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The South African Maize Milling Industry: Can Small and Medium-scale Maize Milling Enterprise Survive and Thrive?

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Abstract

This paper investigates the competitiveness of small and medium-scale maize milling enterprises in South Africa from estimates of a translog stochastic cost frontier model. Results suggest that small and medium-scale maize mills in South Africa are cost-inefficient, operating at 59 percent and 30 percent higher cost than the best practice respectively. This implies that, on average, about 59 percent and 30 percent of the costs incurred by small and medium-scale maize mills respectively can be avoided without a reduction in maize meal output. Given this empirical estimates, if small and medium-scale maize milling enterprises in South Africa are able to reduce cost by 59 percent and 30 percent on average respectively, these mills could become competitive all things being equal, thus creating the much needed competition in the maize milling industry. Furthermore, results show that some mill-specific characteristics such as education, mill size, age of mill and location could contribute significantly to mill-level efficiency.

Introduction

In 1997 the maize industry was deregulated. Deregulation was expected to lead to a proliferation of small and medium scale maize millers, and thereby leading to better competition in the sector resulting ultimately in a reduction in real maize meal prices. These expectations were founded in evidence from elsewhere where deregulation resulted in improved market conditions, increased intensity in competition (Kay and Vickers, 1988), higher levels of efficiency (Berger and Humphrey, 1997) and lower prices (Backman, 1981). Previous studies conducted by (Mukumbu, 1994 and Jayne *et al*, 1995) on the impact of maize market reform in southern and eastern Africa such as Zimbabwe, Zambia, Mozambique and

Kenya, established that the reforms led to lower maize milling/ retailing margins¹ in real terms. One of the reasons given for these reductions in maize milling and retailing margins in these countries was that, the reform opened the maize marketing system to better competition from the small-scale millers and retailers who were formerly excluded from entering the market. As a result of the better competition in milling and retailing margins, a downward force was exerted on the margins of the large-scale industry products thus, benefiting consumers (Jayne *et al*, 1995).

However, the same cannot be said for South Africa. In the case of South Africa, reports by Food Price Monitoring Committee, (2003) and Traub and Jayne, (2004) showed that the maize milling/retail margins in the formal market have been rising in recent years after maize market deregulation. Given the moderately developed economy of South Africa, one would have expected maize milling and retailing margins to decline after deregulation of prices, to levels nearly, if not lower, with those in neighbouring countries assuming there are sufficient competitive pressures (Traub and Jayne, 2004). If marketing margins have not fallen after deregulation of the maize market, this is an indication of potential non-competitive behaviour at the stages of maize milling and retailing.

The continued existence of small and medium-scale maize milling enterprises in a very competitive market dominated by large capital intensive milling companies depends to a large extent upon the competitiveness of these mills with large-scale mills, which may centre on their potential to keep production costs lower than their competitors. Consequently, analysis of the competitiveness of small and medium-scale maize millers could provide policy makers with the insight required in creating programmes that can sustain and facilitate

¹ Milling/retailing margins are defined as the difference between the retail price of maize meal and the price at which millers purchase maize, after accounting for extraction rates and the value of by-products produced in the milling process (FPMC), 2003).

existing as well as new investments in this sector of the South African economy. Hence, until more successful competitors emerge, the South African maize milling industry will remain characterised by few role players and ever increasing margins. This would impact significantly on low-income consumers who spend up to 20 percent of their monthly income on maize meal (Watkinson and Makgetla, 2002). The purpose of this paper is to assess the competitiveness of a sample of small and medium-scale maize millers in South Africa through estimates of a translog cost function.

The reminder of the paper is organized as follows. Section 2 discusses the methodological framework of the stochastic frontier cost function. Section 3 presents the empirical model and description of the data. The empirical results are discussed in section 4 and section 5 presents some concluding comments.

2. Methodology

This paper applies stochastic cost frontier technique to measure the efficiency of small and medium-scale maize mills. Since its first introduction by Farrell (1957), the measurement of efficiency has been applied to a wide array of problems while going through several modifications and developments. One of these developments, which we use in this paper, is the Battese and Coelli (1995) inefficiency effects model.

The theoretical specification of the cost function (Kumbhakar and Lovell, 2000) is defined as:

$$C_i = C_i(Y_i, P_i; \beta) + \varepsilon_i \quad (1)$$

where C_i represents vector of observed total costs of production, $C_i(Y_i, P_i; \beta)$ is the cost frontier common to all producers, Y_i represents vector of output, P_i is a vector of input prices and β is vector of the unknown parameters to be estimated. The difference between the actual and frontier cost is captured by the error term ε_i , which is made up of two components, $\varepsilon_i = V_i$

+ U_i . The (V_i) component captures the effect of the stochastic noise and is assumed to be independently and identically distributed following a normal distribution, $v_i \sim iid N(0, \sigma_v^2)$. This component accounts for measurement error and other random as well as misspecification of functional form in the estimated cost function. The one-sided non-negative disturbance (U_i) component captures the cost inefficiency ($U_i \geq 0$), and is assumed to be independently distributed from V_i , $u_i \sim iid N^+(0, \sigma_{ui}^2)$. Given the cost frontier in equation (1), cost efficiency (CE) of the individual firm relative to the stochastic cost frontier can be expressed as Kumbhakar and Lovell (2000):

$$CE_i = \frac{C(y_i; p_i; \beta) \exp[e_i]}{C_i}, \quad (2)$$

Equation (2) defines cost efficiency as the ratio of minimum feasible cost to actual cost. Using equation (2), a measure of cost efficiency of each firm is provided by:

$$CE_i = \exp\{-U_i\}. \quad (3)$$

To explain inefficiency, the inefficiency effects (U_i) may be defined as:

$$U_i = \sum Z_i \delta_0 + \omega_i \quad (4)$$

where Z_i is a vector of firm-specific the explanatory variables assumed to be associated with inefficiency effects of the firm; δ_0 is a vector of the unknown parameters of the firm-specific inefficiency variables to be estimated; and ω_i capture the unobservable random variables which are assumed to be independently and identically distributed obtained by truncation (at zero) of the normal distribution with mean, μ_i and variance σ_u^2 , such that: $\mu_i = Z_i \delta$.

3. Data and Model Specification

3.1 Data

This study is based on the cross sectional survey and data obtained from a sample of 56 small and medium-scale maize milling enterprises from four provinces in South Africa namely; North West, Mpumalanga, Free State and Limpopo which were purposively selected. The data for this study were collected by means of structured questionnaire. Data collected include output; price of maize grain; price of labour; price of other inputs (include the costs of spare parts, packaging material, transportation and electricity); capital (measured as the sum of the yearly depreciation cost of milling equipment); mill size (measured as milling capacity in tonnes per day); and other mill and miller characteristics. Table 1 presents summary statistics and definition of variables used in the study.

(Insert Table 1 here)

3.2 Model Specification

The functional form employed to specify the stochastic cost is the translog function. The empirical specification of the translog stochastic cost ² frontier model for the small and medium-scale maize millers in South Africa is as follows:

$$\begin{aligned}\ln C_i = & \beta_0 + \beta_{1i} \ln Y_i + \beta_{2i} \ln P_{Mi} + \beta_{3i} \ln P_{Li} + \beta_{4i} \ln K_i \\ & + \frac{1}{2} \beta_{5i} \ln(Y_i)^2 + \frac{1}{2} \beta_{6i} \ln(P_{Mi})^2 + \frac{1}{2} \beta_{7i} \ln(P_{Li})^2 + \frac{1}{2} \beta_{8i} \ln(K_i)^2 \\ & + \beta_{9i} \ln Y_i \ln P_{Mi} + \beta_{10i} \ln Y_i \ln P_{Li} + \beta_{11i} \ln Y_i \ln K_i + \beta_{12i} \ln P_{Mi} \ln P_{Li} \\ & + \beta_{13i} \ln P_{Mi} \ln K_i + \beta_{14i} \ln P_{Li} \ln K_i + V_i + U_i\end{aligned}\quad (6)$$

² Prior to estimation, both the dependant variable (total cost) and the input prices on the right hand side were normalized by the price of other inputs impose the linear homogeneity assumption in the cost function.

where \ln is natural logarithm; C_i is the observed total cost of maize meal production per tonne for i th mill; Y_i is output of maize meal in tonnes; P_{Mi} is price of maize grain per tonne, P_{Li} is price of labour per tonne of maize meal produced; K_i is the capital input (measured as the yearly depreciation costs of milling equipment). β_i 's are vectors of the unknown parameters to be estimated. The V_i and U_i components are as defined earlier. U_i is obtained by truncations (at zero) of the normal distribution with mean, μ_i and variance σ_u^2 , such that:

$$\mu_i = \delta_0 + \sum \delta_k Z_{ik} + \zeta \quad (7)$$

Z_{ik} is the explanatory variable assumed to be associated with inefficiency on firm i and given as $Z_1, Z_2, Z_3, Z_4, Z_5, Z_6$ and Z_7 representing education, age of mill, mill size and location dummies [Limpopo (LP), North West (NW), Mpumalanga (MP) and Free State (FS)] respectively. The study estimates equations (6) and (7) simultaneously through Maximum Likelihood techniques using the FRONTIER version 4.1 computer program developed by Coelli (1996).

4. Results

4.1 Estimates of the Cost Function

The maximum likelihood estimates of the translog cost frontier coefficients of the models obtained from estimating the stochastic frontier cost function and the level of cost inefficiencies of the mills are presented and discussed in this section. The stochastic cost frontier estimation based on equation (6) shows the effects of input prices and the fixed factor (capital) on the total cost of small and medium-scale maize mills. Two models were estimated and analysed, one each for the small-scale mills and medium-scale mills. The results are reported in Tables 2. As expected, the results from the estimation show that the

cost elasticities³ with respect to output, input prices and capital are all positive and significant for both the small-scale mills and the medium-scale mills respectively. This conforms to the basic properties of the cost function that satisfy the cost minimization hypothesis. Since output elasticity is positive, this implies that an increase in maize meal production would also demand an increase in the total cost of milling in small and medium-scale maize milling enterprises. The same results were also recorded for the inputs prices and capital.

The coefficient of the gamma parameter (γ) is estimated as 0.990 and 0.750 for the small-scale and medium-scale mills respectively and significant at one percent probability level. These values are close to one and significantly different from zero indicating that inefficiencies exist in small and medium-scale maize milling enterprises in South Africa. According to Battese and Coelli (1995), inefficiency is absent from a model if γ is not significantly different from zero and the variance of the inefficiency is zero. Since the estimated variance parameter is close to one and significant, it appears that inefficiency is an important cause of reduced efficiency.

(Insert Table 2 here)

4.2 Cost Efficiency Estimates

Table 3 presents the frequency distribution of cost efficiency scores for the small and medium-scaled maize mills in South Africa. The results from the cost efficiency analysis reveal that the surveyed mills operates at different cost efficiency levels ranging from a low of 1.14 (14 percent) to a high of 1.78 (78 percent) for the small-scale maize mills, and a low of 1.01 (1 percent) and a high of 1.61 (61 percent) for the medium-scale maize mills. The average cost efficiency levels in the small-scale maize mills and the medium-scale maize

³ Since total cost and the entire right-hand variable (regressors) of the cost equation in equation (4) are in logarithms and have been normalized, first order coefficients can be directly interpreted as cost elasticities (Filippini and Luchsinger, 2005).

mills are 1.59 (59 percent) and 1.30 (30 percent) respectively. Implying that the average small-scale maize miller has costs 59 percent higher than the minimum cost frontier and the average medium-scale maize miller has costs 30 percent higher than the minimum cost frontier respectively. This also implies that, on average, about 59 percent and 30 percent of the costs incurred by the small and medium-scale maize mills respectively can be avoided without reducing the total output of maize meal produced.

(Insert Table 3 here)

4.3 Determinants of Cost Inefficiency

The inefficiency function is known to provide some explanations for variations in efficiency levels between mills. A negative sign on the coefficient of the inefficiency variable indicates a positive contribution to efficiency while a positive sign indicates that the associated variable has a negative effect on efficiency. The mill-specific characteristics included in the inefficiency model are education, mill size, age of mill and location dummies to control for provincial differences. The result for this empirical analysis for small and medium-scale mills is presented in Table 4.

(Insert Table 4 here)

Based on the results of the inefficiency model, the estimated coefficient of education is negative in both the small and medium-scale maize mills suggesting that education plays an important role in influencing the efficiency level of medium-scale maize millers. Therefore, a higher level of education minimises inefficiency, consistent with previous reports (Lockheed *et al.*, 1980 and Ali and Flinn, 1989). The coefficient of age of mill (proxy for experience) was found to be negative and significant for the medium-scale mills, suggesting a positive relationship between age of mill and cost efficiency. Other studies have also found a positive relationship between firm age and efficiency (Cheng and Tang, 1987; Haddad, 1993). This is expected due to the principle of learning by doing that occurs through

production experience (Admassie and Matambalya, 2002). Therefore, the significant positive relationship between age of mill and cost efficiency in the medium-scale maize mills suggests that medium-scale maize mills are more efficient than the small-scale maize mills. From the fore going, the level of education of millers and age of mill appears, to enhance mill efficiency the most. While education enhances allocative decisions, experienced millers are more proficient in the methods of production and optimal allocation of resources, resulting in mills with better cost efficiency.

The estimated coefficient of mill size was positive and significant for small-scale maize mills. On the other hand, a negative and significant coefficient was found for medium-scale maize mills. This implies that a negative relationship exist between mill size and cost efficiency in small-scale maize mills, further confirming that the smaller the mill size, the more the inefficiency. On the other hand, the negative and significant coefficient of mill size found for the medium-scale maize mills imply that a positive relationship exist between mill size and efficiency in medium-scale maize mills. Meaning that as mill size increases its inefficiency decreases, hence medium-scale maize mills tended to be more cost efficient than the small-scale maize mills. Thus, expanding or upgrading the mill size of small-scale maize mills could possibly prepare the way for the much needed competition in the maize milling industry in the long run.

According to Onder *et al.*, (2003), the location of a firm could influence its performance as situating a firm in any given environment could either limit or enhance its efficiency due to either lack of or availability of useful infrastructure respectively. The results show that the location of maize mills could affect its cost efficiency (Table 4). The fact that both categories of mills were found to be cost efficient in one province and not in the others could be

attributed to provincial cost differential in inputs used in maize meal production. This is not surprising because it was found that the transportation costs in particular per tonne of maize vary across provinces.

4.4. Cost efficient and inefficient mills

Table 5 reports on mean cost efficiency estimates distribution above and below the mean efficiency value. Results show that 42 percent of the small-scale mills were below the mean efficiency value of 1.59, implying that only 42 percent of the small-scale maize millers surveyed were cost efficient than the average miller in the sample of small-scale maize millers. On the other hand, more than half (58 percent) of the small-scale millers were less efficient because they were above the mean efficiency estimates. In the case of the medium-scale maize millers, 39 percent of the millers were below the mean efficiency value of 1.30. Meaning that only 39 percent of the medium-scale maize millers surveyed were cost efficient than the average miller in the sample of medium-scale maize millers with 61 percent of the millers less efficient.

(Insert Table 5 here)

5. Conclusion

This paper examines the competitiveness of small and medium-scale maize milling enterprises in South Africa using stochastic cost frontier approach. A translog stochastic cost frontier model was employed to estimate the cost efficiency of small and medium-scale maize milling enterprises in South Africa. These categories of maize mills were found to exhibit substantial cost inefficiency, indicating that there is significant room for enhancing their competitiveness through improvement in cost efficiency. The evidence provided suggests that the small-scale mills and the medium-scale mills in South Africa are operating at 59 percent and 30 percent higher cost than the best practice respectively. Results indicate that the medium-scale maize mills are more cost efficient than the small-scale maize mills.

However, more than half (58 percent) of small-scale maize mills and (61 percent) of medium-scale maize mills in the sample of were found to be less cost efficient than the average mill in the sample. Overall, empirical results show that small and medium-scale maize mills in South African can survive and thrive if they can cut cost by 59 percent and 30 percent respectively.

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Table 1: Summary statistics and definition of variables in the cost functions analysis for the surveyed small and medium-scale maize mills

Variable	Small-scale maize mills				Medium-scale maize mills			
	Std.				Std.			
	Mean	Dev.	Min	Max	Mean	Dev.	Min	Max
C = Total cost/tonne of maize meal produced (Rand)	1183.8	152.9	917.8	1509.5	1155.7	256.7	846.3	1915.4
Y_i = Output of maize meal produced (tonnes)	2063.6	1208.9	360	4320	11190.4	6212.9	3000	24000
P_{Mi} = Price of raw maize grain/tonne (Rand)	816.8	96.0	700	1099.5	843.6	141.1	700.2	1250
P_{Li} = Price of labour /tonne of maize meal produced (Rand)	84.7	57.7	6.9	281.3	58.9	100.5	10	455
K_i = Capital/tonne of maize meal produced (Rand)	35.1	34.8	1.9	136.6	26.1	33.3	1.3	115.1
P_{oth} = Price of other inputs /tonne of maize meal produced (Rand)	247.1	82.2	119.4	453.7	227.1	78.2	79.9	350.4
Education*	2.6	1.1	0	5	3.3	1.3	2	5
Mill size (milling capacity) tonnes/day	11.5	5.4	1.9	24	51.7	25.1	25.2	96
Age of mill (years)	15.8	18.3	2	76	19.3	19.5	1	66
LP (Dummy: 1 if located in Limpopo and 0 otherwise)	0.3	0.5	0	1	0.2	0.4	0	1
NW (Dummy: 1 if located in North West and 0 otherwise)	0.4	0.5	0	1	0.4	0.5	0	1
MP (Dummy: 1 if located in Mpumalanga and 0 otherwise)	0.1	0.3	0	1	0.3	0.5	0	1
FS (Dummy: 1 if located in Free State and 0 otherwise)	0.2	0.4	0	1	0.2	0.4	0	1

*Education is measured by an index varying from 0 to 5. Where 0 = no formal education; 1 = Primary school; 2 = Grade 12; 3 = Diploma; 4 = Bachelors degree; and 5 = postgraduate

Table 2: Maximum likelihood estimates of the translog stochastic frontier cost function for small and medium-scale maize mills

Variables ^a	Parameter	Small-scale maize mills			Medium-scale maize mills		
		Coefficient	S.E	t-ratio	Coefficient	S.E	t-ratio
Stochastic frontier model							
Constant	β_0	-0.157	21.10	-0.01	14.93	0.99	15.08***
Y_i	β_1	0.80	0.44	1.82**	2.35	0.98	2.53**
P_{Mi}	β_2	1.71	0.52	3.28***	1.61	0.99	1.63**
P_{Li}	β_3	0.67	0.38	1.76**	1.85	0.99	1.87**
K_i	β_4	0.37	0.23	1.61**	2.10	0.99	2.12**
$\frac{1}{2} \ln Y_i * \ln Y_i$	β_5	-0.23	0.07	-3.28***	0.19	0.61	0.32
$\frac{1}{2} \ln P_{Mi} * \ln P_{Mi}$	β_6	0.29	0.21	1.38	0.31	1.00	0.31
$\frac{1}{2} \ln P_{Li} * \ln P_{Li}$	β_7	-0.05	0.04	-1.25	0.18	0.99	0.18
$\frac{1}{2} \ln K_i * \ln K_i$	β_8	0.12	0.02	6.00***	-0.04	0.99	-0.04
$\ln Y_i * \ln P_{Mi}$	β_9	0.46	0.10	4.60***	0.17	0.99	0.17
$\ln Y_i * \ln P_{Li}$	β_{10}	-0.15	0.05	-3.00***	-0.15	0.95	-0.16
$\ln Y_i * \ln K_i$	β_{11}	-0.04	0.03	-1.33	-0.001	0.87	-0.001
$\ln P_{Mi} * \ln P_{Li}$	β_{12}	0.38	0.09	4.22***	-0.08	0.99	-0.08
$\ln P_{Mi} * \ln K_i$	β_{13}	0.25	0.04	6.25***	-0.03	0.99	-0.03
$\ln P_{Li} * \ln K_i$	β_{14}	0.01	0.03	0.33	-0.003	0.99	-0.003
Variance parameters							
Sigma-squared	σ^2	0.002	0.001	4.20***	0.00	0.76	0.00
Gamma	γ	0.990	0.631	1.57**	0.750	0.211	3.55***

Note: a = see variable definition in Table 1. *** = significant at 1percent level; ** = significant at 5 percent level; * = significant at 10 percent level. S.E: Standard Error

Table 3: Distribution of cost efficiency scores for small and medium-scale maize mills

Efficiency level	Small-scale maize mills		Medium-scale maize mills	
	Frequency	Percentage	Frequency	Percentage
1.0-1.1	1	2.7	5	27.8
1.2-1.3	0	0	6	33.3
1.4-1.5	9	25	6	33.3
1.6-1.7	24	66.7	1	5.6
1.8-1.9	2	5.6	0	0
Total	36	100	18	100
Mean	1.59		1.30	
Minimum	1.14		1.00	
Maximum	1.78		1.61	
Standard deviation	0.12		0.18	

Table 4: Estimates of the determinants of cost inefficiency for small and medium-scale maize mills

Variables	Parameter	Small-scale maize mills			Medium-scale maize mills		
		Coefficient	S.E	t-ratio	Coefficient	S.E	t-ratio
Constant	δ_0	0.37	16.81	0.02	-0.00	0.99	-0.00
Education	δ_1	-0.03	0.01	-3.00***	-1.50	0.98	-1.53**
Size	δ_2	0.06	0.02	3.00***	-1.00	0.44	-2.27**
Age of mill	δ_3	0.00	0.00	0.00	-0.99	0.61	-1.62**
LP	δ_4	0.01	4.23	0.00	-0.00	0.99	-0.00
NW	δ_5	0.01	4.23	0.00	-2.10	0.99	-2.12**
MP	δ_6	0.02	4.23	0.00	-0.00	0.99	-0.00
FS	δ_7	-0.04	4.23	-0.01	0.00	0.99	0.00

Note: *** = significant at 1percent level; ** = significant at 5 percent level; * = significant at 10 percent level.

S.E: Standard Error; LP = Limpopo, NW = North West, MP = Mpumalanga, FS = Free State.

Table 5: Mean cost efficiency estimates and the distribution above and below mean efficiency estimates by mill size

Variable	Mill size	
	Small-scale maize mills (n = 36)	Medium-scale maize mills (n = 18)
Mean efficiency estimates	1.59	1.30
Distribution of efficiency estimates above mean	21 (58%)	11(61%)
Distribution of efficiency estimates below mean	15 (42%)	7 (39%)