

# Land Misallocation and Productivity

Diego Restuccia  
University of Toronto

Raul Santaaulalia-Llopis  
Washington University in St. Louis

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# Motivation

- ▶ Why are some countries richer than others?
- ▶ Many useful perspectives. We focus on two dimensions:
  - (a) Agriculture is important in accounting for productivity differences across countries:
    - ▶ poor are much less productive in agriculture than in non-agriculture relative to rich countries
    - ▶ low productivity in agriculture means more people in agriculture to satisfy subsistence consumption
    - ▶ Challenge: why are poor countries so much less productive in agriculture?...
  - (b) Misallocation of factors across heterogeneous production units have a role explaining productivity levels.

- ▶ We argue that land (mis)allocation is important for agricultural productivity.
- ▶ We focus on Malawi. Why?
  - ▶ **Land markets are restricted and underdeveloped:** Most land is either inherited (73%) or granted by local chiefs (11.9%). Only 1.1% of land is purchased (with a title) and only 6.9% is rented.
  - ▶ We have detailed representative household-farm data to identify farm-level productivity.

# What We Do and Find

1. We **estimate farm-level productivity** using unique micro data from household-farms in Malawi. From very detailed data on farm output and inputs:
  - ▶ We capture the full degree of heterogeneity in land quality & rain (unanticipated output shocks).
  - ▶ Development accounting: **Negligible role of quality & rain.**
2. We **estimate extent of factor misallocation**: yield and capital productivity are strongly positively related to productivity, providing empirical evidence of misallocation.
3. We **assess the impact of misallocation** for agricultural productivity with a simple efficient framework:
  - ▶ Counterfactual: If land is efficiently reallocated **agricultural productivity increases by 3 times its value.**
  - ▶ Our result is robust to within narrow definitions of geographical areas, traditional authority, language, human capital.

# The Micro Data: Malawi ISA 2010

- ▶ New and unique nationally-representative household data, World Bank (see de Magalhaes and Santaaulalia-Llopis, 2014).
- ▶ The original sample includes 12,271 households of which about 81% live in rural areas.
- ▶ The survey follows a stratified 2-stage sample design.
  1. 768 enumeration areas (EAs) were selected with PPS within each district.
  2. Random systematic sampling was used to select 16 primary households and 5 replacement households from the household listing for each EA.
- ▶ Very detailed information on inputs and outputs makes this dataset ideal for our exercise.
- ▶ Sample is rolled over 12 months from March 2010 to March 2011. Seasonality is accurately addressed.

# The Micro Data: Malawi 2010 ISA: A Snapshot

- ▶ **Agricultural Production:** 70% of all income in rural Malawi. Rainy season 93% of total crop. Maize represents 78% of total production. Resolve issues of physical units conversion to estimate the unsold production.
- ▶ **Land:** Info on each cultivated household plot (owned plus rented-in). Average plots per household-farm are 1.8. Size accurately measured via GPS. The sum of all operated plots is land size.
- ▶ **Capital:** Full array of capital types. Equipment: includes implements (hand hoe, etc.) and machinery. Structures: includes chicken houses, livestock kraals... etc. We use the selling price.
- ▶ **Hours:** Most households members work in the field (size=4.57). Individual info on extensive and intensive margins of labor supply: (i) weeks worked, (ii) days/week, and (iii) hours/day by plot & by agricultural activity:
  - ▶ land preparation/ planting,
  - ▶ weeding/fertilizing, and
  - ▶ harvesting and by season (rainy, dry and permanent).

## Some Facts

# Fact 1: Small Farm Operational Scale

Percentage of Farms by Size Class

Hectares	Malawi (cum)	Belgium (cum)	USA
≤ 1 Ha	77.7	14.6	–
1 – 2 Ha	17.3	8.5	–
2 – 5 Ha	5.0 (100)	15.5 (38.6)	10.6
5 – 10 Ha	0.0	14.8	7.5
10+ Ha	0.0	46.6	81.9
Average Farm Size (Ha)	0.7	16.1	187.0

Notes: Data for Belgium and USA from the 1990 Census.

- ▶ In acres, 40% of Malawi's farmers have <1, 73%<2, 90%<3, 95%<4.
- ▶ Variance of logs is .618, 90/10 is 7.67, 75/25 is 2.78, Gini .50.



## Fact 2: Most production used for own consumption

- ▶ Food insecurity last 12 m is on average 50.6% (top 10% of agri. production face 28%, bottom 10% face 80.7%). High food consumption/ag. production. 67% of all consumption is food.

## Fact 3: Farms use land at (almost) full capacity

- ▶ We include owned plots, and rented-in plots. There are 283 rural households without plots. The total share of land that is not cultivated is: less than 3%. Some left fallow.

## Fact 4. Evidence by Farm Productivity

- ▶ Fact 4.1: Land does not increase with farm productivity (uncorrelated)
- ▶ Fact 4.2: Capital does not increase with farm productivity (uncorrelated)
- ▶ Fact 4.3: Capital-land ratio is roughly constant across farm productivity.
- ▶ Fact 4.4: Yield (output per unit of land) increases with farm productivity.
- ▶ Fact 4.5: Capital productivity (output per unit of capital) is increases with farm productivity.

# Estimating Farm Productivity

We identify household farm productivity  $s_i$  as the unobservable  $s_i$  in

$$y_i = s_i \zeta_i k_i^{\theta_k} (q_i l_i)^{\theta_l}$$

where  $\theta_x$  are input factor shares.

- ▶  $\zeta_i$  represents unanticipated shocks (e.g. rain), and
- ▶  $q_i$  is an index of land quality.

# Land Quality Dimensions

VERY detailed information on the land quality per plot (and household). We use full set of 11 dimensions reported in ISA.

1. Elevation
2. Slope
3. Erosion
4. Soil Quality
5. Nutrient Availability
6. Nutrient Retention Capacity
7. Rooting Conditions
8. Oxygen Availability to Roots
9. Excess Salts
10. Toxicity
11. Workability

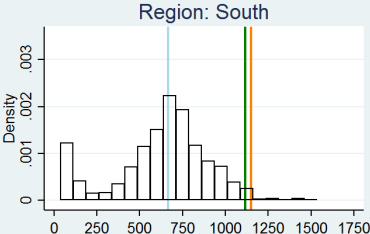
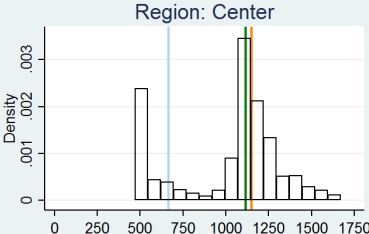
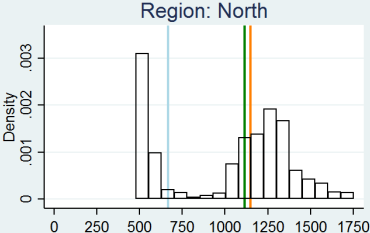
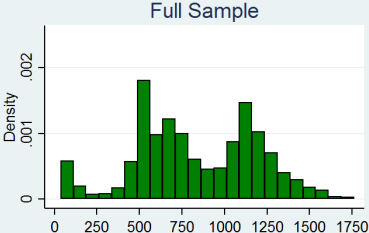
## Land Quality Dimensions (continued)

Farm heterogeneity in terrain roughness (elevation and slope):

	Type (%)	Full Sample Elevation (meters)	Slope (%)	North	Regions Center Type (%)	South
Lowlands	1.03	132	5.98	.00	.00	2.16
Rugged Lowlands	.11	106	16.23	.00	.00	.24
Plains	4.92	86	1.71	.00	.00	10.33
Mid-altitude Plains	8.31	474	1.76	8.85	8.73	7.81
High-altitude Plains	34.88	873	2.34	23.24	46.63	30.55
Platforms (very low plateaus)	2.11	401	6.19	1.40	.23	3.74
Low plateaus	20.57	727	6.46	14.62	7.56	32.28
Mid-altitude plateaus	19.25	1,218	6.55	34.65	32.09	4.19
Hills	.62	381	16.83	.29	.00	1.20
Low Mountains	3.38	769	15.98	3.90	.26	5.48
Mid-altitude Mountains	4.82	1,314	16.59	13.05	4.50	2.03
	100.00	834	5.29	100.00	100.00	100.00

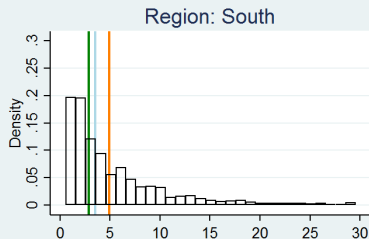
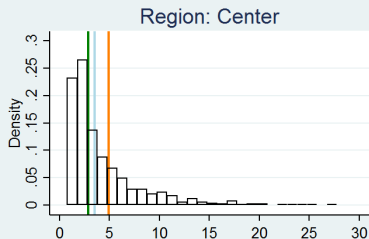
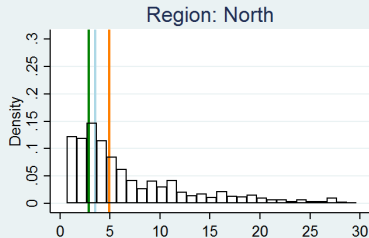
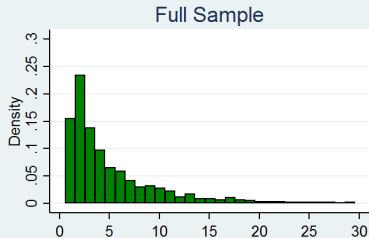
Notes: Type refers to the percentage of land according to land quality dimensions. Elevation is reported in meters and Slope in percent.

# Elevation (meters), Malawi ISA-2010/11



Notes: Median values in orange (North), green (Center) and blue (South).

# Slope (in %), Malawi ISA-2010/11



Notes: Median values in orange (North), green (Center) and blue (South).

► More dimensions of land quality: Empirical properties

## Land Quality Index, $q_i$

- ▶ Our benchmark land quality index:

$$q_i^0 = g(\bar{q}_i)$$

where the vector  $\bar{q}_i$  for household  $i$  contains the following 11 land quality dimensions

$$j = \{sl, ele, ero, sq, na, nc, rc, oar, exs, tox, w\}$$

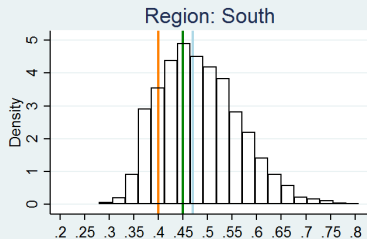
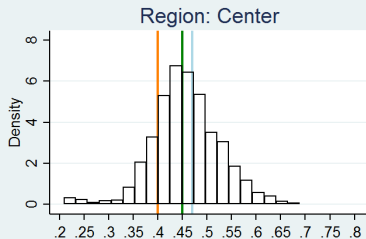
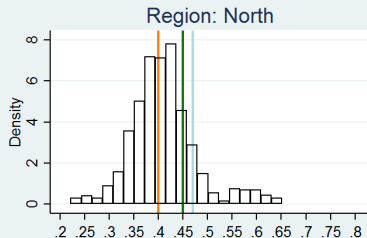
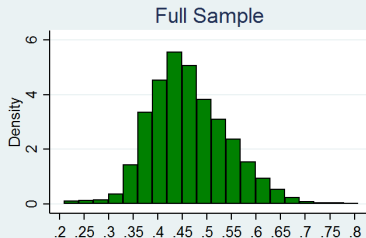
and,

$$g(\cdot) = \prod_{j=1, n} q_j^{\omega_j},$$

where  $n=11$  and  $\omega_j = \omega \forall j$ .



# Land Quality Index $q_i$ , Malawi ISA-2010/11



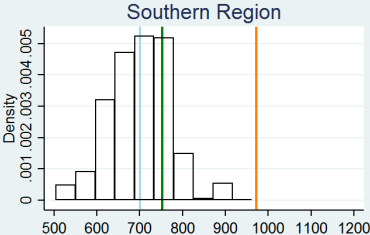
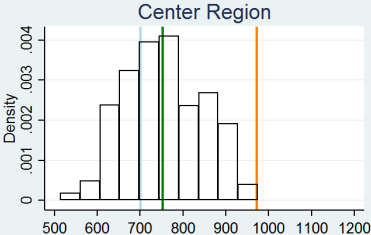
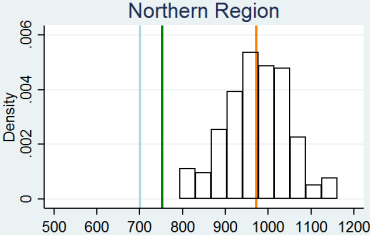
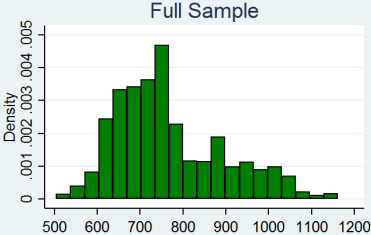
Notes: Median values in orange (North), green (Center) and blue (South).

# Dispersion (Variance) of Land Quality vs. Land Size

	By Geographic Aggregation Level:			
	Full Sample	Regions	Districts	Enum. Area
Land Size, $L_i$ :	.618	.595	.545	.488
Land Quality Index: $q_i^0$	.029	.026	.019	.004
Land Quality Items:				
Elevation	.439	.349	.075	.001
Slope (%)	.657	.635	.453	.093
Erosion	.188	.187	.175	.162
Soil Quality	.156	.155	.144	.133
Nutrient Avail.	.190	.162	.099	.007
Nutrient Ret. Cap.	.119	.105	.068	.005
Rooting Conditions	.209	.195	.161	.013
Oxygen Avail. to Roots	.079	.079	.059	.003
Excess Salts	.031	.031	.029	.002
Toxicity	.022	.022	.021	.001
Workability	.226	.201	.154	.014

Notes: All variables have been logged.

# Rain Shocks, $\zeta_i$



Notes: Median values in orange (North), green (Center) and blue (South).

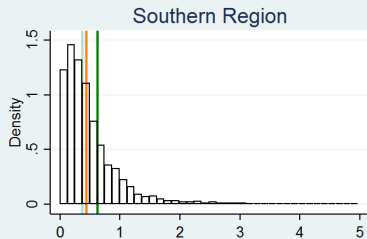
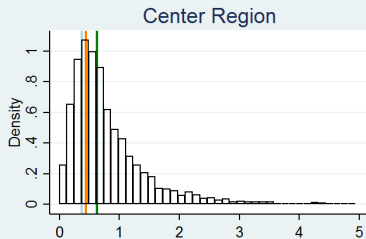
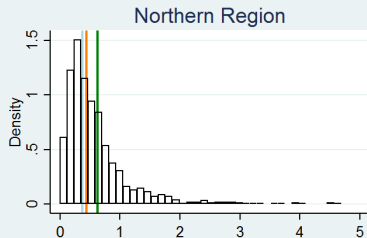
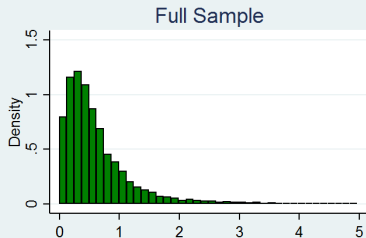
# Dispersion (Variance) of Rain Shocks, $\zeta_i$

		By Geographic Aggregation Level:		
	Full Samp.	Regions	Districts	Enum. Area
Land Size, $L_i$ :	.618	.595	.545	.488
Rain:				
Annual Precip. (mm)	.025	.010	.004	.000
Precip. of Wettest Qrter (mm)	.026	.013	.005	.000
Unanticipated Rain Shocks:				
Annual Precip. (mm)	.008	.007	.004	.000
Precip. of Wettest Qrter (mm)	.011	.010	.004	.000

Notes: All variables have been logged. By region, Northern has a variance in  $\zeta_i$  of .005, Center .015, and Southern .009.

► Rain Variables

# Farm Productivity, Malawi ISA-2010/11



Notes: Median values in orange (North), green (Center) and blue (South).

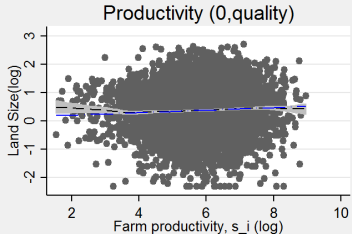
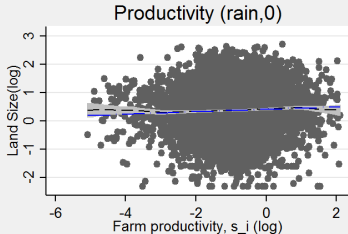
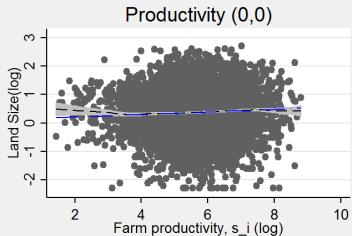
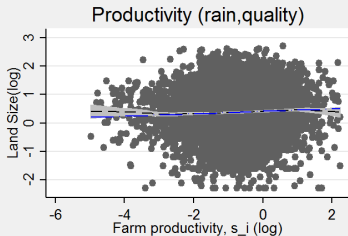
# Variance Decomposition $y_i$

	$\zeta_i$ Yes	$q_i$ Yes	%	$\zeta_i$ No	$q_i$ No	%
$var(y)$	1.423		100.0	1.423		100.0
$var(s)$	.968		68.0	.937		65.8
$var(\zeta)$	.007		.5	–		–
$var(f(k, ql))$	.297		20.9	.303		21.3
$2cov(s, \zeta)$	-.012		-.8	–		–
$2cov(s, f(k, ql))$	.156		11.0	.172		12.1
$2cov(\zeta, f(k, ql))$	.003		.3	–		–

Notes: All variables have been logged.

► More on Var-Decomp

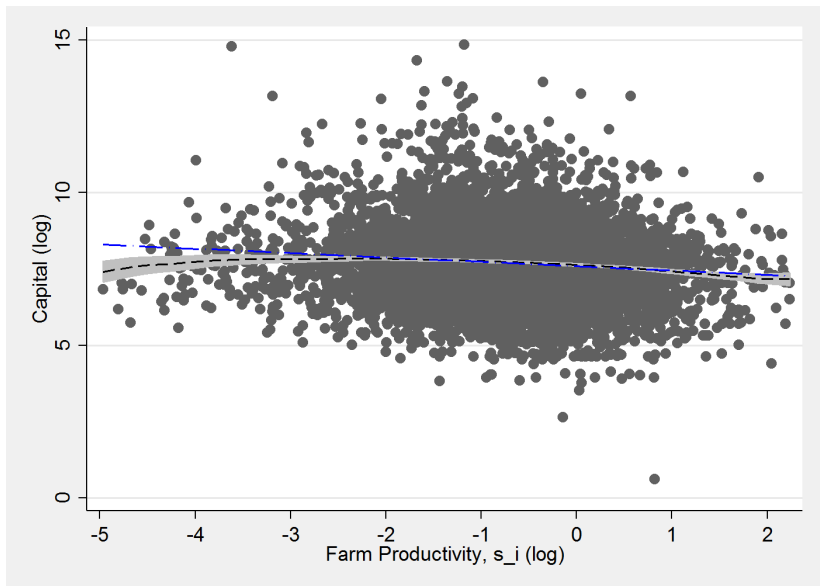
## Fact 4.1: Land Size by Farm Productivity $s_j$



Notes: The correlations b/w land size and  $s(\zeta_j, q_j)$  is .04,  $s(0,0)$  is .01,  $s(\zeta_j, 0)$  is .09, and  $s(0, q_j)$  is -.07.

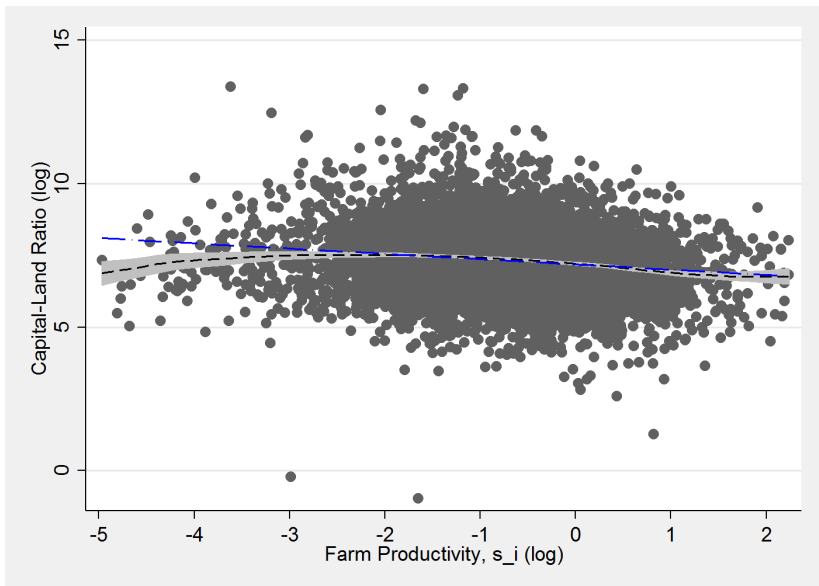
► More on Productivity and Land Size

## Fact 4.2: Capital by Farm Productivity

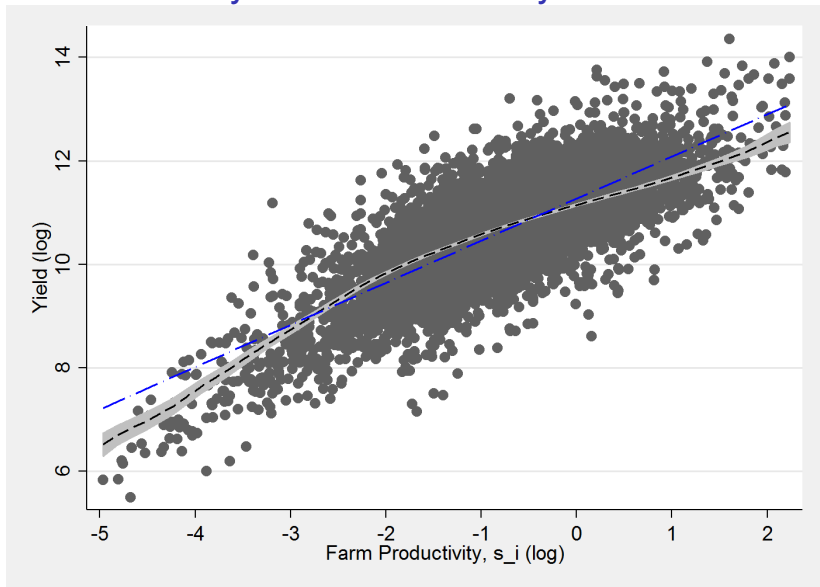




## Fact 4.3: Capital-Land Ratio by Farm Productivity

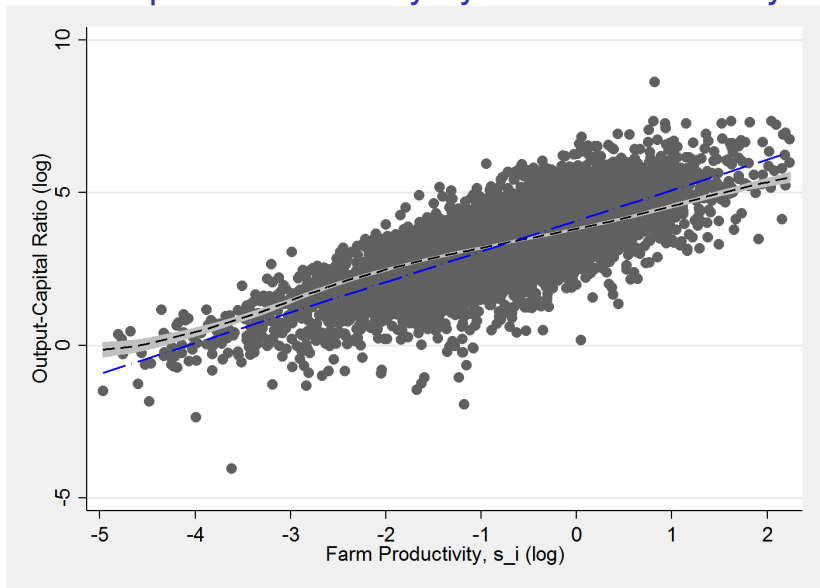


## Fact 4.4: Yield by Farm Productivity



Notes: The correlation is .77 (N .70, C .71, S .81).

## Fact 4.5 Capital Productivity by Farm Productivity

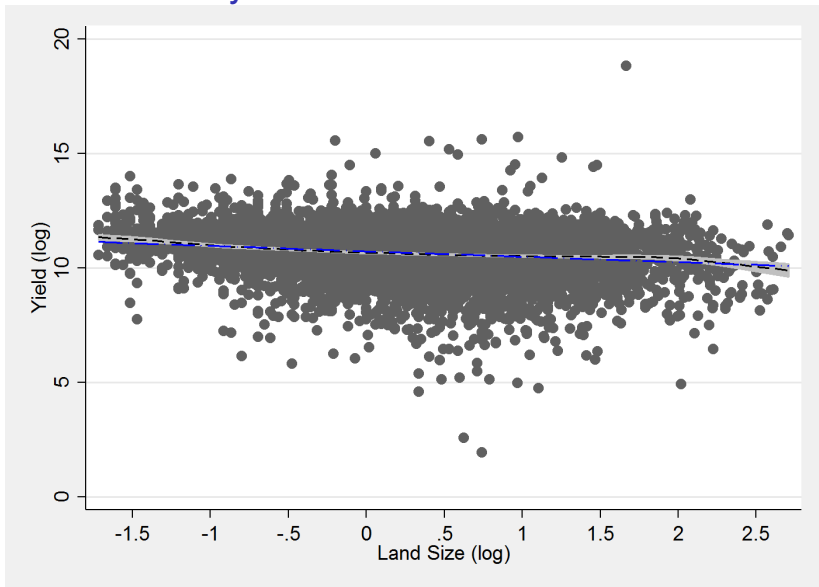


Notes: The correlation is .76 (N .71, C .71, S .79).

## Fact 5. Evidence by Farm Size

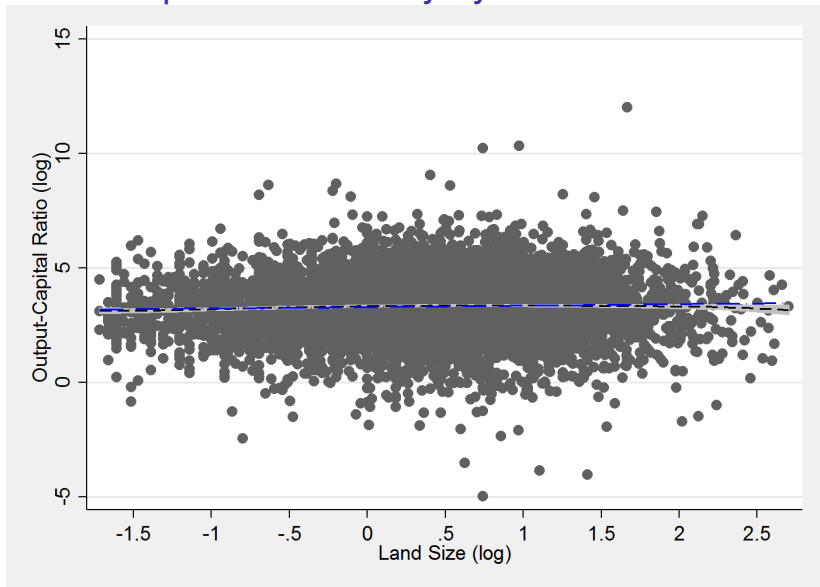
- ▶ Fact 5.1: Capital increases with farm size
- ▶ Fact 5.2: Capital-land ratio is roughly constant across farm size.
- ▶ Fact 5.3: Yield (output per unit of land) weakly declines with farm size.
- ▶ Fact 5.4: Capital productivity (output per unit of capital) is roughly constant with farm size.

## Fact 5.3: Yield by Farm Size



Notes: The correlation is  $-.18$  (N  $-.28$ , C  $-.08$ , S  $-.33$ ).

## Fact 5.4: Capital Productivity by Farm Size



Notes: The correlation is .03 (N .08, C .00, S -.02).

# Assessing Productivity Effect of Misallocation

## Misallocation and Productivity

- ▶ Solve efficient allocation of capital and land across a fixed set of heterogeneous farmers.
- ▶ Planner chooses allocations to maximize agricultural output given fixed amounts of capital and land:

$$Y^e = \max_{\{k_i, l_i\}} \sum_i s_i (k_i^{\alpha_k} l_i^{\alpha_l})^\gamma,$$

subject to:

$$K = \sum_i k_i,$$

$$L = \sum_i l_i.$$

- ▶ Efficient allocation equates marginal products of capital and land and has a simple form, let  $z_i \equiv s_i^{1/(1-\gamma)}$ ,

$$k_i^e = \frac{z_i}{\sum z_i} K, \quad l_i^e = \frac{z_i}{\sum z_i} L.$$



# Main Reallocation Result

- ▶ The output (productivity) loss is defined as

$$\frac{Y^a}{Y^e} = \frac{\sum y_i^a}{\sum y_i^e} = .330$$

where  $y_i = s_i (k_i^{\alpha_k} l_i^{\alpha_l})^\gamma$ , and  $y_i^e$  is evaluated at efficient allocations.

- ▶ That is, if we were to efficiently reallocate land and capital, **aggregate output would increase by a factor of 3.**

# Reallocation Results

## Output (Productivity) Loss ( $Y^a/Y^e$ )

	Aggregate	Median	Min	Max
Nationwide	.330	–	–	–
Region	.376	.429	.232	.564
District	.436	.443	.163	.692
Traditional Authority	.546	.578	.130	.878
Language	.375	.326	.194	.818

Notes: Table reports ratio of actual to efficient output. By region, median is Center, min is North, max is South.

# Actual vs. Efficient Distribution

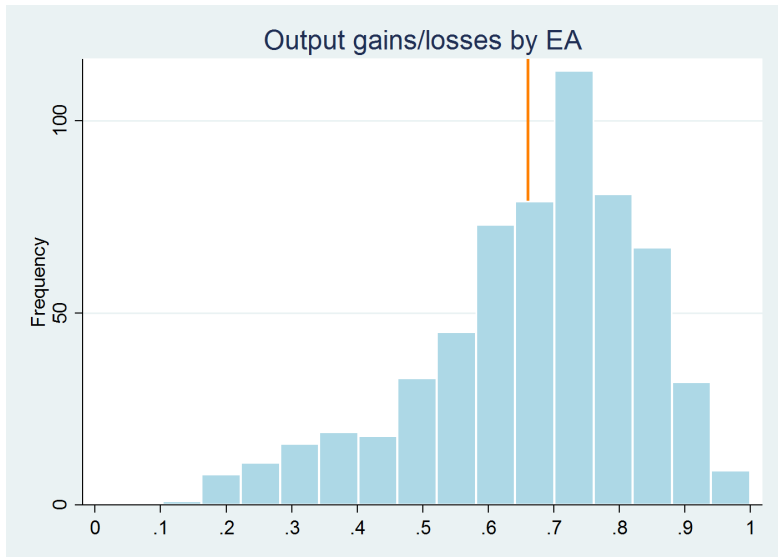
	Bottom(%)			Quartiles				Top(%)		1
	0-1	1-5	5-10	1st	2nd	3rd	4th	10-5	5-1	
Prod. $s_j$ :	.00	.00	.04	.11	.29	.47	1.95	2.80	4.03	9.67
Land:										
Actual	1.78	1.79	1.77	1.82	1.90	1.82	2.06	2.14	2.07	2.11
Eff.	.00	.00	.00	.01	.06	.17	13.30	25.67	49.54	231.02
Capital:										
Actual	2,105	2,530	5,465	6,688	8,513	4,819	3,800	3,968	2,933	2,695
Eff.	0	0	7	37	196	509	38,014	73,344	141,550	660,054
Yield:										
Actual	.00	.00	.02	.07	.18	.26	.38	.97	1.35	3.28
Eff.	.00	.00	.02	.07	.18	.26	.38	.97	1.35	3.28

Notes: Farm households are ranked according to farm productivity.

[▶ More on Actual vs. Efficient Inequality](#)

# Reallocation within Enumeration Areas

## Land Quality Check



# Reallocation within Skill Groups

## Human Capital Check

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	Schooling Groups:			
	No Schooling	Dropouts	Primary	> Primary
Output Loss ( $Y^a/Y^e$ )	.382	.290	.336	.463
	Terrain-roughness Specific Skills:			
	High Altitude Plains	Low Plateaus	Mid-Altitude Plateaus	Mid-Altitude Mountains
Output Loss ( $Y^a/Y^e$ )	.262	.451	.480	.393

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Notes: By education groups, no Schooling 24.83%, primary school dropouts 44.92%, primary 23.12%, and more 7.14%.

# Conclusion

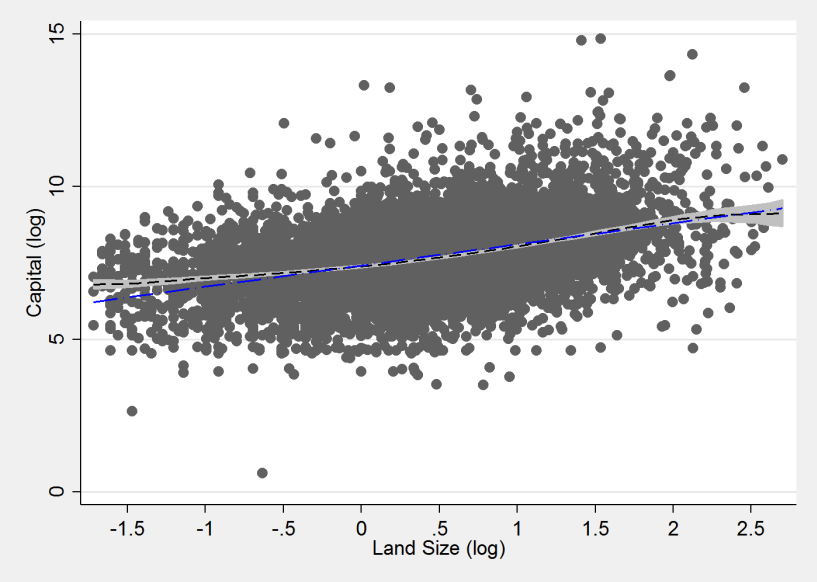
1. We **estimate productivity for household-farms**. Excellent output and input data that also allows to control for land quality & rain shocks. We find **little quantitative role of land quality & rain in accounting for output differentials across farms**.
2. An **efficient reallocation of capital and land across the existing set of farmers increases agricultural output and total factor productivity by a factor of 3-fold**.
3. **Similar** increase in productivity arises in reallocating **within regions, districts, and much narrower enumeration areas**. Also within a wide set of factors such as language, human capital, among others.
4. Productivity effects can be larger when allowing for endogenous productivity investment, GE effects in the number of farms (increase in average farm size), selection, among others.

# Measurement Error

- ▶ There are very few missing observations.
- ▶ Our understanding from the World Bank field managers in charge of the data collection is that this is due to the fact that respondents took the survey as 'official'.
- ▶ Internal consistency reliability checks are conducted (e.g., individuals are asked total sales, and also sales by crop; the interviewer checks that the sums coincide).
- ▶ We exclude outliers: Trimming the top and bottom 1%
- ▶ While not in our benchmark, to deal with potential recall and telescopic measurement error in agriculture production and activities we re-conduct our exercise for households that were interviewed within the three months after and including March (the harvest month).

▶ Back

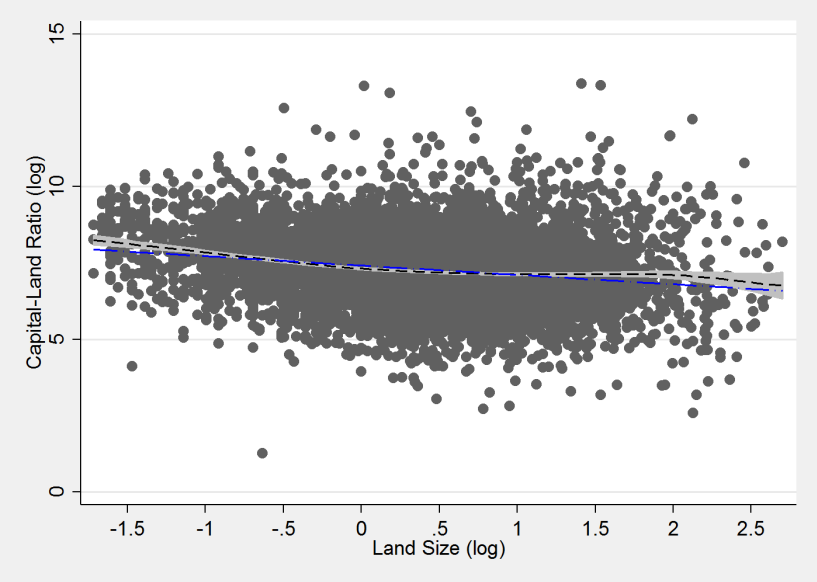
# Fact 4.1 Capital vs. Farm Size



Notes: The correlation is .42 (N .37, C .48, S .35).

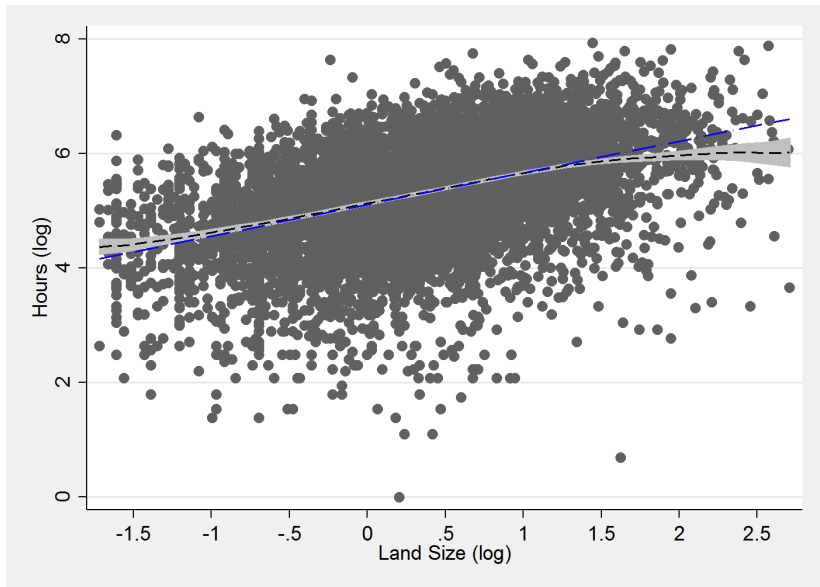


# Fact 4.2 Capital-Land Ratio vs. Farm Size



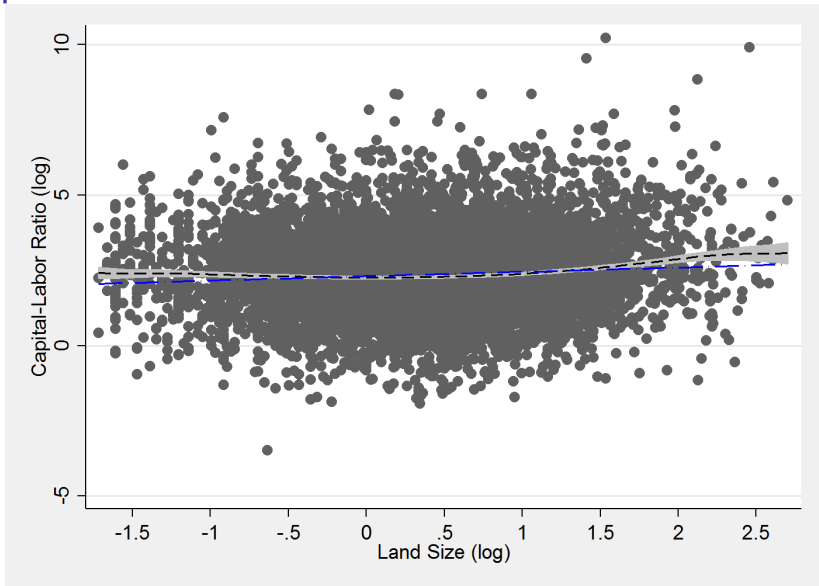
Notes: The correlation is  $-.20$  (N  $-.31$ , C  $-.05$ , S  $-.30$ ).

# Hours vs. Farm Size



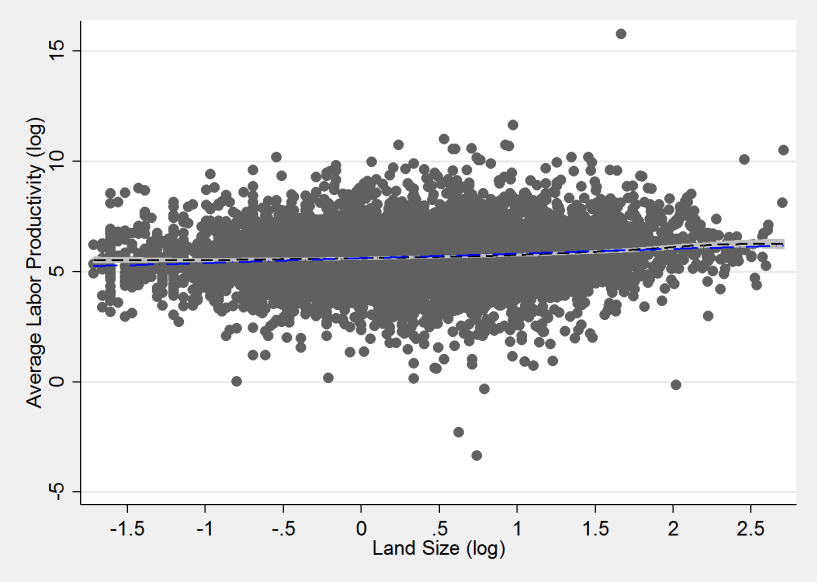
Notes: The correlation is .45 (N .45, C .47, S .41).

# Capital-Labor Ratio vs. Farm Size



Notes: The correlation is .07 (N -.03, C .16, S .03).

# Labor Productivity vs. Farm Size



Notes: The correlation is .13 (N .03, C .21, S -.01).

## Land Quality Dimensions (continued)

- ▶ Global Agro-Ecological Zone (GAEZ):

Use latitude and longitude coordinates. Within Malawi we can identify four zones.

	Full Sample	North	Regions	
			Center	South
Tropic-warm/semiarid	47.49	4.31	63.13	51.90
Tropic-warm/subhumid	35.23	50.47	11.12	47.41
Tropic-cool/semiarid	10.55	10.24	24.17	.68
Tropic-cool/subhumid	6.72	34.98	1.58	.11
	100.00	100.00	100.00	100.00

In rural areas, population distribution across regions is 17.49% in Northern Malawi, 34.89% in Center, and 47.62% in Southern Malawi.

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# Land Quality Dimensions (continued)

	Full Sample		North		Regions Center		South	
Slope:								
Flat	56.24	(2.5)	57.07	(3.6)	54.84	(2.4)	56.98	(2.4)
Slight	32.54	(4.9)	27.99	(5.8)	34.77	(3.7)	32.45	(5.7)
Moderate	8.14	(6.2)	8.68	(8.0)	8.24	(5.4)	7.88	(6.5)
Steep/Hilly	3.08	(10.3)	6.26	(14.6)	2.15	(6.7)	2.68	(10.7)
	100.00	(3.5)	100.00	(4.9)	100.00	(2.9)	100.00	(3.5)
Erosion, $q_i^{ero}$ :								
No Erosion	60.69		51.62		61.82		62.96	
Low	26.66		31.56		25.82		25.60	
Moderate	7.57		10.23		7.65		6.60	
High	5.08		6.59		4.71		4.84	
	100.00		100.00		100.00		100.00	
Soil Quality, $q_i^{sq}$ :								
Good	45.95		48.86		44.91		45.72	
Fair	42.63		43.47		40.51		43.89	
Poor	11.42		7.67		14.58		10.39	
	100.00		100.00		100.00		100.00	

Notes: Regressing  $\ln(\text{slope})$  on self-reported slope dummies we find all dummies significant, and capturing 17% of the slope variation.

# Land Quality Dimensions (continued)

	Full Samp.	North	Regions Center	South
Nutrient Availability, $q_i^{na}$ :				
No or Slight Rest.	59.63	28.29	47.05	80.37
Moderate Rest.	22.13	43.13	25.74	11.76
Severe Rest.	13.51	22.24	18.24	6.84
Very Severe Rest.	.42	6.34	1.20	1.03
	100.00	100.00	100.00	100.00
Nutrient Retention Capacity, $q_i^{nc}$ :				
No or Slight Rest.	65.12	43.42	51.81	82.85
Moderate Rest.	28.81	44.24	38.38	16.12
Severe Rest.	1.51	6.00	1.31	.00
Very Severe Rest.	.51	6.34	1.46	.00
	100.00	100.00	100.00	100.00
Rooting Conditions, $q_i^{rc}$ :				
No or Slight Rest.	63.75	38.53	72.36	66.70
Moderate Rest.	15.69	26.19	10.80	15.42
Severe Rest.	14.01	26.78	9.05	12.96
Very Severe Rest.	2.33	2.15	.76	3.55
	100.00	100.00	100.00	100.00

# Land Quality Dimensions (continued)

	Full Samp.	North	Regions Center	South
Oxygen Availability to Roots, $q_i^{par}$ :				
No or Slight Rest.	85.50	84.40	81.67	88.71
Moderate Rest.	6.35	6.11	4.12	8.08
Severe Rest.	3.42	3.14	5.25	2.18
Very Severe Rest.	.67	.00	1.93	.00
	100.00	100.00	100.00	100.00
Excess Salts, $q_i^{exs}$ :				
No or Slight Rest.	91.35	84.40	90.81	94.31
Moderate Rest.	3.50	5.94	.70	4.66
Severe Rest.	.84	3.32	.73	.00
Very Severe Rest.	.25	.00	.73	.00
	100.00	100.00	100.00	100.00
Toxicity, $q_i^{tox}$ :				
No or Slight Rest.	93.08	84.40	90.81	97.93
Moderate Rest.	1.99	7.10	.70	1.05
Severe Rest.	.63	2.15	.73	.00
Very Severe Rest.	.25	.00	.73	.00
	100.00	100.00	100.00	100.00



## Land Quality Dimensions (continued)

	Full Samp.	North	Regions Center	South
Workability, $q_i^w$ :				
No or Slight Rest.	48.31	37.25	69.47	36.87
Moderate Rest.	27.83	27.88	13.46	38.34
Severe Rest.	15.67	26.37	9.28	16.42
Very Severe Rest.	3.97	2.15	.76	6.99
	100.00	100.00	100.00	100.00

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# Dispersion (Variance) of Land Quality

	Full Samp.	By Geographic Aggregation Level:		
		Regions	Districts	Enum. Area
Land Size, $L_i$ :	.618	.595	.545	.488
Quality-Adjusted Land Size:				
$q_i^0 L_i$	.647	.625	.568	.485
$q_i^1 L_i$	.636	.618	.566	.486
$q_i^2 L_i$	.704	.691	.609	.510
$q_i^3 L_i$	.942	.927	.736	.514

Notes: All variables have been logged.

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## Rain Shocks, $\zeta_j$

- ▶ Annual Precipitation (total rainfall, mm) (last 12 months), and average 12-month total rainfall (mm) in last 10 years (since 2001).

To compute the unanticipated amount of rain in 2010/11,  $u_{2010}$ , we remove from the current annual precipitation the average of total rainfall of the past 10 years,

$$\ln \text{total rainfall}_{2010} = \text{cons} + \beta \ln \text{average total rainfall}_{\text{since2001}} + u_{2010} \quad (1)$$

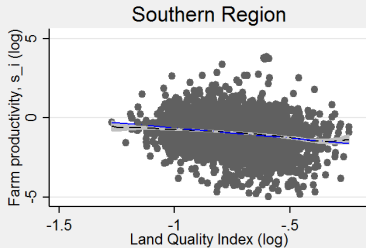
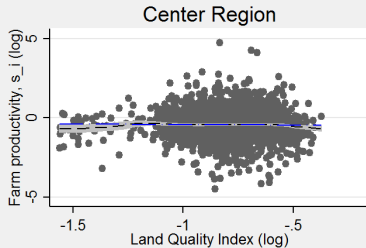
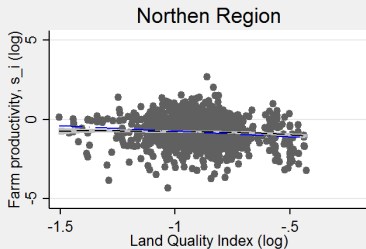
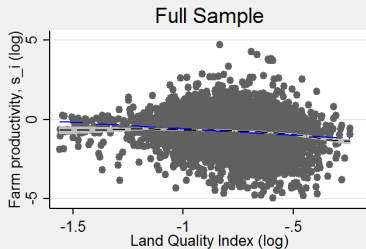
- ▶ Precipitation of wettest quarter (mm) (within last 12 months), and average precipitation of wettest quarter (mm) in last 10 years (since 2001).<sup>1</sup>

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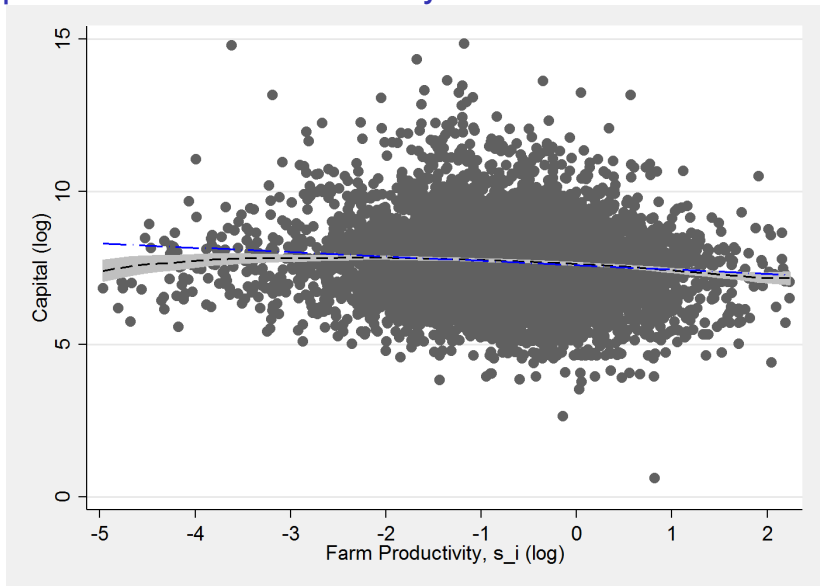
<sup>1</sup> For now, we ignore temperature and greenness.

# Productivity $s_i$ vs. Land Quality Index $q_i$ : By Region



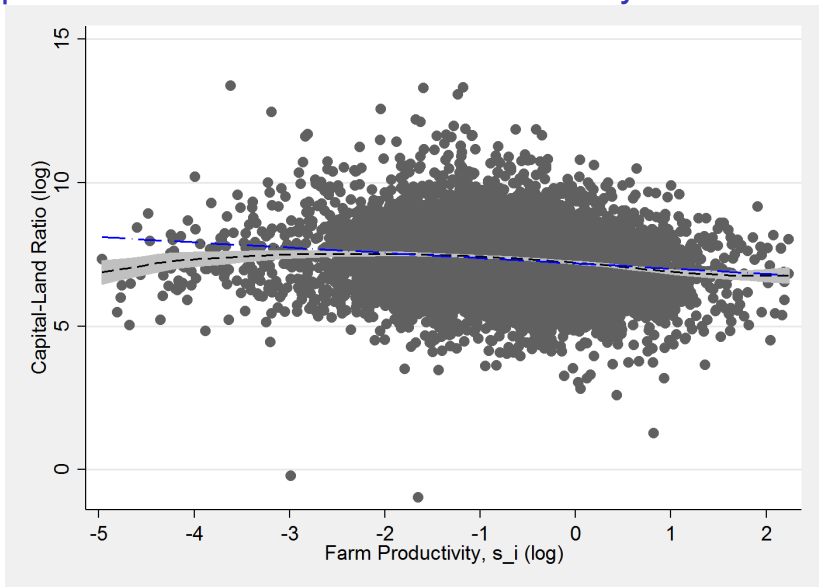
Notes: The correlations b/w land quality and  $s_i$  is  $-.14$  in the full sample,  $-.13$  in the Northern region,  $-.01$  in the Center region, and  $-.21$  in the Southern region.

# Capital vs. Farm Productivity



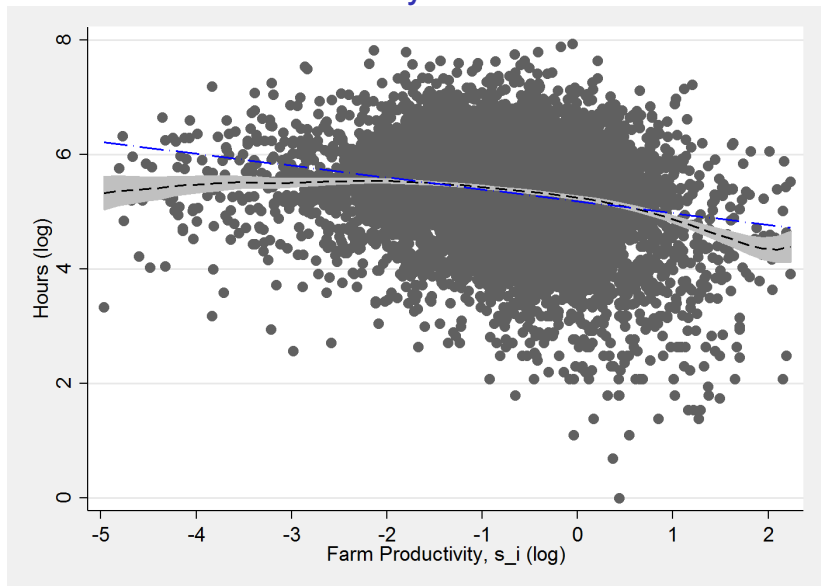
Notes: The correlation is  $-.10$  (N  $-16$ , C  $-.15$ , S  $-.14$ ).

# Capital-Land Ratio vs. Farm Productivity



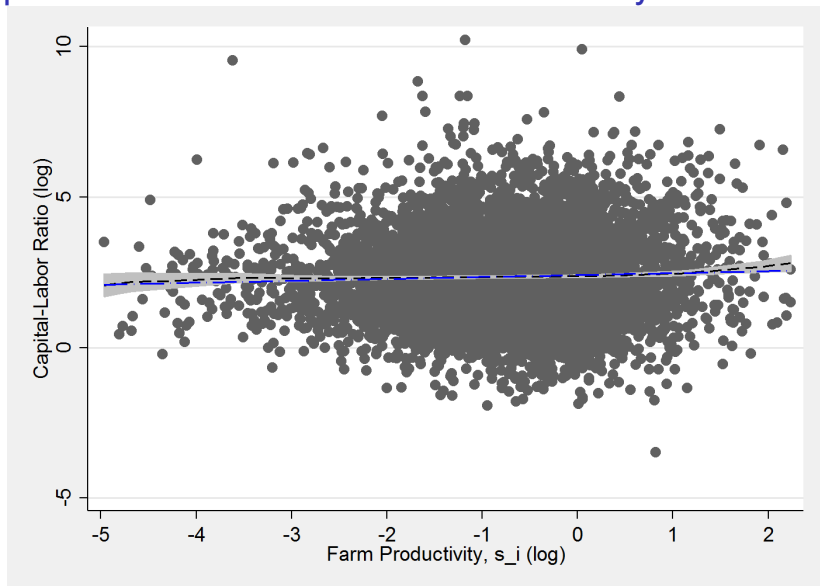
Notes: The correlation is  $-.14$  (N  $-18$ , C  $-.22$ , S  $-.09$ ).

# Hours vs. Farm Productivity



Notes: The correlation is  $-.21$  (N  $-.32$ , C  $-.23$ , S  $-.25$ ).

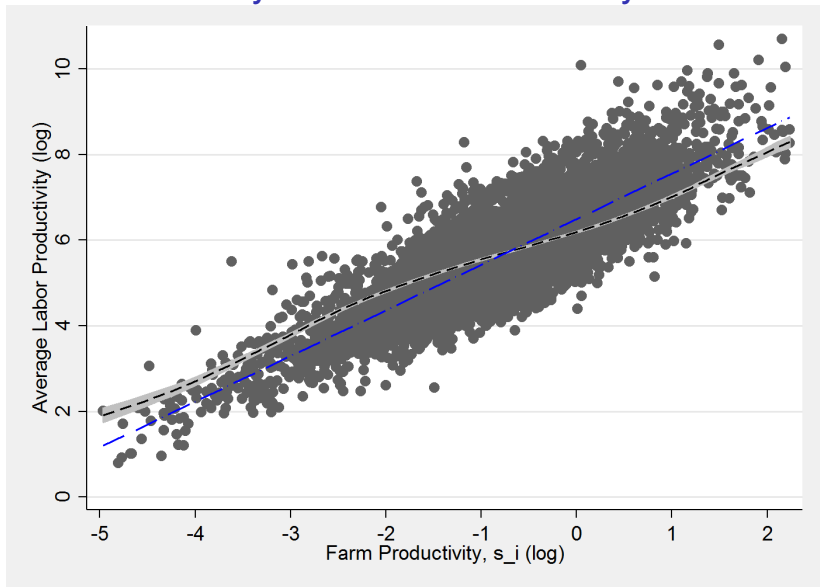
# Capital-Labor Ratio vs. Farm Productivity



Notes: The correlation is .04 (N .11, C -.00, S .04).



# Labor Productivity vs. Farm Productivity



Notes: The correlation is .84 (N .85, C .80, S .87).

# Variance Decomposition $y_i$

	$\zeta_i$ Y	$q_i$ Y	%	$\zeta_i$ N	$q_i$ N	%	$\zeta_i$ Y	$q_i$ N	%	$\zeta_i$ N	$q_i$ Y	%
$var(y)$	1.423		100.0	1.423		100.0	1.423		100.0	1.423		100.0
$var(s)$	.968		68.0	.937		65.8	.943		66.3	.962		67.6
$var(\zeta)$	.007		.5	—		—	.007		.5	—		—
$var(f(k, q l))$	.297		20.9	.303		21.3	.303		21.3	.297		20.9
$2cov(s, \zeta)$	-.012		-.8	—		—	-.012		-.8	—		—
$2cov(s, f(k, q l))$	.156		11.0	.172		12.1	.170		11.9	.158		11.1
$2cov(s, \theta_k k)$	.082		5.8	.084		5.9	.082		5.8	.086		6.0
$2cov(s, \theta_l q)$	-.012		-.8	—		—	—		—	-.014		-1.0
$2cov(s, \theta_l l)$	.086		6.0	.088		6.2	.088		6.2	.086		6.0
$2cov(\zeta, f(k, q l))$	.003		—	—		.3	.004		.3	—		—
$2cov(\zeta, \theta_k k)$	.003		.2	—		—	.003		.3	—		—
$2cov(\zeta, \theta_l q)$	-.000		-.0	—		—	—		—	—		—
$2cov(\zeta, \theta_l l)$	.000		.0	—		—	.000		.0	—		—

Notes: All variables have been logged.

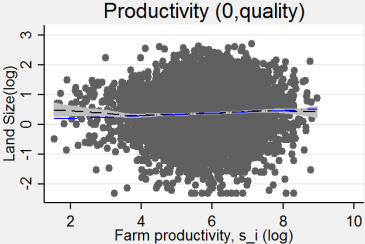
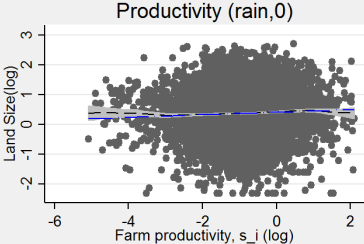
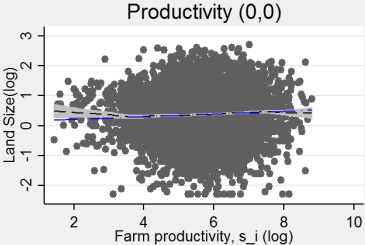
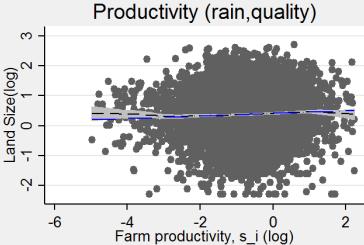
# Variance Decomposition $y_i$ , by region (with $q_i$ and $\zeta_i$ )

	Full S.		Regions							
		%	North	%	Center	%	South	%		
$var(y)$	1.423	100.0	1.252	100.0	1.156	100.0	1.432	100.0		
$var(s)$	.968	68.0	.735	58.7	.726	62.8	1.054	73.6		
$var(\zeta)$	.007	.5	.004	.3	.012	1.0	.004	.3		
$var(f(k, ql))$	.297	20.9	.292	23.3	.324	28.0	.263	18.4		
$2cov(s, \zeta)$	-.012	-.8	-.006	-.5	-.024	-2.1	.001	.1		
$2cov(s, f(k, ql))$	.156	11.0	.204	16.3	.116	10.0	.103	7.2		
$2cov(\zeta, f(k, ql))$	.003	.2	-.001	-.1	.004	.3	.000	.0		

Notes: All variables have been logged.

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# Productivity $s_i$ vs. Land Size



Notes: The correlations b/w land size and  $s(\zeta_i, q_i)$  is .05,  $s(0,0)$  is .01,  $s(\zeta_i, 0)$  is .09, and  $s(0, q_i)$  is -.06.

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# Inequality

	Productivity	Land	Data Capital	Output	Efficient $\{l_i, k_i, y_i\}$
Variance	.909	.841	1.715	1.161	4.297
75-25	3.61	2.78	4.95	4.22	12.20
90-10	10.82	7.67	24.21	19.96	177.12
Gini	.51	.50	.72	.63	.94

Notes: To compute the variance, variables are in logs. Output is net of quality and rain shocks.

# Inequality By Region

Northern Region :	Productivity	Land	Data Capital	Output	Efficient $\{l_i, k_i, y_i\}$
Variance	.688	.821	1.619	1.191	3.253
75-25	2.83	3.21	5.08	4.14	9.65
90-10	7.82	9.27	24.11	15.46	87.46

Center Region :	Productivity	Land	Data Capital	Output	Efficient $\{l_i, k_i, y_i\}$
Variance	.700	.672	1.886	1.136	3.310
75-25	2.67	2.79	5.26	3.57	8.48
90-10	7.14	7.32	29.68	12.86	71.83

Southern Region :	Productivity	Land	Data Capital	Output	Efficient $\{l_i, k_i, y_i\}$
Variance	1.024	.687	1.469	1.398	4.843
75-25	3.36	2.70	4.51	4.39	13.95
90-10	17.91	7.44	19.45	28.18	529.90