Technology adoption and the multiple dimensions of food security: the case of maize in Tanzania

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Outline of the presentation

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Added Values

- we use a **nationally representative dataset**, going beyond the usual approach to investigate local case studies which are not completely informative to implement policies at national level
- we investigate the adoption of **two agricultural technologies**, namely **improved seeds and inorganic fertilizers**, instead of partially looking to a single innovation
- we do not limit ourselves to analyze the impact on production/monetary proxies, rather we use direct and specific measures for the **four dimensions of food security**

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Matching Techniques

Why do we use Matching Techniques?

- Matching techniques permit to address the potential existence of selection bias;
- The decision of the maize farmers to adopt agricultural technologies is likely to be driven by a series of characteristics which are also correlated to the food security indicators (e.g. education, access to credit, extension services, ect);
- The most applied Matching Technique in this strand of literature is the Propensity Score Matching (e.g. Mendola, 2007, Kassie et al. 2011. Amare et al., 2012; Kassie et al.; 2012);

Matching Techniques (2)

How does it work?

- we focus our analysis on the Average Treatment Effect on the Treated (ATT) because it can be considered the main parameter of interest (Becker and Ichino, 2002).

$$\tau_{ATT} = E(Y(1) - Y(0) \mid T = 1) = E[Y(1) \mid T = 1] - E[Y(0) \mid T = 1]$$

- The key to estimate the ATT is to assume that once we control for a vector of observable variables X, the adoption of technologies is random (Caliendo and Kopeinig, 2008):

$$\tau_{ATT}(X) = E(Y(1) - Y(0) \mid X) = E[Y(1) \mid T = 1, X] - E[Y(0) \mid T = 1, X]$$

- The limitation is that we cannot control for unobservable heterogeneity. However, this assumption is not more restrictive than the weak instrument assumption in case of Instrumental Variable or Heckman procedure used with cross-sectional datasets (Jalan and Ravallion, 2003).

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We test 1) the **common support** condition and 2) the **balancing property** to verify that the differences in the covariates between A/NA have been eliminated after matching

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fourth step

We calculate the ATT comparing the food security outcomes for the matched sample

The Data

The Sample

- We use data from the household and agriculture questionnaires of the 2010/2011 Tanzania National Panel Survey (TZNPS) which is part of the LSMS-ISA of WB;
- The original sample consists of 3,924 households. In our analysis, we use a sub-sample of 1543 households which contains households cultivating maize during the long rainy season (Masika) all over the country, with the exclusion of Zanzibar.
- For improved seeds the treated HHs are 211 (13.7%) while for inorganic fertilizers the treated HHs are 335 (21.7%)

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The Treatment Variables

Improved Seeds	binary variable equal to 1 if at least one maize plot was sown with improved varieties; and 0 otherwise
Inorganic Fertilizers	binary variable equal to 1 if inorganic fertilizers were used at least on one plot; and 0 otherwise

The Data

The Outcome Variables

General	• Total Consumption Expenditure (THS)
Food Availability	• Yields (mean Kg/acres of harvested maize)
Food Access	• Food Consumption Expenditure (THS) • Caloric Intake (average daily intake per adult-equivalent)
Food Utilization	• Diet Diversity (Nr Items Consumed) • Share of Staple Food (wrt total calories)
Food Variability	• Vulnerability to Poverty ($V_{it} = Pr(C_{i,t+1} < Z \| X_{it})$) • Storage (=1 if HH is storing for food purposes)

The Data

Correlations between Food Security Indicators

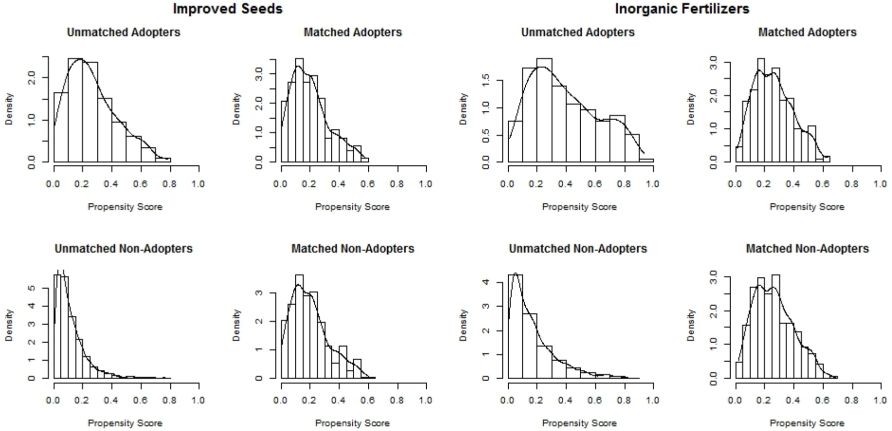
	Total Exp.	Yield	Food Exp.	Caloric Intake	Diet Div.	Staple Sh.	Storage	VEP
Total Exp.	1							
Yield	0.08	1						
Food Exp.	0.93	0.06	1					
Caloric Intake	0.49	0.02	0.57	1				
Diet Div.	0.41	0.09	0.41	0.25	1			
Staple Sh.	-0.44	-0.08	-0.40	-0.08	-0.40	1		
Storage	0.13	0.07	0.12	0.08	0.14	-0.09	1	
VEP	-0.55	-0.03	-0.49	-0.23	-0.24	0.31	-0.11	1

Source: Authors' calculation from TZNPS 2010/2011

First stage - PSM Estimation

	Improved Seed			Inorganic Fertilizer		
	Coeff		SE	Coeff		SE
HH Characteristics						
HH Size	0.124	**	0.060	-0.131	**	0.052
HH Size sq.	-0.001		0.003	0.003		0.002
HH Head Age	-0.049		0.032	0.056	*	0.030
HH Head Age sq.	0.000		0.000	0.000		0.000
HH Head Sex	0.145		0.216	0.101		0.186
HH Head Primary	0.792	***	0.240	1.218	***	0.218
HH Head Secondary	1.591	***	0.347	1.845	***	0.327
HH Head Above Secondary	3.584	***	1.309	1.639		1.320
Structural						
Distance - Main Road (Km)	-0.016	***	0.006	-0.020	***	0.004
Distance - Input Market (Km)	-0.008	***	0.002	0.004	***	0.001
Tropic-Warm Area	-0.677	***	0.251	0.322		0.219
Avg Total Rainfall (mm)	-0.001	***	0.000	0.002	***	0.000
Elevation (m)	0.000	*	0.000	0.219		0.168
Nutrient Availability	-0.555	***	0.182	0.002	***	0.000
Drought or Flood (past 5 yrs)	-0.216		0.234	-0.410	*	0.229
Technical						
Ln Maize Planted Area	0.931	**	0.424	0.675	**	0.344
Ln Maize Planted Area sq.	-0.341	**	0.148	-0.178		0.116
Extension Services	0.632	***	0.199	1.445	***	0.173
Access to Credit	0.300		0.261	-0.042		0.242
Constant	0.937		0.996	-7.67	***	0.958
Observation		1543			1543	
Pseudo_R2		0.151			0.207	

Common Support



Balancing Property

		Improved Seeds	Inorganic Fertilizers
Mean Absolute Bias	Unmatched	32.168	30.869
	Matched	7.531	9.525
Absolute Bias Reduction		76.587	69.143
Pseudo-R2	Unmatched	0.151	0.207
	Matched	0.026	0.040
P-Values	Unmatched	0.000	0.000
	Matched	0.707	0.084

Source: Authors' calculation from TZNPS 2010/2011

ATTs Calculation

Benchmark Estimation using NN(3)

		Improved Seed				Inorganic Fertilizer			
		Treatment		*SE*	Γ	*Treatment*		*SE*	Γ
	Total Expenditure	0.184	***	0.039	1.55	0.093	**	0.037	1.20
Availability	**Yield**	246.260	***	82.112	1.65	163.487	***	19.782	2.20
Access	**Food Expenditure**	0.161	***	0.037	1.45	0.063	*	0.037	1.10
	Caloric Intake	0.080	***	0.031	1.25	0.066	**	0.029	1.15
Utilization	**Diet Diversity**	0.246	***	0.073	1.30	0.294	***	0.078	1.40
	Staple Share	-0.042	***	0.010	1.45	0.005		0.010	1.00
Stability	**Storage**	0.104	***	0.033	1.45	0.111	***	0.030	1.55
	Vulnerability	-0.021	***	0.007	1.30	-0.001		0.006	1.00

Source: Authors' calculation from TZNPS 2010/2011

Robustness Tests

We also replicate the exercise using:

- Kernel estimator;
- Genetic Matching with multiple matches (in terms of covariates)
- simple OLS estimation

Results are generally confirmed except

- For improved seeds: Caloric Intake and Storage are positive but not significant
- For inorganic fertilizer: Vulnerability to Poverty is negative and significant

Conclusions

- Overall, the impact of maize technologies on food security is positive and significant;
- Improved seeds show a stronger effect on **Food Availability** and **Food Access**;
- For **Food Utilization** inorganic fertilizers show a higher impact on diversity but they do not reduce the staple starch dependency;
- For **Food Variability** improved seeds reduce the HH probability to be poor in the near future while both technologies impact positively on HH resilience, favoring storage for consumption purposes.

THANK YOU FOR YOUR ATTENTION!!!

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Balancing Property - Improved Seeds

	Unmatched				Matched			
Covariate	μ **Ad.**	μ **Non-Ad.**	**Diff**	**% Bias**	μ **Ad.**	μ **Non-Ad.**	**Diff**	**% Bias**
HH Size	6.398	5.505	**0.894**	40.785	5.772	5.894	-0.122	-4.106
HH Size sq.	52.493	39.475	**13.018**	31.946	42.035	46.475	-4.440	-8.957
HH Head Age	47.479	48.770	-1.291	-11.571	47.124	49.202	-2.078	-13.622
HH Head Age sq.	2482.588	2630.213	-147.625	-12.510	2451.731	2650.730	-198.999	-12.536
HH Head Sex	0.825	0.746	**0.078**	25.841	0.779	0.767	0.012	2.983
HH Head Primary	0.735	0.652	**0.082**	24.595	0.779	0.741	0.038	9.142
HH Head Secondary	0.123	0.047	**0.077**	46.744	0.048	0.052	-0.004	-1.924
HH Head Above Secondary	0.010	0.001	0.009	28.011	0.000	0.000	0.000	0.000
Distance - Main Road (Km)	13.283	21.828	**-8.546**	-53.501	15.201	17.979	-2.778	-12.084
Distance - Input Market (Km)	57.208	86.071	**-28.863**	-74.420	67.910	63.937	3.973	7.569
Tropic-Warm Area	0.531	0.643	**-0.113**	-32.932	0.524	0.550	-0.026	-5.161
Avg Total Rainfall (mm)	711.924	807.875	**-95.951**	-63.835	710.324	700.128	10.196	4.063
Elevation (m)	1063.592	968.668	**94.924**	26.422	1111.593	1089.757	21.836	4.634
Nutrient Availability	1.469	1.662	**-0.193**	-56.692	1.483	1.394	0.089	17.696
Drought or Flood (past 5 yrs)	0.133	0.132	0.001	0.238	0.117	0.146	-0.029	-8.901
Ln Maize Planted Area	1.135	1.110	0.024	5.221	1.104	1.046	0.058	9.459
Ln Maize Planted Area sq.	1.673	1.663	0.010	0.762	1.586	1.425	0.162	9.396
Extension Services	0.261	0.135	**0.126**	49.391	0.186	0.178	0.008	2.060
Access to Credit	0.128	0.077	**0.051**	25.772	0.103	0.077	0.027	8.801

Balancing Property - Inorganic Fertilizers

	Unmatched				Matched			
Covariate	μ **Ad.**	μ **Non-Ad.**	**Diff**	**% Bias**	μ **Ad.**	μ **Non-Ad.**	**Diff**	**% Bias**
HH Size	5.528	5.654	-0.126	-5.733	5.416	4.922	0.493	16.815
HH Size sq.	40.579	41.442	-0.863	-2.118	37.890	33.570	4.320	9.104
HH Head Age	47.508	48.894	-1.387	-12.429	48.279	49.585	-1.306	-8.198
HH Head Age sq.	2475.979	2647.199	-171.220	-14.509	2583.448	2726.695	-143.247	-8.382
HH Head Sex	0.800	0.745	**0.055**	18.118	0.753	0.737	0.016	3.699
HH Head Primary	0.776	0.633	**0.144**	42.990	0.763	0.755	0.008	1.874
HH Head Secondary	0.102	0.045	**0.057**	34.621	0.073	0.046	0.027	10.504
HH Head Above Secondary	0.003	0.002	0.001	4.267	0.000	0.003	-0.003	5.754
Distance - Main Road (Km)	15.400	22.119	**-6.719**	-42.062	16.710	17.329	-0.619	-2.936
Distance - Input Market (Km)	84.326	81.513	2.814	7.254	82.261	86.212	-3.951	-6.215
Tropic-Warm Area	0.442	0.680	**-0.238**	-69.569	0.489	0.580	**-0.091**	-18.228
Avg Total Rainfall (mm)	853.081	778.580	**74.501**	49.565	838.502	842.569	-4.066	-2.142
Drought or Flood (past 5 yrs)	0.090	0.144	**-0.054**	-22.742	0.105	0.102	0.003	0.867
Nutrient Availability	1229.946	912.791	**317.155**	88.281	1154.676	1107.115	47.561	10.285
Elevation (m)	1.710	1.615	**0.095**	28.022	1.662	1.601	0.061	12.842
Ln Maize Planted Area	1.178	1.096	**0.081**	17.707	1.158	1.034	**0.124**	18.241
Ln Maize Planted Area sq.	1.788	1.630	0.158	11.564	1.797	1.495	0.301	14.501
Extension Services	0.343	0.099	**0.244**	95.983	0.105	0.155	-0.050	-16.346
Access to Credit	0.113	0.076	**0.037**	18.972	0.078	0.040	0.038	14.046