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Abstract

Rice mills in Uganda have increased rapidly during the past decade, presumably in response to increasing demand for milling services. Despite notable improvements in access to milling services, farmers still sell rice un-milled hence attracting lower prices. Mainly the study examined why some rice-growing households sold un-milled rice and its effect on production profitability. Data was collected in 2009, in a survey of 194 farmers. Descriptive statistics were used to characterize households and profitability estimated using gross margin analysis. Factors influencing proportions of rice sold as grain were analysed using a tobit regression. Households were categorized basing on the form in which they sold rice i.e. "un-milled", "milled" and "both". Results indicate that most households invest in milling. Averagely completely milling households had bigger landholdings than other cohorts. Completely non-milling households covered longer distances to the nearest mill. Rice production is associated with positive gross margins. Price of milled rice, volume harvested, household size, group membership and distance to nearest mill significantly influenced proportions sold as grain. Rice milling supporting extension services and low power consuming stationary and mobile mills need be observed to ensure better rice production returns to farmers.

Key words: rice milling, rice forms, proportions, tobit model, profitability, factors

1 Back ground

Rice is a staple food for more than half of the world's population. Also, one-fifth of the world's population depends on rice production for their livelihood, and there are more than 200 million rice farms world wide (IRRI, 2010). The total area under rice cultivation globally is estimated to be 150 million hectares with annual production averaging 500 million metric tons (Tsuboi, 2005). In the developing world, rice has twice the value of production compared to any other food crop, and it represents 29% of the total output of grain crops worldwide (Xu and Guofang, 2003).

In Africa, rice is becoming increasingly popular judging from the steady growth in its production, which, however, still lags behind consumption. The annual production of rice in Africa is estimated at 14 million metric tons while consumption is within the range of 16 million metric tons per annum (UNRDS, 2009). With this deficit and the rapid urbanization and population growth in Africa, it is likely that the area under rice production in African countries will continue to expand in the foreseeable future. As part of the efforts to enhance rice yield as a means to reduce the gap between supply and demand, and to curb food insecurity and income poverty in Sub Saharan Africa (SSA), New Rice for Africa (NERICA) was recently developed by the West Africa Rice Development Association (WARDA) (Africa Rice Center, 2006).

In the case of Uganda although rice production started in 1942 mainly to feed the World War II soldiers, production remained low due to various constraints. However, starting in the early 1970s the government of Uganda recognized the need to address these constraints and promote rice production, by establishing large commercial farms of paddy rice at Kibimba (Bugiri district) and smallholder farmer managed schemes at Doho (Tororo district) and Olweny (Lira district) (Kijima and Sserunkuuma, forthcoming). Since then, the acreage under rice in Uganda steadily increased, especially in the densely populated districts of Eastern Uganda, with the planted area nearly doubling from 39,000 hectares in 1990 to an estimated 72,000 hectares in 2000 (UBOS, 2002).

In 2002, NERICA was introduced in Uganda as one of the government's strategies for achieving its overarching development goals of reducing poverty and food security, as well as import substitution. The introduction of NERICA elevated Uganda to yet a new level in the history of rice production. The total area under rice increased from 80,000 hectares in 2002 to 119,000 hectares in 2007 (UBOS, 2007) and (UNRDS (2009) reports an increase in the number of rice farmers from 4,000 to over 35,000 during this period. Despite this impressive growth in production, Uganda still needs to import 60,000 metric tons of rice, as total domestic production is estimated at 165,000 metric tons, which is lower than total consumption estimated at 225,000 metric tons (UNRDS, 2009). With Uganda's population growing at a rate of 3.2% per year (UBOS, 2002), the demand for rice is expected to rise even further, which calls for sustained efforts to increase production to meet the growing demand.

Recent research shows that rice production in Uganda still faces many challenges not only in production, but also in post harvest handling and marketing. Kijima *et al.,* (2006) found that many farmers did not have enough information on how to grow, harvest and dry rice, which negatively affected the harvested yield and milling rate and thus the income realized from rice production. Despite the impressive trend in rice production in Uganda during the past decade, rice production is faced with many constraints, including limited access to markets and milling services. One of the major constraints to NERICA adoption identified by NERICA farmers in 2004 was the absence of rice millers in nearby towns to mill or buy their paddy rice (Kijima *et al.,* 2006), a typical farmer had to travel 15 to 35 km by bicycle to take rice to the nearest rice mill. However, the number of rice mills has increased rapidly presumably in response to the increasing demand for rice milling services by rice farmers. Between 2004 and 2006, access to rice mills improved significantly and this is clearly reflected in the considerably shortened distance from between 15 and 30 km to between 6 and 11 km in 2006 (Kijima *et al*., 2008) as the number of rice mills in Uganda nearly doubled during this period (see figure 1). This distance is believed to have reduced further in recent years, with increased investments in the rice milling services by the private sector.

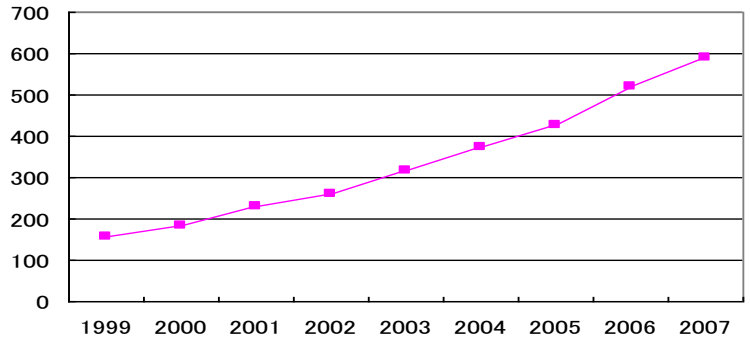

Figure 1: Total Number of Mills in Uganda
Adapted from: Alphonse et al., (2008)

Despite the notable improvements in farmers' access to milling services, some farmers still sell rice in unmilled form as paddy, which attracts a lower price than milled rice (Kijima, 2008). This study was therefore undertaken to fill the existing knowledge gap on the extent to which rice farmers' process rice before marketing and how this affects their returns (profits) from rice production. Estimating the returns from selling milled and unmilled rice is particularly informative, since the profitability of milling (or lack of it) could explain why some farmers sell milled rice and others don't despite the evidence of increased availability of rice mills presented earlier. The purpose of this study was to examine why some rice-growing households in Uganda sell milled rice and others don't, and how this affects the profitability of rice production. Specifically; a) To characterize rice-growing households by the form in which they sell rice, b) To compare the profitability of selling milled versus unmilled rice among rice-

growing households, c) To determine factors affecting the proportion of rice sold after milling. These were based on hypotheses that; i) Households which sell rice after milling receive higher profits than those selling paddy, ii) Distance to nearest rice mill negatively affects the proportion of rice sold as grain, iii) Membership to rice farmers groups is associated with a higher proportion of rice sold as grain.

The rest of the paper is organized as follows. The literature review section presents literature on rice production systems, processing, markets and marketing of rice in Uganda, factors that influence the proportion of output sold. The methodology section describes the study area, data sources, sampling design, sample size and analysis. This is followed by the results and discussion section. The paper ends with conclusions and policy recommendations.

2 Literature review

Rice is grown mainly under three systems in Uganda, namely; rain-fed upland, rain-fed lowland and irrigated (UNRDS, 2009). Of the three, rain-fed lowland is the most common system, covering 65,000 hectares of land, followed by rain-fed upland with 40,000 hectares and finally irrigated rice which covers 5,000 hectares of land. Most rice in Uganda is grown in Eastern Uganda followed by Western region due to the higher presence of lowlands and wetlands, which have sufficient soil moisture throughout the growing season (UNRDS, 2009). Smallholder farmers in Uganda supply rice to markets in two forms; unmilled (paddy) form and milled form (NPA, 2007). Unmilled rice refers to rice in the form it is harvested in the field, before the husks and bran layer are removed in the process of milling. Where as milled rice, also referred to as white rice, has the husks and bran layer removed. There are about 591 operational rice mills in Uganda (UNDRS, 2009) accessed by rice farmers, 80% of whom are smallholders.

In literature, a number of factors have been postulated to influence the proportion of output sold or the level of commercialization. Otieno *et al.*, (2009); Rios *et al.*, (2009); Omiti *et al*., (2009); Komarek (2010); Sserunkuuma *et al*., (2010) observed that household size affects family labor supply for production and post-harvest handling, as well as the level of household consumption. A larger household provides cheaper labor and produces more output in absolute terms such that the proportion sold remains higher than the proportion consumed. However, if a larger household is labor-inefficient and produces less output, it consumes a higher proportion, leaving smaller and decreasing proportions for sale.

Omiti *et al*., (2009); Otieno *et al.*, (2009); Sserunkuuma *et al*., (2010) observed that human capital measured by the education level of the household head may have mixed impacts on market participation as well as the proportion of output sold. On one hand, education enhances the skill and ability to better utilize new technologies and market information, which may reduce marketing costs and make it more profitable to participate in the market. Education, however, raises

the opportunity cost of labor and may reduce the profitability of agricultural production, processing and market participation by farmers where alternative employment opportunities exist and are more profitable to engage in. The age of the household head is also symbolic of human capital endowment in that it reflects the ability to access and use information, with younger heads having a higher ability to accurately process and use market information, thereby reducing the cost of participating in market transactions. Households headed by older people also tend to have more dependants and subsistence production activities, which limit their participation in markets (Ehui et al, 2009).

Ahuja *et al*., (2003); Bellemare and Barrett (2004); Otieno *et al*., (2009); Komarek (2010) noted that price is expected to influence the proportion of output sold, with high prices encouraging market participation and sales, while the converse is true for low prices. The higher price for milled rice (grain) relative to unmilled rice (paddy) is also hypothesized to encourage rice-milling before sale. Distance is another factor that is hypothesized to affect market participation. It is considered as an instrument of market access and transactions costs under the hypothesis that the longer the distance to the market, the higher are the transactions costs of marketing and the lower is the sales-orientation of the household. However, those households closer to markets have a higher likelihood of being net sellers and generating larger sales volumes (Otieno et al., 2009; Rios *et al.,* 2009; Komarek, 2010) because they are more likely to recover their production and marketing costs. In the same respect, households closer to milling services are more likely to mill their rice before sale because they face lower transactions costs of milling.

Household assets represent agricultural inputs that improve the productivity of farms; and the resultant yield increases from using these assets in production influence both market participation and sales volumes. Assets also play a role in buffering households against various income shocks. Physical assets such as land may have indirect positive impacts on market participation by enabling farmers to overcome credit constraints, through use of land as collateral for credit to invest in productivity-increasing technologies and value addition, as well as direct positive impacts by permitting the adoption of technologies or even crops that require large acreage. Rios *et al.,* (2009) and Komarek (2010) observed a positive association between farm size and sales orientation, at a decreasing rate for the largest farms.

Output is also hypothesized to influence the proportion of sales because higher production translates into higher surplus for sale. Otieno *et al.,* (2009); Komarek (2010) found output to have a positive effect on market participation and marketable surplus volumes. Also, farmers harvesting larger volumes are more likely to invest in value-addition before sale because of their ability to spread the costs over a larger volume of output. Finally, membership in farmers groups is cited in literature to influence market participation and sales. Farmers groups facilitate transport pooling, group loans, group bargaining power and access to other services such as milling which enhances farmers' returns from

production and marketing. Alene *et al*., (2008) found that group membership positively influenced participation in maize markets and sales.

3 Research methodologies

This study was conducted in four major rice-growing districts of Eastern Uganda, namely, Pallisa, Bugiri, Bukedea and Mayuge. Data were collected in October 2009, through a household survey of rice farmers by Makerere University and Japan International Cooperation Agency (JICA) under the project entitled "An Empirical Analysis on Expanding Rice Production in Sub Saharan Africa". The data was gathered using a structured questionnaire administered through one-on-one face to face interviews. The gathered data included; socio-demographic characteristics of the households and household heads, inputs into rice production, the area planted to rice, quantities of rice harvested and sold, form in which rice was sold, the selling price, place of sale and distance and transportation costs to rice mills or other selling places.

The study sample was drawn following a purposive sampling procedure, with sub-counties being the primary sampling units. In each of the four districts, sub-counties were purposively selected based on participation in JICA's project entitled "Sustainable Irrigated Agriculture Development Project in Eastern Uganda", which is part of the wider programme of Coalition for Africa Rice development (CARD) and JICA for the expansion of low-land rice production in SSA. This project targeted households that grew rice in wetland areas in irrigation schemes or swamps in the first season of 2009 and second season of 2008, and the majority of these were located in the selected sub-counties, which included; Busakira and Buwunga in Mayuge and Bugiri districts, respectively; Butebo, Petete and Bulangira sub-counties in Pallisa district; and Bukedea and Kolir sub-counties in Bukedea district. In each sub-county, local agricultural officers, sub-county community officers, local council one (LC1) chairmen and Farmer Group Leaders led the exercise of generating lists of households that grew rice in wetland areas in the first season of 2009 and second season of 2008, from which households were randomly selected for the survey. Based on these criteria, 75 households were selected in each of the four districts to give a total sample of 300 households. However, the analysis for this study is based on 194 households that harvested and sold rice, because the rest (106 households) did not harvest any rice in the first season of 2009 and second season of 2008 because of serious drought or flooding conditions on their rice plots.

Tests of difference of the means for continuous variables and chi-square for discrete variables were used to determine the differences in demographic and socio-economic characteristics between households that sold rice in unmilled form and those that sold milled rice or a combination of milled and unmilled rice. Comparison of profits from selling milled versus unmilled rice was achieved through a two-step procedure. In the first step, the profitability of selling rice in different forms (milled and unmilled) was estimated using gross margin analysis.

Following (Castle *et al*., 1987), the gross margins (GM) to a rice producing household i from selling rice in milled or unmilled form were computed as:

$GM_i = TR_i - TVC_i$ …….. (i)

Where; $GM_i =$ Gross Margin for household *i* in Ushs per acre

$TR_i =$ Total Revenue received by household *i*

$TVC_i =$ Total Variable Cost incurred by household *i*

In the second step, the gross margins for milled and unmilled rice were subjected to the test of difference of means to determine if there is a significant difference between them. The factors influencing the proportion of rice sold as grain by rice-growing households were analysed using a censored Tobit model. Greene (2000) defines the censored Tobit model as;

$y^* = \alpha X_i + \varepsilon_i, i = 1,2,....,n$ ……..(ii)

Where; y^* is the unobserved latent variable, α is a vector of coefficients to be estimated, $\mathbf{X}_i$ is the vector of explanatory variables and $\varepsilon_i \approx i.i.d.\ \ N(0,\sigma^2)$. Instead of observing y^*, we observe y:

$$y = \begin{cases} 0 \ \ if \ \ y^* \le 0 \\ y^* \ if \ \ 0 \angle y^* \angle 1 \\ 1 \ if \ \ y^* \ge 1 \end{cases} \qquad \text{……..... (iii)}$$

y is the proportion of rice sold as grain, A zero value of y is observed for households that did not sell any milled rice; while y = 1 for households that sold all their rice in milled form. The specific explanatory variables used in the empirical model for estimating the factors influencing the proportion of rice sold as grain by rice-growing households were; X_1=age of household head in years, X_2=Education of household head in years, X_3=household size in number of persons, X_4=price at which milled rice was sold in Uganda shillings (Ushs), X_5=distance to nearest rice mill in kilometers (km), X_6=membership in rice farmers groups, 1 if yes and 0 otherwise, X_7=household experience in growing rice in years, X_8=quantity of rice harvested in kg

4 Results and discussion

The surveyed rice-growing households were grouped into three categories based on the form in which they sold their rice. The first category, "unmilled", consisted of households that sold all their rice as paddy; while the second category, "milled", consisted of households that sold all their rice as grain; and the third category, "both", consisted of households that sold part of their rice as paddy and the other part as grain. Table 1 shows the proportions of households that sold rice in the different forms. Nearly half of the sampled households (48.5%) sold their rice as grain and about one third (34.5%) sold part of their rice as grain and the other part as paddy. The rest (17%) sold all their rice as paddy.

Table 1: Forms in which rice is sold

Form	Percent
Unmilled	17.0
Milled	48.5
Both	34.5
Total	**100**

Source: Survey data 2009

Table 2 shows that nearly all the sampled households (94.6%) were headed by men, although the proportion of male-headed households was lower among households that sold paddy only (91%) than their cohorts who sold grain only (98.9%) and those who sold both paddy and grain (95.5%). Forty percent of the households had membership in farmers groups, but the "both" category had a significantly higher proportion of households with membership in farmers' groups (53.7%) than the "unmilled" (24.2%) and "milled" (35.1%) categories. Nearly half (46.9%) of the households received rice-related training, but the proportion of households with such training was significantly higher in the "both" category (59.7%) than the "unmilled" (39.4%) and "milled" (40.4%) categories.

The majority of the households (61.3%) sold their rice at the nearest trading centre, while the rest sold at the farm gate (10.8%), local market (18.6%), and nearest town (9.3%). As expected, the "milled" category had the smallest proportion of households selling rice at the farm-gate (1%) and the highest proportions of households selling rice at the trading centre (66%) and town (14.9%). This was because rice mills were mostly located in local trading centres and towns, and those who mill rice sell it at the place of milling to avoid the cost of transporting it back to the farm gate. Also, milling places serve as a collection centre for rice traders ready to buy the rice from farmers; and many millers also double as rice traders. So the decision to mill rice is equivalent to choosing the rice mill as the "place of sale". It is interesting to note that even within the "unmilled" category, more households (majority) sold their rice at the trading centre (54.5%) than at the farm-gate (24.2%), an indication that even after incurring costs to transport rice from the farm-gate to the trading centre (possibly with a mill), some farmers still choose to sell their rice as paddy, which attracts a lower price than grain, for various reasons that could include lack of confidence in the milling quality of rice, electricity to run the mill being unavailable.

Table 2: Socio-economic characteristics of sampled rice-growing households (Categorical Variables)

Variable	Overall Sample (N=194)	"Unmilled" (N=33)	"Milled" (N=94)	"Both" (N=67)	Chi-Square	P-value
% male headed households	96.4	90.9	98.9	95.5	4.747	0.093*

% households with group membership	39.7	24.2	35.1	53.7	9.633	0.008***
% households with training	46.9	39.4	40.4	59.7	6.738	0.034**
Place of sale (% households reporting)						
Farm gate	10.8	24.2	1.1	17.9		
Trading center	61.3	54.5	66	58.2	23.839	0.001***
Local market	18.6	18.2	18.1	19.4		
Town	9.3	3	14.9	4.5		
Types of Rice Buyers (% households reporting)						
Local trader	26.3	54.5	14.9	28.9		
Wholesale trader	36.6	6.1	53.2	28.4		
Retail shop	3.1	0	1.1	7.5	50.39	0.000***
Individual customer	8.8	21.2	2.1	11.9		
Rice miller	25.3	18.2	28.7	23.9		
Transportation means (% households reporting)						
Foot	5.2	3	5.3	6		
Bicycle	74.7	87.9	69.1	76.1	6.501	0.369
Motor bike	4.6	3	4.3	6		
Car	15.5	6.1	21.3	11.9		

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

The majority of households sold their rice to wholesale traders (36.6%), local traders (26.3%) and rice millers (25.3%). The "milled" category had the highest proportions of households selling rice to wholesale traders (53.2%) and rice millers (28.7%), which suggest that rice millers double as traders who buy both milled and unmilled rice from farmers. The "unmilled" category had a higher proportion of households selling rice to local traders (54.5%) than the "milled" (14.9%) and "both" (28.9%) categories. Three quarters of the households (74.7%) use bicycles to transport their rice from the farm-gate to the place of sale or milling plant, and the rest use motor vehicles (15.5%), motor bicycles (4.6%) and foot (5.2%). There are no significant differences in transportation means for rice across the different categories of households, although a higher proportion of households in the "milled" category use motor vehicles (21.3%) than the "unmilled" (6.1%) and "both" (11.9%) categories.

Results of analysis of other socio-economic characteristics of the surveyed households are presented in Table 3. They show that on average, households which milled all their rice before selling ("milled" category) are endowed with significantly bigger landholdings (5.33 acres) and households (8 people), which enabled them to cultivate bigger rice plots (1.53 acres) and harvest bigger volumes of rice (982 kg) than their cohorts in the "unmilled" and "both" categories. However, those who sold all their rice as paddy were faced with significantly longer distance to the nearest mill (4.8 km) than households that milled all (3.28 km) or part (3.18 km) of their rice before sale. These results suggest that rice-milling was directly constrained by the distance travelled by farmers to milling services, but was indirectly enabled by household endowment of land and labor through their effect on the size of rice plots (and rice output) that households can cultivate.

Table 3: Socio-economic characteristics of sampled rice-growing households (Continuous Variables)

Variable	Mean values			
	Overall Sample (N=194)	"Unmilled" (N=33)	"Milled" (N=94)	"Both" (N=67)
Age of HH Head	40.093(11.902)	40.485[a] (12.324)	39.191[a] (11.381)	41.164[a] (12.476)
Education of HH Head (years)	5.881 (3.778)	6.424[a] (4.323)	5.947[a] (3.748)	5.522[a] (3.548)
Household size	7.387 (3.512)	6.788[a] (2.770)	8.043[b] (4.122)	6.761[a] (2.686)
Rice plot size (acres)	1.075 (0.955)	0.629[a] (0.505)	1.533[b] (0.893)	0.653[a] (0.918)
Landholding (acres)	4.581 (4.446)	3.746[a] (3.306)	5.330[b] (4.757)	3.942[a] (4.364)
Rice Output (Kg)	776.304 (666.258)	271.879[a] (300.556)	982.192[b] (692.033)	735.896[c] (624.652)
Experience (years)	8.526 (7.761)	6.818[a] (7.338)	8.723[a] (7.482)	9.090[a] (8.326)
Distance to rice mill (km)	3.512 (3.877)	4.841[a] (4.838)	3.280[b] (3.452)	3.184[b] (3.839)

Note: pair-wise t test with equal variances assumed. Superscripts for two categories ab, ba, ac, bc indicates that the variable is statistically different between the categories; A number marked with aa, bb indicates that the variable is not significantly different between the categories. Figures in parentheses are standard deviations.

Table 4 summarizes the costs incurred by the sampled households in the production and marketing of rice. Results show the average cost of labor estimated at Ushs 201,841 per acre for the entire study sample was much higher than the cost of seed (Ushs 10,568 per acre) and transport (Ushs 6,590) incurred by the sampled households. This is consistent with the findings of (Astewel, 2010 and Jamala *et al.,* 2011) who found human labor to be the most significant cost item in rice production. A pair-wise t-test on the difference of means between households selling rice in different forms shows that households which milled all their rice before sale incurred significantly higher costs of labor (Ushs 257,689 per acre) and seed (Ushs 15,138 per acre) than their cohorts who sold all or part of their rice in paddy form. As expected, the mean transportation cost for those selling all their rice as paddy (Ushs 2,167) was significantly lower than for households selling all (Ushs 7,929) or part (Ushs 6,893) of their rice in milled form, mainly because the former mostly sell their rice at the farm-gate and therefore avoid transportation costs. Those selling rice in paddy form also avoid milling charges estimated at an average of Ushs 84.16 per kilogram.

Table 4: Costs of production and marketing of rice

Variable	Mean values			
	Overall Sample (N=194)	"Unmilled" (N=33)	"Milled" (N=94)	"Both" (N=67)
Seed cost (Ushs/acre)	10,568.14 (13,343.73)	7,700.564[a] (7,563.138)	15,138.36[b] (16,416.77)	5,568.57[a] (7,344.676)
Labor cost (Ushs/acre)	201,841.1 (194,704.5)	122,722.3[a] (174,346)	257,689.3[b] (216,622)	162,456[a] (144,399.8)
Transport cost (Ushs)	6,590.722 (10,829.1)	2166.667[a] (5,572.907)	7,928.723[b] (10,070.88)	6,892.537[b] (13,134.83)
Milling cost (Ushs/kg)			84.16 (17.908)	
Price per Kg		900.303[a] (195.424)	1,437.766[b] (312.868)	

Note: pair-wise t test with equal variances assumed. Superscripts for two categories ab, ba indicates that the variable is statistically different between the categories. A number marked with aa, bb indicates that the variable is not significantly different between the categories. Figures in parentheses are standard deviations.

However, the per kilogram price of milled rice (Ushs 1,438) was significantly higher than the price of paddy (Ushs 900); which could more than offset the higher costs (of labor, seed, transportation and milling) incurred by households that mill all their rice before sale to make rice-milling profitable. Table 5 presents estimates of the profitability (Gross Margins) of selling milled and unmilled rice. Results of the estimates of gross revenue, total variable costs and gross margin show that rice production is associated with positive gross margins, regardless of the form in which it is sold, suggesting that rice production is a profitable venture. This is in agreement with the findings of Banta et al., (2008); Sserunkuuma (2008); Elepu and Nalukenge (2009); Fatoba *et al.*, 2009; Astewel (2010).

Table 5: Means of Revenues, Variable Costs and Gross Margins

Variable	Mean values			
	Overall Sample (N=194)	"Unmilled" (N=33)	"Milled" (N=94)	"Both" (N=67)
Total Revenue Per acre	966,056.7 (811,797)	590,170[a] (800,877.5)	1,197,713[b] (783,756.7)	826,185[a] (763,955.2)
Total Variable Cost per acre	219,000 (199,279.8)	132,589.5[a] (174,032.7)	280,756.3[b] (220,495.2)	174,917.1[a] (147,643.6)
Gross margin Per acre	748,927.9 (647,315.1)	457,580.5[a] (644,861.1)	920,977.6[b] (612,287.2)	651,044[a] (633,321)

Note: pair-wise t test with equal variances assumed. Superscripts for two categories ab, ba indicates that the variable is statistically different between the categories. A number marked with aa, bb indicates that the variable is not significantly different between the categories. Figures in parentheses are standard deviations.

However, although households which mill all their rice before sale incur significantly higher variable costs (Ushs 280,756/acre) than their cohorts who sell all (Ushs 132,590/acre) or part (Ushs 174,917/acre) of their rice as paddy, they receive higher gross margins or profits (Ushs 920,978/acre) from rice sales than their cohorts who sell all (Ushs 457,580/acre) or part (Ushs 651,044/acre) of their rice as paddy. This suggested that the higher price of milled rice relative to paddy more than offsets the higher costs incurred by households which sell milled rice to make the selling of milled rice more profitable than selling paddy, as hypothesized. This result is also consistent with that of (Manus and Halim, 2010) who found the selling milled rice to be more profitable than paddy in Papua, New Guinea.

Table 6 presents the results of regression analysis on the determinants of proportion of rice sold as grain. The results show volume of rice produced (rice output), household size, price of milled rice, distance to nearest rice mill and membership in rice farmers' groups had significant effect on the proportion of rice sold as grain.

Table 6: Results of Regression Analysis

Tobit regression: Dependent variable = proportion of rice sold as grain

Explanatory Variables	Coefficients	Marginal effects		
		$\frac{\partial Ey}{\partial X_i}$	$\frac{\partial Ey^*}{\partial X_i}$	$\frac{\partial F(z)}{\partial X_i}$
Age	-0.005	-0.003	-0.002	-0.004
	(0.003)			
Education	0.004	0.003	0.002	0.003
	(0.010)			
Household size	0.027**	0.018	0.011	0.022
	(0.012)			
Price of milled rice	0.001***	0.001	0.0004	0.001
	(0.0001)			
Distance to rice mill	-0.047***	-0.031	-0.018	-0.038
	(0.012)			
Group-Membership^	0.200**	0.136	0.079	0.151
	(0.079)			
Rice-growing Experience	-0.005	-0.003	-0.002	-0.004
	(0.005)			
Rice Output[a]	0.143***	0.096	0.056	0.115
	(0.042)			
Constant	-0.948***			
	(0.318)			

*Observations = 194, Pseudo R2 = 0.514, ^=dummy variable [a] =Logarithm *, **, *** Represents significance of coefficients at 10%, 5% and 1% levels respectively, in parentheses are standard errors*

As hypothesized, the price of milled rice had a positive effect on the proportion of rice sold as grain at 1% significance level. This implies that as the price of milled rice rises, it triggers increasing proportions of rice to be sold as grain. This concurs with the findings of Ahuja *et al*. (2003); Bellemare and Barrett (2004); Otieno *et al*. (2009); Komarek (2010); Sserunkuuma *et al*. (2010)of prices being one of the key determinants of the proportion of output sold because of their effect on the profitability of commodity production and marketing. A one shilling increase in the price of milled rice increases the proportion of harvested rice sold by 0.1%; increases the proportion of rice sold as grain by 0.04%; and increases the likelihood of making a sale by 0.1%.

The volume of rice harvested by the household was also positively and significantly associated with the proportion of rice sold as grain. This was because the fixed transaction costs of milling can be spread over a larger volume of produce, making it cheaper to invest in milling before sale. Mukama (2010) also found the harvested volume of bananas to be significantly associated with the proportion of bananas sold, which corroborates the above finding. Increasing the harvested volume of rice by 1 kg increases the proportion of harvested rice sold by 9.6%; increases the proportion of rice sold as grain by 5.6%; and increases the likelihood of making a sale by 11.5%.

Also, increasing the number of people in a household (family labor) by one person would increase in the proportion of rice sold as grain. This was likely because it enabled the household to produce more, thereby reducing the milling costs i.e., a unit increase in the number of household members by one person increases the proportion of harvested rice sold by all rice-growing households by 1.8%; increases the proportion of rice sold as grain (for households selling milled rice) by 1.1%; and increases the likelihood of selling rice 2.2%.

Membership in a rice-farmers' group was associated with a significantly higher proportion of rice sold as grain. This was because it enabled easier access to milling services through transport-pooling, for example, and entitled member farmers to other benefits that could explain the higher tendency to mill before sale. Therefore, the hypothesis stating that membership to rice farmers' groups positively, affects the proportion of rice sold as grain is supported by the study findings. Having membership in a rice-farmers' group increases the proportion of harvested rice sold by 13.6%; increases the proportion of rice sold as grain by 7.6%; and increases their probability of making a sale by 15.1%.

Finally, distance to the nearest rice mill was negatively and significantly associated with the proportion of rice sold as grain. This was because households that are closer to milling services face lower transactions costs of milling and are thus more likely to mill their rice before sale than more distant households. This result is consistent with the findings of other studies (Rios *et al.,* 2009; Otieno *et al*., 2009; Komarek, 2010; Wakulira, 2010) that increasing distance to markets reduces the proportion of marketed output; and supports the hypothesis that distance to nearest rice mill negatively affects the proportion of rice sold as grain.

Increasing the distance to the nearest rice mill by one kilometer reduces the proportion of rice sold by all rice-growing households by 3.1%; reduces the proportion of rice milled before sale (for households selling milled rice) by 1.8%; and reduces the probability of making a sale by 3.8%.

5 Conclusions and recommendations

Although rice production has been shown to be a profitable venture regardless of the form in which farmers choose to sell their rice, milling rice before sale makes rice production even more profitable. It is important, therefore, that farmers are encouraged and assisted to mill their rice before sale through training and extension; and through interventions that reduce the transactions costs of milling. Such interventions include those that enable farmers to produce more (e.g., by facilitating their access to yield-enhancing inputs) and spread the milling costs over a larger volume of produce; and to market/mill their rice in groups for easier access to milling services and reduction of the fixed transactions costs of milling that they would otherwise face as individuals. Also interventions that enable milling services to be brought closer to farmers in major rice-growing areas (e.g., by facilitating private entrepreneurs to set up milling plants closer to farmers through rural electrification and reduction of electricity tariffs or to invest in mobile rice mills through rural road network improvement) would go further to reduce the transactions costs of accessing milling services and encourage rice-milling before sale. The above interventions need to be complemented by efforts to get and keep prices right, such as developing new markets for rice and rice products to ensure that the intervention-driven increase in production and marketing of rice does not undercut the incentive for production and milling embodied in the prices received by farmers. Further research should focus on assessing the quality of available milling services, because this also could affect their willingness to mill their rice before sale.

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