Interlinkage in the Rice Market of Ghana:
Money-lending Millers Enhance Efficiency

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Abstract

Most of the large-scale millers in Ghana provide a loan to the farmers under the agreement that the farmers will bring their paddy to them. This paper examines the effect of this interlinkage on the efficiency of rice milling. A quadratic cost function was estimated, and capacity utilization was calculated in relation to money lending. The results show that if the millers provide a loan to the farmers, the operating rate will increase by 24%.

Key words: Interlinkage; Rice miller; Capacity utilization; Money lending; Ghana

1. Introduction

The development of local agricultural market is a crucial part of agricultural development in developing countries. Its importance has been enhanced because of recent trade liberalization. One of the significant phenomena in rural economies is interlinked transaction. Although such informal market institutions reflect uneven distribution of social power (Crow and Murshid, 1994), they could be efficient given market conditions. Hence, by studying the nature of interlinkages in a particular region, we will be able to identify the constraints to market development and to obtain meaningful policy implications. On this line, the present paper analyzes the rice markets in Ghana, particularly focusing on rice millers.

In Ghana, average yearly rice consumption per capita increased from 7.3 kg in the 1980's to 13.2 kg in the 1990's. During the same period, rice imports also increased from 53.4

thousand metric tons (MT) to 123.4 thousand MT. This sharp increase in rice imports caused

an expansion of the trade deficit, which has become a serious macro economic problem

(ISSER, 2002). Therefore, enhancing domestic rice supply is an urgent policy issue now. This

requires not only an increase of local rice production but also the development of its markets.

For the local rice to be competitive in the market, the improvement of post harvest processing,

particularly of rice milling, is essential. This urges us to examine the efficiency of rice milling

in Ghana.

Millers are one of the key players in the Ghana's rice market. After hand threshing, rice

producers by themselves bring the paddy to millers. The millers mill the paddy and charge

milling fee to the producers. After milling, the producers sell 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 Ghana is only intermediary: they announce the prices of milled rice

according to the market prices and the transactions between producers and traders take place

based on the prices. It is also frequent that producers leave the milled rice at the mill and the

millers sell it to traders in place of the producers, although millers do not directly purchase

and sell rice.

Not only the act of intermediary, we found that some millers provide rice producers with

funds on a loan basis under the agreement that they will bring paddy to the millers, and

surprisingly in most cases without interest. Now, an interesting question is if this interlinkage

between producers and millers is Pareto improving. However, this paper deals with only millers. That is, we examine if the millers' no interest loan enhances the efficiency of their milling operation. To this end, we estimate a short-run cost function for the millers and evaluate the impact of money-lending on the operating rate as well as profitability.

2. Characteristics of rice millers

Sixty one millers were selected randomly from the Kumasi area in Ghana. We interviewed the owners and the operators to obtain the information on mill and milling activities in 2001.

Most of the rice millers were established in recent years: 44% of them were established during the last five years. This sharp increase in the number of millers reflects the recent policy of the government of Ghana that encourages rice production, and also implies that the milling is profitable.

There is large variation in milling capacity (from 75 to 5220 kg/day: the mean = 1637 kg/day and the standard deviation = 1321kg/day). Relatively large-scale millers use one-path type milling machine made in Japan or China, and the other millers use the Engelberg type milling machine made in India or Ghana. The correlation coefficient of the milling capacity and the variable profit per produced milled rice is found to be 0.445, suggesting that larger scale millers tend to get a higher profit per milled rice production[1].

With respect to interlinkage, twenty seven millers provided a loan to farmers in 2001 under the agreement that they would bring paddy to the millers. Six of these millers imposed

an interest rate and the average rate was 82%, which is close to the market interest rate. The

other twenty one millers did not impose any interest to farmers.

We tried to identify invisible cost imposed to the farmers other than interest, for example

fixed price agreement (Crow and Murshid, 1994), but we could not find anything except for

the paddy-bringing agreement. This agreement incurs additional cost to farmers if there are

more favorable markets for them (e.g. less transportation cost, higher rice price, etc.).

However, it is difficult for millers to enforce this agreement, and hence, we consider that

millers' bargaining position is weak in this interlinkage transaction. Therefore, we

hypothesize that millers can increase the operating rate of their milling machines at the cost of

providing no interest loan to farmers.

Table 1 shows the average economic variables for the millers who lent or did not lend

money. These results suggest that millers who provide a loan to the farmers show a higher

production, lower unit variable cost, and higher unit variable profit.

3. Model

The cost minimization problem of a miller expressed as follows:

min. $\quad C^T = w_L L + w_V V + w_K K$ (1)

s.t. $\quad Y = f(L, V, K),$ (2)

where Y is the milled rice production, L is the labor input, V is the input for machine running

such as fuel, K is the capital input, w_L, w_V, and w_K are input prices for L, V, and K.

If the capital input K is a fixed factor, variable cost function is defined as follows:

$$C^V = C^V (Y, w_L, w_V, K) \tag{3}$$

and short-run cost function is defined as follows:

$$C^S = C^V (Y, w_L, w_V, K) + w_K K. \tag{4}$$

3.1 Capacity utilization

This paper uses "capacity utilization" derived by Morrison (1999) as the index for the operating rate. There are two other indices. One is the rate of actual operating hours observed and maximum possible operating hours. This index is very popular; however, the definition of "maximum possible" is ambiguous. The other index is the rate of actual operating hours observed and maximum operating hours in the past. Although this index is easy to calculate, it can be frequently changed by the addition of data. Therefore, we do not use these indices in our study.

Capacity utilization is based on the production in the steady state of the fixed factor. If a variable cost function is estimated, the parameter of the change of the variable cost to the change of the fixed factor can be obtained. By using the parameter, shadow cost C^{SD} is given by the following equation:

$$C^{SD} = C^V - \frac{\partial C^V}{\partial K} K. \tag{5}$$

On the other hand, total cost C^T is calculated by the following equation:

$$C^T = C^V + w_K K. \tag{6}$$

Then, capacity utilization is expressed as the rate of the shadow cost and total cost as follows:

$$CU = \frac{C^{SD}}{C^T}. \tag{7}$$

This will be used in the miller model as an index of the operating rate of the milling machine.

3.2 Treatment of self-selection bias

In this paper, it will be determined whether a miller operates his or her milling machine close to the optimum level by providing a loan to the farmers. However, because the decision of loan provision is endogenous, an efficient miller may also provide a loan to the farmers. Hence, we need to control for this "self-selection bias." We apply two-stage regression method presented by Carter (1989).

First, the determinate variable D of loan providing is regressed on the vector of exogenous variables X as follows:

$$D = \text{A'X} - u. \tag{8}$$

The following switching regression function is introduced by combining conditional expected values of variable costs:

$$E[C^V] = E[C^V{}_L \mid D > 0]\text{prob}(P = 1) + E[C^V{}_N \mid D \le 0]\text{prob}(P = 0)$$

$$= \text{B'}_N \text{Z} + (\text{B'}_L - \text{B'}_N)\text{Z}\Phi(\text{A'X}) + (\sigma_L - \sigma_N)\phi(\text{A'X}), \tag{9}$$

where Φ is the cumulative distribution function, ϕ is the probability density function, P is binary variables which equals one if a miller provides loan and equal zero otherwise, $\text{prob}(P = 1) = \Phi(\text{A'X})$, $\text{prob}(P = 0) = 1 - \Phi(\text{A'X})$, and Z is the vector of variables in the

short-run cost function given by function (4), i.e., Y, w_L, w_V, and K. To estimate function (9), first, parameter A is obtained by estimating equation (8) in Probit model, and $\Phi(A'X)$ and $\phi(A'X)$ of each miller are calculated by using the parameter. Next, parameters B'$_N$, B'$_L$-B'$_N$, and $\sigma_L - \sigma_N$ are estimated by using the variables Z, $\Phi(A'X)$, and $\phi(A'X)$. (B'$_L$ $-$B'$_N$)$\overline{Z}$ is the average effect that shows the changes in the variable cost when the average miller provides a loan to the farmers, where $\overline{Z}$ is the sample mean of Z. $\sigma_L - \sigma_N$ is the differential effect that indicates differences in the variable cost by factors except for observable variables.

3.3 Empirical model

If the short-run cost function (4) is specified in a normalized quadratic function, the switching regression function (9) will be as follows:

$$
E\left[\frac{C^V}{w_L}\right] = \alpha_{0N} + \alpha_{YN}Y + \alpha_{VN}\frac{w_V}{w_L} + \alpha_{KN}K + \frac{1}{2}\beta_{YYN}Y^2 + \frac{1}{2}\beta_{VVN}\left(\frac{w_V}{w_L}\right)^2 + \frac{1}{2}\beta_{KKN}K^2
$$

$$
+ \beta_{YVN}Y\frac{w_V}{w_L} + \beta_{YKN}YK + \beta_{VKN}\frac{w_V}{w_L}K + \frac{w_K}{w_L}K
$$

$$
+ \left[(\alpha_{0L} - \alpha_{0N}) + (\alpha_{YL} - \alpha_{YN})Y + (\alpha_{VL} - \alpha_{VN})\frac{w_V}{w_L} + (\alpha_{KL} - \alpha_{KN})K \right.
$$

$$
+ \frac{1}{2}(\beta_{YYL} - \beta_{YYN})Y^2 + \frac{1}{2}(\beta_{VVL} - \beta_{VVN})\left(\frac{w_V}{w_L}\right)^2 + \frac{1}{2}(\beta_{KKL} - \beta_{KKN})K^2 + (\beta_{YVL} - \beta_{YVN})Y\frac{w_V}{w_L}
$$

$$
+ (\beta_{YKL} - \beta_{YKN})YK + (\beta_{VKL} - \beta_{VKN})\frac{w_V}{w_L}K \right]\Phi(A'X) + (\sigma_L - \sigma_N)\phi(A'X). \tag{10}
$$

Applying Shephard's lemma to function (10), the following conditional input demand

function of machine running can be derived:

$$E[V] = E\left[\frac{\partial C^V}{\partial w_V}\right] = E\left[\frac{\partial (C^V / w_L)}{\partial (w_V / w_L)}\right] = \alpha_{VN} + \beta_{VVN}\frac{w_V}{w_L} + \beta_{YVN}Y + \beta_{VKN}K$$

$$+ \left[(\alpha_{VL} - \alpha_{VN}) + (\beta_{VVL} - \beta_{VVN})\frac{w_V}{w_L} + (\beta_{YVL} - \beta_{YVN})Y + (\beta_{VKL} - \beta_{VKN})K\right]\Phi(A'X). \qquad (11)$$

From the linear homogeneous condition of prices and variable cost, the following conditional

input demand function of labor is obtained:

$$E[L] = E\left[\frac{\partial C^V}{\partial w_L}\right] = E\left[\frac{C^V}{w_L}\right] - E\left[\frac{\partial C^V}{\partial w_V}\frac{w_V}{w_L}\right]$$

$$= \alpha_{0N} + \alpha_{YN}Y + \alpha_{KN}K + \frac{1}{2}\beta_{YYN}Y^2 - \frac{1}{2}\beta_{VVN}\left(\frac{w_V}{w_L}\right)^2 + \frac{1}{2}\beta_{KKN}K^2 + \beta_{YKN}YK$$

$$+ \left[(\alpha_{0L} - \alpha_{0N}) + (\alpha_{YL} - \alpha_{YN})Y + (\alpha_{KL} - \alpha_{KN})K + \left[\frac{1}{2}(\beta_{YYL} - \beta_{YYN})Y^2 - \frac{1}{2}(\beta_{VVL} - \beta_{VVN})\left(\frac{w_V}{w_L}\right)^2\right.\right.$$

$$+ \frac{1}{2}(\beta_{KKL} - \beta_{KKN})K^2 + (\beta_{YKL} - \beta_{YKN})YK\right]\Phi(A'X) + (\sigma_L - \sigma_N)\phi(A'X). \qquad (12)$$

Parameters of the variable cost function (10) are obtained by system estimation for functions

(10), (11), and (12).

By differentiating the variable cost function in the function (10) with respect to capital

input K and multiplying by the wage rate w_L, the shadow value of capital is given as follows:

$$E\left[\frac{\partial C^V}{\partial K}\right] = E\left[\frac{\partial (C^V / w_L)}{\partial K}w_L\right] = \alpha_{KN}w_L + \beta_{KKN}Kw_L + \beta_{YKN}Yw_L + \beta_{VKN}w_V$$

$$+ \left[(\alpha_{KL} - \alpha_{KN})w_L + (\beta_{KKL} - \beta_{KKN})Kw_L + (\beta_{YKL} - \beta_{YKN})Yw_L + (\beta_{VKL} - \beta_{VKN})w_V\right]\Phi(A'X) \quad (13)$$

By substituting parameters and average values of variables into equation (13), the shadow

value of capital is calculated, and the shadow cost is obtained by substituting it into equation (5). After calculating the total cost, the capacity utilization is obtained by equation (7). Two cases in which millers did not lend money, i.e., the term for $\Phi(A'X)$ is zero and otherwise will be compared.

4. Data

4.1 Price and quantity of capital

In order to estimate the cost function and to obtain capacity utilization, we need to have reasonable estimates for the price of capital, w_K, as well as quantity of capital utilized, K. For the price of capital, we use capital price index. This is the weighted average of the user cost price of the milling machine and construction. On the other hand, capital quantity index is used as the quantity of capital. This is calculated as the total depreciation cost over the capital price index.

The user cost price of the milling machine and construction, p_{ku}, is calculated by using the straight-line method as follows:

$$p_{ku} = p_{kp}(r + D_r), \tag{14}$$

where p_{kp} is the acquisition value, r is the interest rate corresponding to the agricultural market rate of Ghana in 2001, i.e., 0.44, and D_r is the depreciation rate. The straight-line depreciation rate is the reciprocal number of the durable period. Durable period of the milling machine is estimated by millers themselves, and that of the construction is 25 years uniformly.

The depreciation cost of the milling machine and construction is also calculated using the straight-line method. For the calculation, it is assumed that the salvage value, p_{ks}, of the milling machine and construction accounts for 10% of the acquisition value. Then, the depreciation cost, DC, is calculated by using the following equation:

$$DC = (p_{kp} - p_{ks})\, D_r. \tag{15}$$

4.2 Price and quantity of variable inputs

Labor input is the number of workers for rice milling and its price is the wage rate of the operator. Price index of machine running input (i.e., non-labor variable input) is calculated by the weighted average of prices of fuel, electricity, oil, and parts of the milling machine. Cost shares of these inputs are used as the weights. Quantity index of machine running input is the total cost over the price index.

5. Estimated parameters

Table 2 shows the results of the estimation of equation (8) by the Probit model. The results show the following characteristics are significant for the millers who tend to provide rice producers with funds on a loan basis: 1) The millers have large mills, 2) Mills are located in Kumasi city, 3) The millers have been engaged in milling over a long period of time, 4) The owners and operators are relatively young.

These results can be interpreted as follows. First, millers who have large milling machine tend to provide a loan to farmers, probably because such millers can afford it, but also

because such millers need to increase operation rate by providing a loan. Second, the location in Kumasi and experience in milling are advantageous for millers to gather information about the producers and markets. These points facilitate millers to make loan agreement that is not so enforceable. On the other hand, millers in Kumasi have disadvantage in transportation cost compared with millers in satellite towns, and consequently they need to attract producers by providing a loan. Third, younger entrepreneurs may be more positive to expand their business by engaging in non-traditional transactions.

Next, the system of short-run cost function (10), conditional input demand function of machine running (11) and labor (12) is estimated simultaneously by using the predicted values for probability density and cumulative distribution obtained from the first-stage Probit regression[2].

By substituting these parameters and average variables into equation (13), the shadow value of capital is obtained. Using the shadow value, the shadow cost is calculated and its rate for the total cost corresponds to the capacity utilization. Table 3 shows the costs and capacity utilization with and without providing a loan respectively. These results suggest that if an average miller provides a loan to farmers, the capacity utilization will increase by 24%.

6. Concluding remarks

We examined the effect of providing a loan by millers on milling efficiency by estimating the short-run cost function. These results suggest that the operation rate of the mills should

increase by 24% by providing a loan to farmers. Furthermore, in this case, the total cost should decrease by 17.1% corresponding with the case when no loan is provided and consequently the efficiency will increase. Thus, with respect to the interlinkage transaction, we can conclude as follows. (1) The amount of paddy collection increases by providing a loan to the farmers. (2) The operation rate and the efficiency of the millers are increased. (3) The farmers can get their credit with low or no interest.

However, the emergence of this interlinkage implies inefficiency of the Ghananian rice market. First, although our data suggests that relatively larger mills are more technically efficient, the millers cannot fully utilize the capacity up to the optimal level. This may be caused by the underdevelopment of transportation and storage of paddy as well as the difficulty to obtain market information. Second, although we did not investigate the benefit that the farmers gain from this interlinkage, we believe that they enjoy the no interest loan as far as their crop does not fail. However, naturally this implies that demand for credit among cultivators is high and the credit market is not functioning well.

Large-scale mills should be promoted in Ghana, not only because of the superior efficiency but also because of their better milling quality, both of which will enhance competitiveness of locally produced rice. However, efficiency of the rice markets may not be so improved as expected, without complementary policies to develop efficient transportation, storage facilities for alleviating seasonal fluctuations of the operating rate, and information

system related to the demand of paddy for milling.

[1] Timmer (1998) considers capital cost and concludes that small-scale millers are more efficient in Java.

[2] Estimation results are not provided in this short paper, but they are available from the authors upon request.

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Table 1 Money lending and economic variables

Type of Millers (number)	Production of milled rice *** (1000kg/year)	Unit Variable Cost ** (cedi/kg/year)	Unit Variable Profit * (cedi/kg/year)
Lending (27)	116.6	123.3	90.5
No lending (34)	32.3	229.7	6.0

The means are different at the level of 1% significance(***), 5% significance(**), and 10% significance(*), respectively.

Table 2 Estimation of the results of the Probit model

Parameter	Esitmates	t-value
Intercept	0.9169	0.8860
Location (1:Kumasi city, 2:other region)	0.9452	2.2399**
Job related rice before (1:miller of an other region, 2:otherwise)	0.9340	1.2525
Age of owner of mill	-0.0353	-2.1123**
Age of operator	-0.0224	-1.1315
Years of milling	0.0413	1.7380*
Capacity of mill	0.0049	2.4613**
Floor area of milling house	-0.0379	-0.9001

Fraction of correct prediction: 0.7541. **:5%significant, *:10%significant.

Table 3 Costs and capacity utilization

	Estimates and Average	
	No lending	Lending
Unit variable cost (cedi/kg)	66.811	51.971
Unit total cost (cedi/kg)	86.600	71.971
Capacity utilization	0.683	0.925