Farmland Concentration and Rural Labor Productivity: Evidence from Tanzania

Jordan Chamberlin and T.S. Jayne
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Motivation

- Do differences in asset inequality explain part of the variation between ag productivity growth and poverty reduction?
- Longstanding view that land distribution patterns influence how agricultural productivity growth affects economic development (Johnston, Mellor, Lipton, Binswanger)
  - Role of ‘multiplier’; egalitarian land distributions --> larger multiplier effects
- Evidence of rapid change in farm size distributions
  - Rise of ‘domestic investor’ farms

Table 1: Changes in farm structure in Tanzania (2009-2013), National Panel Surveys

Farm size	Number of farms (% of total)		% growth in number of farms between initial and latest year	% of total operated land on farms between 0-100 ha		
	2008	2012		2008	2012	
0 – 5 ha	5,454,961 (92.8)	6,151,035 (91.4)	12.8	62.4	56.3	-6.1%
5 – 10 ha	300,511 (5.1)	406,947 (6.0)	35.4	15.9	18.0	
10 – 20 ha	77,668 (1.3)	109,960 (1.6)	41.6	7.9	9.7	+6.1%
20 – 100 ha	45,700 (0.7)	64,588 (0.9)	41.3	13.8	16.0	
Total	5,878,840	6,732,530	14.5	100.0	100.0	

Main question:

- How does land distribution (inequality) condition how economic growth occurs in predominantly agrarian areas?
  - Focus on labor productivity in both agriculture and non-farm sectors

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Hypothesis:

- The initial distribution of assets affects labor productivity in both ag and rural non-farm economy
    - Concentrated land ownership → lower rates of growth

Applied evidence

- Ravallion and Datt (2002)
  - the initial percentage of landless households significantly affected the elasticity of poverty to non-farm output in India.
- Vollrath (2007)
  - Rate of agricultural productivity growth inversely related to the gini coefficient of landholdings
- Gugerty and Timmer (1999)
  - (n=69 countries); in countries with an initial “good” distribution of assets, both agricultural and non-agricultural growth benefitted the poorest households.
  - In countries with a “bad” distribution of assets, economic growth was skewed toward wealthier households

Our research approach

1. Get best data available on farm size distributions
2. Develop alternative measures of land concentration / inequality
3. Examine the degree of correlation
   - across measures
   - across available data sets
4. Develop and estimate labor productivity models
   - Assess influence of localized land concentration on labor productivity across time
   - Test for potential differential effects by asset wealth category

Data

- Nationwide data sets collected by Tanzania National Bureau of Statistics
  - National Panel Survey (a.k.a LSMS): 2009, 2011, 2013 (n=2,123) NPS
  - Agricultural Sample Census Survey: 2009 (n=52,636 + 1006) ASC
- NPS allows us to discern individuals' labor allocation between farm and non-farm activities, and to construct FTEs of labor time
- ASC includes large commercial landholdings

Outcomes of interest

- Dependent variables (household-level)
  - agricultural output per FTE (adult labor time on farm activities)
  - non-farm output per FTE (adult labor time in non-farm activities)
  - total household income per FTE (adult labor time in farm & non-farm activities)
- All measured in real 2010 TZ shillings

Methods

- Estimated reduced form models of labor productivity
- $Y_{ijkt} = f(X_{ijkt}, C_{jt}, LandIneq_k) + e_{ijkt}$
  - Y_{it} is household gross [farm|non-farm|total] income per FTE, for hh *i*, community *j*, region *k*, in year *t*
  - X_{it} is household socio-demographic-economic covariates
  - C_{jt} is community-level factors
  - $LandIneq_k$ is the measure of land concentration in region *k* at initial period
    - Gini coefficient
    - Skewness
    - Coefficient of variation
    - % of land on farms of > 10 ha

Methods

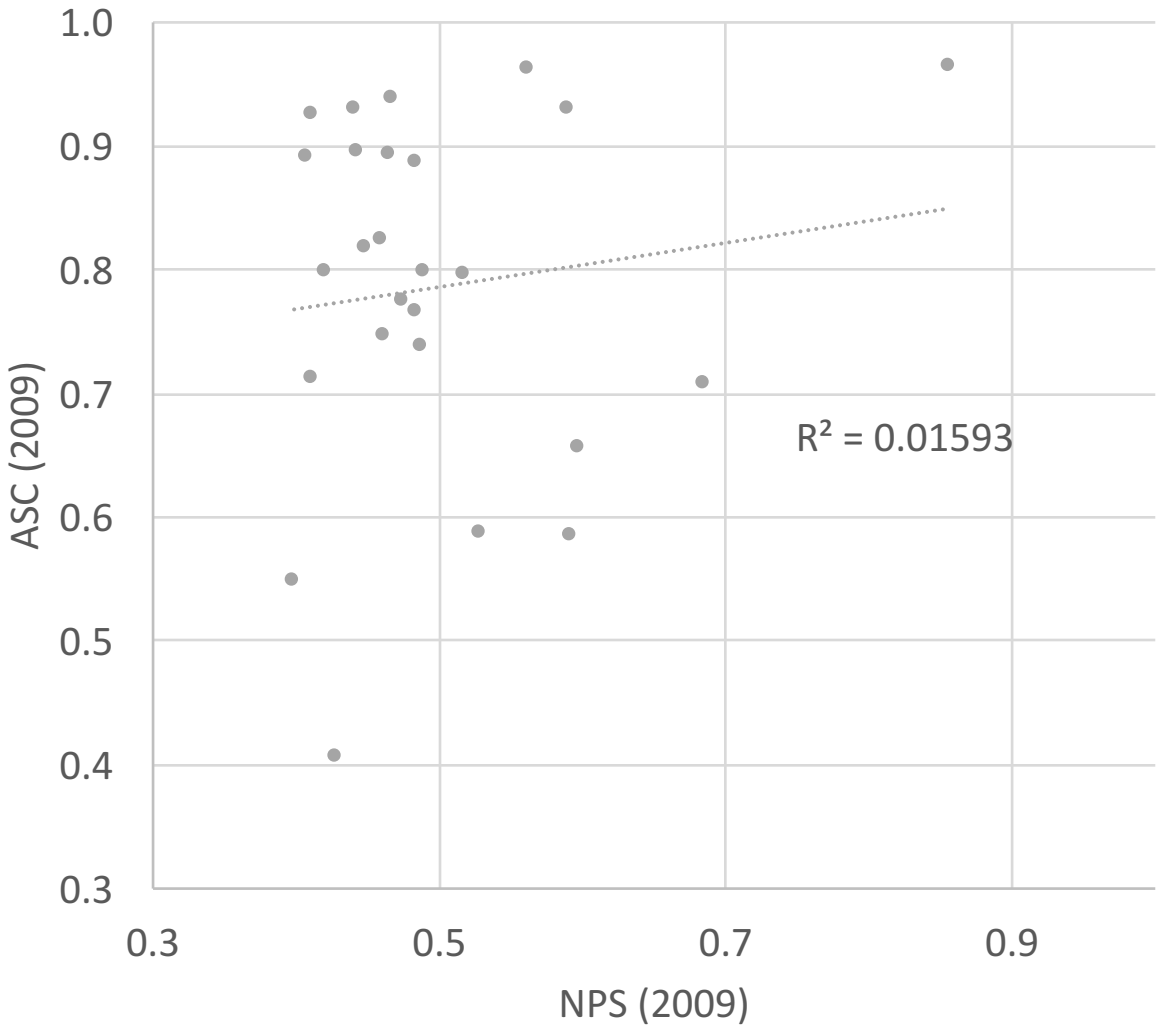
- Three panel waves (n=6,704 HHs)
- Mundlak-Chamberlain device (correlated random effects)
- Heckman selection model

Correlation coefficients of alternative measures of land concentration, Tanzania, 2008, ASC

	Gini	Skew-ness	CV	% land in farms >5 ha
Gini	1			
Skewness	0.3566	1		
CV	0.7425	0.8294	1	
% land in farms > 5 ha	0.8421	0.3764	0.6461	1

Alternative measures are imperfectly correlated….

Figure 2: Scatterplot of regional Gini coefficients on landholdings from ASC and NPS



Standard sampling frames under-represent land concentration….

Estimation results:

Impact of land concentration on labor productivity

Impact of land concentration on income

Selected coefficients from baseline regression models

	dependent variable: farm per-FTE gross income				dependent variable: non-farm per-FTE gross income				dependent variable: total per-FTE gross income			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Land concentration												
Gini	-1.419				-0.7949				-1.3441			
	(0.000)***				(0.000)***				(0.000)***			
skewness		-0.0073				0.003				-0.0037		
		(0.004)***				-0.161				(0.058)*		
CV			-0.0264				-0.003				-0.0193	
			(0.000)***				-0.458				(0.000)***	
share under farms >10 ha				-1.0124				-0.8068				-1.0216
				(0.000)***				(0.000)***				(0.000)***

Notes: Dependent variables are log transformed per-FTE gross income measured in 2010 Tanzanian shillings. Regional-level land concentration measures from 2009 Ag. Sample Census. Dependent variables and other independent control variables are from the NPS. All models include the Mundlak-Chamberlain device. Full model results shown in Appendix A3 of paper. Robust pval in parentheses, with significance indicated by asterisks: *** p<0.01, ** p<0.05, * p<0.1.

Impact of land concentration on income,
with interactions between regional land concentration * hh farm size dummy variables

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Gini	-1.3567				-0.8141				-1.3727			
	(0.000)***				(0.000)***				(0.000)***			
Gini * farm >10 ha	0.2363				0.1761				0.2381			
	(0.025)**				-0.1				(0.024)**			
skewness		-0.0042				0.0026				-0.0042		
		(0.031)**				-0.225				(0.033)**		
skewness * farm >10 ha		0.0074				0.005				0.0074		
		(0.004)***				(0.063)*				(0.004)***		
CV			-0.0208				-0.0043				0.0126	
			(0.000)***				-0.299				(0.024)**	
CV * farm >10 ha			0.0126				0.0105				-0.0209	
			(0.024)**				(0.079)*				(0.000)***	
land in farms >10 ha				-1.0474				-0.8317				-1.0693
				(0.000)***				(0.000)***				(0.000)***
land in farms >10 ha *				0.2556				0.1752				0.2582
farm >10 ha				(0.010)***				(0.081)*				(0.009)***

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Simulated **impacts of changes in land concentration** on total income and farm income

		(a)	(b)	(c)	(d)
		Average per-FTE income predicted for land concentration at 25th percentile	Average per-FTE income predicted for land concentration at 75th percentile	difference (b)-(a)	difference as % of average per-FTE income
		(1000s of 2010 TSh)			
Total income	Gini	1,770	1,327	-443	-61%
	Skewness	1,636	1,538	-98	-13%
	CV	1,694	1,451	-243	-33%
	% land: farms >10ha	1,700	1,418	-282	-39%

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	% land: farms >10ha	1,700	1,418	-282	-39%
Farm income	Gini	842	619	-223	-77%
	Skewness	771	683	-89	-31%
	CV	813	657	-156	-54%
	% land: farms >10ha	809	648	-161	-56%

Summary

1. Landholding distribution appears to influence household income growth in both farm and non-farm sectors
   - Robust to alt. measure of land concentration
2. Effects of land concentration are most adverse on the smallest farm households (majority of farms in Tanzania < 5 ha)
   - Generally insignificant effects on total labor productivity of larger farms

Policy questions

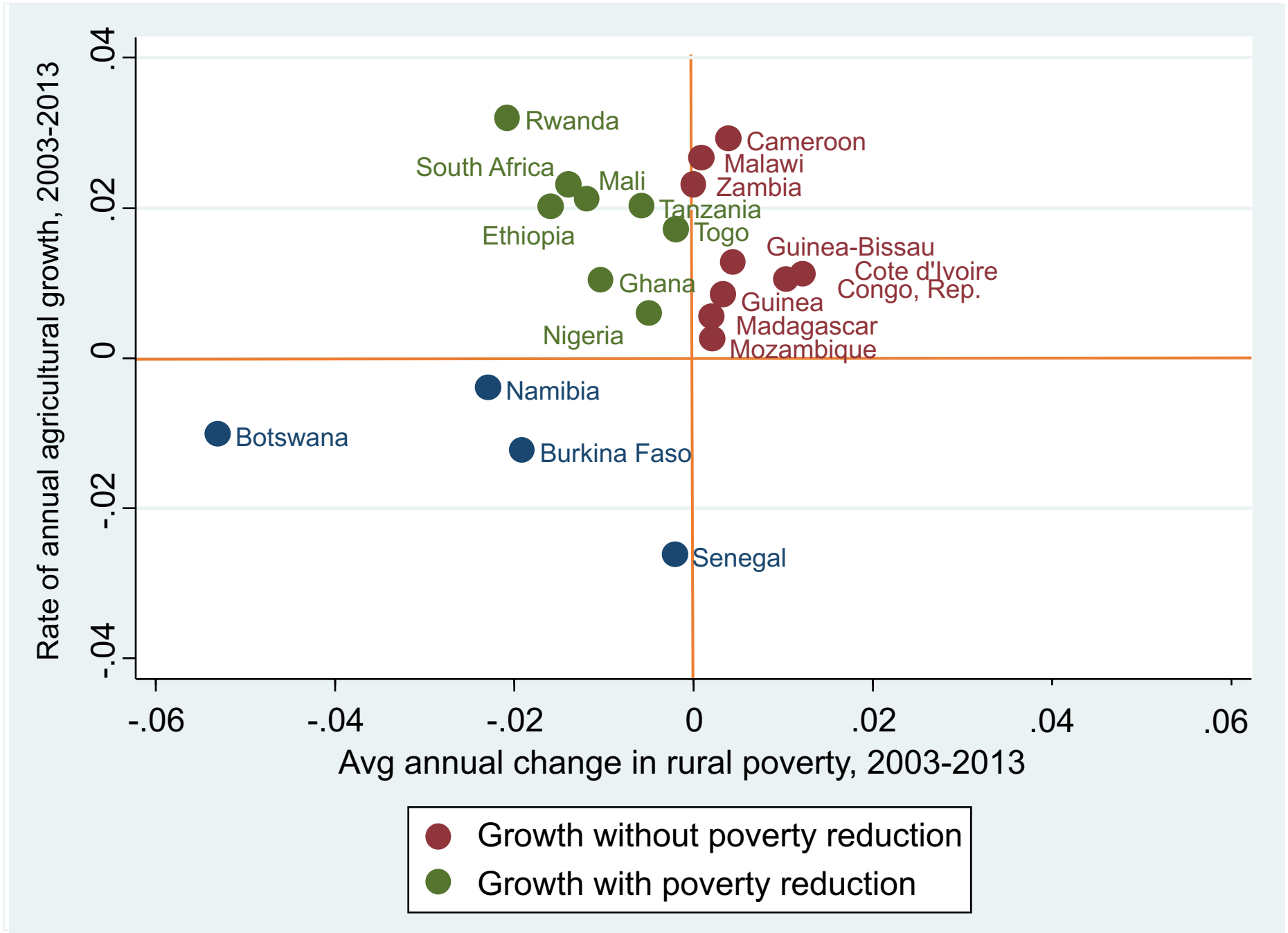
1. Farm structure in many African countries is becoming more concentrated – should governments want to influence this?
2. Is rising land inequality contributing to concentration of marketed farm output? Can agric development still be small-farm led?
3. Implications for poverty reduction strategies?
4. Implications for structural transformation processes?

Methods questions

1. How can we collect better data on farm structure for further evaluation and monitoring of structural changes taking place?

Jordan Chamberlin: j.chamberlin@cgiar.org

T. S. Jayne: jayne@msu.edu



Sources: FAOSTAT, World Bank Development Indicators

Theory

- Why should land concentration affect the link between ag growth and poverty reduction?
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Correlation coefficients of alternative measures of land concentration, Tanzania, 2008, ASC

	Gini	Skew-ness	CV	Landless % of HHs	% land in farms < 2 ha	% land in farms 2-5 ha
Gini	1					
Skewness	0.3566	1				
CV	0.7425	0.8294	1			
Landless % of HHs	0.1438	0.0364	-0.0331	1		
% land in farms < 2 ha	-0.5613	-0.4390	-0.5652	0.2416	1	
% land in farms 2-5 ha	-0.8910	-0.3379	-0.6405	-0.0341	0.8021	1
% land in farms > 5 ha	0.8421	0.3764	0.6461	-0.0341	-0.8829	-0.9886

Alternative measures are not well correlated….

Table 3. Counts of farm holdings over 10 hectares in five districts of Tanzania, according to three data sources.

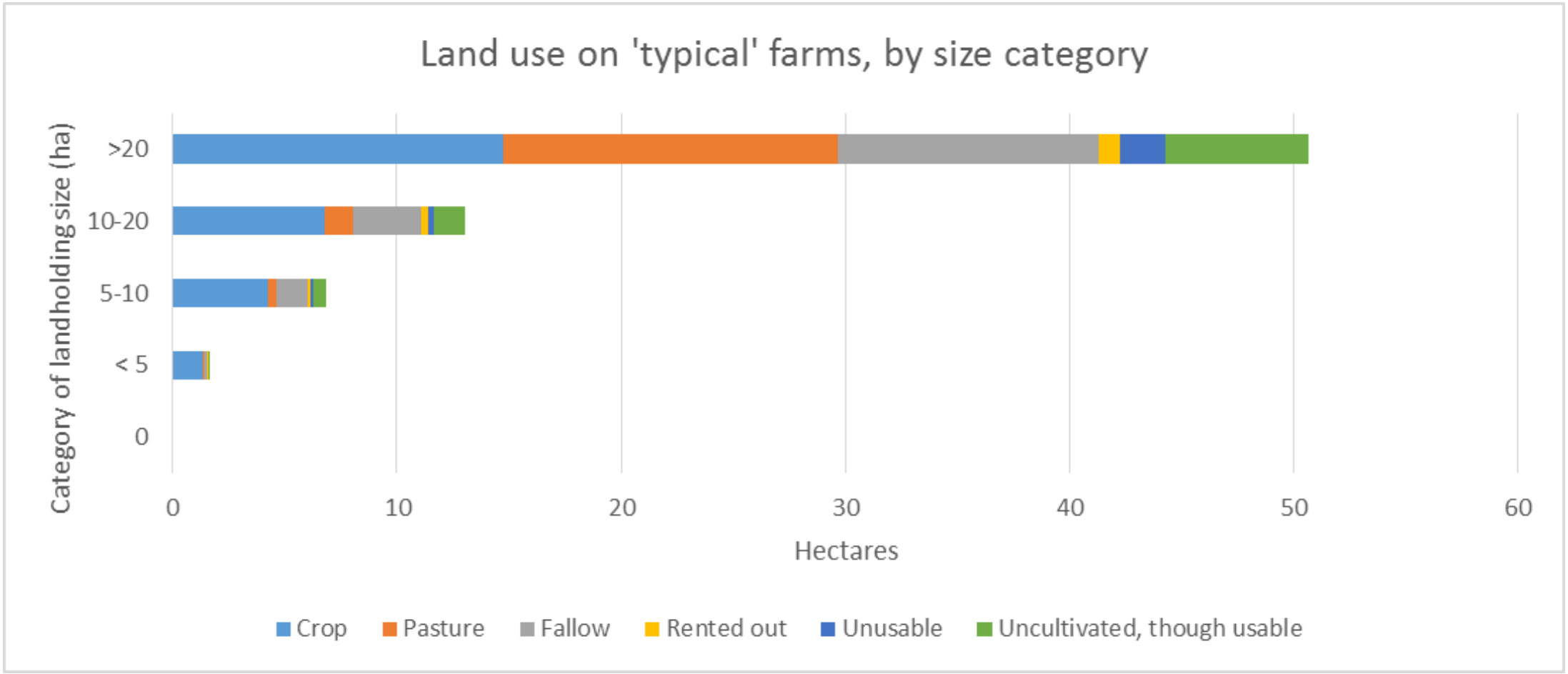
District	Region	2012 Tanzania National Panel Survey	2008 Agricultural Sample Census Survey	Mdoe et al. (2016)
Kilombero	Morogoro	0	1,445	1,348
Moshi (Rural)	Kilamanjaro	2,316	423	489
Njombe	Iringa	0	1,015	1,828
Mvomero	Morogoro	742	1,814	1,910
Kiteto	Manyara	0	2,982	3,668

Sources: 2012 Tanzania National Panel Survey, 2008 Agricultural Sample Census Survey, and the population lists developed by Mdoe et al. (2016).

Table 3. Comparison of farmland owned and land under cultivation in Tanzania, 2008 Agricultural Sample Census Survey vs. 2008 LSMS/National Panel Survey

	Farm land controlled			Land under operation		
	NPS	ASC	% difference	NPS	ASC	% difference
By holdings of:	Million hectares			Million hectares		
0-5 ha	8.246	8.595	+4.2	8.117	8.130	+0.002
5-100 ha	3.872	5.861	+51.4	3.816	5.181	+35.8
Over 100 ha	0.809	1.294	+60.0	0.809	0.942	+16.5

Figure 2. Average land area allocated to each land use, by category of landholding size



Source: Agricultural Sample Census, 2008

Table 3. Proportion of land area allocated to each land use, by category of landholding size

	Category of landholding size				
Land use	0	< 5	5-10	10-20	>20
Crop	N/A	0.82	0.62	0.52	0.29
Pasture	N/A	0.01	0.05	0.10	0.29
Fallow	N/A	0.10	0.21	0.23	0.23
Rented out	N/A	0.01	0.02	0.03	0.02
Unusable	N/A	0.01	0.02	0.02	0.04
Uncultivated, though usable	N/A	0.04	0.09	0.11	0.13

Source: Agricultural Sample Census, 2008

	Land concentration measure
1	Gini coefficient
2	Skewness (3rd standardized moment)
3	Coefficient of variation (standard deviation / mean)
4	% land under largest 10% of farms

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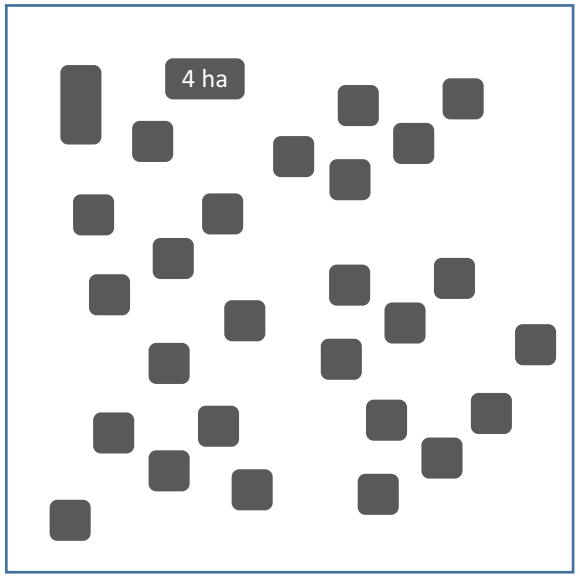
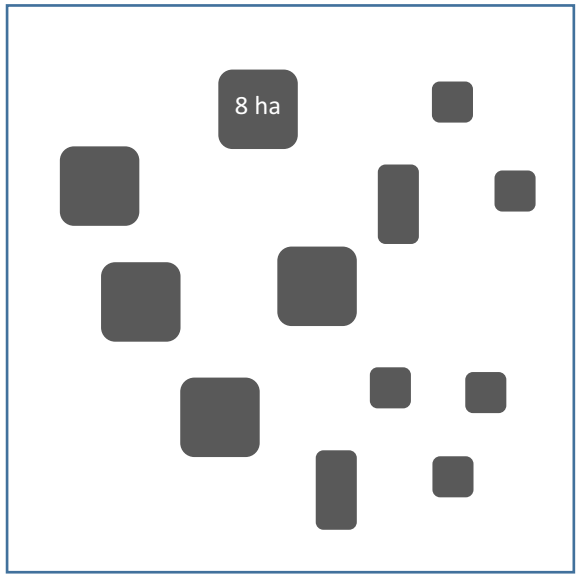


Landscape 1:

Total ha =	58
# farms =	27

Concentration:

Gini =	0.064
Skewness =	3.253
CV =	0.248
%ha>10ha =	0.000



Landscape 2:

Total ha =	58
# farms =	12

Concentration:

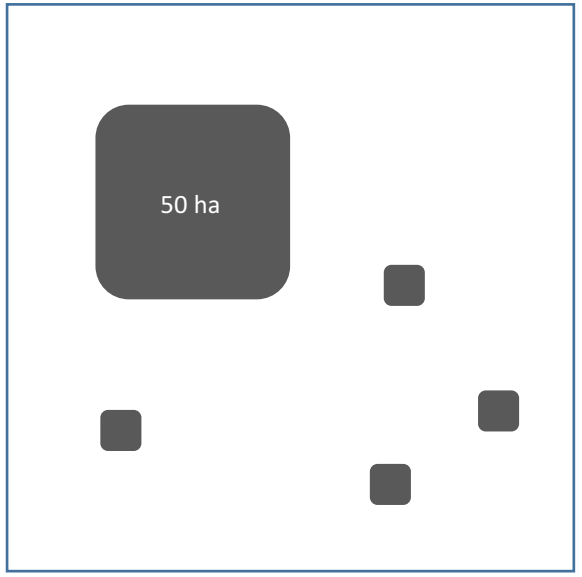
Gini =	0.302
Skewness =	0.173
CV =	0.597
%ha>10ha =	0.000

Landscape 3:

Total ha =	58
# farms =	9

Concentration:

Gini =	0.544
Skewness =	2.132
CV =	1.429
%ha>10ha =	0.517



Landscape 4:

Total ha =	58
# farms =	5

Concentration:

Gini =	0.662
Skewness =	1.500
CV =	1.851
%ha>10ha =	0.862

= 2 ha

Farm structure in Tanzania, NPS 2009 vs. ASC 2008

	percentile								
	5th	10th	25th	50th	75th	90th	95th	99th	mean
cultivated land (NPS)	0.0	0.2	0.4	1.2	2.0	4.0	5.7	12.5	2.0
controlled land (NPS)	0.2	0.4	0.6	1.3	2.4	4.5	6.7	15.2	2.3
controlled land (ASC)	1.0	1.0	2.0	4.0	7.0	12.0	20.0	50.0	6.5

Note: NPS data for 2008/2009; ASC data for 2009. Landless households are not included.

GINI coefficients in farm landholding

	Period	Movement in Gini coefficient:
Ghana (cult. area)	1992 → 2013	0.54 → 0.70
Kenya (cult. area)	1994 → 2006	0.51 → 0.55
Tanzania (landholdings)	2008 → 2012	0.63 → 0.69
Zambia (landholding)	2001 → 2012	0.42 → 0.49

Source: Jayne et al. 2014 (JIA)

Endogeneity concerns

1. Land concentration and income affected by common unobserved factors
   - Include broad set of geographical controls
   - Land concentration enters as initial conditions (2009)
2. Unobserved farm-level time-varying heterogeneity driving income
   - Use Mundlak-Chamberlain device, aka CRE estimator
3. Selection bias: income earners are not random
   - Heckman two-stage selection model with additional first stage regressors:
     - Household drought w/in 2 years
     - Household pest/disease w/in 2 years
     - Household death w/in 2 years
     - Household is landless

Descriptive statistics of variables used in econometric analysis

variable	unit	5th	10th	25th	50th	75th	90th	95th	99th	mean
farm labor prod.	1000s real 2009 TSh	0	0	0	41.3	167.5	403.1	610.0	1627.0	183.4
non-farm non-ag. labor prod.	1000s real 2009 TSh	0	0	0	160.0	1375.0	4656.0	10100.0	37000.0	2748.8
non-farm ag. labor prod.	1000s real 2009 TSh	0	0	0	0	0	90.0	220.0	835.2	45.7
total labor prod.	1000s real 2009 TSh	1.0	31.5	142.3	478.5	1590.5	4890.9	10600.0	37600.0	2977.9
farm size	hectares	0	0.1	0.4	1.1	2.4	4.7	7.2	18.3	2.2
age of head	years	24	27	33	43	56	70	76	86	45.9
size of household	#	1	2	3	5	7	9	10	15	5.1
max. edu. attainment	years	4	5	7	7	10	12	15	22	8.3
female head	binary	0	0	0	0	1	1	1	1	0.3
# of plots		1	1	1	2	3	4	5	7	2.3
Value of productive assets	1000s real 2009 TSh	<1	<1	<1	18	40	159	3,768	10,400	530.3
has ox plough	binary	0	0	0	0	0	1	1	1	0.2
has tractor	binary	0	0	0	0	0	0	1	1	0.1
fertilizer application	kg	0	0	0	0	0	200	800	3000	156.0
distance to road	km	0.1	0.3	1.1	8.3	23.1	43.7	56.0	88.1	16.1
distance to market	km	3.3	5.4	21.3	64.3	97.3	137.9	162.6	209.6	67.0
elevation	meters above sea level	21	40	489	1147	1277	1522	1682	2028	945.3
slope	degrees	1.2	1.4	2.1	3.4	6.2	12.0	16.7	27.2	5.3
pop. density	persons/km2	10	20	60	190	960	6,850	14,100	30,760	2210.0
bimodal rainfall area	binary	0	0	0	1	1	1	1	1	0.5
rainfall (avg. annual)	mm	420	495	677	827	967	1044	1154	1666	821.8

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