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Modelling Adoption and Welfare Impacts of Agricultural Upgrading Strategies (UPS) among Rural Smallholders in Tanzania.

Claudio P. Ngassa[1] Anja Faße[1]

1. TUM Campus Straubing of Biotechnology and Sustainability, Hochschule Weihenstephan-Triesdorf (University of Applied Sciences), Environmental and Development Economics. Am Essigberg 3, 94315 Straubing, Germany. E-Mail: claudio.ngassa@hswt.de

Introduction

Agriculture is a fundamental part of Tanzania's economy. It accounts for 30.1 percent of the country's DGP in 2017 and source of economic livelihood for 66 percent of the population in Tanzania (URT 2017). Smallholder farmers dominate the sector cultivating an average farm size of about 0.9 to 3 hectares (Anderson et al, 2016). Smallholders commonly encounters cyclical and structural challenges including dependence on rain-fed agriculture coupled with lack of irrigation schemes, limited extension services, poor infrastructure and lack of market linkages and lack of financial credits. In this light, majority of rural dwellers live in poverty, facing low crop yields, low income and food insecurity (Kinyondo and Magashi 2017). Insights form literature show that new agricultural technologies have positive welfare impacts in rural areas (Khonje et al 2018). However, adoption of upgrading strategies in Tanzania remains low. In addition, there is little empirical evidence on adoption and impacts of agricultural technologies along the traditional value chain in Tanzania (Kissoly, 2016). Thus, it is vital to inform agricultural policies through empirical research on the adoption and welfare effects of agricultural technologies.

The objectives of this paper is; first, to analyse the household-level drivers of uptake of upgrading strategies (UPS) along the traditional agricultural value chain, secondly, to estimate households' income and households' food security impacts of UPS adoption to the local smallholder farmers in Tanzania using panel data. In addition, we analyse food security effects using six common indicators such as Coping Strategies Index (CSI), Household Hunger Scale (HHS), Household Food Insufficiency Access Scale (HFIAS), Food Consumption Score (FCS), Households Dietary Diversity Score (HDDS) and Months of Adequate Household Food Provisioning (MAHFP) to capture the food security dimensions of access, availability, utilization and stability.

Data and Methods

Our panel data was collected in 2014 and 2016 from four treatment and two control villages selected from sub-humid and semi-arid in Morogoro and Dodoma regions with a sample size of 900 households. Following Khonje et al., 2018, we conceptualize adoption decision based on the random utility theory. Household (i) adopts upgrading strategies if expected utility form adoption (U_A) is higher than expected utility from non-adoption (U_{nA}). Equation 1 is a probit model used estimate the drivers of adoption. (Green, 2012). Evaluating impacts of adoption requires circumventing selection bias (White and Raitzer 2017). Thus, we adapt a panel endogenous switching regression (ESR) model presented in equation 1 to 7. Moreover, it allows construction of counterfactual conditions for adopters and non-adopters (Lokshin and Sajaia 2004).

$P_{it}^{*} = \beta Z_{it} + \mu_{it}$ where $P = \begin{cases} 1 \ if \ \beta Z_{it} + \mu_{it} > 0 \\ 0 \quad otherwise \end{cases}$ 1

Regime1: $Y_{1it} = \alpha_1 X_{1it} + e_{1it} \quad if \ P_{it} = 1$ 2a

Regime2: $Y_{2it} = \alpha_2 X_{2it} + e_{2it} \quad if \ P_{it} = 0$ 3a

P_{it}^{*} is the latent variable and P_{it} is the observed counterpart decision, Z_{it} is the vector of explanatory variables and μ_{it} is an error-term.Y_{1it} and Y_{2it} are outcome variable for adopters and non-adopters respectively. X_{1it} and X_{2it} are vectors of explanatory variables for the two regimes and e_{1it}, e_{2it} are the error terms. Equations 4b and 5b are endogeneity-corrected functions by incorporating the inverse Mill's ratio (M); they enable to predict conditional expectations (equations 4 to 7) for measuring average treatment effects on the treated (ATT) and untreated (ATU) as shown in table 1. (Shiferaw et al 2014).

Regime1: $Y_{1it} = \alpha_1 X_{1it} + \sigma_{1\mu} M_{1it} + \varepsilon_{1it} \quad if \ P_{it} = 1$ 2b

Regime2: $Y_{2it} = \alpha_2 X_{2it} + \sigma_{2\mu} M_{2it} + \varepsilon_{2i} t \quad if \ P_{it} = 0$ 3b

$E(Y_{1it}|P_i = 1, X_{1it}) = \alpha_1 X_{1it} + \sigma_1 \rho_1 f(\gamma Z_{it})/F(\gamma Z_{it})$ 4

Adopters with adoption of UPS (*observed in the sample*)

$E(Y_{1it}|P_i = 0, X_{1it}) = \alpha_1 X_{1it} - \sigma_1 \rho_1 f(\gamma Z_{it})/\{1 - F(\gamma Z_{it})\}$ 5

Adopter had they decided not to adopt UPS *(Counterfactual)*

$E(Y_{2it}|P_i = 1, X_{2it}) = \alpha_1 X_{2it} + \sigma_2 \rho_2 f(\gamma Z_{it})/F(\gamma Z_{it})$ 6

Non-adopters had they decided to adopt UPS (*Counterfactual)*

$E(Y_{2it}|P = 0, X_{2it}) = \alpha_1 X_{2it} - \sigma_2 \rho_2 f(\gamma Z_{it})/\{1 - F(\gamma Z_{it})\}$ 7

Non-adopters without adoption (*observed in the sample*)

Table 1: Average Treatment Effects in the ESR framework (ATT, ATU)

Group	**Decision Stage**		**Treatment Effects**
	Adopts UPS	**Not Adopt UPS**	
Treatment	4. $E(Y_{1it}|P_i = 1, X_{1it})$	6. $E(Y_{2it}|P_i = 1, X_{1it})$	ATT
Control	5. $E(Y_{1it}|P_i = 0, X_{1it})$	7. $E(Y_{2it}|P_i = 0, X_{1it})$	ATU
Heterogeneity effects	BH_1	BH_2	TH

Note: BH_i = the effects of base heterogeneity effects for adopters (i=1), and for non-adopters (i=2) and TH= Transitional heterogeneity (ATT-ATU)

Results and Discussion

Probit estimates in Table 2 show that probability of adopting UPS increases according to the education of households' head, household size, farm size, access to market information and credit, livestock ownership and risk loving attitude as hypothesized and consistent with Ng'ombe et al., 2017 and Khonje et al 2018. Age of the household head, farm distance, distance to the vehicular road, and non-farm employment reveals negative influence on UPS adoption as anticipated, consistent to the results found by Tesfaye et al., 2016. Male-headed households revealed significant negative effects on adoption contrary to our expectations. Gebremariam and Tesfaye 2018 reported similar negative influence of male-headed households towards adoption of agricultural technologies.

Table 2. Panel probit estimates of UPS adoption (486 Adopters and334 Non-adopters)

Explanatory Variables	Adoption decision (1=Yes/0=No)		
	Coefficient	Std error	P>z
Age of household head in years	-0.0024	0.0028	0.384
Gender of household head (1=male)	-0.498	0.110***	0.000
Education of household head in years	0.031	0.014**	0.024
Household size(Nucleus)	0.057	0.020***	0.006
Land holding in ha	0.020	0.018	0.258
Mobile phone (1 if hh owns a mobile and 0 otherwise)	0.064	0.094	0.495
Hhousehold's head Risk attitude (1= averse to10= lover)	0.048	0.016***	0.003
Nonfarm self-employment (no. of hh-members)	-0.096	0.096	0.319
Livestock holding in TLU	0.055	0.018***	0.003
Soil fertility(subjective scale: 1=unfertile to 4=very fertile)	0.092	0.058	0.113
Access to Markets information (1=Yes/0=No)	0.152	0.123	0.216
Access to Credit(1=Yes/0=No)	0.134	0.105	0.203
Distance to farm (walking minutes)	-0.001	0.001	0.235
Distance to road in km	-0.354	0.017***	0.000
Distance to village office in km	0.176	0.029***	0.000
Location (1 if household reside in Kilosa, 0 if household reside in Chamwino)	-2.668	0.173***	0.000
Constant	3.126	0.345***	0.000
Summary statistics			
/lnsig2u	-0.100	0.049**	
Sigma_u	0.951	0.023**	
rho	0.474	0.012**	
Log likelihood = -172.647, Wald chi2(16) = 503.74 Prob> chi2 = 0.000			
LR test of rho: chibar2(01) = 1600.99 Prob>= chibar2 = 0.000			

Note: ** and *** denotes significance level at 5% and 1%; robust standard errors reported

Table 3 presents the welfare impacts of adoption. Beginning with impacts on households' income, we found significant positive average treatment effects on the treated (ATT=235 or 1080 USD, 2010 PPP) for net income or gross income implying that adopters benefited from adoption. Secondly, adoption reduced household's food insecurity captured by negative ATT values of the CSI, HFIAS and HHS indicators and improved household's food security status shown by positive ATT values of FCS, HDDS and MAHFP indicators all being statistically significant.

Table 3. Panel data ESR-based average treatment effects of UPS adoption

Outcome variables	Household sub-sample	Decision stage		
		To adopt	Not to adopt	Treatment effects
Household annual Net Income(USD, 2010, PPP)	Adopters (ATT)	1352	1117	235**
	Non-adopters (ATU)	1397	1105	292**
	Heterogeneity effects	-45.0	11.0	-57.0
Household annual Gross Income (USD, 2010, PPP)	Adopters (ATT)	3388	2307	1080**
	Non-adopters(ATU)	3303	2163	1139***
	Heterogeneity effects	85.0	143.0	-58.0
CSI	Adopters (ATT)	14.36	16.11	-1.74***
	Non-adopters (ATU)	14.36	18.65	-4.29***
HFIAS	Adopters (ATT)	6.067	6.818	-0.75***
	Non-adopters (ATU)	6.080	7.516	-1.43***
HHS	Adopters (ATT)	0.554	0.628	-0.074***
	Non-adopters (ATU)	0.548	0.789	-0.240***
FCS	Adopters (ATT)	46.260	43.671	2.588***
	Non-adopters (ATU)	44.187	42.306	1.880***
HDDS	Adopters (ATT)	7.084	6.727	0.356***
	Non-adopters (ATU)	6.924	6.565	0.358***
MAHFP	Adopters (ATT)	7.213	6.842	0.371***
	Non-adopters (ATU)	7.560	6.791	0.768***

Notes: ** and *** means 5% and 1% significance level. Bootstrapped standard errors using 100 replications

Conclusions

Overall, the findings show that, adoption of UPS has positive welfare impacts. Households with adoption seemed to have higher income relative to their counterparts without UPS adoption. Secondly, we found that adoption resulted into higher food security status among the adopters relative to the non-adopters especially food access, availability and stability. The results sheds lights upon implementation of strategies geared towards improving the local agricultural value chain in rural areas.

References

Anderson, J., Marita, C., and Musiime, D. (2016). National Survey and Segmentations of Smallholder Households in Tanzania: Understanding Their Demand for Financial, Agricultural and Digital Solutions. *CGAP Working Paper*.

Dercon, S and Gallon, D. (2014). Agriculture in African Development: A Review of Theories and Strategies. *Working paper WPS/2014-22*. Centre for the Study of African Economies. Oxford University.

Gebremariam G. and Tesfaye W. (2018). The heterogeneous effect of shocks on agricultural innovations adoption: Microeconometric Evidence from rural Ethiopia. *Food Policy (2018)* 154-161.

Greene W H. (2012). Econometric Analysis. 7th edition. Princeton Hall: New York University.

Khonje M.G., Manda J., Mkandawire P., Tufa A.H., and Alene A.D (2018). Adoption and welfare impacts of multiple agricultural technologies: Evidence from eastern Zambia. *Agricultural Economics 49(2018)*. *599-609*.

Kinyondo, A. and Magashi J., (2017). Enhancing rural livelihoods in Tanzania: A smallholder farmers' perspective. *International Journal of Accounting and Economics Studies.* Doi: 10.14419/ijaes.v5i2.7672. Research paper

Kissoly, L., Faße, A., and Grote, U. (2016). The integration of smallholders in agricultural value chain activities and food security: evidence from rural Tanzania. Food Security. (2017) 9:1219–1235. DOI 10.1007/s12571-016-0642-2

Ng'ombe J.N., Kalinda T.H., and Tembo G. (2017). Does adoption of conservation farming practices result in increased crop revenue? Evidence from Zambia. Agrekon, 56:2, 205-221, DOI: 10.1080/03031853.2017.1312467.

Shiferaw, B., Kassie, M., Jaleta, M., and Yirga, C. (2014). Adoption of improved wheat varieties and impacts on household food security in Ethiopia. *Food Policy* 44(2014) 272-284

URT, (2017). Agricultural Sector Development Programme Phase II (ASDP II). "Agricultural Sector for Industrial Development". ASDP II National Coordination Unit. Kilimo IV. 40487 Dodoma

White H. and Raitzer D.A. (2017). Impact Evaluation of Development Interventions: A Practical Guide. Asian Development Bank. Metro Manila, Philippines: ISBN 978-92-9261-058-6 (print), 978-92-9261-059-3