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Abstract

The main objective of this work was to analyze the factors influencing the adoption of agricultural technologies in Chókwé district. In order to carry out the study, a sample of 150 farmers from the administrative posts of Lionde, Chókwè-sede, Xilembene and Macarretane obtained through a randomized stratified sampling approach was submitted to the survey to obtain primary data. Based on a bivariate probit model, factors that influence the adoption of two agricultural technologies, namely improved seed and mechanization were identified. The results show that factors such as schooling, farm size, purchasing power and market access influence the adoption of improved seed and mechanization. On the other hand, access to extension services reduces the propensity to adopt improved seed.

Keywords: technology adoption; bivariate probit; productivity; Chókwè

1. Introduction

Rising farm productivity and farm incomes are variously considered as important in the fight against prevalent hunger and malnutrition in rural areas of most developing countries. For instance, the Sustainable Development Goals (previously Millennium Development goals) recognize access to sustainable production and marketing systems as the basis for ensuring reduction in environmental degradation and consequently high production and low poverty levels.

Agriculture contributes significant portion of most African countries gross domestic product, informal employment, food and farm incomes for more than a half of rural population (Dorward *et al.,* 2010). Therefore, it is believed that by increasing the production potential per land unit and with access to ready markets, rural populations could experience less hunger and high incomes (Chirwa & Dorward, 2013). However, this requires increased investments in research and development, and use of new farmer friendly technologies in agriculture which in turn increase productivity and ensure food security and better returns. Nevertheless, smallholder farmers face low producer prices and hence incomes, and find it constraining to purchase costly farm inputs and adopt new technologies. This is mainly due to the bureaucracy in procuring formal credit that demands collateral, high interest rates and the risk-averse behavior by agricultural farmers to demand credit considering the risk associated with failure to repay.

In Mozambique agriculture is the backbone of the economy contributing a quarter of domestic gross product and providing livelihoods to more than 80% of the population (IFAD, 2010). According to the Ministry of Agriculture and Food Security, Mozambique has 36 millions of agricultural land and more than 3 million can be irrigated but only 3% is currently under irrigation. Furthermore, agriculture in Mozambique is predominantly subsistence and is characterized by low use of new agricultural technologies and hence low productivity. For example, Guanziroli and Guanziroli (2015) state that the average yields of staple crops in Mozambique is between one fifth and half of the worldwide average productivity.

To address this situation, the government of Mozambique together with its partners have been developing programs and strategies such as the Green Revolution, Plan of Action for Poverty Reduction, Strategic Plan for Agricultural Development , with the aim of improving access to improved seeds, agricultural mechanization, access to credit, low-cost irrigation, inorganic fertilizers, improved access to local and regional markets through increased market linkages, product marketing training, pricing, and marketing. In general, the objective is to enable small and medium-sized farmers to contribute to the transformation of agriculture into a competitive and sustainable sector that increases food security and income for rural households through use of agricultural technologies.

Although the country has experienced some improvement in recent years, it is mainly due to the expansion of growing areas and / or improved climatic conditions in some regions of the country and not necessarily to the improvement of technical conditions of production (Cunguara, 2011). Therefore, it is important to invest in agricultural technologies, especially in developing countries such as Mozambique, where agriculture is the main source of livelihood. A dearth of empirical studies on determinants of agricultural technologies adoption in Mozambique exists, thus, the main objective of this work is to evaluate the factors influencing the use of improved agricultural technologies in the district of Chókwè.

2. Materials and Methods

2.1 Study area and Sampling Design

The study was done in Chókwè district of Gaza Province in south western Mozambique. Chókwè district is located in south western part of Gaza province; it borders Limpopo River to the North, Bilene district to the South, Chibuto district to the East and Magude -Massingir districts to the West side. The district occupies a total area of 2466Km^2. Administratively, the district has 4 divisions (administrative posts): Macarretane, Lionde, Chókwè and Xilembene, these divisions are divided into 8 locations and 36 sub-locations (Ferro, 2005).

According to the latest district statistics, the population of Chókwè is about 215 941 people, with a population density of 80.6 inhabitants per Km^2. 55.8% are women (INE, 2018). Economic activities in Chókwè district include crop production, livestock and commercial businesses. Most agricultural activities are practiced under rain fed systems. The majority of active population in Chókwè practice agriculture and more than 80% of farming population are smallholder farmers with less than 5ha of land. The main crops include maize, beans, rice, potatoes and vegetables. With 80 000 ha of agricultural land, this district hosts the largest irrigated perimeter of the country with an area of 26000 ha. Due to different factors hindering the development of irrigation schemes only 300ha occupied by smallholder farmers can actually be irrigated (Amilai, 2008). The average annual temperature varies from 22°C to 26°C and the average annual rainfall varies from 500 to 800mm.

The sample size was determined using the stratified sampling approach. It is a technique that consists of dividing the population into different subgroups called strata, then randomly choosing the elements proportionally from the different strata to allow them to be incorporated into the sample. Finally the simple random sampling technique was used to select 150 farmers. Primary data were collected from sampled households in the four administrative posts (Chókwè-Sede, Xilembene, Lionde and Macarretane) through questionnaire containing structured and semi-structured questions.

2.2 Model specification

The Bivariate probit model use binary dependent variable, where two equations are estimated. It represents decisions that are interrelated rather than independent. In these models the assumption is that the errors are drawn from a standard bivariate normal distribution with zero means (Li, Poskitt & Zhao, 2016). In this case, the null hypothesis is that there is no significant difference between the characteristics of the farmers and the adoption of any of two agricultural technologies. In order to test the null hypothesis, one can either estimate two separate probit models or a bivariate probit. But, since the correlation coefficient (rho) is statistically significant, two separate probit models would generate biased estimates, that is, the decisions to use mechanization and improved seeds are interrelated, so the bivariate probit model was used.

The equations can be represented as follow:

$$Y_{1_i} = \beta_1 X_1 + \varepsilon_{1_i} \qquad (1)$$

$$Y_{2_i} = \alpha_1 X_2 + \varepsilon_{2_i} \qquad (2)$$

Where, $\begin{matrix} Y_1 \\ Y_2 \end{matrix}$ _ Are the binary variables that represent the probability of farm household i using mechanization and improved seed respectively. Xs are explanatory variables that determine the use of mechanization and improved seed.

The outcomes are specified as:

$$Y_1 = \begin{cases} 1 \text{ if } y > 0 \\ 0 \text{ if } y \leq 0 \end{cases} \quad \text{and} \quad Y_2 = \begin{cases} 1 \text{ if } y > 0 \\ 0 \text{ if } y \leq 0 \end{cases}$$

The wald test $\chi^2(20) = 45.96, p < 0.0008$ suggests that the data fit the model and the correlation coefficient rho (ρ) between the bivariate outcomes is significant and the correlation between the two outcomes is 0.91, meaning that the models are strongly correlated and interrelated.

3. Results and Discussion

3.1 Descriptive Statistics

The table below (Table 1) provides descriptive statistics of the variables used in the model. From Table 1 it can be noted that the adoption of technology (both mechanization and improved seed) in Chókwè district is mainly associated with the farm size and market orientation. It is worth mentioning that there were included in the sample small and large holder farmers. Farmers who do not adopt any of the two technologies cultivate in average less than 2 hectares of land, while the adopters on the other hand cultivate an average of 16 hectares. These results are consistent with those of the CGAP report (2016). According to Mozambique Agricultural Development Strategy – PEDSA (2012) smallholder farmers in Mozambique represent more than 80% of the farming population and, in general practice rain-fed agriculture and use traditional varieties of crops and low-intensity fertilizer. Farming is mainly done without mechanization and productivity of the land is very low and the produce is for personal and family subsistence. On the other hand, farmers with larger plots are market-oriented and their produce is for commercial purposes.

Variable (Continuous)	Mechanization=0 (n=56)		Mechanization=1 (n=94)		Improved seed=0 (n=56)		Improved seed=1 (n=94)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Years of Schooling	3.48	3.45	9.08	3.68	3.27	3.47	9.21	3.46
Age of the household	54.33	9.86	52.95	8.75	54.73	9.73	52.72	8.79
Years of Experience	15.41	5.67	15.79	5.64	15.64	5.58	15.65	5.70
Farm size (hectares)	1.21	.82	16.93	2.40	1.14	.64	16.97	2.39
Distance to the market	2.5	1.19	3.56	1.34	2.51	1.17	3.55	1.36
Variable (Categorical)	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Extension=0	15	26.79	43	45.74	14	25	44	46.81
Extension=1	41	73.21	51	54.26	42	75	50	53.19
Female	24	42.86	17	18.09	25	44.64	16	17.02
Male	32	57.14	77	81.91	31	55.36	78	82.98
Extra income=0	50	89.29	42	44.68	50	89.29	42	44.68
Extra income=1	6	10.71	52	55.32	6	10.71	52	55.32
Market=0	51	91.07	12	12.77	52	92.86	11	11.7
Market=1	5	8.93	82	87.23	4	7.14	83	88.3

Table 1: Description of the variables used in the model

3.2 Results of bivariate probit

Mechanization			Coef.	Std. Err.
	Extrsor	Extra Source of Income (=1 if yes; 0 otherwise)	1.066**	.466
	Gen	Gender of the household head (=1 if male; 0 otherwise)	-.073	.418
	Age	Age of the household head in years	.146	.187
	Agesq	Age squared	-.001	.001
	Schl	Years of schooling	.072	.052
	Exten	Contact with extension service providers (=1 if yes; 0 otherwise)	-.501	.395
	Exp	Years of experience	.018	.038
	Fmsize	Farm size in hectares	.412**	.188
	Dist	Distance in kilometres	.050	.156
	Mrkt	Market orientation (=1 if sells produce; 0 otherwise)	1.195***	.446
	_cons	Intercept	-6.317	5.147
Improved Seed				
	Extrsor	Extra Source of Income (=1 if yes; 0 otherwise)	.832**	.442
	Gen	Gender of the household head (=1 if male; 0 otherwise)	-.028	.460
	Age	Age of the household head in years	.203	.197
	Agesq	Age squared	-.001	.001
	Schl	Years of schooling	.139**	.074
	Exten	Contact with extension service providers (=1 if yes; 0 otherwise)	-1.093**	.437
	Exp	Years of experience	.003	.039
	Fmsize	Farm size in hectares	.669***	.215
	Dist	Distance in kilometers	-.080	.176
	Mrkt	Market orientation (=1 if sells produce; 0 otherwise)	1.093**	.442
	_cons	Intercept	-7.332	5.378

LR test of rho=0: chi2 (1) = 28.4366 Prob> chi2 = 0.0000:**,***=Significant at 5% and 1% level respectively

Table 2: Bivariate probit model results

Results on table 2 above show that five out of ten variables included in the model are statistically significant at 1 and 5% levels. Interestingly, the results suggest that farmers who had contact with extension service providers are less likely to adopt improved seed. These findings contrast to those obtained by Uaiene (2011) and Cavane *et al.* (2013) who believe that farmers receiving extension services are more likely to adopt improved agricultural technologies. However, Zavale, Mabaya and Christy (2005) found the same result, but they point to bureaucratic inefficiency, shortcomings in the design of extension programs and information asymmetry as some of the factors that contribute to the poor performance of extension services. Agricultural technologies used in Mozambique are imported (Benson, Cunguara & Mogues, 2012) and the cost of shipment is mostly supported by farmers, hence making technologies more expensive. One of the reasons behind this finding may be related to the fact that providers of extension services attempt to disseminate new environmental friendly farming practices rather than promote the use of agricultural technologies, most of the time considered expensive and subject of criticism from ecologists.

Farm size had a significant and positive effect on improved seed and mechanization adoption. Farmers with larger land size are more likely to produce more and find it challenging to use manual process and traditional methods. Langyintuo and Mekuria (2008) and Cavane *et al.* (2013) also found that increase in farm size increases the probability of a household in using agricultural technologies because larger scale farmers benefit from economies of scale and are market-oriented.

Farmers with other sources of income are more likely to adopt both mechanization and improved seed. This result is consistent with that found by Come and Neto (2017) and Benson *et al*. (2012). The reason behind this result is that many farmers do not use improved seed and mechanization because of financial constraints, therefore farmers with other sources of income have money to purchase the seed and other inputs needed for production, such as farmers with access to credit as Uaiene (2011) and Langyintuo and Mekuria (2008) advance.

Education level was found to be statistically significant meaning that it influences the adoption of improved seed and mechanization. Many studies reach almost the same conclusion, for example Zavale *et al.* (2005), Uaiene (2011) and Cavane *et al.* (2013). Educated farmers are more likely to adopt improved seed probably because they readily perceive the utility derived from the use of new agricultural technologies.

Finally farmers who sell their produce or have access to ready markets are more likely to adopt agricultural technologies. Farmers who can access markets in order to sell their produce need to increase their productivity and consequently use improved seeds and mechanization. By increasing productivity, they minimize cost and maximize profits.

4. Conclusions and Recommendations

The study aimed to identify factors that influence the adoption of agricultural technologies in the Chókwè district using the bivariate probit model. The results show that factors such as market access, purchasing power, years of schooling and farm size influence the adoption of improved seed and use of mechanization. On the other hand, access to extension services reduces the propensity to adopt improved seeds. Thus, the study recommends policy interventions to educate and training more farmers and extension service providers to mitigate problems of information asymmetry, it also recommends agricultural inputs price control or subsidies and promote market integration for smallholder farmers.

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