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# Economics of rice/ paddy production in Kano and Niger States of Nigeria in the presence of technological heterogeneity

**Matthew O. Adewumi[1], Mohammed Murtala[2] and Oladele C. Ajewole[3]***

[1]Department of Agricultural Economics and Farm Management, Faculty of Agriculture, University of Ilorin, Nigeria.
[2]Notore Seeds, Notore Chemical Industries, Notore Industrial Park, Abuja, Nigeria.
[3]Department of Agricultural Economics and Extension Services, Ekiti State University, Ado Ekiti, Nigeria.

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**For decades, debates among African leaders have centred on possible solutions to the continent's food security dilemma. If not addressed, the continued increase in population density and the accompanying pressures from conflicting demands for land in many Sub-Saharan African nations, including Nigeria, have the potential to exacerbate the arable land situation in the near future. To achieve increased production, African farmers must increase their use of productivity-enhancing tools such as irrigation, improved seeds, fertilizer, and modern farm management practices. The use of Urea Deep Placement (UDP) technology to boost nitrogen availability, a key ingredient in rice production, was introduced to rice farmers in selected Northern Nigerian states. Empirical information on the economics of the use of this technology in rice production is scanty, hence this study. Based on data collected from three hundred UDP users and non-users, this study examined the cost structure, the profitability and productivity of rice farm in the presence of technological heterogeneity. The study employed descriptive statistics, logistic regression, and the Latent class generation modes. The data was divided into two groups based on their production functions. The study concluded that farmers that used urea deep production technology outperformed non-users. However, in the short run, this technology is labour intensive. To solve the excessive labour use in the short run and to make rice production appealing to the young people who make up the majority of Nigeria's labour force, labour-saving technology must be combined with UDP technology.**

**Key words:** Productivity, profitability, technological heterogeneity, urea deep placement, rice.

## INTRODUCTION

Rice (*Oryza* spp.) the primary food for more than 3 billion people around the world, is the grain with the second highest world production, after maize. Rice is the most important grain with regards to human consumption and calorie intake, which provides more than 20% of the calories consumed worldwide by humans (Wikipedia,

*Corresponding author. E-mail: matolade@unilorin.edu.ng or matolade@yahoo.co.uk. Tel: +2348033769233.

2013). It has become an important crop in Nigeria and relatively easy to produce and grow for commercial and subsistence usage. Rice has emerged as one of the widely grown agricultural commodities and has moved from a ceremonial grain to a staple food, in many Nigerian homes, in the last two decades to the extent that, some of the families cannot do without rice in a day (Onuk et al., 2010).

Available statistics revealed a production shortfall of about 3 to 3.5 million metric tonnes per annum. The deficit in rice production of about 3.5 million per annum encapsulates the fact, that, there is a problem of food insufficiency in Nigeria. This has resulted in massive rice importation into the country. For Nigeria to be self-reliant in rice production, the farmers need to find a way to improve on the average yield, per hectare. This will mean employing the Good Agricultural Practices (GAP), on rice production, to improve the yield, from present average of about 1.7 metric tonnes, per hectare to more realistic averages of 3 - 5 metric tonnes, per hectare. It is worrisome that Nigeria has not yet been able to source for better technology in relation to the traditional method of rice production, which will improve the average yield of rice in the country. Studies (Tarfa and Brian, 2013) have shown that one of the GAP is the use of Urea Deep Placement (UDP) technology. Providing information of the UDP technology and cost benefit, for increase in rice yield, is very important.

There is therefore, the need for the application of an appropriate technology, in order to increase rice yield, in Nigeria agriculture. UDP technology could be viable with potential to make-up for the discrepancy and it is worthwhile, to look at the factors, that will affect its adoption. Studies (Tarfa and Brian, 2013) have shown that under conventional fertilizer application, through broadcasting, two out of five bags of fertilizers applied on rice fields, are not available as nutrients to the rice plants. This encourages the loss of money, as a result of fertilizers evaporation in the atmosphere, run-off or leaching by rain water and weed competition.

With the use of primary data collected from three hundred rice farms in Kano and Niger States of Nigeria, this study examined the cost structure, the profitability and efficiency of rice farms in the presence of technological heterogeneity, which is a common phenomenon in agricultural production. Studies using micro data had in the past control for the possibility of technological heterogeneity using observable farm characteristics to separate the sample into groups and subsequently estimating different function for each group.

The sample observations are usually classified into several groups based on either some a priori sample separation information or observable farm characteristics (e.g. adoption rate of a particular technology, private, public or foreign, large or small scale, the ecology, land type, or seed variety to mention a few. Separate analyses may then be carried out for each class/sub-sample. This procedure is not known to be efficient since the information contained in one class is not used to estimate the technology (production or cost frontier) of farms that belong to other classes (Adewumi et al., 2013). However, in most of the empirical applications this inter-class information may be quite important because farms belonging to different classes often come from the same industry/sector. Although their technologies may be different, they share some common features. Econometric techniques, such as, latent class models, often referred to as mixture models, assume there are a finite number of groups underlying the data and estimate a different function for each of these groups. Since we believe that the farmers using the urea deep placement technology adopts it at various levels and hence there are discrete number of farm groups, this study therefore employs the latent class models.

The issue of heterogeneity was addressed in this study using Latent Class Model in a cross-section data collected from selected farms in the study area. This model exploits the information contained in the data more efficiently compared to the traditional cluster analysis. Estimation in ordinary regression models typically assumes that the underlying production technology is the same for all firms. There might, however, be unobserved differences in technologies and input/output qualities that can be inappropriately labelled as inefficiency if such differences are not taken into account.

## METHODOLOGY

### Study area

This study was conducted in Niger and Kano states, Nigeria (Figure 1). Niger State is located in the Guinea savanna vegetative belt, at latitudes 8° and 11°3` N and longitudes 03°30` and 7°40` E. The state is made up of 25 Local Government Areas (LGAs). These are divided into three Agricultural Development Project (ADP) zones. The state has a population of 4,717,056, across the LGAs (Central Intelligence Agency, 2013).

The temperature ranges from 26 to 36°C (Fatoba et al., 2009). The rainy seasons last for about 150 days in the northern parts to about 120 days in the southern parts of the state (Chianu et al., 2004). Kano State on the other hand is located in the Sudan Guinea Savanna agro-ecological zone of Nigeria, between latitudes 13° N and 11° S and longitude 8° W and 10° E. It has 44 LGAs which are divided into three ADP zones, with a population of 11,213,392 (Central Intelligence Agency, 2013).

The rainfall ranges from over 1,000 mm in the extreme south to a little less than 800 mm in the extreme north. The rain usually last for three to five months (mid-May to September), with mean temperature ranging from 26 to 33°C (Kano State Government, 2014). The length of growing period in the state is 90-150 days.

The rainfall distribution in two ecologies is uni-modal (Auta and Dafwang, 2010). Major crops grown in the two states are cereals; mainly, rice, maize, sorghum; leguminous crops such groundnut and melon, as well as roots and tubers. Niger and Kano States are part of the rice producing areas identified in Nigeria by Notore/USAID Markets II at the inception of UDP technology in 2009 and the UDP activities are still on-going in the two states. Although Notore/USAID MARKETS II project on UDP is also taking


**Figure 1.** Map of Nigeria showing Niger and Kano States.
Source: Nigerian finder.com: Map of Nigeria Showing Kano and Niger States. https://nigerianfinder.com/.

place in Ebonyi, Enugu, Anambra, Benue, Kwara, Gombe, Jigawa, Kebbi, and Sokoto States and has trained 8,105 farmers on UDP technology in these states, 40% of the trained farmers in Nigeria are both in Niger and Kano States (Tarfa and Brian, 2013). Niger and Kano States have great potentials to support dramatic increases in rice productions in Nigeria (PrOpCom, 2007; Uduma et al., 2016). Niger State was ranked second producer in rice production in the country and Kano State was ranked among the ten-leading rice-producing states, in the country (Agro Nigeria, 2013).

### Sources and types of data

The primary data used for the study were collected through the use of a set of structured questionnaires. Information collected include: farmers socio-economic characteristics, as well as the farm level data on inputs use/output and prices, cost of production and labour (hired and family), among others. The secondary data were sourced from the ADP and Notore/USAID Markets II project offices in the study area. Rice production pattern, fertilizer procurement pattern, the list of users and non-users of UDP, area of rice cultivated, yield of rice and other pertinent data were collected.

### Sampling procedure

The upgraded 2014 farmers and sites listing, was used as the sampling frame for the selection of respondents in the study area. This list was obtained from the Notore/USAID MARKET II Project. In the first stage, twenty villages were selected from the two states, comprising ten villages from each state. The villages were selected based on the areas, where UDP technology was introduced. In the second stage, proportion probability to size (PPS) technique was used to randomly select rice farmers in each village. Thus, 337 rice farmers were selected, interviewed but three hundred samples were found analysable and therefore used for the study. Users of UDP technology were defined as those farmers that were trained and later used the UDP technology, while, the non-users were those, who were not trained and did not use the technology.

### Analytical techniques

Descriptive statistics such as frequency distribution and percentages were used to describe the socioeconomic characteristics of the farmers. The logistic regression model was used to determine the factors influencing adoption of UDP among rice farmers, in the study area. This regression model has a binary response variable and it's a linear regression tool. According to Agresti (1996), it is the appropriate tool to use, when one wants to predict the presence or absence of a dichotomous characteristic, or outcome based on, values of a set of predictor variables. It's a linear regression but useful when the dependent variable is dichotomous (Borooah, 2002). The coefficients from the regression can be used to appraise odds ratio, for each of the independent variables, in the model. Adopting Olawuyi and Raufu (2012), the model is specified as:

$$Prob\ (Y_i = 1) = \frac{\exp(X_i{}' \beta)}{1 + \exp(X'_i \beta)} \quad (1)$$

The dependent variable is a dichotomous variable depicting the farmer's status and took the value of 1 if the farmer is a user of UDP technology and 0, if otherwise. The independent variables are the socio-economic and agronomic factors. The hypothesized independent variables are: farm size (hectares), family labour (man-day), hired labour (man-day), educational status of the farmers (years), sex (dummy), marital status (dummy), household size (adult equivalent), age (years), extension services (number of visits), farming experience (years), access to credit (Naira). The profitability of rice production was determined under the two different observable technologies of production, through the use gross margin of the production process, on per hectare basis. The operating ratio and return on capital invested by the farmers were also used as indices of profitability. The Latent Class model using the ordinary least square method was used to examine the determinants of farmer's output.

The Cobb-Douglas functional form of the regression was employed. The stochastic production frontier model has the advantage of allowing instantaneous estimation of individual technical efficiency, of the farmers, as well as the determinant of technical efficiency (Battese and Coelli, 2004). Following Battese et al. (2004), it is expressed as:

$$Y_i = f(X_i, \beta, Ui) \quad (2)$$

Where: $Y_i$ is the output of the $i^{th}$ farm. $X_i$ is a k x l vector of physical input quantities of the $i^{th}$ farm. β is a vector of unknown parameters estimated. $U_i$ are random variables, which are assumed to be normally distributed N (0, δv2). It is assumed to account for measurement error and other factors, not under the control of the farmer. The explicit form of the model in linear form is expressed as:

$$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \beta_6 lnX_6 + U_i \quad (3)$$

Where: Y = Rice output (kg). $X_1$ = Farm size measured in hectares (ha). $X_2$ = Rice seed measured in kilogrammes (kg). $X_3$ = Fertilizer (Super Granules) (kg). $X_4$ = Herbicides (litres). $X_5$ = Labour input in man-day). $X_6$ = Urea deep placement technology status of the farmer where 1 = users and 0 otherwise. $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$, $\beta_6$ = Parameters to be estimated. These coefficients are the elasticities of the output variable with respect to the X variables. In other words, the coefficients are the estimated percent change in the dependent variable for a percent change in the independent variable (Joseph, 2012).

## RESULTS AND DISCUSSION

Table 1 shows factors influencing adoption of UDP among rice farmers, in the study area. The Chi-square of 169.52 is significant at ($p < 0.01$), this implies that the parameters included in the logistic regression model are significant. Also, likelihood estimated in the model result was significant (Wald = -18.9962, with $p < 0.0000$) showing a strong explanatory power of the model.

All the included explanatory variables had positive coefficient in the adoption. This implies that all the significant variables had positive influence on the adoption of UDP in the area. The significant variables are farm size, level of education of the farmers, family labour, hired labour, age of the farmer, extension visits, farming experience and access to credit facility. Farmers with large land size have tendency of adopting the UDP technology compared to farmers with smaller land size. It is also logical that such farmers will be aiming at more profit arising from increased output from the field. The family labour is also shown to have positive impact on UDP adoption. The implication of this is that as more family labour is available, the tendency of adopting UDP technology increases. This is probably because urea briquettes application required additional labour compared to urea fertilizer broadcasting. In the short run therefore, application of UDP technology requires more family labour. However, in the long run, as productivity of labour increases, the additional labour, compensating variation in output may release more labour from the sector.

Education status of the rice farmers in the study area was found to have positive effect with adoption of UDP. This is possible because, the educated farmers can easily understand and adopt innovations, the more educated a farmer is, the more the probability of adopting UDP technology. Age was also positively related to adoption of UDP in the study areas. This is logical because the older a farmer is, the high tendency that they might want to benefit from technology that will increase their output. The farming experience had a positive relationship with the adoption of UDP technology. Daily activities for a period of time might lead to mastery. The more farmers had experience about a process, the high tendency that they might want to adopt UDP technology. Extension agent's visit to the farmers in the study area had positive relationship with adoption of UDP technology. The more the farmers are trained by the extension agent on new innovation, the probability of adopting the UPD technology. Access to credit showed positive relationship to adoption of UDP technology. The more the farmers have access to credit, the more tendency that they will have enough resources to adopt UDP technology. Table 1 showed the mean values of inputs and output of rice production by users and non-users of urea deep placement technology in the study area.

The mean farm size of the rice farmers in the study area was 2.25 ha. Users of UDP technology used average farm size of 2.5 ha compared to non-users with 2.00 ha (Table 2). There is no significant difference between these sizes. This result however, revealed that rice production is still at small scale in the study area. The average seed rate used ranges between 25 and 33 kg/ha for these rice farmers. The UDP users planted an average of 32 kg/ha of seed which is higher than the average seed rate in the area, while the non-users planted an average of 29.10 kg/ha. The average seed rate of 30.55 kg/ha used by the farmers in the area is lower than the recommended seed rate of 50-60 kg/ha for lowland rice as approved by the International Institute for Tropical Agriculture (IITA) (Ekeleme et al., 2008).

It was observed that, the average fertilizer used by the rice farmers in the study area was 182 kg/ha of urea briquettes and 384.50 kg/ha of conventional fertilizers. For the users of the UDP technology, this result was within the range of the recommended rate of 170 kg/ha of urea briquettes (IFDC, 2009). This level of compliance could probably be attributed to training provided for the rice farmers by the USAID Market in the study area. Similarly, the conventional fertilizer application by the non-users of UDP technology was lower compared to the recommended rate of 730 kg/ ha reported by Gay et al. (2010) in the investigation of the effect of salinity on yield and 2-acetyl-1-pyrroline content in the grains of three

**Table 1.** Determinants of adoption of Urea Deep Placement among the Rice Farmers.

| Variables | Coefficient | Std. Err. | Z |
|---|---|---|---|
| Constant | 0.251*** | 0.077 | 3.26 |
| Farm size | 3.108*** | 0.799 | 3.89 |
| Family labour | 0.002** | 0.001 | 2.00 |
| Education | 1.785*** | 0.479 | 3.73 |
| Sex | 1.443 | 1.899 | 0.76 |
| Marital Status | 0.494 | 2.005 | 0.25 |
| Hired labour | 0.300*** | 0.073 | 4.11 |
| Age | 0.647** | 0.289 | 2.24 |
| Extension Service | 1.689*** | 0.403 | 4.19 |
| Farming Experience | 4.275*** | 1.188 | 3.60 |
| Access to Credit | 3.007*** | 0.827 | 3.636 |
| LR chi2 (ll) =169.52 | | | |
| Prob. > chi2= 0.0000 | | | |
| Pseudo R2 =0.8169 | | | |
| Log likelihood = -18.9962 | | | |

Notes: **, *** represent significance at 0.05, 0.01 level.
Source: Field Survey (2014).

**Table 2.** Average levels of inputs and output of rice/paddy production.

| Input-Output | Users | Non-users | T statistic |
|---|---|---|---|
| Farm Size (ha) | 2.50 | 2.00 | 0.05 |
| Seed Qty. (Kg/(ha) | 32.00 | 29.10 | 1.17 |
| Fertilizer (Kg/ha) | 182.00 | 384.50*** | 7.59 |
| Herbicide (Lit./ha) | 14.60 | 12.60 | 1.61 |
| Labour (Man-day) | 288.50 | 207.30 | 0.29 |
| Output (Kg/ha) | 3,974.20 | 3,057.07*** | 4.63 |

Source: Field Survey (2014).

fragrant rice cultivars in Camargue. Implication of using inadequate fertilizers could be one of the reasons for lower yields obtained from non-users' fields. Fagade and Nguyen (2001) in the study of the evolution of irrigated rice yields in SSA yield differences and yields decline in rice production, agreed with this assessment that fertilizer has been known to account for more than 50% reduction in yield when not applied.

The mean herbicide used for weeds control by the rice farmers in the study area was 13.6 lts/ha. Users of UDP technology had a higher rate of 14.20 lts/ha, while non-users had a lower rate of 12.60 lts/ha. The labour input results suggest that the average labour employed by the rice farmers in the study area was 247, 90 man-day and the users of UDP technology used more labour (288.50 man-day/ha) than this average, while the non-users used less (207.30 man-day/ha). The mean output of the rice farmers in the study area was 3,515.64 kg/ha. Users of UDP technology had a higher average output of 3,974.21 kg/ha, while the non-users had a lower average output of 3,057.07 kg/ha. The users of UDP technology had a significantly higher output of 4,421.89 kg/ha while the non-users had 3,337.11 kg/ha (t-cal. = 8.326; p=0.013). This indicates that UDP technology users were more productive than non-users in the study area. This result agrees with Liverpool-Tasie et al. (2014) while working on productivity effects of sustainable intensification in Nigeria. The author also concluded that the use of urea briquettes technique had resulted in yield increase for the farmers by at least 15%.

The average cost of seeds by the rice farmers in the study area was ₦11,109.05/ha. Users of UDP technology had a lower average cost of ₦10, 355.55/ha on seeds while the non-users incurred an average of ₦11, 863.34/ha. Similarly, the average cost of fertilizer by the rice farmers in the study area was ₦29, 449.07/ha. UDP technology users had a lower average cost of ₦21, 252.31/ha, on fertilizer while the non-users incurred ₦37, 645.83/ha on fertilizer. The lower cost of seeds and fertilizer by the users of UDP technology might be a result of their adherence to training instructions received.

Average labour cost of rice farmers, in the study area

**Table 3.** Analysis of profitability of rice production by the rice/paddy farmers.

| Variable | Value (N/ha) | | |
|---|---|---|---|
| | User | Non- User | Pooled |
| Cost of Seeds | 10,355.55 | 11,863.34 | 11,109.44 |
| Cost of fertilizer | 21,252.31 | 37,645.83 | 29,449.07 |
| Cost of labour | 88,710.69 | 80,414.70 | 84,562.69 |
| Cost of herbicides | 6,074.60 | 7,572.90 | 6,823.75 |
| Cost of pesticides | 3,404.41 | 5,211.33 | 4,307.87 |
| Cost of packaging | 5,833.48 | 4,322.83 | 5,078.16 |
| Cost of transportation | 7,265.50 | 6,791.54 | 7,028.52 |
| Gross value of output (A) | 437,280.51 | 353,048.78 | 395,164.65 |
| Total variable cost (B) | 142,896.54 | 153,822.48 | 148,359.51 |
| Gross margin (C = A – B) | 294,383.97 | 199,226.30 | 246,805.14 |
| Operating ratio (B/A) | 0.33 | 0.57 | 0.45 |
| Return on capital invested (C/B) | 2.06 | 1.30 | 1.68 |

Source: Field survey (2014).

was ₦84, 562.70/ha. Users of UDP technology had a higher average labour cost of ₦88,710.69/ha, while the non-users had a lower average labour cost of ₦80, 414.70/ha. The average cost of labour gulped 57% of the total variable cost in the study area. Users of UDP technology spent 62.1% of their variable cost on labour. The operating ratio for the users of UDP technology was 0.33 while that of the non-users was 0.56. The users of UDP technology thus spent 33% of their gross income as running expenses while the non-users spent 56% of their gross income as running expenses.

The gross margin of UPD users was ₦294,383.97 per hectare while that of non-users was ₦199,226.30. The return on capital invested by the users of UDP technology was 2.06 and that of non-users 1.30. For every ₦1 invested by the users of UDP technology, they earned ₦2.06 while for every ₦1 invested by the non-users they earned ₦1.30. These results indicated that rice production by the users of UDP technology is more profitable than by non-users (Table 3).

### The linear regression latent class model

The coefficient of multiple determination ($R^2$) of the regression equation using Cobb Douglas production function for all the respondents is 0.75 which indicates that the estimated equation explained about 75% of the variability in the farmers' rice output (Table 4).

The F statistic used to test the overall significance of the equation was significant at 5%. Four of the included variables: rice seed in kilogrammes, fertilizer input in kilogrammes, herbicides in litres and the status of the rice farmers were the significant variables explaining the variability in rice output. The coefficients of the estimated prior probabilities for two class membership are significant at ($P \leq 0.005$). Three of the estimated regression coefficients are significant in the first class while all the six regression coefficients are significant in the second class. These suggest that the variables in the class probabilities do provide useful information on the farming practices in the two categories. The two classes do not possess the same production function.

In the first class where the UDP technology might not have been adopted, three input variables fertilizer, herbicides and the farmers' status were significant at less than 5% level. All the included variables were significant at less than 5% in the class two membership model. The result of the latent Class 2 model result revealed that a 1% decrease in farm size, other things being equal, will bring about 0.26% increase in rice output. A 1% increase in seed input will lead to 0.71% increase in output and a 1% increase in fertilizer input will bring about less than 0.01% in rice output. This is expected, since average fertilizer input by the UDP technology users was within the recommended level. Increase in herbicide usage would also lead to increase in rice output. The labour input by the UDP users was, however, confirmed here to be on the high side; since a 1% reduction in labour input will lead to 0.02% increase in rice output. The labour usage by the UDP users was significantly higher than those of the non-users. The sum of the coefficients of 0.97 revealed that the production is in decreasing returns to scale region but very close to the constant returns to scale region. The Stochastic production function could not be estimated because of the non-concavity of the production function, the inefficiency component was found to be zero.

## CONCLUSION AND RECOMMENDATION

(i) Labour input was a major input accompanying the use of UDP in rice production, therefore labour-saving

**Table 4.** Ordinary least squares latent classes regression model results.

| Variable | Coefficient | Standard Error | P[\|Z\|>z] |
|---|---|---|---|
| Constant | 5.22755773 | 0.17946238 | 0.0000 |
| $\ln X_1$ | -0.07551381 | 0.08156509 | 0.3545 |
| $\ln X_2$ | 0.10366573 | 0.04162012 | 0.0127 |
| $\ln X_3$ | 0.19277184 | 0.04002906 | 0.0000 |
| lnX4 | 0.65697648 | 0.06986440 | 0.0000 |
| lnX5 | 0.01179668 | 0.03272956 | 0.7185 |
| X6 | 0.27442412 | 0.04602141 | 0.0000 |
| **Model parameters for latent class 1** | | | |
| Constant | 5.44710007 | 0.21853332 | 0.0000 |
| $\ln X_1$ | -0.03384222 | 0.10119841 | 0.7381 |
| $\ln X_2$ | 0.06008703 | 0.04554517 | 0.1871 |
| $\ln X_3$ | 0.19571399 | 0.04115200 | 0.0000 |
| $\ln X_4$ | 0.63630252 | 0.06155163 | 0.0000 |
| $\ln X_5$ | 0.01785259 | 0.03857768 | 0.6435 |
| $X_6$ | 0.18422700 | 0.05221578 | 0.0004 |
| Sigma | 0.34052971 | 0.01457791 | 0.0000 |
| **Model parameters for latent class 2** | | | |
| Constant | 3.53460704 | 0.01504201 | 0.0000 |
| $\ln X_1$ | -0.26525217 | 0.00630014 | 0.0000 |
| $\ln X_2$ | 0.71225698 | 0.00519384 | 0.0000 |
| $\ln X_3$ | 0.09916237 | 0 .00261628 | 0.0000 |
| $\ln X_4$ | 0.45977399 | 0.00506095 | 0.0000 |
| $\ln X_5$ | -0.02616210 | 0.00203731 | 0.0000 |
| $X_6$ | 0.67070991 | 0.00256876 | 0.0000 |
| Sigma | 0.00672651 | 0.00095736 | 0.0000 |
| **Estimated prior probabilities for class membership** | | | |
| Class1Pr | 0.82394672 | 0.02415422 | 0.0000 |
| Class2Pr | 0.17605328 | 0.02415422 | 0.0000 |
| R-squared | = 0.7508345 | Adjusted R-squared | = 0.7457322 |
| Model test | F[ 6, 293] | (Prob) | = 147.15 (.0000) |
| Log likelihood | = -101.7422 | Chi-sq [ 6] (Prob) | = 416.89 (.0000) |

Source: Data Analysis (2014)

technology to ease farm operations and reduce cost of production should be developed and transferred to farmers by the extension outfit. It is also worthwhile to introduce urea briquettes applicator to the users of UDP technology.

(ii) There should be improvement in the extension linkages, because contact with the extension was found to influence technical efficiency. This can be enhanced by encouraging the farmers to join cooperative organization, so that, they can easily attract extension agents to their group.

(iii) In other to improve the efficiency of non-users in the different environment, the adoption of the UDP technology is a key as the results have shown that farmers who adopted the technology were more efficient than rice farmers who did not adopt the technology in the different states.

Considering the factors which affect adoption of UDP technology by the farmers, there is need to put measures that will stimulate farmers to adopt the technology in place. Thus, financial institutions and agricultural development organization should provide credit to rice farmers at little/less interest rate. Extension services should also be overhauled among rice farmers, especially in the area of adoption of relevant technologies, such as the UDP. Measures that will improve the educational status of household heads should also be implemented by agricultural development agencies. Such measures may include; training rice farmers on the technology and its benefits to rice production. These measures will make rice farmers adopt the use of UDP technology so as to raise productivity.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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