FACTORS INFLUENCING FARMERS' CHOICE TO SELL MILLED VERSUS UNMILLED RICE

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DECLARATION

I Nakazi Florence do declare that this is my original work and has never been presented for a degree in this or any other University or institution of higher learning or even for any publication. However any other sources of information that I have used are duly acknowledged.

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This Thesis has been submitted upon the guidance and advice of University supervisors

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Dr. E. Katungi

DEDICATION

This thesis is first and foremost dedicated to the Good Lord God whose guidance, provision, protection and love guided me to the proper completion of this work. Secondly this work is dedicated to my father Mr. Nsubuga Fred, my mother late Nakintu Margret, my husband Sentumbwe George and my daughter Nakanga Michelle Georgina whose academic, social, and religious support and advice was very instrumental in making this work a success.

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ABBREVIATIONS AND ACRONYMS

CARD:	Coalition for Africa Rice development
e.g.:	For example
IRRI:	International Rice Research institute
JICA:	Japan International Cooperation Agency
KM:	Kilometers
LC:	Local council
NaCRRI:	National Crop Resources Research Institute
NARO:	National Agricultural Research Organization
NERICA:	New Rice for Africa
NGO:	Non-Government Organization
ODA:	Official Development Assistance
Ushs:	Uganda shillings
SSA:	Sub-Saharan Africa
UNRDS:	Uganda National Rice Development Strategy
WARDA:	West African Rice Development Association
VPI:	Vice President Initiative

ABSTRACT

The number of rice mills in Uganda has increased rapidly during the past decade, presumably in response to the increasing demand for rice milling services by rice farmers. However, recent studies show that 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 (grain). This study was undertaken with the overall objective of examining why some rice-growing households in Uganda sell milled rice and others don't, and how this affects the profitability of rice production.

Data for this study were collected in October 2009, through a survey of 194 rice farmers in Eastern Uganda by Makerere University and Japanese International Corporation Agency (JICA). Descriptive statistical methods of data analysis were used to characterize rice-growing households by the form in which they sell rice; while the profitability of rice production was estimated using gross margin analysis and compared using the difference of mean test between households that sell milled rice and those that don't. The factors influencing the proportion of rice sold as grain were analysed using the Tobit regression model.

The surveyed households were grouped into three categories based on the form in which they sold their rice; "unmilled", "milled" and "both". Most of the sampled households (83%) sold all or part their rice as grain. On average, households which milled all their rice before selling were endowed with significantly bigger landholdings and households (family labor) 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 than households that milled all or part of their rice before sale.

Profitability analysis show that rice production is associated with positive gross margins, regardless of the form in which it is sold, implying that rice production is a profitable venture. Although milling households incurred higher costs, they also had higher gross margins, implying that selling milled rice is more profitable than selling paddy. The price of milled rice, volume of harvested rice, household size, membership in rice-farmers' group have significant and positive relationships with the proportion of rice sold as grain; while

distance to the nearest rice mill is negatively and significantly associated with the proportion of rice sold as grain.

Farmers should be encouraged and assisted to mill their rice before sale through training and extension, as well as other interventions that reduce the transactions costs of milling. Such interventions include; facilitating their access to yield-enhancing inputs to increase harvested volumes and helping them to market/mill their rice in groups. Also facilitating private entrepreneurs to set up milling plants closer to farmers through such measures as rural electrification and reduction of electricity tariffs; or to invest in mobile rice mills through improvement of the rural road network, for example, would go further to reduce the transactions costs of accessing milling services and encourage rice-milling before sale.

CHAPTER ONE

INTRODUCTION

1.1 Back ground

Rice is a staple food for more than half of the world's population (Odogola, 2006). Moreover, 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, which implies a deficit of 2 million metric tons (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, 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. NERICA is a high-yielding variety of upland rice developed to suit the African environment by combining resistance to African rice pests, diseases, and water stress with the high yield potential of the Asian species (WARDA, 2001). The average on-farm yield of NERICA in Uganda was found to be 2.5 tons per hectare (Kijima *et al.*, 2006), which is significantly higher than the average upland rice yield of one ton per hectare in SSA.

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), with upland rice area increasing from 1,500 hectares in 2002 to 35,000 hectares in 2007 (Tsuboi, 2008). 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. For example, farmers with limited knowledge on post-harvest handling of rice usually dry it beyond the appropriate moisture content, which increases breakage during milling and downgrades the milling quality, sales price and income received by farmers. UNRDS (2009) adds that the most common method of rice threshing involves mainly beating the heaped rice on a tarpaulin, plastic sheet, mat or bare ground which leads to heavy contamination of the paddy with stones and other foreign matter, denting the quality of the milled rice even further. Even the yield of NERICA was found to be significantly lower among farmers with limited experience in rice growing (1.7 metric ton per hectare) compared to their experienced cohorts with an average yield of up to 2.5 metric tons per hectare (Kijima *et al.*, 2006). These observations led Kijima *et al*., (2006) to conclude that despite the observed upward trend in rice production, Uganda runs a big risk of not only failing to achieve technically feasible higher rice yields but also to translate these into reduced household poverty and food security, unless the problems of weak extension support for rice and lack of rice specialists to provide technical advice on production and post-harvest handling are urgently addressed.

As part of the efforts to address the problems of poverty and food insecurity in Africa, the Coalition for Africa Rice Development (CARD) initiative was launched at Tokyo

International Conference on African Development (TICAD) IV in May 2008. Donors including JICA, international organizations set up a steering committee to implement an extensive range of programs related to expanding rice production in SSA for the alleviation of poverty and food insecurity. In Uganda, JICA, the implementing agency for Japan's Official Development Assistance (ODA) has among other things continued to support NERICA dissemination through technical assistance and field experiments conducted by NERICA experts dispatched from Japan to Uganda.

Through the Japanese experts stationed at the National Crop Research Resources Institute (NaCRRI) of the National Agricultural Research Organization (NARO), JICA has promoted NERICA with close collaboration from the Vice President's Office, Sasakawa Global 2000, and other institutions. Several activities have been implemented as part of this collaboration, including the training of farmers, local government officials, and the NGO staff at NaCRRI and at district headquarters; Distribution of high quality NERICA seeds; provision of training to manufacturers on threshing machine fabrication to enable farmers to buy threshing machines made in Uganda; and development of mobile rice mills (rice milling machines mounted on trucks) as a pilot project to enable farmers in areas without rice mills to mill their rice for home consumption or sale at better prices than when they sell unmilled rice, also known as paddy.

It is evident, therefore, that there have been efforts in the recent past to address the constraints faced by rice farmers in Uganda of lack of knowledge on production and post-harvest handling as well as limited access to milling facilities. However, it is not clear how these have impacted on the behavior of farmers, particularly with regard to rice post-harvest handling and marketing, hence the need for this study.

1.2 Problem statement

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). The common transportation means from the homestead to the rice mill was the bicycle, and 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.

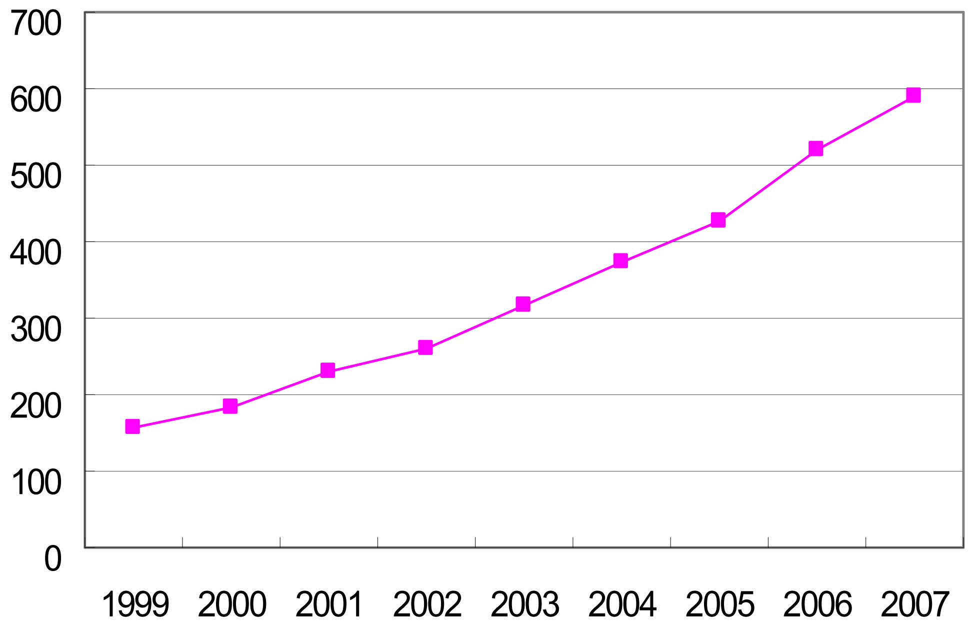

Figure 1: Total Number of Mills in Uganda
Adapted from: Alphonse et al., (2008)

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). Recent studies on rice have mainly focused on analyzing profit inefficiency in rice production (Hyuha *et al*., 2007), rice contract farming schemes (Elepu and Nalukenge, 2009), impact of NERICA on income and poverty (Kijima *et al*., 2008), but with limited attention to rice processing and marketing. 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.

1.3 Objectives of the study

The purpose of this study is 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. Specific objectives of the study are:

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.

1.4 Hypotheses

a) Households which sell rice after milling (as grain) receive higher profits than those selling paddy.
b) Distance to nearest rice mill negatively affects the proportion of rice sold as grain.
c) Membership to rice farmers groups is associated with a higher proportion of rice sold as grain.

1.5 Justification for the study

The National Development plan (NDP) 2010 identifies weak linkages between production, processing and marketing as a major constraint to the transformation of Uganda's agricultural sector from subsistence to commercial production. The plan recognizes that much of the agricultural produce is sold in raw form and where the processing is done, the supply of raw materials is inadequate. It further recognizes that many agricultural producers do not have access to processing services and markets. Therefore, investment in agro-processing/value addition and improved market access is critically important for the improvement of agricultural livelihoods in Uganda.

Despite the government efforts to promote the processing and marketing of agricultural output, little has been done in the rice sub-sector. Improvements in the sector have emphasized the production side, yet meaningful returns to production efforts cannot be realized without an organized and efficient marketing system. Rice farmers have various types of buyers (wholesale traders, individual consumers, rice millers, local traders) to whom they can sell their rice either as milled (grain) or unmilled (paddy) form. However, the form in which a household chooses to sell its rice affects the returns to rice production, which in turn affects the scale of production; the ability and willingness to adopt yield enhancing technologies; the sustainability of rice production and the anticipated contribution to poverty reduction in Uganda. It is important therefore, to examine the extent to which farmers' process rice before offering it for sale, and how this affects rice profitability; and based on this knowledge, to recommend strategies for improving the rice sub-sector in Uganda. Moreover, much as farmers are being encouraged to process and add value to their rice before sale, there is no documented evidence that the returns from doing so are worth the cost and effort, hence the need for this study.

The findings will be useful to farmers, extension workers, non-governmental organizations and private entrepreneurs promoting or investing in rice production and marketing by availing information especially on its milling and profitability. Finally the results will provide useful information for the formulation of appropriate programs and strategies to support rice production, processing and marketing as away of increasing its contribution to poverty reduction in Uganda.

1.6 Organization of the thesis

This thesis has five chapters. The first chapter presents the introduction, problem statement, study objectives and hypotheses. Chapter two reviews the available literature on rice production, processing, and marketing in Uganda; profitability analysis using Gross margins and literature on the factors influencing market participation and sales. Chapter three is the methodology chapter, which describes the sampling procedure, and the methods used for data collection and analysis. Chapter four presents and discusses the results of the study; and the thesis ends with a summary of the findings, conclusions and recommendations in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Rice production systems in Uganda

Rice is grown mainly under three systems, namely rain-fed upland; rain-fed lowland and irrigated. 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 (UNRDS, 2009). 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).

2.2 Processing, markets and marketing of rice in Uganda

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. Milled rice, also referred to as white rice, has the husks and bran layer removed. There were about 591 operational rice mills in Uganda (UNDRS, 2009) accessed by rice farmers, 80% of whom are smallholders.

Efforts to promote rice production and marketing have been championed by the Office of the Vice President (OVP), National Agricultural Advisory Services (NAADS), and Non-Government Organizations (NGOs) such as Sasakawa Global 2000. After harvesting, some farmers transport their rice to the mill and only sell after milling, while others sell paddy usually at the farm-gate for various reasons that may include proximity to mills, milling costs, price of milled rice relative to the farm-gate price offered for paddy rice. More than half of the rice produced by Ugandan farmers is sold for cash income (Sserunkuuma, 2008) meaning that rice is primarily grown as a cash crop; but the contribution of rice to smallholder farmers' income and rural employment is linked to the availability of functional milling services and markets in urban centers and regional markets.

2.3 Studies on rice processing and marketing

Basorun (2008) in a study on factors affecting rice processing in Igbeno-Ekiti, Nigeria employed a chi-square test and found that gender of processors, income, training acquired, the mode of processing, cost of processing were among the major factors that affected rice processing. Orebiyi and Eze (2005) in an economic survey of rice marketing in Anambra state, Nigeria observed a significant difference in the market prices of processed and unprocessed rice, with a greater percentage of rice marketers processing their rice through the local mills. Lwin *et al.,* (2006) in a case study of rice marketing in selected areas of Myanmar used descriptive statistics to study the form in which rice was sold. They found that in Hlegu township, 53.6% of the sampled farmers sold their rice in paddy form, 28.6% in milled and 17.9% in paddy and milled form; and in Pathein township, 68.8% sold in paddy form, 9.4% in milled form and 21.9% in both paddy and milled forms. However, this study did not examine the factors behind selling rice in different forms.

2.4 Profitability

Castle *et al*., (1987) defines profitability as the ability to produce enough returns to reimburse the farm for the opportunity cost of the resources. Profits are a reimbursement for the costs incurred in the production and marketing processes. In order to determine the returns (profits) to any enterprise, several techniques could be used including Benefit-cost ratio, Return per Investment, Net Returns and gross margin analysis (Emokaro *et al.,* 2010). Benefit-cost ratio, Return per Investment and Net Returns techniques are mainly useful when evaluating long term projects where great emphasis is on fixed costs. However, for short-run analysis of profits for an enterprise, gross margin analysis is more commonly used to estimate the returns to such enterprises. Castle *et al*., (1987) estimates gross margin as total revenue less operating expenses. Operating expenses are out of pocket expenses or cash outlays which vary with the size of the enterprise.

A number of studies have been conducted to assess the profitability of different crops using gross margin analysis. Emokaro *et al.,* (2010) studied the profitability of cassava marketing in lean and peak seasons in Benin City, Nigeria. They used gross margin analysis to measure profitability of cassava marketing in Benin City. Empirical results indicate that cassava marketing had a gross margin of 1,545 and -138 Naira in the lean and peak season respectively, implying that cassava marketing was only profitable in the lean season.

Sserunkuuma (2008) used gross margin analysis to study the contribution of NERICA to household income in central, western, eastern and northern regions of Uganda. The results show that growing a hectare of NERICA in the second season of 2007 earned an average income of Ushs 788,175. The study concluded that NERICA was more of a cash crop than food crop in Uganda, and that it significantly contributed to household cash income and poverty reduction.

Manus and Halim (2010) used gross margin analysis to study the profitability of smallholder rice production in selected Agro-ecological zones of Papua, New Guinea. The results showed that milled rice production systems were more profitable than paddy production systems.

Baiyegunhi and Fraser (2009) studied the profitability of sorghum production in Three Villages of Kaduna State, Nigeria. They used gross margin analysis to estimate the profitability of sole sorghum production on small and large scale farms. They found that small farms had gross margins of 5, 414.92 Naira per hectare compared to 6,100.60 Naira per hectare for large farms. They concluded that all farmers profited from sole sorghum production irrespective of scale of operation.

Magino *et al.,* (2004) studied the profitability of sorghum-legume inter-cropping practices among households in Eastern Uganda in which they used gross margin analysis to determine the profitability of intercrops versus sole crops. By subjecting gross margins to Analysis of Variance, they found that the gross margins of sorghum-cowpea, sorghum-groundnut and sole groundnut were not significantly different ($P<0.05$). They concluded that all intercropping systems were equally profitable.

Onu and Edon (2009) used gross margin analysis to compare the profitability of growing improved and local cassava varieties in Taraba state, Nigeria. The results showed that the gross farm margins were Naira 26, 384.62 per hectare and Naira 19, 399.72 per hectare for the improved and local cassava varieties, respectively, implying that farmers would benefit significantly by switching from local to improved cassava varieties.

Finally, Kudi and Abdulsalam (2008) in their study on a striga tolerant maize variety found that its cultivation was highly profitable based on its gross margin of Naira 94,479.21 per hectare compared to a gross margin of Naira 15,683.73 per hectare for the local varieties.

2.5. Factors that influence participation in commodity markets and sales

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).

Komarek (2010); Otieno *et al*., (2009); Bellemare and Barrett (2004); Ahuja *et al*., (2003) 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 (Rios *et al.,* 2009; Komarek, 2010; Otieno *et al.,* 2009) 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.

Other income sources are also hypothesized to influence the proportion of sales it raises household the household purchasing power. In this case, households with other income sources will have a higher probability of participating in the market not as sellers but as buyers due to their access to other incomes which can be used to make food purchases. Ouma *et al.,* (2010) observed that wealthy farmers were less likely to sell their produce to the market possibly because the opportunity cost of their time is higher than the poorer households.

Output is also hypothesized to influence the proportion of sales because higher production translates into higher surplus for sale. Komarek (2010); Otieno *et al.,* (2009) 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 sales that a particular household will make. 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.

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1 Conceptual framework for analysis of decisions on form in which to sell rice

Conceptually, data analysis and hypothesis testing in this thesis is guided by the theory of behavior of agricultural households under imperfect market conditions. These market imperfections create differences in the environment within which different households operate due to differences in household and farm characteristics. This in turn creates differential access to markets and other agricultural services (like milling or processing in general, credit, and extension) across rural households, with some households facing lower transaction costs of accessing markets and other services than others (Sadoulet and de Janvry, 1995).

Rice farmers have various types of buyers, including wholesale traders, retailers, rice millers, and individual consumers to whom they can sell their rice either as milled (grain) or unmilled (paddy) form, and at different locations or markets (farm-gate, local mill, distant mill, local market). Those who sell at the mill after milling their rice receive higher prices but also incur higher marketing and transactions costs, including the costs of transporting the paddy to the mill, milling charges and waiting at the mill for their rice to get milled, which may take a few days depending on availability of electricity, among other things. If these costs are sufficiently higher relative to potential returns from milling the rice before sale, they may make rice-milling unprofitable. In this case, farmers will choose to sell unmilled rice even in areas where rice mills and premiums for milled rice exist. A similar situation may arise when farmers with limited training and experience in rice production and post-harvest handling have low confidence in the milling quality of their rice and thus prefer to sell it at a lower price as paddy rather than facing the risk of investing in milling and not getting the premium price if the milling quality turns out to be low.

Thus, it is anticipated that the decision to sell rice as paddy or grain is influenced by location-level factors that operate at community scale (such as prices, distance and transportation cost to the nearest mill, availability and reliability of electricity, milling charges) as well as household-level factors, such as training and experience in rice production and post-harvest handling, education and age of the farmer which affects their risk preference and ability to decode and use available information on rice production and marketing for decision-making.

3.2.1 Theoretical Underpinnings of the Tobit model

The most commonly used models in static household adoption studies are; the linear probability models, the Logit and Probit models. For all these models, the dependent variable takes on two discrete values of 0 and 1. The Logit and Probit models are also sufficient if the question of interest is just the probability to adopt a technology. However, the dependent variable used in this study is mixed in a sense that those who don't mill rice would have a value of 0 for the dependent variable, while those who mill have a continuous outcome defined by the proportion ($0<p\leq 1$) of rice sold in milled form since some households sell both paddy and milled rice. Since the study is interested in the intensity of rice sold after milling, the Logit or Probit models are inadequate, which makes the censored Tobit model a more suitable tool of analysis. The Tobit model was chosen over the other choice models because; (a) Of all the available choice models, it is only the Tobit that takes into account both the probability and intensity of adoption, (b) It avoids lumping all non-participating households as zero or and all participating households one, thereby masking variation in the dependent variable.

3.2.2 Model specification

The Tobit model assumes normal distribution with constant variance (Greene, 2000). Thus, the dependent variable (proportion of rice sold as grain) is censored with lower limit as zero and upper limit as 1. According to (Greene, 2000), a generalized two-tailed Tobit model is specified as;

$$y_i^* = \alpha X_i + \varepsilon_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where y_i^* is a latent variable (unobserved for values smaller than 0 and greater than 1), α is a vector of coefficients to be estimated, and ε_i is a vector of independently normally distributed error terms with zero mean and constant variance σ^2, X_i is the vector of explanatory variables and i = 1, 2,... n (n is the number of explanatory variables). Denoting y_i (the proportion of rice sold as grain) as the observed dependent (censored) variable. Instead of observing y_i^*, we observe y_i :

$$y_i = \begin{cases} 0 \quad if \quad y_i^* \leq 0 \\ y_i^* \; if \quad 0 \angle y_i^* \angle 1 \\ 1 \; if \quad y_i^* \geq 1 \end{cases} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

The likelihood function for the Tobit is given as;

$$\log \; L = \sum_{y_i \succ 0} -\frac{1}{2}\left[\log(2\pi) + \log\sigma^2 + \frac{(y_i - \beta' x_i)^2}{\sigma^2}\right] + \sum_{y_i = 0} \log\left[1 - \Phi\left(\frac{\beta' x_i}{\sigma}\right)\right] \ldots\ldots\ldots\ldots \text{(3)}$$

The first part in equation (3) corresponds to the classical regression for the non-limit observations and the second part adjusts for the limit observations.

3.2.3. McDonald-Moffit Decomposition of the Tobit

McDonald and Moffitt (1980) demonstrated that the coefficients of the explanatory variable obtained in the Tobit regression results cannot be interpreted directly as estimates of the magnitude of the marginal changes in the explanatory variables on the expected value of the dependent variable. McDonald and Moffitt (1980) show that the effect of an independent variable on the expected value of the dependent variable for all observations can be decomposed into two parts. The first part is the change in the dependent variables of those observations above the limit, weighted by the probability of being above the limit; and the second part is the change in the probability of being above the limit , weighted by the expected value of the dependent variable if above.

The expected value of y in the Tobit model (McDonald and Moffitt, 1980) is given by;

$$Ey = X\beta F(z) + \sigma f(z) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Where $z = X\beta/\sigma, f(z)$ is the unit normal density and $F(z)$ is the cumulative normal distribution function, σ is the standard deviation of the error term that is reported in the Tobit results. The expected value of y for observations above the limit, here called y^* (McDonald and Moffitt, 1980) is given by;

$$Ey^* = X\beta + \sigma f(z)/F(z) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

From equation (4) and (5), it can be shown that

$$Ey = F(z)Ey^* \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(6)}$$

$$\frac{\partial Ey}{\partial X_i} = F(z) * \frac{\partial Ey^*}{\partial X_i} + Ey^* \frac{\partial F(z)}{\partial X_i} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(7)}$$

From equation (7), it can be shown that the effect of an independent variable on the expected value of the dependent variable for all observations can be decomposed into two parts. The first part is the change in y of those observations above the limit, weighted by the probability of being above the limit; and the second part is the change in the probability of being above the limit , weighted by the expected value of y if above.

$$\frac{\partial Ey^*}{\partial X_i} = \beta_i + \frac{\sigma}{F(z)} * \frac{f(z)}{\partial X_i} - \frac{\sigma f(z)}{F(z)^2} * \frac{\partial F(z)}{\partial X_i} = \beta_i \left[1 - \frac{zf(z)}{F(z)} - \frac{f(z)^2}{F(z)^2} \right] \ldots\ldots\ldots\ldots \text{(8)}$$

$$\frac{\partial F(z)}{\partial X_i} = \frac{f(z)\beta_i}{\sigma} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(9)}$$

Substituting (8) and (9) into (7) gives

$$\frac{\partial Ey}{\partial X_i} = F(z) * \beta_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(10)}$$

In equation (7), (8), (9) and (10) z is the z-score for the area under the normal curve, $f(z)$ is the standard normal density function and $F(z)$, is the cumulative standard normal density function. 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 are described in Table 1. The dependent variable is the proportion of rice sold as grain.

Table 1: A priori expectation of explanatory variables in the Tobit model

Label	**Variable**	**Description**	**Measurement**	**Hypothesized effect**
X_1	Experience	Household experience in growing rice	Years	+
X_2	Education	Education level of household head	Years of schooling	+/-
X_3	Household size	Household members	Number of persons	+/-
X_4	Price	Price at which milled rice is sold	Shillings	+
X_5	Distance	Distance to nearest rice miller	Kilometers	-
X_6	Membership	Membership to rice farmers groups	0=Non member 1 = member	+
X_7	Rice Output	Quantity of harvested rice	Kilograms	+
X_8	Other income	Income from other sources	Proportion of total household income	-

3.2.4 Choice of explanatory variables in the Tobit model and hypothesized effects

The choice of explanatory variables listed in Table 1 and their hypothesized effects on the proportion of rice sold after milling (as grain) are based on the conceptual framework (section 3.1) and the empirical research work on determinants of market participation and sales that was reviewed and cited earlier in section 2.5. The working assumption here is that variables that influence market participation and sales volume decisions also affect the decision on whether to invest in value-addition (milling) before sale. For example, just as rice output is hypothesized to positively affect market participation and sales, it is also likely to have a positive effect on the decision to mill before selling because the associated costs are lowered by being spread over a larger volume of produce. Likewise, the higher price of milled rice (grain) relative to that of paddy is hypothesized to be positively associated with the proportion of rice milled before selling in the same way higher prices encourage market participation and sales.

Distance also affects both market participation and sales decisions as mentioned earlier, as well as milling decisions 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. Human capital measured by education of the household head also affects milling decisions the same way it affects market participation and sales decisions, and so does social capital in the form of membership in farmers groups. Through such groups, pooling transport to the mill is possible or one group member may transact business on behalf of others in the group, thereby reducing transactions costs of milling and increasing the proportion of rice milled before sale.

Training and experience in rice production and post-harvest handling increases the milling quality of rice and, thus, farmers' confidence and willingness to mill their rice before sale rather than selling it at a lower price as paddy. Thus, experience in rice production and post-harvest handling is hypothesized to be positively associated with the proportion of rice sold after milling (as grain). Having a greater proportion of income from other sources other than rice is hypothesized to negatively affect the proportion of rice sold as grain because of the reduced importance of rice as an income source.

3.3 Description of the study area

This study was conducted in four major rice-growing districts of Eastern Uganda, namely, Pallisa, Bugiri, Bukedea and Mayuge. Pallisa district has an area of 1,956 km^2 and a population of 394,000. Pallisa District is bordered to the north by the districts of Serere, Ngora, Kumi and Bukedea. To the east lies Mbale District, while the districts of Budaka, Kibuku and Kaliro lie to the southeast, southwest and west of Pallisa district, respectively. The coordinates of the district are: 01 01N, 33 43E. Subsistence crop agriculture and animal husbandry are the two major economic activities in the district. The major crops include cassava, millet, sorghum, maize, groundnuts, beans, peas, sweet potatoes, rice, cotton, and soybeans.

Bugiri district occupies an area of 5,700.93 km^2 and has a population of 332,900 people. It is bordered by Namutumba and Butaleja districts to the north, Tororo District to the northeast, Busia District to the east, Namayingo District to the southeast, and Mayuge and Iganga districts to the southwest and west, respectively. The coordinates of the district are: 00 33N, 33 45E. Agriculture forms the backbone of the district, as it does in the majority of districts in the country. The main crops include lowland rice, cassava, maize, millet, sweet potatoes, coffee, sorghum, peas, sweet bananas and matooke.

Bukedea district has a population of 158,900 people. Its is bordered by Kumi District to the west and north, Bulambuli District to the east, Sironko and Mbale districts to the southeast, and Pallisa district to the south. The coordinates of the district are: 01 21N, 34 03E. Subsistence agriculture and animal husbandry are the two main economic activities in the district. Crops grown include cassava, rice, groundnuts, sorghum and millet.

The district of Mayuge occupies an area of 9,948.6 km^2 and has a population of 407,300 people. It is bordered by Iganga District to the north, Bugiri District to the northeast and east, Namayingo District to the east, the Republic of Tanzania to the south, and Jinja District to the west. The coordinates for Mayuge are: 00 20N, 33 30E. Agriculture in the district is mostly at the subsistence level. The crops grown include: maize, cassava, groundnuts, cocoa, cotton, coffee, beans, sweet potatoes, millet, rice, sunflower, simsim, tomatoes, passion fruit, onions and cabbage.

3.4 Sampling design and sample size

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 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 are located in the selected sub-counties, which include 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, 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 thesis 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.

3.5 Data sources

All the data for this study were collected in October 2009, through a household survey of rice farmers in the above-described Eastern Uganda districts (Pallisa, Bugiri, Bukedea and Mayuge) by Makerere University and the Japan International Corporation Agency (JICA) under the project entitled “An Empirical Analysis on Expanding Rice Production in Sub Sahara Africa”. The project’s aim was to analyze the impact of the CARD (coalition for Africa Rice Development) initiative on rice productivity and poverty reduction, and to assess the effectiveness of various means of improving agricultural production, typified by the development of a new agricultural technology and its dissemination.

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, including gender, age, and education level of the household head; household income and size, farm size, rice growing experience, access to markets and extension services, and membership to farmers groups. Data was also gathered on inputs into rice production, including type, quantity and cost of seed, fertilizer and chemicals, the area planted to rice, family and hired labor, and quantities of rice harvested and sold. Information on the form in which rice was sold, the selling price, place of sale and distance and transportation costs to rice mills or other selling places was also collected. This data was coded, cleaned and entered in a specially prepared Microsoft Access data base prior to analysis.

3.6 Data Analysis

General exploratory data analysis was conducted to determine the distribution of the data for the continuous variables like age, education, family size, output and years of experience; and those that did not fit a normal distribution were transformed before being subjected to further analysis (regression analysis and difference of means and chi-square tests). Multicollinearity was checked using pair-wise correlation tests and found not to be a problem (see Appendix 4).

Descriptive statistical methods (means and percentages, tests of differences between these) were used to characterize rice-growing households by the form in which they sell rice (first objective). The profitability of rice production was estimated using gross margin analysis and compared using the difference of mean test between households that sell milled rice and those that don't (second objective). Finally, the factors influencing the proportion of rice sold after milling were analysed using the Tobit regression model (objective 3).

3.6.1. Characterization of households by the form in which they sell rice (*objective 1*)

Tests of difference of the means (for continuous variables, e.g., age and education of the household head, family size and distance to rice mill) and chi-square (for discrete variables, e.g., gender of the household head and membership in rice farmers' organization) 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.

3.6.2. Comparison of profits from selling milled versus unmilled rice ***(objective 2)***

The profitability of selling rice (milled and unmilled) was estimated using gross margin analysis. Gross margin (GM) analysis was chosen over other methods because; (a) the study focuses on an annual crop with a 3-4 month-long cropping season (i.e., short-run), and GM is an appropriate measure of profits for short-run planning decisions, (b) it is convenient since it provides a measure of returns to variable costs and not fixed costs. 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 GM analysis. Following (Castle *et al*., 1987), the GM to a rice producing household i from selling rice in milled or unmilled form was computed as:

$$GM_i = TR_i - TVC_i \qquad \ldots\ldots (11)$$

Where; $GM_i =$ Gross Margin for household *i*

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

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

The total revenue was computed using the prices at which households sold rice in different forms (milled and unmilled) and the quantity of rice sold in each form. The total variable costs included expenditure on production and marketing activities, such as expenses on seed, chemicals, hired labor, animals and equipment services, such as tractors and ploughs, and post-harvest expenses (e.g., threshing, milling and transportation cost to mills or other places of sale). 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.

3.6.3. Determinants of the proportion of rice sold after milling *(objective 3)*

The factors influencing the proportion of rice sold as grain by rice-growing households were analysed using a censored Tobit model. The model is specified as;

$$y_i = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + \alpha_7 X_7 + \alpha_8 X_8 + \varepsilon_i \quad (12)$$

Where;

y_i = dependent variable (proportion of rice sold as grain)

α_0 = the intercept term

X_1 = Experience in growing rice

X_2 = Education level of household head

X_3 = Household size

X_4 = Price at which milled rice was sold

X_5 = Distance to nearest rice mill

X_6 = Membership to rice farmers groups

X_7 = Rice Output

X_8 = Proportion of Household Income from other sources

$\alpha_1 - \alpha_8$ Represent parameters to be estimated in the model

ε_i = Stochastic error term

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the study results. The first part compares the socio-economic characteristics of sampled households across categories of form in which rice was sold (as grain, paddy or combination of grain and paddy). This is followed by a comparison of the returns (profits) from selling milled (grain) and unmilled (paddy) rice among rice-growing households. The chapter ends with a presentation and discussion of results on the factors influencing the proportion of rice sold as grain by the surveyed households.

4.1 Characterization of rice growing households

The surveyed rice-growing households were grouped into three categories based on the form in which they sold their rice harvested in the first season of 2009 and second season of 2008. 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 2 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. These results show that the majority of the sampled households (83%) invest in rice milling before selling because milled rice attracts a higher price than paddy.

Table 2: Forms in which rice was sold

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

Source: Survey data 2009

Table 3 presents the categorical socio-economic characteristics of the sampled rice-growing households. The results show 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 because rice mills are 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 their homes. 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".

Table 3: 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*

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 or electricity to run the mill being unavailable at the time of visitation to the mill.

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 un-milled rice from farmers. The "un-milled" 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 4. They show that on average, households which milled all their rice before selling ("milled" category) were endowed with significantly bigger landholdings (5.33 acres) and households (8 people), which, among other factors 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 is directly constrained by the distance traveled by farmers to access milling services, but is indirectly enabled by household endowment of land and family labor through their effect on the size of rice plots (and rice output) that households can cultivate.

Table 4: 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.

Surprisingly, all the variables capturing the human capital endowment of the household in this study (age and education of the household head, and experience in rice farming) do not vary significantly across the different categories of households ("milled", "unmilled" and "both"). This suggests that the influence of human capital on the decision of form in which to sell rice may not be as important as hypothesized.

4.2 Profitability of selling milled and unmilled rice

The second objective of this study was to compare the profitability of selling milled over unmilled rice among rice farming households. This involved examining the costs and returns for each form in which rice was sold. Costs included expenditure on labor for various activities including land preparation, weeding and harvesting, seed cost and transportation cost to the mill and/or place of sale. Following Jamala *et al.,* (2011), the family labor input was first converted to man-days using a factor of 1 for mature adult males and females and 0.50 for children (14 years and above). The number of man-days was then multiplied by the shadow price of family labor, valued at the daily wage rate for hired labor.

Table 5 summarizes the costs incurred by the sampled households in the production and marketing of rice. The results show that the average cost of labor estimated at Ushs 184,324 per acre for the entire study sample was much higher than the cost of seed (Ushs 10,568 per acre), transport (Ushs 6,590) and post harvest handling (Ushs 17,517) 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 235,276per 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 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. 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 milling and post harvest handling) incurred by households that mill all their rice before sale to make rice-milling profitable.

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 Elepu and Nalukenge (2009); Sserunkuuma (2008); Fatoba *et al.,* (2009); Astewel (2010); and Banta *et al*., (2008). 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 916,956/acre) from rice sales than their cohorts who sell all (Ushs 457,581/acre) or part (Ushs 651,268/acre) of their rice as paddy. This suggests 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 5: Rice Revenue and Costs of Production and Marketing

Variable	Mean values			
	Overall Sample (N=194)	"Unmilled" (N=33)	"Milled" (N=94)	"Both" (N=67)
A: Rice sales (kg/acre)	772.99(689.94)	668.74(885.29)	859.69(619.27)	702.69(671.16)
Price (Ushs/kg)		900.30[a] (195.42)	1,437.77[b] (312.87)	
Total Revenue/acre	96,6056.7 (811,797)	590,170[a] (800,877.5)	1,197,713[b] (783,756.7)	826,185[a] (763,955.2)
B: Operating Costs				
Seed cost (Ushs/acre)	10,568.14 (13,343.73)	7,700.56 (7,563.14)	15,138.36 (16,416.77)	5,568.57 (7,344.68)
Post harvest handling (Ushs)	17,516.81 (23,201.81)	9,818.18 (17,821.08)	22,413.12 (26,155.79)	14,439.23 (19,565.73)
Transport cost (Ushs)	6,590.72 (10,829.1)	2,166.67[a] (5,572.907)	7,928.72[b] (10,070.88)	6,892.54[b] (13,134.83)
Milling cost (Ushs/kg)			84.16 (17.91)	
C: Labour Cost				
Land preparation(Ushs/acre)	51,389.2 (58,499.32)	33,527.02 (55,604.35)	65,012.73 (67,015.66)	41,073.37 (40,594.53)
Nursery bed (Ushs/acre)	12,228.07 (8,888.29)	7,584.74 (8,932.73)	15,397.87 (8,929.83)	10,067.91 (7,081.05)
Transplanting (Ushs/acre)	22,549.27 (19,659.78)	13,251.52 (17,070.99)	29,601.06 (21,298.52)	17,235.5 (14,388.5)
Chemical application /acre	7,523.58 (13,715.24)	4,415.59 (13,392.21)	10,599.57 (15,742.26)	4,738.81 (9,366.83)
Weeding (Ushs/acre)	35,455.15 (38,871.81)	19,818.18 (26,198.41)	45,882.98 (45,244.11)	28,526.87 (29,588.77)
Bird scaring (Ushs/acre)	28,537.8 (20,279.4)	17,676.77 (17,661.6)	34,207.45 (20,048.65)	25,932.84 (19,321.82)
Harvesting (Ushs/acre)	26,641.24 (31,522.07)	16,630.3 (30,479)	34,574.47 (34,622.77)	20,441.79 (24,235.27)
Total	184,324.3 (174,039)	112,904.1[a] (157,323.6)	235,276.1[b] (193,713.3)	148,016.8[a] (126,931.9)
D: TVC/acre = B+C	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)
E: GM/acre = A-D	747,056.7 (648,787.9)	457,580.5[a] (644,861.1)	916,956.3[b] (616,837.2)	651,267.9[a] (633,087.3)

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

4.3 Factors affecting the proportion of rice sold as grain by rice-growing households

Table 6 presents the results of regression analysis on the determinants of proportion of rice sold as grain. The results show that rice output, household size, price of milled rice, distance to nearest rice mill and membership in rice farmers' groups significantly affect the proportion of rice sold as grain.

Table 6: Results of Regression Analysis

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

Number of obs = 194
LR chi2(8) = 194.88
Prob > chi2 = 0.0000
Log likelihood = -94.00516   Pseudo R2 = 0.5090

Explanatory Variables	Coefficients	Marginal effects		
		$\frac{\partial Ey}{\partial X_i}$	$\frac{\partial Ey^*}{\partial X_i}$	$\frac{\partial F(z)}{\partial X_i}$
Experience	-0.007 (0.005)	-0.005	-0.003	-0.006
Education	0.007 (0.010)	0.005	0.003	0.005
Household size	0.024** (0.012)	0.016	0.009	0.019
Price of milled rice	0.001*** (0.0001)	0.001	0.0004	0.001
Distance to rice mill	-0.045*** (0.012)	-0.030	-0.017	-0.036
Group- Membership^	0.136** (0.076)	0.135	0.077	0.148
Rice Output[a]	0.145*** (0.043)	0.097	0.056	0.115
Other income sources	-0.032 (0.110)	-0.021	-0.012	-0.026
Constant	-1.121*** (0.305)			

Observation summary: *33 left-censored observations at Prop<=0*
69 uncensored observations
92 right-censored observations at Prop>=1

*^=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 Komarek

(2010); Sserunkuuma *et al*., (2010); Bellemare and Barrett (2004); Otieno *et al*., (2009); and Ahuja *et al*., (2003) 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.

The volume of rice harvested by the household is also positively and significantly associated with the proportion of rice sold as grain. This is 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.

Also, the number of people in a household had a positive influence on the proportion of rice sold as grain. Increasing the number of people in a household (family labor) by one person would lead to an increase in the proportion of rice sold as grain. This is likely because the higher family labor endowment enables the household to produce more, thereby reducing per unit fixed transaction costs of milling as explained above.

Membership in a rice-farmers' group is associated with a significantly higher proportion of rice sold as grain. This is because it enables easier access to milling services through transport-pooling, for example, and entitles member farmers to other benefits that could explain the higher tendency to mill before sale. Therefore, the third hypothesis of this study, which states that membership to rice farmers' groups positively affects the proportion of rice sold as grain is supported by the study findings.

As expected, distance to the nearest rice mill is negatively and significantly associated with the proportion of rice sold as grain. As mentioned earlier, this is 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; Komarek, 2010; Otieno *et al.*, 2009; Wakulira, 2010) that distance to market reduces the proportion of marketed output. The result supports the second hypothesis for this study, which states that distance to the nearest rice mill negatively affects the proportion of rice sold as grain.

Following McDonald and Moffitt (1980), the elasticities of the Tobit model are decomposed into three parts as shown in Table 6. The third column of the table shows the marginal effects of unconditional expected value of the dependent variable; the fourth column indicates the marginal effects of the expected value of the dependent variable conditional on being uncensored or above zero; the last column shows the marginal effects of the probability of being above zero or uncensored.

The results show that 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 1.6%; increases the proportion of rice sold as grain (for households selling milled rice) by 0.9%; and increases the likelihood of selling rice 1.9%. Also, 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%.

Increasing the distance to the nearest rice mill by one kilometer reduces the proportion of rice sold by all rice-growing households by 3%; reduces the proportion of rice milled before sale (for households selling milled rice) by 1.7%; and reduces the probability of making a sale by 3.6%. Having membership in a rice-farmers’ group increases the proportion of harvested rice sold by 13.5%; increases the proportion of rice sold as grain by 7.7%; and increases their probability of making a sale by 14.8%. Finally, increasing the harvested volume of rice by 1 kg increases the proportion of harvested rice sold by 9.7%; increases the proportion of rice sold as grain by 5.6%; and increases the likelihood of selling rice by 11.5%.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Summary of findings

This study was undertaken with the overall objective of examining why some rice-growing households in Uganda sell their rice in paddy form (unmilled) which attracts a lower price than milled rice (grain), despite notable improvements in availability of milling services in the recent past; and how this affects the profitability (net returns) of rice production. Comparing returns from selling milled versus unmilled rice was presumed to be particularly informative, since the profitability of milling (or lack of it) could explain why some farmers sell milled rice and others don't; the increased availability of rice mills notwithstanding. The study is justified on the grounds that the form in which a household chooses to sell its rice affects the returns to rice production, which in turn affects the scale of production; the ability and willingness to adopt yield enhancing technologies; as well as the sustainability of rice production and its contribution to poverty reduction in Uganda.

Data for this study were collected in October 2009, through a survey of 194 rice farmers in Eastern Uganda districts of Pallisa, Bugiri, Bukedea and Mayuge districts, who grew rice in the first season of 2009 and second season of 2008. The data was analyzed using both univariate and multivariate methods. Descriptive statistical methods (means and percentages, tests of differences between these) were used to characterize rice-growing households by the form in which they sell rice; while the profitability of rice production was estimated using gross margin analysis and compared using the difference of mean test between households that sell milled rice and those that don't. The factors influencing the proportion of rice sold in milled form (grain) were analysed using the Tobit regression model.

The surveyed households were grouped into three categories based on the form in which they sold their rice produced in the first season of 2009 and second season of 2008. The first category, “unmilled”, consisted of 17% of the sampled households that sold all their rice as paddy; while the second category, “milled”, consisted of 48.5% of the sampled households that sold all their rice as grain; and the third category, “both”, consisted of 34.5% of the sampled households that sold part of their rice as paddy and the other part as grain. This shows that most of the sampled households (83%) invest in milling all or part of their rice before selling because milled rice attracts a higher price than paddy. The average price for milled rice was estimated at Ushs 1,438 per kilogram, which is significantly higher than the price of paddy, estimated at Ushs 900 per kilogram.

Nearly all the sampled households (94.6%) were headed by men, but less than half of the households (40%) had membership in farmers groups. 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%). The “milled” category had the largest proportion of households selling rice at the trading centre (66%) and town (14.9%), largely because rice mills are mostly located in local trading centres and towns, and those who mill rice sell it at the place of milling. 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, or electricity to run the mill being unavailable at the time when they visited the mills. The majority of households sold their rice to wholesale traders (36.6%), local traders (26.3%) and rice millers (25.3%). 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 labor was found to be the most significant cost item in rice production.

On average, households which milled all their rice before selling ("milled" category) were endowed with significantly bigger landholdings (5.33 acres) and households (8 people), which, among other factors enabled them to cultivate bigger rice plots (1.53 acres) and harvest bigger volumes of rice 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.

Profitability analysis show that rice production is associated with positive gross margins, regardless of the form in which it is sold, implying that rice production is a profitable venture. However, although households which mill all their rice before sale incur significantly higher variable costs on labor, seed, transport and milling charges than their cohorts who sell all or part of their rice as paddy, they receive higher gross margins. This implies that the higher price of milled rice (Ushs 1,438/kg) relative to paddy (Ushs 900/kg) 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.

Results of regression analysis on the determinants of proportion of rice sold as grain show that human capital endowment of the household (measured by education of the household head and experience in rice farming) does not significantly affect the proportion of rice sold as grain, which is consistent with the descriptive results. However, the price of milled rice, volume of harvested rice, household size and membership in rice-farmers' group have significant and positive relationships with the proportion of rice sold as grain; while distance to the nearest rice mill is negatively and significantly associated with the proportion of rice sold as grain. These results imply that the hypotheses for this study (positive relationship between the proportion of rice sold as grain and membership to rice farmers' groups; and negative positive relationship between the proportion of rice sold as grain and distance to nearest rice mill) cannot be rejected on the basis of the study findings.

The positive relationship between the price of milled rice and the proportion of rice sold as grain implies that the price of milled rice acts as an incentive for investment in rice-milling before sale. The positive effect of volume of rice harvested on the proportion of rice sold as grain implies scale economies in rice milling, with larger farmers finding it cheaper to invest in milling before sale because of their ability to spread the fixed transaction costs of milling over a larger volume of produce. Also, household size is positively associated with the proportion of rice sold as grain likely because larger households are endowed with more family labor, which enables them to produce more and reduce the milling costs they face because of scale economies.

Membership in a rice-farmers' group is associated with a significantly higher proportion of rice sold as grain because it enables easier access to milling services through transport-pooling and entitles member farmers to other benefits that motivate them to mill their rice before sale. Finally, distance to the nearest rice mill is negatively and significantly associated with the proportion of rice sold as grain as hypothesized. This is 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.

5.2 Conclusion 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 may 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. This recommendation is supported by the positive relationships between the proportion of rice sold as grain and membership in farmers' groups and volume of rice harvested.

The negative relationship between the proportion of rice sold as grain and distance to the nearest rice miller suggests that interventions that enable milling services to be brought closer to farmers in major rice-growing areas would go further to reduce the transactions costs of accessing milling services and encourage rice-milling before sale. Possible areas of intervention include facilitating private entrepreneurs to set up milling plants closer to farmers through rural electrification and reduction of electricity tariffs or improving the rural road network to facilitate private investments in mobile rice mills.

The positive relationship between the price of milled rice and the proportion of rice sold as grain suggests that in the future, the above-suggested interventions may 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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APPENDICES

Appendix 1: Stata Results of pair wise t test for continuous variables

```
ttest Age, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    40.48485    2.145344    12.32406    36.11493    44.85477
  milled |      94    39.19149    1.173886    11.38125    36.86038    41.52259
---------+--------------------------------------------------------------------
combined |     127    39.52756    1.029124    11.59764    37.49095    41.56416
---------+--------------------------------------------------------------------
    diff |            1.293359    2.353188               -3.363892     5.95061
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =   0.5496
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7082         Pr(|T| > |t|) = 0.5836          Pr(T > t) = 0.2918
```

```
ttest Age, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    40.48485    2.145344    12.32406    36.11493    44.85477
both mil |      67    41.16418    1.524205    12.47616    38.12101    44.20735
---------+--------------------------------------------------------------------
combined |     100       40.94    1.236794    12.36794    38.48593    43.39407
---------+--------------------------------------------------------------------
    diff |           -.6793306    2.642782               -5.923846    4.565185
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -0.2571
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3988         Pr(|T| > |t|) = 0.7977          Pr(T > t) = 0.6012
```

```
ttest Age, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    39.19149    1.173886    11.38125    36.86038    41.52259
Both mil |      67    41.16418    1.524205    12.47616    38.12101    44.20735
---------+--------------------------------------------------------------------
combined |     161    40.01242    .9340018    11.85115    38.16786    41.85698
---------+--------------------------------------------------------------------
    diff |            -1.97269    1.894339               -5.714002    1.768622
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =  -1.0414
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1496         Pr(|T| > |t|) = 0.2993          Pr(T > t) = 0.8504
```

```
ttest Education, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    6.424242    .7525591    4.323123     4.89133    7.957155
  milled |      94    5.946809    .3866235    3.748454    5.179051    6.714566
---------+--------------------------------------------------------------------
combined |     127    6.070866     .345518    3.893791    5.387096    6.754636
---------+--------------------------------------------------------------------
    diff |            .4774339    .7898598               -1.085797    2.040665
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =   0.6045
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7267         Pr(|T| > |t|) = 0.5466          Pr(T > t) = 0.2733


ttest Education, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    6.424242    .7525591    4.323123     4.89133    7.957155
both mil |      67    5.522388    .4334281    3.547762    4.657021    6.387755
---------+--------------------------------------------------------------------
combined |     100        5.82    .3822792    3.822792    5.061475    6.578525
---------+--------------------------------------------------------------------
    diff |            .9018544    .8120351               -.7096029    2.513312
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =   1.1106
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.8653         Pr(|T| > |t|) = 0.2695          Pr(T > t) = 0.1347


ttest Education, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    5.946809    .3866235    3.748454    5.179051    6.714566
Both mil |      67    5.522388    .4334281    3.547762    4.657021    6.387755
---------+--------------------------------------------------------------------
combined |     161    5.770186    .2885292    3.661025     5.20037    6.340003
---------+--------------------------------------------------------------------
    diff |            .4244205    .5862206                -.733363    1.582204
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   0.7240
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7649         Pr(|T| > |t|) = 0.4701          Pr(T > t) = 0.2351


ttest HHsize, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    6.787879    .4821778      2.7699    5.805715    7.770043
  milled |      94    8.042553    .4251085    4.121579    7.198372    8.886734
---------+--------------------------------------------------------------------
combined |     127    7.716535    .3412809     3.84604    7.041151     8.39192
---------+--------------------------------------------------------------------
    diff |           -1.254674    .7732117               -2.784956    .2756076
------------------------------------------------------------------------------
```

```
    diff = mean(unmilled) - mean(milled)                          t =  -1.6227
Ho: diff = 0                                     degrees of freedom =      125

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0536         Pr(|T| > |t|) = 0.0921          Pr(T > t) = 0.9464


ttest HHsize, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    6.787879    .4821778      2.7699    5.805715    7.770043
both mil |      67    6.761194    .3281526    2.686044    6.106016    7.416372
---------+--------------------------------------------------------------------
combined |     100        6.77         .27         2.7    6.234261    7.305739
---------+--------------------------------------------------------------------
    diff |            .0266848    .5771241               -1.118599    1.171969
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =   0.0462
Ho: diff = 0                                     degrees of freedom =       98

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.5184         Pr(|T| > |t|) = 0.9632          Pr(T > t) = 0.4816


ttest HHsize, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    8.042553    .4251085    4.121579    7.198372    8.886734
Both mil |      67    6.761194    .3281526    2.686044    6.106016    7.416372
---------+--------------------------------------------------------------------
combined |     161    7.509317    .2868925    3.640258    6.942732    8.075901
---------+--------------------------------------------------------------------
    diff |            1.281359     .574944                .1458469    2.416871
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   2.2287
Ho: diff = 0                                     degrees of freedom =      159

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9864         Pr(|T| > |t|) = 0.0272          Pr(T > t) = 0.0136


ttest Riceplotsize, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    .6286364    .0878872    .5048735     .449616    .8076567
  milled |      94    1.533085    .0921391    .8933217    1.350115    1.716055
---------+--------------------------------------------------------------------
combined |     127    1.298071    .0799768    .9012927    1.139799    1.456343
---------+--------------------------------------------------------------------
    diff |           -.9044487    .1642548               -1.229529    -.579368
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =  -5.5064
Ho: diff = 0                                     degrees of freedom =      125

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000


ttest Riceplotsize, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    .6286364    .0878872    .5048735     .449616    .8076567
```

```
both mil |      67    .6533284    .1121138    .9176909     .429486    .8771708
---------+--------------------------------------------------------------------
combined |     100      .64518    .0802474    .8024743    .4859517    .8044083
---------+--------------------------------------------------------------------
    diff |           -.024692    .1715123               -.3650527    .3156687
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -0.1440
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.4429         Pr(|T| > |t|) = 0.8858          Pr(T > t) = 0.5571
```

```
ttest Riceplotsize, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    1.533085    .0921391    .8933217    1.350115    1.716055
Both mil |      67    .6533284    .1121138    .9176909     .429486    .8771708
---------+--------------------------------------------------------------------
combined |     161    1.166975    .0788295    1.000234    1.011295    1.322656
---------+--------------------------------------------------------------------
    diff |           .8797567    .1444601                .5944486    1.165065
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   6.0900
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

```
ttest land, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    3.746061    .5754664    3.305803    2.573874    4.918247
  milled |      94    5.330319    .4906737    4.757258    4.355938      6.3047
---------+--------------------------------------------------------------------
combined |     127    4.918661    .3965024    4.468355    4.133995    5.703328
---------+--------------------------------------------------------------------
    diff |          -1.584259    .8966064               -3.358754    .1902369
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =  -1.7669
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0398         Pr(|T| > |t|) = 0.0797          Pr(T > t) = 0.9602
```

```
ttest land, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    3.746061    .5754664    3.305803    2.573874    4.918247
both mil |      67     3.94197    .5330993    4.363606    2.877603    5.006337
---------+--------------------------------------------------------------------
combined |     100     3.87732    .4029268    4.029268    3.077826    4.676814
---------+--------------------------------------------------------------------
    diff |          -.1959095    .8610366               -1.904609     1.51279
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -0.2275
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.4102         Pr(|T| > |t|) = 0.8205          Pr(T > t) = 0.5898
```

```
ttest land, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    5.330319    .4906737    4.757258    4.355938      6.3047
Both mil |      67     3.94197    .5330993    4.363606    2.877603    5.006337
---------+--------------------------------------------------------------------
combined |     161    4.752559    .3652639    4.634679    4.031199    5.473919
---------+--------------------------------------------------------------------
    diff |            1.388349    .7351495               -.0635686    2.840267
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   1.8885
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9696         Pr(|T| > |t|) = 0.0608          Pr(T > t) = 0.0304
```

```
ttest Output, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    271.8788    52.32011    300.5561    165.3062    378.4514
  milled |      94    982.1915    71.37778    692.0332    840.4494    1123.934
---------+--------------------------------------------------------------------
combined |     127     797.622     61.1072    688.6432    676.6927    918.5514
---------+--------------------------------------------------------------------
    diff |           -710.3127    124.6377               -956.9862   -463.6392
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =  -5.6990
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

```
ttest Output, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    271.8788    52.32011    300.5561    165.3062    378.4514
both mil |      67    735.8955    76.31337    624.6519     583.531    888.2601
---------+--------------------------------------------------------------------
combined |     100      582.77    58.08715    580.8715    467.5125    698.0275
---------+--------------------------------------------------------------------
    diff |           -464.0167     114.975               -692.1809   -235.8525
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -4.0358
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0001         Pr(|T| > |t|) = 0.0001          Pr(T > t) = 0.9999
```

```
ttest Output, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    982.1915    71.37778    692.0332    840.4494    1123.934
Both mil |      67    735.8955    76.31337    624.6519     583.531    888.2601
---------+--------------------------------------------------------------------
combined |     161    879.6957    53.11132    673.9071     774.806    984.5853
---------+--------------------------------------------------------------------
    diff |             246.296    106.3074                36.33929    456.2526
------------------------------------------------------------------------------
```

```
    diff = mean(milled) - mean(Both mil)                          t =   2.3168
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9891         Pr(|T| > |t|) = 0.0218          Pr(T > t) = 0.0109
```

```
ttest Experience, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    6.818182    1.277319    7.337636    4.216369    9.419995
  milled |      94    8.723404    .7717567    7.482459    7.190848    10.25596
---------+--------------------------------------------------------------------
combined |     127    8.228346    .6622641    7.463338    6.917745    9.538948
---------+--------------------------------------------------------------------
    diff |           -1.905222    1.506551               -4.886873    1.076428
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =  -1.2646
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1042         Pr(|T| > |t|) = 0.2084          Pr(T > t) = 0.8958
```

```
ttest Experience, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    6.818182    1.277319    7.337636    4.216369    9.419995
both mil |      67    9.089552    1.017204    8.326175    7.058639    11.12047
---------+--------------------------------------------------------------------
combined |     100        8.34    .8048113    8.048113     6.74308     9.93692
---------+--------------------------------------------------------------------
    diff |            -2.27137    1.704931                -5.65475    1.112009
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -1.3322
Ho: diff = 0                                     degrees of freedom =       98

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0929         Pr(|T| > |t|) = 0.1859          Pr(T > t) = 0.9071
```

```
ttest Experience, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    8.723404    .7717567    7.482459    7.190848    10.25596
Both mil |      67    9.089552    1.017204    8.326175    7.058639    11.12047
---------+--------------------------------------------------------------------
combined |     161    8.875776     .616401    7.821251    7.658445    10.09311
---------+--------------------------------------------------------------------
    diff |            -.366148    1.254102               -2.842995    2.110699
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =  -0.2920
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3853         Pr(|T| > |t|) = 0.7707          Pr(T > t) = 0.6147
```

```
ttest Distance, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    4.840606    .8421452    4.837756    3.125212       6.556
  milled |      94    3.279734    .3560139    3.451683    2.572761    3.986707
---------+--------------------------------------------------------------------
combined |     127    3.685315    .3460677    3.899984    3.000457    4.370173
---------+--------------------------------------------------------------------
    diff |            1.560872    .7798742                .0174042     3.10434
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =   2.0014
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9762         Pr(|T| > |t|) = 0.0475          Pr(T > t) = 0.0238
```

```
ttest Distance, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    4.840606    .8421452    4.837756    3.125212       6.556
both mil |      67    3.183806    .4690301    3.839177    2.247357    4.120255
---------+--------------------------------------------------------------------
combined |     100     3.73055    .4243127    4.243127    2.888622    4.572478
---------+--------------------------------------------------------------------
    diff |              1.6568    .8914016               -.1121574    3.425758
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =   1.8586
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9670         Pr(|T| > |t|) = 0.0661          Pr(T > t) = 0.0330
```

```
ttest Distance, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    3.279734    .3560139    3.451683    2.572761    3.986707
Both mil |      67    3.183806    .4690301    3.839177    2.247357    4.120255
---------+--------------------------------------------------------------------
combined |     161    3.239814    .2842368    3.606561    2.678474    3.801153
---------+--------------------------------------------------------------------
    diff |            .0959281    .5784006               -1.046411    1.238267
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   0.1659
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.5658         Pr(|T| > |t|) = 0.8685          Pr(T > t) = 0.4342
```

Appendix 2: Stata results of pair wise t test on gross margins

```
ttest TRperacre, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33      590170    139414.9    800877.5    306191.2    874148.9
  milled |      94     1197713    80838.33    783756.7     1037184     1358242
---------+--------------------------------------------------------------------
combined |     127     1039847    73593.99    829362.1    894206.9     1185488
---------+--------------------------------------------------------------------
    diff |           -607542.6    159479.1               -923171.5   -291913.8
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =  -3.8095
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0001         Pr(|T| > |t|) = 0.0002          Pr(T > t) = 0.9999
```

```
ttest TRperacre, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33      590170    139414.9    800877.5    306191.2    874148.9
both mil |      67      826185    93331.98    763955.2    639841.7     1012528
---------+--------------------------------------------------------------------
combined |     100    748300.1    78028.72    780287.2    593474.2      903126
---------+--------------------------------------------------------------------
    diff |             -236015    165075.2               -563601.4    91571.39
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -1.4297
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0780         Pr(|T| > |t|) = 0.1560          Pr(T > t) = 0.9220
```

```
ttest TRperacre, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94     1197713    80838.33    783756.7     1037184     1358242
Both mil |      67      826185    93331.98    763955.2    639841.7     1012528
---------+--------------------------------------------------------------------
combined |     161     1043102    62630.77    794695.4    919412.2     1166791
---------+--------------------------------------------------------------------
    diff |            371527.6    124007.7                126612.9    616442.4
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   2.9960
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9984         Pr(|T| > |t|) = 0.0032          Pr(T > t) = 0.0016
```

```
ttest TVCperacre, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    132589.5     30295.2    174032.7    70880.22    194298.8
  milled |      94    280756.3    22742.34    220495.2    235594.6    325918.1
---------+--------------------------------------------------------------------
combined |     127    242256.3    19407.06    218706.5    203850.3    280662.3
---------+--------------------------------------------------------------------
```

```
    diff |           -148166.8    42407.15              -232095.8    -64237.8
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =  -3.4939
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0003         Pr(|T| > |t|) = 0.0007          Pr(T > t) = 0.9997


ttest TVCperacre, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    132589.5     30295.2    174032.7    70880.22    194298.8
both mil |      67    174917.1    18037.54    147643.6      138904    210930.2
---------+--------------------------------------------------------------------
combined |     100      160949    15723.36    157233.6    129750.4    192147.6
---------+--------------------------------------------------------------------
    diff |            -42327.6    33335.92              -108481.6    23826.45
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -1.2697
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1036         Pr(|T| > |t|) = 0.2072          Pr(T > t) = 0.8964


ttest TVCperacre, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    280756.3    22742.34    220495.2    235594.6    325918.1
Both mil |      67    174917.1    18037.54    147643.6      138904    210930.2
---------+--------------------------------------------------------------------
combined |     161    236711.4    15760.23    199974.9    205586.5    267836.3
---------+--------------------------------------------------------------------
    diff |            105839.2    30955.89               44701.45      166977
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   3.4190
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9996         Pr(|T| > |t|) = 0.0008          Pr(T > t) = 0.0004


ttest GMperacre, by(Group1)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    457580.5    112255.9    644861.1    228922.7    686238.3
  milled |      94    916956.3     63621.9    616837.2    790615.9     1043297
---------+--------------------------------------------------------------------
combined |     127      797591    58008.67    653724.5    682793.5    912388.4
---------+--------------------------------------------------------------------
    diff |           -459375.8    126286.5              -709312.4   -209439.2
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(milled)                          t =  -3.6376
Ho: diff = 0                                     degrees of freedom =      125
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0002         Pr(|T| > |t|) = 0.0004          Pr(T > t) = 0.9998
```

```
ttest GMperacre, by(Group2)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
unmilled |      33    457580.5    112255.9    644861.1    228922.7    686238.3
both mil |      67    651267.9    77343.92    633087.3    496845.8      805690
---------+--------------------------------------------------------------------
combined |     100    587351.1    64030.68    640306.8    460300.3    714401.8
---------+--------------------------------------------------------------------
    diff |           -193687.4    135461.2               -462505.7    75130.92
------------------------------------------------------------------------------
    diff = mean(unmilled) - mean(both mil)                        t =  -1.4298
Ho: diff = 0                                     degrees of freedom =       98
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0780         Pr(|T| > |t|) = 0.1559          Pr(T > t) = 0.9220
```

```
ttest GMperacre, by(Group3)
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  milled |      94    916956.3     63621.9    616837.2    790615.9     1043297
Both mil |      67    651267.9    77343.92    633087.3    496845.8      805690
---------+--------------------------------------------------------------------
combined |     161    806390.3    50077.39    635410.9    707492.4    905288.3
---------+--------------------------------------------------------------------
    diff |            265688.4     99710.6                68760.36    462616.5
------------------------------------------------------------------------------
    diff = mean(milled) - mean(Both mil)                          t =   2.6646
Ho: diff = 0                                     degrees of freedom =      159
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9957         Pr(|T| > |t|) = 0.0085          Pr(T > t) = 0.0043
```

.

Appendix 3: Stata results for Tobit model

```
tobit  Prop  Experience  Education  HHsize  price  Distance  Membership  Inoutput
Otherincome, ll(0) ul(1)

Tobit regression                                  Number of obs   =        194
                                                  LR chi2(8)      =     194.88
                                                  Prob > chi2     =     0.0000
Log likelihood = -94.00516                        Pseudo R2       =     0.5090
----------------------------------------------------------------------------
        Prop |    Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+--------------------------------------------------------------
  Experience |-.0069794   .0047165    -1.48   0.141    -.0162841    .0023253
   Education | .0068525   .0097051     0.71   0.481    -.0122937    .0259988
      HHsize | .023562    .0115172     2.05   0.042     .0008409    .0462831
       price | .0009576   .0000972     9.85   0.000     .0007657    .0011494
    Distance |-.0447594   .0120598    -3.71   0.000     -.068551   -.0209678
  Membership | .1981017   .0802515     2.47   0.014     .0397815    .3564219
    Inoutput | .145163    .042788      3.39   0.001     .0607509    .2295752
 Otherincome | -.032136   .1096173    -0.29   0.770    -.2483891    .1841172
       _cons |-1.120812   .3050469    -3.67   0.000    -1.722609   -.5190154
-------------+--------------------------------------------------------------
      /sigma | .3891592   .0379514                      .3142887    .4640298
----------------------------------------------------------------------------
  Obs. summary:         33  left-censored observations at Prop<=0
                        69     uncensored observations
                        92 right-censored observations at Prop>=1
```

```
-------------------------------------------------------------------------
         | Marginal Effects at Means
         |----------------------------------------------------------------
         |   Latent      Unconditional     Conditional on      Probability
  Name   |  Variable     Expected Value    being Uncensored    Uncensored
---------+----------------------------------------------------------------
Experience |-.00697943     -.00465681        -.00269253        -.00555244
Education |  .00685255      .00457215         .00264358          .0054515
  HHsize |   .02356198      .01572101         .00908976         .01874459
   price |   .00095756       .0006389         .00036941         .00076178
Distance |  -.04475936      -.0298643         -.0172673        -.03560804
Membership*| .19810167      .13470809         .07744028         .14798536
Inoutput |   .14516304      .09685556         .05600111         .11548358
Otherincome |-.03213595    -.02144172        -.01239743        -.02556556
   _cons |   -1.120812     -.74782723        -.43238769        -.89165521
---------+----------------------------------------------------------------
(*) dF/dx is for discrete change of dummy variable from 0 to 1
```

Appendix 4: Partial correlation index

```
cor Prop Experience Education HHsize price Distance Membership Inoutput
Otherincome(obs=194)

             | Prop  Experi~e Educat~n  HHsize  price   Distance Member  output Other
-------------+------------------------------------------------------------------------
        Prop | 1.0000
  Experience | 0.0787  1.0000
   Education |-0.0540 -0.1000  1.0000
      HHsize | 0.1333  0.2189 -0.0153  1.0000
       price | 0.4179  0.1760 -0.1054  0.0979  1.0000
    Distance |-0.1103  0.1081 -0.0671  0.0508  0.0939   1.0000
  Membership | 0.0181  0.0987  0.0115 -0.0625  0.0258  -0.3947  1.0000
    Inoutput | 0.4989  0.1343 -0.0164  0.0936  0.4078  -0.2591  0.1885  1.0000
   Other~ome |-0.1079 -0.0581  0.1687  0.0393 -0.1144   0.0541 -0.1525 -0.3070 1.0000
```