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Effect of input credit on smallholder farmers' output and income: Evidence from Northern Ghana

Adam Iddrisu, Isaac Gershon Kodwo Ansah, Paul Kwame Nkegbe,

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Adam Iddrisu
International Crops Research Institute for the Semi-Arid Tropics, Tamale, Ghana
Isaac Gershon Kodwo Ansah
Department of Agricultural and Resource Economics, University for Development Studies, Tamale, Ghana, and
Paul Kwame Nkegbe
Department of Economics & Entrepreneurship Development, University for Development Studies, Tamale, Ghana

Abstract

Purpose – The purpose of this paper is to examine the effect of input credit on smallholder farmers' output and income using Masara N'Arziki support project in Northern Ghana.

Design/methodology/approach – A cross-sectional primary data set was used to estimate the effect of project participation on farm output, yield and income using propensity score matching (PSM) methods.

Findings – The findings are that project participation is skewed towards experienced farmers with big-sized households and farms. The effect of project on outcomes is somewhat unsatisfactory in the sense that participation only raises output and yield, but not income.

Research limitations/implications – The paper only examined the project effect on farm outcomes among smallholder farmers participating in the programme in just one operational area in the Northern region. Future research should consider all the operational areas for an informed generalisation of findings.

Practical implications – Greater benefits to farmers from programme participation would require project management to review the contractual arrangement so that the high cost of input credit is significantly reduced.

Originality/value – The paper applied the PSM to estimate the effect of project participation on farm output, yield and income among smallholder farmers which is non-existent in the literature on the study area, at least as far as we know. This paper can inform future policy on the direction and nature of support for smallholder farmers in Northern Ghana.

Keywords Ghana, Participation, Propensity score matching, Farmer support projects, Input credit

Paper type Research paper

1. Introduction

Land is an important resource for agricultural production in Ghana, and the contribution of the agricultural sector to GDP is significant, standing at about 20 per cent (Victor, 2015). Agriculture has a central role to play in promoting growth and poverty reduction in the Ghanaian economy and Ghana needs an agricultural revolution based on productivity growth (Gobind, 2009). The livelihood of majority of people from Northern Ghana is also largely dependent on rain-fed farming. The World Food Programme (2009) notes that about 1.2 million people in Ghana are food insecure, arising partly from low productivity. The low productivity in turn adversely affects the performance of the agricultural sector. As a result, farmers are compelled to sell some of the crops at harvest at very low prices to be able to raise funds to meet their cash needs. This implies that large quantities have to be sold at low price to meet farmer's needs. This phenomenon traps farmers in a vicious cycle

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of poverty (Akudugu, 2016) as this is influenced by multiple factors (Besharat and Amirahmadi, 2011; Mbam and Edeh, 2011; Benin *et al.*, 2012; Gebremichael, 2012).

According to Awotide *et al.* (2015) the major source of achieving a drastic reduction in poverty and alleviating the poor welfare situation of rural farmers is to increase agricultural productivity; this will, at the micro level, translate to increases in farm income, food security, poverty reduction and improved rural household welfare. Statistics indicate that "Northern region has the third highest poverty headcount in Ghana. […] The lowest poverty incidence of 24.6 percent is observed in Tamale Metropolis [unlike other districts recording high incidence]" (Ghana Statistical Service, 2015, p. xi). According to Cooke *et al.* (2016), Ghana is categorised as having one of the fastest increasing inequality levels in Africa. There is also concern that growing inequality means that large pockets of people in the northern rural areas are seeing significantly less benefit from Ghana's development (Ghana Statistical Service, 2008), while some other groups have benefited disproportionately more. People below the poverty line are largely smallholder farmers (whose farms average just about 1.2 ha) with limited opportunities for prosperity (Zaney, 2016).

Research by ActionAid Ghana on public financing of agriculture in the Northern and Upper East regions of Ghana shows that there is widespread hunger and, particularly, in the northern parts of the country, most farming households still experience food insecurity for 3-7 months within the year (Zaney, 2016). Empirical research has argued that agricultural productivity increases depends on better access to agricultural credit. According to Abdallah (2016), availability and thus access to credit provides the ability for farmers to diversify by undertaking investment in new technologies. In addition, credit at the disposal of farmers provides opportunity for better mix and higher use of inputs. Thus, the existence of Masara N'Arziki in the Northern region of Ghana provides smallholder farmers the opportunity to embark on farming through their input credit support model (ICSM). This study evaluates the performance of smallholder farmers participating in the Masara N'Arziki project. Results from probit regression based on farm household characteristics indicate that household size, farming experience, farm size and project experience are among the factors that influence farmer's participation in Masara N'Arziki project. These factors drive the logic of farmer support project operations in the Northern region of Ghana.

A report by USAID and EAT (2012) stated that the Masara N'Arziki programme is indirectly contributing to enhanced food security for participating households. But in this same programme document, it is also reported that farmers participating in the project do not have a voice. A relevant question to pose is what accounts for these contrasting remarks and what is the real situation pertaining to the farmers participating in the programme? Are they indeed benefitting from this support project or not? The study explores the differences that may exist between the output and income of smallholder farmers participating in the farmers' support project and non-participant farmers, using propensity score matching (PSM) analyses. The emerging policy implications from the study could indicate the importance or otherwise of providing input credit support to smallholder farmers.

In this study, theoretical insights into the causal relationship between risk of farm production and credit-market imperfections are explored with participation in Masara N'Arziki project as an example. An equally important contribution is the use of classical economic argument that helps address the major finding of high cost of input credit by the project. This can help to adapt strategies that maintain and enhance household food needs of smallholder farmers amidst the effect of global climate variability on crop production in Northern Ghana. According to Food and Agricultural Organisation (2003), the major problem with food crops production is low productivity caused by many factors including dependence on seasonal and irregular rainfall, inadequate irrigation facilities and inadequate use of improved technologies (certified seeds, organic/inorganic fertilisers), poor husbandry practices, high field losses due to uncontrolled pests and diseases. For these reasons, if a farmer support project is able to address these challenges for smallholder farmers then such a project is worth sustaining. Against this background, this research is undertaken to determine whether such projects are able to give smallholder farmers a competitive edge and improve their farm output and income, using the Masara N'Arziki project as a case study.

2. Literature review

2.1 Masara N'Arziki project

Masara N'Arziki project is among the major smallholder input credit support project (ICSP) in maize cultivation in Ghana, and has been operational in the three northern regions of the country since 2008. The project facilitates the adoption and utilisation of new and improved technologies for maize production. The project model ensures that farmers receive timely and quality inputs. Wienco Company is the sole agent of the agro-input brands used and the sole supplier for Masara N'Arziki project; the company is able to ensure that the inputs are delivered on time. Masara N'Arziki project in the Northern region of Ghana consists principally of smallholder farmers. These farmers are provided with hybrid seeds, agrochemicals (including fertilizer, herbicides and insecticides) and innovative farm implements on credit basis. The project operates with the following model: willingness to belong to a group of between 8 to 12 members and completing two contractual forms for Masara N'Arziki project. Farmers go into a contract to sell all realized production to the project, which in turn facilitates the harvest and credit recovery from beneficiary farmers. There is a legally enforceable contract that binds the farmer into contract for which he/she is compelled to sell all the produce to the company. Farmers must therefore proactively source other inputs to produce a separate plot for household consumption. In addition, the inability for the project to accurately assess farm sizes in the contract agreement results in farmers either receiving more inputs than they actually need, or less than they require, which in turn results in yield estimates based on input provision being either over- or understated, and this directly or indirectly increases the cost of credit recovery after harvest by the participant farmers.

On the contractual agreement, farmers are expected to pay back in kind. Although the Masara N'Arziki project is promoted as farmer owned, participant farmers still complain of high cost of inputs which is repaid from their output after harvest. In addition, smallholder farmers in the project have to bear the cost of land preparation before ploughing. And for those without household labour, this constitutes an extra cost since it will have to be done either by communal or hired labour. Furthermore, farmers bear the full cost of harvesting. Interestingly, these smallholder farmers are only satisfied with the agro-inputs given to them on credit due to their inability to afford them for cultivation. The additional labour required in bagging the maize produce after shelling by the project's mechanical corn shellers is also provided by the participant farmers. Farmers who cannot pay for the cost of shelling resort to in-kind barter payment with some of the harvested maize produce at a cost of 20 kg/ha to the mechanical sheller provided by the project and any other person who assists in the harvest. This extra labour cost and in-kind shelling expenditures ultimately reduce the net quantity of maize output available to the farmer, and hence net income from the programme participation. The situation worsens during poor harvests caused by unfavourable rainfall distribution in the farmer's field in a bad year.

However, access to mainstream credit by these smallholder farmers for production is constrained by inefficiencies such as high and divergent lending and deposit rates, transactions costs, regulatory restrictions and difficulty in accessing banks (Kelsey, 2013; Abdallah, 2016).

In the context of the above discussion, it is clear that farmer productivity is challenged by numerous problems which negatively affect the living conditions of the farmer. However, Northern Ghana is targeted by most development projects and government for obvious reasons: it is characterised by high incidence of food insecurity and poverty caused by over-reliance on rain-fed agriculture and limited use of improved farm input (Martey *et al.*, 2014).

2.2 Farmer support project and effect on output and income

Farmers' participation in agricultural projects refers to involvement of individuals and groups in development processes with the aim of ensuring self-reliance and better standard of living (Nxumalo and Oladele, 2013). A number of studies including that by van Rooyen *et al.* (1987) claim that smallholder production has declined due to limited support. As a result, the divide between smallholder and commercial farmer productivity levels appears to be growing. The decision of whether or not to adopt or participate in a new technology will be based on careful evaluation of a large number of technical, economic and social factors associated with the technology. Martey *et al.* (2015) report that participation of smallholder farmers in support project did not significantly translate into higher farm incomes. Their finding suggests that exposing farmers to agricultural development projects may directly increase their technical capability within the short term but does not guarantee higher incomes. The adoption of technology is urgently required to increase productivity so as to meet the increasing demand for food for the rapidly growing population of the Northern region. Unfamiliarity with the new technology makes the initial impact on yields and input usage uncertain (Etwire *et al.*, 2013). However, a recommendation by Martey *et al.* (2015) suggests that the design of any agricultural development project must incorporate the specific needs of the farmers to ensure ownership, increased participation and sustainability.

The study by Kinati *et al.* (2014) in Central Rift Valley of Oromia using the PSM revealed that participation in farming research group intervention increased participant households' yields on average by 36 per cent. However, further analysis by the authors revealed that farmer support project yielded no significant changes in smallholder farmer's income and thus food security. On the contrary, Amaza *et al.* (2009) seemed to reveal that intervention projects have caused significant changes in food security and poverty of participating farmers. Alene and Hassan (2003) used robust stochastic efficiency decomposition of farmers on a new extension programme and established that both participant and non-participant farmers had considerable overall productive inefficiencies, thereby concluding that no empirical evidence of a positive impact of new extension programmes on overall productive efficiency existed.

However, empirical evidence elsewhere shows that farmers' participation in support project increases technical efficiency significantly. This emanates from the fact that their participation improves efficiency by providing easy access to productive inputs and embedded support services such as training, information and extension on input application. This is revealed by the work of Martey *et al.* (2015) that participation in the Agriculture Value Chain and Mentorship Project (AVCMP) had positive impact on technical efficiency and farm income of farm households in Northern region of Ghana. Their study suggests that participation in the development project does not necessarily improve farm income, though impact may be realized in the long run with continuous use of the knowledge acquired from the project. Sikwela and Mushunje (2013) also report that farmer support project represents a great opportunity for deprived smallholder farmers to improve their welfare. Their work further reveals that unless access barriers to markets can be reduced, smallholder farmers may remain at the margin of economic development and poverty even with their participation in farmer support projects in the rural communities of South Africa.

3. Methodology

3.1 Study area

The study was conducted in the Savelugu-Nanton Municipality of the Northern region of Ghana. The municipality has a total land area of about 1,790.70 sq. km. It is generally flat with gentle undulating low relief. Savelugu-Nanton municipality has grown from 91,415 (2000 population census) to 139,283 (2010 Population and Housing Census) (Ghana Statistical Service (GSS), 2011). This shows a growth rate of 52 per cent within ten years. The population is broken down into 67,531 representing 49.7 per cent male and 71,752 representing 50.3 per cent female, and a population density of about 78 persons per sq. km (GSS, 2011), made up of 143 communities described as mostly rural. The majority of the populace depends on rain-fed agriculture with low income for women than men. Cash crops grown in the area include shea nut, cotton and cashew. The shea nuts are found in the whole area and they form part of the natural vegetation. Farming along river courses has also caused vast silting of the few drainage systems which as a result dry up quickly in the dry season and flood easily in the wet season.

Masara N'Arziki operates in four districts and municipalities in the Northern region. However, the Savelugu-Nanton municipality was selected due to the higher concentration of project farmer groups in the area. Masara N'Arziki project has a total of 16 farmer groups in the area (with an average membership of ten), spread across 24 operational communities. Farmers who are willing to benefit from the project must sign on to a contractual agreement to sell their output to the project equivalent to the cost of the inputs received at a predetermined output price by the project. The participant farmers in the project for this study were identified in each community through contact with the group leader and/or secretary, who possess(es) records on all participant farmers.

3.2 Theoretical model of agricultural credit

We use the Masara N'Arziki project as the case study given that the participant farmers receive (borrow) input for their farm production under the condition of output being used to repay the cost of input received after harvest. The model is developed following Shee and Turvey (2012), with the underlying economics of risk-contingent credit motivated by defining the optimal choices of a borrower and the lender. Like Shee and Turvey (2012), the model employs the classical approach to agricultural production, but with the acknowledgement that it may not realistically fit all environments of production or decision making with considerable risks, market failures and other constraints as pertains in Northern Ghana. With that in mind, the profit made from production by the smallholder farmer after credit recovery is given by:

$$\pi = PQ(x|\theta) - (\alpha r + (1-\alpha) r (1+i))x \tag{1}$$

where α is the quantity of output received by farmer after recovery by the project to guarantee him to receive input x for the current cropping season at a cost of credit r. If the quantity of output received by the farmer's household is insufficient to borrow the required input from the project, then some proportion of debt owed the project after recovery, $(1-\alpha)rx^*$ is required in addition at an interest rate of i and adjusted marginal cost of $r(1+i)$. The output price is defined by P over risk-adjusted production $Q(x|\theta)$ with θ defined as the probability of an acceptable outcome in productivity. It is assumed that risk aversion appropriately adjusts output and inputs to account for risk (Shee and Turvey, 2012). Thus the optimum input choice of the farmer is determined by:

$$P\frac{\partial Q(x|\theta)}{\partial x} = (\alpha r + (1-\alpha) r (1+i)) \tag{2}$$

If, for example, a quadratic production function $Q(x|\theta) = \alpha + bx - cx^2$ is assumed, then:

$$x^* = \frac{b}{2c} - \frac{\alpha r + (1-\alpha) r (1+i)}{2cP} \tag{3}$$

and:

$$\frac{\partial x^*}{\partial \alpha} = \frac{ri}{2cP} > 0 \tag{4a}$$

$$\frac{\partial x^*}{\partial P} = \frac{(\alpha r + (1-\alpha) r (1+i))}{2cP^2} > 0 \tag{4b}$$

$$\frac{\partial x^*}{\partial i} = -\frac{(1-\alpha) r}{2cP} < 0 \tag{4c}$$

$$\frac{\partial^2 x^*}{\partial P \partial i} = \frac{(1-\alpha) r}{2cP^2} > 0 \tag{4d}$$

Equation (4a) indicates that input demand rises with savings (output received after recovery) and (4b) with output price. Equation (4c) indicates that input demand will fall as cost of credit or interest rate rises, while (4d) indicates that higher credit rate can be offset by higher prices (guaranteed price of farm produce purchased by project). In other words, the higher the credit cost or interest rate on borrowed input, the lower will be the optimal level of inputs and total productivity (Shee and Turvey, 2012).

If output price is the risk outcome with probability density function $f\,(P)$, then the expected profit (quantity of output received by farmer after recovery) can be written as follows:

$$\pi = \int_1^u PQ(x|\theta) f(P) dP - (\alpha r + (1-\alpha) r (1+i)) x \tag{5}$$

The distribution of profit can be broken down into three regions:

$$\pi = \begin{cases} \int_{\varphi 1}^{u} PQ(x|\theta) f(P) dP - \alpha r x - (1-\alpha) r (1+i) x > 0 \\ \int_{\varphi 2}^{\varphi 1} PQ(x|\theta) f(P) dP - (1-\alpha) r (1+i) x < \alpha r x \\ \int_{1}^{\varphi 2} PQ(x|\theta) f(P) dP < \alpha r x + (1-\alpha) r (1+i) x \end{cases} \tag{6}$$

with the interior boundaries defined by $\varphi_1 = (\alpha rx + (1-\alpha) r (1+i) x)/(Q(x|\theta))$ and $\varphi_2 = ((1-\alpha) r (1+i) x)/(Q(x|\theta))$. If the price exceeds the first threshold φ_1, harvest sales (bought by the project) will be sufficient to recover the sunk input costs as well as full repayment of the additional credit. When prices fall between the two thresholds φ_1 and φ_2 the farmer will have enough cash to repay the credit but will not have received enough to recover input costs purchased through savings from the farm output after the project recovery. But if the price falls below the second threshold φ_2, harvest sales (through recovery by the project) do not provide enough cash flow to meet accrued financial obligations (Shee and Turvey, 2012). The study is built around this theory and examines whether participant farmers are able to repay the input credit and still have enough to meet other needs.

3.3 Data
A cross-sectional data set was used for the study. The study employed a stratified random sampling approach to select respondents. First, the population of the survey area was stratified into participant and non-participant groups. In a second stage, 195 smallholder farmers were randomly selected from participant and non-participant farmer groups within 14 communities of the Masara N'Arziki project in the municipality. The selection of 14 communities out of a total 24 was done through the Yemane's sample calculation formula. On average, eight participants were randomly selected from each chosen beneficiary group in all the communities. Respondents were also selected through the use of Cochran's sample calculation. Equal sampling was applied in each stratum. Data collection was accomplished in ten days using semi-structured questionnaire for interviews. The survey covered 118 participants in the project and 77 non-participant farmers.

3.4 Probit model
To examine the impact of project on outcomes, first a binary probit model is used to examine factors that influence farmers' participation in the Masara N'Arziki input credit project. Project participation is captured as a dummy variable (1 if farmer participates in the project, 0 for non-participants). The probit model is based on the random utility framework. In this framework, a farmer is exposed to alternative sets of decisions, where he/she has the privilege to choose between participating in the Masara N'Arziki project or not. Whatever option the farmer chooses, there is an associated utility which has both a systematic ($V_{i,m}$) and random ($e_{i,m}$) components. It is assumed that the farmer (being rational) chooses the alternative that maximises utility. For example, consider an individual farmer i, who chooses alternative m among the choice set. The utility function of such an individual is given by the following equation:

$$U_{i,m} = V_{i,m} + e_{i,m}, \tag{7}$$

where $V_{i,m} = X_{i,m} b_{i,m}$.

The systematic component is assumed to be a linear function of vector of characteristics, including socioeconomic and other variables (X), stated as:

$$U_{i,m} = X_{i,m}\, b_{i,m} + e_{i,m} \tag{8}$$

From (8), the individual is assumed to participate in the Masara N'Arziki project if and only if $U_{i,m} > U_{i,j}\ \forall j \neq i$.

The probability that a farmer participates in the project is simply the probability that the utility obtained from participation is larger than the utility from non-participation. This is expressed in the following equation:

$$\begin{aligned}\Pr(Y=1) &= \Pr\left(U_{i,1} > U_{i,0}\right) = \Pr\left(V_{i,1} + e_{i,1} > V_{i,2} + e_{i,2}\right)\\ &= \Pr\left(e_{i,2} - e_{i,1} < V_{i,1} + V_{i,2}\right)\end{aligned} \tag{9}$$

The error component is assumed to follow a standard normal distribution with mean zero and constant variance, so that the probit model becomes an ideal means to estimate the parameters through maximum likelihood procedure.

The empirical model for the determinants of project participation (Y) is presented in the following equation:

$$Y_i = \sum_{k=1}^{8} b_k X_{i,k} + e_i \tag{10}$$

where the variables are as defined in Table I.

3.5 PSM

In examining the impact of project participation on selected outcomes, the PSM analysis is used. PSM, as a modelling technique, is designed to help the comparison of experimental outcomes between treated and untreated groups. Specifically, in relation to this study, the approach is to help compare the observed output, yield and income of Masara N'Arziki project participants to the output of counterfactual non-participants based on the predicted propensity scores of participating in the ICSM project (Rosenbaum and Rubin, 1983; Heckman *et al.*, 1998; Smith and Todd, 2005). Following the work of Godtland *et al.* (2004) and Bernard *et al.* (2008), the approach consists of two main steps. The first step involves estimating the propensity scores using a binary choice model such as contained in Equation (10). The essence of the propensity scores is to account for sample selection bias due to observable differences that may occur between treatment and comparison groups (Dehejia and Wahba, 2002). This step constructs a statistical comparison group by matching every individual observation on participants with individual observations from the group of non-participants having similar characteristics based on the propensity scores (Austin, 2011).

The second stage estimates an average treatment effect (ATE) for participation in the programme on response variable of interest. The propensity scores generated in the first step are used to match treated observations (participants) with untreated observations (non-participants). The ATE is estimated as the mean difference in response variable (output, yield or income) between participants, denoted by $Y(1)$ and matched control group, denoted by $Y(0)$. Y can be π or Q as shown in the theoretical model. The following equation represents the model for estimation of the ATE:

$$\text{ATE} = E[Y(1)-Y(0)] = E[Y(1)]-E[Y(0)] \tag{11}$$

The ATE model compares the output, income or yield of farmers who participated in the ICSM with that of non-participant farmers that are similar in terms of observable characteristics, and also partially controls for non-random selection of participants in the Masara N'Arziki programme. The ATE as calculated in Equation (11) could be interpreted as the effect of the project participation on maize farmers' output, income or yield.

Apart from the ATE, an average treatment effect on the treated (ATT or ATET) is also estimated for the project participants. The ATT model measures the effect of adoption on output for only farmers who actually enrolled in the Masara N'Arziki project rather than across all maize farmers who could potentially participate in the project. ATT is calculated using the expression in the following equation:

$$\text{ATT} = E[Y(1)-Y(0)|D=1] = E[Y(1)|D=1]-E[Y(0)|D=1] \tag{12}$$

where D is a dummy or indicator variable for treatment ($D=1$ participants, 0 for non-participants). Again, one could also estimate the ATE on the untreated or control group (ATU), which measures what the effect of participation would have been on output,

Table I. Description of variables and a priori expectations

Variable	Definition and measurement	Expected sign
Education	Years of formal education respondent has obtained	+
Age	Age of farmer (in years)	−
Marital status	Dummy, 1 if married, 0 otherwise	+
Household size	Number of people in household that assist in farm activities	+
Project experience	1 if farmer has previous experience with other projects, 0 otherwise	+
Farm experience	Number of years farmer has experience in agricultural production	+
Off-farm job	1 if farmer engages in off-farm employment/activity, 0 otherwise	±
Farm size	Total farm size owned by farmer	+

income or yield for farmers who did not actually participate in the project. The model for measuring such ATU is expressed by the following equation:

$$\text{ATU} = E[Y(1) - Y(0)|D = 0] = E[Y(1)|D = 0] - E[Y(0)|D = 0] \quad (13)$$

These parameters are not observable, since they depend on counterfactual outcomes. For instance, using the fact that the average is the difference of the averages (see Equation 12), $E[Y(0)|D=1]$ is the average outcome that participants would have obtained in the absence of participation, which is not observed and $E[Y(0)|D=0]$ is the value of $Y(0)$ for the untreated individuals. The difference Δ is calculated as: $\Delta = E[Y(1)|D=1] - E[Y(0)|D=0]$. The difference between Δ and ATT is:

$$\Delta = E[Y(1)|D = 1] - E[Y(0)|D = 1] + E[Y(0)|D = 1] - E[Y(0)|D = 0]$$

$$\Delta = \text{ATT} + E[Y(0)|D = 1] - E[Y(0)|D = 0]$$

$$\Delta = \text{ATT} + \text{SB} \quad (14)$$

where *SB* is the selection bias, which is the difference between the counterfactual outcomes for participant farmers and the observed outcomes for the non-participants. If this term is equal to 0 then the ATE can be estimated by the difference between the mean observed outcomes for participants and non-participants as in Equation (11).

In estimating ATE, ATT and ATU, a PSM estimator is selected which describes how comparison units relate to treated units. The procedure also checks the matching quality of the propensity scores, i.e. whether the matching procedure is able to balance the distribution of the relevant variables in both the control and treatment groups (Smith and Todd, 2005)[1].

Once the PSM estimation is done, it is important to verify the common support or overlap condition. The assumption for this condition is that the probability of participation in Masara N'Arziki ICSP lies between 0 and 1 (implying participation is not perfectly predicted). The assumption is critical to the propensity score estimation, as it ensures that units with the same covariate values have a positive probability of being both participants and non-participants. Checking the overlap or region of common support between treatment and comparison groups can be done by visual inspection of the propensity score distributions for both the treatment and comparison groups. The visual check of overlap condition is to see whether matching is able to make the distributions more similar.

If there are unobserved variables which affect participation and the outcome variable simultaneously, a "hidden bias" might arise (Marco and Sabine, 2005). This is the essence of sensitivity analysis of matching estimators to test for unobserved heterogeneity (Duvendack and Palmer-Jones, 2012). Sensitivity analysis is performed to determine how strongly an unmeasured variable must influence the selection process in order to undermine the implications of matching analysis by creating a hidden bias.

4. Results

4.1 Descriptive statistics

Generally, participants in the Masara N'Arziki project obtained higher outputs on an average (3,026.69 kg/ha) than non-participants (1,129.87 kg/ha) as shown in Table II. These translate into mean farm incomes from maize farming of GH¢193.36 for non-participants and GH¢225.72 for participants[2]. The statistics show that averagely the participants did better than non-participants both in terms of output and income. This is against the backdrop that participants used more labour than non-participants. Again, participants had more experience in farming (24 years) than non-participants (18 years). It is quite intriguing to find that some farmers deliberately increased their farm size more than the labour they

Variable	Unit	Participants Mean	SD	Non-participants Mean	SD	Pooled sample Mean	SD
Output	Kg	3,026.69	1,487.32	1,129.87	689.21	2,277.69	1,544.14
Farm income	GH¢	225.72	150.60	193.36	203.47	212.94	173.64
Marital status	Dummy	0.97	0.181	0.97	0.23	0.97	0.20
Education	Years	1.29	0.628	1.47	0.89	1.36	0.75
Household size	Count	15.52	6.46	10.45	4.64	13.53	6.29
Age	Years	47.14	10.12	46.12	9.70	46.74	9.92
Farm experience	Years	24.41	10.67	18.69	7.87	22.16	10.01
Off-farm job	Dummy	0.25	0.43	0.26	0.44	0.25	0.43
Farm size	Hectare	4.09	2.38	3.09	1.66	3.69	2.17
Project Experience	Dummy	0.23	0.42	0.16	0.37	0.20	0.40

Table II. Descriptive statistics of variables used in model

can provide in production since the quantity of agro-inputs received was proportional to farm size. This resulted in low output of some farmers in the project. In the traditional farming settings of the Northern region, large household size determines the household farm size. It is likely the intensive labour nature of the project accounted for the participation of households with many people.

In terms of education, the results show that participants were less formally educated (1.29 years) than non-participants (1.47 years). However, in relation to farm size, the reverse is the case, where we find participants holding an average of 4.09 ha compared to the 3.09 ha for non-participants. The relative differences in the ages of participants and non-participants imply that more of the aged were willing to participate than the younger ones who had more years of education (see Table II).

4.2 Factors influencing farmers decision to participate in Masara N'Arziki project

The probit model was used to estimate the parameters of the factors that influence participation in Masara N'Arziki project by farmers in the study area, and results are reported in Table III. The significant likelihood ratio ($p < 0.00$) and the correctly classified counts of 73.9 per cent indicate adequate explanatory power of the independent variables in relation to Masara N'Arziki project participation. Variables that significantly determine project participation include household size, farm experience, farm size and project experience. The other factors (age, education, off-farm income and marital status) do not affect participation in the project.

Variable	Coefficient estimates Estimate	SE	Marginal effects Estimate	SE
Household size	0.0915***	0.0196	0.0345***	0.0074
Education	−0.1909	0.1514	−0.0721	0.0572
Farm experience	0.0289*	0.0128	0.0109*	0.0048
Farm size	0.1201*	0.0582	0.4534*	0.0219
Age	−0.0136	0.0120	−0.0051	0.0045
Off-farm job	−1.1191	0.2393	−0.0426	0.0917
Project experience	0.4987*	0.2806	0.1756*	0.0908
Marital status	−0.2442	0.5308	−0.0922	0.2003
Constant	−0.9274	0.7489	–	–

Notes: Model diagnostics number of observations = 195; likelihood ratio $\chi^2 = 55.31$; Prob(χ^2) = 0.000; Pseudo $R^2 = 21.14\%$; log likelihood = −103.164; per cent correctly classified = 73.85%. *$p < 0.1$; ***$p < 0.01$

Table III. Probit model results of determinants of participation in Masara N'Arziki project

The probit analysis yielded a positive significant marginal effect of farm experience. Practically, experienced farmers have greater probability of participation in Masara N'Arziki project. A year increase in farm experience significantly increases the likelihood of participating in the project by 1.09 per cent. Usually, experienced farmers have in-depth managerial skills and knowledge in farming. Such farmers may also know the importance of using improved production techniques as opposed to new entrants. This finding confirms conclusions reached by Adesiji *et al.* (2011). They found that farmers with more experience in farming tended to be more knowledgeable, are more acquainted with the use of credit facilities from similar projects and therefore are often more willing to participate. In addition, Martey *et al.* (2015) and Donkoh *et al.* (2016) revealed that participation of smallholder farmers in AVCMP and Block Farm Credit Programme (BFCP), respectively, in the Northern region of Ghana are significantly determined by the experience of the farmer. However, Ebojei *et al.* (2012) found a contradictory result, where experienced maize farmers were less likely to participate in hybrid maize production.

The study found that farmers with larger households have significantly higher probability to participate in the project. Any additional member to the household workforce increases the probability of participation by 3.5 per cent. Martey *et al.* (2014) stated that household size serves as a source of family labour, which complements the effort of the household head on the farm and therefore increases participation in support project.

Farmers who had experience from previous or similar projects tend to have access to information which is important to production and marketing decisions. The results show that farmers who participated in other projects had a higher probability of participation in the Masara N'Arziki project. Farmers with previous or other project experience are 17.6 per cent more likely to participate in the project. The experience acquired from other projects may enable farmers to work effectively for higher yields in the project. This is consistent with the work of Botlhoko and Oladele (2013), who noted that participation in other projects increased farmers' ability to adopt new agricultural practices and improved their performance for enhanced yields.

Finally, farm size relates positively to farmers' decision to participate in the Masara N'Arziki project, where farmers with larger farms are about 45.3 per cent more likely to participate in the project. This is consistent with a number of previous studies including Martey *et al.* (2013), Mohammad (2013) and Nxumalo and Oladele (2013). These studies observed that farm size influenced household heads' decision to participate in agricultural projects. Farmers who had large farm sizes under the project received corresponding higher farm inputs required for a good yield. Hence many of them were encouraged to increase their farm sizes to enable them acquire more farm inputs such as fertiliser which was given at the ratio of 11 bags (i.e. 550 kg) per ha.

4.3 Effect of project participation on output, yield and income of farmers

The PSM estimation of outcomes from the survey was done using nearest neighbour matching (NNM) and kernel-based matching (KBM) algorithms in order to establish the robustness of the estimates. Results are presented in Table IV. The ATE of maize output from the project participation with NNM and KBM were 1,735.39 and 1,921.79 kg, respectively. All calculations were based on a one-to-one matching pairs, and were all significant at the 1 per cent level. Thus, in terms of output, project participants significantly do better than non-participants. For the participants alone, the impact of the project, measured by the ATT parameter are 1,895.35 and 1,808.75 kg for the NNM and KBM algorithms, respectively. These significant values mean that, based on output, the Masara N'Arziki project impacted positively on farmers who participated. Given that the potential output of the non-participant farmers in the project, represented by ATU, is statistically significant and also implies that if the non-participant farmers had actually

Model/outcome	NNM Coefficient	NNM SE	KBM Coefficient	KBM SE	RA Coefficient	RA SE
Maize output						
ATE	1735.39***	153.51	1921.79***	220.51	1589.41***	129.21
ATT	1895.35***	172.17	1808.75***	253.28	1658.59***	152.28
ATU	1490.26***	209.09	2093.51***	320.75	–	–
Maize yield						
ATE	427.99***	40.29	439.02***	57.04	437.91***	35.53
ATT	443.20***	40.95	410.40***	40.10	431.64***	37.15
ATU	404.68***	59.81	482.88***	111.02	–	–
Income from maize production						
ATE	25.93	33.95	33.18	29.99	234.41***	39.31
ATT	14.88	34.23	35.51	47.39	218.19***	30.45
ATU	10.68	34.67	58.89	50.25	–	–

Notes: Number of observation = 195. Number of matches = 1. Minimum = 1. Maximum = 3. ***$p < 0.01$

Table IV. PSM estimates of outcomes (output, yield and income) from maize production

participated in the project, their potential output from maize would have been higher than the participants in the project. So in terms of output, the Masara N'Arziki project has been important at raising the output of the farmers.

Similar conclusions are drawn based on estimates from the regression adjustment (RA), which accounts for systematic differences in baseline characteristics between treated and untreated subjects. The essence of the RA is to check whether the propensity score model has been adequately specified (Linden and Adams, 2012). RA also reduces bias due to residual differences in observed baseline covariates between treatment groups. As shown in Table IV, the RA result for ATE and ATT are 1,589.41 and 1,658.59 kg, respectively, and both are significant at the 1 per cent level.

In terms of yield (i.e. output per hectare), the results provide statistical evidence that the Masara N'Arziki project increases yield significantly. Participant farmers generated yields that were considerably higher than non-participants. Both the ATE (427.99 kg/ha) and ATT (443.20 kg/ha) figures based on the NNM demonstrate important contribution of project participation to overall maize yield. This result is consistent with Donkoh *et al.* (2016) who reported that farmers who participated in the BFCP obtained 10 per cent higher crop yield than those who did not participate in the BFCP. Benin *et al.* (2012) also made a similar observation and reiterated the fact that farmers who participated in the Masara N'Arziki project had access to low-cost credit in the form of inputs resulting in greater farm output.

In terms of income, the results appear to validate the many complaints by farmers about their inability to earn reasonable returns from their efforts in the project. Participants are required to pay the cost of inputs supplied by management of Masara N'Arziki using their produce. Therefore, it may not be surprising to see some participant farmers worse off in terms of income due to low farm output which must be used to pay for the cost of credit received, usually at harvest hence leaving farmers either receiving little or no farm produce for their household. This finding is consistent with Martey *et al.* (2015) where participation of smallholder farmers in support project did not significantly translate into higher farm incomes. Thus, though in the short term, participants' productive capability may directly increase that does not guarantee increases in incomes. Both the ATE and ATT based on income from maize farming for participants are higher than non-participants. The difference, however, is not significantly different from zero for both matching algorithms.

Other empirical studies have shown that the radius matching algorithm has the ability to avoid the risk of poor matches, which may be associated with the NNM and KBM.

For this reason, the ATT was estimated for the three outcomes using the radius matching (see Table V). Out of a total of 77 non-participants, 65 and 66 individuals matched within the calliper radius of the various outcomes with the participant group in the project. This represents 84.4 per cent maize output, 85.7 per cent maize yield and 85.7 per cent of farm income of the matching quality of the control group. The average effect of the project on the participants was 1,691.12 kg of maize output and 418.87 kg/ha of yield, which were all significant at the 5 per cent level. The average income is GH¢14.42/ha, but this is not significant, showing that the income of project participants was no better than non-participants.

Participant farmers outlined a number of challenges that reduce the income earned from maize production in the Masara N'Arziki project. Farmers generally think that they are not getting the expected net output to make them compete profitably with non-participant farmers due to the high cost of input credit. It is therefore understandable that in terms of net income, participant farmers were no better than non-participants. Farmers have the responsibility to bear the cost of land preparation before ploughing, as well as cost of harvesting and bagging. All these raise the cost incurred by farmers and reduce their net income.

4.4 Sensitivity analysis – Mantel and Haenszel (1959) test for hidden bias

Aakvik (2001) suggested the use of Mantel and Haenszel (1959) test statistic for the detection of hidden bias, since the PSM approach cannot be fully controlled for unobservable characteristics (Tagel and Anne, 2015). The Mantel-Haenszel (MH) non-parametric test compares the successful number of participants against the same expected number given that participation is zero. This test is used to check the sensitivity of the estimated treatment effects to selection on unobservables using the bounding approach developed by Rosenbaum (2002). We applied the procedure by Becker and Caliendo (2007) to aid in the construction of Rosenbaum bounds for sensitivity testing. Table VI reports the outcome from the MH bounds tests, showing that under the assumption of hidden bias when $\Gamma = 1$,

Outcome	Participants	Non-participants	ATT	SE
Maize output	118	65	1691.12**	174.05
Maize yield	118	66	418.87**	37.96
Farm income	118	66	14.42	34.39

Notes: NB, the numbers of participants and non-participants refer to the actual matches within the radius. **$p < 0.05$

Table V. PSM estimates on outcomes based on radius matching algorithm

γ	Q_mh$^+$Q_	mh–P_	mh$^+$P_	mh–
1	3.932	3.932	0.000046	0.000042
1.05	4.043	3.850	0.000026	0.000059
1.1	4.138	3.761	0.000017	0.000084
1.15	4.281	3.678	0.000012	0.000017
1.2	4.323	3.600	7.7e-06	0.000159
1.25	4.411	3.527	5.1e-06	0.000211
1.3	4.498	3.457	3.4e-06	0.000270
1.35	4.583	3.392	2.3e-06	0.000350
1.4	4.667	3.329	1.5 e-06	0.000440
1.45	4.749	3.270	1.0e-06	0.000540
1.5	4.829	3.214	6.8 e-06	0.000650

Notes: MH bounds using STATA 13. $\Gamma = 1 \approx$no "hidden" bias. Q–mh$^+$ = Mantel-Haenszel statistic; Q–mh$^-$ = Mantel-Haenszel statistic; P–mh$^+$ = Significance level; P–mh– = Significance level

Table VI. Mantel-Haenszel bounds for the outcome variable (income from maize farming) the Q_{mh} test statistic indicates a highly significant treatment effect for Masara N'Arziki project participation on the maize output. The two bounds in the MH tests can be interpreted in the following way; the Q_{MH+} statistic adjusts the MH statistic downwards for positive unobserved selection or hidden bias.

A positive selection bias would occur only when those most likely to participate have a higher farm income that accrue from the project output even without participation in the project, and given that they have the same characteristics as individuals in the group. This effect leads to upwards bias in the estimated treatment effect. When there is no hidden bias, the effect is significant under $\Gamma = 1$ and becomes even more significant for increasing values ($\Gamma > 1$). The Q_{MH+} reveals that the study is insensitive to hidden bias at the 1 per cent significance level. The sensitivity analysis of the study indicates that the observed results of the effects of Masara N'Arziki project on the farmers' output and income are insensitive to selection on unobservables or hidden bias.

5. Conclusions

The concept of farmer support projects, like the one proposed and implemented by Masara N'Arziki project, is a good one to help bridge the gap in crop yields created by missing markets in agricultural production. Ultimately, such projects through increased yields are expected to improve food security and livelihoods through increased incomes. However, this study has revealed important findings that need to be highlighted and discussed further. First, participation in the Masara N'Arziki project tends to be skewed towards experienced farmers with big-sized households, larger farm sizes and with previous project experience. These findings point to the issue often raised by farmers in the project communities about the enormous labour requirements in the project due to many of them cultivating larger farm sizes than the labour they can provide for the agronomic farm activities. The demanding nature of the arrangement means that farmers with experience in similar projects are better able to cope than new entrants. Such experienced farmers tend to have the nitty-gritty for such contractual arrangements so that they can gain in the end.

Second, granting the usual limitations of the PSM approach within acceptable limits (since we employ an array of matching algorithms and comparative techniques), the results on the various outcomes provide some key lessons and management implications. Even though farmers who participate in the project tend to have higher overall output and yield, they were relatively not better off than the non-participants in terms of net output or income especially farmers whose output were not enough to pay for the cost of input received from the project after harvest. Net output or income is a better measure of welfare effects of the project compared to output and yield. Hence, if output or yield increases but income is not affected, then there is a mismatch between revenues and costs. This will mean that participant farmers are either incurring higher costs or lower revenues. During the survey, farmers complained of high costs of the input credit. Farmers with low outputs find it difficult to save farm produce for their household food needs and this tends to erode the expected gains. At the same time, however, the results tend to verify the claim (under the theoretical model) that farmers in the developing country context examined (i.e. Northern Ghana) do not necessarily optimise according to classical rules. They appear to be maximising output rather than profits under credit policy.

Additionally, considering the strenuous efforts that must be expended by project participants to be able to repay the cost of input credit, the non-significant differences in income compared to that of non-participants leaves participant farmers relatively worse off. However, this finding contrasts with that of Banerjee *et al.* (2005) and Binswanger *et al.* (1993) who, respectively, observed sustainable improvement in income for the ultra-poor using multipronged approach and multiplicity of factors (such as input and output prices, educational infrastructure and rural banks availability) affecting agricultural output positively.

If farmers would be motivated to continue enrolling on such kinds of projects, management would have to re-examine the terms and conditions of contract so that participant farmers will have a competitive edge in terms of net output. The project should also be expanded to cover some more incentives. When these conditions are satisfied, the Masara N'Arziki project could be scaled up to more food insecure farming communities in the Northern region, and other parts of Ghana.

In terms of policy, the regional and district authorities in charge of agriculture can help farmers, especially through their associations, to negotiate for fair and liberal terms with project management. This will tend to enforce and ensure the attainment of the core aims of the project, such as improving livelihoods and food security.

Notes

1. Interested readers can consult Dehejia and Wahba (2002), for detailed treatment of the matching estimators.
2. The exchange rate as at 5 May 2016 stood at US$1.00 = GH¢3.83958 (see www.xe.com).

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Corresponding author
Paul Kwame Nkegbe can be contacted at: pnkegbe@uds.edu.gh