FERTILIZER AND HYBRID SEEDS ADOPTION AMONG SMALLHOLDER MAIZE FARMERS IN SOUTHERN MALAWI *

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Abstract: Despite decades of agricultural policies that promoted the adoption of fertilizer and hybrid seeds technologies as a way of improving maize productivity, technology adoption rates in Malawi remain relatively low among smallholder farmers. Using bivariate probit analysis and controlling for technology acquisition through grants, we find that fertilizer adoption is positively associated with the level of education, plot size and non-farm incomes but negatively associated with belonging to female-headed households and distance to the input market. Adoption of hybrid seeds is positively associated with market-based land tenure systems and fertile soils but negatively associated with age of the farmer and distance to input markets.

1. Introduction

The agricultural sector in Malawi remains the most important sector in achieving pro-poor growth in the medium term, and increasing agricultural incomes will be a key source of poverty reduction since more than 90 percent of the population derives livelihoods from agriculture (GoM, 2002). One of the strategies for improving agricultural incomes stipulated in the Malawi Poverty Reduction Strategy Paper (MPRSP) is to expand and strengthen access to agricultural inputs such as fertilizers, manure and improved seeds against a background of low fertilizer and hybrid seeds adoption rates among smallholder farmers (GoM, 2002). In the past decades the government invested substantially in the promotion of modern technologies in the agricultural sector, including subsidization of agricultural inputs. There was considerable public sector investment in a series of integrated rural development projects with a range of services introduced through these projects, including extension services and rural credit facilities.

More particularly, there is evidence that technological developments such as seed variety development, fertilizer adoption and integrated farming systems have been central to these efforts in Malawi (Malawi Government, 1971 and 1987; Smale, 1995; Smale et al., 1995; Lele, 1989). For instance, the marketing and pricing of fertilizers in the smallholder sector has been under the control of government through the Agricultural Development and Marketing Corporation (ADMARC) and the Smallholder Farmer Fertilizer Revolving Fund (SFFRF). The distribution of fertilizers to the smallholder sector was monopolized by ADMARC at subsidized prices in order to encourage the use of fertilizers with the objective of raising agricultural output particularly for maize, the dominant smallholder crop (Sahn and Arulpragasam, 1991). However, within the program of economic reforms implemented by the

Malawi Government the subsidy on fertilizers and agricultural inputs has been removed and agricultural input markets have been liberalized.

Maize is the main staple crop in Malawi, and is mainly grown by smallholder farmers with land holdings of less than 2.0 hectares. Alwang and Siegel (1999) note that about 70 percent of Malawian smallholder farmers cultivate less than 1.0 hectare, with a median area under cultivation is about 0.6 hectares. This category of smallholder farmers devotes about 70 percent of the land to maize. With the growing population land holdings have been declining over time through family subdivisions. It is apparent that the success of the agricultural sector in Malawi hinges on the use of high yielding technologies and farming systems.

Our understanding of the factors that affect the adoption of fertilizer and hybrid seeds technology will likely redress the policy failures associated with technology promotion in Malawi. Although, there have been studies in Malawi on factors affecting technology adoption (Green and Ng'ong'ola, 1993; Zeller et al., 1998), the focus has been on fertilizer technology adoption and has ignored the joint decision of adopting both fertilizer and hybrid seeds technologies. Hence, previous studies assume that there is no interdependence between the decisions to adopt fertilizer or hybrid seeds technologies. This study contributes to the agricultural technology adoption literature in Malawi by exploring factors that are important for the adoption of fertilizer and hybrid seeds technologies among smallholder farmers.

The rest of the paper is organized as follows. Section 2 reviews the existing theoretical and empirical literature on factors influencing agricultural technology adoption. Section 3 outlines the methodology and data used in the study. Section 4 reports and discusses empirical results from the bivariate probit regression. Section 5 provides concluding remarks.

2. Literature Review

Literature suggests several theoretical or conceptual models on farmers' decisions to adopt new technology (Feder and Slade, 1984; Abadi Ghadim and Pannell, 1999; Isham, 2002; Negatu and Parikh, 1999). Feder and Slade (1984) develop a model of technology diffusion based on human capital and land constraints. Their model postulates that farmers with more education and larger land will hold more knowledge of improved farming systems and are likely to adopt technology more rapidly. Isham (2002) extends the model of Feder and Slade (1984) by incorporating social capital as a fixed input into the decision to adopt technologies. This extended model predicts that farmers with neighbours that adopt the technology and those with higher levels of social capital accumulate more information and adopt technology more rabidly. Abadi Ghadim and Pannell (1999) place emphasis on the role of learning by doing and the impact of the learning on personal perceptions of the innovation.

Negatu and Parikh (1999) review three groups of models on adoption of agricultural technologies by smallholder farmers. First, the innovation-diffusion or transfer of technology model in which technology is transferred from its source to the smallholder farmer through an intermediary such as extensions systems, and the diffusion of the technology depends on the characteristics of the farmer. Secondly, the economic constraint model takes the view that farmers have different factor endowments and the distribution of endowments determines the adoption of technology. Thirdly, the technology characteristics – user's context model assumes that technology characteristics and the underlying farmer's agro-ecological, socio-economic and institutional circumstances play a central role in the adoption of technology.

The technology adoption models have been empirically tested using data from developing countries, particularly investigating the factors that affect the adoption of fertilizer and improved seed varieties (Green and Ng'ong'ola, 1993; Smale et al., 1995; Croppenstedt and Demeke, 1996; Zeller et al., 1998; Negatu and Parikh, 1999; Kosarek et al, 2001; Doss and Morris, 2001; Weir and Knight, 2000; Isham, 2002).[1] The factors influencing technology adoption decisions include farm size, risk exposure and capacity to bear risks, human capital, labour availability, land tenure, access to financial and produce markets, access to information, participation in off-farm activities, social capital, household characteristics and ecological and environmental factors. GoM (2002) attributes the low rate of technology adoption in the smallholder agricultural sector to the problem of incomplete financial markets, an argument empirically supported in a study by Green and Ng'ong'ola (1993) and Zeller et al. (1998). Green and Ng'ong'ola (1993) find that tobacco farming, improved variety, access to credit, participation in off-farm activities and regular employment are the main factors influencing fertilizer adoption in Malawi. Zeller et al. (1998) find that adoption of hybrid maize and tobacco were affected by factor endowments, exposure to agro-ecological risks, and access to financial and commodity markets.

[1] See Feder et al. (1985) for a review of earlier studies.

3. Methodology and Data

In Malawi, two types of technologies have been promoted by the government since independence in 1964, particularly for maize farmers. First, government has been investing in maize seed research and has since released several high yielding varieties. Smale (1995) notes that most of the maize hybrid varieties that were developed in the national research program were dent varieties based on the belief that dents had higher yield potential than flint varieties.[2] Secondly, the government has been promoting the use of inorganic fertilizers in improving the fertility of soils as a way of increasing maize productivity. The prices of fertilizers were heavily subsidized, and the marketing and distribution of fertilizers were controlled by the Ministry of Agriculture and ADMARC (Sahn and Arulpragasam, 1991; Zeller et al., 1998).

The adoption of hybrid seeds and inorganic fertilizer technologies were being promoted concurrently. The smallholder farmer in Malawi has to decide whether to adopt hybrid seeds or inorganic fertilizers or both technologies. Although yields per hectare for unfertilised hybrid maize were higher than yields of local maize in normal and drought situations, hybrid maize were more responsive to fertilizers (Smale, 1995). However, the adoption rates between hybrid seeds and chemical fertilizer technologies are bound to be different among smallholder farmers in Malawi. Doss and Morris (2001) note that hybrid seeds are relatively simple technologies considering that they require relatively few changes to farmers' practices while chemical fertilizer technologies are complex – requiring farmers to know different varieties and optimal application rates.

Although alternative econometric techniques have been used in the empirical literature to analyse the factors associated with the decision by smallholder farmers to adopt technologies, modelling such decisions as a latent variable using either probit or logit regression analyses has been most common. Others have used the decision to use technology as a selection variable and then estimate the demand for fertilizer (Croppenstedt and Demeke, 1996). In most of the studies on adoption of technology, only a single technology decision is considered and ignores the possibilities of joint or sequential decisions over complementary technologies. Doss and Morris (2001) recognize the possibility of the link that exists between the decisions to adopt chemical fertilizer and improved maize varieties and use a two-stage

[2] Flinty maize types have higher proportion of hard starch granules in the kernel than dents and they have the higher flour-to-grain extraction rate because the germ separates more easily from the bran when pounded in a mortar. Flinty varieties also tip cover and harder grains that protect them from the weevils (Smale, 1995).

approach in which predicted fertilizer adoption and predicted maize variety adoption are included as explanatory variables in the maize variety and fertilizer adoption models, respectively. Following the linkage recognized by Doss and Morris (2001), we estimate the models using bivariate probit or seemingly unrelated bivariate probit regressions represented in the following system:

$$fertilizer_{ki} = \alpha_0 + \alpha_i X_i + \alpha_j Y_j + \varepsilon_1 \quad (1)$$

$$hybrid_{ki} = \beta_0 + \beta_i X_i + \beta_j Y_j + \varepsilon_2 \quad (2)$$

where *fertilizer* and *hybrid* are dummy variables representing whether farmer *k* adopted fertilizer and hybrid seeds on plot *i*, respectively; X_i is a vector of plot-level and smallholder farmer characteristics; Y_j is a vector of household, institutional and infrastructure characteristics; ε_1 and ε_2 are error terms whose covariance is non-zero.

Several characteristics of the farmer and plot are included as explanatory variables in the models. The farmer characteristics include gender, age and education of the smallholder farmer cultivating the plot. The gender differences in technology adoption are captured by a dummy variable, *female,* that takes a value of 1 if the farmer is female. *Age* and *education* are expressed as years of age and numbers of years of formal schooling completed by the smallholder farmer, respectively. We also include plot-level characteristics including plot size, land tenure, perceived soil fertility, perceived steepness of the land and use of hired labour in crop production on the plot. The plot size variable, *plotsize*, measured in hectares captures the effects of land constraints on technology adoption. We expect technology adoption to be positively associated with land size. Doss and Morris (2001) note that although fertilizer and maize variety technologies are scale-neutral, those with more land are able to afford fertilizers because they produce a marketable surplus. Some of the farmers control more than one plot of maize and a dummy variable, *mplots*, which takes a value of 1 if the plot belongs to the farmer that has multiple plots. This variable also captures the effect of land fragmentation on technology adoption. The land tenure systems in Malawi are non-market oriented based in the traditional marriage systems (Place and Otsuka, 2001). A dummy variable, *landmkt*, takes the value of 1 if the land tenure on the plot is market-based such as lease and freehold and captures the incentive effects in investing in high productivity technologies. The use of hired labour on the plot, *hiredlabor*, captures the effect of augmenting family labour supply to successfully implement adopted technologies. Dummy variables that control for ecological differences are included in the model captured by perceptions about soil fertility (good soil fertility - *soilgod* and average soil fertility - *soilavg*) and perceptions about the terrain, *terrain*, which is equal to 1 if the terrain of the plot was perceived by the farmer as being more generally flat.

Two household characteristics, the headship of a household to which the smallholder farmer belongs and non-farm incomes, are included in the model. The poverty profile in Malawi reveals that female-headed household tend to be poorer and more resource-constrained (GoM, 2002), which may affect the adoption of technology, especially fertilizer technologies that are more expensive than maize variety technologies.[3] The gender of the household headship is captured by a dummy variable, *hhfemale*, which takes a value of 1 for female-headed households. It is also important to control for the role of non-farm incomes in technology adoption decisions. Non-farm incomes enable farmers to raise incomes which may be used to purchase new technologies. Green and Ng'ong'ola (1993) in an earlier study on fertilizer adoption in Malawi find the probability to adopt as an increasing function of non-farm incomes and regular labour. The variations in adoption of technologies due to differences in household non-farm incomes is captured by the variable, *nonfarm*, measured in thousands of Malawi Kwacha.

We also include three institutional variables and one infrastructure variable in the model to account for differential access to basic social services and agricultural extension services. The variable, *club*, takes the value of 1 if the any member of the household belongs to a farmer's club or association. The club or association represents some form of social capital and can serve as a forum for disseminating important agricultural messages. Prior to the collapse of the smallholder agricultural credit scheme in 1992, the farmers' clubs were also used as a vehicle for farmers' access to agricultural credit for inputs. These clubs are less common in the agricultural sector today, but it is important to investigate the importance of associations in technology decisions. Isham (2002) argues that farmers in villages with higher levels of social capital are likely to have higher levels of cumulative information and adopt new technology more rapidly. Access to agricultural extension services may also be important in influencing the decision to adopt technology. We include the number of extension visits, *extension*, the farmer had in the agricultural season to capture the effect of

[3] Similarly, Croppenatedt and Demeke (1996) in the case of Ethiopia argue that female-headed households are less likely to use and apply fertilizer because they tend to be poorer and more subsistence and labour-constrained.

expert advice. Since the 1990s, the Malawi Government and non-governmental organizations have been implementing various safety net programs in the agricultural sector through the distribution of free inputs (fertilizer and hybrid seeds) to food insecure households (Sibale et al., 2001; Dzimadzi et al., 2001). In a model of technology adoption, it is important to control for use of technology acquired through gifts or grants. We therefore include a dummy variable, *grants*, taking the value of 1 for farmers that received agricultural grants and used such grants on the plot. The distance to input markets, *distance*, is captured by the distance from the plot to ADMARC markets. Although ADMARC has recently been experiencing financial difficulties that led to problems in supplying inputs to smallholder farmers it remains the most accessible source of inputs (Mvula et al., 2003).

The data used in this study were collected through a questionnaire administered to 156 households in Machinga district in southern Malawi. We randomly selected two Traditional Authorities in the selected district and two enumeration areas in each Traditional Authority.[4] In each selected enumeration area, at least 37 households were randomly selected based on a simple household listing. In each of the selected households, we interviewed the household head or a person with information about the farming activities of other household members, and individual members where necessary. The 156 households interviewed had a total of 444 plots used for the production of various crops. Of the 444 plots, 202 plots from 139 farmers generated usable data to estimate the technology adoption model.

4. Empirical Results

Table 1 presents the definition of variables used in the econometric model and their descriptive statistics.[5] Despite a long history of promotion of fertilizer and hybrid seed technologies in Malawi, only 54.5 percent and 40.6 percent of the plots used the technologies, respectively. The gender distribution of control of plots (persons making most farming decisions) shows that women control 42.8 percent of the plots in the sample. The level of education among maize farmers is low as revealed by the mean years of schooling of 3 years. Most of the plots on which maize is grown are small, with a mean plot size of 0.57 hectares.

[4] An enumeration area is the smallest stratification that is used by the National Statistical Office in national surveys and has an average of 250 households.

[5] The descriptive statistics are presented at plot-level, which implicitly assumes that farmers treat each plot equally. However, plot level analysis in the econometric modelling accounts for the likelihood that farmers with multiple plots may treat them differently, aspects that are masked when the analysis is done at farmer or household levels like in most studies.

This implies that most of the farmers interviewed were net food buyers. Thus, the maize on these plots is grown purely for subsistence, with maize from only 5 of the 202 plots reported as having been sold in the 2001/2002 season. With the famine in the previous season, 2000/2001, many households ate most of the maize while green to meet food deficits in the pre-harvest season. About 45.1 percent of the plots are controlled by farmers with multiple plots.

The average distance from the plot to ADMARC markets is 6.8 kilometres. Only 5.5 percent of the plots have a market-based land tenure system. Most labour used in the cultivation of maize is from family members while hired labour was only used in nearly 20 percent of the plots. Only 10.9 percent of farmers come from households in which at least one member has membership in a club or association. The average number of extension visits to any household member per year is 1.5, with substantial variations in the sample. In recent years, government agencies and non-governmental organisations have been implementing safety nets for resource poor farmers through the provision of agricultural input grants (hybrid seeds and fertilizers). Our sample shows that 22.3 percent of the plots utilized agricultural input grants.

Table 1
Definition of Variables and Descriptive Statistics

Variable	Description	Mean	SD
fertilizer	Dummy: 1 if the farmer used fertilizer on the plot	0.5446	0.4992
hybrid	Dummy: 1 if the main type of maize on the plot is hybrid	0.4059	0.4923
female	Dummy: 1 if the farmer in control of the plot is female	42.802	15.201
age	Age of the farmer in number of years	0.4356	0.4971
education	Number of years of schooling for the farmer	3.4406	3.4883
plotsize	Size of the plot under maize cultivation (hectares)	0.5641	0.5041
mplots	Dummy: 1 if the farmer controls more than one maize plot	0.4505	0.4988
landmkt	Dummy: 1 if the land tenure system is market based (lease/freehold /rented)	0.0545	0.2275
hhfemale	Dummy: 1 if the farmer belongs to a female-headed household	0.2723	0.4462
nonfarm	Household non-farm income in Thousands of Kwacha per year	7.2709	8.8289
soilgod	Dummy: 1 if the fertility of the soil is good	0.2178	0.4138
soilavg	Dummy: 1 if the fertility of the soil is average	0.3614	0.4816
terrain	Dummy: 1 if the terrain of the plot is flat	6.7525	4.5712
distance	Distance of the plot from ADMARC market (kilometres)	0.6535	0.4770
hiredlabor	Dummy: 1 if hired labour was used in crop production	0.1980	0.3995
club	Dummy: 1 if any of the members of the household belongs to a club	0.1089	0.3123
extension	Number of extension visit the farmer in the household had in the agricultural season	1.4951	2.3862
grants	Dummy: 1 if the farmer received agricultural input grants and used them on the plot	0.2228	0.4171

Table 2 reports results of the standard bivariate probit estimation and marginal effects for the seemingly joint decision of fertilizer and hybrid seeds technologies adoption by smallholder farmers. The Wald (χ^2) test for overall performance of the model shows that we cannot accept the null hypothesis that all the coefficients are equal to zero. Similarly, the null hypothesis of zero covariance between the error terms in the fertilizer and hybrid seeds adoption equations is rejected by the Wald (χ^2) test at the 1 percent significance level.

Table 2
Bivariate Probit Model of Adoption of Technologies

	Fertilizer Adoption		*Hybrid Seeds Adoption*		*Marginal*
Variables	coefficient	t-ratio	coefficient	t-ratio	*Effects*
age	0.0028	0.42	**-0.0143**[b]	-2.00	-0.0031
female	-0.1461	-0.58	0.0963	0.37	0.0034
education	**0.0930**[a]	2.70	0.0432	1.30	0.0231
plotsize	**1.0489**[a]	3.49	-0.1853	-0.79	0.0958
mplots	**-0.3565**[c]	-1.75	-0.1846	-0.93	-0.0926
landmkt	0.0311	0.07	**1.1609**[a]	2.70	0.2334
hhfemale	**-0.7341**[a]	-2.57	-0.2330	-0.85	-0.1525
nonfarm	**0.0186**[c]	1.65	0.0064	0.54	0.0041
soilgod	-0.3114	-1.16	**0.5793**[b]	2.22	0.0727
soilavg	-0.3065	-1.32	**0.4581**[b]	2.03	0.0604
terrain	0.1594	0.73	0.2854	1.41	0.0894
distance	**-0.0574**[b]	-2.21	**-0.0530**[b]	-2.21	-0.0207
hirelabor	**0.4486**[c]	1.73	-0.1130	-0.44	0.0213
extension	0.0071	0.15	0.0667	1.40	0.0173
club	-0.0769	-0.30	**-0.6065**[c]	-1.86	-0.1493
grants	**1.3723**[a]	4.89	**0.6987**[a]	2.84	0.3550
constant	-0.5101	-1.05	0.0070	0.01	-
Model Statistics					
Log Likelihood	-208.26				
N	202				
ρ	0.521				
Wald $\chi^2_{(16)}$	111.22	[0.00]			
Wald Test: $\rho = 0$	13.169	[0.00]			

The standard errors of the model are heteroscedastic-consistent. Figures in square brackets are the probabilities. The superscripts *a*, *b* and *c* represents statistically significant at the 1 percent, 5 percent and 10 percent levels, respectively.

Of the farmer and plot level characteristics included in the model, age of the farmer, education of the farmer, size of the plot, land tenure and soil fertility are statistically significant at the conventional levels. The gender of the farmer, terrain of the plot and hired labour are not significant determinants of technology adoption both with respect to inorganic fertilizers and improved maize varieties. The age of the farmer is statistically significant at the 10 percent level only in the adoption of hybrid seeds. The negative relationship shows that older farmers are less likely to adopt hybrid seeds. Local maize, which has a flint grain texture, has always been favoured by smallholder subsistence farmers due to the high proportion of hard starch granules, the ease in storage management and high flour to grain extraction to make the favoured refined flour for cooking '*nsima*' – the traditional food (Smale, 1995). Older people, who are used to the traditional flour, are more resistant to change to hybrid seeds which have either dent or semi-flinty grain textures.

Although the coefficient of *education* has expected signs in both technology adoption functions, the level of schooling is only statistically significant at the 1 percent level in farmer's decision to adopt inorganic fertilizers. The results with respect to inorganic fertilizer adoption support the hypothesis that farmers that are more endowed in human capital are receptive to new ideas and are therefore more likely to adopt productivity-enhancing technologies, but contrary to earlier studies in Malawi agriculture.[6]

The size of the plot is only a significant factor in influencing the decision to adopt fertilizer technology and the coefficient is statistically significant at the 1 percent level. Thus, it may not be economically efficient for smallholder farmers with small plot holdings to apply fertilizers due partly to the packaging of fertilizers. Control of multiple maize plots by the farmer is negatively related to adoption of technology, but the coefficient is statistically significant at the 10 percent level only in the fertilizer adoption model. This implies that land fragmentation reduces the probability of fertilizer adoption. The market-based land tenure system is positively associated with technology adoption decisions, but the coefficient of *landmkt* is only statistically significant at the 1 percent level with respect to the adoption of hybrid maize seeds. Although Place and Otsuka (2001) find that some traditional land tenure systems provide security, are therefore not a binding constraint to in land improving investments in Malawi, the evidence in this study is that farmers are more likely to use hybrid seeds on rented or leased or freehold land. This behaviour may be motivated by the relative profitability of hybrid maize over local maize and the fact that maize on market-based land tenure systems is cultivated to generate commercial returns rather than meet household subsistence needs. The results also suggest that perceived fertility of soils is important in the farmers' decision to adopt hybrid maize seeds and the probability of adoption increases with the quality of soils, lower for average soils (*soilavg*) and higher for good soils (*soilgod*). However, soil fertility is not a significant factor in the adoption of inorganic fertilizer

[6] Similar evidence of a positive role of education is reported from studies in Ethiopia (Weir and Knight, 2000; Croppenstedt and Demeke, 1996) and Ghana (Doss and Morris, 2001). However, others such as Isham (2002) for rural Tanzania, Green and Ng'ong'ola (1993) and Zeller et al. (1998) in Malawi do not find significance evidence on the role of education in technology adoption.

technology.

The two household characteristics in the model are significant determinants of adoption of technology only in the inorganic fertilizer decision. We find evidence that farmers that belong to female-headed households are unlikely to adopt farming technologies, however, the coefficient of *hhfemale* is only statistically significant at the 1 percent level with respect to the adoption of fertilizer technology. Green and Ng'ong'ola (1993) observe that fertilizer adoption among female-headed households may be low due to their limited contact with extension services. However, as we note below contact with extension services is not important and this may suggest that the household resource envelope and distribution may be central to understanding adoption rates among farmers from female-headed households. Although the coefficient of non-farm income, *nonfarm*, has the expected signs in both adoption decision functions, it is only statistically significant at the 10 percent level with respect to fertilizer technology adoption. Since the fertilizer technology is more expensive than hybrid seeds technology, income augmentation from non-farm sources increases affordability for such technologies.

Among the institutional and infrastructure variables in the model, distance, club membership and grants are important factors in explaining the probability of technology adoption. Contacts with extension services (*extension*) and membership of clubs or association (social capital) have inconsistent signs, with the former being statistically insignificant in both cases. The insignificance of extension visits reflects the inefficiency of the agricultural extension system in recent times. According to GoM (2002), the agricultural extension system has in recent years come under pressure from financial and human resource constraints. Club membership, *club*, is negatively associated with hybrid maize seeds adoption and the coefficient is statistically significant at the 10 percent level. The distance to ADMARC markets from the plot, *distance*, are negatively associated with farmers' decisions to adopt fertilizer or hybrid maize technologies. In addition, most of those farmers that received grants used the technologies in the 'grant packs' – fertilizers and fertilizers.

The last column of Table 2 reports the marginal effects of joint probability of adopting inorganic fertilizer and hybrid maize seeds technologies, indicating the change in the probability resulting from a unit change in continuous explanatory variables and change from zero to one for dichotomous explanatory variables. The predicted probability (computed at the means) that a smallholder maize farmer will jointly adopt fertilizer and hybrid seeds technology is 30 percent. The probability of adopting both inorganic fertilizer and hybrid maize seeds technologies falls by 16.1 percentage points for female-headed households, a unit increase in years of education increases the probability of adopting both technologies by 2.5 percentage points while a unit increase in the distance to ADMARC markets reduces the probability of adoption by 2.1 percentage points.

5. Conclusions and Policy Implications

After years of government investment in the agricultural sector, particularly investments in research on modern maize seed varieties and promotion of the use of fertilizers among smallholder farmers as productivity-enhancing technologies, the adoption rate remains low and Malawi has not yet achieved self-sufficiency in food production. This study sought to understand the factors that determine the adoption of agricultural technologies by smallholder farmers cultivating maize, the main staple crop in Malawi. Using the bivariate probit model, after controlling for technologies provided as grants, we find the probability of adopting both inorganic fertilizer and hybrid maize seeds technologies to be 30 percent. The probability of fertilizer adoption increased with the level of education, size of the cultivated plot, and level of non-farm incomes, but is a decreasing function of female headship of the households and distance of the plot from ADMARC markets. The probability of hybrid maize seeds adoption is an increasing function of market-based land tenure systems and soil fertility, but a decreasing function of age of the farmer, distance of the plot from ADMARC markets and membership of a club or association.

We can derive several policy implications from the results of this study. First, similar to other studies of technology adoption among smallholder farmers in developing countries, education plays a central role in the adoption of more complex technologies such as use of fertilizers compared to relatively simple technologies such as maize seeds in which historical inertia and not education is critical in the adoption decision. Thus, improving the level of education of smallholder farmers in the medium and long-term is likely to lead to productivity gains in food production in Malawi. Secondly, addressing the land holding size among smallholder farmers has the potential to increase fertilizer adoption rates and hence increase productivity in maize production. The implementation of the land reallocation program as articulated in the Malawi Poverty Reduction Strategy Paper (GoM, 2002) is likely to lead to increased productivity through application of fertilizers.

Thirdly, the significance of female-headed households and non-farm incomes reflects the importance of household resource endowments. Improving fertilizer adoption among smallholder maize farmers will require addressing the resource constraints of female-headed households and promotion of livelihoods diversification. Fourthly, the negative relationship between adoption of technology and distance to ADMARC markets casts doubts on the wisdom of closing some of the markets insofar as access to inputs are concerned. Due to the operational inefficiency of ADMARC, government is under pressure from the World Bank, International Monetary Fund and the donor community to privatise ADMARC – a policy that would consequently lead to closure of non-commercial markets. As Mvula et al. (2003) note, the private sector has not responded favourably to the liberalization of agricultural input markets – only a few large scale enterprises sell agricultural inputs and these are usually located in urban or peri-urban centres far away from many smallholder farmers.

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