ICRISAT
Science with a human face

Welfare Effect of Modern Agricultural Technologies: A Micro-perspective from Ethiopia and Tanzania

Solomon Asfaw, Bekele Shiferaw & Franklin Simtowe

CPRC International Conference 2010

Manchester, UK
08-10 September 2010

ICRISAT
Science with a human face

Structure of the presentation

1. Background
2. Research Objectives
3. Data & Econometric Framework
4. Results
5. Conclusions

ICRISAT
Science with a human face

Background

- The underlining objectives of developing and releasing modern agricultural technologies are often to reduce hunger, malnutrition, poverty and increase the incomes of poor people
- Benefit from improved agricultural technologies – raising income, employment, wage rate, lowering price of food etc.
- Most of the impact studies related to modern agricultural technologies were conducted for staple crops like maize wheat and rice.
- Limited knowledge on impact of the legume technologies under smallholder agriculture

Technology development and transfer

- Years of research investment by NARS and ICRISAT in developing dryland legume varieties – pigeonpea in Tanzania and chickpea in Ethiopia

- Investment in building seed supply systems
  - A number of varieties disseminated through various pathways (demonstrations, seed production & delivery through FA/FO, small-scale producers)
  - A number of farmers empowered to produce and market seed
  - Seed disseminated through small pack schemes via local retailers

ICRISAT
Science with a human face

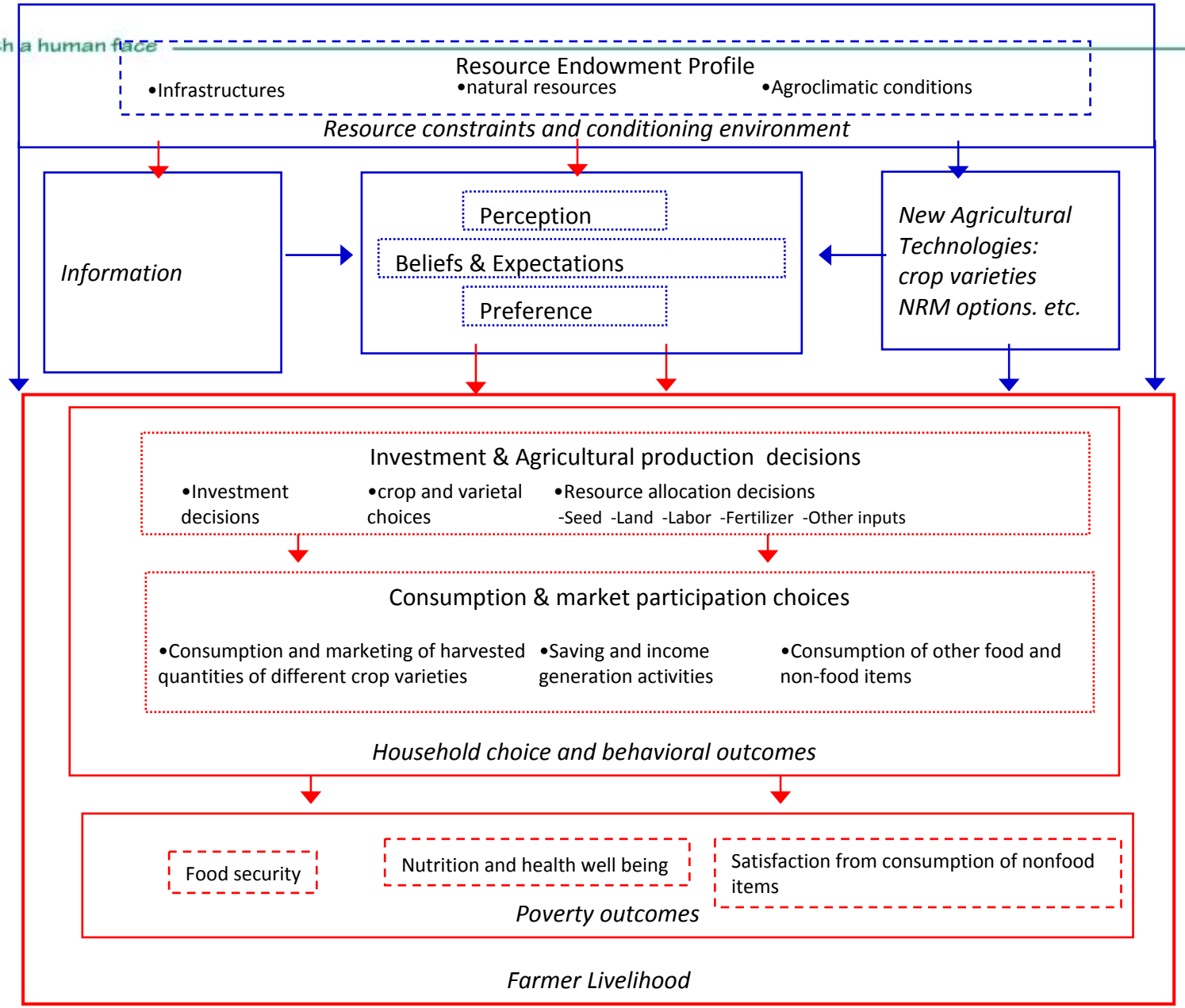
Objectives

The objective was to provide rigorous empirical evidence on the role of adoption of improved chickpea and pigeonpea technology on household welfare outcomes measured by crop income and consumption expenditure in rural Ethiopia and Tanzania

Conceptual framework

ICRISAT
Science with a human face

The Agricultural Household Model



Survey design and data

Tanzania

- Selected four pigeonpea producing districts in Northern zone of Tanzania purposively
- Selected 24 wards randomly
- Selected 613 households randomly
- Data for 2007-2008 cropping season
- About 32% are adopters of improved pigeonpea

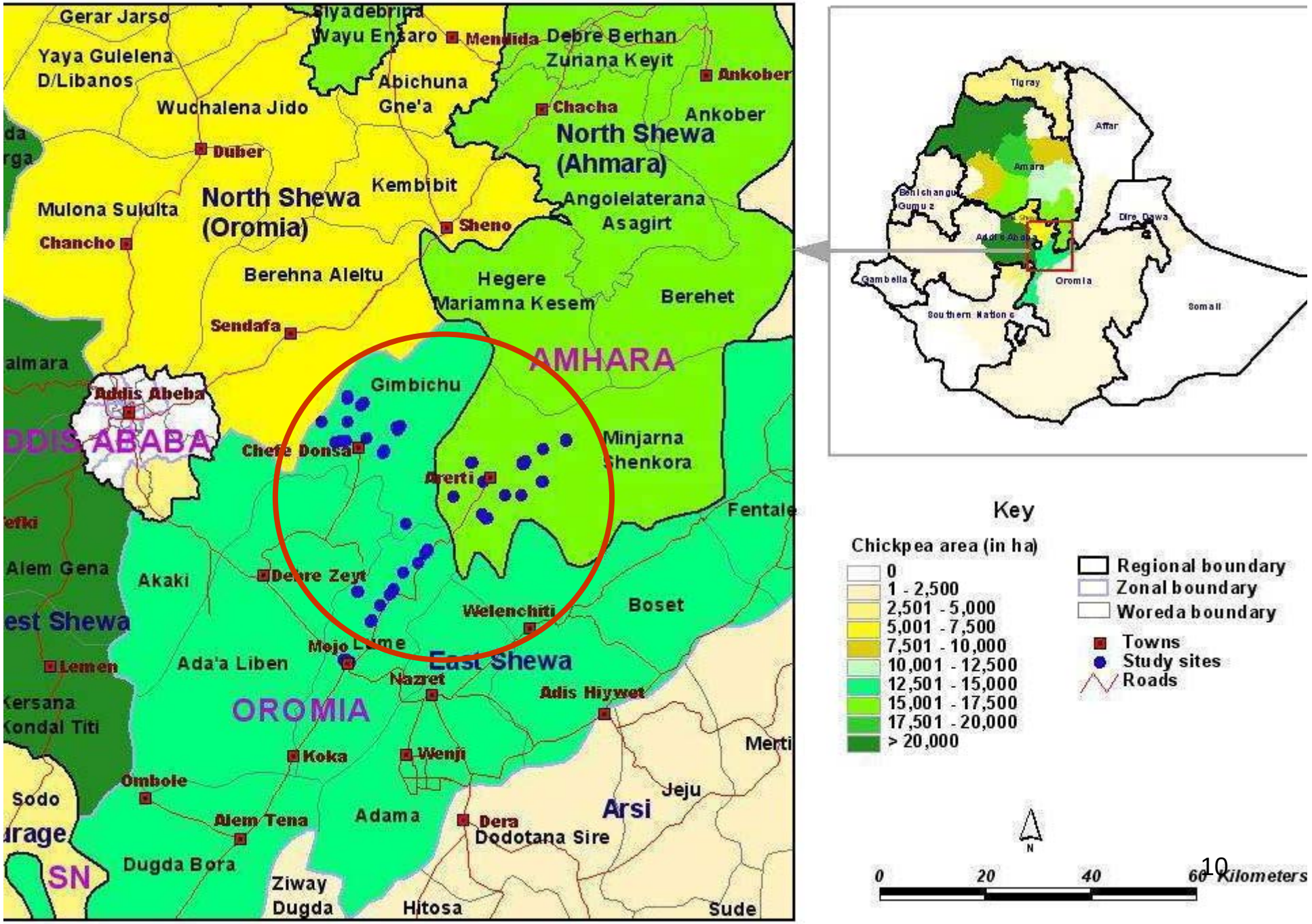
Area under pegionpea production by region in Tanzania (ha)

Survey design and data

Ethiopia

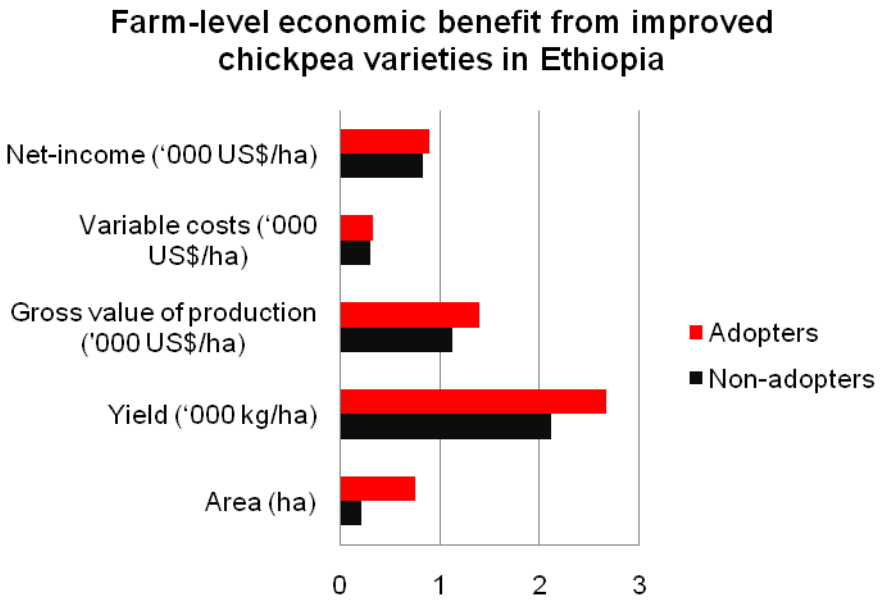
- Selected three chickpea producing districts in central part of Ethiopia purposively
- Selected 26 *kebeles* randomly
- Selected 700 households randomly
- Data for 2007-2008 cropping season
- About 34% are adopters of improved chickpea

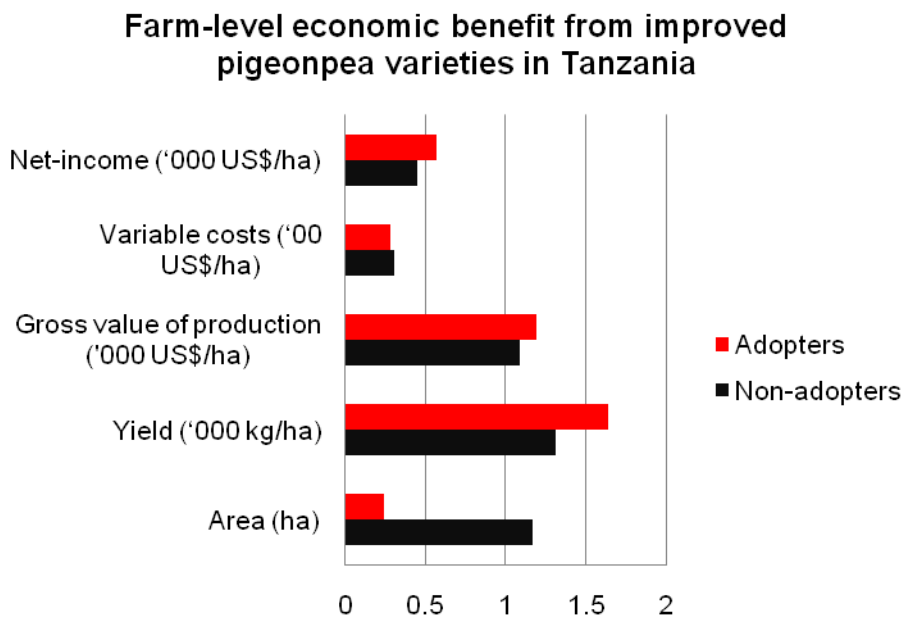
Study sites and distribution of area under chickpea production in Ethiopia (ha)



Data description

Comparative farm-level effect of improved technologies





Variables	Ethiopia			Tanzania		
	Adopters	Non-adopters	t-stat	Adopters	Non-adopters	t-stat
Outcome variables						
Crop income per AEU ('000 Birr/TSh)	3.29	2.87	1.65*	0.26	0.22	0.91*
Consumption expenditure per AEU ('000 Birr/TSh)	3.18	2.74	3.41***	0.21	0.19	0.81

ICRISAT
Science with a human face

Empirical impact evaluation challenges

- Non-experimental observation and counterfactual of intervention – what cannot be observed is the welfare outcome for those farmers who adopted had they not had adopted (or the converse)
- Improved technology is not randomly distributed to farmers
- Simples approach to estimate welfare impact would be to include a dummy variable (0/1) and then apply OLS
- Two major econometric problems
  - Adoption of improved technology is potentially endogenous
  - Using pooled sample of adopter and non-adopters may be inappropriate

Econometric framework

Model 1: Endogenous switching regression model

$$G_i^* = \beta X_i + u_i \qquad G_i = \begin{cases} 1 & if\ G_i^* > 1 \\ 0 & otherwise \end{cases}$$

Regime 1: $$Y_{1i} = \alpha J_{1i} + e_{1i}\ if\ G_i = 1$$

Regime 2: $$Y_{2i} = \alpha_2 J_{2i} + e_{2i}\ if\ G_i = 0$$

➔ Error terms are assume to have a trivariate normal distribution, with zero mean & non-singular covariance matrix

$$\text{cov}(e_{1i}, e_{2i}, u_i) = \begin{pmatrix} \sigma_{e2}^2 & . & \sigma_{e2u} \\ . & \sigma_{e1}^2 & \sigma_{e1u} \\ . & . & \sigma_u^2 \end{pmatrix}$$

$$LnL_i = \sum_{i=1}^{N} G_i \left[\ln \phi \left\langle \frac{e_{1i}}{\sigma_{e1}} \right\rangle - \ln \sigma_{e1} + \ln \Phi(\varphi_{1i}) \right]$$

$$+ (1 - G_i) \left[\ln \phi \left\langle \frac{e_{2i}}{\sigma_{e2}} \right\rangle - \ln \sigma_{e2} + \ln(1 - \Phi(\varphi_{2i})) \right]$$

Econometric framework

Conditional expectations, treatment and heterogeneity effects

Sub-samples	Decisions stage		Treatment Effects
	To adopt	Not to adopt	
Farm households that adopted	$(a)\ E(Y_{1i} / G_i = 1)$	$(c)\ E(Y_{2i} / G_i = 1)$	TT
Farm households that didn't adopt	$(d)\ E(Y_{1i} / G_i = 0)$	$(b)\ E(Y_{2i} / G_i = 0)$	TU
Heterogeneity effects	BH_1	BH_2	TH

Notes: (a) and (b) represent observed expected crop income and consumption expenditures; (c) and (d) represent counterfactual expected crop income and consumption expenditures.
G_i = 1 if farm households adopted improved agricultural technologies: A_i = 0 if farm households did not adopt:
Y_{1i} = crop income and consumption expenditure if the farm households adopted
Y_{2i} = crop income and consumption expenditure if the farm households did not adopt
TT = the effect of the treatment (i.e. improved technologies) on the treated (i.e., farm households that adopted);
TU = the effect of the treatment (i.e. improved technologies) on the untreated (i.e., households that did not adopt);
BH = the effect of base heterogeneity for farm households that adopted (i = 1), and did not adopt (i = 2);
TH = (TT-TU), i.e., transitional heterogeneity

ICRISAT
Science with a human face

Econometric framework

Model 2: Propensity Score Matching (PSM) methods

- Run logistic regression => match each adopter to one or more non adopter on propensity score
- Nearest neighbor matching and Kernel matching

$$(Y_1, Y_2) \perp G_i / X$$

➔ Ignorable treatment assignment

Results

ICRISAT
Science with a human face

FIML Endogenous Switching Regression

Dependent variable: log crop income per AEU for Tanzania

Variables	FIML Endogenous Switching Regression	
	Adoption =1	Adoption=0
Age of household head	-0.006 (0.68)	0.0 12 (0.40)
Family size in AEU	-0.011 (0.04)	-0.03 (0.04)
Education of household head	-0.052 (0.06)	0.002 (0.04)
Log oxen per AEU	-0.001 (0.03)	-0.018 (0.02)
Log non-oxen asset per AEU	0.179 (0.10)*	0.114 (0.09)
Land per AEU	0.376 (0.13)***	0.485 (0.14)***
Total area under pigeonpea	0.114 (0.11)	0.147 (0.10)
Total area under maize	-0.173 (0.14)	-0.116 (0.11)
Log of maize marketed	0.120 (0.03)***	0.039 (0.04)
Average price of maize	0.004 (0.00)***	0.007 (0.00)***
Average price of pigeonpea	0.258 (0.08)***	0.316 (0.06)***
Farming as primary occupation	-0.021 (0.34)	-0.357 (0.74)
Access to market information	0.768 (0.39)*	0.253 (0.26)
Access to credit	-0.164 (0.34)	0.234 (0.50)
Had information related with farm technology	-0.248 (0.30)	-0.191 (0.34)
Access to off-farm	-0.10 (0.25)	-0.398 (0.27)
Access to seed	0.048 (0.33)	0.607 (0.54)
4 district dummies		
σ_{ei}	1.622(0.12)	2.123 (0.08)
φ_j	-0.158 (0.22)*	-0.342 (0.26)*

ICRISAT
Science with a human face

FIML Endogenous Switching Regression

Dependent variable: log consumption per AEU for Tanzania

Variables	FIML Endogenous Switching Regression	
	Adoption =1 (adopters)	Adoption=0 (non-adopters)
Age of household head	0.001(0.00)	0.001 (0.00)***
Head education 1−4 years	-0.651 (0.20)***	-0.043 (0.13)
Head education 5−8 years	-0.578 (0.19)***	-0.187 (0.13)
Head education 9−12 years	-0.634 (0.25)**	-0.144 (0.21)
Head education >12 years	0.000 (0.48)	0.492 (0.34)
Family size in AEU	-0.077 (0.02)***	-0.089 (0.01)***
Gender of household head	-0.240 (0.15)*	-0.055 (0.11)
Land per AEU	-0.020 (0.05)	0.109 (0.04)***
Log non-oxen asset per AEU	0.108 (0.04)***	0.093 (0.03)***
Log oxen per AEU	-0.002 (0.01)	-0.004 (0.01)
Log crop income per AEU from previous year	-0.011 (0.02)	0.015 (0.01)
Log off-farm income per AEU from previous year	0.042 (0.02)*	0.046 (0.02)**
Log livestock income per AEU from previous year	-0.003 (0.02)	0.027 (0.02)
Karatu district (reference)		
Kondoa district	0.061 (0.27)	-0.179 (0.09)*
Babati district	-0.073 (0.14)	-0.397 (0.10)***
Arumeru district	-0.118 (0.14)	-0.032 (0.11)
σ_{ei}	0.615 (0.04)	0.717 (0.03)
φ_j	-0.372 (0.19)*	-0.859 (0.04)***

ICRISAT
Science with a human face

Average expected crop income and consumption expenditure per AEU for pigeonpea adopters and non adopters in Tanzania

Sub-samples	Decisions stage		Treatment effect
	To adopt	Not to adopt	
a) Log crop income per AEU			
Farm households who adopted	(a) 11.61	(c) 10.52	1.09(6.7)***
Farm households who did not adopt	(d) 11.37	(b) 10.93	0.44 (3.3)***
Heterogeneity effects	BH_1= 0.24	BH_2= -0.41	TH= 0.65
b) Log consumption expenditure per AEU			
Farm households who adopted	(a) 5.16	(c) 4.42	0.74(14.9)***
Farm households who did not adopt	(d) 5.64	(b) 4.94	0.70 (19.9)***
Heterogeneity effects	BH_1= -0.48	BH_2= -0.52	TH= 0.04

ICRISAT
Science with a human face

Average expected crop income and consumption expenditure per AEU for chickpea adopters and non adopters in Ethiopia

Sub-samples	Decisions stage		Treatment effect
	To adopt	Not to adopt	
a) Log crop income per AEU			
Farm households who adopted	(a) 3.29	(c) 2.92	0.37 (3.2)**
Farm households who did not adopt	(d) 3.06	(b) 2.87	0.19 (2.1)*
Heterogeneity effects	BH_1= 0.23	BH_2= 0.0.05	TH= 0.18
b) Log consumption expenditure per AEU			
Farm households who adopted	(a) 3.18	(c) 2.93	0.25 (2.8)**
Farm households who did not adopt	(d) 2.89	(b) 2.71	0.18 (1.8)*
Heterogeneity effects	BH_1= 0.29	BH_2= 0.22	TH= 0.07

ICRISAT
Science with a human face

Impact of agricultural technology adoption on income and consumption expenditure using PSM methods

Countries	Adopters	Non-adopters	Difference = average treatment effect on the treated (ATT)	t-stat
(a) Dependent variable: Log crop income per AEU				
Method 1: Nearest neighbour matching				
Tanzania	11.59	10.61	0.98	1.68*
Ethiopia	3.35	3.07	0.29	1.94**
Method 2: Kernel matching				
Tanzania	11.59	10.88	0.71	1.61*
Ethiopia	3.28	3.17	0.11	0.79*
(b) Dependent variable: Log consumption expenditure per AEU				
Method 1: Nearest neighbour matching				
Tanzania	5.16	5.13	0.03	0.24
Ethiopia	3.41	3.38	0.14	0.18*
Method 2: Kernel matching				
Tanzania	5.18	5.16	0.01	0.12
Ethiopia	3.42	3.35	0.10	1.61*

ICRISAT
Science with a human face

Conclusions

Two main conclusions can be drawn from the results of this study:

- First, the group of farm households that did adopt has systematically different characteristics than the group of farm households that did not adopt.
- Second, switching regression results suggest that adopters of improved pigeonpea and chickpea have significantly higher crop income and consumption expenditure than non-adopters after controlling for all confounding factors.
- Results from this paper generally confirm the potential direct role of agricultural technology adoption on improving rural household welfare, as higher incomes from improved technology also mean less poverty.
- Inadequate local supply of seed, access to information and perception about the new cultivars are key constraints for technology adoption

ICRISAT
Science with a human face

THANK YOU !