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Evaluating Agricultural Policy Impacts in Ghana: The Case of Food Crop Development Project in Ejura-Sekyedumase

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Abstract
A Government of Ghana development project known as The Food Crop Development Project (FCDP) was introduced in Ghana with the aim of improving farm incomes, household food and nutrition security and reducing poverty among small-scale farmers. This study sought to find answers to the questions of whether participation in the FCDP improved maize output, household income and food security status. Applying endogenous switching regression (ESR), while accounting for self-selectivity bias, the findings indicate that access to extension and credit services significantly influenced households' participation in FCDP and by extension adoption of improved practices. The results also reveal significant selectivity correction terms in the choices of both participation and non-participation, indicating that accounting for selection bias is a prerequisite for unbiased and consistent estimation. The findings also indicate participation and adoption of improved maize production technologies increase maize output and households' incomes, while non-participation exerts the opposite effect. The policy implication of these findings is that subsidized agricultural input projects like the FCDP, have the potential to improve food security and farm incomes of peasant households.
Keywords: Self-selectivity, endogenous switching regression (ESR), Ejura-Sekyedumase, food security.

1. Introduction

Small-scale farmers constitute a significant proportion of farmers in Ghana. They cultivate a land area of about 13.6 million hectares, constituting 57% of total land area under cultivation. Out of a total of 2 million small-holders, 85% cultivate less than 2 hectares each. This category of farmers produces 80% of domestic food supply and 90% percent of export crops (PCU-MoFA, 2003). Despite this significant contribution of small-holders to the nations agricultural output, their productivity remains low. This is because they rely solely on the already over exploited natural resources, including marginal lands due to their limited access to resources, technology and alternative livelihoods. They therefore need to be supported to expand their production and productivity levels and that requires interventions which promote farmers capacity to use high-return inputs and technology. .

The Food Crop Development Project (FCDP) was one of several measures the Government of Ghana piloted in eight selected districts in the country to address the problems of low yields, resulting in poor farm incomes as well as food insecurity. Ejura-Sekyedumase District was one of the beneficiary pilot districts. The project was aimed at improving household food security, nutrition, farm incomes and reducing poverty among small-scale farmers through increased production, storage and processing of cereals as well as legumes (MOFA, 2003).

Several years after implementation (i.e. 2001-2005), it became necessary to examine the effects of the project on maize farm households in order to provide empirical evidence as to whether the project was successful in achieving its goals. This paper, through descriptive statistics and endogenous switching regression (ESR) approach sought answers to questions as to whether FCDP impacted on welfare of participants through improved maize output, food security and income levels.

The remainder of this paper is structured as follows. We review empirical relationships between project impacts and participant characteristics in the next section and explained the methodology in section 3 where we described in detail the estimation approaches, the data used for the analyses and also presented some descriptive statistics. The results and discussion are presented in section 4. We first highlight the determinants of participation in FCDP and then the impact of participation on household welfare. Finally, section 5 concludes the paper with summaries and policy implication.

1.1 Impacts and Attributes of Participant

The empirics of relationships between impacts of development interventions and participants' socio-economic attributes abound in assessment literature. For instance, household headship influences the kinds of decisions the household makes. It has been observed that male-headed households exhibit greater likelihood to obtain information about new technologies and undertake more risky businesses than female-headed households (Asfaw and Admassie, 2004). It has also been observed that having more female heads of households may hinder the adoption of soil and water conservation measures, because women may have limited access to information, land, and other resources due to cultural or social barriers (Tenge *et al*., 2004).

Hassan and Nhemachena (2008) however, observe contrary results, arguing that female-headed households are more likely to take up climate change adaptation methods. In addition, a de facto female household head who is not usually involved in the decisions to adopt a particular production technology (eg. improved varieties) may continue to use the one originally initiated and practised by her husband.

Age of the household head may signify experience. Studies in some parts of Africa show a positive relationship between number of years of experience in agriculture and the adoption of some agricultural technologies (Deressa *et al*., 2009). However, Shiferaw and Holden (1998) observed that there is a negative relationship between age and adoption of improved soil conservation practices. In the opinion of Maddison (2006) and Nhemachena and Hassan (2007) experience in farming increases the probability of uptake of adaptation measures to climate change.

A survey conducted in Malawi showed higher adoption of hybrid maize among households in the highest quintile of land ownership (66%) than in the lowest quintile (53%) (World Bank, 2006). The study indicated that among maize farmers in southern Malawi close to 60% do not use hybrid maize varieties, and that adoption rises with increasing income level, education, and plot size. Simtowe and Zeller (2006), observed higher maize adoption among households with access to credit. Various reasons have been assigned to farmers' inability to use improved seeds with common among which being the expensive nature of complementary inputs leading to farmers' inability to afford. Thus they do not use high quality external agricultural inputs like fertilizers, weedicides, improved seed and irrigation which ensure high returns. Existing studies document that hybrid seed use, for instance, is correlated with wealth and other indicators of household socioeconomic status

This study hypothesized that age and for that matter experience could positively or negative influence participation and adoption of improved maize production technologies. Tenge *et al.* (2004) in a study also indicate that involvement in off-farm activities, insecure land tenure, location of fields and a lack of short-term benefits from soil and water conservation negatively influence farmers' adoption of soil and water conservation measures. They noted however, that membership in farmer groups, level of education, contacts with extension agents and soil and water conservation programmes positively correlated with the adoption of soil and water conservation measures. Thus, these socioeconomic, household specific, variables were employed as covariates to explain the decision of households to participate in FCDP and adoption of improved practices.

2.0 Methodology

2.1 Study Area and Data

The study was conducted in the Ejura-Sekyedumase District which covers an area of 1,782.2 square kilometers. It is about 7.8% of the total land area of Ashanti Region. The district lies within the transitional zone of the semi-deciduous forest and Guinea Savannah zones. It therefore experiences both the forest and savannah conditions. The district is marked by two rainfall patterns; the bi-modal pattern in the South and uni-modal in the north. Annual rainfall varies between 1,200 mm and 1,500 mm. The vegetation in the district is, to a large extent, dictated by the topography and climatic conditions. The northern part is covered with sparse derived deciduous forest vegetation.

The climatic conditions of the district together with the topographical layout favour cultivation of many food crops. The derived form of savannah at the northern part of the district supports the cultivation of cereals in particular. Agriculture is the main source of livelihood in the district and about 60% of the economically active population is engaged in farming. Major crops cultivated include maize, yams, cassava, cowpea, groundnut and vegetables.

Data for this study were collected from a sample of smallholder food crop farm households. A total of 130 heads of maize farming households (made up of 65 participants and 65 non-participants) were selected for the study. The main instrument for collecting data was a questionnaire that sought appropriate information needed to assess the situations of the two groups of farmers (participants and non-participants in FCDP) in terms of maize output, farm incomes and food security level. Some relevant secondary data; such as (i) climatic information for the district from the Meteorological Services, (ii) background information and area maps from the District Planning Office (Ejura) and (iii) prices and output data from MoFA, Ejura were also used.

Table 1 presents a summary of some of variables used in this study. There appeared to be difference among participants and nonparticipants in the FCDP. Younger farmers (mean age of about 36) were observed to be more interested in participation than older farmers (mean age of about 42).

Table 1: Farm and Household Characteristics Non-participants and Participants

Variable	Description	Non-participants	Participants	Difference
education	level of education (years)	7.33	5.90	-1.43***
Age	Age of respondent (years)	41.87	36.48	-5.39***
Hse_size	household size	6.4	5.7	-0.7
credit	Access to credit (easy access 1), difficult access = 1	10.82	12.04	1.22**
Farm_size	farm size (ha)	2.81	3.67	0.86***
Livestock	Ownership of livestock (1=Y, 0= N)	0.67	0.71	0.04
Extension	Frequency of ext visits	0.30	0.75	0.45**
famlab	HH members helping on farm (1=Y, 0=N)	0.25	0.21	-0.04
Maize output	Maize output per hectare (ton)	1.40	2.52	1.12***
Total income	Total household income	654.02	793.10	139.08***
Coping index	Food insecurity coping index	0.18	0.13	-0.05*

Significance level: *=10%, **=5%, ***=1%

There were also observed differences among participants and non-participant households with respect to access to credit, maize output (ton/ha) as well as household income and food insecurity index (Table 1). Though the differences among respondents could give an indication of impact of participation/adoption of recommended maize production practices, they do not account for selection bias which is important in determining the impact of participation as farmers self-selected themselves into the FCDP. Further analysis is therefore required to isolate the full impact of participation.

2.2 Model Specification

The interest of this study is to estimate the effect of household participation in the FCDP on household welfare indicators such as income and food security. This can be expressed as:

$$y = X\beta + Z\gamma + u \quad (1)$$

where **y** refers to income or other household welfare indicators such as food security. ***X*** is a vector of explanatory variables (excluding participation) which influence the outcome variables, and it includes household, farm and socioeconomic characteristics such as age, gender and educational level of household head, household size, farm size, access to credit, social capital variables. ***Z*** is a vector variables including a dummy for household participation and its coefficient ?**3**, measures the effect of participation on household welfare. The above mentioned socioeconomic factors affect the decision of households to participate and adopt yield enhancing technologies and are therefore further discussed below.

The adoption variable (**Z**) is potentially endogenous since it is not randomly assigned and households might have decided whether or not to participate in the project. This could result in self-selection bias. Consequently, estimating equation (1) with ordinary least squares (OLS) regression technique might produce biased results. In order to overcome such biases Heckman selection, instrumental variable (IV) and propensity score matching (PSM) have often been suggested. However, some limitations have been observed with these methods. For instance, there is a problem of model functional form imposition by either the Heckman selection or IV methods. This assumption implies that household participation only has an intercept shift but not a slope shift in the outcome variables (Alene and Manyong, 2007). Another approach often used to tackle selection bias is propensity score matching (PSM). Although this does not impose functional form assumptions, it assumes selection is based on observable variables (Asfaw, 2010). The PSM, therefore, tends to produce inconsistent result when there are unobservable factors that affect both adaptive behaviour and the welfare outcome indicators.

In order to overcome these issues, this study used the endogenous switching regression (ESR) technique. It (ESR) was first used by Lee (1978) and Maddala (1983) to address self-selection as well any systematic differences across groups. In this approach outcome equations are specified differently for each regime, conditional on the participation decision of households (Kleenman and Abdulai, 2013). The ESR method is recently being applied in evaluating the impacts of decisions of farmers on farm performance and household welfare (e.g. Di Falco *et al*., 2011; Asfaw *et al*., 2012; Kleemann and Abdulai, 2013; Negash and Swinnen, 2013.

This study specifies a model of participation and household welfare (eg. Income and food security indicators), in the setting of a two-stage framework. In the first stage, risk neutral/averse farm households choose to participate in FCDP if it generates benefits. In the second stage, the impact of participation on welfare indicators is explored through a representation of production technology.

2.3 Endogeneity and Impact of participation on Household welfare

A household's decision to participate or not to participate was voluntary and might be based on individual self-selection. Consequently, unobservable characteristics of households as well as their farms could affect both the selection and eventually household welfare. For instance, if some hidden factors such as head managerial skills and abilities which influence adoption but cannot easily be observed are not accounted for this could lead to upward bias. We therefore estimated a simultaneous equations model of participation in FCDP and farm household welfare outcomes with *endogenous switching* which accounted for the endogeneity of the participation decision (Di Falco, *et al*., 2011).

Some studies observe that incomplete adoption of technologies can be caused by heterogeneity in the conditions in which a farming system is operating, such as heterogeneity in soils, climate, prices, transportation costs, and the farm household's characteristics (Suri, 2011). Other studies in the technology adoption literature attribute incomplete adoption partially to constraints such as, liquidity constraints, risk aversion and access to information (Kleenman and Abdulai, 2013).

2.4 Empirical specification

Let I* be the latent variable that captures the expected benefits from the participation with respect to non-participation. The latent variable is specified as (Di Falco, *et al*., 2011):

$$I_i^* = Z_i\gamma + \eta_i \text{ , with } I_i = \begin{cases} 1 \text{ if } I_{i1}^* > 0 \\ 0 \text{ otherwise} \end{cases} \quad (2)$$

where **Z** is a vector of farm and household characteristics which affect the expected benefits of adaptation and η_i an error term account for variations in I_i^*.

In the ESR approach, separate outcome equations are specified for each regime, conditional on a selection equation (ie. Eq. 2). Therefore, in this study, separate household welfare indicators for participants and non-participants were estimated, conditional on the participation as:

Regime 1: $y_{i1} = X_{1i}?2_1 + u_{i1} \text{ if } I_i = 1$ (participants) (3a)

Regime 2: $y_{2i} = X_{2i}?2_2 + u_{i2} \text{ if } I_i = 0$ (non-participants) (3b)

where y_{i1} and y_{2i} represent vectors of welfare indicators for participants and non-participants, respectively. $?2_1$ and $?2_2$ are parameters estimated for the participants and non-participants regimes, respectively. $\mathbf{X_i}$ represents a vector of explanatory variables such as production inputs (e.g., seeds, fertilizers, manure, and labour), household head's and farm household's characteristics also included in $\mathbf{Z_i}$. The vector u_{ij} represents the unobserved stochastic component, which verifies $E(u_{ij}|X_i, Z_i) = 0$ and the Var $(u_{ij}|X_i, Z_i) = ??_j^2$. The error term in the selection equation (η_i) and that of the outcome equations (u_{i1}, u_{i2}) were assumed to have a trivariate normal distribution with zero mean and a non-single covariance matrix ?? expressed as (Asfaw, 2010; Di Falco et al, 2011):

$$\theta = \begin{bmatrix} \sigma_\eta^2 & \sigma_{\eta1} & \sigma_{\eta2} \\ \sigma_{1\eta} & \sigma_1^2 & . \\ \sigma_{2\eta} & . & \sigma_2^2 \end{bmatrix} \quad (4)$$

Where σ_η^2 is a variance of the error term in the selection equation, and $??_1^2$ and $??_2^2$ are variances of the error terms in the welfare outcome equations for participants and non-participants. Also $\sigma_{\eta1}$ and $\sigma_{\eta2}$ represent the covariance of the error term η in the selection equation and that of u_{1i} and u_{2i} in the outcome equations. The covariance between u_{1i} and u_{2i} is not defined, as y_{1i} and y_{2i} (ie. welfare indicators for participants and non-participants) were never observed simultaneously (Madala, 1983, Lokshin and Sajaia, 2004). It is assumed that the variance of the error term in the selection equation is one; ie., $\sigma_\eta^2 = 1$, since $\boldsymbol{\eta}$ is estimable only up to a scale factor.

An important implication of the error structure is that since the error term of the selection equation ηi is correlated with that of the outcome equations $ui's$, the expected values of u_{1i} and u_{2i} conditional on sample selection are stated as (Fuglie and Bosch, 1995; Lokshin and Sajaia, 2004):

$$\left[E(u_{1i}|\, I_i = 1) = \sigma_{\eta1}\frac{\phi(Z_i\gamma)}{\varphi(Z_i\gamma)}\right] = \sigma_{\eta1}\lambda_{1i} \quad (5a)$$

$$\left[E(u_{2i}|I_i=0) = -\sigma_{\eta 2}\frac{\phi(Z_i\gamma)}{1-\varphi(Z_i\gamma)}\right] = \sigma_{\eta 2}\lambda_{2i} \quad (5b)$$

where $\emptyset(.)$ refers to the standard normal probability density function and ??(.) the standard normal cumulative density function, while $??_{ji}$ refer to the inverse Mill's ratio. The covariances $\sigma_{\eta 1}$ and $\sigma_{\eta 2}$ are statistically significant, then the decision to participate and the household welfare will be said to show evidence of endogeneity or sample selectivity bias (Madala and Nelson, 1975).

Equations 3a and 3b can then be specified as (Maddala, 1983, Di Falco et al, 2011):

$$E(y_{1i} \mid I_i = 1, Xi) = X_{1i}\beta_1 + \sigma_{1_\eta}\lambda_{1i} \quad (6a)$$

$$E(y_{2i} \mid I_i = 0, Xi) = X_{2i}\beta_2 + \sigma_{2_\eta}\lambda_{2i} \quad (6b)$$

$$E(y_{2i} \mid I_i = 1, Xi) = X_{1i}\beta_2 + \sigma_{2_\eta}\lambda_{1i} \quad (6c)$$

$$E(y_{1i} \mid I_i = 0, Xi) = X_{2i}\beta_1 + \sigma_{1_\eta}\lambda_{2i} \quad (6d)$$

In this model there is a need for better identification which often requires an exclusion restriction (Lokshin and Sajaia, 2004). This implies, there should be at least one variable that affects farmers' participation decisions but does not directly affect any of the households' output. This study takes inspiration from the agricultural technology adoption literature on the importance of information in farmers' adoption decisions. Many previous studies on impact of agricultural technology adoption and innovations have employed information-related variables for identification purposes (e.g. Asfaw *et al*., 2012; Negash and Swinnen, 2013; Di Falco, *et al.*, 2011).

Given the assumption of the distribution of the error terms in equation 4 above, the logarithmic likelihood function is stated as (Lokshin and Sajaia, 2004):

$$lnL_i = \sum_{i=1}^{N} I_i\left[ln\phi\left(\frac{u_{1i}}{\sigma_1}\right) - ln\sigma_1 + ln\varphi(\theta_{1i})\right] + (1-I_i)\left[ln\phi\left(\frac{u_{2i}}{\sigma_2}\right) - ln\sigma_2 + ln\varphi(\theta_{2i})\right] \quad (7)$$

Where,

$\theta_{ji} = \frac{(Z_i\gamma + \rho_j u_{ji}/\sigma_j)}{\sqrt{1-\rho_j^2}}$, j =1, 2 and ρ_{ij} refers to the correlation coefficient between the error term in the selection equation (η_{ij}) and the error terms u_{1j} and u_{2j} in the outcome equations of adaptors non-adaptors respectively.

The signs of the correlation coefficients $\rho_{1j}$and ρ_{2j} have economic interpretations (Fuglie and Bosch, 1995). If $\rho_{1j}$and ρ_{2j} have alternate signs, then individual farm households participated on the basis of their comparative advantage: those who participated have above-average returns from participation and those who chose not to participate have above-average welfare returns (farm returns) from non-participation.

The impact of participation in FCDP was determined as follows: For a participating farm household with characteristics Z_i and X_i, the expected welfare value y_{1i}, is given as:

$$E(y_{1i}| I_i = 1) = X_{1i}\beta_1 + \sigma_{u1_\eta}\lambda_{1i} \quad (8)$$

The same household if it had not to participated (counterfactual) would have had expected welfare outcome given as:

$$E(y_{2i}| I_i = 1) = X_{1i}\beta_2 + \sigma_{u2_\eta}\lambda_{1i} \quad (9)$$

The change in welfare outcome due to participation in FCDP is determined as:

$$ATT = E(y_{1i}| I_i = 1) - E(y_{2i}| I_i = 1) = X_{1i}(\beta_1 - \beta_2) + \lambda_{1i}(\sigma_{u1_\eta} - \sigma_{u2_\eta}) \quad (10)$$

The impact assessment literature refers to these estimates as average treatment effect on the treated (ATT) (Lokshin and Sajaia, 2004).

3.0 Empirical Results and Discussions

The estimates of the ESR models for the household maize output, income and food insecurity index equations are presented in Table 2. The table shows how each of the explanatory variables affects the three welfare indicators.

Table 2: ESR Results for Farm and Household Maize Output, Income and Food Security Index

	(1)	(2) Endogenous Switching					
Dependent Variable	**Participation**	**Maize Output**		**Household Income**		**Food Security (Coping Index)**	
Explanatory Variable	**1/0**	**2**		**3**		**4**	
		Non-participants	Participants	Non-participants	Participants	Non-participants	Participants
Edu	2.130***	0.0001	0.001	-0.335	-0.532	-0.001	-0.003
Age	-0.054**	0.011	-0.003	-0.909*	0.108	-0.007	0.011

Table 2 cont.

Dependent var	**Participation**	**Maize Output**		**Household Income**		**Food Security (Coping Index)**	
Explanatory Variable	**1/0**	**2**		**3**		**4**	
		Non-participants	Participants	Non-participants	Participants	Non-participants	Participants
Hse_size	-0.135**	-0.037**	-0.021***	1.700***	1.929***	0.3***	- 0.04**
Credit	-0.063**	0.012	0.004	-0.811	-0.694	-0.008	-0.024
Farm_size	.369***	0.016**	0.029**	-0.923	2.825**	-0.003*	-0.016**
Livestock	-0.060	0.162**	0.254*	10.248***	11.558*	-0.006***	-0.053*
Exten. visits	1.213***	0.053	-0.045	0.466	0.924	-0.012	-0.014
famlab	-0.127	0.028**	0.032***	-0.430**	-2.052***	-0.008**	-0.064**
cons	-0.055*	2.037**	2.100***	26.896	15.528	0.066	0.227
??$_1$	0.208		0.140**		14.475**		2.421***
??$_{0D}$	-0.191	0.145**		13.644***		2.370***	
ρ_{1D}	3.146**	0.248***		0.226***		0.092***	
ρ_{0D}			-0.253		0.259		0.432
Number of Observations	**130**						
Log likelihood		**-73.879**	**-1725.720**	**-242.983**			
LR Test of ind. equations $x^2(1)$		**6.2*** **	**4.40*** **	**8.83*** **			

Significance level: *=10%, **=5%, ***=1%

The variables **ρ1** and **ρ0**, are correlation coefficients between the error terms of the selection and outcome equations reported at the bottom part of the table 2, show an indication of selection bias. A statistical significance of any of them suggests that self-selection would be an issue if not accounted for. In all the three income models in Table 2, the correlation coefficients for the participants (ρ1) and non-participants (ρ0) equations are both positive but only the ρ1 coefficients are statistically significant, suggesting that there is self-selection among participants of FCDP.

The results (Table 2) show that household size and livestock holding significantly affect the farm income of both participants and non-participants. An increase in household size results in a decline in farm income while larger livestock holding contributes positively to farm income. There are differences between what determines farm income among participants and non-participants, and this justifies the use of the ESR model. For example, age of household head is significantly associated with the farm income of non-participants, but the effects are insignificant among participants. Conversely, farm size significantly influences the household income of only participants. Age of the household head may signify experience. This was observed to be negatively associated with participation which implies that the elderly were less more likely to participate in FCDP and adopt improved agricultural technologies. This finding seems to agree with the observation by Shiferaw and Holden (1998) that there is a negative relationship between age and adoption of improved soil conservation practices.

4. Conclusion and Recommendations

The findings of the study revealed some fundamental differences between household which participated in the FCDP and those that did not. These included age of household head, access to credit, extension services, mean output and household incomes. Using OLS and failing to account for self-selection might bias the estimates and result in wrong conclusions. Endogenous switching regression approach was therefore employed to simultaneously estimate the decision to participate and the impact of participation in the FCDP.

The results of ESR estimation showed significant and positive selectivity correction term in outcome (maize output, household income and food insecurity index) specification for participation choice, suggesting that the expected maize output for participants was upward biased. This is because farmers who are better suited to participate in the FCDP decided to remain and adopt recommended, leading to a significant positive impact on their outcome variables. The result clearly suggests that unbiased and consistent evaluation of welfare outcomes due to participation decisions must take selectivity effects into account, which confirm the appropriateness of the ESR approach for the analysis.

Given that credit and extension access contribute to higher food security and other welfare outcomes for participants in the FCDP, policy makers could promote effective measures to improve farmers' access to extension agents, and continue to facilitate credit access marketing through farmer-based organizations.

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