Profit efficiency of small and medium scale maize milling enterprises in South Africa

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Despite the reported large margins between producer prices for maize and retail prices for maize meal and the fact that maize meal is a staple food for most of the South African population, there have been only limited investments in small and medium scale maize milling in South Africa since the deregulation of the maize markets. The apparent failure of small and medium scale maize millers to emerge and compete effectively in the maize milling industry in South Africa raises questions about their scale and level of efficiency. Against this background, this paper analyses the profit efficiency of these enterprises, using a translog stochastic profit frontier model. Findings from the profit efficiency analysis show an average profit efficiency score of 80.6 per cent for the small-scale and 87.4 per cent for the medium-scale mills. There is therefore a significant unexplored potential in these categories of mills.

Keywords: Small and medium scale maize millers; Profit efficiency analyses; South Africa

1. INTRODUCTION

Prior to 1997, South Africa's maize marketing system had a single-channel system which discouraged entry by potential competitors, thereby suppressing competition at the milling stage (Bernstein, 1996). In 1997 the South African agricultural market was deregulated. In general it was expected that this would lead to, among other things, a more efficient and competitive agricultural marketing system and increased investment and employment in agriculture (Bayley, 2000). Specifically, the deregulation of the maize market was expected to encourage a proliferation of small and medium scale maize millers, thereby resulting in better competition in the sector and ultimately a reduction in real maize meal prices. These expectations were based on evidence from other countries where deregulation had resulted in improved market conditions, increased intensity in competition, effective resource allocation (Kay & Vickers, 1988), higher levels of efficiency (Berger & Humphrey, 1997) and lower prices (Backman, 1981).

According to Traub and Jayne (2004), previous studies (Mukumbu, 1994; Jayne et al., 1995; Rubey, 1995; Jayne & Jones, 1997) on the impact of maize market reform in southern and eastern Africa established that market reforms led to lower maize milling and retailing margins[2] in real terms. One of the reasons given for this reduction in these parts of Africa was that market reform opened the maize marketing system to better competition from the small-scale millers and retailers who were formerly excluded from the markets. As a result of the

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[2] 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 of the milling process (FPMC, 2003).

competition in milling and retailing margins, a downward force was exerted on the margins of the large-scale industry products, to the benefit of consumers in those countries (Rubey, 1995; Tschirley et al., 1996; Jayne & Argwings-Kodhek, 1997).

However, the same cannot be said for South Africa. Here, reports by the Food Price Monitoring Committee (FPMC, 2003) showed that the maize milling/retail margins in the formal market have been rising in the years since market reform. This finding was also supported by a study carried out by Traub and Jayne (2004), which reported that the maize market reform has not reduced the processing and retailing margins in the maize meal supply chain. These high margins suggest that the small and medium scale maize millers (established and new) have been unable to create the desired competition in the South African maize milling industry. Since South Africa's economy is only moderately developed, one would expect maize milling and retailing margins to decline after deregulation of prices to levels close to, if not lower than, those of neighbouring countries, assuming there are sufficient competitive pressures (Traub & Jayne, 2004). If marketing margins have not fallen after deregulation of the maize market, this may indicate non-competitive behaviour at the stages of maize milling and retailing (Traub & Jayne, 2006).

Furthermore, given the large gap between producer prices for maize (R800 to R1200 per ton) and retail prices for maize meal (about R2800 per ton) (Traub & Jayne, 2006) and the fact that maize meal is a staple food for the majority of the South African population, increased investments in small-scale maize milling in South Africa would have been expected. The apparent failure of small and medium scale maize millers to emerge and compete effectively in the maize milling industry in South Africa raises questions about their scale and level of efficiency. Hence, until more successful competitors emerge the South African maize milling industry will remain characterised by few role players and ever-increasing margins, which will have a detrimental effect on low-income consumers who spend up to 20 per cent of their monthly income on maize meal (Watkinson & Makgetla, 2002). There is an evident need for improved information on the competitive behaviour of small and medium scale maize millers, to help formulate programmes to sustain existing investments and facilitate new ones in the maize meal industry sector in South Africa.

It is against this background that this paper analyses the profit efficiency of small and medium scale maize milling enterprises in South Africa and identifies the determinants of inefficiency.

The rest of the paper is organised as follows. Section 2 provides a brief overview of South African maize milling industry, Section 3 describes the data used in the study the paper is based on and the characteristics of the surveyed mills, Section 4 explains the theoretical measure of profit efficiency, Section 5 presents the model specification and estimation, Section 6 summarises and discusses the results, and Section 7 concludes and offers recommendations.

2. OVERVIEW OF THE SOUTH AFRICAN MAIZE MILLING INDUSTRY

Maize is the most important grain crop in South Africa, being both the major feed grain and the staple food for the majority of the population (FPMC, 2003). About 60 per cent of the maize produced here is white, used primarily for human diets, and the rest is yellow, used mostly for animal feed.

The milling industry has long been a familiar part of the South African economic landscape, providing the staple food for the people (*The Baker*, 2006). Maize milling is of two kinds, wet and dry. Wet milling is done in water and extracts pure starch from the maize; dry milling refines the maize kernels to produce maize meal. The products derived from dry milling are samp,[3] maize grits and maize rice, unsifted and coarse maize meal, and sifted, super and special maize meal, with sifted being the lowest quality and special the highest.

The maize milling industry was deregulated in the 1990s, which enabled new millers to buy and sell to their preferred customers. According to the FPMC report (2003), there are about 190 maize millers in South Africa and the industry currently employs approximately 5300 people. The average annual production of milled maize for the past ten years was 3.7 million tons or 79.5 per cent of the available capacity. In other words, mills are standing idle about 20 per cent of the time. If they were being used to full capacity, millers could be producing in the region of 5 million tons per annum. Twenty-two millers account for 85 per cent of all maize meal produced in South Africa, with the top four companies accounting for 73 per cent of the total share (FPMC, 2003).

3. DATA COLLECTION AND CHARACTERISTICS OF SURVEYED MILLS

3.1 Data collection

The study was based on a cross-sectional survey of small and medium scale maize milling enterprises conducted in the 2005/2006 marketing season in four provinces of South Africa: the North West, Mpumalanga, the Free State and Limpopo. The survey covered a sample of 60 maize milling enterprises engaged in production milling. This sample represents 43.2 per cent of the population of millers recorded in the four provinces. Table 1 shows the distribution of the mills recorded and millers interviewed in each province. The Free State and Limpopo had the highest number of mills, but the majority of the millers interviewed were in the North West Province. Wesley (2003) classifies small-scale milling enterprises as those that can mill between 0.5 and 24 tonnes per day, medium-scale ones as those that can mill between 24 tonnes and 96 tonnes per day, and large-scale ones as those that can mill over 96 tonnes per day. The survey covered 36 small-scale and 18 medium-scale mills. (Of the 60 mills surveyed, six were classified as large-scale and were excluded from the analysis.)

Table 1: Distribution of surveyed mills by province

Province	Number of mills recorded	Number of millers interviewed	Percentage of millers interviewed
North West	39	25	64.1
Mpumalanga	23	9	39.1
Free State	60	12	20
Limpopo	27	14	51.8
Total	139	60	43.2

[3] Samp is dried corn kernels that have been stamped and chopped until broken but not as fine as maize meal or maize rice. The coating around the kernel loosens and is removed during the pounding and stamping process.

Data were collected with the aid of a structured questionnaire and included aspects such as cost of maize grain (per tonne), cost of labour (expenditure on salaries), cost of other inputs (sum total of the cost of spare parts, packaging material, transport and electricity), capital (measured as the yearly depreciation cost of milling equipment), miller characteristics such as education, and mill characteristics such as size, age and location.

3.2 Characteristics of the surveyed small and medium scale millers

A maize mill is an intermediary unit playing two significant roles: as a manufacturing unit it converts raw maize into maize meal, and as a marketing unit it purchases raw maize and forms part of the total supply chain of maize meal to consumers, wholesalers and retailers. South Africa has two main types of small-scale maize milling enterprises: the rural custom or service mills where households in remote rural areas bring their raw maize to be milled for a fee, and the production mills that buy maize grain, mill it into maize meal and then sell to customers (Jayne & Rubey, 1993; Vermeulen, 2006). The medium-scale enterprises tend to be involved mainly in production milling, though some also engage in custom milling, which they do, according to Jonsson et al. (1994), to increase the use of the milling equipment and generate more income.

The characteristics of the surveyed millers and mills are shown in Table 2. In terms of formal education, about 60% of the small-scale maize millers and just under half the medium-scale ones had completed grade 12. Nearly one third of the medium-scale millers had a postgraduate degree, whereas less than 10% of the small-scale ones had achieved this level. Just over half the small-scale millers had been in business for less than ten years, while about 40% of the medium-scale ones had been in business for 20 years and more. Most millers produce a combination of sifted, super and special maize meal. About 40% of the small-scale millers and about 30% of the medium-scale ones produce only special maize meal. Just over half of the medium-scale millers produce a combination of super and special maize meal, but only about 5 per cent of the small-scale millers produce this combination.

Table 2: Characteristics of small and medium scale maize mills in South Africa (%)

Characteristics	Small-scale mills (N= 36)	Medium-scale mills (N = 18)
Miller's education*		
No formal education	1 (2.8)	0 (0.0)
Primary school	1 (2.8)	0 (0.0)
Grade 12	21 (58.3)	8 (44.4)
Diploma	6 (16.7)	2 (11.1)
Bachelor's degree	4 (11.1)	3 (16.7)
Postgraduate	3 (8.3)	5 (27.8)
Age of mill		
1–9 years	19 (52.8)	7 (38.9)
10–19 years	8 (22.2)	4 (22.2)
20 years and above	9 (25)	7 (38.9)
Types of maize meal		
Super	4 (11.1)	0 (0.0)
Special	14 (38.9)	5 (27.8)
Sifted	6 (16.7)	0 (0.0)
Super and special	2 (5.6)	10 (55.6)
Super and sifted	1 (2.8)	1 (5.6)
Special and sifted	9 (25)	1 (5.6)
Combinations of all types of maize meal	0 (0.0)	1 (5.6)
Province		
North West	14 (38.9)	7 (38.9)
Mpumalanga	4 (11.1)	5 (27.8)
Free State	11 (30.6)	3 (16.7)
Limpopo	7 (19.4)	3 (16.7)

Note: N = Number of mills surveyed; figures in brackets are percentages; *Education is measured by an index ranging from 0 to 5. 0 = no formal education, 1 = primary school, 2 = grade 12, 3 = diploma, 4 = bachelor's degree, 5 = postgraduate degree.

4. PROFIT EFFICIENCY: DEFINITION AND MEASUREMENT USING THE STOCHASTIC PROFIT FRONTIER APPROACH

According to Farrell (1957), the efficiency of a firm may be defined as its ability to produce a given level of output at the lowest possible cost. The concept of efficiency has three components: technical efficiency, price or allocative efficiency and economic efficiency (Abdulai & Huffman, 1998). A firm is technically efficient if it produces more outputs from the same quantity of inputs than some other firms or uses the minimum feasible level of inputs to produce a given level of output. Allocative efficiency, on the other hand, is the degree to which a firm makes use of inputs in the best proportions, given the observed input prices (Coelli et al., 2002).

The profit function method combines the theory of technical, allocative and scale inefficiency in the profit relationship and any mistakes in the production decisions are believed to translate into lower profits or revenue for the producer (Rahman, 2003). Profit efficiency is defined as the ability of a firm to achieve the highest possible profit given the prices and levels of fixed factors of the firm. Profit inefficiency in the context of small-scale millers is defined as the loss of profit from not operating on the frontier, given firm-specific prices and fixed factors (Ali & Flinn, 1989).

Rahman (2003) defines the stochastic profit function as:

$$\pi_i = f(p_i, z_i).\exp(\varepsilon_i) \quad (1)$$

where π_i is the normalised profit of the firm/mill, p_i is the input price, z_i is the level of fixed factor for the *i*th mill, and ε_i is an error term. The error term is assumed to behave in a manner consistent with the frontier concept (Ali & Flinn, 1989), that is, $\varepsilon = V_i - U_i$, where V_i, is the symmetric error term and U_i is a one-sided error term. The V_is are assumed to be independently and identically distributed (i.i.d) as $N(0, \sigma^2{}_v)$. The U_is are assumed to have a half normal non-negative distribution $N(0, \sigma^2{}_u)$ (Abdulai & Huffman, 1998). The V_is and U_is are also assumed to be independent of each other. U_i, is used to represent inefficiency; that is, it represents profit shortfall from its maximum possible value given by the stochastic frontier (Abdulai & Huffman, 1998). Following Rahman (2003), the profit efficiency of firms/mills in the context of the stochastic profit function is defined as:

$$E\pi_i = E[\exp(-U_i)] \quad (2)$$

where ($E\pi$) is profit efficiency and takes the value between 0 and 1 (Hyuha, 2006). Thus, following Ali & Flinn (1989), if $U_i = 0$, the firm/mill lies on the frontier, obtaining potential maximum profit given the prices it faces and the level of fixed factors and if $U_i > 0$, the firm/mill is said to be inefficient and loses profit as a result.

5. SPECIFICATION AND ESTIMATION

Stochastic frontier analysis, originally proposed by Aigner et al. (1977) and Meeusen and Van Den Brooeck, (1977), and data envelopment analysis (DEA), developed by Charnes et al. (1978), are the most popular approaches used to measure efficiency. The stochastic frontier approach is usually selected for assessing efficiency because of its inbuilt stochastic processes (Dey et al., 2000). In this study we employed the stochastic frontier approach following Battese and Coelli’s inefficiency model (1995) to measure profit efficiency and identify the sources of inefficiency in small and medium scale maize milling in South Africa. The Battese & Coelli (1995) model, commonly referred to as the one-stage approach, allows for the estimation of the parameters of the stochastic frontier and inefficiency model simultaneously. According to Coelli et al. (1998), the model constitutes an advance over the two-stage approach where inefficiency scores were estimated in a first step and then regressed on a series of explanatory variables. In spite of the growing number of papers devoted to efficiency measurement in agricultural economics in recent years, few studies, if any, have examined mill-level efficiency and the possible sources of inefficiency of small and medium scale maize milling using this model.

The functional forms most commonly used for profit frontier estimation are Cobb-Douglas and translog (transcendental logarithmic) functional forms (Hyuha, 2006). The Cobb-Douglas specification is very simple and allows the focus to be on the error term (Kumbhakar & Lovell, 2000). However, it is very restrictive. In spite of this limitation it is frequently used to estimate firm efficiency (Kalirajan & Obwona, 1994; Yilma, 1996; Battese & Safraz, 1998). On the other hand, the translog specification provides a more flexible approach to estimation of efficiency. The main disadvantages of the translog model are its susceptibility to multi-collinearity and potential problems of insufficient degrees of freedom due to the presence of interaction terms (Abdulai & Huffman, 2000).

A log-likelihood ratio test was used to test the Cobb-Douglas model against the translog model. In this test λ is expressed as $\lambda = -2 \log [(L(H_0)/L(H_1)]$, where $L(H_0)$ is the value of the likelihood function frontier model, in which the parameter restrictions defined by the null hypothesis (H_0) are imposed and $L(H_1)$ is the value of the likelihood function for the general frontier model. If the null hypothesis is correct, then λ has an approximate chi-squared distribution with degrees of freedom equal to the variation between the number of parameters estimated under the H_0 and H_1 hypotheses (Coelli et al., 1998). The results of the log-likelihood ratio tests showed that the translog model was an appropriate model for our data, so the translog specification is used in this study.

The empirical specification of the translog stochastic profit frontier model is as follows:

$$\ln \pi_i = \beta_0 + \beta_1 Ln\text{ mzcost} + \beta_2 Ln\text{ labcost} + \beta_3 Ln\text{ othcost} + \beta_4 Ln\text{ capital} + ½ (\beta_5 Ln\text{ mzcost}^2 + \beta_6 Ln\text{ labcost}^2 + \beta_7 Ln\text{ othcost}^2 + \beta_8 Ln\text{ capital}^2) + \beta_9 Ln\text{ mzcost } Ln\text{ labcost} + \beta_{10} Ln\text{ mzcost } Ln\text{ othcost} + \beta_{11} Ln\text{ mzcost } Ln\text{ capital} + \beta_{12} Ln\text{ labcost } Ln\text{ othcost} + \beta_{13} Ln\text{ labcost } Ln\text{ capital} + \beta_{14} Ln\text{ othcost } Ln\text{ capital} + V_i - U_i \quad (3)$$

where *Ln* is a natural logarithm; π is the normalised profit[4] defined as total revenue per tonne of maize meal produced minus total cost per tonne of maize meal produced divided by cost of maize meal output; *mzcost* is cost of maize grain per tonne divided by cost of maize meal output; *labcost* is cost of labour per tonne of maize meal produced divided by cost of maize meal output; *othcost* is the cost of other inputs divided by the cost of maize meal output. The capital is computed as the yearly depreciation cost of milling equipment. The V_i and U_i are as defined earlier. Discovering whether mills are profit inefficient might not be an important exercise unless an additional effort is made to identify the sources of the inefficiencies. Taking cognisance of this, the study investigated the sources of mill-level profit inefficiencies for the surveyed mills. Empirically, the inefficiency (U_i) model is specified as:

$$U_i = \delta_0 + \delta_1 education + \delta_2 ageofmill + \delta_3 millsize + \delta_4 LP + \delta_5 NW + \delta_6 MP + \delta_7 FS \quad (4)$$

where δ's are the inefficiency parameters to be estimated. The variance of random errors, σ_v^2 and that of the profit inefficiency effect σ_u^2 and the overall variance of the model σ^2 are related: $\sigma^2 = \sigma_v^2 + \sigma_u^2$ (Battese & Corra, 1977). This measures the total variation of profit from the frontier that can be attributed to profit inefficiency (Battese & Corra, 1977). A maximum likelihood estimation technique (Coelli et al., 1998) is employed to estimate the parameter of the stochastic profit frontier (equation 3) and the inefficiency model (equation 4) simultaneously. This was achieved using the FRONTIER version 4.1 computer program, developed by Coelli (1996), which enabled us to undertake a one-step estimation of the

[4] Prior to estimation, both the costs of inputs and profits are normalised by the costs of maize meal to impose linear homogeneity in the profit function.

stochastic frontier model as well as the parameters of the variables included to explain efficiency.

6. RESULTS AND DISCUSSION

6.1. Summary statistics

The summary statistics of variables included in the estimation of the stochastic profit frontier are shown in Table 3. It appears that medium-scale mills make more profit per tonne of maize meal produced than the small-scale mills. On average, the small-scale mills produce 11.5 tonnes per day and the medium-scale mills 51.7 tonnes per day. The surveyed mills pay different prices for their inputs and this could partly explain the difference in profit efficiency between the small and medium scale mills.

6.2 Estimation of the profit function

The maximum likelihood estimates of the parameters of the model obtained from estimating the stochastic frontier profit function and the level of profit inefficiencies of the mills are presented and discussed in this section. Two models were estimated and analysed, one for the small-scale and one for the medium-scale mills. The results are reported in Table 4. As expected, they show that the coefficients of the costs of maize grain, labour and other inputs are negative for both the small and medium scale maize mills, which indicates a negative relationship between input prices and profit. However, labour cost was not statistically significant in the medium-scale mills. The estimated coefficient of capital is positive and statistically significant in both the small-scale and medium-scale mills. This is expected, since increased capital tends to facilitate increased output, which in turn could lead to increased profit.

The coefficient of the gamma parameter (γ) is estimated as 0.89 for the small-scale mills and 0.99 for the medium-scale mills and significant at one per cent probability level. These values are close to one and significantly different from zero, which indicates that inefficiencies exist in small and medium scale maize milling enterprises in South Africa. According to Battese & 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 profitability. The result implies that the difference between the actual and the potential profit levels is due in part to mill-specific factors and ought to be improved and controlled in order to improve profit efficiency. Furthermore, a generalised log-likelihood ratio test (at 5 per cent probability level) confirmed the presence of inefficiencies in the model and thus the null hypothesis (that inefficiencies may be absent from the model) is rejected.

Table 3: Summary statistics of variables used in the profit function analysis for the surveyed small and medium scale maize mills in South Africa

	Small-scale mills				Medium-scale mills			
Variable	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Profit/tonne of maize meal produced (rand)	458.6	241.7	132.9	952.8	715.6	455.5	155.8	1539.7
Maize costs (*mzcost*)/tonne (rand)	816.8	96.0	700	1099.5	843.6	141.1	700	1250
Labour (*labcost*)/tonne of maize meal produced (rand)	67.3	60.8	6.9	281.3	56.9	101.2	3.8	455
Other costs (*othcost*)/tonne of maize meal produced (rand)	247.1	82.2	119.4	453.7	215.0	91.5	24.2	350.4
Capital/tonne of maize meal produced (rand)	35.1	34.8	1.9	136.6	20.8	26.7	1.3	115.1
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

Note: LP = Limpopo, NW = North West, MP = Mpumalanga, FS = Free State;*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 = bachelor's degree, and 5 = postgraduate degree.

Table 4: Maximum likelihood estimates of the translog stochastic frontier profit function

Variables	Parameter	Small-scale mills			Medium-scale mills		
		Coefficient	SE	t-ratio	Coefficient	SE	t-ratio
Stochastic frontier model							
Constant	β_0	-25.41	2.51	-10.12***	5.16	1.50	3.44***
Ln mzcost	β_1	-4.48	2.76	-1.62*	-22	1.49	-14.76***
Ln labcost	β_2	-1.27	0.53	-2.41**	-0.62	1.31	-0.47
Ln othcost	β_3	-14.7	1.71	-8.61***	-13.7	1.16	-11.81***
Ln capital	β_4	2.06	0.39	5.36***	0.93	0.30	3.20***
Ln mzcost **Ln* mzcost	β_5	-4.06	2.52	-1.61*	-17.7	1.27	-13.93***
Ln labcost **Ln* labcost	β_6	-0.15	0.09	-1.67*	-0.21	0.38	-0.55
Ln othcost **Ln* othcost	β_7	-4.94	0.91	-5.43***	-1.77	0.41	-4.32***
Ln capital * *Ln* capital	β_8	-0.39	0.05	-7.80***	-0.06	0.08	-0.75
Ln mzcost **Ln* labcost	β_9	0.14	0.33	0.42	-4.85	0.28	-17.32***
Ln mzcost **Ln* othcost	β_{10}	-0.47	0.43	-1.09	8.41	0.43	19.56***
Ln mzcost **Ln* capital	β_{11}	-1.07	0.28	-3.82***	0.50	0.16	3.13***
Ln labcost **Ln* othcost	β_{12}	-0.27	0.25	-1.10	1.89	0.29	6.52***
Ln labcost **Ln* capital	β_{13}	-0.001	0.06	-0.02	-0.22	0.14	-1.57*
*L*n othcost **Ln* capital	β_{14}	0.92	0.17	5.41***	-0.17	0.32	-0.53
Variance parameters							
Sigma-squared	σ^2	0.057	0.029	1.97**	0.004	0.005	0.80
Gamma	γ	0.89	0.081	11***	0.99	0.04	24.75***
Log-likelihood function	*LLF*	20.32			39.73		

Note: *** = significant at 1% level; ** = significant at 5%level; * = significant at 10% level; SE: standard error

6.3 Profit efficiency estimates

The surveyed mills operate at profit efficiency levels ranging from a low of 28.3 per cent to a high of 98.1 per cent for the small-scale mills, and a low of 64.9 per cent and a high of 99.9 per cent for the medium-scale ones. The mean level of profit efficiency is 80.6 per cent for the small-scale mills and 87.4 per cent for the medium-scale ones, which suggests that the small ones lose an estimated 17.4 per cent and the medium ones an estimated 12.6 per cent of profit owing to a combination of both technical and allocative inefficiency. In other words, this implies that the small-scale mills can increase their profit on average by 17.4 per cent and the medium-scale ones by 12.6 per cent by improving the their efficiency levels using the existing resources and technology. The medium-scale mills in general seem to be more profit efficient than the small-scale ones. A possible reason for this difference in efficiency could be the larger milling capacity of this group of mills, which could translate into economies of scale in buying inputs and in transport, giving them operational advantages that bring about higher efficiency. The wide range of profit efficiency results for both small and medium scale maize mills is shown in Table 5.

Table 5: Distribution of profit efficiency of small and medium scale maize mills in South Africa

	Small-scale mills		Medium-scale mills	
Efficiency range	Number	% of mills	Number	% of mills
0.20-0.70	8	22.2	2	11.1
0.71-0.80	5	13.9	5	27.8
0.81-0.90	3	8.3	1	5.6
0.91-1.00	20	55.6	10	55.6
Total	36	100	18	100
Mean efficiency (%)	80.6		87.4	
Minimum (%)	28.3		64.9	
Maximum (%)	98.1		99.8	
Standard deviation	0.211		0.122	

6.4 Sources of profit inefficiency

Owing to the differences in the levels of profit efficiency between mills, it was necessary to investigate further why some mills achieved higher efficiency scores than others. The inefficiency function is known to provide some explanations for variations in efficiency levels. A negative sign on the coefficient of the inefficiency variable (Table 6) indicates a positive contribution to efficiency and a positive sign a negative contribution. 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 results of this empirical analysis are presented in Table 6.

Table 6: Estimates of the determinants of profit inefficiency for small and medium scale maize mills

		Small-scale mills			Medium-scale mills		
Variables	Parameter	Coefficient	SE	t-ratio	Coefficient	SE	t-ratio
Constant	δ_0	-0.70	0.75	-0.93	0.39	0.47	0.83
Education	δ_1	-0.02	0.07	-0.29	-0.017	0.003	-5.67***
Mill size	δ_2	0.05	0.04	1.25	-0.007	0.004	-1.75*
Age of mill	δ_3	0.005	0.004	1.25	-0.005	0.002	-2.50**
LP	δ_4	1.51	1.51	0.99	0.12	0.45	0.27
NW	δ_5	-0.09	0.57	-0.16	-0.11	0.045	-2.44**
MP	δ_6	-1.23	0.64	-1.92**	-0.31	0.46	-0.67
FS	δ_7	-0.52	0.62	-0.84	-0.10	0.46	-0.21

Note: LP = Limpopo Province, NW = North West, MP = Mpumalanga, FS = Free State,

Table 7: Constraints facing small and medium scale maize mills in South Africa (%)*

S/No	Constraints	Small-scale mills	Medium-scale mills
1	Credit	11.1	16.7
2	High maize price	50	50
3	High transport costs	61.1	55.6
4	Poor management	11.1	5.6
5	Fortification policy	22.2	16.7
6	Inadequate storage facilities	11.1	27.8
7	Lack of infrastructure	16.7	22.2
8	Lack of customers	13.9	11.1
9	Increasing numbers of competitors	52.8	44
10	Consumer preference for maize meal from large-scale mills	63.9	45

*Figures do not add up to 100 due to multiple responses

Based on the results of the inefficiency model, the estimated coefficient of education is negative for both the small and medium scale maize mills, suggesting that education plays an important role in influencing the efficiency level of the medium-scale millers. Therefore, a higher level of education minimises inefficiency, which is consistent with previous findings (Lockheed et al., 1980; Ali & Flinn, 1989; Ali & Byerlee, 1991). This is because education is hypothesised to enhance allocative decisions and thus help millers react to changes in economic conditions, which entails perceiving that change has occurred, collecting, retrieving and analysing useful information, drawing conclusions from the available information and acting quickly (Abdulai & Huffman, 2000). Therefore, the superior education (Table 3) of the medium-scale millers helps make them more efficient than the small-scale ones.

In this study, the coefficient of age of mill was found to be negative and significant for the medium-scale mills, suggesting a positive relationship between age of mill and profit efficiency. Other studies have also found a positive relationship between the age of a firm and its efficiency (Cheng & Tang, 1987; Haddad, 1993; Mengiste, 1996). This is expected, owing to the principle of learning by doing that occurs through production experience (Admassie & Matambalya, 2002). Thus, firms tend to become more efficient as their stock of experience in the production process grows. The significant positive relationship between age of mill and efficiency in the medium-scale mills was therefore not surprising and suggests that the medium-scale millers are more efficient since they are more experienced than the small-scale ones (Table 3). From the foregoing, it appears that the factors that contribute most to mill efficiency are the millers' level of education and the age of the mill. 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 efficiency.

The estimated coefficient of mill size was positive and significant for the small-scale mills, but negative and significant for the medium-scale ones. Several other studies have found similar positive relationships between firm size and efficiency (Pitt & Lee, 1981; Shanmugam & Bhaduri, 2002; Kim, 2003). This implies a negative relationship between mill size and efficiency in the small-scale mills, further confirming that the smaller the mill size, the greater the inefficiency. On the other hand, the negative and significant coefficient of mill size found for the medium-scale mills implies a positive relationship between mill size and efficiency in these mills. In other words, as mill size increases its inefficiency decreases, hence the medium-scale mills tended to be more efficient than the small-scale ones. For this reason, there are economies of scale in maize milling as capacity increases. This could partly explain why the large-scale maize mills dominate the maize meal market in South Africa. Thus, expanding the small-scale maize mills could possibly prepare the way for much needed competition in the maize milling industry in the long run.

Provincial dummy variables were also included to capture the effect of location on profit efficiency. According to Onder et al. (2003), the location of a firm can influence its performance, since situating a firm in an environment that lacks useful infrastructure can limit its efficiency, while situating it in an environment where useful infrastructure is available can enhance it. Our dummy variables took the value of 1 if the mill is located in Limpopo, the North West, Mpumalanga or the Free State and 0 otherwise. The results showed that both the small-scale and medium-scale maize millers in the North West, Mpumalanga and the Free State seem to exhibit higher efficiencies than millers in Limpopo. However, a statistically significant negative coefficient was obtained for small-scale maize mills in Mpumalanga and medium-scale mills in the North West. Thus, small-scale mills in Mpumalanga appear to be more efficient than small-scale mills in the other provinces. On the other hand, medium-scale mills in the North West were more efficient than medium-scale mills in the other provinces. The fact that both categories of mills were found to be inefficient in the Limpopo province could be attributed to provincial differences in production costs. This is not surprising, since it was found that the transport costs per tonne of maize were higher here than in the other three provinces.

6.5 Constraints and needs of the small and medium scale maize milling enterprises

The level of profit efficiency attained by the mills should be seen against the constraints they face. Taking cognisance of this, it is clear that the small and medium scale maize milling enterprises cannot become profit efficient unless the problems they face are tackled successfully. This subsection therefore discusses the constraints faced by the small and medium scale maize milling enterprises in South Africa.

Millers were asked to identify, from a list of possible constraints, their most severe problems (Table 7). They picked a wide array of constraints, ranging from difficulty accessing credit to consumer preferences for the established and well-known maize meal brands produced by large corporate milling companies. Consumer preferences for these brands, high transport costs, high maize grain costs and increasing numbers of competitors were the most pressing problems faced by the surveyed small and medium scale maize millers. This could perhaps explain why, despite their considerable profit efficiency levels, these enterprises are still unable to compete in a maize milling industry dominated by large-scale mills. Small and medium scale millers seem to be more or less equally concerned about high transport costs (around 60% picked this constraint), though a slightly higher proportion of the small-scale ones were concerned, perhaps because of their lower economies of scale. The small and medium scale millers were equally concerned about high maize costs (50 per cent picked this constraint). Consumer preferences for established maize meal brands from large-scale mills seem to affect small-scale millers more than the medium-scale millers (about 60 per cent picked this, compared with 45 per cent of the latter). Increased numbers of competitors seem to affect small-scale millers more (just over 50 per cent) than the medium-scale millers (just over 40 per cent). This is a significant problem, given that competition can push the small and medium scale millers out of the existing markets and prevent them from thriving in the new ones.

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10	Consumer preference for maize meal from large-scale mills	63.9	45

*Figures do not add up to 100 due to multiple responses

7. CONCLUSIONS AND RECOMMENDATIONS

Since the current deregulation of the maize milling industry, the survival of less efficient small and medium scale maize mills has become highly uncertain as they become less competitive. They therefore need to improve their internal efficiency significantly so as to become competitive in the South African maize meal market. This study employed a translog stochastic profit frontier model to estimate the profit efficiency of small and medium scale maize milling enterprises in South Africa. Findings from the profit efficiency analysis show an average score of about 80.6 per cent for the small-scale mills and 87.4 per cent for the medium-scale ones. In other words, an estimated 17.4 per cent and 12.6 per cent of potential profit is lost in small and medium scale maize milling enterprises respectively owing to a combination of technical and allocative inefficiencies.

Overall, our empirical results show that mills with larger milling capacities are more efficient than those with small milling capacities. This implies that large mills have an advantage over smaller ones because they benefit from economies of scale. The ever-increasing competitiveness of large millers poses a threat to the small maize mills. Some mill-specific characteristics, such as the miller's level of education and the size, age and location of mills, could have significant implications for the efficiency of the mills, so efficiency gains could come from improving the millers' education and investing in mill expansion. The majority of the mills in this survey were small-scale ones and therefore less efficient.

It is essential that government provide support for upgrading some of the small-scale mills into medium-scale ones in order to boost competition in the maize meal market. This can be achieved by subsidising the cost of mill expansion. Upgrading of this nature would increase the number of medium-scale mills in the maize milling industry and pave the way for much-needed competition in the industry. All things being equal, increased competition could lead ultimately to a reduction in maize meal prices. This would in turn benefit the low-income group who spend over 20 per cent of their income on maize meal.

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