Journal of Agricultural Science; Vol. 10, No. 7; 2018
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Gender Effect on Adoption of Selected Improved Rice Technologies in Ghana

Monica Addison[1], Kwasi Ohene-Yankyera[2] & Robert Aidoo[2]

[1] Bureau of Integrated Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

[2] Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Correspondence: Monica Addison, Bureau of Integrated Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Tel: 233-244-539-734. E-mail: monicaddo@yahoo.com

Received: March 15, 2018 Accepted: May 16, 2018 Online Published: June 15, 2018

doi:10.5539/jas.v10n7p390 URL: https://doi.org/10.5539/jas.v10n7p390

The research is financed by Africa Rice Centre (AfricaRice), through financial support from African Development Bank (AfDB) under the project dubbed "Sustainable Agricultural Research for Development of Strategic Crops in Africa (SARD-SC)".

Abstract

The study sought to test the hypothesis that gender influences adoption of innovations in the rice sector of Ghana. There is an existence of gender gap in adoption of farm innovations in Ghana. After desk review, it was found that the existing literature has not provided a clear linkage between gender and adoption of agricultural technologies. Thus, the objective of this study was to determine how the interaction between gender and other socio-economic factors influence the incidence of adoption of improved rice variety and fertilizer. Drawing on 917 face-to-face interviews with rice producers, the results show that child care and limited access to land inhibit female incidence of adoption. It is recommended that the innovation system should take cognizance of female reproductive role and develop, as much as possible, technology options that rely less on intensive use of labour. Furthermore, government should facilitate the development of land markets to improve female access to land, especially in northern Ghana where cultural norms restrict women's access to land.

Keywords: gender studies, gender roles, rice sector innovations

1. Introduction

Ghana's agricultural policy identifies rice as an important food crop that has the potential to ensure food security (Anang, Bäckman, & Sipiläinen, 2016). According to Chamberlin (2007), Ghana's rice sector is dominated by smallholders and more than 70 percent of them have farm holdings not greater than three (3) hectares. Rice production by smallholder farmers is confronted with numerous challenges. Many of these farmers continue to invest in low-yielding traditional varieties and produce rice crop using rudimentary farm equipment. As a result, the rice sector is underperforming (national average yields is as low as 2.4 t/ha), although achievable yield of 6 t/ha have been recorded (MoFA, 2009). In the absence of competitive local rice production, the current trend of low rice production is likely to affect rice farmers' income and food security in Ghana (Robinson & Kolavalli, 2010). Against this background, government has facilitated the promotion and dissemination of improved rice technologies in rice sector, to increase productivity on already cultivated lands (Faltermeier, 2007). The focus has been to improve national and household food security and incomes, provide a mechanism to reduce poverty (World Bank, 2008). Evidence suggests that the use of improved rice technologies, for instance, could raise productivity from 1.3 t/ha to 2.1 t/ha (Minten & Barrett, 2008).

Ragasa et al. (2013) concluded that the rate of adoption of improved rice technologies in Ghana is low. Furthermore, Doss and Morris (2001) have recorded lower rate of adoption of improved maize seed among females than males. According to Paris and Pingali (1995), in societies where roles and responsibilities are highly gendered, gender is likely to affect adoption of improved rice technologies. Nevertheless, past research efforts around the globe have focussed less on the effect of gender on adoption decisions of the target group, and focused mostly on issues ranging from personal and household characteristics, institutional factors and farmers resources endowment (Abdullah & Samah, 2013; Akudugu, Guo, & Dadzie, 2012). Development practitioners have sought to remove some of the identified constraints, expecting to enhance adoption and increase productivity, yield and average farm incomes. However, results have been below expectations and adoption of improved agricultural technologies still remains low, especially among female rice farmers (Ragasa, 2012).

Gender is a very important socio-economic factor, critical to well-functioning of farm household agricultural activities in general (Garcia, 2001). Researchers and policy makers need to understand and address gender gap in technology adoption. Therefore, this study is motivated by the fact that there has been too little attention given to the influence of gender on adoption of agricultural technologies in existing studies. Specifically, this study intends to analyse how the interaction of gender and other socio-economic factors influence incidence of adoption of improved rice variety (Jasmin 85) and inorganic fertilizer technologies. The study focused on these selected improved rice technologies because farmers in the study area mostly apply inorganic fertilizer and grow Jasmine 85 improved rice variety. The finding shall inform policy and ensure the development of gender sensitive strategies critical to an effective technological innovation system in rice sector of Ghana. The study could help close gender gap in technology adoption and address the problem of income disparity in the farm households. Closing the gender gap in technology adoption could generate significant gains for the rice sector and for the country at large. Finally, the study seeks to contribute to existing gender and innovation studies.

2. Method

2.1 Gender

2.1.1 The Concept of Gender

Gender has been used to describe and analyse a range of practices, in relation to social and cultural differences, which give rise to differences between male and female, in terms of the division of labour and resources, and perception of acceptable behaviour for males and females. Philips (2005) indicated gender encompasses both sex differences and social constructs that give rise to differences between males and females. Gender is grounded on the understanding that certain functions, jobs and roles are ascribed to males and females in society—in both their public and private lives. Generally, society has ascribed domestic activities to females and productive activities to males (Hesse-Biber & Carger, 2000; Xinyu & Yanwei, 2007). Thus, each society decides which tasks, resources, as well as which opportunities, should be assigned to males and females, young and old.

Gender is also described by the relationship between males and females in societies. IFAD (2000) noted gender relations refer to a multifaceted system of individual and communal (societal) connection of domination and power by which males and females are socially fashioned and maintained, and through which they are ranked within society, gain access to power and material resources. Kabeer and Subrahmanian (1996) opined that gender power relations are socially constructed, and are fruits of the processes in which institutions and socialization are planned and reconstituted. Connell (1987) reiterated the unequal resource allocation between males and females in societies is as a result of sexual division of power. In general, gender power relations translate into female limited access to resources at the farm household level.

2.1.2 Measurement and Operationalization of Gender in this Study

Some authors have tried to measure gender in their studies (*e.g.*, Bem, 1981; Clark et al., 2005; Wylie et al., 2010). Bem (1981) measured gender by the levels of masculinity, femininity and androgyny, whilst Clark et al. (2005) measured gender by appearance conformity. Also, Wylie et al. (2010) measured gender by gendered appearance and gendered mannerisms. Few adoption studies have measured gender differently. Generally, the available adoption studies measured gender by the sex of the respondents. Specifically, the sex of the respondent, either an individual farmer or the household head, is used as a proxy for 'gender' (Overfields & Fleming, 2001). The conventional approach to measure the effect of gender on adoption was to dummy 'gender' (1 = male; 0 = otherwise), and included in the adoption model.

A previous study has shown that gender influences technology adoption, particularly in rural societies where men and women play different roles (Paris & Pingali, 1996). Evidence suggests that institutional cultures have created gender disparities in access to resources (Connell, 1987). FAO (1995) stated that although women are the backbone of small scale agriculture, they encounter more difficulties than men in the acquisition of productive resources and services. Due to the fact that gender is a social construct, this study sought to find out how gender role affects incidence of adoption. The research measured gender role by the degree of participation in domestic activities. This was operationalized by identifying the respondents who contributed at least 50% of their total time used to carry out domestic activities daily. The approach to measure the effect of participation in domestic activity on incidence of adoption was to use a dummy (1 = contributes at least 50% of the total time to domestic activities; 0 = otherwise). Until recently, the unit of observation has been focussed on the household head. However, the unit of analysis in this study is the individual rice producer at the plot level.

2.1.3 The Influence of Gender on Adoption of Agricultural Technologies

Gender of the farmer has become an important socio-economic variable in adoption studies. Ragasa (2012) recorded gender gap in adoption of agricultural technologies. Tanellari et al. (2014) indicated that women in female-headed households are less likely to adopt improved varieties of peanut, as compared to women and men in male-headed households, as a result of unequal access to resources. Kassa et al. (2014) identified male-headed households have a higher probability of participation in fertilizer application than female-headed households, *ceteris paribus*. Mugonolaa et al. (2013) noted that male-headed households are more likely to adopt soil and water conservation technologies than female-headed households, while Overfield and Fleming (2001) found insignificant effect of gender on adoption. Namonje-Kapembwa and Chapoto (2016) identified female farmers as less likely to adopt hybrid seed, fertilizer, and use of animal traction, as compared to their male counterparts. The evidence so far shows that female-gender negatively and significantly influences adoption of improved agricultural technologies.

2.2 Theories of Adoption of Agricultural Technologies

This study employs two theories, namely the economic constraint theory and Rogers' diffusion of innovations theory, to explain and outline the factors that influence target group adoption decision process.

2.2.1 The Economic Constraint Theory

The economic constraint theory assumes that, in the short run, critical factors of production are fixed, which limit production elasticity and condition technology adoption decisions (Smale et al., 1994; Shampine, 1998). The proponents further put up an argument that unequal access to resources is the major determinant of observed differences in adoption behaviour of males and females. Mendola (2007) indicated farmers who own larger farms are more likely to try improved agricultural technologies as they can afford to devote part of their field to try out the new technologies. Mugisa-Mutetikka et al. (2000) reported that farm size has a neutral relationship with technology adoption, while Yaron, Dinar, and Voet (1992) documented that farm size negatively and significantly influences technology adoption.

Labour availability is another important variable that affects farmers' adoption decisions. Udry (1996), and Dillon and Quiñones (2010) reiterated family labour is used less intensively on plots controlled by women than on plots controlled by men. Strikingly, Quisumbing and Pandolfelli (2010) stated women depend on their husbands' labour when they are able to access it. High labour cost is likely to inhibit female adoption of improved rice technologies due to their limited access to resources (Nin-Pratt & McBride, 2014). Monfared (2011) found a positive correlation between technology adoption and amount of family labour available. Access to family labour is more likely to enhance adoption of improved rice technologies.

2.2.2 Rogers' Adoption and Diffusion of Innovations Theory

The Roger's adoption and diffusion of innovations theory outlines that technology adoption is influenced by individual characteristics, perceived characteristics of the technology and institutional framework within which the adoption process occurs (Rogers, 2003).

Personal and household characteristics such as years in school, age, marriage and size of children have been identified to influence adoption decision. Education has been found to positively and significantly relate to agricultural technology adoption (Mugonolaa et al., 2013), but there is a higher illiteracy rate among females as compared to their male counterparts in Ghana (GSS, 2012). Females' high illiteracy rate is likely to inhibit their adoption of technological innovations.

It is often believed that older farmers have more experience in farming than the younger farmers due to their work experience. Thus, older farmers have a higher probability of taking informed decision about improved technologies than the younger farmers. Boahene, Snijders, and Folmer (1999) recorded that age has positive and significant relationship with farmers' adoption decision, while Bekele and Drake (2003) revealed that age is negatively and significantly related to adoption of improved technology. The older farmers are more likely to be risk-averse, less likely to be flexible than younger farmers, and are less likely to adopt improved technologies that are labour demanding.

Marriage and child care have been identified to be an important factor in farmers' adoption decision. Married females have greater responsibility in managing home than their spouses, reducing their available time to engage in other economic activities. Umeh and Chukwu (2013) reported that marriage negatively and significantly influences adoption of improved rice production technologies. According to Kes and Swaminathan (2006), child care and cooking are the most time consuming activities of females. Available evidence suggest marriage and child care are likely to negatively and significantly influence adoption.

In addition to personal characteristics, the nature of technology is very important to the target group. Perceived attributes of technologies are likely to influence adoption (Adesina & Baidu-Forson, 1995). Studies have reported farmers' perceptions of improved agricultural varieties are important in determining adoption (Sall et al., 2000; Rogers, 2003; Joshi & Pandey, 2006). Farmers' perceptions of the appropriateness or inappropriateness of the characteristics of the technology influence their adoption decisions.

Furthermore, institutional factors such as land tenure extension services influence adoption. An institutional factor such as land tenure system influences farmers' ownership of land. Abdulai, Owusu, and Goetz (2011) reiterated tenure security tends to influence farmers' decisions to invest in improved agricultural technologies. Paris, Feldstein, and Duron (2001) reported that women with secured access to land are likely to benefit from agricultural technologies. Arcand, Ai, and Ethier (2007) shown that the impact of tenancy arrangement on investment in soil conservation measures is quite weak. The evidence suggests that land ownership is likely to positively influence adoption.

Similarly, participation in relevant extension training programmes has been identified to positively influence adoption of agricultural technologies (Shampine, 1998; Smale, Just, & Leathers, 1994). Monfared (2011) found out that participation in extension training programme significantly and positively influenced female adoption.

2.3 Sampling Procedures, Sample Size and Data Collection

A quantitative design was employed to collect a cross sectional data from individual rice farmers within the selected rice households between November 2015 and January 2016. A multistage sampling technique was used to select regions, districts, communities and respondents. The first stage involved the purposive selection of regions and districts with different social and cultural backgrounds. The second stage involved the criterion sampling of the communities based on the following: (1) the availability of improved rice technologies, good agronomic and post-harvest handling practices have been extensively promoted by development partners for not less than 5 years; and (2) the rice producing communities have at least 10 years of engagement in rice production. The third stage involved proportionate sampling of rice producers from the selected communities. The final stage involved randomization of the respondents using computerized random numbers. The total sample size was 917, comprising 546 males and 371 females. This represented 516 adopters and 401 non-adopters. A total of 440 and 477 rice producers were selected from Ashanti and Kassena Nankana Districts, respectively.

The questionnaire captured information on socioeconomic characteristics of the rice producers, namely age, marriage, gender, level of education, household size, and work experience. Institutional factors such as land ownership, extension service and information, were sourced from the rice producers. Technology characteristics such as perception of labour demanding and capital intensive improved rice technology were also recorded. Finally, farmers' resources endowment such as total land holding, income from other crops, hours' of family labour, hours spent on cultivation of other crops, total number of livestock and communal hours among others were solicited from the respondents.

2.4 Data Analysis

The study employed Multinomial Probit (MNP) regression model for rice producers' alternative choices because in the dissemination of bundle of technologies, farmers' adoption decision is a dependent and joint process. MNP has errors which are not independent, and are distributed by a multivariate normal distribution (Greene, 2000).

2.4.1 Theoretical Model of the Multinomial Probit Model

Let the probability that the i^{th} farmer chooses the j^{th} technology be P_{ij} and denote the choice of the i^{th} farmer by $Y_i = (Y_{i1}, Y_{i2}, \dots Y_{ij})$; where, $Y_{ij} = 1$ if the j^{th} technology is chosen and all other elements of Y_i are zero. If each farmer is observed only a single time, the likelihood function for a sample of N independent observations with j alternative option is presented as:

$$U_{ij} = \beta_j x_{ij} + \omega_j Z_{ij} + \varepsilon_{ij} \tag{1}$$

Where, U_{ij} denotes the choices of technologies; x_{ij} denotes a vector of explanatory variables; Z_{ij} indicates a set of attributes associated with the technologies. β_j and ω_j are the parameters to be estimated. ε_{ij} is the error term which is assumed to be a multivariate normal distribution. The probability of a respondent i using technology j can be presented in a multinomial Probit form as:

$$P_{ij} = \Pr(y = j) = \Pr\{(\varepsilon_{ik} - \varepsilon_{ij}) \leq (x_{ij} - x_{ik})' + z'(\omega_j - \omega_k)\} \quad (2)$$

Note that the probability of a respondent i choosing category j must add to one:

$\sum P_{ij} = P_{i1(improved\ variety)} + P_{i2(fertilizer)} + P_{i3(fertilizer+improved\ variety)} = 1$

and coefficients sum to zero:

$\sum_{j=1}^{J} \beta_{jk} = 0$

The likelihood functions for multinomial probit is as follows:

$$\text{Let } \lambda_{ij} = \begin{cases} 1 \ if\ y_i = j \\ 0 \ if\ y_i \neq j \end{cases} \quad (3)$$

Then the likelihood function is,

$$L = \prod_{i=1}^{N} \prod_{j=1}^{M} P(y_i = j)^{\lambda_{ij}} \quad (4)$$

which is maximized with respect to the coefficients, and in the case of MNP, the unconstrained variances and co-variances.

2.4.2 Empirical Model Specification of the MNP

The empirical MNP model to examine the effects of the explanatory variables on the choices of improved rice technologies (y) is given as follows:

$$Y_i = 1, \ldots j = \beta_0 + \beta_1\chi_{1i} + \beta_2\chi_{2i} + \ldots + \beta_n\chi_{ni} + \varepsilon \quad (5)$$

Where, β_0 is the intercept, β_{1-n} are the coefficients of the various explanatory variables, χ_{i-n} are the various explanatory variables and ε is the error term. The explanatory variables age, years in school, number of adults, number of infants, total rice land holding, time allocated to other economic activities, hours of communal activities, number of hours of family labour and number of livestock owned are continuous non-negative variables, while married, own land, participation in extension training programs, perceptions of capital intensive and perceptions of labour demanding improved technologies are dummy variables coded with 1 for yes and 0 otherwise (see Table 1 for the descriptive results).

The study hypothesizes that gender influences adoption. In order to test this hypothesis, gender was introduced into the model. For moderation, this is expanded to include not only the moderator variable (gender), but also the interaction between gender and each of the independent variables, which is created by multiplying gender and independent variables (gender × independent variables). This is called a two-way interaction, as it involves two variables (one independent variable and one moderator): This is given as,

$$y_{ik} = \beta_0^g + \beta_1^g sex_{ik} + \beta_2^g age_{ik} + \beta_3^g educ_{ik} + \ldots + \beta_{16}^g TLU_{ik} + \delta_0 gender_{ik} + \delta_1(gender_{ik} \times yrschool_{ik}) \quad (6)$$

Where, y_{ik} is a categorical variable describing farmers' choices of improved rice variety ($j = 1$), fertilizer ($j = 2$), improved rice variety plus fertilizer ($j = 3$) and non-adoption ($j = 4$), g represents gender, * represents interactions between gender and explanatory variables. The interaction terms are at the heart of testing moderation. If (and only if) any of these terms is significant—tested by F-joint statistics—it can be said that gender is a statistically significant moderator of the linear relationship between dependent and independent variables. The coefficients β_1, β_2, β_3, … β_{16} determine whether there is any main effect of independent variables, respectively, independent of the other on dependent variable, but it is only δ_1, δ_2, δ_3, … δ_{16} that determine whether there is moderation (interaction effect), and whether the moderator strengthens or weakens the nature of the relationship between the dependent variable and independent variables. The joint effect is estimated from the first derivative of an equation:

Joint effect = a(gender) + b(gender)(land ownership) + c(gender)(Infants) + d(gender)(location)

The joint effect is estimated from the first derivative of the equation (this is evaluated at the mean values of the gender-related variables). The economic implication of the joint effect (Note 1) is that that, if the joint influence exceeds that of the individual and interaction effect, addressing them individually would not achieve the desired results.

In a non-linear model such as the MNP, the estimated coefficients are not interpreted directly. The parameter estimates of the MNP model provide only the direction of the effect of the independent variables on the dependent (response) variable, but estimates do not represent either the actual magnitude of change or probabilities. There is the need to calculate the marginal effects to provide better understanding about the magnitudes of the coefficients (Greene, 2012). By differentiating Equation (2) with respect to explanatory variables, the marginal effects of the explanatory variables (Greene, 1997) are given as:

$$\delta_i = \frac{\delta P_j}{\delta x_i} = P_j \left[\beta_j - \sum_{k=0}^{j} P_k \beta_k = P_j(\beta_j - \beta)\right] \quad (7)$$

Where, δ_i denotes the marginal effect of the explanatory variable and P is the probability that the alternative j is preferred.

3. Results and Discussion

3.1 Descriptive Results

Table 1 presents the summary statistics of the average values of the variables considered in the study: by adopters and non-adopters as well as the t-test values of their differences. Socio-economic characteristics are important factors that could influence rice producers' adoption decisions (Leinbach, 2003). For instance, in many African contexts, age and sex could influence a person's contribution to decision making in the farm households. The t-test results of the differences of all variables considered in the model are all highly significant, suggesting there are differences in the values of the variables of adopters and non-adopters. The location dummy indicates that 64 percent of the adopters were sampled from the south (Atwima Nwabiagya district). Similarly, 73 percent of the non-adopters were located in the north, suggesting low rate of adoption among those in the north, as compared to those in the south. Again, the results show there is low rate of adoption (20%) among females, as about 67 percent of the non-adopters represented females, justifying the need to examine the influence of gender on adoption of improved rice technologies. This is consistent with that of Doss and Morris (2001) who reported low rate of adoption among females.

Approximately 81 percent of the non-adopters contributed more than 50 percent to domestic activities (gender), as compared to that of adopters (22%). The non-adopters were generally older (50.95 years) than adopters (43.87 years). This is understandable because improved rice cultivation is labour demanding and older people may not be able to engage in it. According to Ghana population census, the economically active age group falls within 15-35 years (GSS, 2012). The adopters spent greater number of years in school (6.66 years) than non-adopters (about 5.22 years), suggesting majority of respondents who indicated that they had acquired formal education were basically at the primary level. About 89 percent of non-adopters were married as compared to 55 percent of adopters, though this is slightly higher than the national value of 42.9 percent (GSS, 2012). A study has indicated marriage can influence the roles and responsibilities as well as occupation of members of households and their families (Dennis and Peprah, 1995). The adopters cultivated larger acreages (3.86 acres) than the non-adopters (3.10 acres). This lends support to what was recorded by Ministry of Agriculture, that about 90 percent of farm holdings in Ghana are less than 2 hectares in size (MoFA, 2011). About 66 percent of adopters owned land, while a smaller percentage (36%) of the non-adopters owned land. Greater percentage (39%) of adopters received training as compared to only 18 percent of non-adopters.

A smaller percentage (39%) of adopters perceived improved rice variety cultivation to be labour intensive, as compared to that of non-adopters (60%). Similarly, a smaller percentage (45%) perceived fertilizer application to be labour intensive, as compared to that of the non-adopters (75%). Furthermore, smaller percentage of non-adopters (48%) perceived fertilizer application to be capital intensive, while 67 percent of the non-adopters perceived fertilizer application to be capital intensive. Adopters spent GH¢142.33 on improved rice variety. Tropical Livestock Units are livestock numbers converted to a common unit. In general, adopters had larger number (1.89) of livestock than that of non-adopters (0.99). Similarly, adopters had 2.26 infants as compared to about twice (3.57 infants) of that of non-adopters. Adopters spent 20.45 hours per week on other economic activities, while that of non-adopters recorded 44.86 hours. Surprisingly, adopters obtained a higher income (GH¢298.32) from other crops than non-adopters (GH¢224.57). Income from other crops is likely to relax adopters' liquidity problem in the absence of credit, to engage in improved rice cultivation (see Table 1).

Table 1. Summary statistics for adopters and non-adopters of improved rice variety, fertilizer, and fertilizer and improved

Variable Male (female)	Adopters (n = 516) 0.67 (0.47)	Non-Adopters (n = 401) 0.20 (0.40)	Mean Difference (t-Value)
Gender (yes)	0.22 (0.41)	0.81 (0.39)	-0.59 (-22.24)***
Age (years)	43.87 (12.24)	50.95 (13.20)	-7.08 (-8.31)***
Years in school (years)	6.66 (5.48)	5.22 (4.73)	1.44 (4.27)***
Married (yes)	0.51 (0.50)	0.89 (0.32)	-0.37 (-13.67)***
Farm size (acres)	3.86 (2.72)	3.10 (3.62)	0.77 (3.54)***
Land ownership (yes)	0.66 (0.47)	0.36 (0.48)	0.30 (9.65)***
Attend relevant training programme (yes)	0.39 (0.49)	0.18 (0.39)	0.21 (7.12)***
Labour intensive improved rice variety (yes)	0.39 (0.49)	0.60 (0.49)	-0.21 (-6.47)***
Labour intensive fertilizer use (yes)	0.45 (0.50)	0.75 (0.43)	-0.30 (-10.00)***
Capital intensive fertilizer use (yes)	0.48 (0.50)	0.67 (0.47)	-0.19 (-5.93)***
Seed cost	142.33 (192.38)	0.00 (0.00)	142.33 (16.81)***
Total Livestock Unit (*TLU) (Number)	1.89 (4.90)	0.99 (3.16)	0.90 (3.32)***
Number of infants (Number)	2.26 (1.49)	3.57 (1.52)	-1.31 (-13.12)***
Hours used to engage in communal activities (**hours)	11.41 (1.96)	13.72 (4.56)	-2.32 (-9.51)***
Hours used to engage in other economic activities	20.45 (18.29)	44.86 (29.49)	-24.41 (-14.54)***
***Location	0.64 (0.48)	0.27 (0.45)	0.37 (11.88)***
Income from other crops (Ghana Cedis GH₵)	298.32 (572.85)	224.57 (478.35)	73.75 (2.12)**

Note. Values in parentheses are standard deviation and *, **, *** denote 10%, 5% and 1% significant levels, respectively.

* Following Jahnke (1982) and Runge-Metzger (1991), the TLU was estimated by multiplying the average value of a particular livestock by their standard conversion values.

** Hours are captured on a weekly basis.

***Reference Location is Kassena Nankana district.

Source: Field data, 2016.

3.2 The Influence of Gender on the Incidence of Adoption of Improved Rice Variety and Fertilizer

The results of the MNP estimates are presented on Table 2. The Log-likelihood Ratio (LR) for all coefficients, non-interacted terms and interacted terms were all found to be highly significant at the 1 percent level. This means that all the explanatory variables included in the model jointly influenced farmers' probability of adoption of improved rice variety and fertilizer. Overall, these results indicate a good model fit with the predictor incidence of adoption of the selected improved rice technologies, suggesting all the models are well fitted. Given the foregoing goodness of fit measures, it can be concluded that the Multivariate Probit Model employed had integrity and hence appropriate for this research.

The study tested the hypothesis that gender (participation in domestic work) negatively and significantly influences incidence of adoption of improved rice variety and fertilizer. The results show that participation in domestic activities reduced the probability of adoption of fertilizer only and both improved rice variety and fertilizer by 15.74 percent and 36.38 percent, respectively. The findings from the interaction between gender and land ownership indicate that, among the farm household resources available to rice farmers, land ownership enhanced the probability of adoption of fertilizer only and both improved rice variety and fertilizer by 16.17 percent and 14.55 percent, respectively. Females in the north are disadvantaged in this regard due to their limited access to land (Bugri, 2008) Furthermore, the result demonstrate that among the domestic activities, child care decreased the probability of adoption of fertilizer only and both improved rice variety and fertilizer by 5.65 percent and 13.86 percent, respectively. Generally, females care for children in the farm household. The joint effects (see notes after references for its estimation) of gender (participation in domestic work), land ownership and child care decreased the probability of adoption of fertilizer only and both improved rice variety and fertilizer by 12.84 percent and 52.62 percent, respectively. This finding could explain why adoption rate for women is consistently lower than men (Doss & Morris, 2001; Ragasa, 2012). The bigger values of the joint effects, as compared to that of the individual and interaction effects, suggest the need to address the identified gender related issues concurrently to enhance female incidence of adoption. This finding is consistent with that of Mugonolaa et al. (2013), Tanellari et al. (2014), Kassa et al. (2014), and Namonje-Kapembwa and Chapoto (2016), and inconsistent with that of Overfield and Fleming (2001) who found insignificant effect of gender on adoption. Thus, the findings reject the null hypothesis that there was no gender effect in incidence of adoption of improved rice variety and fertilizer. The alternative hypothesis that gender influences incidence of adoption of improved rice variety and fertilizer is therefore accepted.

Furthermore, the results in Table 2 show that a 100 percent increase in age of the respondents reduced the probability of adoption of fertilizer only and both improved rice variety and fertilizer by 8.30 percent and 6.15 percent, respectively. This finding supports what was reported by Bekele and Drake (2003) and contradicts that of Boahene et al. (1999) who reported negative relationship between age and adoption. A 100 percent increase in number of years in school was associated with 1.26 percent increase in the probability of adoption of both improved rice variety only. This finding is consistent with that of Mugonolaa et al. (2013) who reported a positive relationship between education and adoption. Marriage reduced the probability of incidence of adoption of improved rice variety only, fertilizer only and both improved rice variety and fertilizer by approximately 5 percent, 6 percent and 5 percent, respectively. This is consistent with a study conducted by Umeh and Chukwu (2013) who reported a similar finding. A 100 percent increase in farm size was associated with 4.31 percent increase in probability of adoption of both improved rice variety and fertilizer. This suggests rice farmers increased production through area expansion and intensification. This finding supports the report by Mendola (2007) suggesting farm size is more likely to be associated with adoption, and inconsistent with that of Mugisa-Mutetikka et al. (2000) who found a neutral relationship between adoption and farm size.

Land ownership increased the probability of incidence of adoption of fertilizer only and both improved rice variety and fertilizer by approximately 10 percent and 5 percent, respectively. This finding is consistent with that of Paris et al. (2001), reporting a positive relationship between land ownership and adoption, and inconsistent with that of Arcand et al. (2007), indicating a weak relationship between tenancy arrangement and adoption of soil conservation measures. Farmers' participation in extension training programmes was associated with 1.31 percent and 3.43 percent increase in probability of incidence of adoption of fertilizer only and both improved rice variety and fertilizer, respectively. This is consistent with that of Monfared (2011) who reported similar finding. Rice farmers perception of labour intensive improved variety cultivation reduced the probability of adoption of improved rice variety only and both improved rice variety and fertilizer by approximately 8 percent and 4 percent, respectively, while their perceived labour intensive fertilizer application lowered the probability of adoption of improved rice variety only, fertilizer only and improved rice variety plus fertilizer by 7.68 percent, 8.93percent and 4.71 percent, respectively. Rice farmers' perception of capital intensive fertilizer application lowered the probability of adoption of improved rice variety only, fertilizer only and improved rice variety plus fertilizer by 5.88 percent, 4.68 percent and 4.78 percent, respectively. These findings lend support to that of Adesina and Baidu-Forson (1995), Rogers (2003) and Langyintuo and Mungoma (2008) who reported perception of the nature of technology influence adoption.

Table 2. Determinants of incidence of adoption of improved rice varieties and fertilizer: BFG First Stage

Independent variable	Improved rice variety only		Fertilizer only		Both rice variety and fertilizer	
	Coeff (Std. Err)	**Marginal effect (Std. Err)**	**Coeff (Std. Err)**	**Marginal effect (Std. Err)**	**Coeff (Std. Err)**	**Marginal effect (Std. Err)**
Gender	-1.2828 (0.4170)***	-0.0499 (0.0591)	-0.1453 (0.4745)	-0.1574 (0.0434)***	-3.7187 (0.7577)***	-0.3638 (0.0813)***
*Ln_Age	-0.5576 (0.2249)**	-0.0407 (0.0251)	-1.6143 (0.3065)***	-0.0830 (0.0222)***	-1.2932 (0.2797)***	-0.0615 (0.0252)**
Ln_Years_Sch	0.1455 (0.0950)	0.0126 (0.0104)*	0.1737 (0.1125)	0.0096 (0.0082)	0.0628 (0.1066)	0.0079 (0.0095)
Marital_Status	-1.3020 (0.2741)***	-0.0468 (0.0249)*	-1.6572 (0.3033)***	-0.0573 (0.0186)***	-1.5837 (0.2943)***	-0.0489 (0.0212)**
Ln_Farm_Size	0.4629 (0.1561)***	0.0061 (0.0187)	0.5292 (0.1850)***	0.0078 (0.0143)	0.7575 (0.1951)***	0.0431 (0.0194)**
Land_Ownership	0.6389 (0.2592)**	0.0290 (0.0272)	1.4902 (0.3225)***	0.1028 (0.0234)***	0.4048 (0.2770)	0.0461 (0.0238)*
Attend_Training_Prog	0.3483 (0.2232)	-0.0007 (0.0237)	0.4982 (0.2571)	0.0131 (0.0180)*	0.6162 (0.2480)	0.0343 (0.0213)**
Lab_Inten_Imp_Rice_Var	-0.4515 (0.2252)**	-0.0814 (0.0239)***	0.2309 (0.2619)	-0.0255 (0.0183)	-0.1774 (0.2496)	-0.0407 (0.0214)*
Lab_Inten_Fert_Use	-0.0677 (0.2409)	-0.0768 (0.0241)***	-1.3620 (0.2716)***	-0.0893 (0.0190)***	-0.8445 (0.2554)***	-0.0471 (0.0210)**
Cap_Inten_Fert_Use	-0.0040 (0.2455)	-0.0588 (0.0243)**	-0.7861 (0.2762)***	-0.0468 (0.0185)**	-0.6405 (0.2654)**	-0.0478 (0.0211)**
Ln_seed_cost	-0.1817 (0.0515)***	-0.0199 (0.0049)***	-0.2448 (0.0637)***	-0.0339 (0.0038)***	-0.1982 (0.0553)***	-0.0218 (0.0039)***
ln_TLU	-0.2270 (0.1114)**	-0.0342 (0.0113)***	-0.1349 (0.1250)	-0.0095 (0.0086)	0.0819 (0.1204)	-0.0289 (0.0098)***
Ln_Hours_Other_Eco_Act	-0.2458 (0.3471)	-0.1719 (0.0376)***	-1.6489 (0.4076)***	-0.0424 (0.0285)	-2.6795 (0.3962)***	-0.2467 (0.0343)***
Ln_Infants_cent	-1.1285 (0.5919)*	-0.0275 (0.0408)	-1.7505 (0.6059)***	-0.0748 (0.0244)***	-1.4560 (0.5940)**	-0.0408 (0.0247)*
Ln_Hours_Com_ activities	-4.6982 (0.7081)***	-0.4163 (0.0736)***	-3.7439 (0.8125)***	-0.1209 (0.0562)**	-2.6220 (0.8041)***	-0.1133 (0.0691)
Location	0.6711 (0.2966)**	0.0768 (0.0302)**	0.7448 (0.3327)**	0.0497 (0.0222)**	0.0091 (0.3073)	0.0681 (0.0250)***
Ln_Income_Other_ Crop	0.0002 (0.0002)	-0.0000 (0.0000)	0.0002 (0.0002)	-0.0000 (0.0000)	0.0007 (0.0002)***	0.0001 (0.0000)***
Gen_Land_Own	0.9099 (0.4614)**	0.0701 (0.0555)	0.9776 (0.5772)*	0.1617 (0.0458)***	1.3713 (0.5950)**	0.1455 (0.0589)**
Gen_Infants_cent	-0.6386 (0.1955)***	-0.0080 (0.0251)	-0.1843 (0.1327)	-0.0565 (0.0129)***	-1.5329 (0.2899)***	-0.1386 (0.0296)***
Gen_Location	1.3242 (0.4739)***	0.0091 (0.0581)	2.0937 (0.5538)***	0.0780 (0.0441)*	2.0679 (0.6387)***	0.0897 (0.0389)**
Constant	13.0434 (2.0447)***		16.0160 (2.4475)***		13.8671 (2.3192)***	

No. Obs = 917

LR for all coefficient chi2 (66) = 436.63***; LR for non-interacted terms chi2 (57) = 422.90***

LR for interacted terms chi2 (9) = 59.93***; Log likelihood = -551.9129

Note. * Ln refers to natural log; *, ** and *** are Significant at 10, 5 and 1 percent levels respectively.

Source: Authors own computation, 2016.

A 100 percent increase in seed cost decreased the probability of adoption of improved rice variety only, fertilizer only and both improved rice variety and fertilizer by 1.99 percent, 3.39 percent and 2.18 percent, respectively. A 100 percent increase in the total number of livestock decreased the probability of adoption of improved rice variety only and both improved rice variety and fertilizer by 3.42 and 2.89, respectively. This finding is consistent with that of Pingali, Khwaja, and Meijer (2005) who recorded that, as the level of commercial orientation increases, smallholder farmers' move away from mixed farming systems into specialized production units for the livestock production. Similarly, Alene et al. (2008) indicated that rearing of livestock negatively influences households' participation in the crop market as a result of the possibility of it interfering with farming.

A 100 percent increase in the hours used to engage in cultivation of other crops suppressed probability of adoption of improved rice variety only and both improved rice variety and fertilizer by 17.19 percent and 24.67 percent, respectively. The engagement in other crops is likely to subtract from time available to farm operator to consider and adopt improved rice technologies. A 100 percent increase in the number of infants to cater for inhibited probability of adoption of fertilizer only and both improved rice variety and fertilizer by 7.48 percent and 4.08 percent, respectively. Child care reduces the available time for other activities. A 100 percent increase in the number of hours of communal activities decreased the probability of adoption of improved rice variety only and fertilizer only by 41.63 percent and 12.09 percent, respectively. Location of a farmer in the Ashanti Region recorded 7.68 percent, 4.97 percent and 6.81 percent higher probability of adoption of the alternative technology choices than those in Upper East Region. This can be attributed to higher concentration of poverty and gender-related issues in the northern Ghana than in the Southern Ghana. A 100 percent increase in income of other crops increased the probability of adoption of both improved rice variety and fertilizer by 0.01 percent. This lends support to that of Kayizzi-Mugerwa et al. (2017) who found out that income from other crops positively influences adoption of improved rice variety.

4. Conclusions and Policy Recommendations

The study sought to test the hypothesis that gender influences incidence of adoption of the selected improved rice technologies. Overall, the model fit statistics results indicate a good model fit with the predictor incidence of adoption of the selected improved rice technologies. The Multinomial probit estimates show that education, farm size, land ownership, participation in extension training program, hours of family labour available, location, and income from other crops enhanced the probability of adoption, while age, marriage, perception of high labour demand and capital intensity of technology, total number of livestock, seed cost, hours spent on other economic activities, child care and hours of communal activities inhibited incidence of adoption of improved rice technologies. The results show that female engagement in child care and limited access to land jointly influenced female incidence of adoption. Whereas the joint effect of gender and other variables (land ownership and child care) on the adoption of improved rice variety only was not statistically significant, their effects on the adoption of fertilizer only and both improved rice variety and fertilizer were statistically significant.

Based on the findings, the following policy recommendations are proposed:

(1) Given that access to land enhanced adoption and land ownership is passed on to males in the northern part of Ghana, government should facilitate the development of land market to improve land access for women, especially in the north.

(2) Given that extension training program enhanced adoption but females recorded lower rate of participation, MoFA should ensure that the timing and location of training should not interfere with women's participation in domestic activities. Thus, MoFA should collaborate with key stakeholders such as farmers, input dealers and NGO's to embark on on-farm training of the farmers.

(3) Because target group has negative perception that technology is labour demanding and capital intensive, MoFA should address the negative perception, either real or imaginary, through education. In addition, Researchers should identify more efficient means of accomplishing the agronomic practices that are found to be labour-intensive.

(4) Due to the fact that child care inhibited female incidence of adoption, Ministry of Gender, Children and Social Protection should facilitate the development of childcare support network in rural areas to enhance female adoption of improved rice technologies.

(5) Since the joint effect of gender and land ownership as well as child care was greater than the individual and interaction effects, policy makers should design interventions to address all the gender related issues to enhance incidence of adoption of improved rice technologies. Also, there should be affirmative action to create awareness of the effect of gender on the farm households, the communities and the nation at large.

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Notes

Note 1. The influence of gender on incidence of adoption is not only derived from the marginal effect of the gender variable alone but also the corresponding interaction terms. Hence, the first derivative of equation: Joint effect = a(gender) + b(gender)(land ownership) + c(gender)(Infants) + d(gender)(location). The first derivative of the equation was evaluated at the mean values of the gender-related variables.

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