

## **ECONOMIC EFFICIENCY OF RICE MILLING INDUSTRY AMONG VALUE CHAIN PROCESSORS IN NORTH WEST OF NIGERIA.**

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### **ABSTRACT**

*This study evaluated economic efficiency (EE) of the rice milling industry among value chain processors in North West of Nigeria. A purposive sampling technique was employed. A total sample size of 80 rice processors was selected. About 41 (51.25%) of rice processors were from Kano State, while 39 (48.75%) of rice processors were from Kaduna State. Primary data were obtained using a well-designed and a well-structured questionnaire. Data were analyzed using descriptive statistics, gross margin analysis, financial analysis, stochastic frontier efficiency model, Tobit dichotomous regression model, and principal component analysis. The results showed that the mean age of rice millers was 46 years. Averagely, about 289,906 Kg of rice paddy were purchased by the rice millers and 217, 216 Kg (75% of paddy rice purchased) of milled rice were processed per annum. Rice processing was profitable in the area with a net income of 13,*

522, 068 Naira per annum. The mean allocative, economic and technical efficiency scores of rice millers were 0.6320, 0.6220 and 0.5795, respectively. The significant socio-economic factors influencing EE of rice processing activities included: age of processor ( $P < 0.05$ ), educational level ( $P < 0.05$ ), membership of cooperatives ( $P < 0.05$ ), access to credit facilities ( $P < 0.05$ ), and experience in processing ( $P < 0.05$ ). The major constraints faced by rice millers included: lack of credit, high cost of processing equipment, lack of storage facilities, bad road infrastructures, high cost of inputs, poor price information, lack of training, and lack of extension services. The study recommends that rice paddy production should be improved through research and extension, and improved seeds variety, fertilizers inputs, chemical inputs and credit facilities should be adequately provided to the farmers.

**Keywords:** Economic Efficiency, Rice Processors, Value Chain, North West, Nigeria.

## INTRODUCTION

Rice (*Oryza sativa*) is an important and staple food crop in Nigeria, majority of Nigerians rely on rice for their daily diet. Rice milling or processing is an essential and significant part of Nigeria's agricultural sector. Rice processing or milling has become an important agro-processing sector employing thousands of millers, traders, and parboilers as demand for rice has grown over the years (Johnson and Masias, 2016). Nigeria consume 7 million tonnes of milled rice as against 2.5 million tonnes of milled rice produced by farmers (which equals to 4 million tonnes of paddy produces by farmers) in 2017, leaving a huge supply gap (Foyeku, 2017). About 4.4 million tonnes of paddy and 2.8 million tonnes of milled rice (100Kg of paddy rice equals 63Kg of milled rice) was produced in Nigeria with an estimated national consumption of about 6 million tonnes of milled rice leaving a gap of about 3.2 million tonnes in 2013 (GAIN Report, 2014). In 2022, not all 8 million metric tonnes of milled rice consumed was produced in Nigeria, the quantity of milled rice produces in 2022 was estimated at 5.4 million metric tonnes (Danbaba, 2023). In 2008, about 2 million metric tonnes of milled rice was produced in Nigeria (USAID, 2009). Rice processing can reduce post-harvest losses and add value to the grain. Rice processing promotes local consumption and production. Rice milling or processing is a combination of activities or operation that turn paddy into high quality white rice, the operation is highly dependent on the management capabilities of the processors (Obianefo et al., 2023). Rice milling will help reduce poverty, has the potentials to create jobs, and can generate additional income, and improve overall standard of living for

farmers. Rice milling improve processors livelihood and promote Nigeria's economic stability. About 95% of rice processors are smallscale and they use low capacity and outdated mills and this result to poor quality of rice than imported rice, however, there is still an overall acknowledgement of higher organoleptic properties of local rice (Olaniyi, 2011; Bamidele et al., 2010; Lancon et al., 2003). Johnson and Ajibola (2016) reported that the average paddy production costs, including rice processing and marketing costs in Nigeria tends to be higher than those in Thailand. The higher milling costs in Nigeria were primarily due to the high costs of procuring paddy which involve high search cost and a premium for the scarce superior paddy varieties sought by large mill operators. The trade and marketing costs also are high because of the distance to urban markets throughout the country. The poor performance of the entire Nigerian rice value chain compared to that of Asian countries leaves significant room for improvement. Actors in the rice value chain have different skills and degree of access to improved technology, information, services, and thereby rarely upgrade to better paddy varieties and processing technology. The final milled rice from processors is therefore broken, discolored, contains foreign debris and stones, the consumers view the rice as inferior and non-substitutable with the higher quality premium rice obtained from modern mills. Small-scale rice milling operators serve a large number of people including rural traders, paddy farmers, retailers, wholesalers, final consumers and supply almost 70% of the domestic rice consumed in Nigeria. The small-scale processors make up the most significant sub-sector of the domestic rice milling industry in Nigeria. The various activities involved in rice processing from paddy stage include: cleaning, hulling, milling, polishing, grading, sorting, and packaging (Ibitoye et al., 2014). Agricultural productivity is determined by crop yield, marketing and efficiency of post-harvest processing (Sakurai et al., 2006). The processing efficiency of rice millers is very important for decision makers and has policy implications towards rice value addition. Rice processing form the major part of rice value chain has been identified as one of the ways of preventing post-harvest losses (Appaiah et al., 2011). Efficiency can be defined as the possibility of firms producing a certain level of output at minimum cost or a certain optimum level of product from a given bundle of inputs. Efficiency is a significant factor that can raise productivity growth, without developing a new technology or increasing the resource base (Adeyemi et al., 2017). A technical efficient firm is the one that produces the maximum output for a given amount of inputs given the level of production technology available. Allocative efficiency produces the optimal mix of outputs using the optimal amount of inputs given the production technology and the prices it faces. Economic efficiency is achieved when both allocative and technical efficiencies

have been attained. Economic efficiency is the product of technical and allocative efficiencies.

## METHODOLOGY

This research study was conducted in Kano and Kaduna States, North West of Nigeria. Kaduna State occupies between Longitudes  $06^{\circ} 15'$  and  $08^{\circ} 50'$  East and Latitudes  $09^{\circ} 02'$  and  $09^{\circ} 02'$  North of the equator. The State has a total land area of 4.5 million hectares. The state vegetation is divided into 2, the Southern guinea savanna and the Northern guinea savanna. There are 2 seasons, they are: the wet and the dry seasons, the dry season is between October to March, and the wet season starts from April to October and in between the wet and dry seasons is the brief harmattan period which span from November to February. The mean rainfall is about 1,482mm, the temperature of the State ranges from  $35^{\circ}\text{C}$  -  $36^{\circ}\text{C}$ , which can be as low as  $10^{\circ}\text{C}$  to  $23^{\circ}\text{C}$  during the harmattan period. The population of the State in 2021 stood at 8.9 million people. They are involved in farming. Crops grown include: okra, maize, pepper, rice, sorghum, ginger, millet, yam, tomatoes and cassava. Animal reared include: sheep, cattle, rabbit, goats, and poultry. Purposive method of sampling was used. About 80 rice processors were selected. Data obtained from rice processors were of primary sources and were collected using a well-structured and also a well-designed questionnaire. The questionnaire was administered to rice processors using well trained enumerators.

Kano State occupies between Longitudes  $08^{\circ} 35'$   $31''$  East and Latitudes  $12^{\circ} 0'$   $8''$  North of the equator. The state is bordered by the states of Jigawa to the North and East Bauchi to the South-East, Kaduna to the South-West, and Katsina to the North-West. The total area of the state is 20, 280 Sq Km, with an annual temperature of  $26^{\circ}\text{C}$  -  $30^{\circ}\text{C}$ . Kano is very hot for most of the year peaking in April with  $39.1^{\circ}\text{C}$ , from December through February, the city is less hot, with morning temperatures during the months of December, January, February averaging  $14^{\circ}\text{C}$  -  $16^{\circ}\text{C}$ . Kano has an average of about 109.0 mm of rainfall per year. Kano is a tropical savanna climate, which consists of wooden savanna in the South, and scrub vegetation in the North. The population of Kano is about 13,852,238 in 2018 and 14, 253,549 as at 2019. They are involved in farming. Crops grown include: groundnut, millet, tomatoes, cowpeas, sorghum, maize, rice and cotton. Animal reared include: goats, cattle, sheep, rabbit, and poultry.

### Research Design

A descriptive and cross-sectional research design was employed with the aim of describing the socio-economic characteristics of rice processors, and to evaluate

factors influencing economic efficiency (EE) of rice processing activities among value chain processors.

**Sampling Techniques and Sample Size**

A purposive sampling technique was adopted. A reconnaissance survey was conducted to identify the rice milling enterprises in Kaduna and Kano States, Nigeria. A total sample size of 80 rice processors comprising of 41 (51.25%) smallscale rice processors from Kano State, and 39 (48.75%) smallscale rice processors from Kaduna State) was identified and they were purposively selected for this study.

**Methods of Data Collection**

Primary data were used for this research study. The data were collected through the use of a well-designed and well-structured questionnaire. The questionnaire was administered to rice processors through well-trained enumerators. Data were analyzed through the use of descriptive and inferential statistics:

**Descriptive Statistics:** This involves the use of mean, frequency distributions, and percentages, to present the summary statistics of the rice processors and the rice milling enterprises. This was to achieve specific objectives 1 (i) and 2 (ii).

**Gross Margin Analysis:** Gross margin (GM) and net farm income analysis of rice milling enterprises was estimated using the following models:

$$GM = TR - TVC \dots \dots \dots (1)$$

$$NFI = TR - TC \dots \dots \dots (2)$$

Where

*TR* = Total Revenue obtained from Rice Milling Activities (₦),

*GM* = Gross Margin (Naira)

*TVC* = Total Variable Cost (₦),

*NFI* = Net Farm Income (Naira)

The gross margin analysis was used to specifically achieve objective 3 (iii).

**Financial Analysis:** According to Alabi et al. (2020), gross margin ratio (GMR) is defined as:

$$GMR = \frac{Gross\ Margin}{Total\ Revenue} \dots \dots \dots (3)$$

According to Olukosi and Erhabor (2015), operating ratio (OR) is defined as:

$$OR = \frac{TVC}{GI} \dots \dots \dots (4)$$

Where,

*TVC* = Total Variable Cost (Naira),

*GI* = Gross Income (Naira),

The rate of return per naira invested (RORI) in rice processing is defined as:

$$RORI = \frac{NI}{TC} \dots \dots \dots (5)$$

Where,

$RORI$  = Rate of Return per Naira Invested (Unit),

$NI$  = Net Income (Naira),

$TC$  = Total Cost (Naira).

The financial analysis was used to analyze the profitability of rice processing as stated specifically in objective 3 (iii).

**Stochastic Production Efficiency Frontier Model**

According to Alabi et al. (2022), the stochastic production frontier model is stated thus:

$$Y_i = f(X_i, \beta_i)e^{v_i-u_i} \dots \dots \dots (6)$$

where,

$Y_i$  = Output of Rice Processing Facilities (Kg)

$X_i$  = Vectors of Factor Inputs

$\beta_i$  = Vectors of Parameters

$V_i$  = Random Variations in Rice Milling Output

$U_i$  = Error Term due to Technical Inefficiency

The stochastic frontier model, according to Obianefo et al. (2023) is defined as:

$$LnY_i = \sum_{j=1}^6 \beta_j LnX_{ji} + (V_i - U_i) \dots \dots \dots (7)$$

$Ln$  = Natural Log

$Y_i$  = Milled Rice Produced (Kg)

$X_1$  = Paddy Rice (Kg)

$X_2$  = Labour Input (Manhour)

$X_3$  = Diesel (Litres)

$X_4$  = Water for Parboiling (Litres)

$X_5$  = Amount Spent on Firewood (Naira)

$X_6$  = Depreciation of Assets (Naira)

$V_i$  = Random Noise

$U_i$  = Error due to Inefficiency

$$U_i \sim N^+(V_j(Z_j)) \dots \dots \dots (8)$$

They are individual variables which include: age (years), level of education (years), processing experience (years), and household size (numbers)

This was used to achieve specifically objective 4 (iv).

**Economic Efficiency (EE)**

Economic efficiency was derived from the product of TE and AE for individual rice processors. The EE of rice processing activities among processors is therefore specified as:

$$EE_i = TE_i \times AE_i \dots \dots \dots (9)$$

Where,

$EE_i$  = Economic Efficiency (Number)

$TE_i$  = Technical Efficiency (Number)

$AE_i$  = Allocative Efficiency (Number)

This was used to achieve specifically objectives 4(iv) which is to determine the AE, TE, and EE scores of rice processors, and 5 (v) which is to evaluate socio-economic factors influencing EE of rice processing activities.

**Tobit Dichotomous Regression Model:** The dichotomous Tobit response model following Gujarati (2004) is defined as follows:

$$Y_i^* = X_i\beta + \varepsilon_i$$

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon_i \dots (10)$$

$$Y_i = \begin{cases} 1 & \text{if } Y_i^* \geq 1 \\ Y_i^* & \text{if } 0 < Y_i^* < 1 \\ 0 & \text{if } Y_i^* \leq 0 \end{cases}$$

$Y_i^*$  = Latent or Unobserved Variable

$Y_i$  = Efficiency Score Representing EE (Number)

$X_1$  = Age of Processors (Years)

$X_2$  = Sex of Processors (1, Male; 0, Otherwise)

$X_3$  = Marital Status (1, Married; 0, Otherwise)

$X_4$  = Household Size (Number)

$X_5$  = Educational Level (Years)

$X_6$  = Membership of Cooperative Society (1, Member; 0, Otherwise)

$X_7$  = Access to Credit Facilities (1, Access; 0, Otherwise)

$X_8$  = Experience in Processing (Years)

$\varepsilon_i$  = Disturbance Term,

$\beta_1 - \beta_8$  = Regression Coefficients,

$\beta_0$  = Constant Term,

This was used to achieve specifically objective 5 (v) which is to evaluate socio-economic factors influencing economic efficiency of rice processing activities.

**Principal Component Analysis:** The constraints facing rice processors and militating against rice milling activities were subjected to principal component analysis. This was used to achieve specifically objective 6 (vi).

## RESULTS AND DISCUSSION

### Summary Statistics of Rice Millers, Rice Milling Capacity, and Processing Activities

Table 1 presented the summary of data of rice millers and processing activities in Kano and Kaduna States, North West, Nigeria. The average rice paddy supplied to the milling machine was 289, 906.0 Kg, after milling activities that helped to convert the grain to milled rice, an average output of 217, 216 Kg milled rice was recorded. This shows that 25.07% of the initial paddy weight was lost along the rice value chain. This is in line with Obianefo et al. (2023) who reported that 25% of the initial paddy weight was lost along the rice value chain. The result is also in consonance with Sadiya and Hassan (2018) who reported that 21% of rice is lost at the processing stage. The mean age of rice processors was 46 years, this shows that they are in their active and productive age, age of rice processors had an impact on the managerial capability of the rice millers. This is consistent with the results of Adeyemi et al. (2017) who reported the mean age of 48 years among rice millers in southwest Nigeria. The mean household size of rice millers was 9 members. This is in consonance with findings of Ugwanyi et al. (2008) who reported an average household size of 6 members for rice millers in Enugu State, Nigeria. This is also in line with findings of Ojumu and Adeyelu (2014) who reported an average household size of 6 members for rice millers in Cross River State, Nigeria. The mean processing experience of rice millers was 12 years', this mean they could have acquired the good experience required in paddy rice processing. This is similar to findings of Adeyemi et al. (2017) who obtained the mean experience of 15 years for rice millers in Southwest, Nigeria. Education is an important socio-economic factor that influence rice millers' decision because of its influence on rice processors perception, awareness, adoption and reception of innovations the can bring about increase in profit margin. Averagely, rice processors spent 13 years in formal learning institutions, this means they are literate and can read and write.

This is consistent with the results of Bime et al. (2014) who reported that 58% of rice processors had primary education. About 88% of rice processors were male, this is in consistent with the findings of Ugwanyi et al. (2008) who reported that male dominated the rice processing activities due to the physical labour required in handling the milling activities. The milled rice activities and trade involves travelling from villages to villages in search of paddy rice, bagging, measurements, loading, and parboiling which are too cumbersome for females.

About 8% of rice processors had access to credit facilities, and the average land owned by rice millers was 1.52 hectares.

**Table 1. Summary statistics of rice processors and processing activities**

| S/N | Variables                     | S.I. Units      | Mean      | SD        |
|-----|-------------------------------|-----------------|-----------|-----------|
| 1   | Average Output of Milled Rice | Kg              | 217,216.0 | 616,213.1 |
| 2   | Average Rice Paddy            | Kg              | 289,906.0 | 757,113.4 |
| 3   | Age                           | Years           | 46        | 10.30     |
| 4   | Household Size                | Number          | 9         | 3.70      |
| 5   | Processing Experience         | Years           | 12        | 5.90      |
| 6   | Level of Education            | Years           | 13        | 6.21      |
| 7   | Sex                           | Dummy(1=Male)   | 0.88      | 0.32      |
| 8   | Access to Credit Facilities   | Dummy(1=Access) | 0.08      | 0.27      |
| 9   | Total Land Own                | Ha              | 1.52      | 1.27      |

Source: Field Survey (2022) SD-Standard Deviation

### **Analysis of Average Costs and Returns of Rice Milling per Annum**

The cost and return analysis of rice processing activities was presented in Table 2. The cost incurred and revenue obtained was based on the prevailing prices as at the time of this survey. The revenue obtained and TC of milling 217, 216 Kg of paddy rice per annum was 139, 018, 240 Naira and 125, 496, 172 Naira respectively. This was due to the fact that most rice mills operate on different levels. The analysis of the cost structure revealed that rice paddy cost account for 97.02% of the TC, this implies that rice paddy supply is low hence the high cost of purchase. This is followed by energy cost (Diesel) which accounted for 0.78%, milling machine which accounted for 0.684%, and labour which accounted for 0.44% of the total cost respectively. This result is similar to the findings of Adeyemi et al. (2017) who reported that rice paddy cost accounts for about 88%, energy accounts for 8.5%, transport accounts for 3.2% and labour accounts for 1.6% of the TC among rice millers in Southwest, Nigeria. The TVC (124, 261, 238 Naira) and TFC (1, 234, 914 Naira) accounted for 99.01% and 0.99% of the TC respectively. The FC consists of milling machine, depreciation of assets, and electricity bills/taxes. The GM and net income of rice processing per annum was 14, 757,002 Naira and 13, 522, 068 Naira respectively. This shows that rice processing was profitable in the area. The GMR and rate of return on investment was 0.106 and 0.107 respectively. The rate of return of 0.11 implies that for every one Naira invested in rice paddy processing, 11 kobo was realized. This result is in line with Ojumu and Adeyelu (2014) who reported an average rate of return of

0.35 for locally milled rice at micro scale in Ogoja local Government Area of Cross River State, Nigeria.

**Table 2. Average Costs and Returns Analysis of Rice Milling per Annum**

| <b>Variables</b>                     | <b>Naira</b> | <b>Percentage</b> |
|--------------------------------------|--------------|-------------------|
| Milled Rice ₦ per Kg                 | 640          |                   |
| Revenue (@ 217,216.0Kg)              | 139,018,240  |                   |
| Gross Income                         | 168,211,135  |                   |
| <b>Variable Cost</b>                 |              |                   |
| Paddy Rice (420 ₦/Kg @ 289,906.0 Kg) | 121,760,520  | 97.02             |
| Firewood                             | 141,225      | 0.11              |
| Water                                | 25,005       | 0.01              |
| Parboiling/Drying                    | 22,750       | 0.02              |
| Hulling                              | 247, 120     | 0.196             |
| Milling                              | 256, 565     | 0.20              |
| Grading                              | 27,247       | 0.02              |
| Sorting                              | 23,984       | 0.02              |
| Parking                              | 17,892       | 0.014             |
| Labour                               | 555,790      | 0.44              |
| Loading and Offloading               | 22, 400      | 0.02              |
| Transportation                       | 140,750      | 0.11              |
| Bagging                              | 16, 570      | 0.01              |
| Sewing                               | 11, 270      | 0.008             |
| Cost of Bags, Needle, Thread         | 12,670       | 0.01              |
| Diesel                               | 979,500      | 0.78              |
| <b>Total Variable Cost (TVC)</b>     | 124,261, 238 | 99.01             |
| <b>Fixed Cost (FC)</b>               |              |                   |
| Milling Machine and other Assets     | 859,250      | 0.684             |
| Depreciation of Mills                | 26,751       | 0.02              |
| Electricity Bill/Taxes               | 221, 370     | 0.176             |
| Deprecation of other Assets          | 127, 543     | 0.10              |
| <b>Total Fixed Cost (TFC)</b>        | 1,234,914    | 0.99              |
| <b>Total Cost (TC)</b>               | 125, 496,172 |                   |
| <b>Gross Margin (GM)</b>             | 14,757,002   |                   |
| <b>Net Income (NI)</b>               | 13,522,068   |                   |
| <b>Rate of Return on Investment</b>  | 0.107        |                   |
| <b>Operating Ratio (OR)</b>          | 0.738        |                   |
| <b>Gross Margin Ratio(GMR)</b>       | 0.106        |                   |

Source: Field Survey (2022) 1 USD = 710 Naira

The summary statistics of AE, EE and TE scores of rice processors are presented in Table 3. It was observed that there are variations among the rice miller's allocative, economic and technical efficiencies. All the rice processors were

technically, allocatively, and economically inefficient in the processing of rice paddy. This means that their levels of efficiency were less than 100%. The highest frequencies of occurrences of the AE, EE, and TE were between 0.61 (61 percent) and 0.80 (80 percent). This represent 36.25%, 46.25% and 26.25% of the AE, EE and TE scores for the sampled rice millers respectively. The mean AE, EE, and TE of the rice millers based on their milling capacities were 0.6320 (standard deviation=0.2022) ,0.6220 (standard deviation=0.2132) and 0.5795 (standard deviation = 0.2561), respectively.

**The Allocative (AE), Economic(EE) and Technical Efficiency(TE) Scores of Rice Millers**

These results showed that processors can increase their rice paddy processing by 42.05%. It also shows that they can reduce their cost of processing by 37.80% to achieve the potential minimum cost of processing relative to the efficient processors given the current output level.

The mean TE score of 0.5795 (maximum = 0.951) for the rice millers implies that they are operating at 42.05% below their optimal capacity (full capacity). The results imply that there are opportunities for processors in the industry to increase their milling capacities by engaging in activities such as entrepreneurship training, and participate in capacity program to improve their managerial skills. This result is in consistent with the findings of Obianefo et al. (2023) who recorded TE of 0.506 for smallscale rice processors in Anambra State, Nigeria.

**Table 3. Summary statistics of technical, economic and allocative efficiency scores**

| Efficiency Score     | Allocative efficiency |       | Economic Efficiency |       | Technical Efficiency |       |
|----------------------|-----------------------|-------|---------------------|-------|----------------------|-------|
|                      | Frequency             | %     | Frequency           | %     | Frequency            | %     |
| 0.00 – 0.20          | 02                    | 02.50 | 03                  | 3.75  | 07                   | 08.75 |
| 0.21 – 0.40          | 08                    | 10.00 | 12                  | 15.00 | 15                   | 18.75 |
| 0.41 – 0.60          | 24                    | 30.00 | 14                  | 17.50 | 18                   | 22.50 |
| 0.61 – 0.80          | 29                    | 36.25 | 37                  | 46.25 | 21                   | 26.25 |
| 0.81 – 1.00          | 17                    | 21.25 | 14                  | 17.50 | 19                   | 23.75 |
| <b>Mean</b>          | 0.6320                |       | 0.6220              |       | 0.5795               |       |
| <b>St. Deviation</b> | 0.2022                |       | 0.2132              |       | 0.2561               |       |
| <b>Minimum</b>       | 0.161                 |       | 0.157               |       | 0.126                |       |
| <b>Maximum</b>       | 0.927                 |       | 0.873               |       | 0.951                |       |

Source: Field Survey (2022)

### **Socio-Economic Factors Influencing Economic Efficiency (EE) among Rice Millers**

Table 4 presents the Tobit dichotomous regression model used to analyze the socio-economic factors influencing EE of rice processing activities among rice millers. Economic efficiency measures which is the product of technical efficiency (TE) and allocative efficiency (AE) are regressed on age of processors, dummy variable for sex of the processors (male = 1, and 0 if otherwise), dummy variable for marital status (married = 1, and 0 if otherwise), household size, educational level, dummy variable for membership of cooperative (membership = 1, and 0 if otherwise), dummy variable for access to credit (access = 1, and 0 if otherwise), and experience in paddy processing. The result of the model shows that four (4) out of the eight (8) variables were found to have a significant influence on the EE of rice millers. These variables included age of processors, educational level, membership of cooperatives, access to credit facilities, and experience in paddy processing. The coefficient of age of processors was negative (-0.00106) and significant at ( $P < 0.05$ ), this implies that older processors are less economically efficient than younger processors who are more receptive to technological changes in processing that influence efficiency. As rice processors advanced in age, the probability of rice millers being economic efficient decreases by 37.16%. The coefficient associated with the educational level was positive (0.00287) and significant at ( $P < 0.05$ ). This signifies that the level of education of processors contributes to the reduction in inefficiency in paddy rice processing. As education increase by one year, the probability of rice processors being economic efficient increase by 16.23%. Similar results were obtained in the works of Degefa et al. (2020), Tesema (2021) and Moges (2018). The coefficient of membership of cooperatives was positive (0.00348) and significant at ( $P < 0.05$ ). Membership of cooperatives enables the rice processors have access to credit facilities, purchase their inputs in bulk and also jointly sell their products at affordable prices. As rice processors become member of cooperative group, the probability of being economic efficient increase by 8.78%. The result also indicated that access to credit facilities had a positive sign (0.05924) and statistically significant effect on EE level at 5% level of significance. This also indicated that rice processors who use credit facilities tend to unveil higher levels of efficiency. A change in the dummy variable representing the uses of credit facilities by the rice processors from 0 to 1 would increase the probability of the rice processors being economically efficient by about 27.67%. A significant positive influence was also reported by Awudu and Wallace (2016), Assefa et al. (2019), and Tesema (2021). The coefficient of experience in rice processing was positive (0.00272) and significant at 5% level of significance. An increase in

experience in rice processing will lead to probability of the rice processors being economic efficient by 6.58%. The Tobit dichotomous regression model carried out and evaluate socio-economic factors influencing EE of rice processing activities in North West of Nigeria was significant at one percent (1%) level of significant ( $P = 0.000$ ). The Pseudo- $R^2$  obtained is equal to 0. 6471. This result signifies that the variables included in the regression model explained the EE of rice processing activities in the study area at 64.71%.

**Table 4. Maximum likelihood results of the tobit dichotomous regression model**

| Variables                    | Parameters | Coefficient | Standard Error | t-Value | ME     |
|------------------------------|------------|-------------|----------------|---------|--------|
| Constant                     | $\beta_0$  | 1.2302      | 0.5419         | 2.27    | 0.0548 |
| Age of Processors            | $\beta_1$  | -0.00106**  | 0.00047        | -2.25   | 0.3716 |
| Sex of Processors            | $\beta_2$  | 0.03205     | 0.03724        | 0.860   | 0.2619 |
| Marital Status               | $\beta_3$  | 0.00407     | 0.00538        | 1.322   | 0.4131 |
| Household Size               | $\beta_4$  | 0.00807     | 0.00967        | 0.845   | 0.0176 |
| Educational Level            | $\beta_5$  | 0.00287**   | 0.00786        | 2.74    | 0.1623 |
| Membership of Cooperatives   | $\beta_6$  | 0.00348**   | 0.00866        | 2.49    | 0.0878 |
| Access to Credit Facilities  | $\beta_7$  | 0.05924**   | 0.02743        | 2.15    | 0.2767 |
| Experience in Processing     | $\beta_8$  | 0.00272**   | 0.00097        | 2.80    | 0.0658 |
| <b>Diagnostic Statistics</b> |            |             |                |         |        |
| Sigma                        | 0.09724    |             |                |         |        |
| LR Chi <sup>2</sup> (8)      | 82.85***   |             |                |         |        |
| Pseudo R <sup>2</sup>        | 0.6471     |             |                |         |        |
| Log Likelihood               | 57.2512    |             |                |         |        |
| Prob > Chi <sup>2</sup>      | 0.00000*** |             |                |         |        |

Source: Data Analysis (2022), ME=Marginal Effect

\*Significant at ( $P < 0.10$ )., \*\*Significant at ( $P < 0.05$ ), \*\*\*Significant at ( $P < 0.01$ ).

This implies that the model has good explanatory power on the changes in socio-economic factors influencing EE of rice processing activities among the respondents with 99% level of confidence. The Likelihood ratio obtained is relatively high. This shows that considering the variables included in the model rice processing has 82.85% chance of being economically efficient in the study area.

#### Constraints Faced by Rice Processors in the Study Area

The constraints facing rice processors were subjected to principal component analysis (Table 5). The constraints with Eigen-values greater than one were retained by the model. Those constraints with Eigen-values less than one were

discarded by the model. Lack of credit facilities with Eigen-value of 2.5740 was ranked 1<sup>st</sup> based on the perceptions of the rice processors. This explained 10.37% of all the constraints retained by the model. High cost of processing equipment's with Eigen-value of 2.2567 was ranked 2<sup>nd</sup> based on the perceptions of the rice processors and this explained 10.42% of all the constrained retained by the model. Lack of storage facilities with Eigen value of 2.0176 was ranked 3<sup>rd</sup> based on the perceptions of the rice processors and this explained 10.67% of all constraints retained by the model. This result is in consonance with the findings of Alabi and Anekwe (2023), Alabi and Chiogor (2023). All constraints retained by the principal component model explained 81.43% of all constrained included in the model. These challenges are in agreement with issues raised by Sennuga et al. (2021) who reported that rice processors in developing countries lack access to reliable market information, additionally, poor road network makes it difficult for processors to transport their products to access wider market option and that the smallscale processors lack the needed knowledge and skills necessary to maximize their production process. These findings are consistent with the study of Akinnira and Faleye (2020) who express concerns about poor access to storage facilities which leads to spoilage and pest infestations, and inadequate finance which will limit the processors ability to take advantage of new market opportunities.

**Table 5. Principal component analysis of constraints encountered by rice processors**

| Constraints                        | Eigen-Value | Difference | Proportion | Cumulative | Rank            |
|------------------------------------|-------------|------------|------------|------------|-----------------|
| Lack of Credit Facilities          | 2.5740      | 0.3173     | 0.1037     | 0.1037     | 1 <sup>st</sup> |
| High Cost of Processing Equipment  | 2.2567      | 0.2391     | 0.1042     | 0.2079     | 2 <sup>nd</sup> |
| Lack of Storage Facilities         | 2.0176      | 0.1231     | 0.1067     | 0.3146     | 3 <sup>rd</sup> |
| Bad Road Infrastructures           | 1.8945      | 0.1989     | 0.1178     | 0.4324     | 4 <sup>th</sup> |
| High Cost of Input                 | 1.6956      | 0.1324     | 0.1074     | 0.5398     | 5 <sup>th</sup> |
| Poor Price Information             | 1.5632      | 0.1035     | 0.1302     | 0.6700     | 6 <sup>th</sup> |
| Inadequate Capacity Building       | 1.4597      | 0.3318     | 0.0967     | 0.7667     | 7 <sup>th</sup> |
| Lack of Extension Services         | 1.1279      | 0.1292     | 0.0476     | 0.8143     | 8 <sup>th</sup> |
| <b>Bartlett Test of Sphericity</b> |             |            |            |            |                 |
| Chi Square                         | 204.26      |            |            |            |                 |
| KMO                                | 0.7601      |            |            |            |                 |
| Rho                                | 1.0000      |            |            |            |                 |

## CONCLUSION

This study was conducted to evaluate EE of rice processing industry among rice millers in Northwest, Nigeria. To this end, information on the socio-economic characteristic of rice millers, the costs and returns data, TE, AE and EE of rice processing activities were collected. The findings have demonstrated that the rice millers were mostly male, young, energetic, resourceful and well educated. They have large household size with 9 members and had considerable experience in rice processing with 12 years processing experience. Averagely, about 289,906 Kg of rice paddy were purchased and 217, 216 Kg of milled rice were produced annually. Rice processing was profitable in the study area with an estimated net income of 13, 522, 068 Naira per annum. Based on the results obtained from the applied econometric models, socio-economic factors such as the age of processors, educational level, memberships of cooperatives, access to credit facilities, and experience in processing affects EE of rice processing activities. The mean AE, EE and TE scores of rice millers were 0.6320, 0.6220, and 0.5795 respectively. However, it was noted that the most relevant constraints faced by rice processors were lack of credit facilities, high cost of processing equipment, lack of storage facilities, bad road infrastructures, high cost of inputs, poor price information, inadequate training, and lack of extension services.

## RECOMMENDATIONS

The rice paddy production should be improved through research and extension, improved seeds variety should be provided for farmers, and farm inputs such as fertilizers and chemicals should be adequately provided for farmers.

Strategies must be developed to facilitates producers access to production inputs and adequate agricultural equipment.

Credit facilities should be provided for millers at low interest rate this will enables millers to have access to modern technologies and equipment's, rice millers would be able to increase the efficiency of their operations and ultimately increase their profits.

Storage facilities should be constructed by government to reduce rice paddy or milled rice spoilage and pest infestations.

The energy sectors should be looked into to reduce cost of diesel.

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