

Factor Market Activity and the Inverse Farm Size-Productivity Relationship in Tanzania

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Background

- One explanation suggested for the IR is **market failures**, especially the markets for land, labor, and credit (Lamb 2003; Ali and Deininger 2013; Deininger et al. 2015).
- When labor markets do not functioning well, farmers may allocate more labor per hectare on small farms (Sen 1966; Feder 1985).
- Thin/missing markets mean:
 - **small farmers can't optimally arrange their land-to-labor factor ratios**
 - large farms that rely on hired labor are paying more per labor day than small farms.

Background

- Some evidence that the IR is linked to factor market performance:
 - China - Excess returns to land were greatest where markets were less active (Benjamin and Brandt 1997).
 - India - The IR has attenuated over ~20 years, attributed to improved labor markets over time (Deininger et al. 2015).
- Hypothesis: **The inverse relationship will be weaker where factor markets are more active.**
- We exploit variation over time and space in how active these markets are in Tanzania.

Data and methods

- 3 waves of LSMS Tanzania, 2009-2013.
- 8,044 farms in pooled sample, 2,083 cropping households in household-level panel.

Step 1. Confirm that the IR is evident in Tanzania:

$$Y_{it} = \alpha + \beta [Area_{it}] + X'_{it}\theta + \varphi_t + \delta_i + \varepsilon_{it}$$

Gross returns to land
Net returns to land
Total Factor Productivity
For year & main season

Area held
Area under crops

Year fixed effects
Household fixed effects

Household characteristics
Community characteristics
Weather
Crops grown
Inputs applied (irrigation, fertilizer intensity, manure intensity, labor intensity)

Data and methods

- 3 waves of LSMS Tanzania, 2009-2013.
- 8,044 farms in pooled sample, 2,083 farms in household-level panel interviewed in all waves.

Step 2. Interact farm size with level of local market activity:

$$Y_{it} = \alpha + \beta[Area_{it}] + \lambda[Area_{it} \times Activity_level_{it}] + \rho[Activity_level_{it}] + \mathbf{X}'_{it}\boldsymbol{\theta} + \varphi_t + \delta_i + \varepsilon_{it}$$

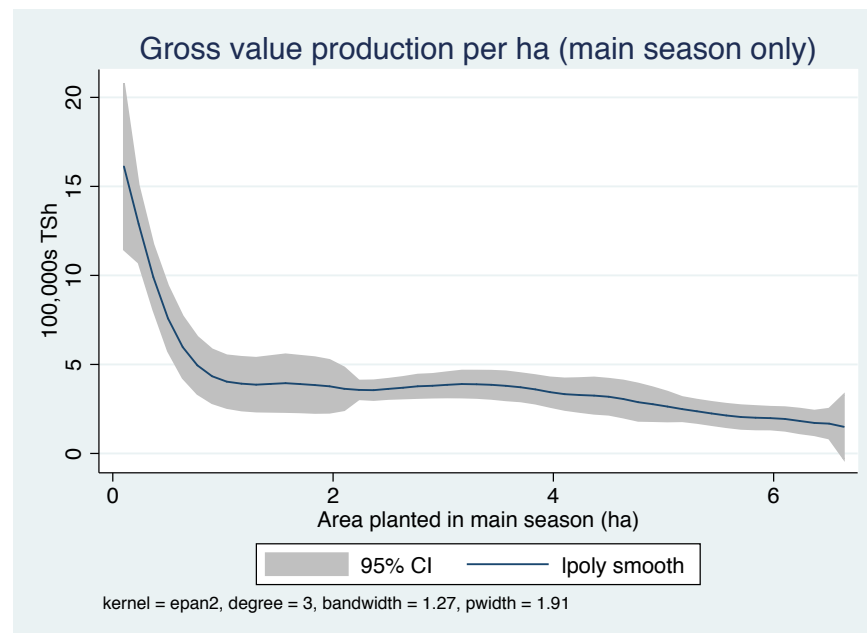
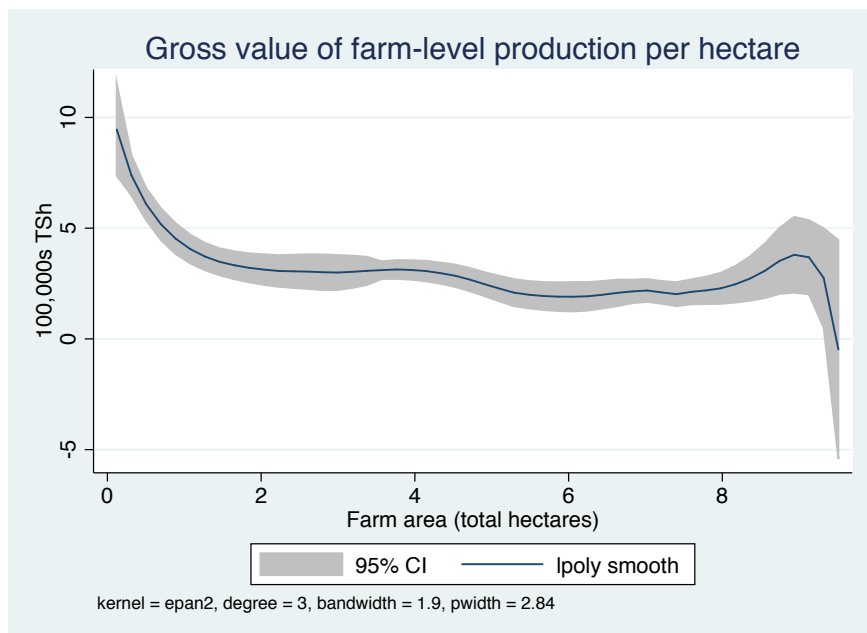
Interaction between area and local market activity level

Activity level measured as % cropping households in district/region engaged in the market.

- Land rental/ Land purchase
- Agricultural labor
- Credit
- Oxen rental/ Tractor rental

Relationship between farm size and crop revenue

– Non-parametric polynomial regressions –



For visual clarity, samples exclude observations below the 2nd percentile and above the 98th percentile.

	<i>Farm size (ha)</i>
<i>Mean</i>	<i>2.1</i>
<i>Median</i>	<i>1.2</i>
<i>95th percentile</i>	<i>6.1</i>

	<i>Area planted in main season (ha)</i>
<i>Mean</i>	<i>1.5</i>
<i>Median</i>	<i>0.9</i>
<i>95th percentile</i>	<i>4.4</i>

Household fixed effects regressions

	(1)	(2)	(3)	(4)	(5)
Dependent variable:					
Gross value crop production per ha (summed over the year) (100,000s TSh)					
Farm area (ha)	-0.26*** (0.003)	-0.27*** (0.003)	-0.27*** (0.004)	-0.26** (0.021)	-0.06 (0.244)

Year fixed effects	Y	Y	Y	Y	Y
Household characteristics		Y	Y	Y	Y
Community characteristics & weather			Y	Y	Y
Crops grown (proportion of value or area)				Y	
Inputs applied (included family labor intensity)					Y
Household fixed effects	Y	Y	Y	Y	Y

	Year	Main season
Observations	5,674	4,927
Households	2,083	1,984

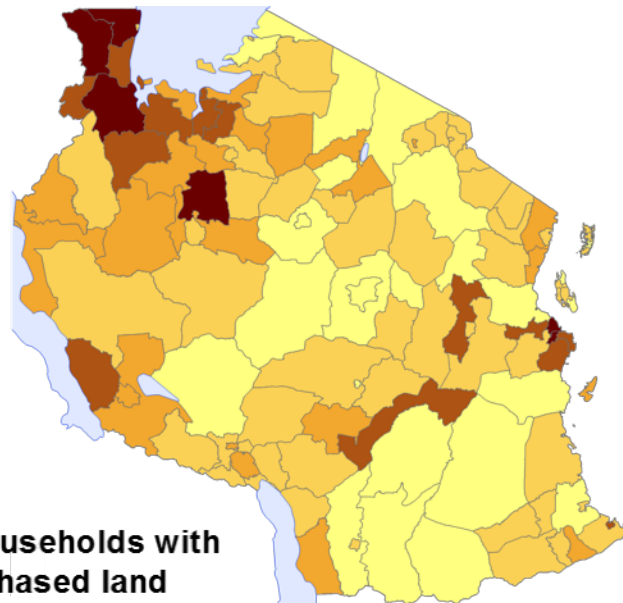
Household fixed effects regressions

	(1)	(2)	(3)	(4)	(5)
Dependent variable:					
Net value crop production per ha (summed over the year) (100,000s TSh)					
Area (ha)	-0.22*** (0.003)	-0.23*** (0.003)	-0.22*** (0.003)	-0.22** (0.026)	-0.08* (0.078)

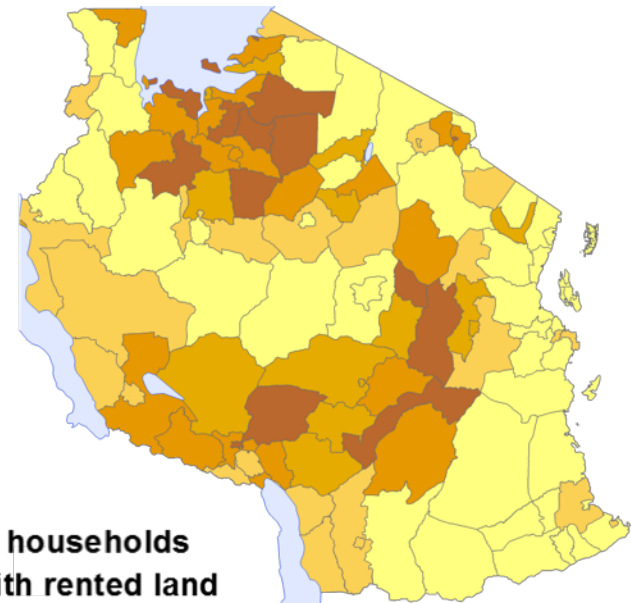
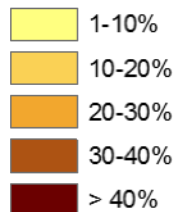
Year fixed effects	Y	Y	Y	Y	Y
Household characteristics		Y	Y	Y	Y
Community characteristics & weather			Y	Y	Y
Crops grown (proportion of value or area)				Y	
Inputs applied (excludes family labor when costs are netted out)					Y
Household fixed effects	Y	Y	Y	Y	Y

	Year	Main season
Observations	5,673	4,927
Households	2,083	1,984

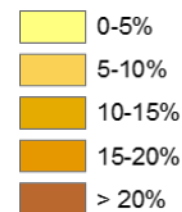
Land market activity among agricultural households across districts, 2007/08 (Source: ASCS)



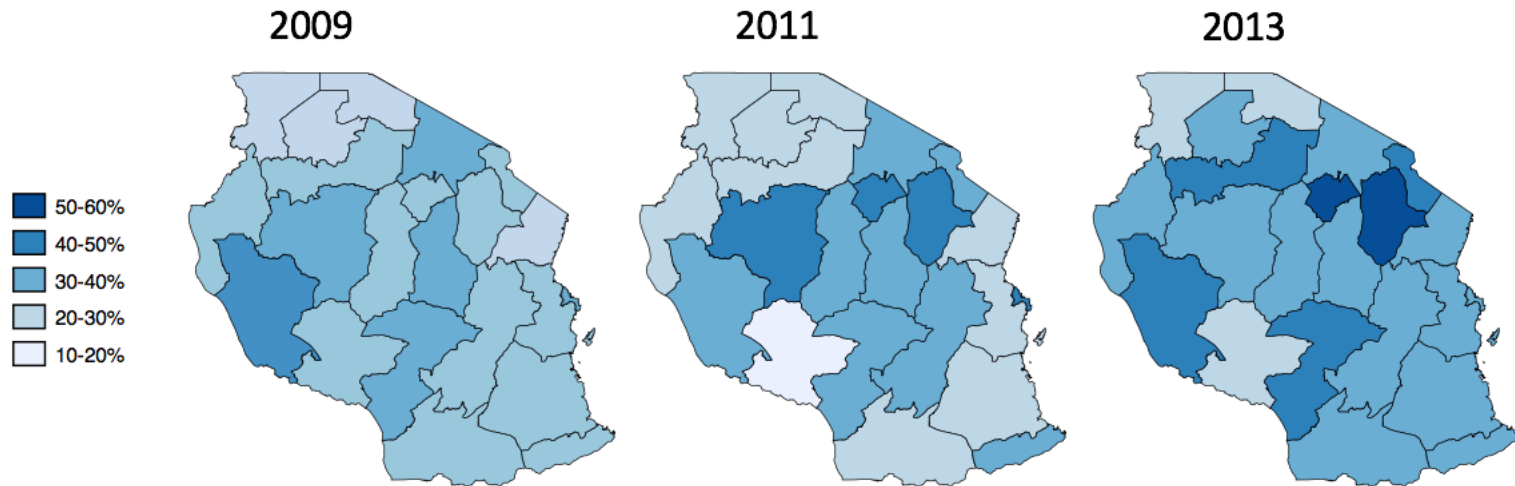
% households with purchased land



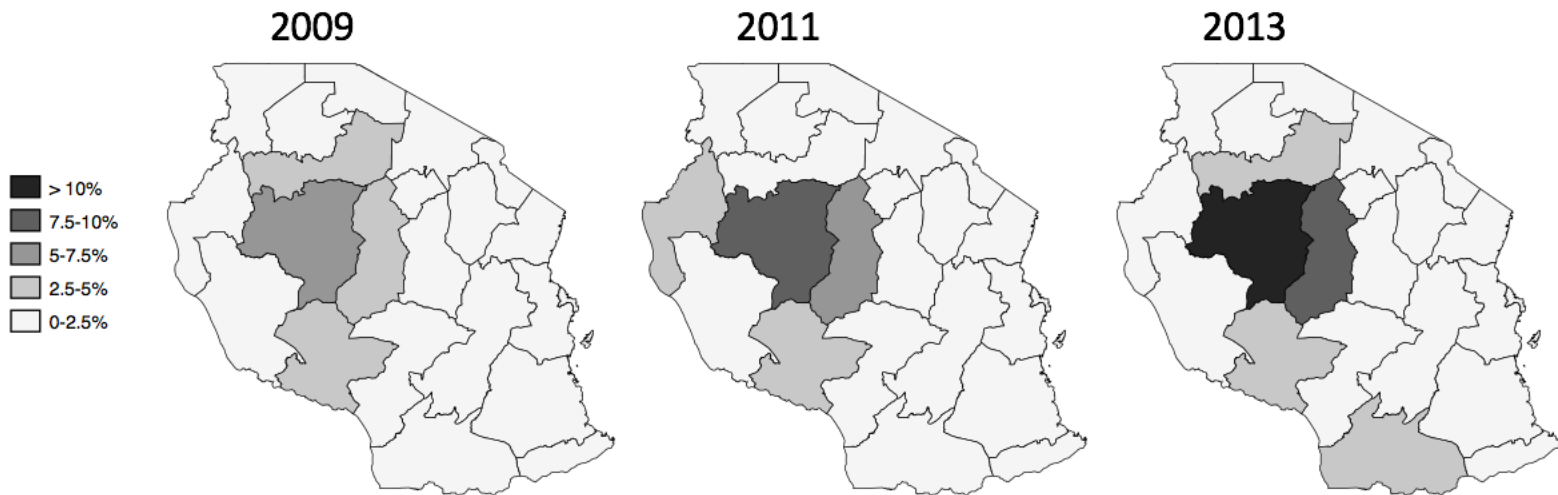
% households with rented land



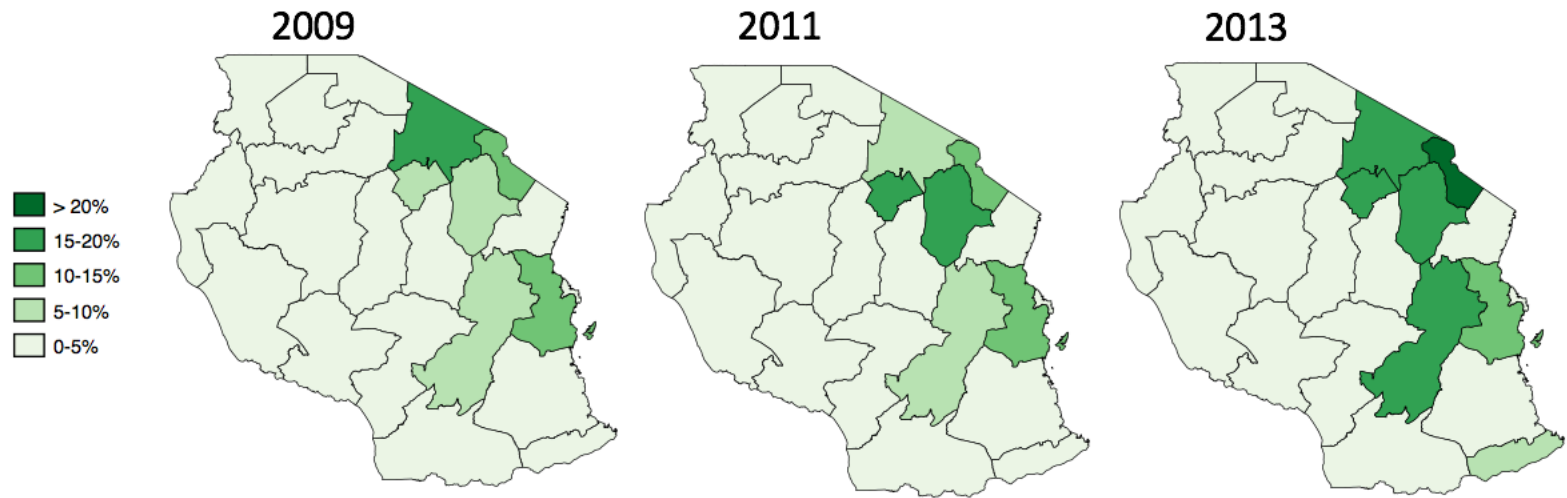
% Cropping households that hired in agricultural labor



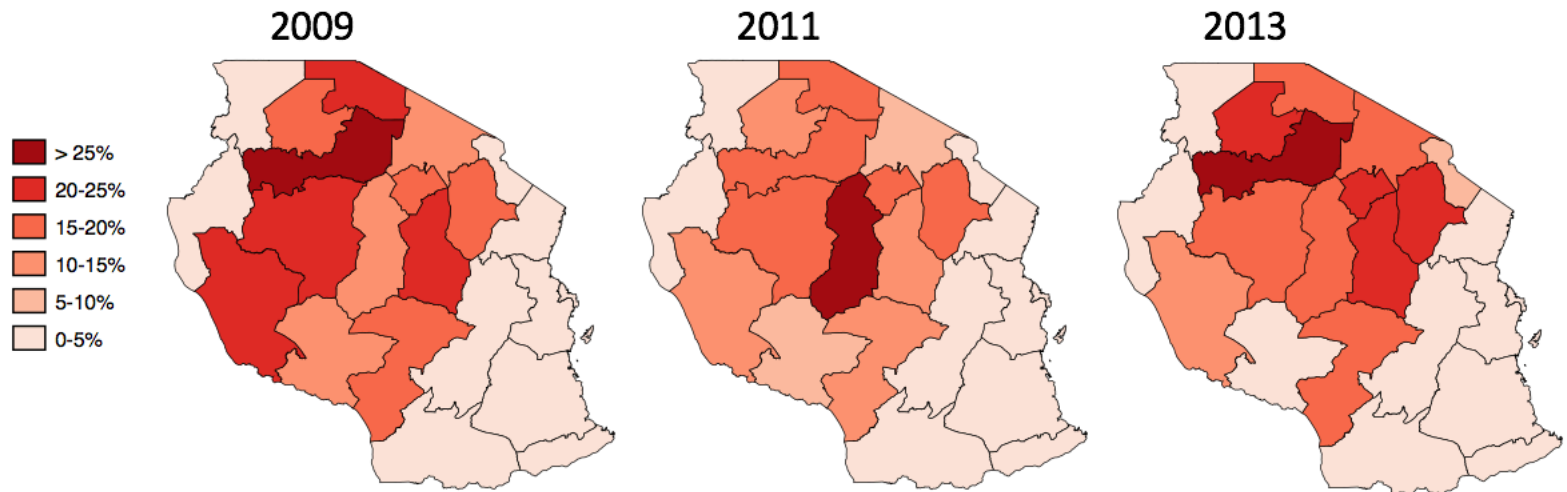
% Cropping households that accessed agricultural credit



% Cropping households that rented a tractor



% Cropping households that rented oxen



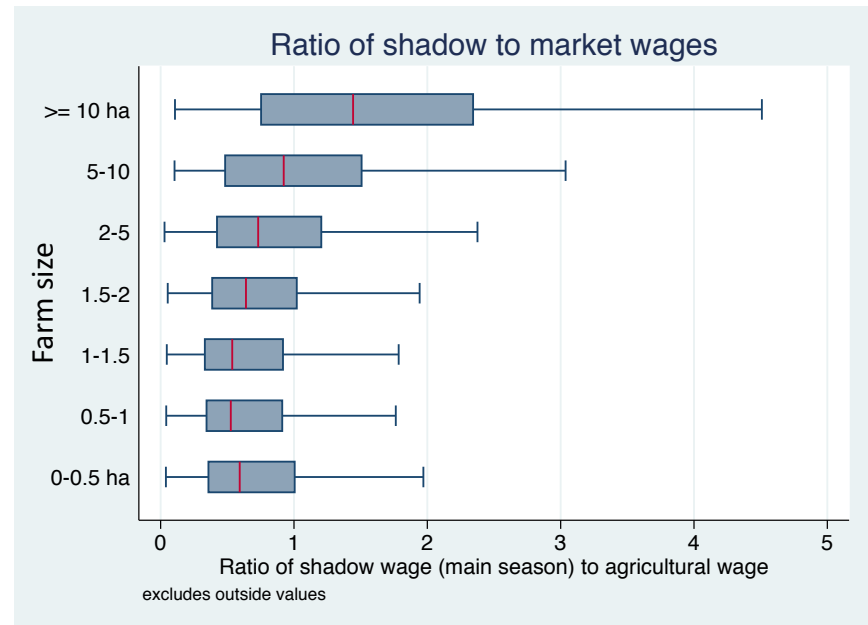
Evidence of labor market imperfections

Household demographics are determinants of labor applied.

Labor applied to farm, main season (ln)	
Area planted (ha, ln)	0.49*** (0.000)
Agricultural wage (ln)	-0.03 (0.290)
Household size (ln)	0.41*** (0.000)
Proportion of HH not of working age	-0.41*** (0.000)
Other HH characteristics	Y
Community characteristics	Y
Year fixed effects	Y
Household fixed effects	Y

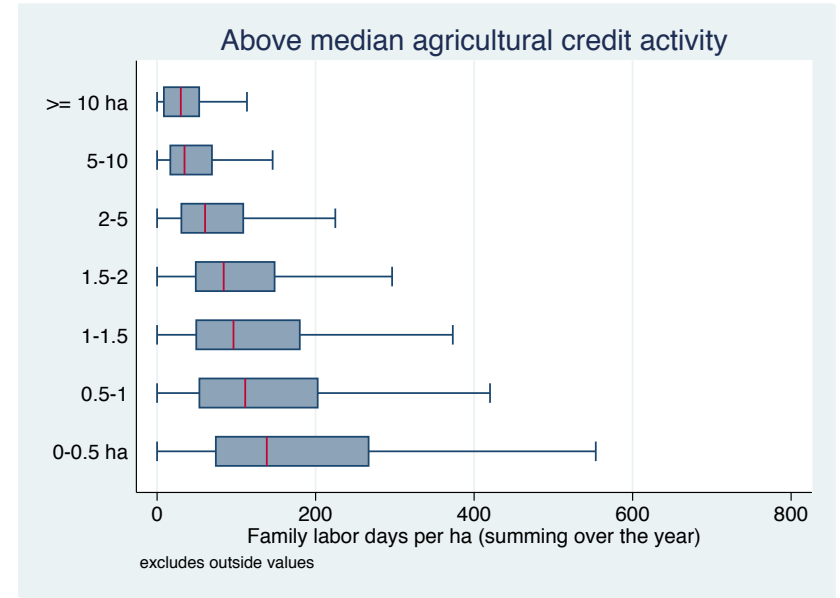
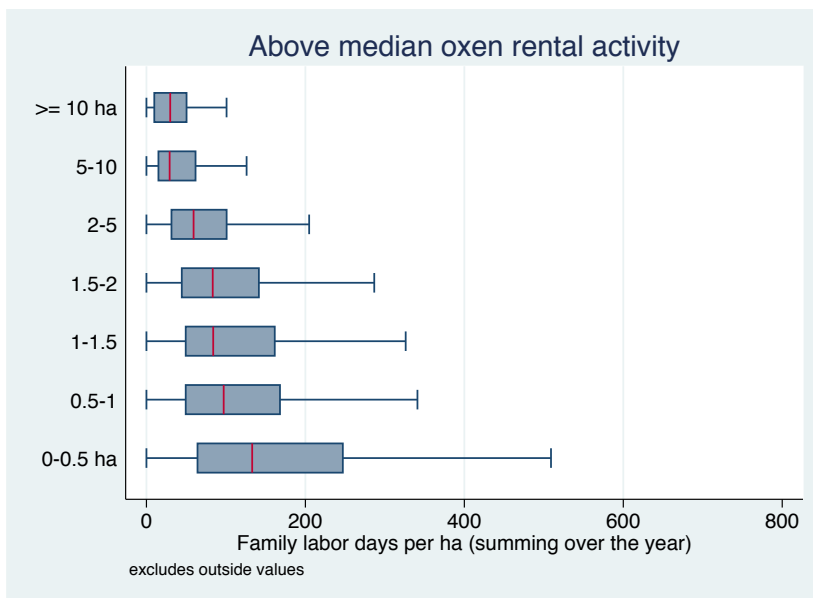
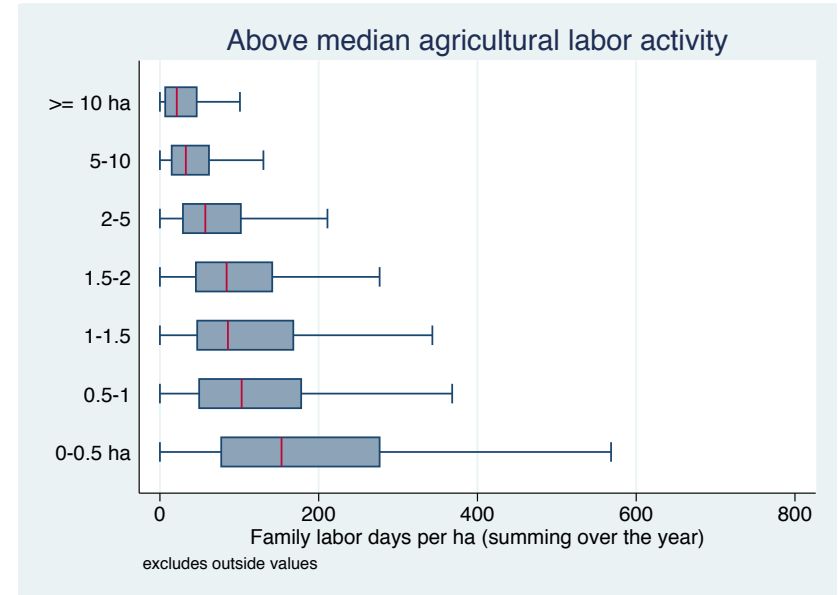
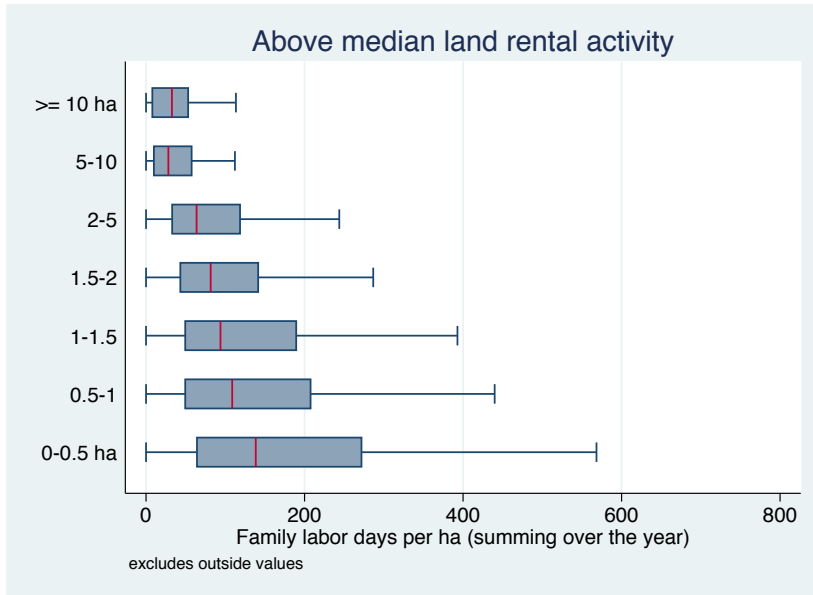
Shadow wages are usually lower than the prevailing market wage.

...But they tend to equal or exceed the market wage among larger farms.



Boxes show 25th quartile, median value, 75th quartile.

Family labor per hectare by farm size, disaggregated by low/high market activity level



Household fixed effects regressions

Dependent variable: Gross value of crop production per ha, main season (100,000s TSh)

	(1)	(2)	(3)	(4)	(5)	(6)
Area planted in main season (ha)	-1.77*** (0.00)	-1.01 (0.12)	-6.29** (0.01)	-1.98*** (0.00)	-2.99*** (0.00)	-1.51*** (0.00)
→ Area * Land rental market activity level	4.47* (0.09)					
Area * Land purchase market activity level		-1.73 (0.67)				
→ Area * Ag labor market activity level			12.81** (0.04)			
Ag labor market activity level			-48.32 (0.10)			
→ Area * Ag credit market activity level				12.09*** (0.00)		
Ag credit market activity level				-62.30*** (0.00)		
→ Area * Oxen rental market activity level					12.16*** (0.00)	
Oxen rental market activity level					-22.45* (0.10)	
Area * Tractor rental market activity level						4.30 (0.19)
Tractor rental market activity level						-25.83 (0.15)
Household/ Community characteristics/ local weather	Y	Y	Y	Y	Y	Y
Crops grown on the farm						
Inputs						
Year fixed effects, Household fixed effects	Y	Y	Y	Y	Y	Y
Observations	4,927	4,927	4,927	4,927	4,927	4,927
Households	1,984	1,984	1,984	1,984	1,984	1,984

Household fixed effects regressions

Dependent variable: Total Factor Productivity (year)

	(1)	(2)	(3)	(4)	(5)	(6)
Farm area (ha)	-2.41*** (0.00)	-3.13*** (0.00)	-5.93*** (0.00)	-1.97*** (0.00)	-3.78*** (0.00)	-0.95* (0.06)
→ Area * Land rental market activity level	7.16** (0.02)					
→ Area * Land purchase market activity level		8.43** (0.04)				
→ Area * Ag labor market activity level			11.74*** (0.01)			
Ag labor market activity level			-89.93** (0.01)			
→ Area * Ag credit market activity level				14.65*** (0.00)		
Ag credit market activity level				-153.28*** (0.00)		
→ Area * Oxen rental market activity level					13.47*** (0.00)	
Oxen rental market activity level					-41.05* (0.09)	
Area * Tractor rental market activity level						-14.83 (0.27)
Tractor rental market activity level						41.16 (0.40)
Household/ Community characteristics/ local weather	Y	Y	Y	Y	Y	Y
Crops grown on the farm						
Inputs						
Year fixed effects, Household fixed effects	Y	Y	Y	Y	Y	Y
Observations	5,673	5,673	5,673	5,673	5,673	5,673
Households	2,083	2,083	2,083	2,083	2,083	2,083

Preliminary findings

- The IR is evident in Tanzania (among the farm sizes captured here). It remains strong in a household fixed effects regression, where we focus on variation in returns to land (or TFP) and farm size over time.
- The intensity of the IR is weakest when we control for inputs.
- Across farm sizes, labor intensity per hectare is clearly greater for small farms. But this pattern is weaker where land, credit, and labor markets are more active.
- The interaction between farm size and measures of factor market activity is often positive and significant. **The IR is diminished in the presence of more active markets.**

Preliminary conclusions

- The IR is sometimes referenced as a rationale for focusing development efforts on smallholder farmers in pursuit of aggregate efficiency (e.g., Larson et al. 2016).
- If the IR is at least partly a reflection of market failures, the policy response should be to improve factor markets.
- The patterns observed in this paper suggest that other explanations offered for the IR (e.g., “border” effect) may not be sufficient.

Thanks for your attention!



Thank You



Linear piecewise (spline) regression

The original variable (in our case, plot area): \mathcal{V}

Create a set of variables: $V_i, i = 1, \dots, n$

Corresponding knots (values where the \mathcal{V} is segmented): $k_i, i = 1, \dots, n - 1$

$$V_1 = \min(\mathcal{V}, k_1)$$

$$V_i = \max\{\min(\mathcal{V}, k_i), k_{i-1}\} - k_{i-1} \quad i = 2, \dots, n - 1$$

$$V_n = \max(\mathcal{V}, k_{n-1}) - k_{n-1}$$

The equation is:

$$Y_p = \alpha + \beta_1 V_{1p} + \beta_2 V_{2p} + \beta_3 V_{3p} + \dots + \beta_n V_{np} + \varepsilon_p$$

Net revenue
per area unit

$$\beta_2 = \frac{dY}{d\mathcal{V}} \text{ if } k_1 \leq \mathcal{V} < k_2$$

$$\beta_1 = \frac{dY}{d\mathcal{V}} \text{ if } \mathcal{V} < k_1$$

Gross value crop production/ ha		
	Coef	P-value
< 0.5 ha	-30.81***	0.00
0.5-1	2.45	0.40
1-1.5	-3.56*	0.05
1.5-2	0.07	0.94
2-4	-0.07	0.79
4-6	-0.66***	0.01
6-8	0.42	0.10
8-10	-0.44**	0.03
≥ 10 ha	-0.02	0.33
Constant	19.13***	0.00
Observations	8,044	
R-squared	0.01	

*** p<0.01, ** p<0.05, * p<0.1

These coefficients represent the *slope* at this section of the farm-size spectrum.

Family labor per hectare by farm size, disaggregated by low/high market activity level

