IMPACT OF IMPROVED VARIETY ADOPTION ON FARM INCOME IN TOLON DISTRICT OF GHANA

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Abstract: This paper estimates the effect of improved maize variety adoption on farm income in the Tolon District of Ghana. The study covered the 2017/2018 farming season and involved 160 randomly selected maize farmers from four communities in the district. A regression with endogenous treatment effect model, which accounts for selection bias arising from both observable and unobservable factors was used to estimate the effect of improved maize variety adoption on farm income. The results indicate that men have lower probability of adoption while adoption increased with extension contact, access to fertilizer subsidy and cattle ownership but decreased with the cost of adoption. The results further indicate that adoption is significantly and positively related to farm income. Adoption of improved maize varieties increased gross farm income of maize farmers by GH¢852. Farm income also increased with farm size and cattle ownership but was lower for female farmers. Institutional factors such as provision of agricultural extension advisory services and subsidized fertilizer are essential to promote adoption of improved varieties; hence these services should be made readily available to farmers. Addressing the problem of inadequate extension staff and logistical challenges confronting extension workers are some of the pragmatic steps required to promote adoption of improved varieties in order to improve farm incomes. Furthermore, subsidized fertilizer should be made available to farmers on time and in the right quantities to enhance adoption and farm incomes, while farmers should be encouraged to rear livestock as this enhances both adoption and farm income.

Keywords: *Adoption, improved maize varieties, farm income, regression with endogenous treatment effect model, Ghana*

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INTRODUCTION

Agriculture is an important economic sector of most African countries, contributing immensely to the continent's socio-economic development. Despite the agricultural potential of the continent, economic transformation is very slow in many African countries including Ghana. The slow growth of Africa's economy is blamed partly on an underperforming agricultural sector. Several factors including low adoption of improved agricultural technologies, reliance on primitive production methods, declining soil fertility, lack of capital and inadequate credit, and land tenure problems

contribute to the poor state of agriculture in Africa, including Ghana.

Agriculture in Africa and particularly in Ghana requires a paradigm shift in order to make significant progress in productivity and the sector's contribution to economic development. This calls for a shift from diversified, subsistence and outmoded farming practices towards a more specialized, commercialized and modernized farming practices. There is the need for increased participation of farmers in the input and output markets and increased integration of agriculture with other sectors of the domestic and international economies. There is also the need to incorporate

indigenous knowledge and modern scientific knowledge into African agriculture in a bid to stimulate growth and transformation.

Traditionally, Ghana's economy has over the past decades relied heavily on the agricultural sector. However, the contribution of the agricultural sector to gross domestic product (GDP) in recent years has consistently declined, partly as a result of the discovery of oil, faster growth of other economic sectors especially the services, manufacturing and industrial sectors, as well as declining profitability of farming. The agricultural sector contributed 22.6% to Ghana's GDP in 2016 (Bank of Ghana, 2017) while about 60% of the population rely on the sector for their livelihood (Government of Ghana, 2017).

Maize is among the main cereal crops cultivated, marketed and consumed in Ghana. It is an important crop for food and raw material for oil and starch extraction globally. Despite the importance of maize to the citizens of Ghana, its production is below expected yield levels. Yields of staple crops such as maize and rice, are generally about half the economically attainable yields (MOFA, 2011). The demand for maize exceeds its supply by most households creating a demand-supply gap resulting from low productivity. The low productivity of maize is ascribable to low adoption of new technologies including improved maize varieties and good management practices. The adoption choices at the household level are based on the socioeconomic conditions of the farmer and the properties of the technology. Similarly, farmers decisions toward technology adoption can be influenced by the factors related to their aims and limitations including access to formal education, farm size, labor availability, access to extension services and credit, membership in farmer group and age of household head (CIMMTY, 1993).

Available studies on adoption of improved maize varieties in Ghana include Alhassan et al. (2016) who examined farmers' adoption of improved maize varieties in Wa Municipality, Upper West Region of Ghana, using discriminant analysis. Salifu and Salifu (2015) also investigated the factors influencing farmers' decisions towards adoption of improved maize varieties in the Wa Municipality. Both studies however did not assess the effect of adoption on farmers' income.

Mendola (2007) argued that adoption of improved agricultural technology by peasant

farmers might improve their welfare and food security. Similarly, empirical studies indicate that agricultural technology adoption can lead to poverty reduction both directly and indirectly (Moyo et al., 2007; Becerril and Abdulahi, 2010). The direct benefit is that adopters earn high farm income while the indirect benefit may come in the form of reduction in food prices as a result of increased supply of food. In addition, an impact study in rural China by Wu et al. (2010) showed that adoption of agricultural technologies had a positive influence on farmers' income.

Farm income refers to both monetary and non-monetary income accrued through the operation of a farm. Mathematically, farm income is calculated by subtracting both paid and non-paid factor costs from total revenue. According to Ibrahim et al. (2012), adoption of agricultural technology leads to high yields and increase in farmers' income. Khonje et al. (2015) also observed a significant increase in farm incomes, consumption expenditure and food security at the household level as a result of improved maize variety adoption in Zambia. Hence, adoption of improved agricultural technology is a tool for increasing agricultural production as well as increasing farm income, reducing poverty, improving standard of living and increasing food security.

Some authors have argued that improving the welfare of rural farm households in developing countries through agricultural productivity would remain a mere wish if agricultural technology adoption rate remained low (Gemedla et al., 2001; Ajayi et al., 2003). Hence, adoption of improved agricultural technology is a precondition for improving living standards of the rural poor.

Maize is an important cereal produced by most farm families in Ghana because of its importance as a staple and cash crop. According to Tweneboah (2000), a household is described as food insecure if it is low-income and has no maize stock irrespective of other crops produced by the household. In Ghana, mean yield for maize is estimated at 1.99 metric tons/hectare with a potential achievable yield of 5.5 tons/hectare (MOFA, 2017). This shows that Ghana is producing below the actual attainable yield. One way to minimize the yield gap and enhance farm incomes is to increase agricultural productivity through the adoption of improved maize varieties and good management practices.

The paucity of research on the effect of improved maize variety adoption on farm income in Ghana provided the motivation for this study. This study thus aimed at evaluating the effect of adoption of improved maize varieties on farm income of adopters, using the Tolon district in northern Ghana as a case study. Specifically, the study seeks to (1) investigate the determinants of adoption of improved maize varieties; (2) assess the factors influencing farm income; and (3) assess the effect of adoption of improved maize varieties on farm income.

LITERATURE REVIEW

Factors affecting farmers' decision to adopt improved maize varieties

Karki and Bauer (2004) defined adoption as a mental process through which an individual adopts an innovation based on awareness, interest, evaluation, trial, and decision to adopt. Feder et al. (1985) have also defined adoption as the incorporation of new ideas into farmers' common farming practices for a long period of time. According to CIMMYT (1993), the adoption choices at the household level are based on the factors facing farmers' socioeconomic situations and the conditions of the technology.

Several variables influence farmers' adoption decisions. As a result, various studies have been conducted to gain understanding of the factors influencing farmers' decision to adopt agricultural technologies. For instance, the adoption choices at the household level are based on farmers' socioeconomic conditions and the content of the technology. In addition, farmers' adoption decision towards agricultural innovation can be influenced by factors such as farmers' age, access to formal education, farm size and asset ownership, size of family labor, institutional support system such as access to extension services, access to credit, and belonging to farmer associations or organizations (CIMMYT, 1993). Again, Enki et al. (2001) revealed that farmers' decision towards adoption of agricultural technology in Ethiopia was based on land ownership, total land for agricultural production, attributes of the technology, level of education, wealth, off-farm income and assistance from different sources.

Katengeza et al. (2012) identified labor, access to credit and extension, livestock, farm size and off-

farm employment as significant factors influencing the adoption of improved maize varieties in Malawi. Livestock wealth and fertilizer use were found to be negatively related to intensity of adoption. Conversely, age, labor and off-farm activities were positively related to intensity of adoption whereas livestock ownership was negatively related to intensity of adoption.

A study in Zambia by Kalinda et al. (2014) indicated that adoption decision is determined by expectations about yield and output price. The authors found adoption to be directly correlated with farm size, gender of the household head and membership in a farmer group. Household wealth and education also showed significant influence on adoption of improved maize varieties. Moreover, Ebojei et al. (2012) revealed that age, education, access to extension services and income are significant factors determining technology adoption in Nigeria. However, family size and farming experience did not influence adoption of hybrid maize. In addition, Beshir and Wegary (2014) reported that farmer's age significantly influenced adoption of improved maize seeds in the Central Rift Valley of Ethiopia.

Again, Tura et al. (2010) revealed that farmers' decisions to adopt improved maize varieties is strongly influenced by human capital, experience in hiring labor, size of land owned, while the farm size for maize production, literacy of the household head, access to extension services and farmers' experience influence the continuous use of improved seed.

Results of a logistic regression analysis by Salifu and Salifu (2015) showed that adoption of improved maize varieties was significantly influenced by marital status, age, farming experience, education of household head and varietal characteristics while access to extension services, farm labor, and membership in farmer-based organizations were insignificant in their effect on adoption of IMVs. Furthermore, in a study using a logit model, Alemaw (2014) demonstrated that adoption of improved maize varieties among households in Ethiopia was positively influenced by adult literacy, family size, livestock wealth, access to output market and credit. On the other hand, membership in farmer group, distance to main markets and fertilizer credit had negative influence on adoption.

Furthermore, Audu and Aye (2014) in a study on maize technology effect on welfare, showed that age, household size, off-farm income, and education are significant determinants of adoption. Finally, de Jaleta et al. (2015) showed that the major determinants of households' decision to adopt improved maize varieties include education, farm size, social network, and better agro-ecological potential for maize production.

Empirical studies on the impact of improved maize varieties

Kassie et al. (2012) used propensity score matching (PSM) to analyze the impact of the intensity of improved maize variety adoption on food security and poverty in rural Tanzania. The results indicated that maize technology adoption had a significant and positive relation with food security and that the impact varied by the level of adoption. On average, a unit increase in farm size for the cultivation of improved maize varieties had the probability of reducing chronic and transitory food insecurity between 0.7 – 1.2 % and 1.1 – 1.7 %, respectively. Amare et al. (2012) employed both PSM and switching regression to assess the impact of adoption on welfare, in a research which examined the driving forces behind farmers' decisions to adopt improved pigeon pea and maize varieties and estimated the causal impact of technology adoption on household welfare in Tanzania. The causal impact estimation from both the PSM and switching regression suggested that maize/pigeon pea adoption had a positive and significant impact on income and consumption expenditure among households. Audu and Aye (2014) used OLS in their analysis and concluded that adoption of improved maize varieties was positively and significantly related to household welfare and contributed to poverty reduction among adopters.

The results of a study by Zeng (2014) indicated that adoption of improved maize varieties reduced the degree of poverty and poverty ratio in Ethiopia, with farmers having small landholding benefitting the least from adoption. Audu and Aye (2014) on their part, showed that household welfare was positively and significantly related to adoption of improved maize varieties in Nigeria. The results of the study showed that adoption of improved maize varieties led to poverty reduction among farm households in the study area.

In another study by Mugisha and Diiro (2010) in Central Uganda, it was shown that the mean yields from local maize varieties (1694 kg/ha per season) was significantly lower than the mean yields from improved maize varieties (2941.5 kg/ha per season). The authors therefore concluded that adoption of improved maize varieties resulted in increased yield. The authors also observed that adoption of improved maize varieties was strongly influenced by access to extension services while maize yields responded inelastically to adoption. In addition, de Jaleta et al. (2015) observed that adopters had higher average per-capita food consumption than non-adopters of improved maize varieties in Ethiopia. Moreover, Karanja et al. (2003) found that the income effect of adopting improved maize technology was higher for areas with high agricultural potential relative to areas with low agricultural potential in a study in Kenya.

Becerril and Abdulai (2010) concluded that the adoption of improved maize varieties significantly improved household welfare (measured as per capital expenditure and reduction in poverty) in Mexico. In addition, de Janvry and Sadoulet (2002) in their paper on world poverty and the role of agricultural technology argued that agricultural technology can reduce poverty through direct and indirect ways. Improved crop varieties lead to high yields directly. The indirect benefits may result from increased supply of food at lower cost. These changes are in favor of consumers, but adversely affect producers who are non-adopters. Similarly, an impact study in rural China by Wu et al. (2010) indicated that adoption of agricultural technologies improved household income through positive impact on farmers' well-being.

RESEARCH METHODS

The Tolon District is located in the Northern Region of Ghana. The Tolon District was separated from the Tolon-Kumbugu District in 2012 with Tolon as its administrative capital. The population of the district according to 2010 population and housing census stands at 72,990 with 36,360 males and 36,630 females. The district experiences a unimodal rainfall regime. The rainy season starts in May and ends in mid-October. The mean annual rainfall ranges between 950mm – 1,200mm. The rainfall pattern restricts staple crop production to one cropping season. The district experiences a dry season from November to April. During this season, mean

temperatures vary from 33°C to 39°C and 20°C to 26°C in the day and night respectively. In addition, there is occasional storms and depending on its frequency and intensity results in base soil erosion.

Sampling and method of data collection

Data for the study was obtained from a cross-section of 160 maize farmers in four communities in the Tolon district in Northern Region of Ghana. The data covered maize production for the 2017/2018 cropping season. Data collection was by means of a

semi-structured questionnaire which was administered to each respondent in a face-to-face interview.

The sample was obtained using multistage sampling technique. In the first stage four communities were purposively selected on the basis of their maize production potential. In the second stage, random sampling was used to select 160 farmers from the selected communities. The distribution of the respondents is presented in Table 1.

Table 1. Distribution of adopters and non-adopters in the various communities

Community	Non-adopters	Adopters	Total
Cheyohi	13	21	34
Nyankpala	13	10	23
Woribogu Kukuo	27	14	41
Kpalsogu	27	35	62
Total	80	80	160

Source: Field Survey 2018

Model Specification: Regression with endogenous treatment effects model

Impact evaluation studies typically rely on the estimation of average treatment effect, which measures the effect of a treatment (for example adoption) on an outcome of interest (for example farm income). Propensity score matching is commonly employed in the estimation of average treatment effect. However, one common limitation with propensity score matching is the inability to account for biases arising from unobservable factors. Consequently, more appropriate estimation procedures have been proposed to account for both observable and unobservable biases. The linear regression with endogenous treatment effects model has been proposed as an appropriate procedure to estimate the impact of a treatment on an outcome variable. The endogenous treatment effect model (ETEM) can be used to estimate the average treatment effect (ATE) or the average treatment effect on the treated (ATET or ATT). The ATE is the same as the ATT when the binary treatment variable is not interacted with any of the explanatory variables in the outcome or substantive equation. Unlike the case of propensity score matching, the endogenous treatment effect model generates both the impact parameter as well as other parameters using a linear regression model which is augmented with an endogenous treatment variable. In this study,

the endogenous treatment variable, which is binary, is adoption of improved maize varieties and the outcome variable is gross farm income.

To estimate the endogenous treatment effect model, we specify an equation for the endogenous treatment variable, Z_i (adoption) as well as the outcome equation, Y_i (i.e., farm income equation) as follows:

$$Y_i = X_i\beta + \delta Z_i + v_i \quad (1)$$

$$Z_i = w_i\gamma + u_i \quad (2)$$

$$\text{where } Z_i = \begin{cases} 1, & \text{if } w_i\gamma + u_i > 0 \\ 0, & \text{if } w_i\gamma + u_i \leq 0 \end{cases} \quad (3)$$

Z_i is the observable adoption variable and takes the values of 1 for adopters, and 0 otherwise. X_i and w_i represents a vector of outcome covariates and a vector of endogenous treatment covariates, respectively; β and γ are unknown parameters, while v_i and u_i represent error terms having the following covariance matrix:

$$\begin{bmatrix} \delta^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix} \quad (4)$$

The empirical farm income model (outcome equation) is represented as follows:

$$Y_i = \beta_0 + \beta_1 sex_i + \beta_2 age_i + \beta_3 edu_i + \beta_4 fmsize_i + \beta_5 group_i + \beta_6 ext_i + \beta_7 ofw_i + \beta_8 catt_i + \beta_9 cred_i + \beta_{10} subsidy_i + \beta_{11} cost_i + \beta_{12} Z_i + u_i \quad (5)$$

where Z_i is the adoption variable and the rest of the variables are as defined in Table 1.

The empirical adoption model is similarly presented as follows:

$$Z_i = \gamma_0 + \gamma_1 sex_i + \gamma_2 age_i + \gamma_3 edu_i + \gamma_4 fmsize_i + \gamma_5 group_i + \gamma_6 ext_i + \gamma_7 ofw_i + \gamma_8 catt_i + \gamma_9 cred_i + \gamma_{10} subsidy_i + \gamma_{11} cost_i + u_i \quad (6)$$

where the variables are as defined in Table 1. The parameters of the outcome and selection models were estimated using Stata version 15.

Data description

The variables and their description are provided in Table 2. As shown in the table, the respondents had a mean age of 42.9 and mean household size of 10. The respondents also had an average of 16.8 years of farming experience with 26 percent having formal education. On average 89.4% of the total sample had access to fertilizer subsidy which could positively influence the adoption decision of farmers. Close to 86% of the respondents perceived the cost of improved maize varieties to be high and this is likely to negatively influence the adoption decisions of maize farmers. Out of the one hundred and sixty farmers sampled, 32% participated in off farm work. This implies that 68% of the respondents relied solely on farming for their livelihood. About 11% of the respondents had access to credit. This could negatively influence farmers' decision towards adoption. Nearly half of the respondents (48%) belonged to a farmer group.

Table 2. Definition of variables in the study

Variable	Mean	Std Dev
Variety (= 1 if improved)	0.500	0.502
Gender (= 1 if male)	0.863	0.345
Age in years	42.93	12.84
Education (= 1 if educated)	0.256	0.438
Household size	10.24	4.899
Farming experience (years)	16.88	11.02
Extension (= 1 for access)	0.538	0.500
Credit (= 1 for access)	0.113	0.317
Subsidy (= 1 for access)	0.894	0.309
Cost of adoption (= 1 if high)	0.863	0.345
Farm income in Ghana cedi	1181	742.4
Off-farm work (=1 if yes)	0.319	0.467
Farmer group (= 1 if member)	0.475	0.501
Marital status (= 1 if married)	0.919	0.274

^ψ 1 US dollar = 4.8 GH¢. Source: Field Survey 2018

RESULTS AND DISCUSSION

Characteristics of the respondents according to adoption status

Table 3 presents a description of the characteristics of adopters and non-adopters in the study. Adopters had, on average, higher means for most of the variables in the study. Membership in farmer group, access to subsidy and extension services, farm income and cost of adoption had significant mean differences between adopters and non-adopters,

hence these variables are likely to influence adoption of IMVs.

The mean difference for membership in farmer group and access to fertilizer subsidy were significant at 5% implying that these variables are likely to influence adoption decisions. Fifty-six (56) percent of adopters were members of farmer groups while 95% of adopters had access to fertilizer subsidy. The mean difference for cost of adoption between adopters and non-adopters was negative and significant at 5%, hence likely to negatively influence adoption. With regards to the cost of

adoption, 80% of adopters thought it was high while 93% of non-adopters considered it to be high. Hence, majority of the respondents considered the cost of adoption to be high, which is expected to negatively affect farmers decision to adopt improved maize varieties. Access to extension services and farm income had significant mean differences for adopters and non-adopters at 1%. The results show that 66.3% of adopters had access to extension services. Meanwhile, the average farm income of adopters of IMVs was found to be GH¢ 1298.3

whiles that of non-adopters was GH¢ 628.8, with a significant mean difference at 1% level. This implies that adopters of IMVs had higher farm income than non-adopters and the huge difference could indicate that IMVs are high-yielding. Other variables such as farmers' age, gender, household size, off-farm work, farming experience, access to credit and marital status did not show any significant difference between adopters and non-adopters.

Table 3. Characteristics of the respondents according to adoption status

Variable	Adopters		Non-adopters		Difference in means
	Mean	Std. Dev.	Mean	Std. Dev.	
Age in years	42.85	12.39	43.01	13.34	0.160
Gender	0.825	0.382	0.900	0.302	0.075
Household size	11.05	4.875	9.625	4.643	1.425
Education	0.288	0.501	0.225	0.047	0.902
Access to extension	0.663	0.476	0.413	0.495	0.250***
Off-farm work	0.350	0.480	0.288	0.455	0.062
Experience in years	18.23	11.29	15.54	10.65	2.690
Group membership	0.563	0.499	0.388	0.490	0.175**
Access to credit	0.138	0.347	0.088	0.284	0.050
Farm income	1298.3	828.4	1064.3	628.8	234.0***
Marital status	0.925	0.265	0.913	0.284	0.012
Cost of adoption	0.800	0.403	0.925	0.265	-0.125**
Subsidy	0.950	0.219	0.838	0.371	0.113**

*** and ** represent 1% and 5% significant levels. Source: Field survey 2018.

Maximum likelihood estimates of the endogenous treatment effect model

The results of the regression with endogenous treatment effect model are presented in Table 4. The test of independence of the two equations reveal dependence between the adoption and farm income equations as shown by the significance of the likelihood ratio test at 5% level. The test result justifies joint estimation of the two equations.

Determinants of improved maize variety adoption

The influence of gender on adoption was found to be significant at 5% with a negative sign. This implies that male-headed households adopted improved maize varieties less than female-headed households, which is contrary to a priori expectation. The result disagrees with the findings of Mwangi et al. (2012) and Kalindan et al. (2014) which indicate that female-headed households adopt improved technologies less than male-headed households.

Cattle ownership was found to be significant at 5% and positively related to adoption. This result implies that owners of cattle are more likely to adopt IMVs. This result is consistent with a priori expectation. A positive relation between cattle ownership and adoption is anticipated because owners of cattle are considered to be wealthier and hence more likely to be able to afford the cost of adoption. Wealthier farmers may also have access to other productivity-enhancing technologies.

The coefficient of access to extension service was positively related to adoption and significant at 10%. Farmers who receive extension services are assumed to receive education on the benefits associated with IMVs such as high yields and resistance to unfavorable environmental conditions, thus enhancing their decision to adopt. In addition, by means of extension agents, farmers who receive education on good management practices can increase their yields from planting IMVs. Thus, access to extension is expected to enhance adoption of IMVs. The result of this study shows that the probability of adoption of IMVs is higher for

farmers who received extension services. Similar result was obtained by other researchers including

Kebede (2006), Mugisha and Diiro (2010), Ebojei et al. (2012) and Katengeza et al. (2012).

Table 4. Maximum likelihood estimates of the regression with endogenous treatment effect model

Variables	Farm income model		Adoption model	
	Coefficient	Std. Error	Coefficient	Std. Error
Gender	402.9**	175.2	-0.920**	0.368
Age	-3.514	4.215	0.002	0.009
Years of Education	-3.341	11.58	0.038	0.026
Farm size	732.0***	95.27	0.234	0.217
Group membership	-198.4	135.1	0.111	0.291
Extension	-121.2	137.6	0.514*	0.293
Off-farm work	77.09	112.0	0.000	0.241
Cattle ownership	307.6**	149.2	0.535*	0.314
Credit	65.33	173.8	0.052	0.387
Subsidy	43.77	181.3	1.203***	0.421
Cost of adoption	205.9	159.3	-0.724**	0.338
Adoption	852.2***	199.0		
Constant	-275.6	317.5	-0.503	0.685
/athrho	-0.892***	0.253		
/lnsigma	6.421***	0.096		
Rho	-0.713***	0.125		
Sigma	614.4***	59.16		
Lambda	-437.8***	113.5		

***, ** and * indicate statistical significance at 1, 5 and 10 per cent level, respectively. Note: LR test of indep. eqns. (rho = 0): chi2(1) = 4.11 Prob > chi2 = 0.043. Source: Computed from survey data, 2018

The study also showed that access to fertilizer subsidy had a positive and significant association with adoption at 5% level. This implies that farmers who benefitted from the fertilizer subsidy program adopted IMVs more than those who could not participate. This result is consistent with a priori expectation because a subsidy on fertilizer will lead to reduction in prices of fertilizer which will enable maize farmers to purchase the required quantities of the input. Again, a subsidy leads to reduction in the cost of production which will allow maize farmers to purchase improved maize varieties for cultivation. Typically, most IMVs require inorganic fertilizers to give optimum yields. Hence, without subsidy, many poor farmers cannot afford the cost of fertilizer and therefore less likely to adopt IMVs. The result of this study agrees with Bezu et al. (2014) in their study on the welfare effects of improved maize variety adoption in Malawi.

Finally, cost of adoption was negatively related to adoption of improved maize varieties and significant at 5%. The result is in line with a priori expectation because as cost of adoption increases, many poor farmers are likely to opt for alternatives with lower cost. The result suggests that efforts to increase adoption of improved maize varieties must

consider the cost of adoption to farmers. Subsidizing the cost of improved seeds is therefore important to enable more farmers to adopt improved seeds, thereby enhancing farm yields.

Effect of improved maize variety adoption on farm income

The main objective of the study was to assess the effect of improved maize variety adoption on farm income. This section reports the findings arising from the endogenous treatment effect model as presented in the 2nd and 3rd columns of Table 4. Adoption of IMVs was found to have a positive and highly significant effect on farm income. According to the estimated average treatment effect on the treated, adopters of improved varieties increased their farm income by GH¢852.2, relative to non-adopters. The result is consistent with the findings of Bezu et al. (2014) which showed that farm income of farmers in Malawi increased with the area under improved maize varieties. The result confirms the good attributes and benefits of IMVs which include higher yields. The result confirms findings of Karanja et al. (2003) and Wu et al. (2010).

Apart from the impact parameter, the endogenous treatment effects model also provided

estimates of other parameters that explain farm income. As indicated in Table 4, male farmers have higher farm income than female farmers. The result is consistent with many research findings which indicate that men usually have greater control over productive assets in household and are more likely to have access to services and inputs in rural communities.

The results further indicate that farm size positively and significantly influence farm income at 1% level. All things being equal, the larger the farm, the higher the income expected to be derived. Farmers with larger farm sizes can invest more resources into their farm operation to increase their income from farming.

The results also indicate that cattle ownership has a positively significant influence on farm income at 5% level. The result is consistent with a priori expectation because animal power enables farmers to carry out some of the farm operations faster and more efficiently, while reducing drudgery.

CONCLUSION

The study evaluated the effect of adoption of improved maize varieties on farm income of farmers in four selected communities in Tolon District in the Northern Region of Ghana. The study used regression with endogenous treatment effect model to evaluate the effect of adoption on farm income. The results indicate that adoption increased with extension contact, access to fertilizer subsidy and cattle ownership but decreased with cost of adoption. In addition, adoption was lower for male farmers. The results further indicate that adoption of improved varieties increased gross farm income of maize farmers by GH¢852. Farm income also increased with farm size and cattle ownership but was lower for female farmers.

Despite the positive effect of improved variety adoption, the rate of adoption of IMVs among smallholders remains low, with 50% of the respondents relying on traditional varieties. Hence, efforts are required to improve the level of adoption of IMVs among small-scale farmers in order to enhance maize output and farm income. Institutional factors such as provision of agricultural extension advisory services and subsidized fertilizer are essential to promote adoption of improved maize varieties. As indicated by the findings of this study, farmers who received these services are more likely to adopt improved varieties. Addressing the problem of inadequate extension staff and logistical constraints facing extension workers are some of the

pragmatic steps required to promote adoption of improved varieties in order to ensure higher farm incomes. Furthermore, subsidized fertilizer should be made available to farmers on time and in the right quantities to enhance adoption and farm incomes, while farmers should be encouraged to rear livestock as this enhances both adoption and farm income.

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