

# The inverse farm size productivity relationship: new evidence from Sub-Saharan African countries

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Farm Size and Productivity:

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# Objectives

The literature points to the existence of an IR as a well-established and smooth tendency of productivity to decline with farm size pointing towards decreasing return to scale

Our contribution to the conventional wisdom:

- 1 We test the IR using cross-country, panel data in a sample of SSA countries.
  - **Cross-country analysis:** LSMS-ISA from MWI, NER, NGA, TZA, UGA, with geo-referenced exogenous variables (2010-2011)
  - **Panel Data:** Longitudinal Ethiopian Rural Household Survey (2004-2009)
- 2 We use a novel approach, **quantile regressions** to take into account farmers' heterogeneity (only one study Evenson and Mwangi, 1998).
- 3 We find evidence of systematic non monotonic relationship with sign's switches at different points of the distribution of farms' productivity level and growth(both cross section and panel data)
- 4 Advantage & Limitation of our study: sample of farm household, no commercial large farm



# Background

## the IR according to Binswanger, Deininger & Feder 1995

$$\frac{Y}{K} = f(AO, AW, H, Z)$$

- $Y$  = Proxy for average agriculture production (gross output or profit to properly account for input use). This equation is assumed to hold, given optimal farm choices, and thus depends (as a profit or revenue function) only on exogenous variables.
- $K$  = generic asset i.e. land (owned or operated)
- $A0$  = Land operated (supervision constraints)
- $AW$  = land owned (credit constraints)
- $H$  = Labor endowment
- $Z$  = HH characteristics or land quality



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## the IR according to Binswanger, Deininger & Feder 1995 (ctd.)

**Market failures:** Labor and credit and supervision constraints for hired labor (Scandizzo and Kutcher, 1971; Eswaran and Kotwal 1985a,b; Barrett, 1996; Benjamin and Brandt 2002; Berry and Cline 1979; Feder 1986; Binswanger et al. 1995).

**Statistical issues and measurement errors in land and agriculture output:** Lamb 2003; Barrett et al. (2010); Goldstein and Udry (1999), De Groote and Traorè (2005); Carletto et al. (2013); Deininger et al. (2012)

**Omitted variables and unobserved heterogeneity:** size is sensible to quality of factor endowments, especially soil quality (Carter 1984; Bhalla and Roy 1988; Walker and Ryan, 1990; Benjamin 1995; Lamb 2001;).



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## Cross Section – OLS – Panel Data

- Estimates the average effect over the entire distribution. The effects of land at the conditional mean of the dependent variable (land productivity)
- Not representative of the relationship at any part of the distribution of the land productivity
- Does not account for farms heterogeneity, omitted variable bias
- PANEL DATA: controls for unobserved farm/plots specific heterogeneity (time invariant or not)



## Quantile regressions

- Gives information on heterogeneity in the effect of land on the dependent variable. The estimated regression coefficients can be interpreted as the partial derivative of the conditional quantile of the productivity with respect to a land
- the marginal change in productivity at the  $k$ th conditional quantile due to a change in land.
- For each quantile, it can be shown whether the effect farm size is positive or negative, and how large this effect is compared to other quantiles
- Less sensitive to outliers (mainly the case for profit, output quantity and land)





# Outline of the empirical estimation

- 1 The intuition: quantile regression (QR) from 5 SSA countries with one round of the LSMS-ISA dataset: 2010-2011
  - IR exhibits non-linearities on the productivity distribution. Based on managerial performance, the farm is a bundle of options and opportunities
- 2 Extension to the panel : Evidence from the Rural Household Survey ETH (CSAE-IFPRI) 2004-2009
  - QR for panel data (limitation of the program in Stata)
  - Fixed Effect Regression to recover unobserved managerial ability
  - Use the structure of the panel data to run QR in year 2 and analyze the role of managerial ability, and the options and opportunities exercised by farmers
  - QR on land productivity in year 2
  - QR on changes in productivity



# 1. The intuition: cross-sectional quantile regression: MWI, NER, NGA, TZA, UGA from LSMS-ISA 2010-2011

	Gross Crop Income/ha	Q10	Q20	Q30	Q40	Q50	Q60	Q70	Q80	Q90
MWI	Farm Size	+	+		-	-	-	-	-	-
	Farm Size Sq	-	-		+	+	+	+	+	+
NER	Farm Size	+	+		-		-	-	-	-
	Farm Size Sq	-	-		+		+	+	+	+
NGA	Farm Size	-	-	-	-	-	-	-	-	-
	Farm Size Sq	+	+	+	+	+	+	+	+	+
TZA	Farm Size	+	+	+	+	+			-	-
	Farm Size Sq	-	-	-	-	-			+	+
UGA	Farm Size	+	+	+			-	-	-	-
	Farm Size Sq	-	-	-		+	+	+	+	+
Pooled	Farm Size	+		-	-	-	-	-	-	-
OLS	Farm Size Sq	-		+	+	+	+	+	+	+

With the exception of NGA:

Nonlinearities and switches signs across farm size groups for countries located in difference AEZ

Average land productivity (ALP) exhibits an **inverted U-shaped** relation with farm size for the **bottom deciles**

ALP shows the opposite pattern of a **U-shaped** relationship for the **top deciles**

Revisiting the IR: New evidence from SSA countries, (Scandizzo P.L., and S. Savastano, 2017 forthcoming )  
OLS regression on Gross crop income/ha. Only significant signs of land are reported.

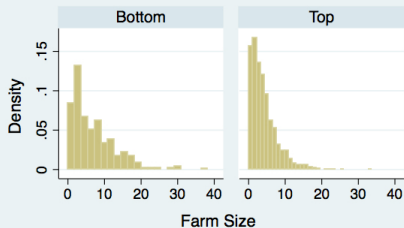
Other controls include: HH characteristics, GEO var, (Urban gravity, infrastructure , and soil quality, AEZ).



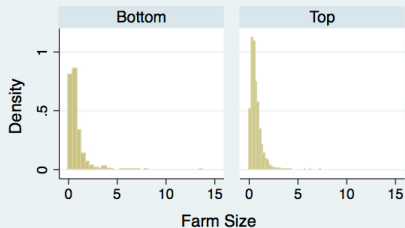
# Farm Distribution by Productivity

## Farm Distribution by Productivity

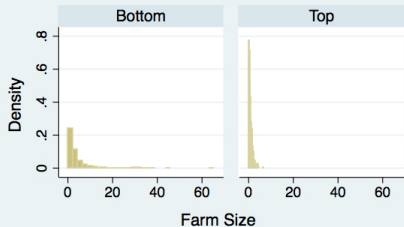
NER



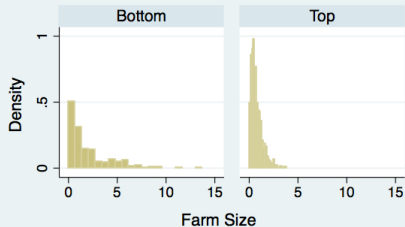
MWI



TZA



UGA



# Evidence from the Cross Sectional Study

- As a general tendency across farms of all sizes, IR may be an artifact of the central tendency indicators (OLS) used, mostly based on conditional expectations. Its form, shape and importance may significantly differ across the spectrum of farm productivity performance.
- Once the whole land productivity distribution is considered, our analysis shows that for all countries, the IR holds only for the top quantiles of the productivity variable while for the bottom quantiles a positive relationship tends to hold.
- The literature on transaction costs and the role of the firm suggests that these differences will require a deeper analysis of some of the critical factors determining the performance of the farm as a 'productivity agent' and of the role played by **management and abilities in shaping farmers' choices.**



## 2. Panel Analysis ERHS 2004-2009

### Summary main statistics

	2004	2009	Total
<b>Farmers' characteristics</b>			
Head's age	50.49***	52.53***	51.51
Head's education (years)	1.4***	1.8***	1.6
Max years of education of HH members	3.8**	5.7**	4.7
HH size	5.93	5.91	5.92
<b>Income, poverty and inequality</b>			
Income per capita (Const. 2009 US\$)	105.3	152	129
Gross agriculture income/ha	446.81***	549.92***	497.8
<i>Share of income from:</i>			
agriculture (crop+liv)	0.82***	0.73***	0.78
from crop	0.61***	0.55***	0.58
from livestock	0.21***	0.18***	0.2
from wage and other sources	0.18**	0.27**	0.22
Farm size	1.40**	1.52**	1.46
Number of plots	4.7	5.1	4.9
Dummy hired labor	0.32***	0.37***	0.34
<b>Farming conditions</b>			
<b>Agriculture options in round 2</b>			
Dummy Option land expansion		0.52***	0.76
Amount of land increased		0.75	0.75
Dummy option soil conservation		0.18	0.18

Young farmers

Very little education

Large family (6 members in avg.) Very

poor

Bulk of the income from agric.

Land productivity increased in 2009

**Smallholders + fragmentation:**

1.46 Ha on an avg of 5 plots = 0.3 ha per

plot Little labor mrkt. Agric. Options:

Increase productivity through land expansion



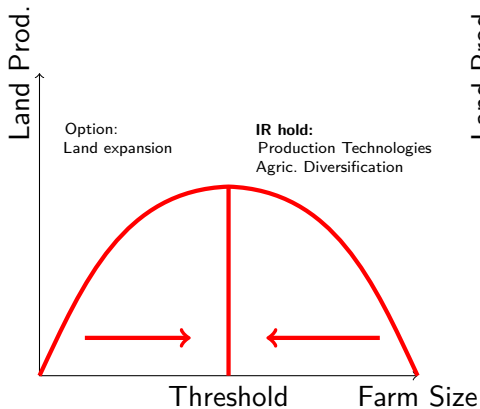
## 2. Recovering Unobserved ability:

	Pooled OLS		HH Fixed Effect		QR - Top Distribution			
					Q 0.6	Q 0.7	Q 0.8	Q 0.9
<b>Gross Agric. Income/ha</b>	.		.					
Farm size	<b>-298.11</b> ***		<b>-656.34</b> ***		<b>-147.10</b> ***	<b>-218.95</b> ***	<b>-346.01</b> ***	<b>-582.43</b> ***
Farm size sq.	<b>42.28</b> ***		<b>84.92</b> ***		<b>13.74</b> *	<b>22.21</b> ***	<b>41.05</b> ***	<b>74.36</b> ***
Dummy if raise livestock	405.33 ***		209.75 ***		342.75 ***	410.38 ***	505.42 ***	607.93 ***
HH size	15.33 ***		13.32 ***		17.35 **	22.93 **	32.35 ***	33.13
Age of HH head	1.06		-1.35		-5.62 ***	1.20	1.79	3.00
Dummy for female HH head	-24.96		-63.69		-11.34	-23.18	-40.94	-53.25
Years of education of HH members	35.92 ***		-10.85		25.49 ***	35.58 **	40.53 **	56.42 **
Nb. of plots with steep slope	-44.36 ***		-13.32		-32.25 ***	-47.15 ***	-55.26 *	-64.87 **
Share of land with good soil quality	46.51 *		-18.47		42.97	68.17	91.13 *	91.22
Dummy too little rain on HH fields during rainy season	-134.46 ***		-150.03 ***		-84.58 ***	-120.47 ***	-134.22 ***	-198.52 ***
Producer price Index for Cereals	146.29 ***		213.53 ***		144.59 ***	178.15	202.06	239.08
Constant	-20.14		736.45 ***					
<b>Threshold Land (ha)</b>	<b>3.53</b>		<b>3.86</b>		<b>5.35</b>	<b>4.93</b>	<b>4.21</b>	<b>3.92</b>
Observations	2,176		2,176		2,176	2,176	2,176	2,176
R-squared	0.158		0.243					
Number of groups/observations	2226		1,113		1,113	1,113	1,113	1,113



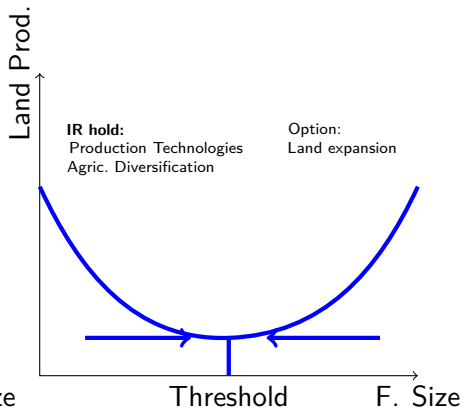
## LESS PRODUCTIVE FARMS

Inverted U-Shape Lower ability



## MORE PRODUCTIVE FARMS

U-Shape Higher ability



# Conclusions

- Our results suggest that at the two ends of the productivity distribution, farmers' performance is influenced by land size in a markedly different way.
- As already noted, although in a different context by Evenson and Mwabu (1998), this may be due to the fact that individual management factors do matter and that in the two areas of the distribution, different complementary and substitute relations may exist between land sizes and unobserved human capital variables, such as farmers' abilities, skills and experience.
- **Policy implications:** land reform and redistribution policies effective for less efficient producers only if they are below a critical farm size, after which management and technology are better instruments to improve their lot. Viceversa, for producers that are already at a reasonable level of efficiency and dynamism, the opposite is true: land policies, be they in the form of redistribution or more secure tenure, would be more effective than extension and technological innovation.
- **Methodological implications: extend national representative surveys to commercial farms**

