Rice Miller Cluster in Ghana and Its Effects on Efficiency and Quality Improvement*

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INTRODUCTION

It is widely recognized that the improvement of agricultural productivity is critical for poverty alleviation and economic growth in sub-Saharan Africa, where agriculture is the primary source of livelihood for about 65 percent of population. Agricultural productivity, however, does not just depend on crop yield, but is also determined by the efficiency of post-harvest processing and marketing. Because of the recent trade liberalization, the efficiency of post-harvest processing and marketing is becoming more and more important for local agriculture to compete with imports. In the urban market, particularly, locally-processed foods need to have high quality to attract urban consumers. Hence, the main question of this paper is how local food processing industry in sub-Saharan Africa improves its efficiency and product quality.

Recent studies on industrial development show that industrial clusters have a positive effect on the efficiency and product quality, because clusters generally reduce the costs of information, transaction, marketing, and so on. But most of the studies conducted in developing countries deal with the cases of non-food manufacturing in Asia and Latin America such as clothing in Peru (Visser, 1999), surgical instruments in Pakistan (Nadvi, 1999), machine tool in Taiwan (Sonobe, Kawakami, and Ostuka, 2003), etc. Even in sub-Saharan Africa, it is true: e.g. vehicle repair in Kenya and Ghana (Kinyanjiui, 1996), hotel furniture in Kenya (Schneider, 1999), garment in Kenya (Akoten, 2003), and a review (McCormick, 1998). As mentioned above, agriculture and agro-based industry will be the engine of economic growth in sub-Saharan Africa, and we observe a lot of different kinds of clusters in various places in sub-Saharan Africa. But we have little knowledge on the role of industrial clusters. In order to fill this gap, this paper takes the case of rice milling industry in Ghana as an example, and analyzes its efficiency and product quality improvement with a focus on the role of industrial cluster.

RICE AND RICE MILLING IN GHANA

As is the case in other West African countries, Ghana has recently seen a dramatic increase in rice consumption per capita due to urbanization; average yearly consumption of milled rice per capita increased from 7.7 kg in the 1980s to 13.6 kg in the 1990s (FAO, 2004). During the same period, while domestic rice production increased from 46,500 tons to 110,600 tons in milled rice equivalent, milled rice imports also increased from 50,400 tons to 122,400 tons (FAO, 2004). This indicates that domestic production could not sufficiently meet the increasing demand for rice. Therefore, enhancing domestic rice supply has become an urgent policy issue in Ghana. This could be achieved by farmers through paddy field expansion and/or paddy yield enhancement. But little attention is paid to the efficiency in the post-harvest processing and marketing.

To investigate this issue, we select Kumasi area, central Ghana for the study site. There are several reasons. First, Kumasi is the second largest city in Ghana with more than one million population according to the 2000 census. Hence rice demand should be growing fast due to urbanization as noted above. Second, Kumasi is an inland city located 250 km away from the coastal capital, Accra. This location could provide advantage to locally produced rice over the imports because of the transportation cost. Third, in the Kumasi area, a significant expansion of lowland rice area is possible.

Millers are one of the key players in the rice market in the Kumasi area. After hand threshing, rice producers transport the paddy to millers by themselves. The millers mill the paddy and charge a milling fee to the producers, depending on the volume of milled rice produced. Then, the producers sell the milled rice to traders who come to the millers to purchase it. Unlike other places where rice millers are also rice traders, the role of millers in the Kumasi area is only as an intermediary.

It is important to note here that in the study site rice is not a traditional, subsistence crop, but is a cash crop cultivated in lowlands mainly by immigrants from other regions. Since rice production is not yet very common in the study site, most of the villages have no miller in the village. Therefore, farmers choose a miller based on the transportation cost from the village to the miller, milling fee, the expected sale price of milled rice, etc.

HYPOTHESES

In our preliminary observation in the study site, we found that there are several clusters of millers within the city of Kumasi and a lot of millers are scattered in satellite towns or villages around Kumasi. Hence, our question is how millers in the clusters are different from those scattered.

One significant difference is technological innovation in the rice milling machines. There are two types of milling machine in the study site: one-pass type mill and Engelberg type mill. The former is usually made in Japan or China and has a relatively large capacity, while the latter is locally made or imported from India. The roles of miller clusters in this innovation of milling technology may be the spillover of technical information and the formation of skilled labor market. Thus, regarding the adoption of one-pass type mill, the following hypothesis is postulated.

- **Hypothesis 1**: Millers in the clusters are more likely to adopt innovative technology.

As explained above, millers' revenue is the milling fee that depends on the volume of output. Therefore, miller's efficiency will be improved by the adoption of one-pass type mill if it uses less input per output. Hence, the second hypothesis is as follows.

- **Hypothesis 2**: Milling with the innovative technology is more efficient.

However, since one-pass type mills are larger, millers need to process more paddy to increase capacity utilization up to the optimal level. It means that millers using one-pass type mills have to attract more rice producers. More paddy can be collected if one-pass type mills produce better quality milled rice and if the market pays a premium for the better quality. Hence, it is important to test if one-pass type mills produce better quality milled rice, as postulated below.

- **Hypothesis 3**: The innovative technology gives a better quality product.

But this product quality improvement will benefit neither millers nor rice producers, if the quality of milled rice does not affect its price. In Asian countries where rice is the most important staple food, rice grain quality always affects its price (Unnevehr, Duff, and Juliano, 1992). But since rice is a newly emerging cash crop to feed urban population in Ghana, quality grading system has not developed and hence rice price does not always depend on its quality, or even if it depends on the quality the relationship between the price and the quality may not be consistent. It is considered that the concentrated transactions of milled rice in the clusters will foster an informal grading standard in which milled rice price is determined by its grain quality in a consistent manner. Based on this consideration, hypothesis 4 is postulated as follows.

- **Hypothesis 4**: Product price depends on its quality in the clusters.

RICE MILLER SURVEY

First, 19 rice-producing villages are identified out of 60 randomly selected villages within a 60 km radius of the Kumasi area. Then 63 millers are listed as the millers that the rice producers in the 19 villages regularly use. Among them, 24 millers are located within the city of Kumasi forming clusters and the remaining 39 millers are scattered over 25 satellite towns or villages around the city.

The interview of mill owners and mill operators were conducted in February and March 2002, and all the types of milled rice available at the time of interview were collected. Total number of milled rice samples is 85, of which the majority (60 samples) is a local variety called "Ashanti Rice", the second largest group (15 samples) is an old improved variety called "Ashanti White", and the others are diverse. Physical and chemical characteristics of all the samples were determined by WARDA's grain quality laboratory.

INNOVATION AND MILLING EFFICIENCY

The hypotheses are tested in a multiple regression framework as follows:

$$D = H(K, \mathbf{X}) \qquad (1)$$

where D is a binary dummy variable for the technology innovation taking 1 if a miller uses a one-pass type mill and 0 if a miller uses an Engelberg type mill. The explanatory variables include K, a binary dummy variable for the Kumasi clusters, and $\mathbf{X}$, a vector of miller's characteristics including a constant term. Variables for owner's experience before the establishment of the mill are included in $\mathbf{X}$ because previous occupation is known to have significant effects on the business development (Sonobe, Hu, and Otsuka, 2002). But for the technology adoption, we do not have any specific hypothesis concerning the effect of those dummy variables. Equation (1) is estimated by Probit method.

The estimation result of equation (1) is reported in Table 1. First of all, the coefficient for the Kumasi cluster dummy is significantly positive. Hence, hypothesis 1 is supported. The results also indicate that relatively new millers tend to adopt the one-pass type mill and that miller's wealth proxied by the floor size of workshop has a positive effect on the investment in new technology.

Then, in order to test hypothesis 2, the following equation is constructed.

$$P = F(K, \mathbf{Z}, \Phi_D, \phi_D) \qquad (2)$$

where P is profit per output deflated by milled rice price. K is the same as in equation (1). $\mathbf{Z}$ is a vector of miller's characteristics that are assumed to have a direct impact on the profit. In addition to them, the explanatory variables include Φ_D and ϕ_D instead of the technology dummy variable D, because D is endogenous in equation (2). Equation (2) is specified as a switching regression model (Maddala, 1983), where Φ_D is the predicted probability of having one-pass type mill and ϕ_D is the corresponding predicted value of the probability density. The estimated coefficient of Φ_D is the effect of having a one-pass type mill.

Regression result is given in Table 1. The coefficient for the predicted probability of having one-pass type mill is positive and significantly different from zero, which means that the innovation reduces the unit cost of labor and machine running and increase the profit per output. Thus, hypothesis 2 is clearly supported. It should be pointed out that Kumasi location dummy has a significantly negative effect on the profit. This may be due to the lower milling fee in the Kumasi cluster, and since the size of the positive effect of one-pass type mill is greater than the absolute size of the negative effect, the support to hypothesis 2 is still valid. On the other hand, owner's experience in rice trading significantly enhances profit, indicating that traders' knowledge in rice marketing system, rice quality, and consumers' preference should be the advantage in running a rice mill, which is consistent with the case of garment industry in China reported by Sonobe, Hu, and Otsuka (2002).

Table 1 Determinants of Technology Innovation and Its Effect on Milling Performance

	Dummy for One-pass Mill	Profit per Output (10^{-3} cedi/kg)
Constant	-3.12 (1.46)**	-877 (414)**
Located in Kumasi (dummy)	1.93 (0.85)**	-52.6 (29.5)*
Years since Establishment	-0.087 (0.039)**	1.88 (1.31)
Owner's Age	-0.014 (0.030)	NA
Operator's Age	NA	-1.09 (0.97)
Years of Operator's Experience	NA	-1.55 (1.86)
Owner's Experience in Rice Farmer (dummy)	1.22 (0.76)	7.39 (19.7)
Owner's Experience in Rice Trader (dummy)	-0.20 (0.99)	63.7 (33.4)*
Owner's Experience in Milling (dummy)	-0.68 (1.79)	-18.4 (28.7)
Workshop Floor Size (m^2)	0.057 (0.022)**	NA
Predicted Probability of Having One-pass Mill	NA	786 (318)**
Predicted Value of Probability Density	NA	1247 (643)*
Fraction of Correct Prediction/R^2	0.92	0.24
Number of Positive Observations	24	NA
Sample Size	63	63

Standard errors are in parentheses. ***, ** and * indicate significance levels of 1%, 5% and 10% respectively.

Table 2 Milled Rice Quality of Local Variety (Ashanti Rice)

	Millers in Kumasi	Millers in Rural Area	Test
Price (cedi/kg milled rice)	2737 (160)	2802 (377)	
Quality Depending on Processing			
Whole Grain (weight %)	67.1 (10.7)	60.4 (12.2)	**
Large Broken Grain (weight %)	2.98 (1.51)	3.90 (2.00)	**
Small Broken Grain (weight %)	21.8 (8.33)	26.7 (10.8)	*
Impurity (weight %)	0.43 (0.33)	0.60 (0.40)	*
Colored Grain (weight %)	5.60 (9.78)	3.54 (3.49)	
Immature Grain (weight %)	1.44 (0.98)	1.82 (1.31)	
Quality Depending on Genetics and Processing			
Red Colored Grain (weight %)	0.64 (1.34)	3.03 (2.00)	***
Whiteness (score)	33.9 (6.21)	35.0 (5.86)	
Transparency (score)	1.54 (0.29)	1.39 (0.35)	*
Quality Depending on Genetics			
Grain Shape (length/width)	2.34 (0.11)	2.35 (0.18)	
Amylose Content (weight %)	26.9 (1.08)	26.0 (1.64)	***
Volume Expansion Ratio	4.65 (0.21)	4.65 (0.33)	
Cooking Time (minutes)	24.3 (1.79)	24.27 (2.08)	
Sample Size	27	33	

Standard deviations are in parentheses. Two means are different at the significance level of 1% (***), 5% (**) and 10% (*) respectively.

PRODUCT QUALITY IMPROVEMENT

Through a simple observation it is obvious that the quality of locally produced rice is lower than the imports as the former contains a lot of broken grains and foreign materials. Hence, there is no doubt that the quality of local rice needs to be improved to compete with the imports. The question is if the millers' clusters foster the quality improvement. The quality characteristics of milled rice are classified physically as well as chemically (Unnevehr, Duff, and Juliano, 1992). Post-harvest handling and milling technology determine the physical characteristics of milled rice although other factors also affect physically, for example some rice varieties are more easily broken than others.

Table 2 compares milled rice quality between the millers in the Kumasi clusters and the millers scattered in rural area. The physical quality of Ashanti Rice is obviously better at the millers in the Kumasi clusters than in rural area: the content of whole grains is higher; and the content of large broken grains, small broken grains, and impurity is lower. The content of red colored grains is genetically determined, but also reflects the degree of milling. Table 2 shows that Ashanti Rice at the rural millers is significantly more reddish and less transparent after milling also due to the poor milling technique in rural area.

Table 3 Determinants of Milled Rice Quality

	Whole Grain Content (weight %)	Small Broken Grain Content (weight %)
Constant	-2.13 (40.6)	95.0 (35.9)
One-path Type Mill (dummy)	6.40 (2.48)**	-6.12 (2.19)***
Grain Shape (Length/Width)	25.2 (7.29)***	-21.5 (6.45)***
Amylose Content (weight %)	0.57 (0.82)	-0.41 (0.72)
Volume Expansion Ratio (after/before cooking)	-12.7 (4.96)**	12.8 (4.39)***
Cooking Time (minutes)	1.37 (0.68)*	-2.16 (0.60)***
Ashanti Rice, local variety (dummy)	14.4 (4.60)***	-13.9 (4.07)***
Ashanti White, improve variety (dummy)	1.60 (4.57)	-4.31 (4.04)
R^2	0.29	0.36
Sample Size	83	83

Standard errors are in parentheses. ***, ** and * indicate significance levels of 1%, 5% and 10% respectively.

Table 3 is the results of regression analyses that explain the physical quality of milled rice by (1) milling technology, (2) chemical characteristics that are normally assumed to be genetically determined, and (3) rice variety (Ashanti Rice and Ashanti White). The coefficients for the dummy variable of one-pass type mill are significantly different from zero, which means that one-pass type mill improves the physical quality. Hence, hypothesis 3 is supported. In addition, it is found that Ashanti Rice has characteristics that give better milling quality, i.e. it yields higher content of whole grains and lower content of small broken grains than other locally produced varieties.

PRICE DETERMINATION

In the previous sections it was shown that millers with one-pass type mills are more efficient and the quality of their milled rice is better than millers with Engelberg type mills. However, as discussed, only if the rice price reflects the quality, both farmers and millers will be benefited by the quality improvement. In order to see the effect of milled rice quality on the price, price determination functions are estimated, where milled rice price is a function of physical as well as chemical characteristics of milled rice and rice variety. Although rice variety is considered to determine some of the characteristics genetically (e.g. amylose content, grain shape, etc.), the model includes both variety and measured characteristics variables because there seems to be large genetic diversity within the same variety.

The results are in Table 4. The first regression uses all the Ashanti rice samples regardless of millers' location, and shows the following: the contents of red-colored rice and long-shaped rice increase significantly milled rice price; and milled rice price in the area along Sunyani road is significantly lower than in other rural areas and the Kumasi clusters. The lower price in the Sunyani area is as expected because rice production is more prevalent in the Sunyani area than others and rice supplied to local market should be higher. Although the content of red-colored rice depends on the degree of milling to some extent, it is genetically determined property. Hence, the regression results suggest that milling technology has no effect on the price. However, if we compare the last two columns, price determination is significantly different. In the Kumasi clusters, the content of whole grains significantly increases the milled rice price, while in rural area milling quality has no significant effect on the price. This finding supports to hypothesis 4 that clusters foster the quality-price relationship.

In addition to the hypothesis, the regression results indicate that red-colored rice is preferred in the study site regardless of milling quality or location, which is a quite special preference. Moreover, in the rural area amylose content has a positive effect on milled rice price. It is known that amylose content is inversely related to tenderness and moistness after cooking and is directly related to volume expansion and stickiness, and this finding is the same as rural Philippines (Abansi, et al., 1992). On the other hand, consumers in the Kumasi clusters demand for rice with shorter cooking time, which is explained by the higher opportunity cost of urban consumers and is also consistent with the finding in the case of the Philippines (Abansi, et al., 1992).

Table 4 Determinants of Milled Rice Price at the Millers

	Ashanti Rice (cedi/kg)	Ashanti Rice in Kumasi (cedi/kg)	Ashanti Rice in Rural Area (cedi/kg)
Constant	-138 (1245)	2319 (967)**	-2752 (2118)
Millers in the Kumasi Cluster	-108 (79.0)	NA	NA
Millers Scattered on Sunyani Road	-300 (107)***	NA	-265 (137)*
Whole Grain Content (weight %)	1.88 (3.33)	6.62 (2.56)**	-3.07 (5.81)
Impurity (weight %)	91.9 (98.9)	60.1 (81.9)	167 (167)
Red Colored Grain (weight %)	37.9 (12.7)***	38.6 (20.2)*	32.8 (17.4)*
Grain Shape (length/width)	1112 (281)***	193 (245)	1898 (456)***
Amylose Content (weight %)	40.4 (24.8)	21.2 (26.0)	68.7 (38.6)*
Volume Expansion Ratio	-152 (144)	-40.4 (134)	-230 (219)
Cooking Time (minutes)	-7.78 (19.3)	-37.5 (16.4)*	20.5 (30.8)
R^2	0.45	0.52	0.58
Sample Size	57	27	30

Standard errors are in parentheses. ***, ** and * indicate significance levels of 1%, 5% and 10% respectively.

CONCLUSIONS

This paper investigates the role of industrial cluster on the efficiency of rice milling and the improvement of milled rice quality.

Regression analyses reveal that rice millers in the Kumasi clusters tend to adopt more advanced technology in rice milling, and that the innovation increases milling efficiency and improves milling quality. Moreover, it is found from the estimation of price determination function that in the Kumasi clusters milled rice price is affected by milling quality namely the content of whole grain, while in the rural areas there is no significant relationship between milling quality and the price. This indicates that the clusters, probably because of the higher concentration of transactions, will be the basis of informal product-quality grading system, which is critical for the market development.

Once price-quality relationship is established in the market, rice producers will pay more attention to post-harvest handling and the product will be able to compete with imports, resulting in stimulation of local rice production. Hence, in conclusion, the clusters in post-harvest industry play significant roles in the market development, which will benefit not only the industry itself but also traders as well as producers.

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