MANAGEMENT AND RETURNS TO FARM SIZE: RESULTS OF A CASE STUDY USING PARAMETRIC AND NON-PARAMETRIC METHODOLOGY TO MEASURE SCALE EFFICIENCIES

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Abstract
Management and returns to size: Results of a case study using parametric and non-parametric methodology to measure scale efficiencies

Two hypotheses are tested empirically using cross sectional data from Vaalharts: Firstly, it is hypothesized that economies of scale exist and, secondly, that optimal farm size will not be the same for any two managers; the better the manager, the larger the optimum farm size. These hypotheses are tested by means of both parametric and non-parametric methods, respectively. Managerial skill was measured explicitly. The results support both the hypotheses which were tested empirically. There also appears to be no inconsistency between the results obtained with parametric or non-parametric methods. These findings have important implications for structural adjustment of South African agriculture.

Uittreksel
Bestuur en skaalopbrengs: Resultate van 'n gevallestudie in die gebruik van parametriese en nie-parametriese metodes vir die meting van skaaldoeltreffendhede

Twee hipoteses word empiries getoets deur gebruik te maak van dwarssnit data van Vaalharts: Eerstens word gehipotiseer dat ekonomie van grootte bestaan en, tweedens, dat die optimale plaasgrootte vir enige twee bestuurders nie dieselfde sal wees nie. Die hipoteses word getoets deur middel van beide parametriese en nie-parametries metodes. Bestuursvaardigheid is eksplisiet gemeet. Die resultate ondersteun beide die hipoteses. Dit blyk verder dat daar nie teenstrydighede tussen die resultate van die parametriese en die nie-parametriese metodes is nie. Die bevindinge het belangrike implikasies vir die strukturele verandering van die Suid-Afrikaanse landbou.

1. Introduction

Much research has focused on the economic efficiency of agricultural production. The analysis has typically centred on technical, allocative or price and scale efficiency of farm production (for example see, amongst others, Timmer, 1971; Lau and Yotopoulos, 1971; Hall and Leveen, 1978; Garcia *et al*, 1982; Chavas and Aliber, 1992). It has been motivated in large by an attempt to identify the factors influencing efficiency of resource allocation in agriculture.

The analysis of efficiency has fallen into two broad categories: parametric and non-parametric. The parametric approach relies on a parametric specification of the production function, cost function or profit function (see, for example, Forsund *et al*, 1980; Bauer, 1990). It provides a consistent framework for investigating econometrically the technical, allocative and scale efficiency of profit-maximizing production units. However, it relies on a fairly restrictive Cobb-Douglas technology, which implies an unitary Allen elasticity of substitution among inputs. This illustrates an important weakness of the parametric approach - in general, it requires imposing explicit parametric restrictions on the technology and the distribution of the inefficiency terms (Bauer, 1990). Alternatively, production efficiency analysis can rely on non-parametric methods (see, for example, Seiford and Thrall, 1990). Building on the work of Farrell (1957) and Afriat (1972), the non-parametric approach has the advantage of imposing no ***a priori*** parametric restrictions on the underlying technology (see, for example, Färe *et al*, 1985). It can also easily handle disaggregated inputs and multiple output technologies. As the non-parametric approach develops, its applications to production analysis have become more refined (Chavas and Aliber, 1992). This provides some new opportunities for empirical analysis of economic efficiency.

This paper concerns the role of management in farm size. As mentioned by Groenewald (1991), awareness of the effect of management on returns to size is nothing new. It appears that over the last two decades, much research on size relationships has involved dynamic elements. The mere introduction or dynamic elements involves management. Changes in farm firm sizes must be seen as deliberate actions by managers involving *inter alia* decisions and actions regarding investment, finance, procurement and operation.

This paper supports these sentiments on the grounds of empirical analyses of the role of managerial ability on economies of scale in South African commercial agriculture in the Vaalharts Irrigation area. Two hypotheses are tested empirically in this paper: Firstly, it is hypothesized that economies of scale exist and, secondly, that

optimal farm size will not be the same for any two managers; the better the manager, the larger the optimum farm size.

These hypotheses are tested by means of both parametric and non-parametric methods, respectively; (1) cross-sectional Cobb-Douglas production functions with total farm revenue as dependent variable are estimated parametrically – an investigation of the sum of the coefficients obtained in the functions sheds some light on the existence of scale, namely a sum of elasticities of less than one implies decreasing returns to scale; a sum of elasticities of one implies constant returns to scale; and a sum of greater than one implies increasing returns to scale (Heady & Dillon, 1961). (2) Non-parametric methods, following the example of Chavas & Aliber (1992), are also used to determine scale efficiencies in the Vaalharts Irrigation Area by utilising the same data set. Using both parametric and non-parametric approaches has the advantage of comparing the two methodologies, as well as testing the consistency of the results.

Managerial skill was measured explicitly according to the method proposed by Burger (1971), who developed and validated a scale of 'managerial aptitude' of farmers. This scale is based on five different factors: future image, record keeping, an office, budgeting and maintenance tasks. This scale was found to be positively associated with some other variables, including gross income (Groenewald, 1991).

2. Data

Data from 34 commercial farmers in the Vaalharts Irrigation Area were analysed to test the above hypotheses. Pearson's correlation coefficients showed some interesting results: Managerial ability, as measured by Burger's (1971) index, was highly correlated with the farm size (0,529) and total farm income (0,607) ($p < 0,0001$ in both cases).

The respondents were also divided into two groups according to managerial ability, namely relatively good managers and relatively bad managers. Table 1 shows that the better managers had significantly larger farms and cultivated significantly more land than the bad managers. They had also invested significantly less in fixed improvements per hectare and were significantly more cost effective with respect to machinery and other allocatable costs on a per hectare basis. Good managers had significantly lower medium-term liabilities per hectare, while their net disposable income per hectare was significantly higher than that of the bad managers.

3. Results obtained: parametric procedures

Parametric procedures to estimete efficiency is well known in South African agriculture (see, for example, Viljoen and Groenewald, 1977; Nel and Groenewald, 1987; Sartorius von Bach and Van Zyl, 1992; etc). This analysis is based on the methodology and results of Callow, Sartorius von Bach and Van Zyl (1992).

Table 2 gives the results of the cross-sectional Cobb-Douglas production function analysis. Table 2 shows that the sums of elasticities (Σb_i) are significantly greater than one ($p = 0,030$ and $p = 0,012$, respectively) when managerial ability is included in the function (Functions 1 and 2), indicating increasing returns to size. Production therefore increases proportionally more than improvements in measured management and increases in other inputs. However, when the functions are refitted without the management variable (Functions 3 and 4), the sums of elasticities do not differ significantly from one ($p = 0,790$ and $p = 0,841$, respectively), indicating constant returns to size.

4. Results obtained: non-parametric methods

In contrast to parametric methods, non-parametric methods have not yet been used to determine efficiency, and specifically scale efficiency, in South African agriculture. This analysis of scale efficiency in Vaalharts is based on the methodology described by Chavas and Aliber (1992), with the difference that managerial ability is included as an additional 'input'. Given appropriate software, the determination of indexes of scale efficiency is relatively easy -- it involves the solutions of linear programming problems.

Figures 1 and 2 present the results of the analysis by plotting the inverse of the scale efficiency index (1/SE) against total output and farm size (adjusted for quality on basis of land value), respectively. This inverse (1/SE) can be interpreted in a way similar to an average cost function: (1/SE) is a decreasing function of outputs under increasing returns to scale, and an increasing function under decreasing returns to scale. The figures show that there is evidence of substantial economies of scale for very small farms, particularly when scale is measured in terms of total output (Figure 1). However, Table 3 which present correlations between scale efficiency and key variables, also show that the issue of scale efficiency is a complex one, and is influenced by a variety of factors. Figure 3 for example expresses the fact that managers with better managerial abilities are generally more scale efficient.

Table 1: Differences between the means of key variables for good and bad managers, Vaalharts

Variable	Mean value: good managers	Mean value: bad managers	Significance of differences between means (p values)
Farm size (ha)	64,5384	41,9047	0,0962
Area cultivated (ha)	61,4165	40,3333	0,0802
Fixed improvements (R/ha)	1849,41	2470,09	0,0175
Other allocatable costs (R/ha)	550,06	658,19	0,0176
Medium term liabilities (R/ha)	630,81	1792,87	0,0017
Net disposable income (R/ha)	-8,00	-910,24	0,0928

Table 2: Best fit Cobb-Douglas equations for determining the gross value of production, Vaalharts (n = 34)

Item	Function 1	Function 2	Function 3	Function 4
Intercept (b_0)	4,2640*			0,7306*
Managerial ability (b_1)	0,4317***	0,6023**		
Ha used (b_2)	0,3648***		0,2308***	0,4779**
Total alloc. costs (b_3)	0,4559*	0,3956*	0,4378**	0,5096*
Bare-soil value (b_4)		0,1961***		
Total assets (b_5)		0.2559***	0,3655*	
Adjust R^2 value	77,43%	99,96%	99,96%	79,80%
F-value for the model	38,73**	21470,05*	24627,10	52,68**
Sum of elasticities (Σb_1)	1,2524	1,4499	1,0341	0,9875

Note:
* significant at p = 0,0000; ** significant at p = 0,001; *** significant at p = 0,01;
**** significant at p = 0,1

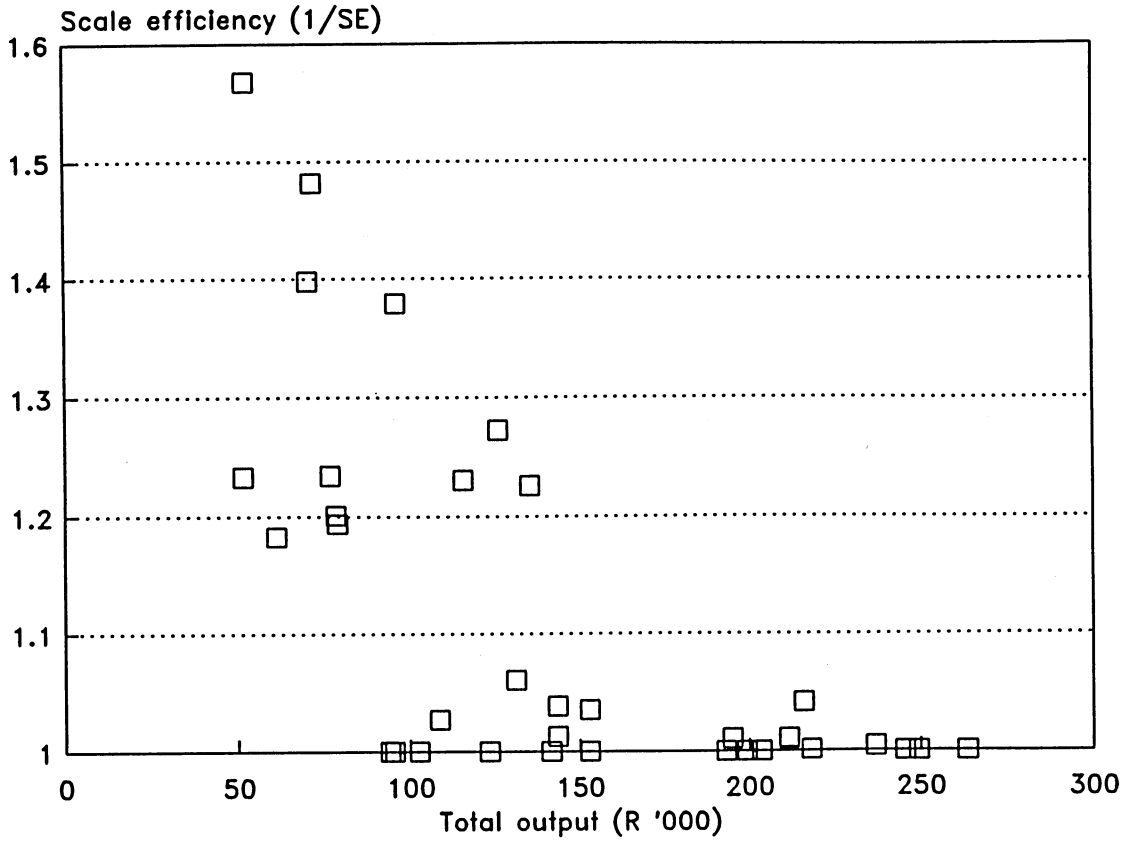

Figure 1: Inverse of scale eficiency against total output

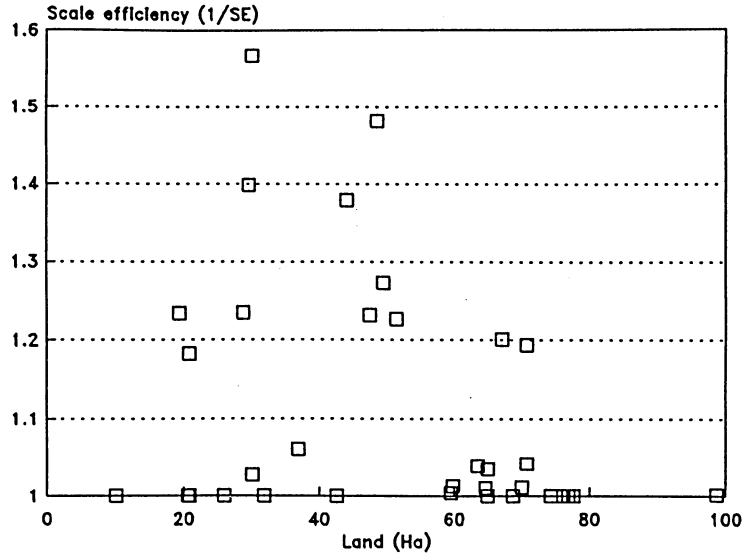

Figure 2: Inverse of scale eficiency against adjusted farm size

Table 3: Pearsons Correlation coefficients between SE and key variables

Item	Scale efficiency	
	Correlation	Significance
Farm size adjusted for quality	0,9482	0,0001
Managerial ability	0,5998	0,0002
Output per hectare	0,4987	0,0027
Total costs per hectare	0,3609	0,0360
Net farm profit per hetare	0,3011	0,0835

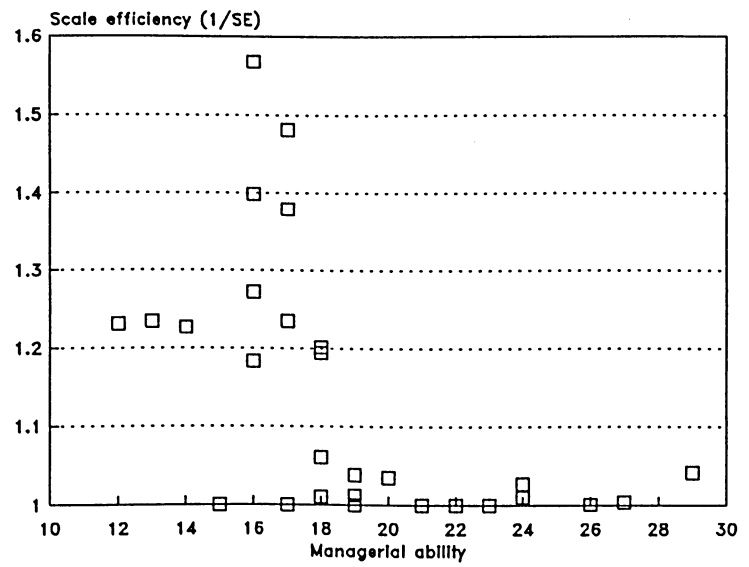

Figure 3: Inverse of scale efficiency against managerial ability

A whole range of farm sizes seems to be scale efficient, depending on how farmers organise their specific variable and fixed input mix, as well as the combination of outputs they produce. In this respect a number of relatively small farms are scale efficient, although there seems to be a bias towards a larger number of relatively small farms being scale inefficient. This again emphasises the importance of management: better managers have bigger farms.

5. Discussion

It can be concluded that better managers in general have lower fixed improvements per hectare, lower farm expenditures per hectare and higher disposable income per hectare. Furthermore, results support the notion that better managers are more efficient and operate on bigger farms than less skilled managers.

When managerial ability is not taken into account, constant returns to size are encountered. This means that increasing farm sizes will lead to increasing revenues. However, this assumes average management, and there is no such thing as an 'average manager'. When managerial ability is explicitly taken into account, increasing returns to scale are implied. Ignoring the effect of management can thus be misleading and perhaps even dangerous. Wrong policy decisions can for example easily result in the latter case.

The case study supports both the hypotheses which were tested empirically: Firstly, economies of scale exist in South African agriculture and, second, optimal farm size is not the same for any two managers; the better the manager the larger the optimum farm size. Furthermore, there appears to be no inconsistency between the results obtained with parametric or non-parametric methods: although they are based on totally different methodology utilizing 'average' and 'frontier' technology, respectively, the results are rather complementary.

6. Conclusions

The results obtained above have important implications for structural adjustment of South African agriculture. Results support the immediate repeal of the Act on the Subdivision of Agricultural Land (Act 70 of 1970). Applications for the subdivision of agricultural land are based on the notion of 'average management'. As has been shown, the failure to take specific managerial levels into account leads to erroneous policies since each farmer has an unique economical optimum farm size.

This paper thus supports Groenewald's (1991) call for flexibility in policies regarding farm size and structure of agriculture. The analysis also shows the value of proper training and extension aimed at increasing the farmer's managerial ability. The latter should form an integral part of the agricultural restructuring process in a future South Africa, and not legislation controlling minimum farm sizes. However, this does not imply that there is no minimum size (dependant on managerial ability), below which scale inefficiencies occur.

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