Impact of Seed Voucher System on Income Inequality and Rice Income per Hectare among Rural Households in Nigeria: A Randomized Control Trial (RCT) Approach

Bola Amoke Awotide, Taiwo Timothy Awoyemi and
Kabir Kayode Salman
University of Ibadan, Nigeria

Aliou Diagne
Africa Rice Centre, Cotonou, Benin Republic

Abstract

The Seed Voucher System (SVS) was adopted by the Emergency Rice Initiative (ERI) to grant farmers access to certified improved seed, in order to mitigate the adverse effect of the 2008 global food crisis on resource poor farmers in rural Nigeria. This study examined the impact of the SVS on income inequality reduction and rice income per hectare among rice farming households in Nigeria. Structured questionnaire was used to collect Baseline (2008) and post-voucher (2010) data, using multistage sampling procedure. Using Randomized Control Trial approach, 160 farmers out of the 600 rice farmers randomly selected in 2008 received the seed voucher (treated), and others did not (control). The results revealed that poverty and income inequality declined significantly after the intervention. The SVS also lead to significant increase in rice income per hectare. Therefore, the use of seed vouches to grant farmers access to production inputs could actually be a way out of the endemic poverty situation in rural Nigeria and can also be used to redistribute income among rural households in Nigeria.

Keywords: impact, rice, voucher, poverty, income inequality, LATE, Nigeria
JEL: B21, C12, I32, Q12, Q16

1 Introduction

Poverty and income inequality has been the bane of economic growth and development, particularly in developing countries and most especially those in Sub-Saharan Africa (SSA). Poverty and income inequality are closely related and it has been argued that income inequality is a manifestation as well as a strong cause of poverty (UNU/

WIDER, 2000). In most developing countries like Nigeria, poverty is essentially a rural phenomenon, due to the fact that a large majority of the rural dwellers are below the poverty line or survive on less than $1 per day. For instance, in Nigeria poverty incidence in the rural area was 46.0%, 69.3%, 63.3% in 1992, 1996 and 2004, respectively. While the corresponding figures for the urban area was 37.5%, 58.2% and 43.2% for the same periods (National Bureau of Statistics (NBS), 2005). In the same vein, the income inequality as revealed by the Gini-Coefficient was estimated to be 0.4882 for the national, 0.554 and 0.5187 for urban and rural areas, respectively (NBS, 2005). The scenario presented above is highly detrimental to economic growth and achievement of improved welfare among the rural majority in most developing countries; it requires a pragmatic approach to eradicate it. Hence, the reduction of poverty and income inequality has become one of the paramount developmental agenda in developing countries, particularly in SSA.

The majority of Nigerians live in the rural areas and depend on agriculture, specifically the production of staple food crops to meet households' consumption and cash needs through sales. However, the composition of rice (Oryza sativa) in the daily diet of most Nigerians is highly significant. A large majority of Nigeria's teeming population lives on rice, which is their primary base for food security; presently and in the near future Nigeria is entirely dependent on the volume of rice produce, thus making rice the most important staple food crop. In terms of output, rice accounts for 12.0% of the total output of cereals produced in Nigeria (CBN, 2009). Therefore, the production and availability of rice at affordable prices is central to the achievement of national and households' food security and also paramount in the achievement of self-sufficiency in food. Additionally, in the producing areas, it provides employment for more than 80.0% of the inhabitants as a result of the activities that take place along the distribution chains from cultivation to consumption (OGUNDELE and OKORUWA, 2006). Against this background, an unprecedented attention has been devoted to the development of the rice sector. However, while the annual domestic consumption rose from 5kg/person in 1970 (OBIECHINA and OTTI, 1985), to 25kg/person in 2004 (HUSSIEN, 2004) rice production, despite all the efforts, has only been expanding at the rate of 6.0% per annum, meaning that the demand for rice is growing faster than production. The self-sufficiency ratio has also declined from 0.87 and 0.93, in the 80s and 90s respectively to 0.64 between 2001 and 2005 (AFRICARICE, 2005), thus, making the country dependent on imported rice, such that Nigeria was ranked first in Africa and second in the world with importation of 1.6 million tons in 2006 (AFRICARICE, 2008) which later rose to 1.7 million tons in 2007, supplying about one-third of the estimated total national rice demand of five million tons (THE PUNCH, 2008).

Finding a lasting solution to the precarious food crisis in developing countries through an increase in productivity has been a major focus of most development oriented organisations. The WORLD BANK (2008) reported that the adoption of new agricultural technology, such as high yielding varieties that kick-started the Green Revolution in Asia, could also generate the desired increase in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy. However, lack of access to improved seeds has been identified as one of the major constraints to improved variety adoption (DONTSOP-NGUEZET et al., 2011). Meanwhile, adoption would not be possible without access to the certified improved seeds. Farmers continued to use own seeds from the past harvest or other farmers in the village and rural markets. These other sources of seed, which are referred to as informal sources, are noted for their high level of impurity due mainly to poor handling techniques. The Nigerian government, in order to circumvent these problems adopted a national seed subsidy program. However, as a result of the many implementation bottlenecks and constrained access of the intended beneficiaries to subsidized seeds, the problem of lack of access to good quality seed persists.

One option out of this predicament of lack of access to good quality seed according to BRAMEL, REMINGTON and MCNEIL (2004), is smart seed subsidies that target particularly needy farmers. The targeted approach of input subsidies, which is supported by a range of donors and governments, advocates the use of vouchers that can be exchanged at agro-dealer shops across rural areas. In Malawi for instance, the fertilizer and seed subsidy program reportedly helped double its agricultural productivity, turning the country into a net food exporter after decades of famine as a perennial food importer (UNITED NATIONS, 2008). In addition, the bumper harvests resulting from the program also assisted poor farmers to earn more income, thus reducing their propensity to fall into poverty.

In the same vein, the Emergency Rice Initiative (ERI) to boost rice production in Sub-Saharan Africa was launched in 2008 by the Africa Rice Centre (Ex-WARDA) in collaboration with the International Fertilizer Development Centre (IFDC), and Catholic Relief Services (CRS), within the framework of the Food and Agricultural Organization's (FAO) Initiative on Soaring Food Prices (ISFP) (AFRICARICE, 2009). The ERI adopted the seed voucher system to grant some randomly selected rice farmers' access to certified improved rice seed at a subsidized rate. The voucher was designed to be used in just one day. All the treated farmers were supposed to come to a meeting point (in most cases, the village square) on an agreed date and time for the collection of the seed voucher and immediately proceed to the agro-dealer to collect the desired seed varieties. The agro dealers later redeemed their money from the designated banks. The design of the voucher system was to eliminate or at best discourage the creation of a secondary markets for the voucher. The broad aim of the intervention was to improve the farmers' access to certified improved seeds, and the resultant increase in yield is expected to generate increased incomes and reduced income inequality. However, the extent to which the seed voucher system has impacted rice income per hectare and reduced income inequality and poverty has not been assessed. Therefore, this study empirically investigates the impact of seed voucher system on income inequality and rice income per hectare of rice farming households in Nigeria. The rest of the paper is organized as follows: section two presents the analytical framework. Section 3 contains the data and descriptive statistics. The results of the analyses are presented in section 4. Finally, section 5 contains the summary, conclusion and a brief policy recommendation.

2 Analytical Framework

2.1 Measurement of Poverty

A critical assessment of the poverty profile of the respondents before and after the intervention is capable of providing a clear insight into the poverty situation among the respondents and to achieve this, the commonly adopted poverty measurements such as (1) the headcount index, (2) the poverty deficit or gap index, and (3) the poverty severity index were adopted (FOSTER et al., 1984). However, it would not be possible to carry out the poverty measurement without the generation of the poverty line. Hence, a relative poverty line computed as 2/3 of the mean per capita consumption expenditure was utilised and thus, served as the threshold by which the households were classified as either poor or non-poor. The three poverty measures as presented by FOSTER et al. (1984) are as described below:

$$(1) \qquad p(\alpha) = \frac{1}{n}\sum_{i=1}^{m}\left[\max\left(\frac{z-c_i}{z},0\right)\right]^{\alpha}$$

Where z is the poverty line, c_i is the per capita consumption expenditure of the farmer *i, n* is the total number of farmers.

2.2 Measurement of Income Inequality

The commonly adopted measurement of income inequality in the literature is the Gini-coefficient. Assuming the rural farming household income are ordered such that $y_1 \leq y_2 \leq y_3 \leq y_4 \leq y_{n.}$, then, following MORDUCH and SICULAR (2002), the Gini-coefficient is computed as:

$$(2) \qquad I_{Gini}(Y) = \frac{2}{n^2\mu}\sum_{i=1}^{n}\left(i - \frac{n+1}{2}\right)y_i$$

Where: n is the number of observation, μ is the mean of distribution and y_i is the income of the ith household.

2.3 Impact of Seed Voucher System on Rice Income per Hectare

Overt (selection on observables) and hidden (selection on unobservables) biases are the two most recognised biases in program impact evaluation (ROSENBAUM, 2001; LEE, 2005), and failure to deal appropriately with them can lead to overestimation or underestimation of program impact and thereby generate erroneous policy recommendations. Put more succinctly, overt bias arises as a result of the difference in the observed outcomes which by no means could be attributed to the seed voucher system, but which is due to differences in observed characteristics of the farmers. Hidden bias is defined as the difference in the observed outcome which is not due to the seed voucher system, but can be attributed to some unobservable characteristics of the farmers. Another problem usually common in program evaluation is associated with "non-compliance" and is also called the "endogenous" treatment variable problem in econometrics (IMBENS and RUBIN, 1997a; IMBENS and ANGRIST, 1994; HECKMAN and VYTLACIL, 2005).

Due to the fact that the subjects of treatments in this study were farmers who can decide either to stick to their assigned treatments or not, even if the treatment was assigned randomly, thus leading to the problem of non-compliance. Consequently, the difference in an individual farmers' potential outcomes may not be due to the seed voucher system, but rather it could be as result of some unobserved factors that caused the farmer not to stick to his or her assigned treatment. As a result, the Average Treatment Effect (ATE) for the entire population will not be the same as the mean treatment effect that would have been obtained if the seed voucher system had been randomly assigned and every farmer in the population complied with their assignment (IMBENS and RUBIN, 1997b; IMBENS and ANGRIST, 1994). From the foregoing, it is quite obvious that despite the use of RCT approach, it will not be plausible to interpret the mean difference in all the outcomes of interest between the treated and the control farmers as the impact of the program, meaning that it does not have any causal interpretation. However, the basic objective of this study is to provide a consistent estimate of the impact of seed voucher system on all the outcomes of interest, therefore in order to achieve this objective, the study used the mixed methods approach which involves a combination of other methodologies that are capable of removing both hidden bias and non-compliance such as IPSW, LATE by Wald estimator and by Local Average Response Function (LARF).

2.3.1 Inverse Propensity Score Weighting Technique (IPSW)

First, this study adopted the conditional independence-based estimators of Average Treatment Effect (ATE), Average Treatment Effect on the Treated (ATE1) and Average Treatment Effect on the untreated (ATE0), usually referred to as the IPSW, which can correct the problem of overt bias. The IPSW is estimated using the following formulae (see IMBENS, 2004; LEE, 2005; DIAGNE and DEMONT, 2007; DONTSOP-NGUEZET et al., 2011; AWOTIDE et al., 2011):

(3) $$AT\hat{E} = \frac{1}{n}\sum_{i=1}^{n}\frac{(t_i - \hat{p}(x_i))y_i}{\hat{p}(x_i)(1-\hat{p}(x_i))}$$

(4) $$AT\hat{E}1 = \frac{1}{n_1}\sum_{i=1}^{n}\frac{(t_i - \hat{p}(x_i))y_i}{(1-\hat{p}(x_i))}$$

(5) $$AT\hat{E}0 = \frac{1}{1-n_1}\sum_{i=1}^{n}\frac{(t_i - \hat{p}(x_i))y_i}{\hat{p}(x_i)}$$

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 the seed voucher in the population

ATE1 = is the impact of the seed voucher on the subpopulation of the farmers in the treated group.

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 receive the seed voucher.

The propensity score was calculated using the probit model. The results of the ATE cannot be interpreted as the impact of the intervention, due to the fact that the ATE estimates do not correct for hidden bias and the problem of non-compliance or endogeneity.

2.3.2 Instrumental Variable (IV) Estimation Methods

Local Average Treatment Effect Estimation (LATE) Technique

The instrumental variable methods are designed to eliminate both overt and hidden biases and deal with the problem of endogenous treatment and has been adopted in the literature by HECKMAN and VYTLACIL (2005, 2007a, 2007b), HECKMAN et al. (1997), CARD (2001), IMBENS (2004), ABADIE (2003), IMBENS and ANGRIST (1994), DIAGNE and DEMONT (2007) and DONTSOP-NGUEZET et al., (2011). The IV methods according to Khandker et al. (2010) involves finding a variable (instrument) that is highly correlated with participation in the program, but is not correlated with unobservable characteristics of the farmers that could affect the outcomes. 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 potential outcomes y_T and y_C, once the effects of the covariates $\boldsymbol{x}$ are controlled for (RUBIN, 1974; ROSENBAUM and RUBIN,1983, DIAGNE and DEMONT, 2007; DONTSOP-NGUEZET et al., 2011). Succinctly, the methods rely on finding a variable excluded from the outcome equation but which is also a determinant of program participation. Apparently, in the case of the RCTs approach or the social experiment, it is often common that some of those randomly selected for the program may decide not to participate and obviously, the outcome of interest could only be affected if farmers were not only randomly selected to receive the voucher but they actually received it. Therefore, to estimate the causal effect of the seed voucher system when the compliance is not perfect, following KATZ et al. (2001), GALASSO et al. (2004) and RAVALLION (2005), the random assignment was used as a natural choice of instrumental variable.

Furthermore, in order to eradicate the problem of non-compliance in the population after RCT approach, IMBENS and ANGRIST (1994) partitioned the population into four distinct 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* denoted by LATE. Thus, LATE estimate provides the impact of the seed voucher system on all the outcomes of interest with a causal interpretation. However, according to IMBENS and ANGRIST (2004) both monotonicity and the independence assumptions must be satisfied before the estimates of the IV can be interpreted as the causal effect of a treatment on the compliers. 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.

It is worthy of note that the monotonicity assumption was trivially satisfied in the case of the seed voucher system, based on the fact that it will be impossible for any of the treated farmer to have received the seed voucher without being randomly selected to receive it, therefore, eliminating both the defiers and always takers in this study. In order to assess the impact of the seed voucher system on the farmer's outcomes, the sampled population were partitioned into only two distinct groups: the group of compliers, which is the group of potential receivers of the seed voucher (those who will receive the seed voucher when they are randomly selected to receive it), and the group of never takers, which is the group of farmers that would not have received the seed voucher, even if they were given the opportunity to receive it. Hence, the LATE estimate of the mean impact of seed voucher system on all the outcomes of interest has a causal interpretation, applies only to the sub-population of potential receivers of the seed voucher. Specifically, the LATE estimates the treatment effect only for those who decided to receive the seed voucher as a result of a change in the instrument (Z) (ANGRIST, 1994).

For the LATE estimate, this study first adopted the simple non-parametric Wald estimator proposed by IMBENS and ANGRIST (1994), which requires only the observed outcome variable y, the treatment status variable t, and an instrument z. However, in view of the expressions of the IMBENS and ANGRIST (1994) LATE estimator and that of ABADIE (2003), it was discovered that the random assignment is a "natural" instrument for the receipt of seed voucher. This is based on the premise that, it will be absolutely impossible for any farmer to have actually received the seed voucher without being randomly selected to receive it. In other words, it is plausible to conclude that the impact of the seed voucher system on all the outcomes of interest can be observed only when the randomly selected farmers actually received the seed voucher. In other words, being randomly selected would not have any impact on the income inequality and rice income per hectare, except the farmers actually receive the seed voucher. Hence, the two vital requirement of the random assignment to be a valid instrument are met. The mean impact of the seed voucher system on income inequality and rice income per hectare on the sub-population of compliers (i.e. the LATE) is as given by IMBENS and ANGRIST (1994), IMBENS and RUBIN (1997), LEE (2005) and DIAGNE and DEMONT (2007):

$$(6) \qquad \hat{\lambda}_{IV\ \text{IATE}} = E\left(y_T - y_C \mid t_1 = 1\right) = \frac{E(y|z=1) - E(y|z=0)}{E(t|z=1) - E(t|z=0)}$$

The denominator in equation (6) is the difference in the probability that a farmer would receive the seed voucher (probability of T=1) under the different values of the instrument. The right hand side of (6) can be estimated by its sample analogue:

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

Equation (7) is the Wald Estimator. The effects of the seed voucher system on those farmers whose treatment status were affected by the instrument were given by the Wald estimates and this is referred to by ANGRIST and IMBENS (1994) as LATE. They are the farmers who in the absence of the randomly assigned instrument, would not have received the seed voucher, but were stimulated to receive the seed voucher by the assignment. This group of farmers is known in the impact assessment literature as compliers. We also noted the non-randomness of the distribution of the seed voucher in the population of rice farmers in Nigeria; this is based on the fact that the seed voucher system was targeted at rural based rice farmers in the three prominent rice producing ecologies. The above observation necessitated the adoption of ABADIE'S estimation of LATE using the LARF, which requires only the Conditional Independence Assumption (CIA) instead of the randomness assumption.

Local Average Response Function (LARF)

Following DIAGNE and DEMONT (2007), the LARF involves 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, but will become so conditional on some vector of covariates x that determines the observed outcome y. With these assumptions, according to DIAGNE and DEMONT (2007) 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):

(8) $$f(x,1) - f(x,0) = (y_T - y_C \mid \boldsymbol{x}, t_1 = 1)$$

(9) $$E\left(g(y,t,x) \middle| t_1 = 1\right) = \frac{1}{P(t_1 = 1)} E\left(k \cdot g(y,t,x)\right)$$

Where

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

Equation (10) 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) and the estimation proceeds by a parameterization of the LARF (ABADIE, 2003)

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

Then, using equation (4) with $g(y,t,x) = (y - f(\theta;x,t))^2$, the parameter θ was 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 (9) was used to recover the conditional mean treatment effect $E(y_T - y_C|x,t_1 = 1)$ as a function of x. The LATE was therefore obtained by averaging across x using equation (9). 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 was no need for averaging to obtain the LATE, which is here equaled to α. Hence, a simple linear functional form for the LARF with no interaction between t and x implies a constant treatment effect across the sub-population of potential compliers.

In this study, following DIAGNE and DEMONT (2007) we postulated an exponential conditional mean response function with and without interaction to avoid the predicted outcomes from being negative and also accounted for the heterogeneity of the treatment effect across the sub-population of potential receivers (those who will receive the seed voucher when randomly selected to receive). Because, being randomly selected to receive the seed voucher was a necessary condition for the receipt of the seed voucher, hence, it can be shown that the LATE for the subpopulation of potential receivers of the seed voucher (i.e. those with $t1$=1) is the same as the LATE for the subpopulation of actual receivers of the seed voucher (i.e. those with t=$zt1$=1).

3 Data and Descriptive Statistics

Nigeria with a population of 160 million (NBS, 2006), on a land area of 924,000 square kilometres is purely an agrarian economy. Rice is grown in all agro ecological zones of Nigeria under three major production systems namely; irrigated, rain-fed upland and lowland and these ecologies accounted for 16%, 30% and 47%, respectively, of the total land area devoted to rice, and jointly they contributed about 97% to the national rice output (DARAMOLA, 2005). This study adopted the two steps RCT approach in order to improve both internal and external validity. The design of the two steps RCT approach is presented in Table 1.

Table 1. Sampling Techniques and Data Collection Methods

Step 1: The multistage random sampling for the baseline data		
Stages	**Selection**	**Comments**
1	Rice growing systems	Irrigated Lowland Upland
2	States	Kano Niger Osun
3	ADP zones	2 from each state
4	LGAs	5 from each state
5	**Villages from each LGA** Kano=2 Osun=2 Niger=3	**Total villages selected** 10 10 15
6	**Households from each village** Kano=15 Osun=15 Niger=20	**Total households selected** 150 150 300

Step 2: Randomization - random selection of villages and treated farmers		
State	**Number of villages**	**Total households**
Niger	4	60
Kano	4	50
Osun	4	50
Total	4	160

Source: field survey (2008 and 2010)

The first step involved the use of a multistage random sampling technique to collect the baseline data in 2008 prior to the intervention. Three prominent Rice Growing Systems (RGS) were purposively selected, and a state each was selected from each of the RGS, hence Kano, Osun and Niger states were randomly selected. From each of the three states, five rice producing Local Government Areas (LGAs) were selected and three villages were selected from each of the LGAs. In all, 600 rice farmers were randomly selected in year 2008 based on probability proportionate to the size of rice farmers in the villages. The second step involved the random selection of the 600 farmers into treated and control group. Hence, about 160 rice farmers received the seed voucher (treated group), while the remaining farmers did not (control group). The treated farmers received the seed voucher that granted them access to subsidized certified improved rice seed for two production seasons. The voucher was used to collect seed of desired varieties by the farmers. In order to avoid the creation of secondary markets for the voucher, vouchers were issued and used the same day to collect seed from the agro-dealers situated nearby. However, we still observed that some farmers actually used the voucher to collect seed, but some used the seed for other purposes such as exchange, or resale to other farmers and thus created endogeneity in the treatment which was appropriately corrected using the instrumental variable approach. After the intervention in 2010, data were collected from both the treated and control farmers. The attrition rate was, however, negligible as we experienced only two drop outs. One was due to death of the household head and was replaced by the eldest son. The other was due to migration, and this was dropped from the data The data were analyzed using descriptive statistics, Foster-Greer-Thorbecke (FGT) poverty measure, Inverse Propensity Score Weighting Technique (IPSW) and the Local Average Treatment Effect (LATE).

As shown in Table 2, about 90.0% of the respondents had agriculture as their main occupation. The majority of the respondents (80.6%) were males, while only 19.4% were females. A higher percentage (44.8%) of the respondents were within the age group of 41-50 years, while a negligible proportion (0.9%) were above 70.0 years of age and a total of 76.2% were between 18-50 years of age. Average age of household head was 45 years. This shows that the 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%) were within the household size group of 1-10 people per household. The average household size was 8 persons. About 87.0% of the respondents were native of their respective villages and 52.0% have spent between 41-60 years in the study area. The respondents had spent on the average about 40 years in their respective locality. The educational background of the household's head revealed that the majority of the respondents (32.0%) lacked formal education. While 15.0% had at least primary education, 10.0% had secondary education and 40.0% had Islamic education. Only five of the respondents representing 0.9% had university education. The average years of formal education was 5 years.

Table 2. 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
Average age of household heads (year): 45.00		
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
Average years of formal education: 5.00		
Household size		
1-10	429.00	76.20
11-20	125.00	22.20
21-30	9.00	1.60
Average household size: 8.00		
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
Average years of residence in the village: 40.00		

Source: field survey (2010)

4 Results and Discussion

4.1 Descriptive Analysis of the Impact of Seed Voucher System

The mean difference of poverty reducing and welfare improving variables was analysed and the significance of the differences in these variables between the treated and the control farmers was also tested using the t-test. There was a positive and significant difference in most of the selected variables as shown in Table 3. This implies that the farmers in the treated groups performed better than those in the controlled group in all the selected variables and the test of mean difference also further buttressed this fact. The differences between the treated and the control group in all the selected variables were statistically significant. Most importantly, although the farmers in the control group cultivated larger farm size than the farmers in the treated group, it was observed that the treated farmers had higher output, yield and rice income per hectare than the controlled farmers. Thus, implying that the increase in yield could not be a result of an increase in area cultivated, but rather could be due to the use of certified improved seed granted through the seed voucher system. Similarly, the treated farmers also had higher income from the production of other crops than the farmers in the controlled group. This implies that, the higher income obtained from the increase in rice yield brought about by the seed voucher system was also reinvested in the production of other staple food crops which will also enhance total household income, with a possible positive effect on poverty reduction and improve household welfare. However, these observed positive effects have no causal interpretation as they cannot be solely attributed to the seed voucher system, because it could also be as a result of the influence of other exogenous factors that were not captured by the study.

Table 3. Descriptive analysis of the impact of seed voucher system by treatment status

Variable	Treated	Control	Mean difference
Rice income per hectare (₦/ha)	143665.50	118658.40	25007.19*
Rice output (kg)	3659.39	3181.84	477.00***
Farm size cultivated to rice (ha)	1.95	2.56	0.60***
Yield (kg/ha)	2099.00	1663.49	435***
Total income from rice production (₦)	215193.80	181912.70	33281.08***
Total income from other crops (₦)	153630.90	84355.78	69275.07***
Non-agricultural income (₦)	109910.30	94052.53	15857.81
Total agricultural income (₦)	382567.90	274273.00	108294.8***
Total household income (₦)	492478.20	368325.60	124152.60***

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

Source: field survey (2010)

4.2 Poverty Profile of the Treated Farmers

The result of the poverty profile of all the treated farmers as presented in Table 4 shows that poverty incidence, depth and severity was reduced by 23.41%, 26.28% and 34.48% among all the treated farmers after the intervention. A gender based poverty assessment was also carried out in order to examine the gender difference in the poverty profile between the treated and the controlled farmers before and after the intervention. Furthermore, among all the treated farmers poverty incidence, depth and severity were observed to decline more among the female headed households compared with the male counterparts after the intervention.

Table 4. Poverty profile of the treated farmers

Poverty profile of all the treated farmers				
Statistics		**Before (%)**	**After (%)**	**Percentage change**
	Head count	57.33	43.91	-23.41
	Poverty depth	27.37	20.37	-26.28
	Poverty severity	17.11	11.21	-34.48
Poverty profile of all the treated farmer by gender				
Male	Head count	61.07	40.98	-32.89
	Poverty depth	29.46	18.38	-37.61
	Poverty severity	18.18	9.73	-46.48
Female	Head count	57.69	31.58	-45.26
	Poverty depth	29.72	15.04	-49.39
	Poverty severity	18.16	9.70	-46.59

Note: negative means reduction
Source: field survey (2008 and 2010)

4.3 Econometric Impact Evaluation of the Seed Voucher System

4.3.1 Impact on Rice Income per Hectare

The rice income was calculated as total rice output multiplied by the prevailing market price of rice per kilogram. The total rice income generated was then divided by the area cultivated to rice to get the rice income per hectare. The impact of the seed voucher system on rice income per hectare was examined using several methods such as the mean difference, IPSW, LATE by WALD estimator and by LARF. Essentially this was done to ensure that a consistent estimate of the impact devoid of any bias was provided and also to compare the results obtained from the different estimation methods.

The rice income was calculated as the total rice output produced by each respondents multiplied by the prevailing market price at the time of the data collection. The result of the impact of the seed voucher system on rice income per hectare is presented in Table 5.

Table 5. Impact of seed voucher system on rice income per hectare

Estimation	Parameter	Robust std. error	Z-value	P>|Z|
Observed sample mean outcome and differences				
Observed difference	25,007.19*	13841.06	1.79	0.073
Treated	143,665.50***	12119.53	11.85	0.000
Control	118,658.40***	6889.56	17.22	0.000
Inverse Propensity Score Weighting (IPWS) Estimates				
ATE	2615.69	21866.72	0.12	0.905
ATE1	32191.03*	19188.15	1.68	0.093
ATE0	15058.67	27503.56	0.55	0.584
PSB	34806.72	22191.26	1.57	0.117
Local Average Treatment Effect Estimation (LATE)				
LATE by WALD estimators	25996.11	641330.80	0.04	0.968
LATE by LARF	37557.26*	20431.15	1.84	0.066
Late (by LARF) estimates by gender, poverty status and rice ecologies				
Impact by gender				
Male	34,435.10**	27625.67	0.49	0.662
Female	13,637.66	61267.99	2.19	0.028
Impact by poverty status				
Poor	43,299.56*	17231.99	1.74	0.082
Non-poor	30,003.48*	24113.99	1.80	0.073
Impact by rice ecologies				
Upland	61,091.96	55335.33	1.10	0.270
Lowland	34,349.49	23387.45	1.47	0.142
Irrigated	52237.02***	13776.90	3.79	0.000
Impact by state				
Niger	37528.85	31567.26	1.19	0.234
Osun	27358.47	42951.06	0.64	0.524
Kano	44611.31***	14904.03	2.99	0.003

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

Source: field survey (2010)

The result of the mean difference showed that there was a positive and significant observed difference of ₦25,007.91/ha in rice income per hectare between the treated and the control groups. The Average Treatment Effects was estimated using the IPSW technique. The Average Treatment Effect on the Treated (ATE1) was positive and statistically significant (₦32199.03/ha). This implies the seed voucher system significantly increased rice income per hectare among the treated farmers by ₦32199.03 per hectare. However, due to the problem of non-compliance, the ATE estimations of the impact of seed voucher on rice income per ha do not have a causal meaning.

The result of the WALD estimate showed a positive but non-significant impact of 25,996.11 on rice income per hectare. While the result of the LARF revealed a positive and significant impact of ₦37,557.26 on rice income per hectare. The impact was also positive among the female headed households (₦13,637.66/ha), it was, however, not significant. It had a positive and significant impact of ₦34,435.10/ha among the male headed households. The disparity in impact across gender could be due to the fact the female headed households unlike the male headed households seldom engage in other secondary activities, and therefore may not have an additional income to invest in farming. The impact by poverty status revealed that although it impacted both the poor and the non-poor households positively and significantly, however, it has a higher impact on the poor (₦43,299.56/ha) farming households than the non-poor (₦30, 003.48/ha) counterparts. This signifies that the seed voucher system is pro-poor in nature.

The impact across the selected prominent rice producing ecologies also differs. In particular it had a positive and significant impact only in the irrigated rice ecology (₦52237.02/ha). Although the impacts in the upland (₦61091.9/ha) and lowland (₦34349.49/ha) rice ecologies were also positive, they were non-significant. This is plausible in the sense that rice production in Nigeria is usually rain-fed hence, upland and lowland rice ecologies are often affected by the vagaries of weather, thus limiting the yield potential. Meanwhile, the irrigated rice ecology usually has an abundant supply of water all year round and this could avail the farmers the opportunity to produce even during the dry season hence have an edge over the other farmers in the other ecologies in terms of yield and income. In the same vein, the impact across the selected states also varied, with the highest positive and significant impact of ₦44611.31/ha coming from the respondents selected from Kano State. However, the impact in Niger State (₦37528.85/ha) and Osun State (₦27358.47/ha) were only positive, but not significant. One important explanation for this is also as a result of the fact that Kano State is one of the states in Nigeria that has irrigated rice ecology and, therefore, is expected to do better in terms of yield than the other states.

4.3.2 Determinants of Rice Income per Hectare

The determinants of rice income per hectare as revealed by the LARF estimate are shown in Table 6. The analysis disaggregated the explanatory variables into two different groups: 9 non-interacted terms and 7 interacted terms. The non-interacted terms are the independent variables that explain variation in rice income per hectare. The result shows that apart from the receipt of the seed voucher there were other socioeconomic characteristics of the farmers that had significant effects on the rice income per hectare. These variables included gender of household head, secondary occupation and household size. Specifically, the coefficient of gender of household head was positive and significant, which implies that the male headed households had higher income per hectare than the female counterparts. This is expected since the male headed households in most cases have easier access to productive resources than the female headed households. Similarly, the negative and significant coefficient of secondary occupation implies that those that do not have any secondary occupation have higher rice income per hectare than those that engaged in other occupation than farming. This could be due to the fact that those that have farming as their main occupation tend to devote more time and attention to farming, which could lead to efficiency in production and hence generate an increase in output. The positive and significant coefficient of household size also implies that a large household size significantly increases rice income per hectare. This could be due to the fact that most households in rural areas rely extensively on family labour which can reduce the cost of production; also farmers with a large household are likely to have a large farm size.

The Wald test of the interacted terms is statistically significant (Prob< F=0.0000), thus confirming the heterogeneity of the impact of seed vouchers on rice income per hectare. This implies that there are significant interactions between the covariates and receive of seed voucher. The interaction term for gender was negative and significant, suggesting that the impact on rice income per hectare would be smaller among the female headed households than the male counterparts. The interacted term for secondary occupation and training were positive and significant, implying that the impact of the seed voucher on rice income per hectare will be higher among the farmers with secondary occupation and those that attended training.

Table 6. Estimated coefficient of the exponential LARF for rice income per hectare

Variables	Coefficient	Std. error	t-statistics
Seed voucher	11.629***	0.455	25.53
Gender	11.377***	0.519	21.90
Secondary occupation	-0.554***	0.192	-2.88
Number of years of education	0.006	0.014	0.46
Years of experience in upland rice farming	0.003	0.009	0.31
Training	0.484	0.374	1.30
Age	0.009	0.011	0.92
Contact with extension agents	0.006	0.179	0.03
Household size	0.034*	0.017	1.93
Interacted terms			
Gender	-11.641***	0.558	-20.87
Secondary occupation	0.665**	0.318	2.09
Number of years of education	-0.003	0.016	-0.20
Years of experience in upland rice farming	0.022	0.015	1.53
Training	0.805*	0.412	1.95
Age	-0.026	0.014	-1.92
Household size	0.029	0.025	1.16
Number of observations		539.00	
R-squared		0.4180	
Adjusted R-squared		0.4002	
Wald test for the coefficient of the non-interacted terms		4761.77***	
Wald test for the coefficient of the interacted terms		81.00***	

Legend: significance level **P<0.05, *P<0.10, *** P<0.01
Source: field survey (2010)

4.3.3 Impact on Income Inequality

The impact on income inequality was assessed using the Gini index. This is important because it is widely believed that reducing income inequality could benefit the poor both immediately and in the long run by facilitating economic growth (LANJOUW, 2001). The result of the impact of the seed voucher system on income inequality as reported by the Gini-index is presented in Table 7. The analysis shows that the 0.47 income inequality in the subpopulation of treated farmers declined by 12.76% to 0.41% after the intervention in 2010. In the same vein the observed income inequality among the control group which was 0.49%, decreased marginally by 4.08% to 0.47% after the intervention in 2010.

Table 7. Impact of seed voucher system on income inequality

Period	Treated	Control	Total
Before: (2008)	0.47	0.49	-0.46
After: (2010)	0.41	0.47	-0.33
Change (%)	12.76	4.08	-28.26
Income inequality decomposition			
Group	**Before (2008)**	**After (2010)**	**Change (%)**
Gender			
Male	0.45	0.32	-28.88
Female	0.49	0.33	-32.65
Main occupation			
Farming as main occupation	0.43	0.32	-25.58
Farming as secondary occupation	0.49	0.46	-6.12

Note: negative implies reduction
Source: field survey (2008 and 2010)

The analysis of the income inequality was further decomposed by gender and main occupation. The results reveal that income inequality among the female headed households declined by 32.65% after the intervention, while that of the male headed households was reduced by 28.88% after the intervention. With respect to the main occupation, farming households experienced a 25.58% reduction in income inequality compared with a 6.12% reduction among the household with farming as a secondary occupation after the intervention. The implication of the above findings is that the use of the seed voucher system can generate redistribution in income among the rice farming households and consequently lowered income inequality in rural Nigeria.

5 Summary, Conclusion and Recommendations

This study examined the impact of the seed voucher system adopted by the Africa Rice Centre to grant some randomly selected resource poor farmers from rural areas access to certified improved rice seed at a subsidized rate on income inequality and poverty reduction among rural farmers in Nigeria. Given the experimental approach adopted, the farmers were partitioned into two distinct groups (treated and control), first to remove selection bias and also to enhance appropriate comparison. The farmers in the treated group were given the seed voucher to procure certified improved rice seed at a subsidized rate, while those in the control were not given vouchers. In order to provide consistent estimates, devoid of any form of bias of the impact on the selected outcomes, we adopted the LATE estimation methods. The results of the analyses showed that income inequality and poverty were significantly reduced among the rice farming households after the intervention. Overall, this study revealed that, the use of a seed voucher system can be a way out of the prevalent poverty in Nigeria, particular in the rural areas where poverty is highly endemic. It can also assist in the redistribution of income and thereby engendering economic growth and development in Nigeria. This study recommends the use of seed voucher system to distribute seed to the rural farmers. It has been shown that the use of seed vouchers can actually enhance adequate and timely access to seed and hence generate increase in income per hectare.

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Contact author:
Bola Amoke Awotide
c/o Africa Rice Centre, International Institute for Tropical Agriculture (IITA), P.M.B. 5320, Ibadan, Nigeria
e-mail: bawotide@yahoo.com