The Development of Agricultural Markets in Sub-Saharan Africa: The Case of Rice in Uganda

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Abstract

If agricultural markets do now work well in sub-Saharan Africa, it is inconceivable to increase crop yields, as this requires the increased application of purchased inputs and the marketing of increased output.   This study investigates whether and to what extent rice markets function in Uganda, where rice is a new crop.   We found that the number of rice millers has increased responding to the increased demand for their services. Milled rice prices tend to be equalized across wide areas, which indicates that local rice markets are integrated.   Furthermore, non-price completion, e.g., the provision of credit and free storage services by rice millers, is observed in areas where the competition is intense.

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1. Introduction

The Rural population in Sub-Saharan African countries (SSA) highly depend on agriculture for their livelihood. Using agriculture as the basis for economic growth and poverty reduction in the agriculture-based countries requires a productivity revolution in smallholder farming (World Bank, 2007). Given that rice is a major cereal crop that has great potential for an increase in productivity in SSA, strategic efforts to enhance rice production are urgently needed not only for food security but also for income generation (Kijima et al., 2008; Diao, et al., 2008; Otsuka and Kijima, 2010; Larson et al., 2010). It is not possible to realize a rice Green Revolution in SSA, however, if agricultural markets do not function well since inefficient markets discourage producers from intensifying input use and expanding production by increasing input prices, depressing output prices, and heightening price volatilities. How well agricultural markets function, therefore, is critically important to enhance the income and productivity of the smallholders in SSA.

It is widely believed that the market does not function well in SSA because the poor infrastructure, weak institutions, and lack of credit lead to inefficient operation (Fafchamps, 2004; Stephens and Barrett, 2011). This belief has been reinforced by empirical analyses testing whether an agricultural market is regionally integrated or not by using time-series price data (Fackler and Goodwin, 2001). The recently

recommended test for market efficiency is to analyze not only price information but also

additional information on non-price data to describe the function of the markets (Moser

et al., 2009; Rashid and Minot, 2010). In this study, we look closely at the entry

decision of market agents. To our knowledge, few studies have examined such entry

decisions in SSA with the exception of Barrett (1997). As a case of a newly emerging

agricultural market, we examine the rice milling industry in Uganda, where rice is not a

traditional crop but its production has been expanding rapidly because of relatively high

rice prices and the introduction of new upland and lowland rice production technologies

(Kijima et al. 2006, 2010, 2011).

In Uganda, similar to other SSA (Furuya and Sakurai, 2005), rice producers

transport their paddy to rice millers by bicycle and motorcycle if the distance between

the farm-gate and the rice miller is short or by loading the rice on buses and hiring

trucks if the distance is long. Rice millers charge milling fees to the producers

depending on the amount processed. Producers sell milled rice to traders who wait for

producers to come to the rice millers. It is rare that traders buy paddy rice from rice

millers.[1] The currently traded price is announced by the rice miller and the transaction

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[1] In some of the rice producing areas with high transportation costs to the rice millers,
the wholesaler comes and buys the paddy rice at the farm-gate. This practice, however,
is not common. In Asia, it is common that traders and middlemen buy paddy from
farmers (Hayami and Kawagoe, 1993; Minot and Goletti, 2000). According to Fujiie
(2009), since the quality of milling machines is not good in Uganda and buying rice in
paddy form leaves the risk of getting low quality rice to traders, traders prefer milled
rice to paddy rice.

between the producers and traders is made based on such a price. In other words, rice millers seem to play the role of intermediary between producers and traders. Without rice millers, marketing rice by smallholder farmers could be quite difficult. In fact, in areas where rice production has recently started, farmers had problems with selling rice after harvest because of the poor access to rice millers (Kijima et al., 2008).

To investigate how the rice market systems function, we interviewed 374 rice millers in 43 districts in Uganda. We find surge in the number of rice millers, particularly after 2005, which coincides with the rapid expansion of rice production in this country. This suggests that rice millers enter the market where the demand for rice milling services has increased. Thanks to the entry of rice millers, and probably wholesale traders as well, the rice market appears to function better more recently. Thus, we would like to postulate the hypothesis that the differences in rice prices across wide areas are explained by the transport cost, particularly in recent years, due to the integration of local rice markets. The market of rice milling services tends to be more localized than rice markets because each rice miller serves only small neighbouring areas, whereas a rice trader covers much wider areas. Therefore, it is likely that the conditions of the local market affect the rice milling fees and the provision of additional services by rice millers. In more competitive local markets, the rice miller will set lower milling fees, offer cheap credit to customers, and provide free storage services.

In markets where the demand for high-quality rice is high, high-quality milling machines may be used. These efforts by rice millers are made to attract customers to enhance and stabilize the utilization rate of milling machines.

The rest of the paper is structured as follows. Section 2 describes the survey data and the characteristics of the rice millers. Section 3 postulates the hypotheses. In Section 4, the empirical model and the estimation results are presented. Section 5 concludes.

2. Data and Sample

Since there is no directory of all the rice millers in Uganda, in our survey we attempted to cover all rice millers in major rice production areas in Uganda as well as those in the list shown in the ANNEX of Alphonse et al. (2008)[2]. The sample rice millers are located throughout Uganda. We conducted data collection in March 2009 using a questionnaire which consists of questions on the type of rice milling machines installed; the amount and source of rice milled; the owner, manager, and operator's

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[2] We did not cover Kampala even though it is in the ANNEX2 of Alphonse et al. (2008). Some of the districts shown in the ANNEX3 of Alphonse et al. (2008) also were not covered (Amuru, Busia, Kapchorwa, Kumi, Sironko, Tororo, Kalangala, Kibaale, Masindi). The districts not covered in Alphonse et al. (2008) but covered in this survey are Katakwi, Ibanada, and Isingiro. We did not interview Tilda Uganda Limited, the largest processor of rice in Uganda. Tilda processes 20% of Uganda's rice for domestic market consumption and for export. The reason why we did not interview Tilda is because Tilda not only processes rice but also pack it with Tilda's brand name, which is different from the other rice millers.

characteristics; and assets, revenues, and costs.   As shown in Table 1, the number of

rice millers interviewed is 374 in 43 districts.[3]   Among them, 326 rice millers operated

in 2009.   Sixty-three percent of them are located in the Eastern region, which is a

major lowland rice production area in Uganda.   The locations of the rice millers are

categorized into urban towns with populations of more than 60,000, rural clusters where

there are more than 4 rice millers in the same small locality, and rural non-clusters.[4]

Sixty-two percent of operating millers are located in rural non-cluster.

In columns 4 to 7, the distribution of rice millers are indicated by the years of

starting the business and the location.   Only 4 percent of the rice millers entered the

rice milling market before 1990, and these early entrants are located in the Northern and

Eastern regions where lowland rice cultivation was introduced by the Chinese in the

1970s along with a few irrigation schemes (FAO, 2006).   Rice millers in urban towns

seem to have entered the market earlier than those in rural areas.[5]   The entry of rice

millers was accelerated in the 2000s, especially after 2005.   More than half of the

sample rice millers started their business between 2005 and 2009, especially in the

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[3] The rice millers who did not operate anymore but were included in the list of Alphonse et al (2008) were also interviewed. The forty-three districts are Northern region (Gulu, Lira, Amuru, Apac), Northwestern region (Adjumani, Arua, Yumbe, Moyo, Koboko), Northeastern region (Amuria), Eastern region (Soroti, Butaleja, Bugiri, Pallisa, Kaliro, Iganga, Budaka, Kamuli, Kamutumba, Mbale, Mayuge, Katakwi), Western region (Rukingiri, Kanungu, Kbarole, Kamwenge, Hoima, Ibanda, Kenjojo, Kasese, Bushenyi, Isingiro), Central region (Nakaseke, Wakiso, Kiboga, Mpigi, Mubende, Masaka, Rakai, Kayunga, Mukono, Luwero, Mityana).

[4] All rice millers in urban towns are in cluster.

[5] It is also found that the rice millers formed clusters in town in Ghana (Sakurai et al., 2006).

Western and South-western regions, where new upland rice varieties have been introduced since 2004 through the dissemination program provided by the government and international donor agencies (Kijima et al., 2008, 2011).

The entry pattern of rice millers and the location shifts are clearly seen in Figure 1. Each dot on the map indicates the location of a sampled rice miller. Panel A shows the situation in 1990 when rice millers were only found in the Eastern and Northern regions. Even in 2000, most of the rice millers were located in the Eastern and Northern regions (Panel B). By 2005, however, rice millers had entered the Central and Western regions (Panel C). In the Eastern region, many dots overlap, which indicates the formation of clusters where huge wetland areas had been converted to paddy fields. As is shown in Panel D, by the time of our data collection, the number of rice millers had increased in the Western region close to the border of Congo and Rwanda, where informal cross-border trade, especially the export of agricultural commodities, has been increasing recently (UBOS, 2006). Compared with the Eastern region, the number of rice millers in the Northern region has not increased probably because until recently, attacks and abduction of children by rebels had caused farm households to escape to refugee camps and thus deterred agricultural production in many of the Northern districts since 1996 (Blattman and Annan, 2009). Overall it seems clear that rice millers have entered the market in areas where the demand for rice

milling services has newly emerged.

In the rice miller survey, we asked rice millers the names of the major rice producing areas from which their customers (i.e., rice producers) come. Subsequently, we visited 107 sub-counties[6] and interviewed key informants[7] by using a simple questionnaire about rice production in each sub-county, regarding the year when rice cultivation started, the proportion of rice growing households, the availability of government and NGO programs related with the promotion of rice production, common practices of rice cultivation, and the availability of electricity.

Table 2 shows the characteristics of the rice producing sub-counties. The first column shows the earliest year in which rice production began in the sub-county in each region, while the second column shows the median year. When the rice production started, the demand for rice milling service would have emerged. Thus, in sub-counties where rice production started early, rice millers should have been in operation for long periods. In the Northern and Eastern regions, rice production started around 1960, while it began in 2000 in the Central region. As can be seen from Table 1, rice millers tended to be located in urban towns before 1990. One reason may

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[6] In each district, there are two to four counties, in each of which there are three to six sub-counties. The population size of each sub-county varies across districts, but ranges from 2000 to 7000. In each sub-county, there are about 50 LC1s (lowest administrative unit in Uganda, similar to a village).

[7] Respondents were sub-county agriculture officers, sub-county chiefs, sub-county NAADS coordinators, LCIII chairmen, sub-county production officers, or chairmen of farmers' groups.

be the availability of electricity, which is often needed to operate milling machines. As shown in Column 3, most of the production areas did not have access to electricity. This means that rice millers in rural areas have to use alternative sources of energy to operate rice milling machines such as diesel, which is more expensive than electricity. Another reason could be that when rice producing areas were scattered and only a relatively small amount of rice was produced in each location, it would have been advantageous for rice millers to be located in commercial centres.

In the last three columns, the years and coverage of rice production programs available in sub-counties are shown. Rice programs have started in the past 2 to 4 years and 20 to 40% of households have benefited from these programs. This suggests the rapid increase in rice production after 2005 thanks to these rice programs, which may explain the massive entry of new rice millers since then.

It is common that each rice variety has unique characteristics such as the ease of breaking, length of grain, and colour. In Uganda, a whiter colour and longer rice grains are preferred. In addition to such physical characteristics, consumers prefer rice with a lower content of impurities (stones, husks, dust, etc). According to our analyses on the milled rice sample, Supa and upland varieties other than NERICA have less broken grains and Supa has more appealing characteristics such as whiteness and translucency than the other varieties. The proportion of broken grain is higher in rural

non-clusters than in rural clusters.

Table 3 describes the distribution of the rice varieties which are milled at rice millers by region and across the type of locations. In the Eastern region, 78% of the rice milled is lowland rice varieties, while upland varieties are common in the Central and Western regions. Indeed in the Western region, the proportion of NERICA varieties is quite high (36%), which suggests that rice millers in this region started their businesses recently because the demand for rice milling services increased due to the introduction of NERICA varieties to this region. In the Eastern region, lowland rice varieties such as Supa and K5 developed initially for the Kibimba irrigation scheme are commonly grown and milled. The origin of the K5 variety is known to be one of the early Asian high-yielding modern varieties. Since K5 is higher-yielding than Supa, it is popularly grown in the Eastern region. In urban towns, Supa accounts for nearly one half of the milled rice during the main harvest season. This is probably because urban consumers value the quality of grain more than rural consumers.

Table 4 shows the characteristics of the owners of the rice mills, the milling machines, and business performances by location. The education level is higher than the farm household heads in Uganda in general (Matsumoto et al., 2006) and rice farmers in particular (Kijima et al., 2011). Four percent of the millers used to be rice traders, who would have been knowledgeable about whether and where the operation of

rice mills is profitable. Rice millers in urban towns are larger measured by the number

of permanent and temporary employees and milling capacity.[8] Income per 1 kg of

milled rice is calculated by deducting the labour and operating costs per kg (variable

costs) from the milling charge per kg (revenue per 1 kg of milled rice).[9] Operating

costs consists of the costs of electricity and diesel used for generators. Rice millers in

urban towns process a larger amount of rice than those in rural areas. In rural cluster,

millers processed lesser amounts of paddy at cheaper milling fees, resulting in lower

income than those in urban areas and rural non-clusters. Given that the labour costs

and operating costs per kg of milled rice in rural clusters are not significantly different

from those in urban clusters and rural non-clusters, the lower income in rural clusters is

mainly due to the lower milling charge.[10] The number of rice millers within a district

is highest in rural clusters. These observations suggest that competition in rural

clusters is quite high.

In urban areas and rural clusters, Milltop milling machines are more widely

used. The other type of milling machine, namely Engleberg, can be used for other crops

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[8]The capacity is measured for each milling machine by the amount of rice in kilograms
which can be milled per hour. If one miller operates more than one milling machine,
we simply sum the capacities of all the milling machines.

[9]A milling fee is charged either on the amount of paddy before mill or the amount of
rice after mill. The former is mainly undertaken in the Northern and Southwestern
regions, while the latter is taken in the Central, Western, and Eastern regions.

[10] We tested whether there is scale economy or not by estimating the Cobb-Douglas
cost function of rice millers. The result suggests that there is scale economy in the rice
milling industry in Uganda (the coefficient of the log of the demeaned quantity milled is
0.228, which is smaller than unity).

such as maize and cassava. The quality of rice milled by Engleberg tends to be lower than that by the Milltop type (Sakurai et al., 2006). To the extent that the quality of milled rice affects the price, there should be increased demand for Milltop milling machines.[11] Additional devices which can improve the quality of milled rice, such as moisture meters, dryers, cleaners, and de-stoners, are rarely installed in Uganda (not shown in the table). In rural non-clusters, diesel, instead of electricity which is cheaper, is widely used as the energy source for milling machines. This may partly explain the high milling charge in rural non-clusters.

Most of the rice millers in rural cluster offer storage services without any cost, because when farmers come to the rice mill to sell rice, there may be no traders in the rice mill. This is another way of attracting farmers to use rice milling machines to enjoy the scale economy. If no trader happens to be at the rice mill, farmers have to go to another rice mill or return home with paddy rice and come back to the mill the next day in the absence of storage services. This is why the provision of free storage services in areas where traders come only occasionally is valuable. The proportion of

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[11] The quality of milled rice is determined by (1) varietal characteristics, (2) post-harvest handling such as threshing, drying, storing, removing husks, and milling, and (3) the production environment such as soil fertility, rainfall, and cultivation practices. Post-harvest handling is affected not only by the type of milling machine and the possession of moisture meters and de-stoners but also by the operators'' experience in milling rice. According to our field observations, experienced operators check the moisture of paddy rice before using milling machines and if the paddy rice is not dry enough, then the paddy rice is dried in the yard and then milled. Improperly dried paddy rice tends to break easily during milling. The impurities not only damage the milling machines but also tend to break the grains.

rice millers providing free storage services is lower in rural non-clusters than in the other locations.   Since rice millers in rural non-clusters tend to be located close to rice farms, it may not be so costly for farmers to return home and come back to rice mills to sell the next time.

Another service offered by rice millers is credit.   In most of the credit transactions, no interest is charged.   The likely reason for rice millers to offer credit is to assure the high utilization rate of the milling machines.   Rice millers offer credit to farmers with the condition that farmers mill rice at the miller who lends the money.[12] Though in some cases, rice millers have stopped providing credit after experiencing default, the repayment rate is generally quite high: Forty-one percent of millers offering credit to farmers answered that they had recovered 100% of the credit and 80 % of them had recovered at least 70% of the credit.   Rice millers ensure repayment mainly by lending to those who can be trusted based on their past transactions (73%).   Using the village chairman's guarantee (10.5%), taking collateral (2.5%), and monitoring at harvesting time (14.3%) as enforcement mechanisms are rare.

3. Hypotheses

Based on the descriptive statistics and field observations, we would like to

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[12] Although it is seldom reported, traders commonly provide credit to farmers in Asia.

postulate several hypotheses on rice miller's entry, price competition, and non-price competition in this section.

Rice Miller's Entry

The decision of potential rice millers as to whether to enter the market or not is affected by the expected profit.   The profit is determined by the demand for the service and market-specific costs (Klepper, 1996).   Since rice is not a common food crop in rural areas of Uganda, it is produced primarily for sales to the market (Haggblade and Dewina, 2010).   Wherever rice is cultivated, there must be demand for the milling service.   One milling business can be started with small initial investment and, hence, the entry barrier is not high (Barrett, 1997).   In areas with long rice growing experience, the demand for the milling service should have been created some time ago and, hence, rice millers must have been in operation for many years.   In areas where rice has been newly introduced, many rice millers should have entered the market recently.   Such information about the increasing demand for rice milling services in particular areas could have been obtained earliest by rice traders, who travel around the country.   Therefore, those who had experience of trading rice are likely to be the early innovative entrants.

To increase profits, rice millers need to maintain a high utilization rate of the milling machines given that there is scale economy in the milling business.   When rice

producing areas were scattered and the amount of production was small, rice millers would choose to locate in big towns to attract customers from the wider surrounding areas as explained in the well-known Hotelling's law (Hotelling, 1929).   Once rice production has increased enough for millers to earn profits in a particular rice producing area, rice millers come to locate themselves near the production areas.   Based on these arguments, we would like to postulate the following hypothesis

Hypothesis 1: In areas where rice production started earlier and in areas closer to Kampala, rice millers enter the business earlier.

Milled Rice Price

Traders buy rice in rice surplus areas where a large amount of rice is produced, such as the Eastern region, and sell rice in rice deficit areas including the capital city, Kampala, where the demand for rice is highest.   If the rice market functions well in Uganda, the rice price observed at the rice mills in rice surplus areas is expected to be lower than the price in Kampala due to the transportation cost.   If the area under study is a rice deficit area, the local price may be higher than in Kampala due to the transportation cost, to the extent that Kampala is a centre of the rice trade in Uganda. Since the number of rice millers has dramatically increased in the past five years, the efficiency of the rice market would have improved particularly in recent years.   Thus, it seems reasonable to postulate the following hypothesis:

Hypotheses 2: If milled rice markets are competitive and integrated, the price at a particular rice miller is explained by the transport cost from Kampala, which may be measured by the travelling time between the two locations. If rice markets are not competitive or disintegrated, which is likely to be the case in earlier years, regional rice price gaps may not be explained by the transport cost.

Milling Fee

Rice millers charge milling fees to those who use the milling machines. Farmers in Uganda have a disadvantage when transporting paddy rice compared with traders since farmers normally do not have their own transportation means other than bicycles, so that they cannot canvass many rice millers. Thus, farmers tend to mill rice at the nearest rice mill from their houses. Because of this, the rice milling market tends to be more localized than the milled rice market. Therefore, milling fees should be determined by local market conditions, to a certain extent, including the rice milling cost. If there is one rice miller in a locality, the milling charge may be set higher than the marginal cost due to monopolistic pricing than that in local markets with many competing rice millers. In such monopolistic market, rice millers can stay in business even with high costs and the high milling fees. Thus, we would like to put forth the following hypothesis:

Hypothesis 3: Since the market for rice milling services tends to be localized, the fee

for milling services is set higher in areas where there are fewer rice millers in the surrounding areas than in areas where there are more competitors nearby.

Non-Price Competition

Since rice millers in clusters are under fierce competition with other rice millers, some of them may want to provide extra services to increase the utilization rate of their milling machines.   One way of increasing the utilization rate is to offer cheap credit and free storage services.   Another way is to guarantee the quality of milled rice by installing a better milling machine (Mill-top), so that farmers can sell the milled rice to traders at higher prices.   Thus, rice millers in rural clusters are expected to install Mill-top milling machines and to offer credit and storage services to farmers more often than rice millers in other areas.   Mill-top machines will be also used in urban areas where the demand for high-quality rice is high.   It is expected that information about market transactions can be easily shared among rice millers within a cluster so that the transaction costs are lower in the rice milling cluster as in industrial clusters (Sonobe and Otsuka, 2006, 2011).   In the case of offering credit, rural clusters can provide an effective enforcement mechanism, because a farmer loses access not only to the current miller-lender but also to other rice millers within the cluster if the farmer-borrower does not repay the debt to the miller-lender.   In addition, it is less costly for rice millers in rural areas to visit borrowers' farms and to check whether the borrowers can harvest

without any failure before offering credit, which also encourages rice millers to offer credit to rice producers. Thus, it is reasonable to expect that credit is offered more often in rural clusters than in other areas. We summarize these arguments in the following three hypotheses:

Hypothesis 4: Since the quality of rice is more valued by consumers and traders in areas close to Kampala, where high-quality packed rice and imported rice are sold in supermarkets for high-income households at higher price, rice producers near Kampala prefer to mill rice using better quality milling machines. Thus, rice millers near Kampala tend to install high-quality milling machines.

Hypothesis 5: Since rice millers in rural clusters have better access to information about their customers (i.e., rice producers) due to the geographical proximity, the transaction costs of offering credit to rice producers are lower in rural clusters and, hence, the interlinked credit contract is more likely to be offered by rice millers in rural clusters.

Hypothesis 6: Since traders come to rice millers in rural areas less frequently than in urban areas, free storage services are more often offered in rural areas, especially in rural clusters, where millers face competition with other rice millers.

4. Estimation Model and Results

Entry of Rice Millers

The determinants of the timing of entry are analyzed by Ordinary Least Squares (OLS),

in which the dependent variable is the log of the years in the rice milling business and

the independent variables include the proxies for the demand for rice milling services,

and the location and personal characteristics of the rice millers. The demand for rice

milling services is measured by the log of the years of rice production in the

surrounding sub-counties and the log of the years since rice promotion programs started

in the sub-county. As a variable indicating the location of towns, we use an urban

town dummy (population more than 60,000), a rural cluster dummy, and the travelling

time to Kampala interacted with the four region dummies. Travelling time is

calculated by using GIS position coordinates at the miller. We overlaid their positions

on digitized road maps and selected the shortest route from each miller to Kampala by

using ArcGIS. We classify roads into four groups: trekking paths (no vehicles

allowed), dirt roads (or dry-weather only roads), loose-surface roads (all-weather roads),

and tarmac roads (all-weather roads, bound surface). Except for the trekking paths, we

apply the average driving speed on each of the three road types and calculate the driving

time from each miller to Kampala. On the trekking paths, we calculate the walking

time and add the walking time to the driving time. Although the estimated coefficients

are unreported, the district dummies and region dummies are also included.

The results are shown in Table 5. As may be expected, the coefficient of the

years since rice production started in the surrounding sub-counties is positive and

significant.   This corroborates hypothesis 1 that rice millers enter markets where the

demand of rice producers for the rice milling service emerged.   This finding is

important because Kijima et al. (2011) find that the establishment of rice mills nearby

rice growing households promoted the expansion of rice production in Uganda.

Although the coefficient of the urban dummy is only weakly significant, that of the rural

cluster dummy is positive and highly significant, indicating that rural clusters were

formed in the earlier years.   A more important finding is the negative and significant

effects of the travelling time to Kampala in the Northern and Eastern regions where rice

has been grown for long periods, which clearly supports hypothesis 1.   The coefficient

of the trader dummy is positive and significant, suggesting that the experience of rice

traders was significantly related with the early entry into the rice milling industry.

Milled Rice Price

In order to test hypothesis 2, we estimate the milled rice price determination function by

OLS for each year from 2004 to 2008, separately.   For this analysis, we collected three

kinds of milled rice prices traded at rice millers: the average prices in the off-harvest

season, the major harvesting season, and the minor harvesting season.   This is because

the rice prices in the off-harvest and minor harvesting seasons tend to be higher than in

the main harvesting season since the amount of rice produced and traded is less in the

off-harvest and minor harvesting seasons.[13]   The number of observations is different in

different years because the number of rice millers operate if is not the same over time.

Although the price of the milled rice should be adjusted by an appropriate price an

index, such index is not available in Uganda.   In this analysis, the differences in price

level across space are controlled for by the district dummies and the location variables

(urban area and rural cluster dummies).   According to the field interviews, the milled

rice prices are higher for Supa variety than others.   Our price data, however, are

average prices and not variety-specific.   For this reason, the proportions of the rice

varieties traded in a rice mill are used as additional explanatory variables.

The estimation results are shown in Table 6.   The effects of the distance from Kampala

may be different depending on whether the rice mill is located in a rice surplus or a rice

deficit area.   Since in a rice surplus area, rice is exported to other regions such as

Kampala, its price tends to be low.   In a rice deficit area, its price tends to be high as

the transport cost from such commercial centres as Kampala must be shouldered.   In

order to analyze the effects of the distance from Kampala in different regions in more

detail, the interaction terms of the travelling time to Kampala with the region dummies

are used.   In 2004, the coefficient of the travelling time to Kampala is positive and

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[13] There are two cropping seasons in Uganda.   In the Eastern and Northern regions, the 1st cropping season is the major one, while the 2nd cropping season is the major one in the Central and Western regions.   It is common that farmers plant rice only in the main cropping season.

significant in the Central region but the coefficient is negative and significant in the Western region, suggesting that milled rice was traded from the Western region to Kampala and from Kampala to the Central region. This makes sense since rice production in the Central region was quite limited in 2004 but the demand for rice had been high due to the proximity to urban towns. In the Western region, upland rice production has picked up quite quickly in recent years, especially in the Hoima and Kamwenge districts. After 2006, the signs of the coefficients of the interaction terms with the Central and Western dummies become opposite. The former can be explained by the fact that the increase in rice production in the Central region took place recently, which has an advantage in selling rice to urban towns. The latter can be explained by the emerging export of rice from the Western region to neighbouring countries, Rwanda and Democratic Republic of Congo (UBOS, 2006), so that rice price near the border, which is far away from Kampala, tends to be higher. In the Eastern region, the coefficient of the travelling time to Kampala is negative and significant only in 2008, indicating that the local rice markets began to be integrated gradually over time. In the Northern region, the travelling time to Kampala does not have any impact on the milled rice price. This many be because cross-region trades has not yet developed in the Northern region where conflicts had affected the local economy until very recently. As would be expected, the coefficients of the off-season dummy are positive and highly

significant, whereas those of the first (main) cropping season dummy are negative and significant.

Price and Non-Price Competition among Rice Millers

How rice millers compete with each other is analyzed by OLS. As an indicator of price competition, we use the rice milling fee and estimate the milling fee determination function where the dependent variable is the log of the milling fee per 1 kg of milled rice. For non-price competition, we estimate the determinants of the adoption of Milltop machines and the provision of interlinked credit contracts and free storage services by the linear probability model. The key explanatory variables are those indicating (a) the market conditions such as the number of rice millers in the same local market, and urban and rural cluster dummies and (b) the rice miller's characteristics such as the capacity of milling machines, electricity use, the owner's managerial ability, average rainfall, and district dummies, which are expected to control the amount of rice traded between the local market and other areas

The estimation results are reported in Table 7. According to the first column which shows the result for the milling fee, millers located in districts with a larger number of other rice millers tend to charge lower milling fees. This finding supports hypothesis 3.

In the second column of Table 7, the result of adoption of Milltop milling

machines is shown.   In areas with higher competition (more rice millers within a district), the adoption rate is higher.   The travelling time to Kampala in the Northern region is the other variable whose coefficient is significant.   Its negative sign suggests that rice millers located closer to Kampala are more likely to install Milltop machines, which supports hypothesis 4 that high-quality machines are used to serve the markets where the preference for high-quality rice is high.[14]

Column 3 shows the result for the determinants of offering interlinked credit contracts.   Being located in a rural cluster increases the probability of offering credit to farmers due presumably to the low monitoring cost of borrowers and the high penalty on defaulting by borrowers.   This renders support for hypothesis 5.

In column 4, the result of the provision of free storage services is shown. Similar to the credit offer (column 3), the coefficient of rural clusters is positive and significant, supporting hypothesis 6.   The result also shows that rice millers far from Kampala in the Central and Northern regions tend to offer free storage services.   This may be explained by the fact that areas closer to Kampala tend to be more populated and thus land shortage is more serious.

5. Concluding Remarks

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[14] Although the result is not shown, the coefficient of the traveling time to Kampala is significant at the 5% level when it is used instead of the interaction terms with the region dummies.

In this study, we examined the development of rice marketing systems in Uganda where rice is a relatively new crop and its production has been rapidly expanding in recent years. The regression analyses on the timing of rice miller's entry corroborated the hypothesis that rice millers entered in areas where the demand for milling services increased. Since it is not common that paddy rice is purchased by traders at the farm gate, rice millers play a critical role in assisting farmers to sell rice to traders. In all likelihood, it would have not been possible for rice production in Uganda to expand so rapidly in recent years without such a development of the rice milling industry. The rice price analyses provided consistent results that the rice market has become integrated widely in recent years. There are also some indications that the rice markets were regionally connected even before 2008.

Unlike rice output markets, the market for rice milling services tends to be localized because rice millers do not compete over wide areas due to high transaction costs. We found that in areas where rice millers compete with one another locally, they tend to offer lower milling fees, install better milling machines, and offer credit and storage services to farmers to assure the high utilization rate of their machines. In short, as far as rice and rice milling markets in Uganda are concerned, market forces seem to be at work, even though these markets may not be truly competitive.

The emergence of the interlinked credit contract deserves special attention. In

SSA, chemical fertilizer prices are high and its application rate is quite low, especially in Uganda (Matsumoto and Yamano, 2009). When the Green Revolution took place in Asia, the demand for fertilizer increased, and rice traders provided interlinked credit to farmers. Currently, the credit is used primarily to hire labour for harvesting and weeding, but not for fertilizer in Uganda. As the soil fertility becomes poorer and the output-input price ratio of rice changes in favour of farmers, the demand for chemical fertilizer is expected to increase. Subsequently, rice millers may play an important role in realizing a rice Green Revolution in SSA by offering credit to farmers. This is likely to happen, if the intensity of rice production further increases in Uganda.

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Figure 1: Location of Rice Millers by Establishment Year
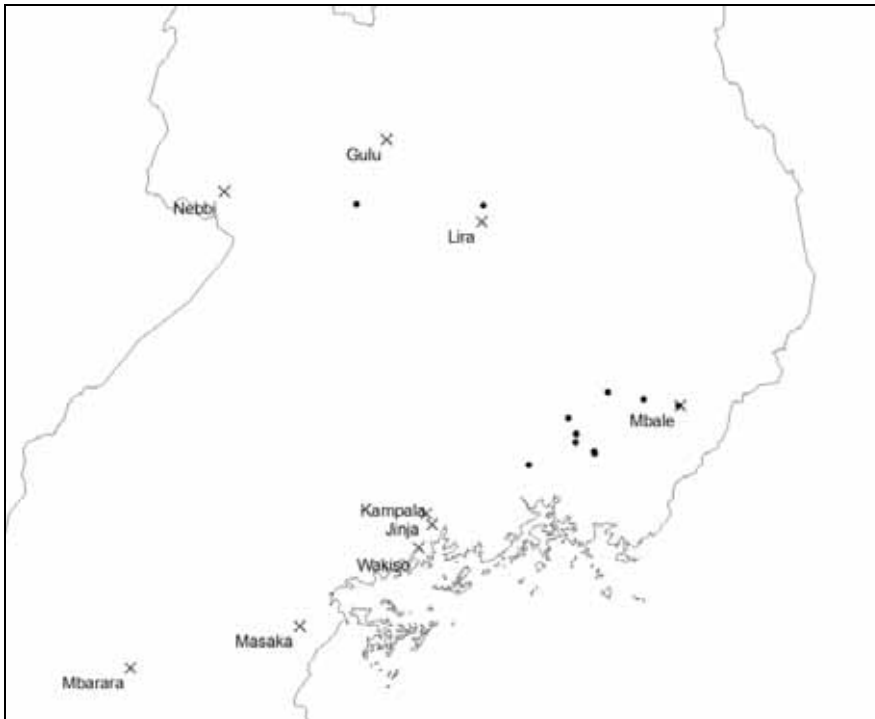
Panel A. 1990
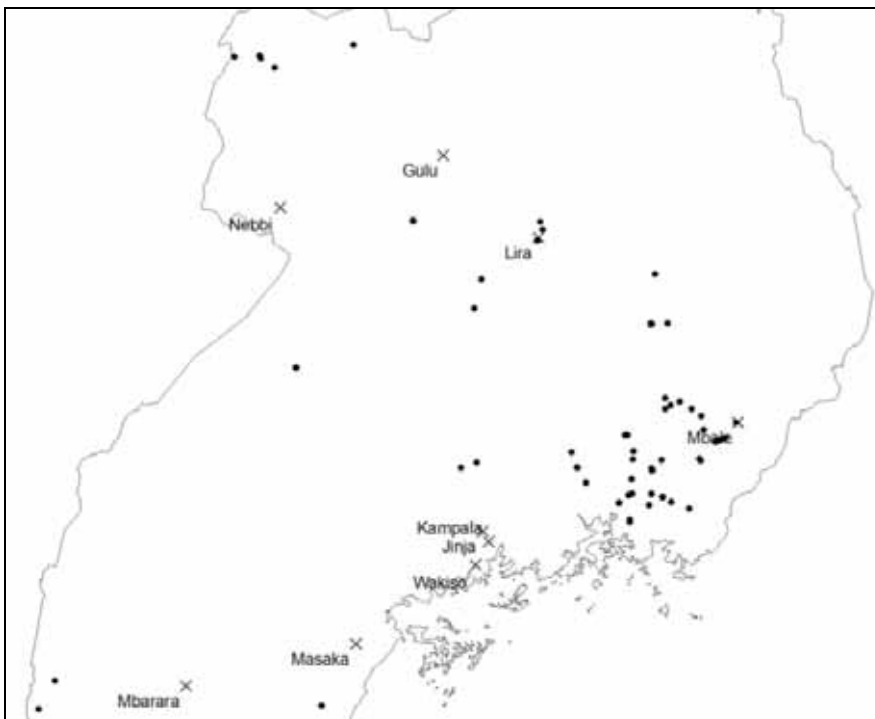
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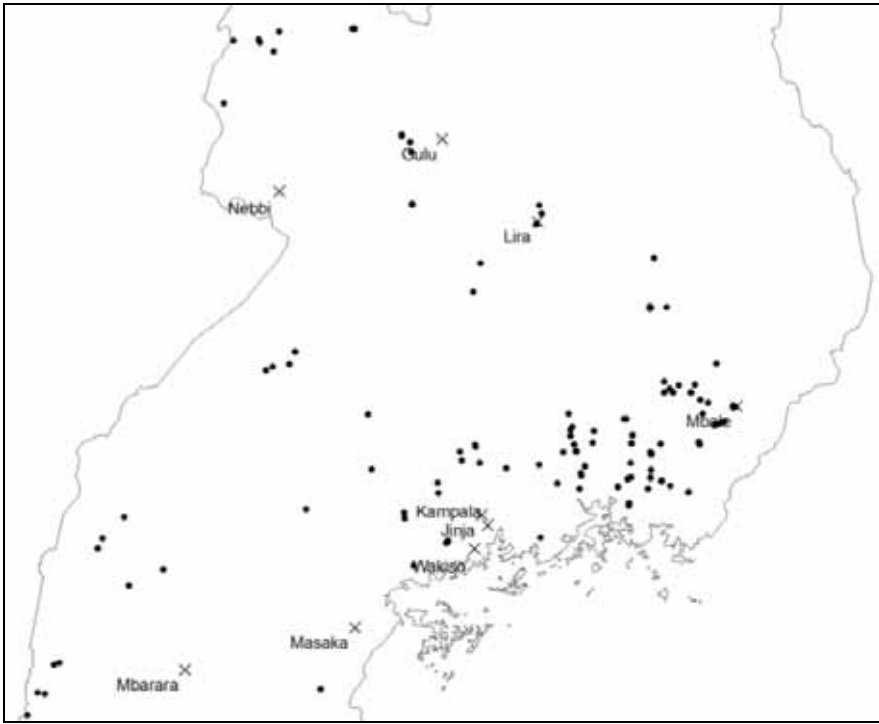
Panel C. 2005

Panel D. 2009

31
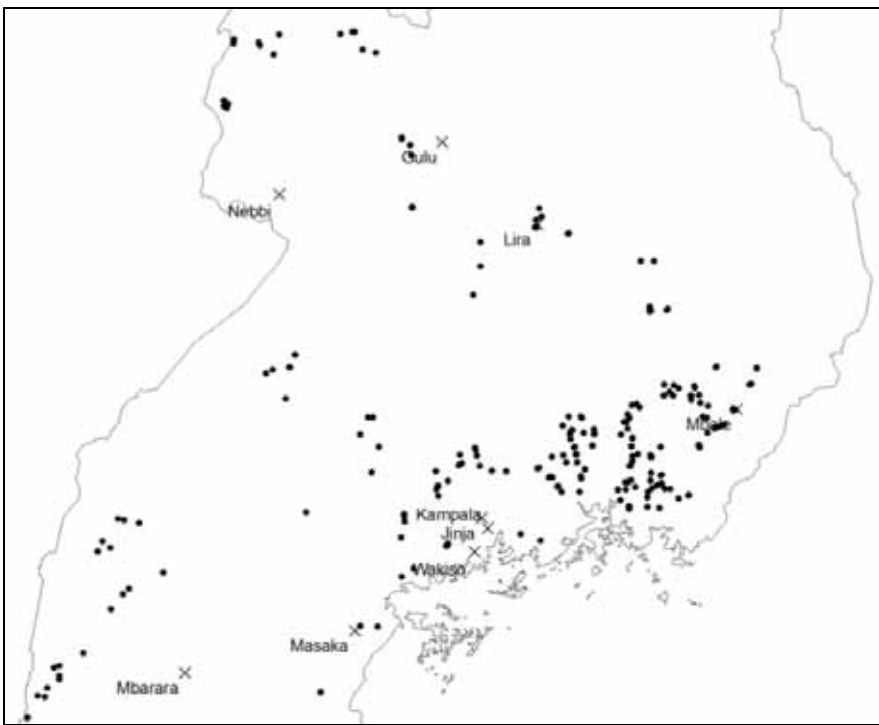
Table 1: Number of Rice Millers by Region and Establishment Year

Region	Number of Sample	Operating in 2009 (% across location)	Not operating in 2009 (% of not operating millers among sample)	% of sampled rice miller by year of starting business			
				before 1990	1990 -1999	2000- 2004	2005- 2009
All	374	326 (100%)	48 (13%)	3.8	17.6	26.5	52.0
North	47	38 (12%)	9 (19%)	4.4	28.9	26.7	40.0
East	229	207 (63%)	22 (10%)	5.3	19.7	28.1	46.9
Central	49	41 (13%)	8 (16%)	0.0	4.1	30.6	65.3
West/Southwest	49	40 (12%)	9 (18%)	0.0	10.4	14.6	75.0
Urban	28	23 (7%)	5 (18%)	10.7	17.9	39.3	32.1
Rural cluster	114	101 (31%)	13 (11%)	5.3	23.9	38.1	32.7
Rural non-cluster	232	202 (62%)	30 (13%)	2.2	14.4	19.2	64.2

"Cluster" = Area where there are more than 4 rice millers in same location.

Urban = Towns with population more than 60,000.

Table 2: Year When Rice Production Started by Region

| Region | Year when rice production started | | Years since electricity became available | Rice related program | | |
	Earliest	Median		Years since program started	Number of LC1s benefited from program	% of households benefited from program
North	1960	1993	0.06	2.55	4.5	22.5
East	1960	1986	3.33	3.74	5.3	24.7
Central	2000	2004	3.56	2.92	3.5	26.9
West/ Southwest	1977	2002	0.36	2.64	3.5	38.5

Source: Sub-county level data.

Table 3: Percentage of Milled Rice Processed at Rice Miller by Variety and Location in 2008

	Lowland Rice Varieties			Upland Rice Varieties	
	Supa	K series	Other	NERICA	Other
All	23.9	26.8	12.4	7.7	29.2
North	37.4	7.3	5.7	11.6	38.0
East	28.5	37.5	11.9	0.0	22.1
Central	4.9	13.0	10.6	15.3	56.2
West/South west	6.5	4.5	23	35.8	30.2
Urban	48.9	23.8	3.9	1.9	21.5
Rural cluster	22.5	31.8	20	2.4	23.3
Rural non-cluster	21.6	24.7	9.6	11.0	33.1

From the data in the peak season per day.

Table 4: Rice Miller's Average Characteristics in 2008 by Location

	Urban	Rural cluster	Rural non-cluster
Age of owner	41.8	42.3	40.7
	(11.4)	(12.8)	(13.9)
Years of education	9.8	8.9	9.6
	(4.5)	(3.6)	(3.8)
Rice trader experience dummy (%)	7.1	4.6	2.4
	(7.9)	(7.1)	(4.3)
Capacity of milling machine (kg/hr)	1,277	1,114	719
	(1991)	(1190)	(900)
Number of permanent employees	2.7	1.6	1.8
	(1.9)	(1.9)	(1.6)
Number of temporary employees	6.0	2.3	1.4
	(7.3)	(3.9)	(2.2)
Number of family workers	0.5	0.5	0.6
	(0.8)	(1.0)	(1.3)
Amount of paddy milled (ton/year)	314	105	135
	(381)	(131)	(201)
Milling charge (Uganda shilling /kg)	70	59	77
	(25)	(15)	(34)
Hired labour cost ((Uganda shilling /kg)	11.8	22.8	23.7
	(14.2)	(26.7)	(28.8)
Operating cost ((Uganda shilling h/kg)	50.3	41.3	39.7
	(57.0)	(38.9)	(45.1)
Income ((Uganda shilling /kg)	9.7	-3.2	14.6
	(56.0)	(51.3)	(62.5)
Number of rice millers within district	11.5	26.3	13.9
	(2.5)	(11.3)	(11.2)
Adoption of milltop milling machine (%)	47.8	50.5	36.1
	(51.1)	(50.2)	(48.2)
Provision of free storage service (%)	78.3	88.1	71.3
	(42.2)	(32.5)	(45.4)
Credit offer to customer (%)	37.8	47.5	25.7
	(51.1)	(50.2)	(43.8)
Diesel use (%)	34.8	37.6	62.4
	(48.7)	(48.7)	(48.6)
Milled rice price (shilling/ kg) in 2008			
1st cropping season	1,370	1,650	1,432
	(225)	(254)	(286)
2nd cropping season	1,486	1,209	1,264
	(259)	(285)	(317)
Off-harvest season	1,650	1,272	1,321
	(255)	(271)	(314)

The numbers in parentheses are standard deviations.

Table 5: Determinants of Rice Miller's Entry (Dependent variable: log of years since establishment) (OLS)

	(1)	(2)	(3)	(4)
Characteristics of major source of rice				
Log of years since rice production started (sub-county level)	0.282**	0.329**	0.282**	0.329**
	(1.971)	(2.259)	(1.971)	(2.259)
Log of years since electricity became available to this sub-county	0.068	0.132	0.068	0.132
	(0.368)	(0.698)	(0.368)	(0.698)
Log of years since rice related program started in this sub-county	0.164	0.071	0.164	0.071
	(1.389)	(0.600)	(1.389)	(0.600)
Location of rice miller				
Log of travelling time to Kampala (hours) x North	-3.101**	-3.081**	-3.101**	-3.081**
	(-2.487)	(-2.418)	(-2.487)	(-2.418)
Log of travelling time to Kampala (hours) x East	-1.044***	-1.279***	-1.044***	-1.279***
	(-3.269)	(-4.002)	(-3.269)	(-4.002)
Log of travelling time to Kampala (hours) x Central	0.066	0.061	0.066	0.061
	(0.182)	(0.165)	(0.182)	(0.165)
Log of travelling time to Kampala (hours) x West	-0.435	-0.562	-0.435	-0.562
	(-0.585)	(-0.741)	(-0.585)	(-0.741)
Urban town =1 (population more than 60000)	-0.961*	-0.904*	-0.961*	-0.904*
	(-1.919)	(-1.769)	(-1.919)	(-1.769)
Rural cluster = 1	0.363***		0.363***	
	(3.596)		(3.596)	
Characteristics of rice miller				
Log of age of owner	0.183	0.187	0.183	0.187
	(1.422)	(1.418)	(1.422)	(1.418)
Log of years of education of owner	0.003	0.006	0.003	0.006
	(0.0429)	(0.0748)	(0.0429)	(0.0748)
Rice trader experience dummy	0.026***	0.028***	0.026***	0.028***
	(3.842)	(4.100)	(3.842)	(4.100)
Average rainfall (mm)			0.018**	0.018**
			(2.305)	(2.258)
Number of observations	326	326	326	326
R-squared	0.349	0.318	0.349	0.318

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1.   District dummies are included as explanatory variables in all specifications.

Table 6 Determinants of log of Milled Rice Price (Uganda shilling/ kg), OLS

	2004	2005	2006	2007	2008
Location of rice miller					
Log of travelling time to Kampala (hours) x North	3.713	7.272	2.490	0.931	-0.013
	(1.377)	(1.602)	(1.090)	(1.476)	(-0.053)
Log of travelling time to Kampala (hours) x East	-0.075	0.057	0.117	-0.029	-0.093*
	(-0.538)	(0.483)	(1.178)	(-0.321)	(-1.701)
Log of travelling time to Kampala (hours) x Central	0.759**	0.305	-0.226**	-0.225***	-0.146***
	(2.022)	(0.951)	(-2.195)	(-2.597)	(-2.789)
Log of travelling time to Kampala (hours) x West	-2.474***	-0.147	0.481**	0.406**	0.266**
	(-2.699)	(-0.426)	(2.138)	(2.034)	(2.024)
Urban town =1 (population more than 60000)	3.215	8.491**	2.283	0.364*	-0.010
	(1.243)	(2.447)	(0.800)	(1.657)	(-0.081)
Rural cluster = 1	0.038	0.033	0.044*	0.020	-0.012
	(1.112)	(1.068)	(1.744)	(0.861)	(-0.743)
Average rainfall (mm)	-0.020	-0.042**	-0.016	-0.006**	0.001
	(-1.270)	(-2.490)	(-1.164)	(-2.521)	(0.425)
Other factors					
Off-harvest season	0.105***	0.097***	0.114***	0.092***	0.115***
	(3.635)	(3.550)	(5.067)	(4.525)	(8.364)
First cropping season	-0.066**	-0.066**	-0.072***	-0.070***	-0.059***
	(-2.256)	(-2.410)	(-3.214)	(-3.431)	(-4.190)
Proportion of Supa	-0.005	0.096	0.086	-0.001	-0.021
	(-0.056)	(1.195)	(1.250)	(-0.019)	(-0.496)
Proportion of K-series	-0.039	-0.014	-0.048	-0.020	-0.026
	(-0.452)	(-0.185)	(-0.783)	(-0.362)	(-0.702)
Proportion of upland (non-NERICA)	-0.136	-0.087	-0.038	0.000	-0.032
	(-1.456)	(-1.171)	(-0.733)	(0.000)	(-0.913)
Proportion of NERICA	-0.326***	-0.293***	-0.042	-0.048	-0.014
	(-2.831)	(-2.953)	(-0.665)	(-0.837)	(-0.344)
Observations	394	498	634	742	937
R-squared	0.516	0.429	0.442	0.349	0.425

t-statistics in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$, District dummies are included as explanatory variables in all specifications.

Table 7 Competition by Rice Miller (OLS)

	Log of milling fee (shilling/ milled rice kg)	Adoption of Milltop milling machine	Credit offer to customer	Offer free storage service
	(1)	(2)	(3)	(4)
Location of rice miller				
Log of number of rice millers within district	-1.562***	0.945*	0.184	-0.437
	(-2.932)	(1.741)	(0.354)	(-0.976)
Log of travelling time to Kampala (hours) x North	2.211**	-1.554*	0.546	1.778**
	(2.246)	(-1.692)	(0.619)	(2.348)
Log of travelling time to Kampala (hours) x East	-0.021	-0.232	-0.178	0.248
	(-0.168)	(-0.975)	(-0.781)	(1.264)
Log of travelling time to Kampala (hours) x Central	-0.398***	-0.428	0.069	0.541**
	(-2.934)	(-1.616)	(0.273)	(2.473)
Log of travelling time to Kampala (hours) x West	0.132	-0.198	-1.307**	-1.372***
	(0.382)	(-0.371)	(-2.542)	(-3.106)
Urban town =1 (population more than 60000)	0.373	-0.706*	0.294	0.277
	(0.893)	(-1.927)	(0.837)	(0.917)
Rural cluster = 1	-0.062*	0.096	0.120*	0.156***
	(-1.669)	(1.318)	(1.717)	(2.600)
Average rainfall (mm)	0.005	0.085	0.040	-0.064
	(0.112)	(0.901)	(0.441)	(-0.823)
Electricity use	0.005	-0.042	-0.001	-0.056
	(0.167)	(-0.718)	(-0.023)	(-1.166)
Characteristics of rice miller				
Log of capacity (kg/hr)	-0.003	-0.008	0.006	0.001
	(-1.267)	(-1.622)	(1.231)	(0.241)
Log of age of owner	-0.009**	0.006	-0.003	-0.006*
	(-2.304)	(1.513)	(-0.766)	(-1.905)
Log of years of education of owner	-0.004	-0.046	0.046	0.022
	(-0.097)	(-0.639)	(0.655)	(0.370)
Rice trader experience dummy	-1.562***	0.945*	0.184	-0.437
	(-2.932)	(1.741)	(0.354)	(-0.976)
District dummies, region dummies	Yes	Yes	Yes	Yes
Number of observations	326	326	326	326
Pseudo R-squared or R-squared	0.583	0.241	0.244	0.293

t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1