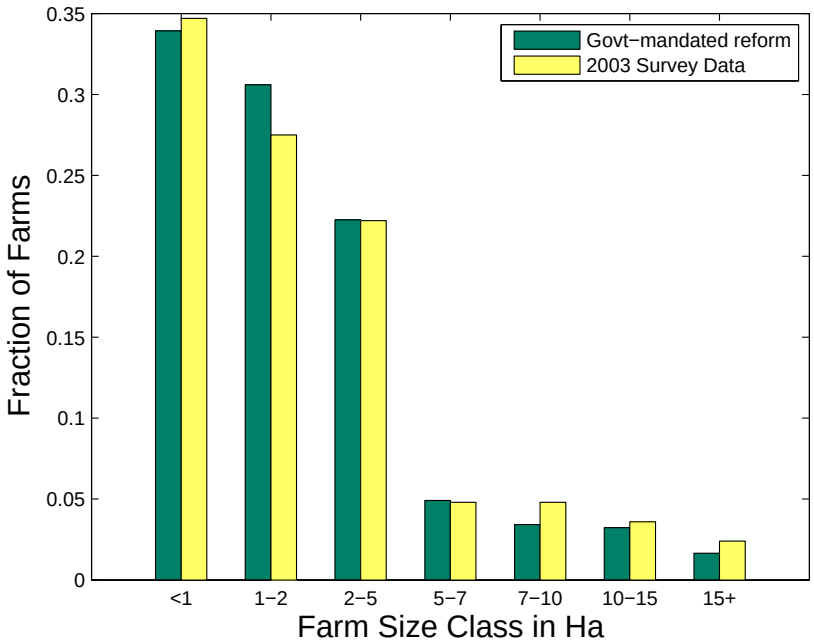
Philippine Land Reform

Experiment

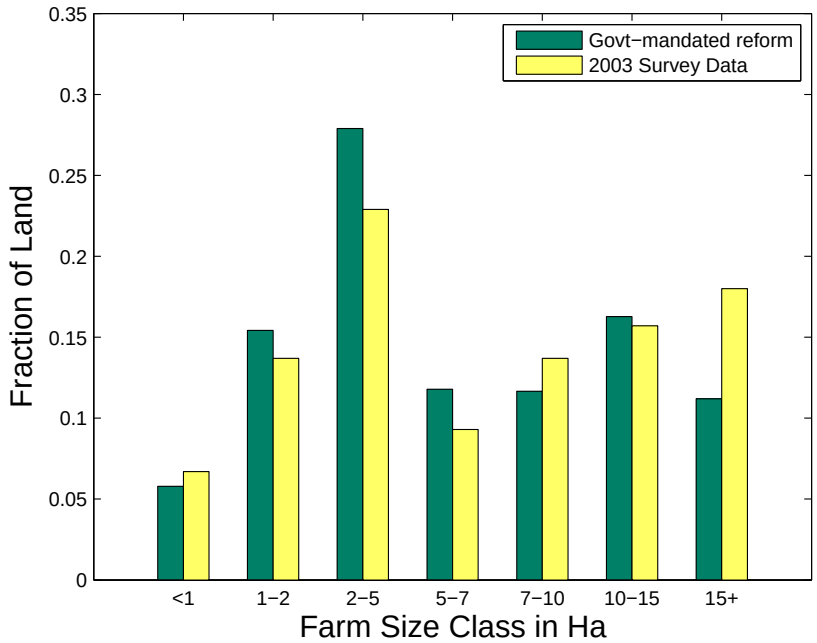
- take the benchmark economy calibrated to (pre-reform) Philippines
- consider the above government-mandated land redistribution
  - feed in ceiling of 5 Ha
  - pick θ to roughly match farm distribution > 5 ha
  - pick (β, ψ) to roughly match farm distribution for bins $0-1$ ha, $2-3$ ha.

Land Reform vs. 2003-04 Survey Data

Farm-size distribution



Share of land by size



Aggregate Effects of Land Reform

	Government-mandated Land Redistribution	Market-based Land Redistribution	Data
Farm Size	-34.2	-9.3	-29.6
Productivity	-17.0	-5.0	-11.6
Landless (%)	-20.0	-4.0	-19.0

Degree of Enforcement of Reform

	Enforcement			
	$\theta = 0.8$	$\theta = 0.4$	$\theta = 0.1$	$\theta = 0$
Average Farm Size	-34.2	-39.2	-42.5	-46.5
Ag. Labor Productivity	-17.0	-22.6	-27.5	-34.2

- Enforcement of reform ceiling is quantitatively important for the magnitude of size and productivity drop

Importance of Vehicle of Redistribution

- Land market "shut-down" key for magnitude of productivity decline
- Consider market-based redistribution
  - only restriction is the ceiling
  - land market is allowed to work
- Ceiling with land market reallocation compresses the farm and land distribution creating smaller size and productivity effects

Aggregate Effects of Land Reform

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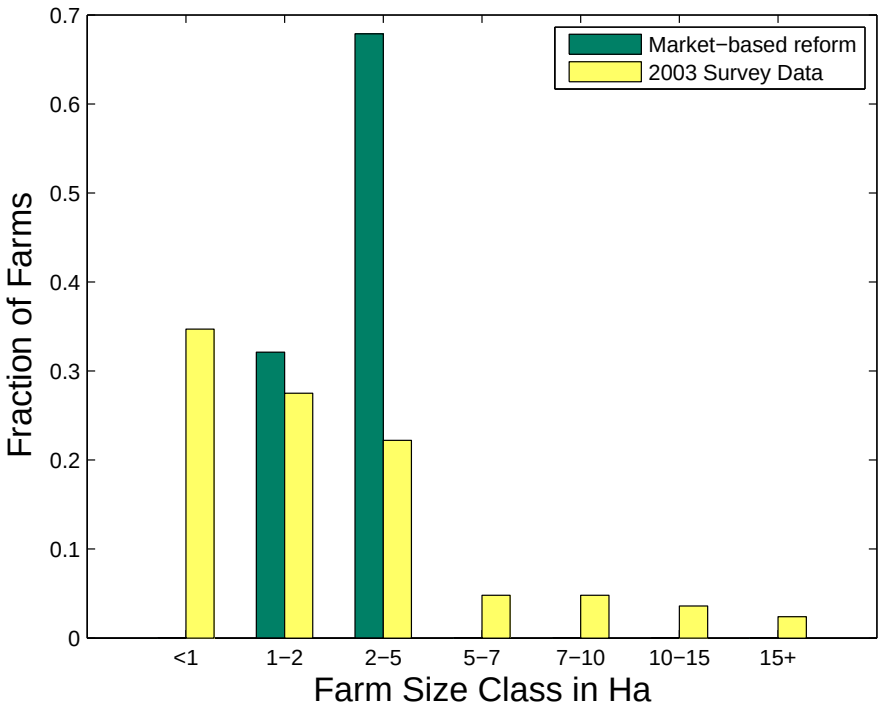
Productivity	-17.0	-5.0	-11.6
Landless (%)	-20.0	-4.0	-19.0

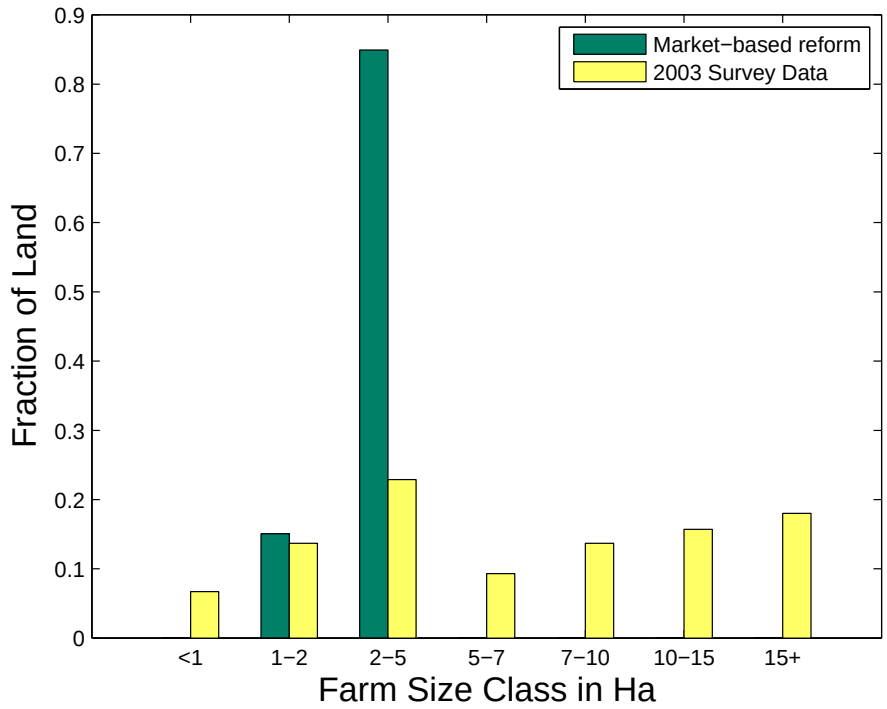
- Market-based redistribution generates less than 1/3 of the effects

Market-based Redistribution vs. 2003-04 Survey Data

Farm-size distribution



Land Share by Farm Size



- Does not capture the reality of reform in the Philippines

Productivity Decomposition

	Government-mandated Land Redistribution	Market-based Land Redistribution
Total Effect	-17.0	-5.0
Misallocation Effect	-1.1	-3.0
Selection Effect	-15.9	-2.0

- Misallocation effect roughly similar, but selection effect much larger under government-mandated redistribution

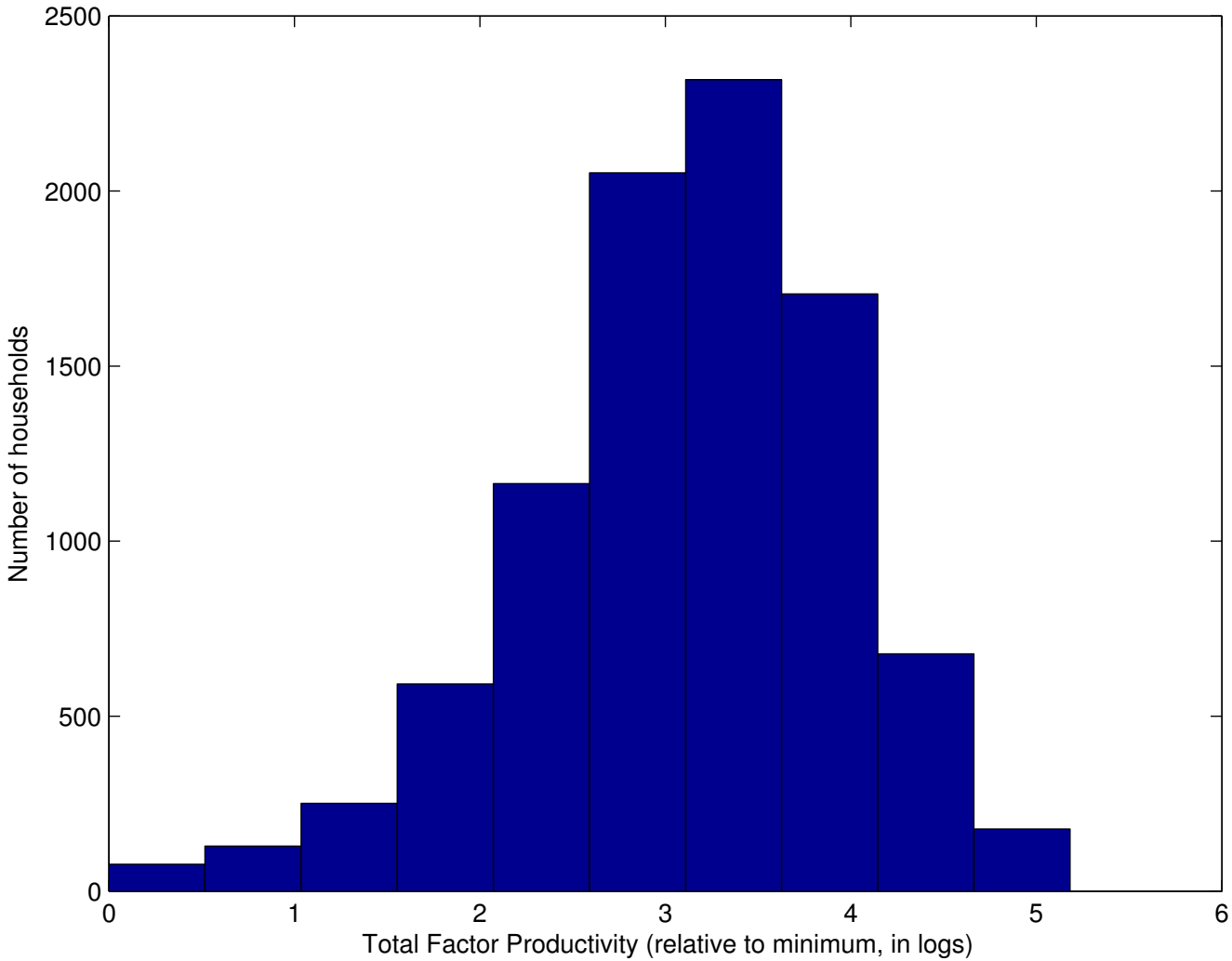
Two Specific Applications

(2) "Land Misallocation and Productivity" (with Raul Santaeulalia-Llopis)

Land Misallocation in Malawi

- Large, representative micro data with excruciating detail on agricultural production and productivity
- Land markets largely undeveloped in Malawi
  - more than 70% of land is inherited
  - almost none of the land comes with a title
  - almost no rentals
- Land fairly evenly distributed across households at very low operational scales
  - more than 70% of households operate less than 2 acres of land

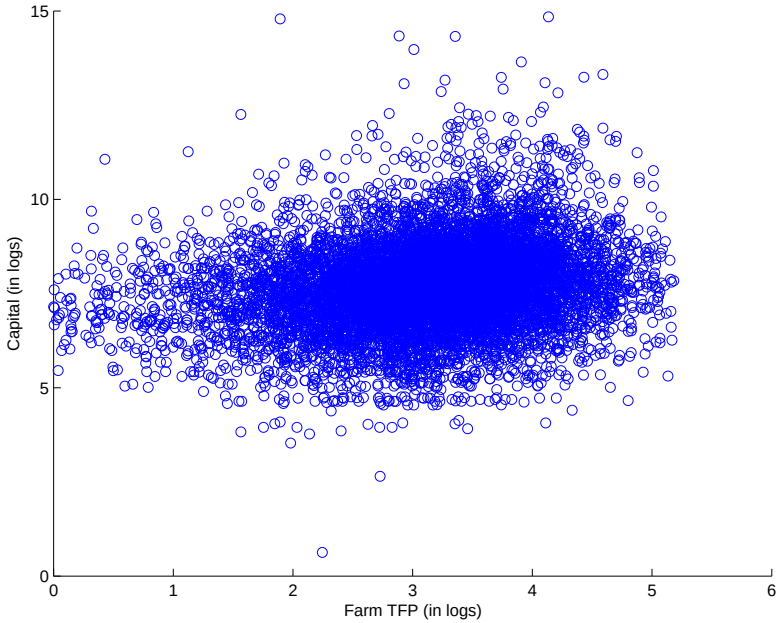
Distribution of Farm Productivity in Malawi

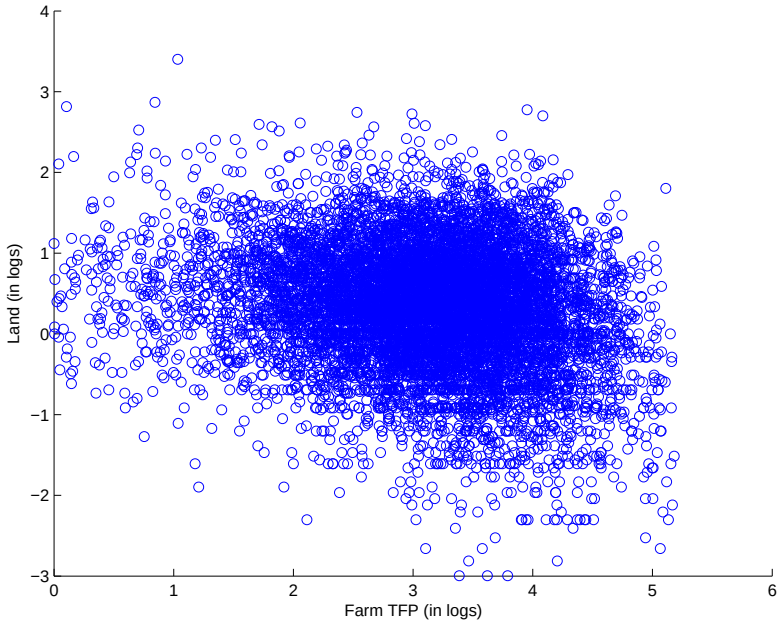


Dispersion of Farm and Plant Productivity

Statistic	Malawi 2010	USA 1977	China 1998	India 1987
SD	0.86	0.85	1.06	1.16
75-25	1.08	1.22	1.41	11.55
90-10	2.14	2.22	2.72	2.77
N	10,000	164,971	95,980	31,602

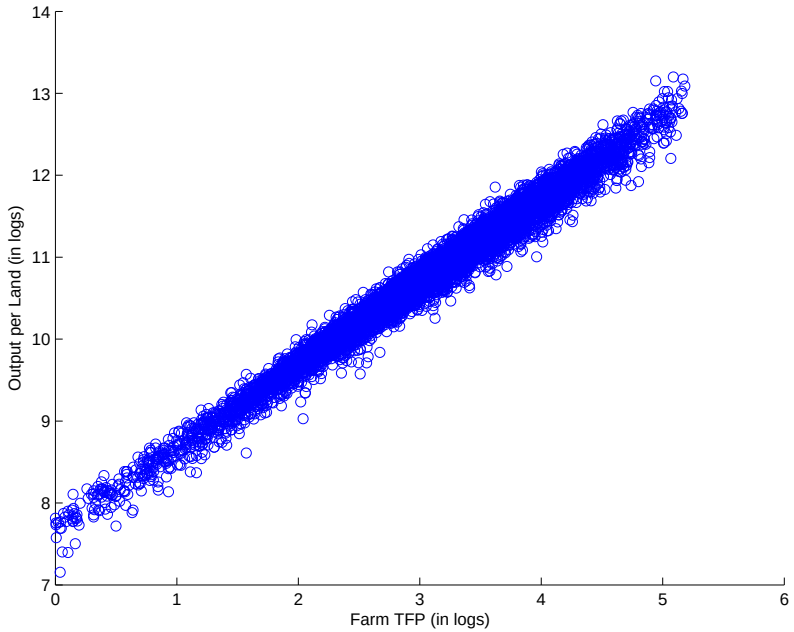
Farms by Productivity

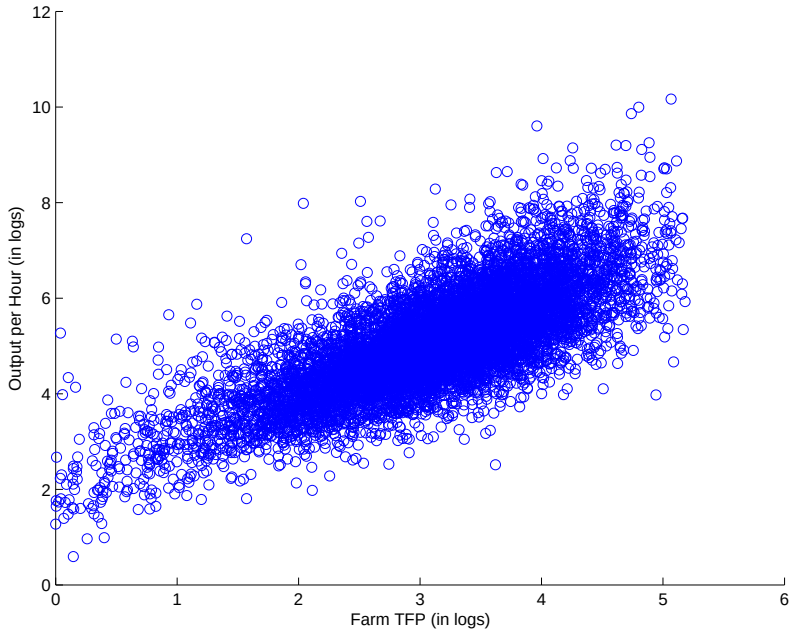




- Capital and land size not related to productivity!

Farms by Productivity





- Land productivity increases with farm TFP, indicative of misallocation!

Counterfactual

- Q: What would the agricultural productivity increase be of land reallocation across existing farmers to maximize output?
- The reallocation involves reallocating land to equalize yields (land productivity) across farmers
- A: Agricultural productivity would increase by a factor of 4-fold!
- The increase would be much larger if the number of farms is adjusted via general equilibrium effects (average farm size increase) and if there is selection into the farm exit
- Efficiency of land markets key

Final Remarks

- Measurable land reform policies generate land misallocation
- Redistributive land policies affect operational farm scales through limited or not well functioning land markets
- Implied land misallocation generates substantial negative effects on agricultural productivity
  - Land reform in Philippines generates a 17% drop in productivity, a very large effect for a single policy
  - Eliminating land misallocation in Malawi among existing farmers can generate a 4-fold increase in productivity
- These result emphasize the importance of developing efficient land markets