FACTORS INFLUENCING THE USE OF GOOD QUALITY IMPROVED RICE SEED IN NIGERIA: IMPLICATION FOR SUSTAINABLE RICE PRODUCTIVITY

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Abstract: Good quality seed has the potential to generate increase in rice yield and make Nigeria self-sufficient in rice production. However, farmers' access to this seed is a function of many factors that has not been well documented in Nigeria. This study identified some factors that influenced the probability and intensity of adoption of improved rice variety in Nigeria, using double hurdle model. A multistage random sampling procedure was employed to select 600 rice farming households across the three prominent rice producing ecologies in Nigeria. The results that emanated from the analyses showed that age, secondary activity, cost of seed, distance to the nearest seed source negatively and significantly influenced the probability of a farmer adopting at least one improved rice variety in the study area and the intensity of adoption. While household size, membership of organization, house ownership, income from other crop production and experience in lowland rice production positively and significantly influenced both. The result of the marginal effects also showed that an additional increase in income from other crop production increases the probability of adoption by 25.0 per cent and intensity of adoption by 39.0 per cent. While an additional year to the age of the farmer reduces the area cultivated to improved rice varieties by 1.6 per cent. Therefore to achieve a sustainable increase in rice production, adoption enhancing information should be targeted at the younger farmers. Also farmers should be encouraged to diversity crop production to boost household income. Finally, improved rice seed varieties should be made available within the rural areas at an affordable cost.

Keywords: adoption, improved rice, farmers, double hurdle, Nigeria

INTRODUCTION

Rice is an important staple food crop in Nigeria. It constitutes a larger percentage of the calorie requirement of the teeming population. Nigeria consumes the highest volume of rice in Sub-Saharan Africa (Momoh, 2007). Since mid-1970s, rice consumption in Nigeria has risen tremendously growing at 10.3% per annum, due to accelerating population growth rate, increase per capita consumption, rapid urbanization among many other factors(Akpokodje et al.,2001; Akande, 2002; UNEP, 2005). Average rice consumption expenditure represents 60% of the total expenditure on cereals and 17% of expenditure share of food commodities (NLSS, 2004). Nigeria though naturally endowed has not been able to produce enough rice for the teeming population and the gap between demand and supply has further widened by decades of growing importance of the commodity among household across the length and breadth of the country (Saka et al., 2005). Consequently, rice is imported to the country at a colossal foreign exchange. NAMIS (2004) reported that, Nigeria imported 1.4 million tons of rice equivalents to 4.8% of global rice import and hence tops the list of rice importers in the year 2007. The value of rice import has also increased from 60 million U.S dollars in 1990 to 288 million U.S dollars in 2001 and thereafter increased astronomically to 1.7 billion U.S. dollars in 2008.Apart from the negative implication of this on the importation of capital goods for industrial development, it also exposes the country to

international shocks such as the 2008 global food crisis that threatens the nation food security.

In the last few years, the Nigerian government has embarked on a lot of programs and intervention to improve rice production and attain self-sufficiency both for local consumption and also for export. Due to the recognition of the fact that seed is a very important and major input in agriculture and to a greater extent the yield and quality of the crop depends on the quality of the seed planted. The attributes of the seed planted in terms of its genetic potential, purity and germination, resistance to diseases, its adaptation to local agro-ecological situation among many others, set a limit to the gains in productivity to be attained from the use of expensive inputs like fertilizer, pesticide, herbicide and management techniques (Adekoya and Babaleye, 2009). Hence, at least 57 improved rice varieties have been developed by the national and international research institutes in collaboration with international organizations. Some of these improved varieties include NERICA 1(FARO 55), NERICA 2 (FARO 56), ITA 150 (FARO 46), CISADANE (FARO 51), WITA 4 (FARO 52), ITA 321 (FARO 53), WAB 189 (FARO 54) and FOX 40004-43 (FARO 57) (AfricaRice, 2008). Efforts were also put in place to disseminate these improved varieties to the farmers through different programs and interventions.

Improved seed varieties have a lot of implications in agricultural production. These include the ability of the farmer to crop several times within a planting period because of a relatively shorter growing period. It also has a better genetic potential that ensures bumper harvests, it is disease and pest resistant, drought tolerant and can compete favourably with weed (AfricaRice, 2008). All these collectively have the potential to enhance yield and makes farming profitable for the farmers. 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 uses (Pelmer, 2005). Therefore, in other to preserve the quality of the improved seed and to ensure that farmers use good quality seed, improved rice seed are certified by appointed seed certification agency. The certified improved rice seed were made available to the farmers through the research institutes, the extension agents of the Agricultural Development Programs (ADPs), seed companies and agro-dealers.

Basically, the seed need of the farmers is met through two distinct seed supply systems. These are the formal and the informal seed supply sectors. In the formal seed supply system, regulations exists to maintain variety identity and purity as well as to guarantee physical, physiological and sanitary quality. Seed marketing takes place through officially recognized seed outlets and by way of national agricultural research systems (Louwaars, 1994). While the informal seed system is basically what the formal system is not. seed related activities tend to be integrated and locally organized and the informal system embraces most of the other ways in which farmers themselves produce, disseminate and procure seed : directly from their own harvest through barter among friends, neighbours and relatives, and through local grain production rather than as discrete activities. Local technical knowledge and standards guide informal seed performance. However, according to Maredia et al. (1999) the majority of farmers in Africa mainly get their seeds from informal channels which include farm saved seeds, seed exchanges among farmers or/and local grain/seed market and these channels contribute about 90-100 % of seed supply depending on the crop.

Despite the importance of this system; unlike the formal (regulated) seed systems, the informal is rarely supported. Subsequently, its improvement has been very limited or nonexistent with attendant negative effects on agricultural productivity and income of farmers, more particularly the poor and marginalized farmers. Although, Ezedinma (2005) observed that the land area cultivated to rice in Nigeria experienced a considerable increase from 150,000 hectares in the 1960s to about 1.8 million hectares in 2005, this has not translated into an increase in the yield of rice. In fact rice yield has been on the decline (NBS, 2008) consequently; both legal and illegal rice importation still goes on unabated. Against this backdrop, the persistent decline in the yield of rice can be attributed to the over reliance of the farmers on the informal sector for the bulk of their seed requirement. From the evidence of poor seed handling techniques reported by Awotide (2010), the seed used by the farmers can be regarded as low quality seed.

Although an array of study exists on rice production in Nigeria (see: Ogundele and Okoruwa, 2006; Saka et al., 2005; Awotide, 2004; Akande, 2002; Akpokodje et al., 2001; Tiamiyu, 2010; Rahji and Adewumi, 2008) however, no study to the best knowledge of the authors has examined the factors that influence the use of good quality seed by the farmers despite the importance on rice productivity, farmers income and the overall poverty reduction of the farming households in Nigeria. Therefore this study was carried out to fill the gap in the literature and also complement other studies, particular those that related to the adoption of improved rice varieties in Nigeria by examining the socio-economic/demographic characteristics of the farmers that influence the use of good quality seed in Nigeria. For this study, farmers that obtained seed from the

formal supply sectors such as: the National Cereal Research Institute (NCRI), Africa Rice Center, ADPs, and seed companies are classified as users of good quality improved rice seed.

The rest of the paper is organized as follows: Section 2 contains the review of some relevant literature. Section three presented the materials and methods. The results and discussion are presented in section 4. Section 5 contains the summary of major findings, conclusion and some policy recommendations.

LITERATURE REVIEW

Definitions of agricultural technology adoption

Many scholars have made an attempt to give a concise definition of what the adoption concept actually denotes. Among the endeavours made, the definition given by Rogers (1983) is the one that is widely used in adoption and diffusion studies. He defined diffusion (aggregate adoption) as the process by which a technology is communicated through certain channels over time among members of a social system and adoption as the use or non-use of a new technology by a farmer at a given period of time. Feder *et al.*, (1885) also made distinction between individual adoption and aggregate adoption, defining individual adoption as the degree of use of a new technology in a long-run equilibrium when the farmer has full information about the new technology and its potential. He then defined aggregate adoption as the process of spread of a technology within a region. In a similar vein, Thirtle and Ruttan (1987) defined aggregate adoption as the spread of new technique within a population. Understanding of the similarities and differences between these definitions is imperative to executing an empirical study of adoption.

Defining adoption may be further complicated by the complexity of defining the technology being adopted. Even for the adoption of improved maize and wheat seeds, it is possible to use a variety of definitions. In some cases, farmers were defined as adopters if they were using seeds that had been "recycled" for several generations from hybrid ancestors. In others, adoption was identified with following the extension service recommendations of using only new certified seed (Bisanda et al., 1998; Ouma et al., 2002). Since the definition of adoption encompasses a wide range of dissimilar practices, the results from these studies are not comparable. For management practices, the definitions of adoption may be even more complex. They may include the extent to which farmers use the practice correctly or effectively to gain the full benefits. Studies should explicitly state how they are defining these terms

Furthermore, when implementing an adoption study, it is important to take cognizance of the fact that there are divisible (e.g., improve seed, fertilizer and herbicide) and indivisible (e.g. mechanization, irrigation) technologies. With divisible technologies the decision process involves area allocations as well as level of use or rate of application (Feder *et al.*, 1985). For this reason, a distinction has to be made between technologies that are divisible and those that are not divisible with regard to the measurement of the intensity of adoption. Feder *et al*., (1985) notes that the intensity of divisible technologies can be measured at the individual level in a given period of time by the share of farm area under the new technology or quantity of input used per hectare in relation to the research recommendations.

Categories of adopters and stages of adoption

Adoption studies identified and described five categories of adopters in the social system. These categories include innovators, early adopters, early majority, late majority and laggards (Mosher, 1979; Rogers, 1983). A study by Rogers (1983) indicated that the majority of early adopters are expected to be younger, more educated, venturesome, and willing to take risk. On the contrary, the late adopters are expected to be older, less educated, conservative and not willing to take risk. However, Runquist (1984) believes that a restriction has to be made on the usefulness of the categorization of adopters as there is evidence indicating a movement from one category to the other, depending on the technology introduced.

Moreover, studies by Rogers and Shoemaker (1971) and Rogers (1983) described the technology adoption process as the mental process from the first knowledge of a new technology to the decision to adopt or reject it. These studies further indicated that the technology adoption process takes place within the mind of an individual and based on this theoretical background the studies identified five stages in adoption process. These are (1) awareness and the initial knowledge of the innovation (2) interest and persuasion towards the technology (3) evaluation or the decision whether or not to adopt the technology (4) trial and confirmation sought about the decision made and (5) adoption. Since the adoption decision has to go through different stages before the new technology is finally adopted, Rogers (1983) concluded that adoption is not a random behaviour but is a result of sequence of events passing through the adoption stages.

Mode and sequence of agricultural technology adoption

Abera (2008) identified two common approaches in the adoption literature that explain the mode and sequence of agricultural technology adoption. The first approach emphasizes the adoption of the whole package while the second one stresses step-wise or sequential adoption of components of a package. He

found that technical scientists often recommend the former approach while field practitioners specifically farming system and participatory research groups advance the later. He also notes that there is often a great tendency in agricultural extension programmes of developing countries to promote technologies as a package and farmers are expected to adopt the whole package.

There are studies that have been found to be against the whole package approach by strongly arguing that farmers do not adopt technologies as a package, but rather adopt a single component or a few suitable technologies (Mann, 1978; Byrlee and Hesse de Polanco, 1986). Several other studies on adoption reviewed by Nagy and Sanders (1990) and Leather and Smale (1991) concluded that farmers choose to adopt inputs sequentially by first adopting only one component of the package and sequentially adding components over time, one at a time. Furthermore, profitability, riskiness, uncertainty, lumpiness of investment and institutional constraints were found to be some of the major reason given for the sequential adoption of a package of technologies (Byerlee and Hesse de Polanco, 1986; Leather and Small, 1991).

Factors Influencing the Use (Adoption) of Improved Rice Varieties (IRV)

The observed adoption choice of an agricultural technology is hypothesized to be the end result of socio-economic characteristics of farmers and a complex set of inter-technology preference comparisons made by farmers (Adesina and Forson, 1995). Recent adoption studies in Europe Charmala and Hossain, 1996; Frank, 19997), in Asia (Sharma and Pradhed, 1996; Patel et al, 1996) and in Africa (Abdelmagid and Hassan, 1996) have identified farm and technology specific factors, institutional, policy variables, and environmental factors to explain the patterns and intensity of adoption. Rao and Rao (1996) found a positive and significant association between age of farmers, farming experience, training received, socio-economic status, cropping intensity, aspiration, economic motivation, innovativeness, information source utilization, information source, agent credibility and adoption.

Also Agbamu (1993) found only knowledge of a practice to be significantly related to its adoption. Ikpi et al (1996) shows that where farmers have to adopt a new crop technology that shifts time from their farming to the home production activity sector, the probability and rate of adoption of such technology are higher. Also, as family time is shifted away from the farming sector to home production sector, the economic impact index increases. Arene (1994) reported a positive and significant relationship between family size and adoption. On the other hand Voh (1998) established that household size is not significantly related to adoption. Abdul et al (1993) reported a significant relationship between landholdings (farm size) and adoption.

Voh (1998) also reported that socio-economic status of farmers is positively and strongly related to adoption. This report implied that the higher the socio-economic status, the higher the tendency to adopt innovation. Igodan, et al (1988) reported that farmers who are more exposed to formal extension information have a high propensity towards adoption than those with less exposure. However, Abdul et al.,(1993) did not establish any relationship between education and adoption. Education, size of holdings and cosmopoliteness accounted for significant variation in communication behaviour of farmers. Goswami and Sagar (1994) identified some factors associated with knowledge level of an innovation. They found educational level, family educational status, innovation proneness and utilization of mass media to be positively and significantly correlated with knowledge level.

Hossain et al., (1992), in the case of Bangladesh, reports that farmers with higher level of education have higher probability of adopting improved farming practices than those with lower levels of education. Furthermore, Nkonya *et al* (1997), in the case of Tanzania, and Itana (1985) in the case of Ethiopia indicate that education is an important factor positively affecting the process of adoption of improved maize varieties. Therefore, several hypotheses can be derived on the decision factors that affect the probability and intensity of adoption of improved rice varieties. In this study, the following hypotheses were used as a priori expectations:

Age of household head- may negatively influence both the decision to adopt and extent of adoption of improved rice varieties. It is hypothesized that older farmers are more risk averse and less likely to be flexible than younger farmer counterparts and thus have a lesser likelihood of adopting new technologies.

Genders of household head- Male farmers are likely to adopt improved rice varieties than the female headed households.

Household size- a proxy to availability of family labour, could influence have a positive influence on the adoption of improved rice varieties as its availability reduces the labour constraints faced in rice production and also reduced the cost of production.

Years of formal education- Education according to Wozniak (1984) augments one's ability to receive, decode and understand information relevant to making innovative decisions. Thus, it is hypothesized that farmers with more education are more likely to adopt improved agricultural

technologies than farmers with less or no education. However, Weir and Knight (2000) find that household-level education affects the timing of adoption in Ethiopia, but not whether or not household ever adopts new technologies.

Vocational training- Also influences the adoption of improved varieties positively, since it's a form of human capital development.

Contact with extension agents- may also enhance the efficiency of making adoption decisions. Based on the innovation-diffusion literature (Adesina and Forson 1995), it is hypothesized that extension visit is positively related to adoption by exposing farmers to new information and technical skills.

Membership of organization- being a member of any organization can facilitate access to information and hence influences adoption positively.

Additional income from other crop production and secondary occupation- can positively influence the adoption of improved rice varieties since they can increase the farmer's financial capacity to pay for improved inputs.

House ownership- as a measure of family wealth is expected to have a positive influence on adoption.

Cost of seed: since improved seeds are more expensive relative to local seeds, seed cost is hypothesized to be negatively influence the adoption of farmers.

Access to seed: in order to make use of technologies, farmers should be able to get seeds either in the formal or informal distribution systems. Thus, seed availability is hypothesized to positively influence the adoption of improved rice varieties.

MATERIALS AND METHODS

Sampling and Data Collection

This study focused on rice farming households randomly selected from the three major rice growing systems in Nigeria. The data were collected using multistage random sampling techniques. In the first stage, three major rice growing systems were selected. This led to the selection of upland, lowland and irrigated rice ecologies. Each of the rice ecologies has 30%, 47% and 17% share of national rice area respectively. The second stage involved the random selection of one state each from each rice producing ecologies. Hence, Kano, Osun state and Niger were selected to represent irrigated, upland and lowland rice ecologies respectively. In the third stage, two Agricultural Development Program (ADP) zones that were basically rural were purposively selected from the ADP zones in each state. The fourth stage involved the random selection of five Local Government Areas (LGAs) from each of the zones. The random selection of 3 villages from each of the LGAs constituted the fifth stage. This generated a total of 45 villages for the analysis. While the last stage involved the selection of rice farming households form each of the villages. The number of rice farming households selected from each village was proportionate to size. This generated a total of 500 rice farming households. Data were collected on socio-economic/demographic characteristics, source of seed, methods of seed handling techniques, physical and financial capital using well structured questionnaire. After data cleaning 481, representing 92.6% were finally utilized for the analysis. The double hurdle model was used to analyze factors influencing the probability that a farmer would use good quality seed and the intensity of the use of the good quality seed.

Model and Estimation Techniques

In this study a farmer was defined as an adopter if he or she was found to be growing any improved rice variety. Thus, a farmer could be classified as an adopter and still grow some traditional varieties. The adoption variable was therefore defined as 1 if a farmer is an adopter of improved rice variety and 0 otherwise. Although this issue of whether or not to treat adoption as a dichotomous choice was raised by Feder et al. (1985), but it continues to bedevil adoption studies, often because the available data limit analyses in this direction.

The double-hurdle model is a parametric generalization of the Tobit model, in which two separate stochastic processes determine the decision to adopt and the level of Adoption of the technology (Green, 2000). The double-hurdle model has an adoption (D) Equation

$$\left.\begin{array}{l} D_i = 1 \quad if D_1^* > 0 \\ D_i = 0 \quad Otherwise \\ D_i^* = \lambda Z_i + \pi_i \end{array}\right\} \quad \text{---------- (1)}$$

Where *D** is a latent variable that takes the value 1 if the farmer adopts improved rice varieties and zero otherwise, Z is a vector of household characteristics and λ is a vector of parameters. The level of adoption (Y) has an equation of the following

$$Y_i = \begin{cases} Y_i^* = \gamma' X_i + \tau_i \; if Y_i^* > 0 \; and D_i^* > 0 \\ 0 \; otherwise \end{cases} \quad \mathbf{2}$$

Where Yi is the observed answer to the proportion of area planted with improved rice varieties, X is a vector of the individual's characteristics and γ is a vector of parameters. The error terms, ui and vi are distributed as follows:

$$\left.\begin{aligned} \pi_i &\sim N(0,1) \\ \tau_i &\sim N(0,1) \end{aligned}\right\} \quad 3$$

The log-likelihood function for the double-hurdle model is:

$$LogL = \sum_0 \ln\left[1 - \Phi(\lambda_i Z_i^1)\left(\frac{\gamma X_i'}{\theta}\right)\right] + \sum \ln\left[\Phi(\lambda Z_i')\frac{1}{\theta}\phi\left(\frac{Y_i - \gamma X_i'}{\theta}\right)\right] \quad 4$$

Under the assumption of independency between the error terms π_i and τ_i the model (as originally proposed by Cragg (1997) is equivalent to a combination of a truncated regression model and a univariate probit model. The Tobit model arises if

$$\rho = \frac{\gamma}{\theta} \quad \text{and X=Z}$$

A simple test for the double hurdle model against the Tobit model can be used. It can be shown that the Tobit log-likelihood is the sum of the log-likelihood of the truncated and the probit models. Therefore, one simply has to estimate the truncated regression model, the Tobit model and the probit model separately and use a likelihood ratio (LR) test. The LR-statistic can be computed using (Green, 2000) as:

$$\Gamma = -2\left[\ln L_T - (\ln L_P + \ln L_{TR}) \sim X_K^2\right] \quad \mathbf{5}$$

Where LT = likelihood for the Tobit model; LP=likelihood for the probit model; LTR= likelihood for the truncated regression model; and k is the number of independent variables in the equations. If the test hypothesis is written as Ho: $\rho = \frac{\gamma}{\theta}$ and $\rho \neq \frac{\gamma}{\theta}$ Ho will be rejected on a pre-specified significance level, if $\Gamma \succ X_k^2$. The double hurdle model was adopted by Legese et al (2009) to assess the relationship between household resource endowment and determinants of adoption of drought tolerant maize varieties in Ethiopia. The variables included in the model are shown in table 1.

Poverty Indices

Poverty line is generally defined as the per-capita monetary requirements an individual needs to afford the purchase of a basic bundle of goods and services. It is a minimum acceptable standard of the welfare indicator (Ravallion, 1992; Deaton, 1997) and it is usually adopted to classify the population into poor or non-poor. Thus, a farming household may be categorized as poor if its consumption expenditure falls below the poverty line and non-poor if it is above the poverty line (Adejobi, 2004; Omonona, 2001; Awoyemi, 2010). This study also utilized the relative poverty line approach, defined as the two-thirds of the mean value of the per capita consumption expenditure among the rice farming households in the study area. Thus, households with per capita consumption expenditure below the poverty line are classified as poor and non-poor otherwise. The poverty indices were calculated for the adopters and non-adopters using the standard Foster-Greer-Thorbecke (FGT) (1984). The FGT is often refers to as the P_α class of poverty measures employed to generate the poverty profile of the respondents before and after the project for the two groups (the treatment and the control group) satisfy all the four criteria. The FGT takes the form;

$$P_{\alpha} = \frac{1}{n}\sum_{i=1}^{n} q\left[\frac{Z - Y_{pi}}{Z}\right]\alpha \qquad 6$$

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 consumption expenditure of the i^{th} household

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

$Z\text{-}Y_i$ = poverty gap of the i^{th} 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 (6)

$$P_o = 1/n\,(q) = q/n = H \qquad 7$$

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 money 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)

$$P_{\alpha=1} = PG = \frac{1}{n}\sum_{i=1}^{n} q_i\left[\frac{Z - Y_{pi}}{Z}\right] = HI \qquad 8$$

$$\text{Where I} = \frac{1}{q}\sum_{i=1}^{n} q\left[\frac{Z - Y_{pi}}{Z}\right] = HI \qquad 9$$

is the expenditure 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,

$$P_{\alpha=2}=\text{SPG} = \frac{1}{n}\sum_{i=1}^{n} q_i\left[\frac{Z - Y_{pi}}{Z}\right]^2 \qquad 10$$

$P_{\alpha=2}$ measure is increasingly used as a standard poverty measure by the World Bank, the regional development banks, most United Nation 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.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Respondents by Adoption Status

The socio-economic/demographic characteristics of the farmers by adoption status are presented in table 2. The result shows that majority (81.0 per cent) of the respondents were male. Also 82.0 per cent of the adopters and 78.0 per cent of the non-adopters were male. Average age of the respondents was 45.0 years. The mean age of the adopters (44.0 years) was not significantly different from the non-adopters (46 years). In terms of educational background of the household heads, 32.0 per cent of the respondents had no formal education. The proportion with no formal education is significantly different between the adopters and non-adopters. About 33.0 per cent and 28.0 per cent of the adopters and non-adopters respectively had no formal education and 15.0 per cent of adopters and 13.0 per cent of non-adopters had at least primary education, which implies that they had up to at least 6 years of formal education. The proportion of farmers among the adopters (18.0 per cent) that attended vocational training is also

significantly different from the non-adopters (9.0 per cent).

The proportion of farmers that had experience in the three major rice producing systems in Nigeria also differs between adopters and non-adopters. A set of institutional variables was also included among the characteristics these are: contact with extension agents and access to credit. A larger percentage (45.0 per cent) of the adopters had contact with extension agents, while only 22.0 per cent of the non-adopters had contact with extension agents. In the same vein a larger percentage (42.0 per cent) of the non-adopters had access to credit compare with only 12.0 per cent of the adopters with access to credit.

Adoption and Poverty

The result of the FGT poverty measure is presented in table 3. It shows that all the poverty indices experienced a reduction among the adopters. The incidence, depth and severity of poverty were higher among the non-adopters than the adopters. This could be interpreted to mean that adoption of improved rice varieties is poverty reducing.

Maximum Likelihood Estimation of the Double Hurdle Model

This study adopted the double hurdle model to assess the socio-economic/demographic characteristics that influence the farmers' adoption and intensity of adoption of improved rice varieties. The marginal effects were also adopted to calculate percentage changes in the dependent variable when the exogenous variable shifts from zero to one for categorical variables and elasticities at the sample means for continuous variables (Legese et al., 2009). The first hurdle examined the determinants of probability of adoption and the dependent variable was whether a farmer used(Adopted) good quality improved rice seed or not. The second hurdle examined the intensity of adoption and the dependent variable was the proportion of area cultivated to the improved rice seed of good quality.

The results of the analysis showed that age of household head, household size, secondary activities, membership of organization, house ownership, and income from other crops, education, and age squared significantly influenced probability of adoption. The age of household head negatively and significantly ($p \leq 0.01$) influenced adoption, meaning that the younger farmers tend to adopt more than the older farmers. This implies that as age increases the probability that a farmer would adopt improved rice variety tends to reduce. This finding is contrary to the findings of Hossain et al. (1992) which reported that the probability of adopting a new farm practices increases with farmer's age in Bangladesh. However, as shown by the quadratic of age of household head which was positive and highly significant, age would increase to a certain level and adoption of improved rice variety would begin to increase, this is line with the life cycle hypothesis.

Household size had a positive and significant ($p \leq 0.05$) influence on the probability of adoption. This is in line with a prior expectation and it implies that as household size increases, the probability that a farmer would adopt improved rice variety also increases. In Nigeria, household size is a source of family labour and hence it can reduce labour constraints in rice production and consequently enhance the adoption of improved rice variety.

The influence of secondary activities on the probability of adoption was also negative and significant ($p \leq 0.01$). The implication is that, the involvement of a farmer in other activities besides farming reduces the probability of adoption. If a farmer's overall income is from farming, there is tendency that such a farmer would adopt any improved technology that could boost output and ultimately increase household income. However, diversification of income by producing multiple crops had a positive and significant influence on the probability of adoption.

This study revealed that education had a positive and significant ($p \leq 0.05$) influence on the decision to adopt improved rice varieties in Nigeria. The implication of this is that highly educated farmers are better adopters. This is also consistent with other past research findings. One cogent reason for this is that with an increase in the number of years of education, the ability of farmers to use resources efficiently increases. Allocative effect of education also enhances farmer's ability to obtain, analyse and interpret information. Several studies reviewed by Feder *et al*. (1985) indicate that education level enhances farmers' ability to acquire, interpret and use information, including information about agricultural technologies, and hence leads to earlier and faster adoption.

In line with a priori expectation, being a member of any organisation had a positive and significant ($p \leq 0.01$) influence on the probability of adoption. Membership of any organization can influence access to vital information related to the improved rice varieties and can therefore influence its adoption. In the same vein, house ownership as a measure of farmer's wealth had a positive and significant influence on the probability of adoption. This implies that adoption of improved rice varieties tends to increase more among the farmers that own their respective houses. Cost of house rent contributes significantly to household expenditure in Nigeria and a reduction in expenditure could create opportunity for adoption.

Although gender of household head did not influence adoption significantly, however, its influence was positive, which implies that the male headed households tend to adopt more than the female headed households. An important explanation is that female headed households have poor access and control over resources in general and have shortage of farm labour in particular. Similarly, farmers that have contact with extension agents tend to adopt more than those that do not have contact with extension agents.

Other important variables that were closely linked with adoption such as cost of seed and access to seed were also not statistically significant; however, they had the expected signs. For instance, access to seed was positive which means that those that had access to improved rice seed were more likely to adopt than those that did not have access. Likewise, the cost of the improved rice seed negatively influenced adoption. The implication of this is that as the cost of improved rice varieties increases, the probability that a farmer adopt reduces.

The second hurdle of the model examined the intensity of adoption of improved rice varieties using the proportion of area cultivated to the improved rice varieties as the dependent variable. The result of the analysis shows that out of the twelve variables included in the model, eight significantly influence the intensity of adoption of improved rice variety. Age of household head is negative and significant ($p \leq 0.01$) which implies that the proportion of area cultivated to improved rice variety decreases as age of the farmers increases. This could be due to the fact that as farmers advanced in age, the energy to farm would reduce and since most of the farm work is done manually, this will reduce the land area allocated to improved rice varieties. If the age of the household head increases by one year above the average age (45.0) the area allocated to improved rice variety will reduce by 1.6 per cent.

Similarly, farmer participation in secondary activity, distance to the nearest source of seed and cost of improved rice seed were negative and significant ($p \leq 0.01$) determinants of intensity of adoption. As farmers diversify into other activities, the zeal for farming could reduce and this will negatively affect the area cultivated to improved rice varieties. Furthermore, table 5 revealed that as the cost of seed and distance to the nearest source of seed increase, the proportion of area cultivated to improved rice varieties decreases. If the cost of seed increase by ₦1.0, the area cultivated to improved rice varieties will reduce marginally by 0.2 per cent. In the same vein, if the distance to the nearest seed source increase by 1.0km, the area cultivated to improved rice varieties will by 0.9 per cent.

Furthermore, membership of an organization, house ownership, experience in lowland rice production and income from other crop production are all positive and significant ($p \leq 0.01$) determinants of intensity of adoption. As shown in table 5, an additional year of experience in lowland rice production will increase the area cultivated to improved rice variety by 19.0 per cent. Similarly, if the income from other crop production increases by ₦1.0, the area devoted to improved rice production will increase tremendously by 39.0 per cent. This shows the importance of crop diversification in intensity of adoption.

SUMMARY, CONCLUSION AND RECOMMENDATION

This study examined the factors that influenced the probability of adoption and intensity of adoption using double hurdle model. The results showed that those variables that had significant influence on adoption and intensity of adoption were similar. Meaning that targeting these variables will achieve a twin objective of improving the probability and intensity of adopting improved rice variety. The negative and significant influence of age on both the probability of adoption and the intensity of adoption signifies that attention should be focused on the younger generation to enhance adoption. Rice farmers should be encouraged to diversify into other crop production as the income from other crop significantly influences both the probability and the intensity of adoption.

Although house size positively and significantly influenced the probability of adoption however, larger household could further impoverish a farming household. Therefore, it is advisable that the farmers reduce their household size. Also, improved rice seed should be made readily available within the rural areas, as the poor farmers are likely to be less willing to invest time in searching for seed far away at high cost of transaction. The cost of the improved rice seed should be bearable and the presently available seed subsidy should be well implemented to enable the farmers get access to the seed at the right time and at affordable price.

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Appendix

Variable	Definition
Age	Age of household head in years
Gender	Gender of household head,1 male and 0 otherwise
Household size	Number of persons per households
Educational Background	Number of years of formal education of household head
Contact with extension agents	1 if farmer has contact with extension agent and 0 otherwise
House ownership	1 if farmer is the owner of house and 0 otherwise
Log of income from other crops	Income from other crop production in Naira
Membership of organization	1 if farmer is a member of any organization, 0 otherwise
Secondary activity	1 if farmer has secondary activity, 0 otherwise
Experience in upland rice production	Number of years of experience in upland rice production
Experience in lowland rice production	Number of years of experience in lowland rice production
Cost of seed(₦/kg)	The price of a kilogram of seed
Distance to seed source	Distance to the nearest seed source(Km)
Access to seed	1 if a farmer have access to seed, 0 otherwise
Square of age of household head	Quadratic of age of household head in years

Table 1: Descriptive Statistics of Selected variables in the Empirical Model

Poverty Indices (%)	Adopters	Non-adopters	All Farmers	% Differences
Incidence of Poverty				
Depth of poverty	46.00	51.00	50.00	5.00
Severity of Poverty	15.00	20.00	19.00	5.00
	7.00	10.00	9.6	3.00

Source: Field Survey, 2010

Table 3: Poverty Indices (%) by Adoption Status

Characteristics	Adopters	Non-adopters	All farmers	Difference
Socio-economic/demographic characteristics				
Age	44.00	46.00	45.00	2.00
Household size	9.00	7.00	8.00	2.00
Proportion of male	82.00	78.00	81.00	4.00
Proportion of female	18.00	22.00	19.00	4.00
Mean income from rice production(₦)	195567.30	182720.90	190661.50	12846.40
Human Capital				
Proportion with no education (%)	33.00	28.00	32.00	5.00
Proportion with primary education (%)	15.00	13.00	14.00	2.00
Proportion with secondary education (%)	8.00	11.00	9.40	3.00
Proportion with tertiary education (%)	4.00	3.00	4.00	1.00
Proportion with Islamic education (%)	36.00	44.00	49.00	4.00
Proportion that attended Vocational training (%)	18.00	9.00	15.00	9.00
Proportion with experience in upland rice farming (%)	28.00	34.00	31.00	6.00
Proportion with experience in lowland rice farming (%)	72.00	97.00	81.35	20.00
Proportion with experience in irrigated rice farming (%)	27.00	0.46	16.00	26.54
Institutional factors				
Proportion in contact with extension agents	45.00	22.00	36.00	23.00
Proportion that have access to credit	12.07	42.00	23.45	29.00

Source: Field Survey, 2010

Table 2: Socio-economic Characteristics of the Respondents by Adoption Status

Explanatory Variable	Coefficients	Standard Error	T-value
First Hurdle: Probability of Adoption-Dependent variable: whether a farmer adopt IRV or not			
Age	-0.204	0.058	-3.51***
Gender	0.067	0.187	0.36
Household size	0.051	0.021	2.42**
Access to seed	0.110	0.167	0.66
Cost of seed	-0.001	0.002	-0.13
Secondary activity	-0.802	0.273	-2.94***
Contact with extension agents	0.181	0.173	1.04
Membership of organization	0.722	0.187	3.85***
House ownership	1.248	0.273	4.57***
Income	0.711	0.096	7.43***
Years of formal education	0.027	0.013	2.04**
Age2	0.002	0.001	2.82***
Second Hurdle: Intensity of Adoption: Dependent variable: Proportions of area under IRV			
Age	-0.016	0.004	-4.39***
Gender	0.049	0.082	0.60
Household size	0.006	0.021	0.27
Secondary activity	-0.391	0.123	-3.16***
Education	-0.008	0.005	-1.55
Membership of organization	0.179	0.068	2.63***
Cost of seed	-0.002	0.001	1.75*
Distance to seed source	-0.009	0.005	1.88*
House ownership	0.645	0.132	4.87***
Experience in upland rice farming	0.199	0.166	1.20
Experience in lowland rice farming	0.178	0.058	3.07***
Income	0.385	0.043	9.05***
Number of respondents	538.00		
Log-likelihood	-234.59		
Wald chi2(12)	223.87		
Prob>chi2	0.0000		

Source: Field Survey, 2010

Note: ***, ** and * Significant at 1%, 5% and 10% respectively

Table 4: Maximum Likelihood Estimation of the Double Hurdle Model

Explanatory Variable	Marginal effects
Age	-0.016
Gender	0.049
Household size	0.006
Secondary occupation	-0.391
Education	-0.008
Membership of organization	0.179
Cost of seed	-0.002
Distance to source of seed	-0.009
House ownership	0.645
Experience in upland rice farming	0.199
Experience in lowland rice farming	0.178
Income	0.385

Note: ***, ** and * Significant at 1%, 5% and 10% respectively

Source: Field Survey, 2010

Table 5: Marginal Effect of Adoption Intensity after Double Hurdle Estimation