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Gender, selected agricultural innovations and intra-household income in Ghana

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Abstract

This paper assesses the role of gender in intra-household income in Ghana. Household equity in income is a key objective of societies. The study utilizes a primary dataset generated from nine hundred and seventeen (917) rice farming households in Ghana and employs a two-stage Bourguignon, Fournier, and Gurgand (BFG) selection bias correction model in the empirical analysis. An analysis shows that gender is associated with intra-household income. The result suggests that farm size positively and significantly affects rice farmers' net returns, whereas child care negatively affects net returns. The result further shows that, on the average, the male rice farmers' registered a higher net return than their female counterparts. The study recommends that, in order to ensure equity at farm household level, the government should not only invest in the development and promotion of appropriate improved rice technologies but also ensure equal access to land and participation in domestic work.

Keywords: Equity; gender studies; Ghana; net returns; technological innovations

1. Introduction

Gender affects the social structures of rural producers and their values or ‘culture’. This is because the cultural norms governing the division of labour and resources between men and women (which often disadvantage women) are usually more deeply entrenched in rural areas. Thus, satisfactory analyses of processes of change in rural societies have to embrace gender issues. Indeed, women are often the poorest and most vulnerable members of the rural community, and girls are often subjected to greater neglect than their male siblings (Fikree and Pasha, 2004). Within our societies, men are valued more than women, creating power imbalance between them (Bhasin, 2006). Also, studies have shown that household activities are highly gendered and reproductive activities disproportionately fall on women and girls (Antonopoulus and Hirway, 2010).Women and girls shoulder greater responsibility for unpaid care work (making babies, cooking and providing food for the family and undertaking all the cleaning and menial activities around the home), which are time consuming and challenging (Kes and Swaminathan 2006). Women engagement in reproductive activities prevents them from actively getting involved in income earning activities that require additional investments of time (Gammage et al., 2005; Kaaya et al., 2007). Women and girls problems are compounded in rural areas where there are poor infrastructure and limited investment in childcare support network. Like poverty, gender concerns are not exclusive to rural development but gender-related poverty is often hardest to tackle in rural areas.

In rural households, participation in agriculture is just one of many livelihood activities carried out by the populace (Diao *et al.*, 2010). Apart from being a major source of income, agriculture is one of the many lifestyles and practices that characterise rural life. However, agriculture is characterised by subsistence farming and mostly carried out by smallholder farmers. These farmers see agriculture as a way of life – an embodiment of the culture and values of a particular society. As a result, agriculture is governed by a complexity of norms, beliefs and practices that determine individual household members' roles, rights, expectations, obligations, responsibilities and entitlements within and beyond households (Manyire, 2011). The governing norms, beliefs and practices are gendered. Gender, therefore, impacts on the agricultural activities carried out by rural household members (comprising men and women, boys and girls). There is enough evidence to show that gender explains unequal access to key agricultural resources at farm households (Laven et al., 2009). Due to the fact that agriculture provides employment for the majority of the rural populace, the gender gap in agricultural resources has implications on income and distribution.

A situational analysis suggests that Ghana's agricultural sector is underperforming, partly due to low impact of agricultural innovations (MoFA 2009). Agricultural innovations are improved agricultural technologies and practices that are promoted and disseminated in Ghana's agricultural sector to help farmers find smart ways to use the natural resources required to grow food more efficiently (Feder and Umali 1993). Studies have indicated that the main objectives of promoting and disseminating agricultural innovations are to enhance yield, improve food security, increase incomes and reduce poverty (Norton 2004). In this study, selected improved rice technologies are used as a case study because rice is currently the most important food and cash crop among cereals, and has the highest economic potential among major food crops such as yam, cassava and plantain in Ghana (Nin-Pratt et al. 2009). According to Diagne et al. (2009), improved rice technologies are described as the application of knowledge, skills and farm methods, farm inputs, tools and machinery as well as the environmental arrangement and procedures to enhance rice productivity.

The adoption of the improved rice technologies has implications for household food security and poverty reduction. For instance, Awotide *et al.* (2012) have recorded that poverty levels are higher among non-adopters (51%) of improved rice technologies than among adopters (46%). Moreover, a 1 percent increase in improved rice yields have been shown to reduce the number of people experiencing food insecurity by about 4.6 percent and reduced the length of the hunger season by about 33 percent in Madagascar (Minten and Barret, 2008). Furthermore, an adoption of improved rice technology has been linked to the farmers' income and distribution. After the desk review, it was found out that the available literature suggests a controversy surrounding the impact of adoption of improved rice variety on male and female rice farmers' income For instance, studies have shown that adoption of improved rice variety (NERICA) has skewed income in favour of female rice farmers (Diagne, 2006; Agboh-Noameshie *et al.*, 2007), whereas another study has recorded that adoption has skewed income in favour of male rice farmers (Dontsop-Nguezet *et al.*, 2011). Thus, the linkage between technology adoption, gender, intra-household income and distribution is so far not clear.

Due to the economic notion of equity, gender analysis of the distributional effects and benefits of adoption of improved rice technologies are of immense importance to policy makers. Drafor (2014) has described gender analysis as a set of processes for assessing and deepening understanding about the differences in the lives of males and females, their participation in social and economic life, and the differential impacts of policies, programmes and services on their lives. Hunt (2004) points out that gender analysis makes it possible to evaluate the differential effects of development efforts on a target group, towards sustainability and gender equality in farm households. Therefore, to address this knowledge gap, this study sought to evaluate the link between gender and intra-household income in Ghana. The main objective includes assessing the effect of gender on farmers' net returns. The hypothesis is that gender is likely to skew rice income in favour of males.

This study is relevant because it would generate significant gains for the rice sector and for the country at large. The specific contributions of the study are: First, the study would provide sex-disaggregated data at the farm household level; Second, it would make important contributions to limited literature on gender and innovation; Third, it would give insights to guide policy in terms of the way forward to achieving income equity at the farm household level in Ghana; Fourth, the study would address the goal five (achieve gender equality and empower all women and girls) of the Sustainable Development Goals. The debate on how to improve technology adoption in a sustainable way, based on appropriate strategies and policies is unfolding, and the empirical context this research provides will enhance the discussions.

The paper is organized into four sections. The introduction is followed by section two, which describes the empirical model specification and estimation technique used in the analysis as well as a general description of the data used, while the estimated results are given in section three. Conclusions and recommendations are discussed in section four.

2.0 Materials and Methods

Theoretical Model Specification

This study aims at assessing the effects of adoption of improved rice technologies on intra-household income and distribution in Ghana. Basically, a two-step method has been found to be more appropriate to address the issue of selection bias in the sampled data, most especially when a selection is over a large number of mutually inclusive choices such as this study. Lee (1983) and Dubin and McFadden (DMF) (1984) have suggested two traditional approaches to be used in such a situation. However, Lee's method estimates a single selectivity effects for all choices together and DMF method establishes M−1 selection terms for the M choices, which cannot fully address the selection bias issue arising from multiple choices of adoption options. According to Lokshin and Sajaia (2004), the Full Information Maximum Likelihood (FIML) method can also be used for the estimation of the selection and outcome equations simultaneously. This approach surmounts the disadvantage of estimating the equations individually, which produces residuals that are heteroskedastic. Due to the fact that the selection is over a large number of mutually inclusive choices, the initial method is inappropriate to adopt. As a result, this study engaged a selectivity correction approach proposed by Bourguignon, Fournier, and Gurgand (BFG) (2007), which is more accurate in identifying selectivity effects created by different choices (Khanal and Mishra 2014).

For efficient and consistent estimation, we employed the BFG (Bourguignon, Fournier, and Gurgand), in compliance with Ma and Abdulai (2015). The BFG employed Multinomial Probit (MNP) regression estimates, in the first stage, to determine the factors that influence the alternative choices of rice producers. The MNP was used because in the diffusion of bundle of technologies, rice farmers' adoption decision is a dependent and joint process. Thus, MNP has errors which are not independent, and are distributed by a multivariate normal distribution (Greene 2003). The theoretical reasoning of the MNP is that rice farmers are risk neutral, and consider the best option in their decision-making process (Katchova and Miranda 2004).

Greene (2012) suggested that, in a non-linear model such as MNP, the estimated coefficients cannot be directly interpreted, hence, we computed the marginal effects to provide a clearer interpretation about the magnitudes of the coefficients. Suarez (2010) described the marginal effect as the change in probability of the dependent variable as a result of either an infinitesimal change in continuous independent variable or a discrete change in the binary independent variable. According to Huesca and Camberos (2010), the estimator variances were all bootstrapped with replications due to the generated regressor issue in two step procedures and also to deal with heteroscedasticity.

The second stage of the estimation of the BFG includes two impact assessment methods to address the selectivity bias that usually results from the sampled data. These methods are Propensity Score Matching (PSM) (using probit model), which accounts only for observable factors (Dehejia and Wahba 2002; Lokshin and Sajaia 2004), and Endogenous Switching Regression (ESR) model, which accounts for both observable and unobservable factors. Dehejia and Wahba (2002) have indicated that PSM collates outcomes between a specific type of adopters ('treated') and the non-adopters ('controlled') that are similar in terms of observable characteristics, to reduce the bias that would otherwise occur when the two groups are completely different. PSM method entails two stages: first, we generate propensity score (i.e. the probability) of choosing the given adoption option using a probit model; and second, we calculate the average treatment effect on the treated (ATT) based on the estimated propensity score. The ESR is a parametric approach that uses two different estimation equations for a given adoption option alternatives, by including an inverse Mills ratio to account for selection bias (Lokshin and Sajaia 2004).

In order for the BFG model to properly explain the selection bias and the differences across groups (endogeneity), the selectivity terms for unbiased estimation of net revenue equations are added. Since four types of adoption options are specified for this study, the estimates added four selectivity correction terms which have the following econometric interpretations: (1) if at least one of them is significant, this would indicate the presence of sample selectivity effects arising from unobservable factors (in this case, the ESR model is appropriate in analysing the causal effect of the given adoption choice); and (2) if none of the selectivity correction terms is significantly different from zero in the net revenue specification equation, this shows the absence of selection bias arising from unobservable factors (in such a situation, PSM technique is employed to ascertain the related casual effects). Hence, the predicted coefficients will be biased and inconsistent if the correction terms are not added to the related net revenue equations. Lokshin and Sajaia (2004) have recorded that, for each net revenue equation specification, a positive (negative) coefficient of the selectivity term indicates higher (lower) net revenue for the farmers, relative to a randomly chosen producer. Bourguignon et al. (2007) have concluded that farmers with worse unobserved endowments are more likely to settle on a particular type of improved rice technology rather than other alternatives.

Empirical Model Specification

The study assumes that farmer **i** compares the expected net returns from choosing a specific adoption option (C_{ij}^{A}) to that obtained from not adopting (C_{ij}^{N}). The rational individual chooses best available option, if $C_{ij}^{A} - C_{ij}^{N} > 0$. Although at the time of the survey, the preferences of the farmers were not known to the researcher, issues such as the farm and household-level characteristics of the individual farmers as well as the attributes of the technologies were observed during the survey. Therefore, this study can represent the net returns from adoption of a technology by a latent variable $C*_{ij}$, such that:

$$C_{ij}^{*} = Z_{Yij} + n_i \text{ .... } (1)$$

$$C_{ij} = 1 \quad \text{if } C_{ij}^{*} > 0$$

$$C_{ij} = 0 \qquad \text{if } C_{ij}^{*} \leq 0$$

Where C_{ij} is a binary indicator variable that equals 1, if the individual adopts the selected technology and 0 if the individual does not adopt it. When the first adoption option is considered ($j = 1$), the first step of the BFG method is given as:

$$Y_i = 1...j = \beta_0 + \beta_1\chi_{1i} + \beta_2\chi_{2i} + ... + \beta_n\chi_{ni} + \varepsilon \text{ .... } (2)$$

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, number of adults, number of infants, total rice land holding, time allocated to other economic activities, number of hours of family labour and number of livestock owned are continuous non-negative variables, whereas gender (participation in domestic work), land ownership, participation in relevant extension training programs are dummy variables coded with 1 for yes and 0 for otherwise.

The study evaluated the effect of adoption on net returns per an acre of respondents' rice farm. Net returns refers to gross sales minus the cost of sales, including cost of goods sold. The distribution of rice net revenue was not normal so it was transformed in logarithmic form. The outcome variable, the net revenue from rice production, was derived from the difference between total revenue (TR) and total cost (TC). In principle, an increase in net revenue (NR) results from either a decrease in the real price of inputs (O_i) or an increase in the real price received for output (P_q) (Key *et al.*, 2000; Iliopoulos, 2013). Let ΔTC_i^p and ΔTC_q^p represent a proportionate change in cost per unit of input (I) and a proportionate change in price per unit of output (Q) respectively. The adjusted input price is then given as $O_i^j = O_i + \Delta TC_i^p$ while for that output price is $P_q^i = P_q + \Delta TC_q^p$. Meanwhile, let TC_i^f and TC_q^f denote fixed TC for input used for output produced out of improved rice cultivation, respectively. Given these assumptions, farmers maximize their net revenue ($\pi *$) as:

$$\pi^* = \max\left[TR - [Q(P_q - TC_q^p) - (Q_i - TC_i^p)I - TC_q^f - TC_i^f]\right] \tag{3}$$

From Equation (3), a reduced-form of gross profit function in which the gross profit from rice production are determined by the output and input variable prices. A proportional TC for input and output market participation, and household, individual and farm-level characteristics (Z) can be expressed as:

$$\pi = \pi(P_q, O_i, TR, TC_q^p, TC_i^p, Z) \tag{4}$$

where Z represent household and farm-level characteristics.

The econometric model estimation technique

It is supposed that farmer i compares the expected net returns from choosing a specific adoption option (C_{ij}^A) to that obtained from not adopting (C_{ij}^N). The rational individual chooses best available option, if $C_{ij}^A - C_{ij}^N > 0$. Although the researcher did not have initial information about the preferences of the farmers during the time of the survey, the farm and farmer characteristics and attributes of the technologies were known by the researcher. Therefore, the net benefit from adoption of an improved technology can be represented by a latent variable C^*_{ij} as:

$$C^*_{ij} = Z_{Yij} + n_i \tag{5}$$

$$C_{ij} = 1 \text{, if } C^*_{ij} > 0 \text{ and } C_{ij} = 0 \text{, if } C^*_{ij} \leq 0$$

where C_{ij} is a binary indicator variable that equals 1, if the individual adopts the technology, and 0 if the individual does not adopt it, and n_i represents the error term.

The issue of impact analysis

In order for the study to evaluate the effect of any of the adoption choices on the outcome variables, it is assumed that net revenue is a linear function of a vector of explanatory variables (X_{ij}) and an adoption choice dummy (C_{ij}):

$$Y_{ij} = \beta X_{ij} + \delta C_{ij} + \mu_i \tag{6}$$

where Y_{ij} is the net revenue from rice production (captured in Ghanaian currency) for adopting improved rice variety ($j = 1$), fertilizer ($j = 2$) and the combination of both improved rice variety and technology (j=3); β and δ are parameters to be estimated; μ_i is an error term that satisfies μ i~ N(0, σ), i.e. corr $(n_i, \mu_i) \neq 0$) (the correlation coefficient between μ and η in equations (5) and (6)). The issue of selection bias arises if unobservable characteristics affect both the error terms (n_i , μ_i) in Equations (5) and (6), resulting in a correlation between the two error terms.

BFG method

The second-stage of the BFG method involves the estimation of the impact of adoption on net revenue, using ordinary least square (OLS) regression, where the selectivity correction terms estimated in the first-step are simultaneously included to obtain unbiased and consistent estimation. In order to examine the effect of adoption of the alternative choices on intra-household net revenue, we assumed that net revenue obtained in the farm household is a linear function of a vector of explanatory variables (X_{ij}) and an adoption choice dummy (C_{ij}):

$$Y_{ij} = \beta X_{ij} + \delta C_{ij} + \mu_i \ldots\ldots\ldots\ldots\ldots \quad (7)$$

Where Y_{ij} is the net revenue captured in Ghana cedis for adopting improved rice variety ($j = 1$), fertilizer ($j = 2$) and both technologies (j=3); β and δ are parameters to be estimated; μ i is an error term that satisfies μ i~ N(0, σ).

Given that the adoption option one is chosen ($j = 1$), the outcome equation for net revenue, γ_1 is specified as:

$$\gamma_1 = X\beta_1 + \delta_1 \left[\rho_1^* m(P_1) + \rho_2^* m(P_2)\frac{P_2}{P_2 - 1} + \rho_3^* m(P_3)\frac{P_3}{P_3 - 1} + \rho_4^* m(P_4)\frac{P_4}{P_4 - 1} \right] + \omega_1$$

…… (8)

For unbiased and consistent estimation, the selectivity correction terms ($\eta_1^*, \eta_2^* and \eta_3^*$) estimated in the first-step are simultaneously included in equation (7) as follows:

$$\gamma_1 = X\beta_1 + \delta_1 \left[\rho_1^* m(P_1) + \rho_2^* m(P_2)\frac{P_2}{P_2 - 1} + \rho_3^* m(P_3)\frac{P_3}{P_3 - 1} + \rho_4^* m(P_4)\frac{P_4}{P_4 - 1} \right] + \eta_1^* + \eta_2^* + \eta_3^* + \eta_4^* + \omega_1$$

………….. (9)

Where $m(P_1)$, $m(P_2)$, $m(P_3)$ and $m(P_4)$ are the conditional expectations, $\eta_1^*, \eta_2^*, \eta_3^* and \eta_4^*$ are used to correct for selectivity effects; ρ represents correlation coefficients between μ and η in equations (5) and (6); σ is the standard deviation of the disturbance term from the net revenue equation; and ω_1 is the error term.

The Endogenous Switching Regression (ESR) model
Given the adoption choice and outcome equations specified in (5) and (6), respectively, the relationship between the choice of adoption option and the two regimes can be specified as:

$$C_1^* = Z\gamma_1 + \eta_1 \quad (10)$$

$$Y_1 = X\beta_1 + \varphi_1 \quad \text{if } C_1 = 1 \quad (10a)$$

$$Y_0 = X\beta_0 + \varphi_0 \quad \text{if } C_0 = 0 \quad (10b)$$

Where, Y_1 represents net revenue, if the first adoption option is chosen ($j = 1$), and Y_0 is net revenue derived from choosing other adoption options ($j \neq 1$); X is a vector of exogenous variables that affect the net revenue; φ_1 and φ_0 are error terms, with zero mean and normal distribution.

After estimating the model using the selection Equation (10), the inverse Mills ratios λ_1 and λ_0, and the covariance terms $\sigma_{n1} = \omega v(\eta_1, \varphi_1)$ and $\sigma_{\eta 0} = \omega v(\eta_1, \varphi_0)$ can be calculated and plugged into Equations (10a) and (10b) as follows:

$$Y_1 = X\beta_1 + \sigma_{\eta 1}\lambda_1 + \zeta_1 \quad \text{if} C_1 = 1 \quad (11a)$$

$$Y_0 = X\beta_0 + \sigma_{\eta 0}\lambda_0 + \zeta_0 \, \text{if} C_0 = 0 \quad (11b)$$

where λ_1 and λ_0 control for selection bias resulting from unobservable factors such as the local institutional environment and farmers' inheritability; the error terms ξ_1 and ξ_0 have conditional zero means.

The correlation coefficients, $\rho_{\eta 1}(\sigma_{\eta 1} / \sigma_{\eta}\sigma_{1})$ and $\rho_{\eta 0}(\sigma_{\eta 0} / \sigma_{\eta}\sigma_{0})$ of covariance terms between the error terms $\eta_1, \varphi_1 and \varphi_0$ have econometric interpretations. If $\rho_{\eta 1}$ or $\rho_{\eta 0}$ is significant, this would indicate the presence of selection bias arising from unobservable factors. Moreover, $\rho_{\eta 1} > 0$ implies negative selection bias, suggesting that farmers with time below the average time are more likely to choose the given adoption, while $\rho_{\eta 1} < 0$ implies positive selection bias. The consistent estimation also requires that the correlation coefficient $\rho_{\eta 1}$ in ESR model and the coefficients of the significant selectivity bias terms $m(P_j)$ in BFG model for the given adoption option have opposite signs.

The effect of adoption of any of the alternatives on net revenue is examined by specifying expected values of the outcomes. The change in net revenue due to a specific adoption option relative to another choice is specified as the difference between the two adoption options. These estimates are termed average treatment effects on the treated (ATT).

The $ATT t_{ATT}^{ESR}$ in this case is:

$$t_{ATT}^{ESR} = E\left[Y_1 \mid C_1 = 1\right] - E\left[Y_0 \mid C_1 = 1\right] = X(\beta_1 - \beta_0) + (\sigma_{\eta 1} - \sigma_{\eta 0}) \quad (12)$$

The PSM technique

PSM can be expressed as:

$$\Pr(X_1) = \Pr(C_1 = 1 \mid Z_1) = E(C_1 \mid Z_1) \quad (13)$$

Where $C_1 = \{0,1\}$ is an indicator for choosing the given type of adoption option ($j = 1$) and Z_1 is a vector of pre-choice characteristics. After estimating the propensity scores, the ATT, t_{ATT}^{PSM} can then be estimated as:

$$t_{ATT}^{PSM} = E_{p(z_1)D_1=1}\left\{E\left[(Y_1 \mid D_1 = 1, P(Z_1)\right] - E\left[(Y_0 \mid D_1 = 1, P(Z_1)\right]\right\}$$
(14)

Several techniques have been developed to match the given adopters and non-adopters of similar propensity score (nearest neighbour matching (NNM), kernel-based matching (KBM) and radius matching methods). In this study, we employed the radius matching method to estimate the ATT.

2.2 Data and Description

The study had recourse to a cross-sectional survey data obtained from the Kassena-Nankana and the Atwima Nwabiagya Districts in the Upper East and the Ashanti Regions of Ghana, respectively The survey was carried out between November 2015 and February 2016. A multi-staged sampling technique was used. First of all, the regions, districts and communities were purposively sampled, on the bases of the following criteria: (1) the cultural differences; (2) long history of rice production; and (3) long engagement in improved rice cultivation. In the second stage, a proportionate sampling of rice producers from the selected communities was done. The final stage comprised of randomization of the respondents, employing computerized random numbers. The total sample size used for this study was 917, representing 546 males and 371 females. This number constituted 516 adopters and 401 non-adopters. A total of 440 and 477 rice producers were selected from Atwima Nwabiagya and Kassena Nankana Districts, respectively. The unit of analysis was at the individual rice plot level.

The data collection instrument gathered ample information on rice farmer and households' characteristics, institutional factors influencing technology adoption, hours spent in carrying out domestic activities and rice production activities were sought from the individual respondents. Both qualitative and quantitative surveys, utilizing personal recall interview with the use of well-structured questionnaire and checklist, were utilized to gather enough data for the study during reconnaissance visit and individual interviews. The cross sectional data collected from the respondents was used for the outcome equation. Furthermore, data on gross profit of individual rice farmers was collected. Again, informal discussions were used to explore issues of concerns regarding rice farmers, and key observations were also made. This provided additional informal data for the interpretation of the quantitative data and provided necessary recommendations for the study. Finally, the control group was used as a reference group to approximate the effect of adoption on the respondents' rice income.

Different renowned authors such as Bem (1981), Clark et al. (2005) and Wylie et al., (2010) have measured gender from different perspectives. For instance, Bem (1981) has measured gender by the levels of masculinity, femininity and androgyny. The masculinity and femininity scale of Bem Sex Role Inventory (BSRI) assesses how people identify themselves psychologically. Clark et al. (2005) measured gender by appearance conformity, whilst Wylie et al. (2010) have measured gender by gendered appearance and gendered mannerisms. Overfields and Fleming (2001) have defined gender by the sex of the respondents, and used the sex of the respondent as a proxy for 'gender' (1=male; 0 =otherwise). Due to the notion that gender is a social construct, this study measured gender by the level of participation in the domestic work. This was conceptualized by segregating the respondents into two main groups: those who contributed at least 50% of the total time (hours) used to engage in domestic activities daily. For example, if a respondent accords at least 50% of the total time (hours) used to engage in domestic activities, it suggests that domestic activities are gendered in favour of the respondent. The gender was a dummy variable which was added to the equation to investigate its effect on the respondents' income and distribution.

3. Results and Discussions

3.1 Descriptive Results

Summary Statistics

Table 1 presents the descriptive of the variables considered in the subsequent models. The table describes the mean values as well as the t-test values of the mean differences with regards to adopters and non-adopters. Leinbach (2003) has reported that socio-economic characteristics are relevant factors to consider since they are likely to determine rice producers' adoption decisions. In many African contexts, for example, age and sex could affect a person's contribution to decision making in the farm households.

Apart from the total family labour hours which was insignificant, the t-test results are all highly significant, suggesting there are differences in the mean values of the variables.

Table 1: Summary Statistics for Adopters and Non-Adopters of Improved Rice Variety, Fertilizer, and Fertilizer and Improved.

Variable	Adopters (n=516)	Non-Adopters (n=401)	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)***
Number of Adults (number)	8.35 (2.74)	7.62 (2.51)	0.74 (4.25)**
Farm (plot) 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)***
Seed cost (GHS)	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 of Other Economic Activity (hours)	20.45 (18.29)	44.86 (29.49)	-24.41 (-14.54)***
Income from Other Crops (GHS)	298.32 (572.85)	224.57 (478.35)	73.75 (2.12)**
Total Family Labour Hours (**hours)	539.11 (194.33)	524.53 (169.26)	1Table 4.58 (1.21)

Source: Field data, 2016.

Values in parentheses are standard deviation and *, **, *** denotes 10%, 5% 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 respective tropical livestock units. The livestock reared by respondents in the study area are cattle, sheep, goat, donkey, pig, duck, chicken/ guinea fowl.

** Hours are captured on a weekly basis

Furthermore, the results indicate that only 22 percent of the adopters contributed at least 50 percent of the total time (hours) used to carry out domestic activities daily, whereas the non-adopters recorded 81 percent.

From Table 1, adopters registered an average age of 43.87 years, as compared to that of non-adopters (50.95 years). The age difference could be explained by the fact that improved rice cultivation is labour demanding and is likely older rice farmers 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). This result support that of Abdullah and Samah (2013) who reported low level of interest in farming by the young generation. Adopters' household recorded a greater number of adults (8.35) than non-adopters (7.62). According to Brons (2005) and Minot (2006), the number of adult members of a household is related to labour availability for economic activities.

On the average, the adopters' farm size was larger (3.86 acres), as compared to the non-adopters (3.10 acres). This result is surprising because it was expected that since improved rice cultivation is labour intensive, adopters were more likely to cultivate smaller acreages than non-adopters. It result could be explained by the fact that rice has become both a staple and cash crop and rice farmers increase production through area expansion and intensification. However, this result lends support to what was recorded by MoFA (2011), that about 90 percent of farm holdings in Ghana cultivate less than 2 hectares in farm size. Land ownership plays a critical role in every farming practice. According to FAO (2010), land ownership significantly contributes to increased and/or sustained levels of agricultural production. Also, Shultz et al. (1997) have indicated that land ownership greatly influences farmers' adoption decision. Overall, 66 percent of adopters owned land, whereas that of non-adopters was 36 percent. About 39 percent of adopters received relevant extension training as compared to only 18 percent of non-adopters.

Adopters spent GHS142.33 on improved seeds. Moreover, non-adopters utilized their own traditional rice seeds. The livestock numbers were converted to a common unit known as Tropical Livestock Units (TLU). Overall, adopters registered a larger number (1.89) of livestock units than the non-adopters (0.99). On the average, the adopters recorded 2.26 infants as compared to about twice (3.57 infants) of that of non-adopters. Adopters allocated 20.45 hours per week to other economic activities, whereas the non-adopters recorded 44.86 hours. However, on the average, the adopters obtained a higher income (GHS298.32) from other crops than non-adopters (GHS224.57). Due to the fact that farmers lack credit, income from other crops is likely to relax respondents liquidity problem.

3.2 The impact of adoption of improved rice variety and fertilizer on intra-household rice income distribution

The study tested the hypothesis that gender is likely to skew rice income in favour of males. Here, an emphasis is laid on the gender analysis sex- disaggregation data at the household level as a result of adoption of the selected improved rice technologies. This section concludes on the testing of the hypothesis that adoption of the selected improved rice technologies widened the intra-gender income distribution.

3.2.1 The effect of farmers' adoption choices on net revenue per acre: second-stage BFG estimation

This study is a follow up on a study published last year which focused on determining the determinants of adoption of the selected improved rice technologies. Therefore, the results of the first stage of the BFG, using MNP model to determine the determinants of adoption, is not interpreted in this report. Rather, the results of the second-stage (using OLS regression, in addition to selection bias correction terms derived during MNP model estimate) are interpreted in this report (see Table 2). The Wald test was used to test whether the value of the parameter (either all coefficients or non-interacted terms or interacted terms) is associated with respondents' incidence of adoption. Since all the values of the Wald test for all coefficients and non-interacted terms are significant, it suggests that the parameter has an association with the incidence of adoption. The significant values of Wald test for interacted terms ranges from 1 percent to 10 percent. The results of the R-squared (a goodness of fit measure) show that the descriptive power of regression models for non-adopters, improved rice varieties adopters, fertilizer adopters and improved rice variety and fertilizer adopters are 48.23 percent, 58.67 percent, 60.81 percent and 68.61 percent, respectively.

Table 2: Impact of adoption on net income: second stage BFG estimation

Independent variable	No Adoption (n=401)		Improved Rice Variety only (n=164)		Fertilizer only (n=103)		Rice variety plus fertilizer combination (n=249)	
	Coeff (Std Err)	t-value	Coeff (Std Err)	t-value	Coeff (Std Err)	t-value	Coeff (Std Err)	t-value
Gender	-0.4594 (0.2952)	-1.26	-0.3326 (0.3811)	-0.87	-0.5861 (0.3330)	-1.76*	-0.4512 (0.2498)	-1.81*
Ln_Age	0.0679 (0.0892)	0.76	-0.1938 (0.0565)	-3.43***	-0.1717 (0.0878)	-1.95*	-0.0592 (0.0397)	-1.49*
Ln_Adult_size	0.6624 (0.1894)	3.50***	0.7917 (0.2026)	3.91***	0.8466 (0.2321)	3.65***	1.0201 (0.0955)	10.68***
Ln_Farm_Size	0.0984 (0.0420)	2.34**	0.1863 (0.0561)	3.32***	0.1146 (0.0671)	1.71*	0.0747 (0.0338)	2.21**
Land_Ownership	0.7675 (0.2180)	3.52***	-0.1535 (0.1831)	-0.84	-0.0968 (0.2577)	-0.38	-0.0234 (0.0921)	-0.25
Attend_Training_Prog	-0.0457 (0.1611)	-0.28	0.2033 (0.1491)	1.36*	0.0877 (0.1607)	0.55	0.0006 (0.0783)	0.01
Ln_seed_cost	-0.0068 (0.0214)	-0.32	-0.0235 (0.0110)	-1.18	-0.0250 (0.0238)	-1.05	-0.0237 (0.0096)	-2.47**
Ln_TLU	0.0016 (0.0372)	0.04	-0.0171 (0.0210)	-0.57	0.0352 (0.0270)	1.30	0.0099 (0.0144)	0.69
Ln_other_crop_income	-0.0056 (0.0223)	-0.25	0.0085 (0.0363)	0.23	0.1358 (0.0476)	2.85**	0.0573 (0.0347)	1.65*

Ln_Tot_Fam_Lab_Hours	1.6073 (0.2331)	6.90***	2.0734 (0.2065)	10.04***	1.8543 (0.2839)	6.53***	2.1241 (0.1178)	18.03***
Ln_Infants_cent	-0.0778 (0.1332)	-0.58	-0.1634 (0.0782)	-2.09**	-0.1245 (0.0859)	-1.45*	-0.0887 (0.0333)	-2.67***
Location	0.2824 (0.2456)	1.15	0.2795 (0.2222)	1.26	0.0710 (0.2040)	0.35	0.2615 (0.1117)	2.34**
Gen_Ln_Infants	0.0505 (0.1518)	0.33	-0.0780 (0.2663)	-0.29	-0.4443 (0.2282)	-1.95*	-0.0260 (0.0706)	-0.37
Gen_Location	-0.6626 (0.2910)	-2.28**	-0.4712 (0.1988)	-2.37**	0.0878 (0.3790)	0.23	-0.6946 (0.2413)	-2.88***
Mills0	0.1798 (0.0758)	2.37**	0.0007 (0.0073)	0.10	-0.0001 (0.0066)	-0.02	0.0005 (0.0028)	0.18
Mills1	-0.0096 (0.0131)	-0.74	0.0020 (0.0101)	0.20	0.0015 (0.0151)	0.10	-0.0048 (0.0051)	-0.93
Mills2	0.0072 (0.0134)	0.54	-0.0073 (0.0114)	-0.65	-0.0030 (0.0120)	-0.25	0.0103 (0.0054)	1.92
Mills3	0.0077 (0.0099)	0.78	0.0150 (0.0119)	1.26	-0.0006 (0.0076)	-0.08	0.0064 (0.0075)	0.86
Constant	12.9685 (7.8474)	1.65*	15.2192 (6.2244)	2.45**	7.2933 (3.7873)	1.93*	7.9742 (1.5134)	5.27***
Adj. R-squared	0.4823		0.5867		0.6081		0.0.6861	
Wald test for all coefficient	F(20,381)=2.22***		F(20,144)=4.12***		F(20,81)=2.78***		F(20,229)=2.30***	
Wald test for non-interacted terms	F(13,381)=71.51***		F(13,144)=80.45***		F(13,81)=80.95***		F(12,229)=460.57***	

Wald test for interacted terms	F(4,381)=2.58**	F(4,144)=2.34*	F(4,81)=2.38**	F(2,229)=2.82**

Source: Survey data, 2016.
Note: values in parentheses are standard errors, *,** and *** are Significant at 10, 5 and 1 percent levels respectively; ln is natural log; cent is centred; and reference location is the Kassena Nankana District in the Upper East Region of Ghana.

The results show insignificant selectivity correction in terms of the farmers' alternative adoption choices. (see Table 2). Hence, PSM was used to estimate the average treatment effect (ATT) after estimating propensity scores (see Annex 2 Tables 2A – 2C).

From Table 2, age variable has a negative and significant effect on net income, suggesting older farmers recorded a lower net rice income per acre as compared to the younger ones. The number of adult household members' variable has a positive and significant effect on respondents' net rice income, showing that their labour contribution increased net rice income per acre in the farm household. Farm size has a positive and significant effect on net income of rice producers in the study area. Again, the effect of farm size on net income was greater among adopters than non-adopters, signifying in addition to area expansion, adopters increased rice production through intensification. Land ownership has a positive and significant effect on non-adopters' net income, implying non-payment of land rent by non-adopters is likely to increase their net income. Attending relevant extension training programs has a positive and significant effect on adopters of improved rice varieties' net income, showing training enhanced efficiency of production.

Seed cost has a negative effect on adopters of improved rice variety plus fertilizer's net income. Other economic activities variable has a positive and significant impact on net income, signifying income from these sources assisted adopters of fertilizer only and adopters of improved rice variety plus fertilizer combination to finance their rice production activities. It was found out during focus group discussions that because they depend on rain-fed agriculture and rice is water loving crop, they grow rice once in a year instead of twice per year. As a result, after harvest, they engage in the cultivation of other crops to supplement rice income. Therefore, income from other crops helped rice farmers to invest in improved rice cultivation. Hours of family labour has a positive and significant impact on net income, suggesting family labour played a critical role in rice producers' net returns.

Child care variable has a negative and significant impact on adopters' net income, indicating nursing mothers were constrained with time (labour) to engage in improved rice cultivation; hence, recorded lower net income. Location has a positive and significant impact on net income, suggesting adopters of improved rice varieties plus fertilizer combination in the south obtained higher net income than those in the north.

Gender variable has a negative and significant effect on net income, showing participation in domestic work decreased adopters of fertilizer only and adopters of improved rice variety plus fertilizer combination's net income per acre. The interaction term of gender and child care has a negative and significant effect on net income, signifying among the domestic activities, child care was the main activity that decreased the net income of adopters of fertilizer only and adopters of improved rice variety plus fertilizer combination's net income per acre. The joint effect indicates that participation in domestic work reduced non-adopters, fertilizer adopters only and improved rice variety plus fertilizer combination's net income per acre by 66.26 percent, 159.02 percent, and 89.57 percent respectively. Due to the fact that majority of females participate in domestic work than males, it implies that male adopters of the selected technologies are likely to benefit more from the selected improved rice technologies than their female counterparts in the study area.

3.2.1.1 Effect of the selected improved rice technologies on rice producers' income: PSM estimation

This section examines the effect of the selected improved technologies adoption on farmers' rice income, by comparing income of adopters and non-adopters. Furthermore, there is a comparative analysis of the effect of adoption of the selected technologies on the male and female rice producers' rice income. The estimates for the average treatment effects on the treated

(ATT), which shows the causal effects of farmers' adoption choices on net income, are presented in Table 3 below. The results reveal that the choice of improved rice varieties only tends to significantly increase net income per acre by 61.31 percent when non-adopters are treated as the control group. Similarly, the choice of fertilizer only tends to significantly increase net returns by 86.32 percent, while that of adopters of improved rice variety plus fertilizer combination was increased by 153.54 percent. The findings suggest that the causal effect of improved rice variety plus fertilizer combination on net income was highest (GH¢ 1,339.28), followed by fertilizer (GH¢ 544.66) and finally by improved rice varieties (GH¢ 386.95) (see Table 4.29 and details in Appendix 4).

Table 3: Average treatment effect of improved rice technologies adoption on net income per acre: PSM estimation

	Mean Outcome				
Matching Algorithm	Rice Variety Adopters (n=164)	No Adopters (n=401)	ATT	t-value	Change (%)
Radius	1017.80	630.95	386.85	8.11***	61.31
Matching Algorithm	Fertilizers Adopters (n=103)	Non-Adopters (n=401)	ATT	t-value	Change (%)
Radius	1175.61	630.95	544.66	7.31***	86.32
Matching Algorithm	Both rice variety and fertilizer adopters (n=249)	Non adopters (n=401)	ATT	t-value	Change (%)
Radius	1599.74	630.95	968.79	23.67***	153.54

Source: Survey data, 2016.

Notes: ATT, average treatment effect on the treated, *,** and *** are Significant at 10, 5 and 1 percent levels respectively.

Table 4 presents sex-disaggregated results of the effect of the adoption of the selected improved rice technologies on male and female adopters' rice income. On the whole, the result suggests that on the average, adoption of the selected improved rice technologies had a greater positive effect (GH¢ 688.71) on male rice farmers' net income, per acre, than their female counterparts (GH¢ 565.26), suggesting adoption had a greater impact on males adopters' rice income than that of females. This finding is not surprising because majority of the females were constrained by time due to their participation in domestic work. The finding of higher returns on male rice farmers investment supports that of Dontsop-Nguezet *et al.* (2011), and inconsistent with that of Hossain *et al.* (2003); Diagne (2006); Agboh-Noameshie *et al.* (2007) who recorded otherwise in Bangladesh, Cote d'Ivoire, Benin and Iran respectively. The evidence presented by this study does validate the hypothesis that the adoption of improved rice varieties and fertilizer has greater impact on males' net rice income per acre than that of the females.

Table 4: Average treatment effect of improved rice technologies adoption net income per acre by gender: PSM estimation

	Mean Outcome				
Matching Algorithm	Male Rice Variety Adopters (n=134)	Female Rice Variety Adopters (n=30)	ATT	t-value	Change (%)
Radius	630.95	544.86	86.10	6.13***	15.80
Matching Algorithm	Male Fertilizer	Female Fertilizer	ATT	t-value	Change (%)

	s Adopters (n=80)	s Adopters (n=23)			
Radius	650.95	518.98	131.97	4.97***	22.58
Matching Algorithm	Male Both rice variety and fertilizer adopters (n=200)	Female Both rice variety and fertilizer adopters (n=49)	ATT	t-value	Change (%)
Radius	784.22	631.95	152.27	3.18***	24.10

Source: Survey data, 2016.

Notes: ATT, average treatment effect on the treated, *,** and *** are Significant at 10, 5 and 1 percent levels respectively

4. Conclusions and Recommendations

The study tested the hypothesis that female participation in domestic work will skew rice income in favour of males. It was found that factors such as age, seed cost and number of infants negatively and significantly affected the net returns per an acre of farm land, whereas adult size, farm size, participation in relevant extension training, income from other income generating activities, hours of family labour and location impacted positively and significantly on net returns per an acre of farm land. The findings also indicate that the adoption of the selected agricultural innovations tend to significantly increase rice net returns per an acre of farm land. The results further indicate that adoption of the selected agricultural innovations resulted in an increase in net returns per an acre of farm land. On the average, the male rice farmers' registered 20.82 percent higher net returns per an acre of farm land than their female counterparts. This suggests that the adoption had greater positive effect on male adopters' rice income per an acre of farm land than their female counterparts in the study area. The overall lesson from the research is that gender is a major socio-economic issue affecting farmers' rice income in Ghana. Closing gender gap effectively in technology adoption would require an equal empowerment of the two gender groupings economically to address the problem of income disparity and ensure gender equity in the farm households.

Based on the findings, the following recommendations are made:

1. Since farm size positively and significantly affected net returns per an acre of farm land, and our culture and traditions ensure that land ownership is passed on to males, especially in the Northern part of Ghana, government should facilitates the development of land markets to ensure equal access to farm land, especially in the North.
2. Due to the finding that child care negatively and significantly affected net returns per an acre of farm land, there should be an affirmative action to embark on a sensitization programme to educate the Ghanaian societies of the need for equal participation in domestic work to reduce female unpaid care work to promote income equity. Also, Ministry of Gender, Children and Social Protection should facilitate the development of childcare support centres as well as mainstreaming them into the educational system to help provide free time for females to ensure equal participation in improved rice cultivation.

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ANNEX 1

Table 1A: Probit estimates of propensity score for adoption of improved rice variety only

Variable	**Coefficient**	**Std. Err**	**z-value**
Gender	-2.0152	0.6626	-3.04***
Log_Age	-1.5472	0.6962	-2.22**
log_Years_Sch	0.0108	0.1420	0.08

Marital_Status	-0.7921	0.3606	-2.20**
Eco_Active_HH	0.2902	0.0732	3.96***
log_Farm_Size	0.2624	0.2462	1.07
Land_Ownership	0.4401	0.4089	1.08
Attend_Training_Prog	0.6010	0.3081	1.95*
Lab_Inten_Imp_Rice_Var	-0.1709	0.2970	-0.58
Log_seed_cost	-0.3422	0.0675	-5.07***
log_TLU	-0.0205	0.1709	-0.12
Log_Hours_Other_Eco_Act	-1.4255	0.6976	-2.04**
Log_Infants_cent	-1.5656	0.4682	-3.34***
Log_ Hours_Com_ activities	-8.8679	1.4914	-5.95***
Main_Act_Most_Time_Spent	-0.3688	0.3248	-1.14
Location	1.1381	0.3026	3.76***
Income_Other_Crop	0.0003	0.0003	1.16
Gen_Land_Own	1.5005	0.6478	2.32**
Gen_Infants_cent	-1.8804	0.4958	-3.79***
Constant	23.5505	4.1772	5.64***

Pseudo-R2	0.8369		
Log likelihood	-48.2737		
Observations	606		

Table 1B: Probit estimates of propensity score for adoption of Fertilizer application only

Variable	Coefficient	Std. Err	z-value
Gender	-6.5913	2.7276	-2.42**
Log_Age	-2.1854	1.4886	-1.47
log_Years_Sch	0.0407	0.3960	0.10
Marital_Status	-4.5316	1.8571	-2.44**
Eco_Active_HH	0.7234	0.2616	2.77***
log_Farm_Size	0.0270	0.6343	0.04
Land_Ownership	5.6595	2.1655	2.61***
Attend_Training_Prog	1.7667	0.8360	2.11**
Lab_Inten_Fert_Use	-4.2580	1.5498	-2.75***
Cap_Inten_Fert_Use	-4.1990	1.8155	-2.31**
log_TLU	-0.5215	0.3355	-1.55
Log_Hours_Other_Eco_Act	-9.4689	3.6830	-2.57***
Log_Infants_cent	-5.6025	1.9226	-2.91***
Log_ Hours_Com_ activities	-12.0589	5.4591	-2.21**
Main_Act_Most_Time_Spent	-2.8784	1.6205	-1.78*
Location	4.4825	1.7729	2.53**
Income_Other_Crop	0.0016	0.0009	1.87*
Gen_Land_Own	2.4199	1.9123	1.27
Gen_Infants_cent	-0.5488	0.3318	-1.65*

Constant	36.4770	16.8289	2.17**
Pseudo-R2	0.9322		
Log likelihood	-15.4036		
Observations	568		

Table 1C: Probit estimates of propensity score for adoption of improved rice seed and Fertilizer combination application

Variable	Coefficient	Std. Err	z-value
Gender	-2.6656	0.9370	-2.84***
Log_Age	-0.3925	0.4107	-0.96
log_Years_Sch	0.2049	0.0960	2.13**
Marital_Status	-0.2338	0.2009	-1.16
Eco_Active_HH	0.0395	0.0337	1.17
log_Farm_Size	0.1381	0.2276	0.61
Land_Ownership	0.3784	0.2326	1.63
Attend_Training_Prog	0.4365	0.2029	2.15**
Lab_Inten_Imp_Rice_Var	-0.3629	0.2052	-1.77*
Lab_Inten_Fert_Use	-0.3071	0.2316	-1.33
Cap_Inten_Fert_Use	-1.3206	0.2130	-6.20***
Log_seed_cost	-0.0779	0.0464	-1.68*

log_TLU	0.2830	0.0949	2.98***
Log_Hours_Other_Eco_Act	-2.3951	0.3974	-6.03***
Log_Infants_cent	-0.2484	0.1879	-1.32
Log_ Hours_Com_ activities	-0.8428	0.7330	-1.15
Main_Act_Most_Time_Spent	-0.2673	0.2528	-1.06
Location	0.6989	0.2552	2.74***
Income_Other_Crop	0.0006	0.0002	3.18***
Gen_Land_Own	0.0987	0.6431	0.15
Gen_Infants_cent	-1.6011	0.5485	-2.92***
Constant	0.9554	2.2036	0.43
Pseudo-R2	0.5020		
Log likelihood	-110.5123		
Observations	723		