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Proxy Errors with Policy Consequences: Agricultural Productivity

C. Leigh Anderson, Travis Reynolds, Pierre Biscaye,
Joshua D Merfeld, and Katie Panhorst Harris*

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Increasing Agricultural Productivity

WHAT WE INTEND

Increasing Productivity

Increasing farm productivity is regarded as a prerequisite for improvement of rural livelihoods and development in low-income countries, particularly for SSA (Pingali, 2011)

- **FAO**: "improve agricultural productivity"
- **World Bank**: "increasing agricultural productivity" (75% of ag lending)
- **USAID**: "increased productivity" key to "inclusive agriculture-led growth"
- **BMGF**: "increasing agricultural productivity in a sustainable way"

Governments, non-profits, and others have invested billions in pursuit of higher productivity for smallholder farmers.

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Crop Yield as Proxy for Smallholder Productivity

WHAT WE MEASURE

Productivity Literature

- **Agricultural Productivity Measures**
  - Defined in several ways in the literature:
    - Output per unit of input (total factor productivity)
    - Output per worker (total or partial factor productivity (Fuglie, 2008; Alston et al., 2010))
    - Farm yield by crop or total output per hectare
  - Measured using several different methods:
    - Macro-level studies (Ravallion and Datt, 1996, 1998; Timmer,1995, 1997)
    - Micro-level evidence (Byerlee et al., 2009; Minten & Barrett, 2008; Muyanga et al., 2010)
    - Meta-studies & reviews (Schneider et al., 2011, Irz et al., 2001; Mellor, 1999; Thirtle et al., 2001)

- **Data and Measurement Issues**
  - Administratively reported production estimates, such as those compiled and reported by the FAO, may be fraught with measurement error and/or statistical and political error (Sandefur & Glassman, 2015; Jerven, 2014)
  - Missing markets and missing data: prices, wages, natural resource use etc.

Common Crop Yield

Common crop yield is widely used to proxy for smallholder farm productivity.

$$\text{Common crop yield} = \frac{\sum \text{Quantity harvested in kg}}{\sum \text{Area harvested in ha}}$$

- Similar biases with administrative and/or household (survey) level data
- Similarly national average masks regional or household-level variation
- Additional measurement error with HH survey data self-reporting bias (Carletto et al., 2013a-b; De Groote & Traorè, 2005)

Validity Issues

1. Using yield to proxy productivity

Common crop yield captures a single output from a single input at a single moment

- Use of common crop yield as the sole indicator ignores the value of multiple outputs and the costs associated with other inputs to farm production including labor, tools and environmental services (Reynolds et al., 2015; Cassidy et al., 2013; Alston et al., 2010; Ehui & Pender, 2005)

Quantity harvested: complicated by multi/inter-cropping and ongoing harvesting of crops such as cassava

Area harvested: common yield measurement is complicated by land factors such as irregular plot shapes and non-planted areas due to trees, stumps, anthills/termite mounds and other obstructions (Fermont & Benson, 2011; Casley & Kumar, 1988).

2. Using yield (land productivity) based on area harvested:

Plot area harvested may be substantially smaller than plot area planted due to poor germination, damage from pests or disease, floods, labor constraints, or lack of market opportunities – all common circumstances for small scale farmers (Fermont & Benson, 2011).

Our empirical focus:

a. Do estimates of yield vary?

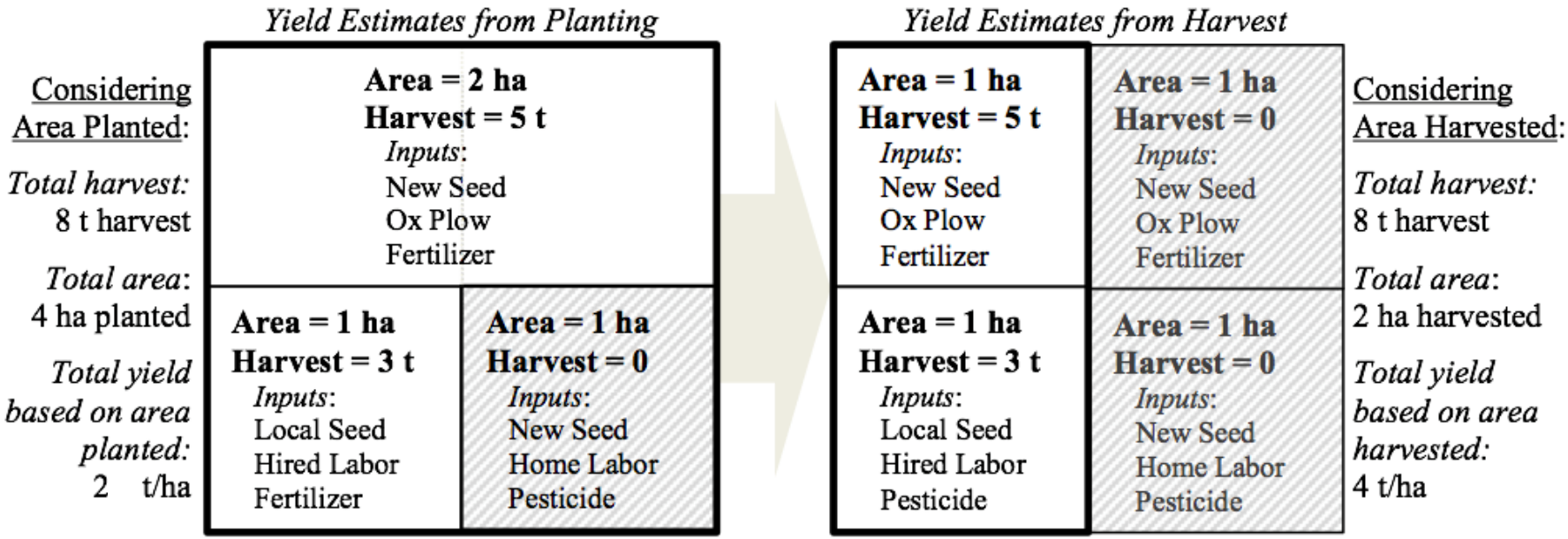
b. Do these differences matter (in directing resources)?

Are data and measurement errors random?

c. How do they matter (in which direction does the bias run)?

Does common yield (using area harvested) overestimate mean crop yield MORE for the smallest landholders?

Example of area planted vs area harvested



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Findings: Maize, Rice, and Sorghum in Tanzania

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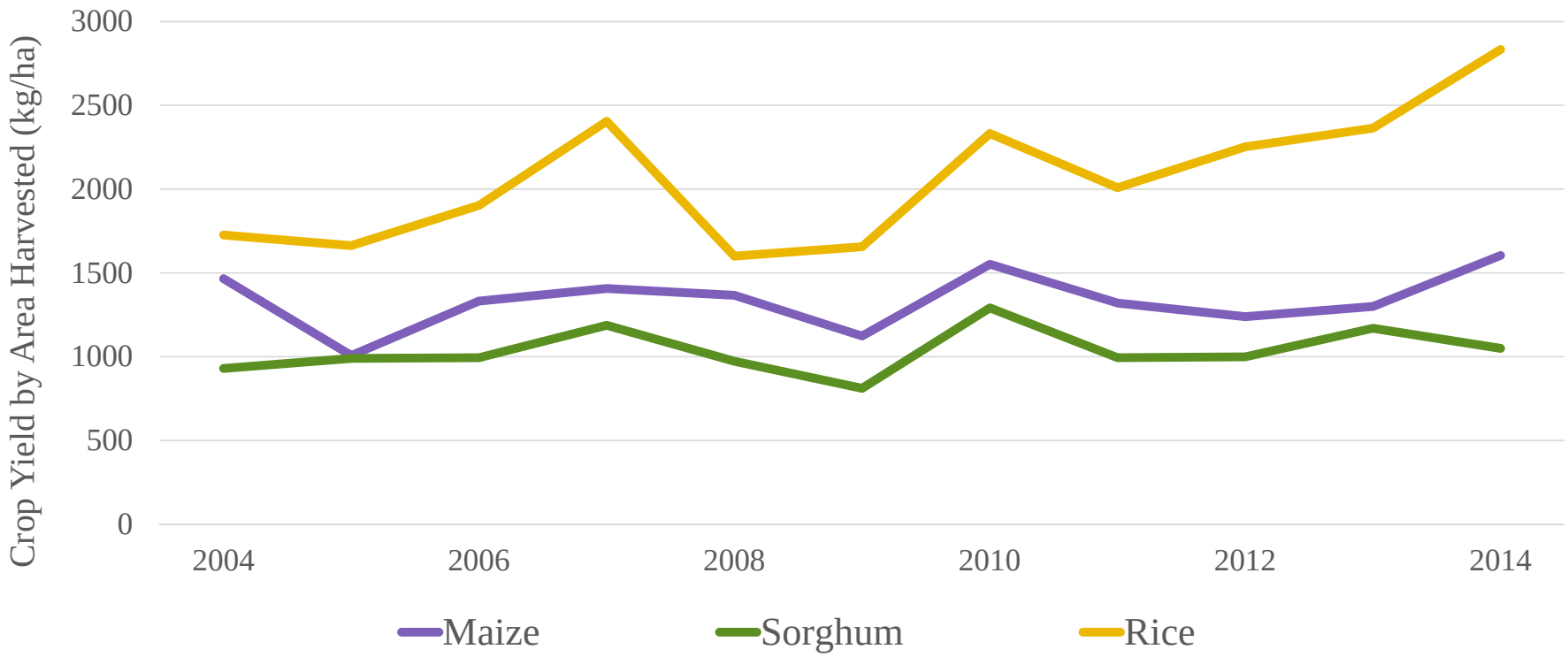
Crop Yield in Tanzania (kg/ha)



Source 1 - FAOSTAT

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OLS Regression Results - Maize

	All Plots			Smallholders (<=2ha)			Non-Smallholder		
Yield (kg/ha) by area…	Harvested		Planted	Harvested		Planted	Harvested		Planted
No to slight soil nutrient constraints				0.04		0.13	-0.14*		-0.17
No to slight soil workability constraints				0.05		0.10	-0.09		0.04
Average annual temperature (Celsius - log)	0.10		-0.45						
High rainfall year									
Low rainfall year									
Improved maize planted on plot	0.07		0.12*	-0.10		-0.01	0.13		0.19*
Pre-harvest loss due to birds (yes=1)									
Pre-harvest loss due to other cause (yes=1)	-0.13*	=	-0.14*	-0.21**	=	-0.26***	-0.14*		-0.01
Used pesticide or herbicide on plot (yes=1)									
Used inorganic fertilizer on plot (yes=1)	0.41***	<	0.51***	0.43***	=	0.41***	0.41***	=	0.51***
Maize intercropped on plot (yes=1)							-0.25**		-0.16
Consecutive years plot left fallow							0.00		0.04
Plot size (ha – log)	-0.04		-0.12**	-0.03		-0.09*	0.02		-0.21***
Household used ox plough, planter, or cart (yes=1)	0.33***	=	0.40***	0.29**	=	0.26**	0.30**	<	0.43***
Household labor days (log)	0.05		0.17***	0.16***	<	0.21***	-0.00		0.18***
Hired labor days (log + 1)	0.03		0.06**	0.07***	<	0.10***	0.02		0.08***
Household received any extension advice (yes=1)				0.20*	=	0.19*	0.07		-0.05
Household sold any maize (yes=1)	0.56***	<	0.76***	0.60***	<	0.71***	0.48***	<	0.77***
Female head of household (yes=1)	-0.10		-0.15*	-0.16**	=	-0.19**	-0.16		-0.26**
Age of household head (log)	-0.09		-0.16*						
Education of household head (years)									
Daily consumption (log)	0.17**	=	0.16**	0.12*		0.10			
Total household hectares (log)									

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OLS Regression Results - Rice

	All Plots			Smallholders (<=2ha)			Non-Smallholder		
Yield (kg/ha) by area…	Harvested		Planted	Harvested		Planted	Harvested		Planted
No to slight soil nutrient constraints				-0.09		0.10			
No to slight soil workability constraints									
Average annual temperature (Celsius - log)									
High rainfall year									
Low rainfall year				-0.19*		-0.13			
Improved paddy planted on plot	-0.28*		-0.07	-0.05		0.14	-0.43*		-0.08
Pre-harvest loss due to birds (yes=1)				-0.00		-0.13	0.04		-0.35*
Pre-harvest loss due to other causes (yes=1)				-0.03		-0.20			
Used pesticide, herbicide, or pesticide on plot (yes=1)									
Used inorganic fertilizer on plot (yes=1)	0.30*		0.29				0.37*		0.40
Paddy intercropped on plot (yes=1)									
Number of consecutive years plot left fallow							0.02		0.07**
Plot size (ha – log)	-0.00		-0.17*	-0.09		-0.24**	0.11		-0.17
Household used ox plough, planter, or cart (yes=1)	0.09		0.35***				0.00		0.39**
Household labor days (log)	0.16**	=	0.26***	0.09		0.12*	0.19*	<	0.31***
Hired labor days (log + 1)	0.08*	=	0.14***	0.08***	=	0.09***	0.11*	<	0.17***
Household received any extension advice (yes=1)									
Household sold any rice (yes=1)	0.58***	<	0.90***	0.56***	<	0.72***	0.52***	<	0.93***
Female head of household (yes=1)	-0.41*		-0.37						
Age of household head (log)									
Education of household head (years)							0.03		0.04*
Daily consumption (log)	0.21*	=	0.30*	0.26**	=	0.25**			
Total household hectares (log)									

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OLS Regression Results - Sorghum

	All Plots			Smallholders (<=2ha)			Non-Smallholder		
Yield (kg/ha) by area…	Harvested		Planted	Harvested		Planted	Harvested		Planted
No to slight soil nutrient constraints							-0.24		0.01
No to slight soil workability constraints	-0.19		0.09				-0.12		0.32*
Average annual temperature (Celsius - log)	2.10		2.92**						
High rainfall year				0.32		0.16			
Low rainfall year									
Improved paddy planted on plot							-0.59		-0.31
Pre-harvest loss due to birds (yes=1)	0.29*		0.10	-0.38*		-0.17	0.40*		0.18
Pre-harvest loss due to other causes (yes=1)	0.37*		0.19				0.42*		0.22
Used pesticide, herbicide, or pesticide on plot (yes=1)	0.55**		0.31				0.58***		0.06
Used inorganic fertilizer on plot (yes=1)	0.37		-0.25	-0.63		-0.82*	0.42		-0.22
Paddy intercropped on plot (yes=1)	-0.26*		-0.21						
Number of consecutive years plot left fallow									
Plot size (ha – log)	-0.23		-0.41**				0.11		-0.24***
Household used ox plough, planter, or cart (yes=1)	0.33*		0.16						
Household labor days (log)	0.12		0.20*	0.19		0.23**			
Hired labor days (log + 1)				0.17*	=	0.17*			
Household received any extension advice (yes=1)				0.59*	=	0.59*			
Household sold any sorghum (yes=1)	0.43**	<	0.74***				0.52***	<	0.73***
Female head of household (yes=1)	-0.03		-0.06						
Age of household head (log)							0.50*		0.25
Education of household head (years)	0.00		0.02						
Daily consumption (log)	0.13		-0.10						
Total household hectares (log)									

Conclusions

The choice of productivity measure matters

- Reasonably robust conclusions regardless of measure and sample used for only a few variables: use of inorganic fertilizer and ox plough on maize plots, and hired labor on paddy plots
- Very different conclusions for many variables, especially plot size, labor days, and the sale of crops
- Labor is consistently important for smallholder farmers
  - When estimates differ, the magnitudes are always larger when using area planted
  - This may reflect the fact that smallholders are less likely to use non-labor inputs
- For sorghum, the choice of yield measure is particularly important for analyses among non-smallholders
- Policy implications?

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Evans School Policy Analysis & Research Group (EPAR)

Professor Leigh Anderson, Principal Investigator

Leigh Anderson, Travis Reynolds, Pierre Biscaye, Katie Panhorst Harris, Josh Merfeld

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Please direct comments or questions about this research to Leigh Anderson at epar.evans.uw@gmail.com