IMPACT OF ACCESS TO SUBSIDIZED CERTIFIED IMPROVED RICE SEED ON INCOME: EVIDENCE FROM RICE FARMING HOUSEHOLDS IN NIGERIA

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Abstract: Seed certification enhances seed quality and has the potential to increase rice yield and improve farmers' income. Rice farmers in Nigeria were granted access to certified improved rice seed at a subsidized rate using the seed voucher system by the Emergency Rice Initiative(2008-2010), formulated by AfricaRice, in response to the global food crisis of 2008, in order to mitigate the adverse effects on poor farmers. The impact of access to the Subsidized Certified Improved Rice seed (SCIRS) on farming households' income has not been documented. Hence, this study was conducted to fill this gap. The data were collected using a multistage random sampling technique. Osun, Niger and Kano states were selected to represent -upland, lowland and irrigated rice growing systems, respectively. Five major rice-producing Local Government Areas (LGAs) were selected from each state, followed by the selection of three villages from each LGA. In all, 600 rice farmers were selected on the basis of probability proportionate to the population size of rice farmers in the villages, out of which 160 farmers were randomly selected to receive the SCIRS (treatment group) and the rest were not given (control group). Data were collected using a structured questionnaire and analyzed using descriptive statistics, ATE estimation method and the Local Average Treatment Effect (LATE) estimation techniques. The result revealed that average income from rice production and per capita household income increased by18.5% and 2.3% respectively at the end of the intervention in 2010. The result of the LATE showed that access to SCIRS increased income from rice production by ₦50, 220.55 per cropping season, thereby reducing the farmers' probability of being poor. Therefore, timely access to seed of good quality can be a route out of the present prevailing rural poverty in Nigeria. It is recommended that seed certification should be intensified.

Keywords: seed certification, rice, staple food security, africa

INTRODUCTION

Africa has become a big player in international rice market, accounting for 32 per cent of global imports in 2006, at a record level of 9 million tons in that year (AfricaRice, 2008). The emergence of Africa as a big rice importer is explained by the fact that during the last decade's rice has become the most rapidly growing food source in Sub-Saharan Africa (Sohl, 2005), due to population growth (4 per cent), rising incomes and a shift in consumer preferences in favour of rice especially in urban areas (Balasubramanian et al., 2007). While rice is very much a cash crop for small –to medium-scale farmers in East and Southern Africa region, it is more of a subsistence crop in West Africa where most of the continent's rice is produced. Nigeria is West Africa's largest producer of rice, producing an average of 3 million metric tons of paddy rice for the past 3 decades.

In Nigeria, rice is the most important staple food crop, both for food security and cash income. In the producing areas, it provides employment for more than 80 per cent of the inhabitants as a result of the activities that take place along the distribution chains from cultivation to consumption (Ogundele and Okoruwa, 2006). It contributes immensely to both internal and sub-regional trade. Rice production is also a profitable enterprise (Awotide, 2004). It is a crop with a great capacity of adaptation to the most varied conditions of climate, soil, topography and moisture and therefore, it is the only crop grown in all agro-ecological zones in Nigeria.

In view of its increasing contribution to per capita calorie consumption of Nigerians, the demand for rice has been increasing at a much faster rate than domestic production and more than in any other African countries since mid 1970 (FAO, 2001). However, despite the huge demand and increase in land cultivated to rice there has not been a significant improvement in rice supply as rice yield has continued to witness a decline in growth rate. The total domestic rice demand is estimated at about 5 million tons while the annual domestic output of rice still hovers around 3 million tons, leaving the huge gap of about 2 million tons annually (NAMIS, 2004), a situation which has continued to encourage dependence on importation. Consequently, rice importation in Nigeria rose from 7000 tons in the 1960s to 657000 tons in 1990s (IRRI, 1991; 1995) and increased tremendously to 1.3 million tons and 2.5 million metric tons in 2000 and 2003 respectively. The cost of rice importation in 2003 was ₦29.85 billion (Daramola, 2005). On the average, Nigeria imports about 16.8 million tonnes of rice annually at a colossal amount of foreign exchange. However, due to serious foreign exchange scarcity, it is becoming increasingly difficult to import the quantities of rice necessary to sustain per capita rice consumption and to also keep the domestic price down. Hence, one of the developmental challenges facing the nation today is how to meet the local demand of rice, and reduce the over-reliance on rice importation.

In order to overcome this challenge at least 57 improved rice varieties have been developed by the national and international research institutes. This is based on the premise that the development and use of improved varieties holds the key to sustainable food production across the globe and also because seeds are basic agricultural input and more importantly, quality seeds of any preferred varieties are basis of improved agricultural productivity since they respond to farmers needs for both their increasing productivity and crop use (Pelmer, 2005). The use of improved seeds is could also help to overcome some of the farm-level constraints that hindered rice production in Nigeria (Awotide et al., 2010).

Despite these laudable efforts, Nigeria still battles with the problem of rice scarcity and its attendant price volatility. Of a major concern is the untold hardship experience by the poor masses particularly the rural poor as a result of the 2008 global food crisis, which necessitated some major rice exporting countries cutting back rice export in order to meet their own local demand for rice. In Nigeria, this generated a nationwide scarcity of rice and increase in food prices. The Nigerian experience was not markedly different from the other sub-Saharan nations where it degenerated into riots and even death in some other countries. In order to mitigate the adverse effects on poor rural framing households in sub-Saharan Africa, an Emergency Rice Initiative (ERI) was proposed by AfricaRice in collaboration with other national and international development agencies and financed by the United State Agency for International Development (USAID) (AfricaRice, 2010). The program recognized the fact that access to certified improved rice seed is a major constraint to increase rice yield in Sub-Saharan Africa. Using the seed voucher system, some randomly selected farmers in four countries (Nigeria, Mali, Senegal and Ghana) were granted access to the Subsidized Certified Improved Rice Seed (SCIRS). This is with a view to generating the desired increase in rice yield which is expected to lead to an increase in farmers' income and consequently generate overall poverty reduction. However, the extent to which these objectives have been achieved is still not known. Therefore, the main aim of this study was to empirically assess the impact of access to subsidized certified improved rice seed on farmers' income in Nigeria.

The assessment of the impact of this intervention is of immense importance. There is dearth of studies on impact assessment of public programs in Nigeria and as a result of that there is dearth of information concerning the actual impact of many programs and projects on the lives of the poor. This knowledge gap exists despite the increasing awareness that good impact analyses will help improve resource allocation—which is especially important for the resource-scarce developing countries like Nigeria. In addition, the impact assessment of the program will not only help decision makers to determine strategic choices for public actions so as to have the greatest impact on pro-poor growth and poverty reduction, it will also provide a better understanding about potential winners and losers of an intervention and thus strengthens a result-oriented approach (OECD, 2007). If programs are poorly designed, do not reach their intended beneficiaries, or are wasteful, with the right information they can be redesigned, improved, or eliminated if deemed necessary. According to Ravallion (2005) the poor will also benefit from good project assessment, as it will detect and weed out defective anti-poverty programmes and identify the effective ones. The knowledge gained from impact evaluation studies will also provide critical input to the appropriate design of future programs and projects.

The rest of the paper is organized as follows: section two contains the conceptual framework. Section three contains the analytical techniques. The data and descriptive statistics are presented in section four. The results and discussion is presented in section five. Finally, section six contains the summary, conclusion and policy recommendations.

Conceptual Framework

A rapid development in agriculture would serve as a catalyst for the improvement of the standard of living for majority of Nigerians and for agriculture to develop, access by farmers to productive resources that are crucial to increase productivity is essential. Improved seed is an important input in all crop based farming system and is a key factor in determining the upper limit of yield and therefore the ultimate productivity of input such as pesticides, fertilizer and agricultural technology (Maredia and Howard, 1998; Cromwell, 1990). Improved genetic material embodied in seeds is the most fundamental and perhaps most familiar type of agricultural research output. "Improved" may refer to any of several desirable characteristics: higher potential grain yield, responsiveness to other inputs such as fertilizer and/or irrigation, greater tolerance to stresses such as droughts, pests or diseases, a shorter duration (length of the growing season), longer storage capability after harvest, higher nutrient content, better taste, and higher fodder quantity or quality (Anderson 1997).

According to Morris et al. (1999) of all inputs used in agriculture none has the ability to affect productivity more than improved seeds. If farmers can obtain seed of improved varieties that performs well under local conditions and also adopt it, the efficiency with which other inputs are converted into economically valuable outputs increases and productivity rises. Productivity increases in agriculture can have a positive impact on poverty by increasing farmer's income, reducing food prices and thereby enhancing increments in consumption (Diagne et al., 2009). Drawing from existing literature, gains from new agricultural technology have influenced the poor directly, by raising incomes of farm households, and indirectly, by raising employment, wage rates of functionally landless labourers, and by lowering the price of food staples (Pinstrup-Andersen et al., 1976; Hossain et al., 1994; Winters et al., 1998; de Janvry and Sadoulet, 1992, 2001; Irz et al., 2001). It is expected that those farmers that received the seed voucher will have better yield and per capita income from rice production and household expenditure than those farmers that did not receive. However, it is important to trace the impact pathway through which this will happen.

This study adopted the sustainable livelihood framework developed by DFID (2001) to trace the impact pathway of the receipt of seed voucher on the poverty reduction among the rice farmers in the study area. It is based on evolving thinking about the way the poor and vulnerable lives their lives and the importance of policies and institutions. It is a useful tool to organize and understand the various factors that constraint or provide opportunities for rice farmers and interaction between them. Key agricultural productivity improvements are improvement in agricultural technologies such as improved seed varieties. However, for improved seed varieties to yield adequate benefits, its quality is of great importance. In Nigeria like many developed countries, access to good quality seed is limited by many constraints and if farmers continue to face these difficulties in accessing these seeds that are crucial to increase in productivity, the goal of poverty reduction, food security and the overall national economic growth and development may be jeopardised. The sustainable livelihood framework recognises the fact that the rice farmers build their livelihood on wide range of assets or resources and when a rice farming household surfers' deprivation in some or all of the various type of capita, it resulted into poverty. Capitals such as: Natural capital, Physical capital, Human capital, Institutional resources have been recognised to have causal impact on poverty. These capitals are also conditioned by some exogenous factors such as agro-climatic condition, outside world conditions, policies etc.

The principle of development intervention is to have appropriate technology, policies, institution that creates incentives for people to behave individually and collectively so as to improve household welfare in a sustainable manner (Diagne, 2010). For instance, when institutional resources are improved upon such as use of seed voucher as an instrument to grant farmers access to certify improved rice seed, it leads to a change in the beliefs and expectations of the rice farmers. Farmers then decide whether to use the seed voucher to obtain the subsidized certified improved rice seed or not. Farmer's decision can be influenced by the community decision and the community decision can also influence the farmer's decision. The farmer decision to receive the seed voucher for the collection of certified improved rice seed will produce some behavioural outcomes, such as sustainable resource use that would lead increase yield, improve household's income, improved social welfare and overall economic growth and vice versa.

ANALYTICAL FRAMEWORK

Impact analysis

In order to empirically assess the impact of access to the SCIRS on farmers' income, the choice of the appropriate model to use depends on how the treatment was disseminated and receipt by the intended beneficiaries. In the case of this study, the overall population of Nigerian rice farmers was not equally exposed to the program (that is the instrument was not randomly distributed). On the other hand, rice farmers that were randomly selected to receive the SCIRS had full control over their decision to receive it or not (the receipt of the instrument is endogenous). Therefore following the impact assessment literatures, the most plausible assumption in this case is that of selection on unobservable (Imbens, and Wooldridge, 2009; Diagne, *et al.*, 2009). Despite the fact that some of the farmers were randomly selected to receive the SCIRS, the farmers' decision to receive it is based on anticipated benefits they would derived by receiving it, however, this anticipated benefit is unobserved by the researcher. Therefore, to estimate the impact of the program, we need an instrument which will be independent of income, but could affect income only through the access to the SCIRS.

Given the fact the study adopted RCT, the simplest way to assess the impact of the SCIRS is by simply examining the differences in mean outcomes of treated and control farmers (Schultz, 2004 and Scriven, 2008) or by using simple regression procedures that include the treatment status variables among the set of explanatory variables. However, as pointed by critics, these procedures have many flaws which include their inability to eliminate biases due to self-selection bias and selection on unobservable (Imbens, and Wooldridge, 2009; Heckman and Vytlacil, 2005; Lee, 2005; Imbens, 2004; Rosembaum, 2002; Heckman and Robb, 1985; Rosembaum and Rubin, 1983; Rubin, 1974). Consequently, researchers have adopted other methodologies which include: propensity score matching (PSM) which can deal appropriately with the self-selection bias problem and estimate the *Average Treatment Effect (ATE)* (Mendola, 2007; Mojo *et al*., 2007; Javier and Awudu, 2010). Other authors have adopted a combination of methodologies such as combining both the PSM and Double Difference (DD) methods (Oni et. al., 2007; Mkonya et. al., 2007). The rationale for this is the fact that although the PSM method fails to deal appropriately with the problem of selection on unobservable, this can be handled conveniently by the DD. Therefore combining the two methods have removed both the hidden and overt biases; however, there is still the problem of non-compliance.

The methods proposed in the statistics and econometric literature to remove (or at least minimize) the effects of overt and hidden biases and deal with the problem of non-compliance or endogenous treatment variable can be classified under two broad categories based on the types of assumptions they require to arrive at consistent estimators of causal effects (see Imbens 2004). There are the methods designed to remove overt bias only. These are based on the "ignorability" or conditional independence assumption (Rubin, 1974; Rosenbaum and Rubin, 1983) which postulates the existence of a set of observed covariates ***x*,** which, when controlled for, renders the treatment status *d* independent of the two potential outcomes y_T and y_C. The estimators using the conditional independence assumption are either a pure parametric regression-based method, where the covariates are possibly interacted with treatment status variable to account for heterogeneous responses, or they are based on a two-stage estimation procedure where the conditional probability of treatment $P(t = 1| x) \equiv P(x)$ (called the *propensity score)*, is estimated in the first stage and ATE, ATE1 and ATE0 are estimated in the second stage by parametric regression-based methods or by non-parametric methods; the latter include various matching method estimators such as those used by Mendola (2006).

The conditional independence-based estimators of ATE, ATE1 and ATE0 that was adopted are the so-called inverse propensity score weighing estimators (IPSW), which are given by the following formulae (see Imbens, 2004; Lee 2005, pp 65-69, Diagne and Demont 2007):

$$A\hat{TE} = \frac{1}{n}\sum_{i=1}^{n}\frac{(t_i - \hat{p}(x_i))y_i}{\hat{p}(x_i)(1-\hat{p}(x_i))} \quad (1)$$

$$A\hat{TE}1 = \frac{1}{n_1}\sum_{i=1}^{n}\frac{(t_i - \hat{p}(x_i))y_i}{(1-\hat{p}(x_i))} \quad (2)$$

$$A\hat{TE}0 = \frac{1}{1-n_1}\sum_{i=1}^{n}\frac{(t_i - \hat{p}(x_i))y_i}{\hat{p}(x_i)} \quad (3)$$

Where *n* is the sample size, $n_1 = \sum_{i=1}^{n} t_i$ is the number of treated and $\hat{p}(x_i)$ is a consistent estimate of the propensity score evaluated at $\boldsymbol{x}$.

ATE= is the mean impact of access to the SCIRS in the population

ATE1=is the impact of access to the SCIRS on the subpopulation of the farmers in the treated group. Heckman and Robb (1984) and Heckman, Ichimura, and Todd (1997) argue that the subpopulation of treated units is often of more interest than the overall population in the context of narrowly targeted programs

ATE0= is the impact on the subpopulation of the farmers in the control group. This is equally of interest in case the program is to be extended to those farmers who currently did not have access to the SCIRS

A probit specification was employed to estimate the propensity score. However, the result of the ATE cannot be interpreted as the impact of the intervention. The ATE estimates do not correct for hidden bias (selection on unobservables) which is due the fact that farmers decision to receive the seed voucher could be based on some anticipated benefits and problem of non-compliance or endogeneity which may arise as a result of the fact that the farmer can decide to receive the SCIRS or not. Hence it is necessary to use other methods such as the instrumental variable techniques that can eliminate these problems.

The instrumental variable methods are designed to remove both overt and hidden biases and deal with the problem of endogenous treatment. The instrumental variable (IV)-based methods was used by Heckman and Vytlacil (2005, 2007a, 2007b); Heckman et al, 1997; Card, 2001; Imbens (2004); Abadie (2003); Imbens and Angrist (1994) and Todd,2006 to deal with overt and hidden biases and also deal with the problem of endogenous treatment. The method involves finding a variable (instrument) that is highly correlated with program participation but is not correlated with unobservable characteristics affecting outcomes (Khandker et al., 2010). In other words, the IV-based methods assume the existence of at least one variable **z** called *instrument* that explains treatment status but is redundant in explaining the outcomes y_T and y_C, once the effects of the covariates $\boldsymbol{x}$ are controlled for(Rubin, 1974; Rosenbaum and Rubin,1983). The methods rely on finding a variable excluded from the outcome equation but which is also a determinant of programme participation. It is often the case in social experiment that some of those that that were randomly given the seed voucher eventually did not receive the SCIRS. Meanwhile, the receipt of the seed voucher only affects the income through the access to SCIRS.

In Random experiments non-compliance with treatment status has been identified to be one of the major problems that could bias the estimate. Imbens and Angrist (1994) solve the problem of non-compliance in the population by dividing the population into four groups based on compliance status: *compliers* (those who adhere to their assigned treatment), *always takers* (those who manage to always take the treatment regardless of their assignment), *never takers* (those who never take the treatment regardless of their assignment) and *defiers* (those who do the opposite of what their assignment asked them to do). The important point made by Imbens and Angrist (1994) is that only the mean treatment effect for the subpopulation of compliers can be given a *causal* interpretation and they called such a population parameter the *Local Average Treatment Effect (*LATE).

Because the receipt of SCIRS is a farmer's choice even when they were randomly given the seed voucher, this led to the problem of non-compliance or endogenous treatment problem discussed above. Therefore, the ATE estimates of the impact of access to the SCIRS have no causal interpretation. Thus, to provide a consistently estimate of the impact of access to SCIRS on farmers' income it is important to estimate the LATE. The monotonicity assumption is trivially satisfied in the case of access to the SCIRS, because one cannot have access to the SCIRS without the seed voucher. This effectively rules out the cases of *defiers* and *always takers*. Thus, for assessing the impact of the SCIRS farmers' income the population was partitioned into only two distinct groups: the group of compliers, which is the group of potential receivers (those who will receive the SCIRS when received the seed voucher), and the group of never takers, which is the group of farmers that will never receive it even when they have the seed voucher. Hence, the LATE estimate of the mean impact of SCIRS on farmers' income has a causal interpretation, applies only to the subpopulation of potential receivers of the SCIRS.

Specifically, the Local Average Treatment Effect (LATE) estimates the treatment effect only for those who decide to receive the SCIRS because of a change in Z (Angrist, 1994). This study adopted the simple non-parametric Wald estimator proposed by Imbens and Angrist (1994) and which requires only the observed outcome variable *y*, the treatment status variable t, and an instrument z. In other for IV estimate to be interpreted as the causal effect of a treatment on the compliers both monotonicity and the independence assumption must hold (Imbens and Angrist,2004).

The independence assumption requires that potential outcomes of any treatment state (y_T, y_C) are independent of the instrument z
i.e. $[y_{iT}, y_{iC}, T_i(1), T_i(0)]$ is independent of Z.
The monotonicity assumption requires that the instrument makes every person either weakly more or less likely to actually participate in the treatment (no defiers)
i.e. $T_i(1) \geq T_i(0)$ for all i.
To give the expressions of the Imbens and Angrist (1994) LATE estimator and that of Abadie (2003), we note that the seed voucher is a "natural" instrument for access to SCIRS (which is the treatment variable here). Indeed, firstly one cannot receive the SCIRS without first receiving the seed voucher. Second, it is natural to assume that the receipt of the seed voucher actually affect the farmers' income only through the access to the seed voucher without being randomly selected to receive it. That is, having the seed voucher have no impact on farmers' income. The income of the farmers' is actually affected only when the farmers have access to the SCIRS. Hence the two vital requirement of the seed voucher to be a valid instrument are met. Therefore, the mean impact of access to the SCIRS on the income of the sub-population of Compliers (i.e. the LATE) is as given by Imbens and Angrist, 1994; Imbens and Rubin 1997, Lee, 2005:

$$\hat{\lambda}_{IV\ \ lATE} = E\left(y_T - y_C \mid t_1 = 1\right) = \frac{E(y|z=1) - E(y|z=0)}{E(t|z=1) - E(t|z=0)} \qquad 4$$

The denominator in equation (4) is the difference in the probability of participation in the program (probability of T=1) under the different values of the instrument.
The right hand side of (4) can be estimated by its sample analogue:

$$\left(\frac{\sum_{i=1}^{n} y_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} y_i (1-z_i)}{\sum_{i=1}^{n} (1-z_i)} \right) \times \left(\frac{\sum_{i=1}^{n} t_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} t_i (1-z_i)}{\sum_{i=1}^{n} (1-z_i)} \right)^{-1} \qquad 5$$

This is the well known Wald estimator. The Wald estimate gives the effect of the treatment on those whose treatment status will be affected by the instrument, which is known as the Local Average Treatment Effect (LATE) (Angrist and Imbens, 1994). These are those who in the absence of the seed voucher would not have had access to the *SCIRS*, but were induced to receive the *SCIRS* because they had the seed voucher. They are often referred to as the compliers.

Because the access to the *SCIRS* is not random in the population due to the fact that farmers in the control group may one or the other have access to the *SCIRS* thus affecting their income. In addition, farmers who were given the seed voucher to grant them access to the *SCIRS* may eventually not used the seed voucher to collect the *SCIRS*. Also, there was endogeneity in the program placement, it was targeted at rural based rice farmers and only farmers in the three major rice producing ecologies were targeted for intervention. The foregoing necessitated the adoption of another methodology which requires the conditional independence assumption instead of the randomness assumption. Therefore, we adopted the Abadie's estimation of LATE using the Local Average Response Function (LARF).

Abadie's (2003) generalization of the LATE estimator of Imbens and Angrist (1994) to cases where the instrument z is not totally independent of the potential outcomes y_T and y_C, but will become so conditional on some vector of covariates x that determines the observed outcome y. With these assumptions, the following results can be shown to hold for the conditional mean outcome response function for potential compliers:

$f(x,t) \equiv E(y \mid x, t; t_1 = 1)$ and any function g of (y, x, t) (Abadie, 2003; Lee 2005):

$$f(x,1) - f(x,0) = (y_T - y_C \mid \mathbf{x}, t_1 = 1) \quad 6$$

$$E(g(y,t,x)|t_1 = 1) = \frac{1}{P(t_1 = 1)} E(k \cdot g(y,t,x)) \quad 7$$

Where $k = 1 - \frac{z}{p(z = 1|x)}(1-t)$ 8

Equation (7) is a weighted function that takes the value 1 for a potential complier and a negative value otherwise. The function $f(x, t)$ is called a Local Average Response Function (LARF) by Abadie (2003). Estimation proceeds by a parameterization of the

LARF $f(\theta; x,t) = E(y|x,t;t_1 = 1)$ 9

Then, using equation (2) with $g(y,t,x) = (y - f(\theta;x,t))^2$, the parameter θ is estimated by a weighted least squares scheme that minimizes the sample analogue of $E\{\kappa\ (y - f\ (\theta\ ; x,t))2\}$. The conditional probability $P(z=1|x)$ appearing in the weight κ is estimated by a probit model in a first stage. Abadie (2003) proves that the resulting estimator of θ is consistent and asymptotically normal. Once, θ is estimated, equation (6) is used to recover the conditional mean treatment effect $E(y_T - y_C|x,t_1 = 1)$ as a function of x. The LATE is then obtained by averaging across x using equation (7)

For example, with a simple linear function $f(\theta,t,x) = \alpha_0 + \alpha t + \beta x$

Where: $\theta = (\alpha_0, \alpha, \beta)$, then $E(y_T - y_C|x,t_1 = 1) = \alpha$.

In this case, there is no need for averaging to obtain the LATE, which is here equaled to α. Hence, a simple linear functional form for the Local Average Response Function (LARF) with no interaction between t and x implies a constant treatment effect across the sub-population of potential compliers. In this study, we postulated an exponential conditional mean response function with and without interaction to guaranty both the positivity of predicted outcome (income) and heterogeneity of the treatment effect across the sub-population of potential receivers(Those who will receive the SCIRS when given the seed voucher). Because been randomly selected to receive the seed voucher is a necessary condition for the access to the SCIRS, it can be shown that the LATE for the subpopulation of potential receivers (i.e. those with $t1$=1) is the same as the LATE for the subpopulation of actual receivers (i.e. those with t=$zt1$=1).

Implicitly the LATE is expressed as follows:

$LATE_Y$=*f(PS, IO,AO,IM)*

Vector of covariates for the propensity score model (PS)

Age= Age of household head (Years)

Gender = 1 if household head is male, 0 if female

Relationship with research institute= 1 if farmer has relationship with research institute, 0 otherwise

Education=number of years of formal education (Years)

Training=1 if farmer has attended any training before, 0 otherwise

Membership of any organization=1 if farmer is a member of any organization, 0 otherwise

Household size= number of person per household

Vector of covariates for the impacted outcome model (IO)

Age= Age of household head (Years)

Gender = 1 if household head is male, 0 if female

Relationship with research institute= 1 if farmer has relationship with research institute, 0 otherwise

Education=number of years of formal education (Years)

Training=1 if farmer has attended any training before, 0 otherwise

Membership of any organization=1 if farmer is a member of any organization, 0 otherwise

Household size= number of person per household

Secondary occupation=1 if farmer has secondary occupation, 0 otherwise

Osun state=1 if farmer is from Osun state, 0 otherwise

Niger state=1 if farmer is from Niger state, 0 otherwise

Vector of covariates to be interacted with the access outcome variable (AO)
Age= Age of household head (Years)
Gender = 1 if household head is male, 0 if female
Relationship with research institute= 1 if farmer had relationship with research institute, 0 otherwise
Education=number of years of formal education (Years)
Training=1 if farmer has attended any training before, 0 otherwise
Membership of any organization=1 if farmer is a member of any organization, 0 otherwise
Household size= number of person per household
Osun state=1 if farmer is from Osun state, 0 otherwise
Niger state=1 if farmer is from Niger state, 0 otherwise

Vector of covariates for the instrument (Seed Voucher) model (IM)
Age= Age of household head (Years)
Gender = 1 if household head is male, 0 if female
Relationship with research institute= 1 if farmer had relationship with research institute,0 otherwise
Education=number of years of formal education (Years)
Training=1 if farmer has attended any training before, 0 otherwise
Membership of any organization=1 if farmer is a member of any organization, 0 otherwise
Household size= number of person per household

Measurement of Poverty Indices
The standard Foster-Greer-Thorbecke (FGT) (1984) was employed generate the poverty profile of the respondents (the treatment and the control group).

FGT takes the form;

$$P_{\alpha} = \frac{1}{n}\sum_{i=1}^{n} q \left[\frac{Z - Y_{pi}}{Z}\right]\alpha \qquad 10$$

Where Z = the poverty line

q= number of individual below the poverty line

n = number of individuals in the reference population

Y_{pi} = per capita income of the ith household

α = FGT index which takes values 0, 1, 2.

Z-Y_i = poverty gap of the ith household

$\frac{Z-Y_i}{Z}$ = poverty gap ratio

This class of poverty measure is flexible in two ways. One, α is a policy parameter that can be varied to approximately reflect poverty "aversion" and two, the P_α class of poverty indices is sub-group decomposable.

When α = 0 in equation 10

P_o = 1/n (q) = q/n = H 11

The head count is the number of people in a population who are poor, while the headcount ratio (H) is the fraction of the population who are poor. The poverty gap measures the total amount of income necessary to raise everyone who is below the poverty line up to that line, When α = 1, the poverty measure becomes the poverty-gap index (PG)

$$P_{\alpha=1} = PG = \frac{1}{n}\sum_{i=1}^{n} q_i \left[\frac{Z - Y_{pi}}{Z}\right] = HI \qquad 12$$

$$\text{Where } I = \frac{1}{q}\sum_{i=1}^{n} q \left[\frac{Z - Y_{pi}}{Z}\right] = HI \qquad 13$$

is the income gap ratio. I is the mean of the poverty gaps expressed as a portion of the poverty line. This measure is insensitive to income distribution among the poor.

When α = 2, the squared poverty gap index (SPG) is generated given by,

$$P_{\alpha\text{-}2} = SPG = \frac{1}{n}\sum_{i=1}^{n} q_i \left[\frac{Z - Y_{pi}}{Z}\right]^2 \qquad 14$$

$P_{\alpha\text{-}2}$ measure is increasingly used as a standard poverty measure by the World Bank, the regional development banks, most UN agencies and it is used in, most empirical work on poverty because of its sensitivity to the depth and severity of poverty. The incidence is measured by the number of people in the total population living below the poverty line while the poverty intensity is reflected in the extent to which the incomes of the poor fall below the poverty line.

In this study relative poverty line was constructed. The poverty line was defined as two-third of the mean per capita income.

DATA AND DESCRIPTIVE STATISTICS

The focus of this study is on rice farming households randomly selected from the three major rice ecologies of Nigeria. Nigeria is the most populous country in Africa with an estimated population of 140003,542 million ,consisting of 51.22 per cent male and 48.78 per cent female(NPC, 2006) and a total land area of 923770 km^2 . Rice production in Nigerian is done under three major rice production systems: upland, lowland and irrigated production system. Each of the rice ecologies has 30.0 per cent, 47.0 per cent and 17.0 per cent share of national rice area respectively. Two different data sets (Baseline collected in 2008 and post intervention data collected in 2010) were utilized for this study. The data were collected using multistage sampling techniques. The three major rice producing ecologies were purposively selected. Followed by the selection of one state from each of the rice producing ecologies, hence, Kano, Osun and Niger state were selected to represent irrigated, upland and lowland rice producing ecologies respectively. From each of the states, three Local Government Areas (LGAs) were selected, out of which 5 villages each were randomly selected. The number of farming households selected was proportionate to size. On the overall, 600 rice farming households were selected.

This study adopted the Randomised Control Trial (RCT) to eliminate selection bias. Therefore, prior to the intervention the farmers were randomly partitioned into two distinct groups. Out of the 600 framing households selected in 2008, 160 farmers were randomly selected into the treated group (those that received the seed voucher for access to subsidized certified improved rice seed) and the rest were in the control group (those that were not given the seed voucher and therefore lack access to the subsidized certified improved rice seed). Using well structured questionnaire, data were collected on a wide range of variables which included: socio-economic/demographic characteristics, household income, treatment status, household expenditure e.t.c. The data were analysed using descriptive statistics, Average Treatment Effect (ATE) estimation Techniques and the Local Average Treatment Effect (LATE) estimation method.

The descriptive analysis of some of the socio-economic/demographic characteristics of the respondents is shown in table 1. The result revealed that agriculture was the main occupation of the respondents as 90.0 per cent of the respondents had agriculture as their main occupation. Because of the tediousness associated with farming, it is not a surprise that majority of the respondents (80.6 per cent) were males, while only 19.4 per cent were females. In terms of age distribution, a higher percentage (44.8 per cent)of the respondents were within the age group of 41-50 years, while a negligible proportion (0.9 per cent) were above 70 years of age and a total of 76.2 per cent were between 18-50 years of age. This shows that majority of the respondents were in their active and productive age and this could have a positive influence on rice productivity.

The household size was relatively higher in the study area. Majority of the respondents (76.2 per cent) were within the household size group of 1-10 people per household. About 87.0 per cent of the respondents were native of their respective villages and 52 per cent have spent between 41-60 years in the study area. The educational background of the household's head revealed that majority of the respondents (32 per cent) lacked formal education. While 15 per cent had at least primary education, 10 per cent had secondary education and 40 per cent had Islamic education. Only 5 of the respondents representing 0.9 per cent had university education.

RESULTS AND DISCUSSION

Descriptive Analysis of the Impact of Access to SCIRS on Household Income

The result of the assessment of improvement in income from rice production and per capita households' income after the intervention for the total population of the sampled farmers and for the treated and control groups is presented in table 3. The result showed that after the intervention in 2010, income from rice production and per capita households' income in the entire population of the sampled farmers increased by 18.53 per cent and 2.60 per cent respectively. While the increase in income from rice production (22.53 per cent) and per capita household income (46.60 per cent) for the treated more than doubled that of the control group. Suggesting that indeed the use of good quality seed can generate increase in yield, which can translate into an increase in households' income. However, this improvement in income cannot be given any causal interpretation, because any other factor could be responsible for the observed increase in income after the intervention. Hence econometric techniques were further adopted to provide the true impact of the intervention on the farming households' income.

Poverty Indices

The result of the poverty measurement between the treated and control group is presented in table 2. The analysis showed that poverty incidence (42%), depth (14%) and severity (6%) were higher among the control group than the treated group. This revealed that access to SCIRS had poverty reducing effect.

Descriptive Analysis of the Impact of access to SCIRS on Income

The descriptive analysis of the impact of access to SCIRS on the farming households' income was assessed and the result presented in table 3. The income of the entire farming households' increased by 18.53% after the intervention in 2010. While the income of the sub-population of the treated farmers increased by 22.53 per cent after the intervention, this more than doubled the increase in income of the farmers in the control group who did not received the SCIRS. Therefore, in can be concluded that access to the SCIRS had a positive effect on the framing households, particularly the treated farmers.

Econometric Analysis of the Impact of Access to SCIRS on Income from Rice Production

The econometric analysis of the impact of access to certified improved rice seed at a subsidized rate was assessed using various methods and the result is presented in table 4. Because the study adopted RCT approach to eliminate selection bias, the simplest way to assess the impact was to use the men difference. The result of the mean difference showed that there was a significant difference of ₦41, 032.47 in the income of farmers that had access to the SCIRS and those that did not have access. However, due to the fact that conducting a perfect randomization in developing countries is not an easy task, hence, the observed difference in income cannot be given a causal interpretation. The analysis further proceeded by using the IPSW methods to estimate the Average Treatment Effects (ATE). Although the results of the ATE were positive they were not statistically significant, moreover, the ATE also do not have any causal interpretation due to its failure to deal appropriately with problems of selection-on-unobservables and non-compliance.

Therefore, to give a consistent estimate of the impact of access to SCIRS on the farmers' income, the LATE estimation both by WALD estimator and by LARF was computed. The LARF uses as explanatory variables (in addition to the treatment status variable) a set of farmers' socio-economic/demographic characteristics variables. In order to account for heterogeneous in the impact, the treatment status dummy variable was interacted with some of the covariates *x*. Furthermore, the study estimated an exponential LARF (Using a nonlinear weighted least square procedure) to avoid some of the predicted values of the reported income to be negative.

The result of the LATE by WALD estimator showed a positive and significant impact of ₦35182.85 on income. While that of LARF showed a positive and significant impact of ₦50220.55 on income. This implies that access to the SCIRS, increased income of the farmers by ₦50220.55. The impact on income was further disaggregated by gender, poverty status and by state using the LARF. The result of the impact by gender showed that access to SCIRS had a higher, positive and significant impact of ₦ 50676.56 on income of the female headed households and a positive but not insignificant impact of ₦ 50054.67 on the income of the male headed households. This could be due to the fact male headed households have a larger household size than the female headed households in Nigeria. Large household size has been reported to have a negative effect on households' income. Furthermore, the intervention can be said to be pro-poor in nature as shown by the higher and positive impact on income of poor households compare with the positive but insignificant impact on the non-poor households' income. In terms of the impact by state, it had the highest impact (₦134911.30) on the income of farmers from Osun state, which was selected to represent the upland rice production ecology. Followed by Kano state (₦117532.80), selected to represent the irrigated rice ecology and the lowest impact (₦51832.66) was recorded in Niger state. Niger state was selected to represent the lowland rice ecology. The lowest impact on income of farmers from Niger state could be due to the fact that lowland rice ecologies in Nigeria is reportedly labour intensive and this could have a negative implication on farmers income.

The determinants of household income as given by their LARF were estimated and the results are presented in table 5. The results revealed that apart from access to SCIRS, other socio-economic variables significantly explain the observed increase in household income. The variables included gender, education, age, household size, secondary activities, farmers from Osun and Niger state. The coefficient

(0.69) of gender of household head was positive and significant implying that, the male-headed households had a higher income than the female-headed households. The coefficient (0.01) of age was positive and highly significant at 1%, indicating that as the age of household head increases, household income also increases; this could be due to the fact that older farmers are more experienced particularly in term of efficient resource allocation. The coefficient (-0.05) of household size was negative, meaning that as household size increases, household income decreases. This can be explained by the fact that large household size implies more mouths to be fed. This will not only reduce the marketable surplus and cut down income; it will also negatively affect the consumption expenditure and thereby increases the household propensity to fall below the poverty line. Contrary to the a priori expectation the coefficient (-0.02) of education was negative and statistically significant; suggesting that education of the household head has a reducing effect on household income. One important explanation that can be proffered for this is the fact that the number of educated households in the rural area that engaged in full time farming is negligible; those that have a substantial number of years of education take farming as a secondary occupation with minimal commitment. The coefficient (11.25) of secondary activities was positive and significant; suggesting that those farmers that had secondary activities also had higher household income, meaning that participation in secondary activities can be an additional source of household income, it can encourages the use of inputs that could engender increase in yield and generate an increase in household income.

A number of coefficients for the interacted terms were also statistically significant, thus confirming the heterogeneity of the impact of access to SCIRS on household income. The coefficients for the interacted terms for education (0.05), training (0.26) and household size (0.07) were positive and statistically significant at 1%, indicating that the impact of access to SCIRS on household income will be higher among households that were educated attended training and had larger number of household size. in view of the fact that rice production is highly labour intensive and labour cost could constitute a higher percentage of total production cost, therefore, larger household size could serve as a source of family labour and may generate a reduction in labour cost with a positive effect on households' income. However, the interacted term of secondary activities was negative and statistically significant, suggesting that the impact of access to SCIRS on household income will be higher among those that had no secondary activities. Furthermore, the F-statistics for the joint significant of the interacted terms as well as the non-interacted terms indicated that they were jointly statistically and significantly different from zero.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study assessed the impact of access to subsidized improved rice seed on rice farmers' income in Nigeria. Although the study adopted the RCT approach, however, given the fact that conducting a perfect randomization is an almost impossible task in developing countries like Nigeria and also due to the problem of non-compliance often associated with RCT approach we adopted the LATE estimation techniques to provide a consistent estimate of the impact of access to SCIRS on farmers' income. In addition, the LARF was adopted to account for other factors that could affect the farmers' income. The result of the analysis revealed that access to SCIRS increased the income of the farmers significantly. The analysis showed further that access to SCIRS had a higher impact on the poor farmers' income, meaning that it is pro-poor. The result of the poverty measurement further confirm that access to SCIRS has a poverty reducing effect and could be a way out of poverty if well implemented and monitored.

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Appendix

Table 1: Socio-economic/Demographic Characteristics of Respondents

Socio-Economic/Demographic Characteristics	Frequency	Percentage
Age of Household Head		
18-30	30.00	5.33
31-40	147.00	26.11
41-50	252.00	44.76
51-60	116.00	20.60
61-70	13.00	2.31
>70	5.00	0.89
Gender of Household Head		
Male	454.00	80.64
Female	109.00	19.36
Educational Background of Household Head		
No education	175.00	31.90
Primary Education	81.00	14.52
Secondary education	53.00	9.50
High education	20.00	3.58
University education	5.00	0.90
Islamic	221.00	39.61
Household size		
1-10	429.00	76.20
11-20	125.00	22.20
21-30	9.00	1.60
Main Occupation		
Farming	504.00	89.52
Non-farming	59.00	10.42
Native of the study area		
Native	491.00	87.21
Non-native	72.00	12.79
Years of residence in the village		
1-20	72.00	12.79
21-40	164.00	29.13
41-60	313.00	55.60
>60	14.00	2.49

Source: AfricaRice/NCRI field Survey, 2010

Table 2: Poverty Indices

Poverty Indices	**Treated**	**Control**	**Difference (%)**
Poverty Headcount	0.42	0.46	**4.0**
Poverty Depth	0.14	0.20	**6.0**
Poverty Severity	0.06	0.12	**6.0**

Table 3: Descriptive Analysis of the Impact of Access to SCIRS on Income

Year	**Average**	**Treated**	**Control**
Income from Rice Production			
2008	160846.00	147280.50	201833.20
2009	172162.00	161495.40	204390.40
2010	190661.50	180458.10	221490.00
Increase after the project (%)	18.53	22.53	9.74
Per Capita Household Income			
2008	59247.30	60657.05	49424.84
2009	55777.11	64336.94	54162.00
2010	60785.73	88925.17	59613.24
Increase after the project (%)	2.60	46.60	20.61

Source: AfricaRice/NCRI field survey, 2010

Table 4: Econometric Analysis of the Impact of Access to SCIRS on Income from Rice Production

Estimates	**parameter**	**Robust std. Error**	**Z-value**
Estimation by Observed Sample Mean Difference			
Treated	221490.50***	12950.24	17.10
Control	180458.10***	4873.01	37.03
Mean difference	41032.47***	13836.72	2.97
Inverse Propensity Weighting (IPSW)			
ATE	2131.76	35094.15	0.06
ATE1	3332.45	19925.95	0.17
ATE0	3944.54	44021.12	0.09
LATE by WALD estimator	35182.85***	32438.55	6.83
LATE by LARF	50220.55*	26199.16	1.92
LARF estimates by gender, Poverty Status and State			
Impact by Gender			
Male	50054.67	34345.01	1.46
Female	50676.56***	18906.53	2.68
Impact by poverty Status			
Poor	44392.20***	10348.42	4.29
Non-poor	59971.58	56851.06	1.05
Impact by State			
Osun	134911.30***	40573.80	3.33
Niger	51832.66***	15054.97	3.44
Kano	117532.8***	23749.84	4.95

Legend: Significance level: *** P<0.01, **P<0.05, *P<0.10

Source: AfricaRice/NCRI field survey, 2010

Table 5: Estimated coefficient of the LARF for Income from Rice Production

Household income	Coefficient	Stand. error	t-statistics
Coefficients of the non-interacted terms			
SCIRS	11.492***	0.272	42.21
Gender	0.688***	0.094	7.33
Education	-0.024***	0.007	-3.55
Training	-0.075	0.073	-1.03
Age	0.010**	0.004	2.38
Household size	-0.050***	0.008	-6.23
Secondary activities	11.247***	0.203	55.30
Farmer from Osun state	-1.247**	0.622	-2.01
Farmer from Niger state	0.416***	0.109	3.79
Coefficients of the interacted terms			
Gender- SCIRS	-0.284	0.191	-1.49
Education- SCIRS	0.047***	0.008	6.21
Training- SCIRS	0.264***	0.101	2.61
Age- SCIRS	-0.008	0.006	-1.40
Household size- SCIRS	0.072***	0.012	6.07
Farmer from Osun state- SCIRS	0.727	0.642	1.13
Farmer from Niger state- SCIRS	-0.145	0.145	-1.00
Secondary activities- SCIRS	-11.334***	0.259	-43.64
R-squared	0.8716		
Adjusted R-squared	0.8658		
Wald test for the joint significant of all coefficient	55535.79***		
Wald test for non-interacted terms	374.00***		

Legend: Significance level: *** P<0.01, **P<0.05, *P<0.10

Source: Field Survey, 2010