Factors influencing the long-term competitiveness of commercial milk producers: evidence from panel data in East Griqualand, South Africa

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Abstract

This study investigates factors influencing the long-term competitiveness of 11 commercial milk producers from East Griqualand (EG), South Africa using unbalanced panel data for the period 1990 to 2006. Results of a ridge regression analysis show that dairy herd size, the level of farm debt, annual production per cow, technology and policy changes over time, and the ratio of trading income to total milk income influence the long-term competitiveness of these milk producers. To enhance their competitiveness in a deregulated dairy market, relatively small and profitable EG milk producers should consider increasing their herd sizes, as the importance of herd size in explaining competitiveness suggests that size economies exist. All EG milk producers should consider utilising more pasture- and forage-based production systems to lower feed costs and select dairy cattle of superior genetic merit to improve milk yields on pasture.

Keywords: Commercial milk production; competitiveness; panel data

1. Introduction

South African (SA) agriculture has undergone major structural change as the country followed the global trend of liberalising the marketing of its agricultural products over the past 20 years. Structural change in agriculture is characterised by changes in product characteristics, production and consumption patterns, size of operation and geographic distribution of producers (Boehlje, 1999). Previously regulated by the Marketing Acts of 1937 (Act 27 of 1937) and 1968 (Act 59 of 1968), the SA dairy industry was gradually deregulated – a process that was completed following the promulgation of the Marketing of Agricultural Products Act of 1996 (Act 47 of 1996) (Vink & Kirsten, 2000).

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Over the past 20 years, the SA dairy industry has seen an increase in the consolidation of dairy farms. Milk producer numbers in South Africa have declined from 9 279 in 1990 (Collins, 1994:61) to 3 655 in 2008, while the average number of cows-in-milk per producer has risen from 88 in 1998 to 151 in 2008 (Coetzee & Maree, 2008). The consolidation of SA dairy farms has led to an improvement in the technical efficiency[3] of the primary sector. Mkhabela *et al.* (2008) found evidence of this improvement on dairy farms in KwaZulu-Natal (KZN), where they showed that, from 1999 to 2007, these farms gained in technical efficiency, with large farms showing greater gains than small and medium farms. Some authors argue that the consolidation of dairy farms and gains in efficiency are driven by forces other than institutional change, e.g. the benefits of size economies (Doll & Orazem, 1984:217; El-Osta & Morehart, 2000) and technological advancement (Weersink & Tauer, 1990; Manchester & Blayney, 1997).

Another structural change that has occurred in the SA dairy industry over time has been a shift in the geographic distribution of milk production from inland to coastal areas (Coetzee & Maree, 2008). Blignaut (1999) contends that the impetus for this shift has been the popularisation of pasture-based production systems, which are more suited to coastal areas. Lower collection costs per square kilometre, due to less dispersion of milk producers, also makes coastal areas more attractive to milk buyers. Coastal areas (KZN, Western Cape and Eastern Cape) accounted for 52.4% and 68.2% of total milk production in South Africa in 1997 and 2007 respectively (Coetzee & Maree, 2008).

In a changing policy environment, milk producers can improve the financial position of their farm businesses by understanding the factors that influence profitability (Short, 2000). As competitors in the global dairy market following deregulation of the SA dairy industry since the 1970s (NAMC, 2001:19), SA milk producers have had to reposition themselves and become more innovative and responsive to future changes to improve their competitiveness. It is critical, therefore, that factors that may enhance or restrict competitiveness at the milk producer level in the long term are identified and better understood. Based on a definition by Esterhuizen (2006:89), competitiveness in this study is defined as the ability of a milk producer to achieve sustainable *business* growth while earning at least the opportunity cost of management. Thus, a producer is competitive if positive land rents (returns to land) are earned. A microeconomic indicator of competitiveness, the Unit Cost Ratio (UCR), developed by Siggel and Cockburn (1995), is used to measure the long-

[3] *Technical efficiency is defined as the ratio of actual output to the maximum possible potential output from a given set of inputs and technology (Kalirajan & Shand, 1997).*

term competitiveness of selected commercial milk producers from the East Griqualand (EG) region of South Africa. Since the UCR is a ratio of total enterprise costs to total enterprise revenue, it can also be considered a measure of enterprise profitability.

Previous studies have varied in their approaches to measuring the competitiveness or profitability for agricultural commodities at the producer level. Some studies have focused on production cost measures of competitiveness (Vink *et al.*, 1998; Blignaut, 1999; Tauer, 2001), whilst others have used profitability measures such as gross margin per litre (Hopps & Maher, 2007), return on assets (ROA) (Gloy *et al.*, 2002) and net farm income (NFI) (El-Osta & Johnson, 1998; Short, 2000). Previous research found a strong link between farm size (total number of cows), milking rate (production per cow) and dairy farm profitability (El-Osta & Johnson, 1998; Short, 2000; Gloy *et al.*, 2002). Other factors that significantly affected dairy enterprise profitability were forage and feed costs per cow (El-Osta & Johnson, 1998), milkings per day and debt-to-asset ratio (DA) (Gloy *et al.*, 2002; Short, 2000), and specialisation in milk production (El-Osta & Morehart, 2000; Short, 2000).

This study aims to address the need for research on factors influencing the competitiveness of South African dairy enterprises by investigating the influence of several financial, risk and management factors on the competitiveness of selected EG milk producers. Whereas the previous local and international studies mentioned above have tended to focused on the influence of these factors on competitiveness at a point in time, this study incorporates *time* as well as cross-sectional dimensions in its investigation.

2. Description of the study area and key characteristics of EG milk producers

2.1 Study area and data collection

East Griqualand (EG) is located on the eastern seaboard of South Africa and is a summer rainfall region receiving an average annual rainfall ranging between 620 mm and 816 mm (Camp, 1999). EG encompasses the areas of Kokstad in southern KZN, and Matatiele and Cedarville in the Eastern Cape Province, and the region is characterised by highland 'sourveld' grazing conditions. Because of fairly high summer rainfall and high altitude, sourveld becomes relatively unpalatable to livestock in the autumn and winter. This has important implications for the type of farming enterprises the region can support. Milk production in EG has traditionally been pasture based, with varying rates of supplementation of concentrate (purchased) feed. In recent years, however, EG milk producers have increased the proportion of pasture in their feeding regimes and are moving towards seasonal calving in an effort to improve profitability. This shift has been driven by reduced profit margins and more efficient use of facilities and management time (Bischoff, 2008).

Data were collected from 11 commercial milk producers from the EG study group who had continuous physical and financial records for the period 1990 to 2006. The EG study group was established in 1983 and its objective is to improve the production and financial performance of its members. These members have received advice from the same consultant over the study period. A total of 30 milk producers were members of the group from 1990 to 2006, although only 11 producers are used in this study due to entries and exits from the group over time and incomplete individual datasets. The sample of 11 producers represents 48% (11/23) of the current group of 23 commercial EG milk producers and is, according to Bischoff (2008), typical of EG milk producers. The total sample size for the panel of EG milk producers is 187 (17 years × 11 milk producers), with 10 observations missing from the dataset.

2.2 Key physical and financial characteristics of EG milk producers

Key physical and financial characteristics of the sample of EG milk producers are shown in Table 1. Over the study period, average real milk prices and real total costs per litre for the sample of EG milk producers declined marginally. Under conditions of declining producer prices, the pressure on a relatively small firm to expand is great if size economies exist (Doll & Orazem, 1984:215). Although these producers have expanded the size of their dairy enterprises over the study period, from a mean of 143 to 299 cows in milk, Bischoff (2008) contends that water availability (rather than farm area) has constrained further expansion of EG dairy enterprises.

Table 1: Mean physical and financial characteristics of panel of EG milk producers, 1990 - 2006

Milk producer characteristics		1990 – 1995 n = 63*	1996 – 2001 n = 63*	2002 – 2006 n = 51*
Real milk price[a] (R/litre)		1.52	1.42	1.49
Real costs[a,b] (R/litre)		1.55	1.40	1.40
Dairy herd size (cows in milk)		143	202	299
Production per cow (litres per annum)		5180	4882	4585
Enterprise mix (% contribution to gross farm income)	**Dairy**	69	70	79
	Beef	10	9	7
	Sheep[c]	7	3	1
	Cash crops	**6**	**10**	**4**
	Maize	**5**	**5**	**7**
	Other income	**3**	**3**	**2**
Debt-to-asset ratio[d]		**0.33 (0.38)**	**0.35 (0.39)**	**0.32 (0.49)**
Pasture and forage feed cost / total feed cost (%)		**39**	**43**	**48**
Trading income[e] / total milk income (%)		**13**	**10**	**11**

Source: Bischoff (2008)
** Periods 1990-1995 and 1996-2001 consist of six years of data, while the period 2002-2006 has five years of data.*
a. Prices measured in Rand (2000 = 100)
b. Total real costs include an opportunity cost of management at 5% of milk turnover (following Calkins and Dipietre, 1983:117).
c. The sheep enterprise includes income from the sale of wool.
d. Range of debt-to-asset ratio shown in parentheses
e. Trading income = (livestock sales + herd closing value) – (livestock purchases + herd opening value)

The decline in mean milk production per cow may be attributed to the substitution of pasture and forages for purchased feeds (to reduce total feed costs), as shown by the increasing ratio of pasture and forage costs to total feed costs for the sample of EG milk producers over the study period. Cross-breeding has also played a role in lowering production per cow over the study period, due to cattle of a smaller, more mobile type being favoured over larger, heavier animals, which also have higher feed requirements. Although milk production per cow is lower when smaller animals are used, production per unit area is greater as the producer is able to increase the stocking rate on pasture (Bischoff, 2008).

The mean debt-to-asset ratio fluctuated marginally over the study period. Relatively higher average debt during the 1996 to 2001 period may have been used to fund dairy enterprise expansion over this period. The range in debt-to-asset ratio, however, suggests that, although EG milk producers on average made use of less debt during the 2002 to 2006 period, a number of producers made greater use of debt. Bischoff (2008) notes that most of the expansion in dairy enterprise size took place in the past five years. The debt-to-asset ratio in the periods 1990 to 1995, 1996 to 2001 and 2002 to 2006 had ranges of 0.38, 0.39 and 0.49, respectively. The enterprise mix shows that the sample of farmers is somewhat diversified, although specialisation in milk production has increased, with milk income increasing from 69% to 79% of gross farm income over the study period. Diversification is a common risk management strategy in EG, due in part to relatively large farm sizes and existing output-specific facilities, e.g. sheep- and cattle-handling facilities, which may be a vestige of previous generations (Bischoff, 2008). The proportion of trading income to total milk income has declined marginally over the study period.

3. Research methodology

The study uses ridge regression – a modification of ordinary least squares (OLS) regression – with imputed observations to estimate factors influencing the competitiveness of this unbalanced[4] panel dataset of 11 commercial milk producers in EG for the period 1990 to 2006.

3.1 Method of analysis and selection of variables

Panel data regression analysis differs from conventional time series and cross-section regression analyses in that time series as well as cross-section dimensions are incorporated into the model's structure (Baltagi, 2005:11; Gujarati, 2003:636). There is substantial debate on the suitability of either a random or fixed effects model for a panel data set. Baltagi (2005:12) notes that a fixed effects model is an appropriate specification if the focus is on a specific set of *N* firms and inference is limited to the behaviour of these firms. Since this study examines firm-specific effects, a fixed effects specification is considered the most appropriate. Equation (1) shows the general form of a fixed effects regression model:

$$Y_{it} = a_1 + a_k D_{ki} + \beta_l X_{lit} + \mu_{it} \quad (1)$$

where i denotes individual milk producers, t denotes time, a_1 represents the intercept of the base category producer, a_k is the differential intercept coefficient indicating the difference between a_1 and the intercept estimates for the other milk producers (k = 2,..., 11), D_{ki} are differential intercept dummy variables used to take into account the 'individuality' of each producer, β_l is the coefficient of explanatory variable X_l (l = 1,...., 7 explanatory variables), and μ_{it} is the error term. Variables that were considered in the fixed effects panel regression model are presented and defined in Table 2.

[4] *A panel dataset is referred to as unbalanced when the number of observations differs between panel members (Gujarati, 2003:640).*

Table 2: Definition of variables used in fixed effects regression model

Variables	Definition	Expected sign of β/α coefficients
UCR_{it}	Unit cost ratio: Measure of milk producer competitiveness (dependent variable)	
$LNCOWS_{it}$	Dairy herd size (number of cows in milk)	–
$PRODCOW_{it}$	Production per cow (litres per annum)	–
$SPECIALISE_{it}$	Specialisation index (ratio of milk income to gross farm income)	–
$TRADINC_{it}$	Ratio of trading income to total milk income	–
$PASCOST_{it}$	Ratio of pasture and forage costs to total feed costs	–
$DEBTASSET_{it}$	Solvency ratio (farm assets financed by debt capital)	+
$YEAR_t$	Trend variable	–
D_i	Differential intercept dummies accounting for differences between milk producers	+/-

The definition of competitiveness in this study is based on a definition by Esterhuizen (2006:89), and is defined as the ability of a milk producer to cover all dairy enterprise accounting costs plus an opportunity cost of management. Following Siggel and Cockburn (1995) and Siggel (2006), a microeconomic indicator, the unit cost ratio (UCR), is used to measure competitiveness at the milk producer level in this study (dependent variable). The UCR is defined as the ratio of total dairy enterprise costs, including an opportunity cost of management computed at 5% of total milk turnover (Calkins & Dipietre, 1983:117) to total dairy enterprise revenue for a milk producer (the 5% opportunity cost for management was also used by Du Toit and Ortmann (2009) in their UCR analysis of trends in the relative competitiveness of EG milk producers over time). The UCR_{it} indicator is interpreted as follows: a score of > 1 indicates that producer *i* earned negative land rents (returns to land) at time *t* and was *not competitive* (total costs > total revenue). A score of < 1 indicates that producer *i* earned positive land rents at time *t* and was *competitive* (total costs < total revenue).

El-Osta and Johnson (1998), El-Osta and Morehart (2000), Short (2000) and Gloy *et al.* (2002) used dairy herd size as a measure of dairy farm size. For the purposes of this study, the natural logarithm of dairy herd size, $LNCOWS_{it}$, was used. The effect of this transformation is to normalise the size distribution by compressing the upper tail of the distribution whilst expanding the lower tail. *Ceteris paribus*, a unitary change in the dairy herd size for a small milk producer will have a greater impact on competitiveness than for a large milk producer. Because dairy herd size could be positively related to profitability, it is hypothesised that there will be a negative relationship between farm size and UCR_{it}. Therefore, as dairy herd size increases, UCR_{it} is expected to decrease, *ceteris paribus*, indicating an improvement in competitiveness.

El-Osta and Johnson (1998), Short (2000) and Gloy *et al.* (2002) found that milking rate (production per cow) is related positively to farm profitability. According to Gloy *et al.* (2002), milking rate is assumed to contain latent characteristics of the milk producer's knowledge, experience, husbandry policy and feeding practices. It is hypothesised, therefore, that a higher milk production per cow, $PRODCOW_{it}$, will enhance milk producer competitiveness and therefore lower UCR_{it}, *ceteris paribus*.

The specialisation index, $SPECIALISE_{it}$, was used in preference to more complex measures of diversification and is defined as the proportion of total milk enterprise income to gross farm income (GFI) (Jacquemin & Berry, 1979, El-Osta & Morehart, 2000). Since previous research has shown that greater specialisation in dairy farming is positively correlated to enterprise profitability (El-Osta & Johnson, 1998; El-Osta & Morehart, 2000; Short, 2000), it is hypothesised that, as a milk producer tends towards greater specialisation in milk production, competitiveness improves (UCR_{it} declines), *ceteris paribus*.

According to Bischoff (2008), dairy enterprise trading income, $TRADINC_{it}$, is an important contributor to the overall profitability of a dairy enterprise. During times of low milk price the role of trading income becomes more pronounced. Milk producers with a greater proportion of trading income to total milk income could, therefore, be considered to be more competitive than milk producers with a lower ratio, *ceteris paribus*.

The $PASCOST_{it}$ variable measures the ratio of forage and pasture costs to total feed costs. According to Standard Bank (2007), between 60% and 80% of a milk producer's total cost comprises feed costs. Studies by Hanson *et al.* (1998) have shown that milk producers in the United States have tended towards a New Zealand-style pasture milk production system to try to lower feed costs and improve enterprise profitability. In recent years, many SA producers have also followed the New Zealand pasture-based system (Bischoff, 2008). Therefore, in this study it is hypothesised that, due to the incentive to lower feed costs, EG milk producers will tend to rely less on purchased feeds and more on pastures and forage, given the availability of land and water, to enhance competitiveness in the long term. A higher ratio of pasture costs to total feed costs is expected to improve competitiveness (UCR_{it} declines), *ceteris paribus*.

$DEBTASSET_{it}$, a measure of farm solvency, was also included in the model. Data on debt level attributable exclusively to the dairy enterprise was not available and, therefore, the farm business debt-to-asset ratio[5] was used. The use of debt has been shown by previous research to negatively affect profitability as by using more debt the producer is obligated to pay more interest (and capital) (El-Osta & Johnson, 1998; Short, 2000; Gloy *et al.,* 2002). Therefore, as debt use increases, competitiveness is expected to decline (UCR_{it} increases), *ceteris paribus*.

A trend variable, $YEAR_t$, is used as a proxy for policy and technology changes over the study period. Institutional changes over the study period occurred with deregulation of the SA dairy industry.[6] New technologies, such as herringbone or rotary milking parlours, improved artificial insemination (AI) practices and dairy animal genetics, are continuously being improved and are expected to raise productivity and lower unit costs over time (El-Osta & Morehart, 2000), thereby improving competitiveness. The expected sign of the coefficient for $YEAR_t$ is negative, as technological change enhances competitiveness and EG milk producers remaining in the industry are expected to have adapted favourably to policy changes over the study period. The $YEAR_t$ variable may also capture other effects not considered in the model.

Ten differential intercept dummy variables, D_i, to account for differences among the 11 milk producers, were added to the model. These individual milk producer dummy variables were added on the basis of a restricted *F*-test, which suggested that management factors such as husbandry policy, parlour type, record-keeping system and the breed of cow used may differ between EG milk producers. According to Gujarati (2003:642), selection of the base category individual is at the discretion of the researcher. The base category milk producer selected had the largest dairy herd size (1 472 cows in milk) in 2006 and was chosen so that differences between milk producers could be better highlighted.

3.2 Ridge regression and multiple imputation

Initial results of the panel data regression analysis identified multicollinearity among some of the explanatory variables. Empirical evidence of multicollinearity is presented in a correlation matrix in Appendix B.

[5] The dairy enterprise, however, contributed on average from 69% to 79% of total farm income over the study period.
[6] Dummy variables for each year of the study period, which may have been more appropriate measures of structural change, were included during initial regression analyses but none of these dummy variables was statistically significant.

Multicollinearity causes the estimated regression coefficients to have relatively large standard errors, leading the researcher to make erroneous inferences on the relative effects of the explanatory variables on the dependent variable (Gujarati, 2003:342-344).

Montgomery *et al*. (2001:346) point out that the four primary sources of multicollinearity are the data-collection method employed, constraints on the model or in the population, model specification and an over-defined model. Several techniques have been proposed for dealing with the problem of multicollinearity in a regression analysis. Some of the general approaches include the collection of additional data, model re-specification and the use ridge regression.

Montgomery *et al*. (2001:348) state that when the method of least squares is applied to non-orthogonal data, very poor estimates of the regression coefficients can be obtained. The variance of the least squares estimates of the regression coefficients may be inflated considerably and the length of the vector of the least squares estimates is too long on the average. The implication is that the absolute value of the least squares estimates are too large and that they are very unstable, i.e. their magnitudes and signs may change considerably given a different sample. Also, the variance of the least squares estimator is supposed to be a minimum and this criterion is not satisfied in cases of multicollinearity, making the least squares estimator unsuitable. Hence, the use of ridge regression, which was originally proposed by Hoerl and Kennard (1970a, 1970b), is suggested. The ridge estimator is found by solving a slightly modified version of the normal regression equations. The procedure is called ridge regression because the underlying mathematical assumptions are similar to the method of ridge analysis used by Hoerl (1959) for describing the behaviour of second-order response surfaces. In ridge regression, a value of a constant, *k*, is chosen so that the mean square error of the ridge estimator, $\hat{\beta}_R$, will be less than the variance of the least squares estimator $\hat{\beta}$. Hoerl and Kennard (1970a, 1970b) state that the appropriate value of *k* may be determined by inspection of the ridge trace. The ridge trace is a plot of the elements of the regression estimator $\hat{\beta}_R$ versus *k* for values of *k* in the interval from 0 to 1. If multicollinearity is severe, the instability in the regression coefficients will be obvious from the ridge trace. As *k* increases, some of the ridge estimates will vary dramatically, but at some value of *k* the ridge estimators $\hat{\beta}_R$ will stabilise. The objective is to select a reasonably small value of *k* at which the ridge estimates $\hat{\beta}_R$ are stable. This will then produce a set of estimates with a smaller mean square error than the least squares estimates. It should also be said that, as a modification of OLS regression, the ridge regression technique introduces a small bias into the regression model so that the estimated coefficients are more efficient (have a greater probability of estimating their true parameters). The biasing constant, *k*, in this study was 0.75.

Due to problems with data availability, 10 of the 187 total observations (17 years x 11 milk producers) were missing. Missing data is a common problem in economic research (Baltagi, 2005:165); in this study the missing values were due to incomplete annual records for some of the selected producers. This study used multiple imputation (MI) and Markov chain Monte Carlo (MCMC) methods to estimate missing observations in the EG milk producer dataset. For each missing observation, *m* values were imputed to create *m* complete datasets; in this case, $m = 20$. Imputations were then randomly drawn from the imputed datasets, which represented the distribution of the data (assumed to be normal in this study), and the missing observations were replaced. Because only 5.3% of the dataset was missing, a small difference between the imputed and unbalanced ridge regression models was expected (for a full discussion on MI and MCMC please see Rubin (1987) and Gilks *et al*. (1996)). The imputed and unbalanced regression models were estimated using the SAS Version 9.1 Statistical Package for Windows (SAS, 2003).

4. Results and discussion

The results for the fixed effects model with imputed observations for the panel of EG milk producers is presented in Table 3. The overall fit of the model was statistically significant, with an *F*-statistic of 13.7. The R^2 value of 0.58, indicating that 58% of the variation in UCR_{it} was explained by the explanatory variables, is comparable to similar studies on dairy enterprise profitability and milk producer competitiveness. For comparison purposes, the results for the unbalanced panel regression analysis are shown in Appendix A.

Neither model showed signs of autocorrelation. The estimated coefficient for dairy herd size, $LNCOWS_{it}$, had the expected negative sign, which supports *a priori* expectations that the size of the dairy enterprise influences competitiveness in the long term. This finding provides evidence of returns to size on EG dairy farms. The gain in competitiveness from increasing dairy herd size, however, will tend to be greater per unit size increase for smaller rather than for larger milk producers, *ceteris paribus*.

Table 3: Results of fixed effects ridge regression model for a panel of EG milk producers, including imputed observations, 1990–2006 (n = 187)

Parameter	β-coefficient	Standardised coefficient	Std error#	t – statistic#
LNCOWS	-0.0352	-0.182	0.0527	-6.68***
PASCOST	-0.0264	-0.0408	0.0189	-1.40
TRADINC	-0.198	-0.0902	0.0678	-2.93***
SPECIALISE	1.60×10^{-3}	2.60×10^{-4}	0.0152	-0.105
PRODCOW	-1.64×10^{-5}	-0.133	3.45×10^{-6}	-4.75***
YEAR	-2.73×10^{-3}	-0.122	6.54×10^{-4}	-4.17***
DEBTASSET	1.90×10^{-3}	0.171	3.09×10^{-4}	6.15***
	α-coefficient			
Base category	1.235		0.0394	31.3***
D_2	-0.0231	-00610	0.0107	-2.16**
D_3	-0.0347	-0.0916	0.0109	-3.18***
D_4	0.0282	0.0744	0.0110	2.56***
D_5	0.0126	0.0332	0.0112	1.12
D_6	0.0153	0.0404	0.0114	1.34
D_7	3.64×10^{-4}	9.61×10^{-4}	0.0107	0.0340
D_8	0.0575	0.152	0.0107	5.37***
D_9	-0.0248	-0.0655	0.0109	-2.28**
D_{10}	0.0246	0.0649	0.0107	2.30**
D_{11}	-0.0175	-0.0462	0.0984	-1.78*
	$R^2 = 0.58$		Adjusted $R^2 = 0.54$	df = 169
	F- statistic = 13.7***		*d* = 2.29	

Note: # The standard errors and t-statistics relate to the initial estimates of the regression and not the standardised coefficients.
, **, * denote significance at the 10%, 5% and 1% levels of probability, respectively*
LNCOWS = natural logarithm of number of cows
PASCOST = ratio of pasture and forage costs to total feed costs
TRADINC = ratio of trading income to total milk income
SPECIALISE = ratio of milk income to gross farm income
PRODCOW = production per cow
DEBTASSET = debt/asset ratio
YEAR = Trend variable
$D_2 \ldots D_{11}$ = Differential intercept dummy variables

The estimated coefficient of $PASCOST_{it}$ had the expected sign, but was not a statistically significant determinant of long-term competitiveness for the 11 EG milk producers. The non-significant coefficient of this variable may indicate that pasture-based dairy farming is already an established method of production among the 11 milk producers, suggesting that there is little variation in this variable in the data.

Another possible explanation is that many EG milk producers are unable to utilise more pasture due to constraints such as farm size, suitability of soil type to pasture and water availability. The negative sign of the coefficient suggests, however, that an increased utilisation of forage and pasture enhances competitiveness. The coefficient estimate of $TRADINC_{it}$ is statistically significant and has the expected sign, supporting *a priori* expectations that trading income affects the overall profitability of the EG dairy enterprise.

The coefficient estimate of $SPECIALISE_{it}$, a measure of specialisation in milk production, did not have the expected sign and was not statistically significant. A possible explanation for this can be found in research by Beca (2005), who analysed the variation in profitability of average and top milk producers in South Africa, New Zealand and Australia. He found that costs of production for SA milk producers are higher than in New Zealand and Australia. High costs of production coupled with higher interest rates in South Africa relative to New Zealand and Australia suggests that SA milk producers may face significantly higher financial risk. Diversification is a risk management strategy for EG milk producers, as shown in Table 2, and although the ratio of milk income to gross farm income increased from 69% to 79% over the study period (1990 to 2006), the benefits of diversification may still outweigh those of specialisation in EG.

The coefficient estimate of $PRODCOW_{it}$ had the expected negative sign and was statistically significant. Bischoff (2008) suggests that concentrates (purchased feeds) are essential to maintaining high milk yields, but that a feeding regime incorporating high levels of purchased feed can also raise production costs. The price premiums offered by milk buyers (based on quality, volume and proximity from the milk buyer's depot) may play a crucial role in determining which feeding and husbandry regime EG producers adopt. For example, a higher milk producer price may warrant additional feeding in the short run, i.e. the profit-maximising level of output may shift (to where marginal cost equals marginal revenue) (Doll & Orazem, 1983:66). Regardless of which feeding and husbandry regimes are implemented, however, high producing dairy cattle have a positive influence on the long-term competitiveness of these producers, *ceteris paribus*.

The coefficient estimate of $YEAR_t$ was statistically significant and had the expected negative sign, showing that the competitiveness of these producers has been improving over time. Possible reasons for this positive trend are: (1)

consolidation of the dairy enterprise, enabling these farmers to produce higher milk volumes and capture economies of size; (2) improved production techniques, such as superior irrigation methods and improvements to milking parlours; and (3) greater focus on dairy enterprise management by these milk producers. $YEAR_t$ was also a proxy for policy change (deregulation) over the study period. The statistical significance and expected negative sign of the estimated coefficient suggests that EG milk producers have adapted favourably to policy change over the study period. The results indicate that these producers have become more efficient (produce at lower cost) and have adopted strategies that enhance their competitiveness in a deregulated dairy market.

The coefficient estimate of $DEBTASSET_{it}$ was statistically significant and shows that the level of farm debt influences the competitiveness of EG milk producers in the long term. The positive sign of the estimated coefficient of $DEBTASSET_{it}$ shows that, as farm debt levels increase, competitiveness declines. This decline can be attributed to an obligation on the part of the producer to pay higher levels of principal and interest associated with increased indebtedness. This finding is consistent with those of other studies on the financial performance of dairy farm businesses, but may be misleading in the context of EG milk producers. This is because the debt-to-asset ratio used reflects the debt level of the entire farm business and, hence, the influence of debt on profitability or competitiveness of the dairy enterprise may be overstated.

The standardised coefficients, which show the relative contribution of each explanatory variable to the explanation of the dependent variable (UCR_{it}), indicate that $LNCOWS_{it}$, $DEBTASSET_{it}$ and $PRODCOW_{it}$ contribute relatively more to the explanation of UCR_{it} than do $YEAR_t$ and $TRADINC_{it}$. This finding is consistent with other studies, that dairy enterprise size and debt-to-asset ratio (El-Osta & Johnson, 1998; Short, 2000), and production per cow (Short, 2000; Gloy *et al.,* 2002) are important determinants of the profitability of US dairy farms.

The inclusion of individual milk producer dummies, on the basis of a restricted *F*-test, improved the overall significance and fit of the model. The coefficient estimates of D_2, D_3, D_4, D_8, D_9, D_{10} and D_{11} are statistically significant. The negative signs of the estimated coefficients of D_2, D_3, D_9 and D_{11} and positive signs of the estimated coefficients of D_4, D_8 and D_{10} indicate that these producers were significantly *more* and *less* competitive than the base category producer, respectively. The differences in competitiveness between these milk producers and the base category producer may be due mainly to differences in management experience and ability.

5. Conclusions and recommendations

The results of the ridge regression show that the size of the dairy enterprise, the debt level of the farm business, production per cow, technological and policy changes, and the ratio of trading income to total milk income, influence the long-term competitiveness of milk producers in EG. The findings are consistent with those of similar studies.

The importance of dairy herd size in the ridge regression model suggests that economies of size exist on EG dairy farms. The study also found that, while the proportion of pasture to total feed costs was not a statistically significant determinant of the long-term competitiveness of EG milk producers over the study period (probably due to a lack of variation in the data), by increasing the proportion of pasture in the feeding regime, milk producer competitiveness can be improved by lowering real total costs per litre. The finding that dairy trading income contributed significantly to the overall profitability of the dairy enterprise was important, as during times of relatively low milk prices, milk producers generally can fall back on the 'beef' value of their cull cows to survive in the short term. Specialisation in milk production was not a statistically significant determinant of the long-term competitiveness of EG milk producers. A possible reason is that, relative to other countries, SA milk producers face higher financial risk and, therefore, have an incentive to adopt appropriate risk-management strategies. With regard to the 11 EG milk producers, relatively large farm sizes may encourage enterprise diversification and, therefore, complete specialisation in milk production may be less likely in EG. Of course, the decision to diversify or specialise in the long term depends on the particular risk preferences of each EG milk producer.

The level of farm debt was found to be an important financial factor influencing the long-term competitiveness of milk producers in EG. With an increase in indebtedness comes an obligation to pay higher levels of interest (and principal), which may reduce competitiveness. The importance of debt in the context of milk production in EG may be overstated, however, due to the use of the overall farm business debt-to-asset ratio in the ridge regression model. Milk production per cow, a proxy for managerial ability in previous studies, was a statistically significant determinant of long-term competitiveness for EG milk producers. Technological change over the study period, such as improvements in AI practice, parlour design and irrigation methods, also influence the competitiveness of EG milk producers in the long term. These producers have responded to policy and technological changes over the study period by increasing dairy herd size and substituting pasture for purchased feed, and many have used cross-breeding to maximise milk output per unit area rather than production per livestock unit. To enhance competitiveness in a deregulated dairy market, profitable EG milk producers should consider increasing their dairy herd sizes, utilise more pasture- and forage-based production systems and select dairy cattle of superior genetic merit that produce high milk yields on pasture.

This study addressed some gaps in previous local research on the impacts of deregulation in the SA dairy industry, with particular regard to the industry's primary sector. The study results can also be used by milk producers, consultants advising milk producers, organisations such as the Milk Producers' Organisation, the National Agricultural Marketing Council and the Department of Agriculture, to better understand the determinants of long-term profitability and competitiveness at the producer level.

Areas for further research include extending the analysis to investigate the determinants of milk producer competitiveness in other major milk-producing regions, such the Eastern Cape and Western Cape. The inclusion of human capital and management factors (such as age, education and experience) may also add value to future research. These factors were omitted in this study due to the length of the study period, as it was assumed that milk producers would not be able give reliable estimates of decisions they made more than 10 years ago. Further analysis should also investigate the specific management responses to an institutional change over time so that a better understanding of how market deregulation affects management responses can be gained. It is also important to understand what management strategies are adopted by agricultural producers to manage the challenges brought about by institutional change so that policymakers and other role players are informed about potential implications of policy decisions at the producer level.

Acknowledgements

The authors would like to thank the National Agricultural Marketing Council (NAMC) for funding this research. All views, conclusions and recommendations expressed in this paper are those of the authors and do not necessarily reflect those of the NAMC. Constructive comments and suggestions by Dr SRD Ferrer and Mr MAG Darroch of the University of KwaZulu-Natal and two anonymous referees are also gratefully acknowledged.

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Appendix A:

Table A1: Results of fixed effects ridge regression model for a panel of EG milk producers with missing data, 1990–2006 (n = 177)

Parameter	β-coefficient	Standardised coefficient	Std error#	t – statistic#
LNCOWS	-0.0346	-0.186	5.25×10^{-3}	-6.59***
PASCOST	-0.0270	-0.0442	0.0191	-1.41
TRADINC	-0.196	-0.0891	0.0685	-2.86***
SPECIALISE	6.23×10^{-4}	1.08×10^{-3}	0.0152	-0.0410
PRODCOW	-1.57×10^{-5}	-0.131	3.37×10^{-6}	-4.66***
YEAR	-2.91×10^{-3}	-0.130	6.82×10^{-4}	-4.27***
DEBTASSET	1.96×10^{-3}	0.181	3.08×10^{-4}	6.36***
	α-coefficient			
Base category	1.230		0.0390	31.5***
D_2	-0.0233	-0.0615	0.0108	-2.16**
D_3	-0.0380	-0.100	0.0113	-3.36***
D_4	0.0276	0.0729	0.0111	2.49**
D_5	0.0120	0.0317	0.0113	1.06
D_6	0.0146	0.0385	0.0116	1.26
D_7	-1.46×10^{-5}	-3.85×10^{-4}	0.0108	-0.0136
D_8	0.0570	0.150	0.0108	5.28***
D_9	-0.0276	-0.0729	0.0116	-2.38**
D_{10}	0.0320	0.0845	0.0124	2.58***
D_{11}	-0.0210	-0.0554	0.0101	-2.08**
	$R^2 = 0.61$		Adjusted $R^2 = 0.54$	df = 159
	F- statistic = 14.5***		*d* = 1.77	

Note: # The standard errors and t-statistics relate to the initial estimates of the regression and not the standardised coefficients.
,,*** denote significance at the 10%, 5% and 1% levels, respectively*
LNCOWS = natural logarithm of number of cows
PASCOST = ratio of pasture and forage costs to total feed costs
TRADINC = ratio of trading income to total milk income
SPECIALISE = ratio of milk income to gross farm income
PRODCOW = production per cow
DEBTASSET = debt/asset ratio
YEAR = Trend variable
$D_2 ... D_{11}$ = Differential intercept dummy variables

Appendix B

Table B1: Pearson's correlation matrix for selected[a] explanatory variables

	LNCOWS	PASCOST	TRADINC	SPECIALISE	PRODCOW	YEAR	DEBTASSET
LNCOWS	1	-	-	-	-	-	-
PASCOST	0.163[b]*	1	-	-	-	-	-
TRADINC	-0.009	-0.079	1	-	-	-	-
SPECIALISE	0.246**	0.086	-0.104	1	-	-	-
PRODCOW	0.197**	-0.112	-0.099	0.180*	1	-	-
YEAR	-0.494**	0.193*	0.236**	0.189**	0.139	1	-
DEBASSET	-0.100	-0.058	-0.126	-0.380**	0.002	0.008	1

Note: *a. In the interest of brevity, the 10 differential intercept dummy variables to account for differences among the 11 milk producers were omitted from this table.*

b. Pearson's correlation coefficient

**, ** denote significance at the 10%, 5% levels of probability, respectively*