REGIONAL ANALYSES OF SOUTH AFRICAN AGRICULTURAL RESOURCE USE AND PRODUCTIVITY[1)]

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Abstract

Cobb Douglas type production functions were fitted in order to evaluate agricultural productivity. The country was divided into five fairly homogeneous regions for this purpose. Agricultural productivity tended to improve between 1976 and 1988, but serious malallocations persist. Overmechanization has occurred in all but one region. Labour is underutilized and underpaid. The Karoo is overstocked with livestock.

Samevatting

Cobb Douglas tipe produksiefunksies is gepas ten einde landbouproduktiwiteit te evalueer. Die land is vir hierdie doel verdeel in vyf redelik homogene streke. Landbou produktiwiteit het tussen 1976 en 1988 verbeter, alhoewel ernstige wanallokasies steeds voorgekom het. Oormeganisasie het in al die streke behalwe een voorgekom. Arbeid word onderaangewend en onderbetaal. Die Karoo word oorbewei.

1. Introduction

Productivity may be regarded as the cornerstone of economic performance. Productivity growth is an essential part of economic development. This pertains to any economic sector and every region. In agriculture, large regional productivity differences may exist both spatially and intertemporarily, as illustrated in for example, North America (Ogg, 1974). Productivity is largely determined by the use and allocation of resources, and involves the relative situation and shape of production functions as well as positions on production functions. Production functions in different regions often have different intercepts, slopes and zeniths. Levels of input use may be in close proximity to economic optima or may deviate substantially from these optimum levels. Knowledge concerning interregional productivity differences may be useful for policy makers in decisions regarding resources, to private business in determining strategic objectives and to financial institutions in their allocation of loan funds.

Certain factors, some of them exogenous, shift production functions upwards or downwards. Changes in input quantities induce shifts along production frontiers. Eventually, productivity relates to the notion of how far input-output ratios and input-input ratios deviate from the theoretical optimum conditions which stipulate that marginal value products must equal marginal costs to all resources.

Productivity is usually measured by either of three techniques, depending on the purpose and type of data used (Louw and Mostert, 1990).

1. Input/output relationships;
2. Monetary ratios; and
3. Value judgements concerning productivity changes.

This article reports on an attempt to use the first approach.

2. Research method

Cobb-Douglas type production functions were fitted on data in the Agricultural Census Reports of 1976, 1981 and 1988. Data pertaining to statistical regions were used for this purpose.

The dependent variable was defined as agricultural production units (APU), which was calculated by deflating regional gross farm income by the index of agricultural producers' prices as calculated by the Directorate of Agricultural Economic Trends (1990).

Four conventional and three non-conventional input variables were used as exogeneous variables. The conventional inputs involved labour, traction, fertilization and livestock. The non-conventional inputs consisted of land resource quality indices as calculated by Van Schalkwyk and Groenewald (1990) and dummy variables which were used to quantify intertemporal shifts.

The production functions were fitted separately for five larger regions which to some degree may be regarded as more homogeneous than the whole country in an agricultural sense:

1. Natal
2. The summer rainfall cropping region, consisting mainly of the maize triangle.
3. Cape Coastal areas, involving those Cape coastal areas which have been identified as high natural resource areas by Van Schalkwyk and Groenewald (1990).
4. Karoo, involving the largest part of the Cape Province and Western and Southern Orange Free State.
5. Grazing region: The Cape north of the Orange River and Northern Transvaal Grazing areas.

Of these five regions, Natal may possibly be regarded as the least homogenous in an agricultural sense.

3. Independant variables and data

As mentioned, four conventional and three non-conventional input variables were involved. These require some explanation.

3.1 Labour

Griliches (1957) pointed out that inclusion of labour in physical terms may cause overestimation of capital coefficients because of relationships between capital and labour. Nieuwoudt (1973) solved this problem by using labour costs rather than physical labour units. If one however wants to use factor costs to determine deviations from economic optima, this approach is less suitable. In this research, it was decided to calculate labour units, which would also reduce the bias which would result if aggregate numbers of regular and seasonal labourers were used.

Regular labour remuneration was determined as follows:

TWg = Wg + Ng

where

TWg = Total remuneration to regular agricultural labourers in RSA

Wg = Total wage to regular labourers

Ng = other remuneration to regular labour, mostly in Natura

The average remuneration now becomes:

AWg = TWg/TRL

where

AWg = Average remuneration per regular labourer

TRL = Total number of regular labourers

Regular labour equivalents now become:

RLE = (TWr + TVc)/AWg

where

RLE = Regular labour equivalents in statistical region

TWr = Total remuneration to regular labourers in statistical region

TVc = Total remuneration to casual labourers in statistical region

If it is assumed that better labourers receive higher wages, this means that a region with high quality labour will have high labour equivalents relative to number of labourers.

3.2 Traction, fertilizer and livestock

Traction was measured in terms of tractor units, with the following weights arbitrarily attached to tractors, depending on engine power capacity:

less than 60 kw	:	0,67
60 - 100 kw	:	1,00
Over 100 kw	:	1,50

In the 1976 Census, tractor engine power capacities were not reported and in 1988 only tractor values were recorded; adjustments were made, using price indices of tractors as published by the Directorate of Agricultural Economic Trends (1990).

Fertilizer inputs were measured by fertilizer expenses, deflated by the price index for fertilizers.

Livestock inputs were measured in terms of calculated animal units. Since the 1988 Census survey reported only livestock values, animal units were determined by using the index of producers' prices for livestock products.

3.3 Non-conventional inputs

As land quality can obviously be expected to influence responses to all inputs in agriculture, the land quality indices as calculated by Van Schalkwyk and Groenewald (1990) were included as non-conventional inputs. The impact of factors that change over time was measured by two dummy variables, D1 and D2.

These variables were specified as follows:

	D1	D2
1976	1	0
1981	0	0
1988	0	1

The significance and signs of these coefficients of variables can serve as indications of improvement, stagnation or decline in productivity, in terms of a movement of the production frontier.

3.4 Functional forms

In the functions fitted, production and input data (excluding land resource quality and dummies) were expressed either on a per hectare basis or in the form of ratios. Agricultural production units were consistently used as dependent variables. The production units were calculated by using real prices as weights to disaggregate gross production value. A similar procedure was used by Ogg (1974). The explanatory variables consisted of combinations of the following:

RLE	: Regular labour equivalents
TR	: Number of tractor units
FER	: Fertilizer equivalents
AU	: Animal units
LRQ	: Land resource quality index
LE/AU	: Labour equivalents per animal unit
FR/LE	: Fertilizer equivalents per labour equivalent
LE/LQ	: Labour equivalents per unit of land quality index
FR/LQ	: Fertilizer equivalents per unit of land quality index
TR/LE	: Tractor units per labour equivalent
TR/LQ	: Tractor units per unit of land quality index
D1	: Dummy variable 1
D2	: Dummy variable 2

4. Empirical results

Considerable multicollinearity existed amongst some explanatory variables in each of the five regions. The problem was resolved by omitting some correlated variables, and in some cases ratios between explanatory variables were used rather than the original variables themselves. The selection of functions fitted were such that no serious multi-collinearity existed in any fit. The results of the various fits for the different regions appear in Tables 1 to 5.

Good statistical fits were obtained for all functions presented; the lowest coefficient of determination (R^2) was 0,7812. In further discussion of results, inputs will be considered separately.

4.1 Traction

The statement is sometimes made that overmechanization has been a general phenomenon in South African agriculture. A number of linear programming studies indicated excess machine capacity on farms (eg. Brotherton and Groenewald, 1982; Van Rooyen, 1973; Hancke and Groenewald, 1972). In an analysis in the Rûens area, the top third farmers, if measured according to productivity, were found to use fewer, older and smaller machines per hectare than those with "average" productivity (Viljoen and Groenewald, 1977). In Western Transvaal, farmers with a low level of profitability had invested significantly more per hectare in machinery and equipment than those with higher profits (Janse van Rensburg and Groenewald, 1987).

This notion is confirmed by results obtained in this study. With the exception of the Karoo and Natal the coefficients of neither TR (tractor units) nor TR/LQ (tractor units per unit of land quality) deviated significantly from zero at p = 0,10. This can be interpreted that so many tractors are used that the marginal productivity thereof has become zero in a macro context.

Table 1: Production functions for Natal

Variables	Function 1.1	Function 1.2	Function 1.3	Function 1.4	Function 1.5
Intercept					
Coefficient	3,054	3,0540	-1,1174	-7,9726	2,8718
T - value	1,538	1,538	-0,726	-8,096****	18,81****
RLE					
Coefficient	0,6795				0,8089
T - value	6,519****				24,365****
FER					
Coefficient	0,0821				
T - value	1,302				
AU					
Coefficient	0,1862	1,0920	0,1862		0,1679
T - value	3,720****	7,383****	3,720****		3,717****
TR					
Coefficient	0,1441				
T - value	0,794				
LRQ					
Coefficient	0,0690	0,0690	0,9748	1,1912	
T - value	0,236	0,236	4,065****	5,423****	
D1					
Coefficient	-0,1923	-0,1923	-0,1923		-0,2817
T - value	-1,650*	-1,650*	-1,650*		-3,889****
D2					
Coefficient	0,1422	0,1422	0,1422	-0,2089	
T - value	1,199	1,199	1,199	-1,843*	
LE/LQ					
Coefficient			0,6795		
T - value			6,519****		
FR/LQ					
Coefficient			0,0821		
T - value			1,302		
TR/LQ					
Coefficient			0,1441		
T - value			0,794		
FR/LE					
Coefficient		0,0821			
T - value		1,302			
TR/LE					
Coefficient		0,1441		-0,9815	
T - value		0,794		-10,465****	
E/AU					
Coefficient		0,9058			
T - value		7,072****			
Total F	96,8****	96,8****	96,8****	95,59****	233,38****
R^2	0,9345	0,9345	0,934	0,8579	0,9368

* Significant at p = 0,10
** Significant at p = 0,05
*** Significant at p = 0,01
**** Significant at p = 0,001

Table 2: Production functions for Summer Rainfall cropping region

Variables	Function 2.1	Function 2.2	Function 2.3	Function 2.4	Function 2.5
Intercept					
Coefficient	5,225	5,225	0,2916	3,1439	-11,0469
T - value	1,917*	1,917*	0,141	17,79****	-8,896****
RLE					
Coefficient	0,5910			0,9358	
T - value	9,96****			17,07****	
FER					
Coefficient	0,2589				
T - value	2,395**				
AU					
Coeffisient	0,0837	1,1552	0,0837		0,5752
T - value	0,765	9,373****	0,765		5,661****
TR					
Coefficient	0,2214				
T - value	1,376				
LRQ					
Coefficient	-0,2418	-0,2418	0,8295		2,1849
T - value	-0,538	-0,538	2,565**		8,781****
D1					
Coefficient	-0,3581	-0,3581	-0,3581	-0,3498	
T - value	-3,337***	-3,337***	-3,337***	-4,763****	
D2					
Coefficient	0,1857	0,1857	0,1857		
T - value	1,775*	1,775*	1,775*		
LE/LQ					
Coefficient			0,5910		
T - value			9,96****		
FR/LQ					
Coefficient			0,2589		
T - value			2,395**		
TR/LQ					
Coefficient			0,2214		
T - value			1,376		
FR/LE					
Coefficient		0,2589		0,2663	
T - value		2,395**		4,75****	
TR/LE					
Coefficient		0,2214			-0,6004
T - value		1,376			-8,338****
E/AU					
Coefficient		1,0714			
T - value		6,578****			
Total F	57,703****	57,703****	57,703****	127,7****	67,638****
R^2	0,8764	0,8764	0,8764	0,8716	0,7812

* Significant at p = 0,10
** Significant at p = 0,05
*** Significant at p = 0,01
**** Significant at p = 0,001

Table 3: Production functions for Cape Coastal region

Variables	Function 3.1	Function 3.2	Function 3.3	Function 3.4	Function 3.5
Intercept					
Coefficient	5,6712	5,6713	0,9605	3,4799	4,1643
T - value	2,372**	2,372**	0,496	19,32****	17,303****
RLE					
Coefficient	0,5643			0,8837	
T - value	6,106****			13,467****	
FER					
Coefficient	0,2311				0,3377
T - value	2,761**				5,18****
AU					
Coefficient	0,2982	1,3212	0,2982	0,3338	0,412821
T - value	2,651**	9,392****	2,651**	3,279***	4,054****
TRK					
Coefficient	0,2273				
T - value	1,376				
LRQ					
Coefficient	-0,2874	-0,2874	0,7354		
T - value	-0,767	-0,767	2,466**		
D1					
Coefficient	-0,2343	-0,2343	-0,2343	-0,2575	-0,386225
T - value	-1,491	1,491	-1,491	-2,367**	-3,353***
D2					
Coefficient	0,1524	0,1524	0,1524		
T - value	1,174	1,174	1,174		
LE/LQ					
Coefficient			0,5643		0,6444
T - value			6,106****		8,06****
FR/LQ					
Coefficient			0,2311		
T - value			2,761**		
TR/LQ					
Coefficient			0,2273		
T - value			1,367		
FR/LE					
Coefficient		0,2311		0,2453	
T - value		2,761**		3,525***	
TR/LE					
Coefficient		0,2273			
T - value		1,367			
E/AU					
Coefficient		1,0229			
T - value		7,809****			
Total F	65,549****	65,549****	65,549****	110,29****	105,01****
R^2	0,9456	0,9456	0,9456	0,9439	0,9412

* Significant at p = 0,10
** Significant at p = 0,05
*** Significant at p = 0,01
**** Significant at p = 0,001

Table 4: Production functions for the Karoo

Variables	Function 4.1	Function 4.2	Function 4.3	Function 4.4	Function 4.5
Intercept					
Coefficient	4,4031	4,4031	0,5809	0,2531	0,4660
T - value	4,253****	4,253****	0,622	0,06	3,25***
RLE					
Coefficient	0,4991				
T - value	6,378****				
FER					
Coefficient	0,0423				0,2478
T - value	1,591				9,056****
AU					
Coefficient	0,2130	1,0430	0,2130		0,5918
T - value	3,669****	24,577****	3,669****		8,758****
TR					
Coefficient	0,2884				
T - value	3,402***				
LRQ					
Coefficient	-0,2341	-0,2341	0,5958	0,8345	
T - value	-1,189	-1,189	3,114***	3,541***	
D1					
Coefficient	-0,1895	-0,1895	-0,1895	-0,1839	
T - value	-2,308**	-2,308**	-2,308**	-2,19**	
D2					
Coefficient	0,3153	0,3153	0,3153	0,3423	0,3370
T - value	4,134****	4,134****	4,134****	4,42****	3,895****
LE/LQ					
Coefficient			0,4991	1,0067	
T - value			6,378****	26,90****	
FR/LQ					
Coefficient			0,0423		
T - value			1,591		
TR/LQ					
Coefficient			0,2884		
T - value			3,401***		
FR/LE					
Coefficient		0,0423			
T - value		1,591			
TR/LE					
Coefficient		0,2884		0,4503	
T - value		3,402***		4,281****	
E/AU					
Coefficient		0,8299			
T - value		14,294****			
Total F	192,38****	192,38****	192,38****	227,33****	161,79****
R^2	0,9456	0,9456	0,9456	0,9216	0,8623

* Significant at p = 0,10
** Significant at p = 0,05
*** Significant at p = 0,01
**** Significant at p = 0,001

Table 5: Production functions for Grazing region

Variables	Function 5.1	Function 5.2	Function 5.3	Function 5.4	Function 5.5
Intercept					
Coefficient	6,4899	6,4898	3,8781	-0,01557	2,5135
T - value	1,306	1,305	0,948	-0,67	11,967****
RLE					
Coefficient	0,7687				
T - value	4,887****				
FER					
Coefficient	0,1056			0,2320	
T - value	1,482			8,815****	
AU					
Coefficient	0,8060	1,3732	0,8060	0,8185	1,1128
T - value	5,75****	5,26****	5,75****	8,258****	13,553****
TR					
Coefficient	-0,3071				
T - value	-1,195				
LRQ					
Coefficient	-0,9087	-0,9087	-0,3416		
T - value	-1,136	-1,136	-2,526**		
D1					
Coefficient	-0,5669	-0,5669	-0,5669	-0,3519	-0,4534
T - value	-2,526**	-2,526**	-2,526**	-3,901****	-4,482****
D2					
Coefficient	0,0340	0,0340	0,0340		
T - value	0,252	0,252	0,252		
LE/LQ					
Coefficient			0,7687		
T - value			4,887****		
FR/LQ					
Coefficient			0,10562		
T - value			1,482		
TR/LQ					
Coefficient			-0,3071		
T - value			-1,195		
FR/LE					
Coefficient		0,1056			
T - value		1,482			
TR/LE					
Coefficient		-0,3072		-0,7699	
T - value		-1,195		-6,232****	
E/AU					
Coefficient		0,5671		0,5900	
T - value		2,737**		9,686****	
Total F	90,756****	90,756****	90,757****	146,82****	144,72****
R^2	0,9647	0,9647	0,9647	0,9621	0,9494

* Significant at p = 0,10
** Significant at p = 0,05
*** Significant at p = 0,01
**** Significant at p = 0,001

In Natal, the Summer Rainfall cropping region and the Grazing region the coefficients for TR/LE (Tractor units per labour equivalent) were both negative and highly significant. These results certainly confirm the notion of overmechanization in large parts of the country.

The Karoo consists of extensive sheep farming areas interspersed with smaller areas of intensive irrigation farming. Results in Table 4 indicate that in this region, tractors have a positive marginal productivity.

4.2 Labour

The coefficient of RLE (regular labour equivalents), LE/LQ (Labour equivalents per unit of land resource quality) and LE/AU (Labour equivalents per animal unit) were consistently positive and significant at $p = 0,05$ to $p = 0,001$. This indicates positive marginal productivity of labour in all regions.

The negative sign of TR/LE referred to earlier implies that should coefficients be fitted for the variable LE/TR in those regions, it would yield highly significant positive coefficients. It may be concluded that in those regions, substitution of labour for capital will lead to increased production. Over at least the next decade, therefore, increased agricultural employment and reduced machinery investment can be expected in those regions, given that subsidization of interest and special tax concessions are bound to be phased out. It is important to note that two of the regions with negative TR/LE coefficients have been those with the highest rates of farm insolvencies.

4.3 Fertilizer

It has been alleged that many farmers in South Africa, particularly grain farmers, have overfertilized (Du Toit, 1986; Groenewald, 1986). In this analysis, the variables FER (fertilizer quivalents), FR/LQ (Fertilizer per unit of land resource quality) and FR/LE (Fertilizer per labour equivalent) did not yield significant coefficients in Natal. The relative heterogeneity of Natal as compared to the other regions may have contributed to this result. In the other regions, however, fertilizer appears to have had significant positive marginal productivities.

4.4 Animal units

Notwithstanding the statement often made that overgrazing is rampant in many parts (De Klerk *et al*, 1983; Groenewald and Nieuwoudt, 1979; Lubbe, 1980; Minnaar and Groenewald, 1990; Transvaal Region, 1984) results obtained in this analysis indicate positive and highly significant marginal productivity to animal units in all regions.

The apparent conflict between these results and the notion of overgrazing may partially be due to the fact that not all livestock are dependent on natural grazing. This pertains for example to slaughter animals in feedlots, dairy and other cattle sustained on planted pastures and feed, as well as the total pig herd and poultry flock of the country.

4.5 Land resource quality

In every region, the land resource quality index yielded positive, significant coefficients in at least some selections. This result appears to confirm the validity of the index.

4.6 Dummy variables: General productivity

The two dummy variables D1 en D2 may be interpreted as shift variables; a negative sign for D1 can be interpreted as improvement in productivity between 1976 and 1981, while a positive sign for D2 may be interpreted as a productivity increase between 1981 and 1988. Results obtained in this respect are summarized in Table 6.

It appears that with the exception of the Cape Coastal Region where three equations yielded non-significant coefficients, D1 was generally negative and significant. It may thus be concluded that productivity was generally higher in 1981 than in 1976.

Results of D2 were as follows:

Natal	: Negative or not significant
Summer Rainfall Region	: Positive
Cape Coastal Region	: Not significant
Karoo	: Positive
Grazing Region	: Not significant

It may thus be concluded that between 1981 and 1988, agricultural productivity improved in the Summer Rainfall Cropping Region and the Karoo; it remained stagnant in the Cape Coastal Region and the Grazing Region; and in Natal, it remained stagnant or declined.

In order to measure these productivity changes, indices (1981 = 100) were determined for productivity in each equation (tables 1-5) in which D1 and D2 appeared. Where the coefficients for D1 or D2 were statistically insignificant, the indices for 1976 or 1988 were assumed to be 100. Geometric means of the productivity indices for each region were computed for 1976 and 1988. Growth rates were computed from these (see Table 7).

Natal appears to have experienced the slowest overall growth rate (1976-1988), followed by the Cape Coastal Region. The growth rate in the Karoo seems to have been the most stable.

These results must be seen in conjunction with the extremely favourable weather conditions prevailing in the summer rainfall areas (which also include Natal, the Grazing region and much of the Karoo) in 1981. The 1981 harvests for major summer crops (including maize sorghum, groundnuts, sunflower and cotton), were at record levels - records which have been maintained this status through 1988 (Directorate of Agricultural Trends, 1990). This factor can partially explain improvement in productivity between 1976 and 1981. The same pertains to very favourable climatic conditions in the Grazing Region in 1981.

The record year 1981 renders the productivity improvement since then in the Summer Rainfall Cropping Region remarkable. It may possibly be partially ascribable to a position in which more successful farmers took over land when less successful operators become insolvent. If it is accepted that while productivity in three regions remained somewhat stagnant, it did in fact improve in the two remaining ones, then one should conclude that agricultural productivity increased for the country as a whole.

This conclusion receives some support from the finding by Liebenberg and Groenewald (1990) who calculated general productivity indices for a few consecutive five year periods. Their indices for the last three periods were as follows:

1975 - 1979	: 99
1980 - 1984	: 105
1985 - 1987	: 108

5. Optimal input quantities

Productivity depends both on the position of a production frontier and the situation on this frontier, as determined by the level of input. Profit and productivity are maximized when Marginal Value Product (MVP) equals Marginal Factor Cost (MFC). A next step in the analysis was to compare these for traction, labour, fertilizers and livestock.

5.1 Traction

Tractors were found to have a significant positive marginal productivity only in the Karoo, implying that agriculture is generally overmechanized in the other regions.

Table 6: Summary of coefficients obtained with dummy variables D1 and D2

Region	Number of fits					
	D1			D2		
	Pos.& Sign.	Not Sign.	Neg. & Sign.	Pos. & Sign.	Not Sign.	Neg. & Sign.
Natal	0	0	4	0	3	1
Summer Rainfall Cropping	0	0	4	3	0	0
Cape Coastal	0	3	2	0	3	0
Karoo	0	0	4	4	0	0
Grazing	0	0	4	0	3	0

Table 7: Productivity indices

Region	Productivity index			Annual Rate of change(%)		
	1976	1981	1988	76-81	81-88	76-88
Natal	78,44	100	94,31	4,97	-0,08	1,54
Summer Rainfall cropping	64,39	100	118,57	9,20	2,46	5,22
Cape Coastal	72,81	100	100	6,55	0	2,67
Karoo	81,05	100	132,50	4,29	4,10	4,18
Grazing	49,18	100	100	15,25	0	6,09

Table 8: Marginal value product (MVP) and Marginal factor cost (MVC) for traction, Karoo

Items		1976	1981	1988
TR	: MVP	3 304	6 951	28 682
	MFC	2 926	6 229	20 482
TR/LQ	: MVP	2 385	6 443	22 418
	MFC	2 927	4 909	18 211
TR/LE	: MVP	15,36 & 22,99	30,11 & 42,63	125,72 & 183,56
	MFC	5,95	6,07	8,64

Note: TR/LE yielded significant coefficients in two selections presented - see Table 4.

What is left is to determine marginal value products for tractor units in the Karoo for the three years and to compare these with marginal factor costs. These calculations appear in Table 8. It appears that overmechanization did not occur in the Karoo, including its irrigation areas. Farmers can improve productivity by moderate additional mechanization.

5.2 Labour

Marginal value products of labour as determined from the various equations with positive and significant labour coefficients together with marginal costs are presented in Table 9.

Labour utilization is clearly suboptimal in all regions. Various reasons have been cited for this. Subsidized low interest rates have encouraged substitution of capital for labour (Bell and Padayachee, 1984) and it has been argued that increasing pressure for wage increases have not been accompanied by higher labour productivity (Spies, 1989). The growing sludgery element in costs of employment (because of intimidation at the work place, strikes, stay-away actions, etc) also increased effective real costs of labour (Sadie, 1990; South African Reserve Bank, 1990). One can also add a mental tendency of many South African farmers and extensionists to imitate labour-saving technology developed to serve the interests of North American and West European agriculture and successful, high powered promotion by the farm machinery industry. The capital/labour substitution resulted in declining capital efficiency (Volkskas Bank, 1990; Louw and Mostert, 1990).

It can also be concluded from Table 9 that labour has been underpaid in agriculture. The Act on Influx Control probably played an important role in this respect.

5.3 Fertilizer

It has in the past been argued that South African farmers had used above optimal amounts of fertilizer (Du Toit, 1986; Groenewald, 1986; Janse van Rensburg and Groenewald, 1987). If this is indeed the case, fertilizer should have a higher MFC than MVP. Table 10 provides results in this respect.

Table 10 gives an indication of overfertilization in Natal but underfertilization in the other regions. These results must however be handled carefully because of fairly high correlations between fertilizer on the one hand and labour and traction on the other. The coefficients may therefore be biased.

Table 9: Marginal value product (MVP) and Marginal factor cost (MFC) for labour

Year		MFC	Marginal value product (MVP)				
			Natal	Summer rainfall cropping	Cape coastal region	Karoo	Grazing region
LE	1976	492	1 038 1 278	1 422 2 218	1 480 3 075	1 456	1 673
	1981	1 026	2 636 3 202	4 240 6 973	3 574 8 808	3 212	4 411
	1988	2 371	6 753 7 739	9 482 14 147	8 391 17 129	8 534	9 205
LE/LQ	1976	492	1 463	1 877	2 089	1 070 2 201	1 510
	1981	809	4 660	6 744	6 867	2 961 5 986	4 887
	1988	2 108	11 132	11 673	15 856	6 589 13 099	9 172
LE/AU	1976	2,46	137,82	1 035,80	929,10	364,65	293,38
	1981	3,01	261,38	2 416,02	2 305,48	785,23	757,55
	1988	3,08	743,02	4 232,55	6 306,06	1 574,15	1 194,21

Note: Where more than one equation for a region yielded positive and significant coefficients, the different MVP's indicate the highest and lowest values obtained

Table 10: Marginal value product (MVP) and Marginal factor cost (MFC) for fertilizer

Year		MFC	Marginal value product				
			Natal	Summer rainfall cropping	Cape coastal region	Karoo	Grazing region
FER	1976	107	ns	298	518 776	705	286
	1981	199	ns	525	905 1 364	790	487
	1988	516	ns	1 777	2 597 3 548	4 326	1 455
FR/LQ	1976	107	ns	381	732,00	ns	ns
	1981	157	ns	833	1 692,00	ns	ns
	1988	459	ns	2 349	4 733,00	ns	ns
FR/LE	1976	0,217	ns	6,82 6,91	30,64 33,41	ns	ns
	1981	0,193	ns	11,91 12,82	38,90 46,15	ns	ns
	1988	0,217	ns	29,27 30,18	162,66 162,33	ns	ns

ns Coefficients not significantly different from zero

Note: Where more than one equation for a region yielded positive and significant coefficients, the different MVP's indicate the highest and lowest values obtained

Table 11: Marginal value product (MVP) and Marginal factor cost (MFC) for livestock (AU)

Year	MFC	Marginal value product				
		Natal	Summer rainfall cropping	Cape coastal region	Karoo	Grazing region
1976	200	83	169	177	19	92
		519	333	1 011	101	179
1981	344	151	453	309	40	277
		963	939	1 925	216	582
1988	770	285	848	1 193	132	900
		1 922	1 775	7 327	680	1 763

Note: Where more than one equation for a region yielded positive and significant coefficients, the different MVP's indicate the highest and lowest values obtained

5.4 Livestock

Table 11 provides a comparison between MVP and MFC of livestock. It has been mentioned earlier that various authors have argued that South africa is overgrazed and that livestock numbers should be reduced.

It appears that in Natal and the Cape Coastal Region, the MFC value was consistently between the higher and lower MVP values, implying that livestock numbers were approximately optimal in those regions. The same could be said with respect to the Summer Rainfall Cropping region in 1976; in 1981 and 1988 however, MVP values were considerably higher than MFC (with the lower MVP value exceeding MFC by 55 per cent in 1988), thus implying that livestock should be expanded in this region. It should, however, also be borne in mind that in 1976 beef prices were halfway through the declining phase of the price cycle, which peaked in 1981 and 1988 (Lubbe, 1990). Trend corrected MVP values for beef in 1981 and 1988 would be lower by approximately 20 and 15 per cent respectively for these two years. If such an adjustment is made to the MVP, it appears that in 1988, the number of animal units also were in the optimal range. It is important to note in this respect that beef is the price leader in the meat market; prices of pork, mutton and poultry follow the upward and downward movement in beef prices within a period of twelve weeks (Van Heerden *et al*, 1989).

In the Grazing Region, MVP was lower than MFC in 1976, but in the latter two years the MFC was between the higher and lower MVP estimates. This would still be the case should these MVP values be cycle adjusted. The conclusion is that economically speaking, livestock numbers in the Grazing Region appeared to be close to optimal. This result does not support the notion of gross overstocking of grazing in the Grazing Region.

The opposite is true with respect to the Karoo, where MFC consistently exceeded MVP. Efficiency will be considerably enhanced by reduced livestock numbers in this region, where livestock production is by far the major agricultural activity.

6. Conclusion

The results of this study indicate growth of total output/input ratios in South African agriculture between 1976 and 1981. The producivity growth was sustained in some regions between 1981 and 1988, but remained stagnant in other regions. There are convincing indications that South African agriculture is overmechanized and simultaneously under utilizes and underpays labour. The Karoo is overstocked with livestock but livestock numbers appear to be fairly close to optimal in other regions.

Notes:

1) Based on an M Com thesis by H D van Schalkwyk at the University of Pretoria. Mr van Schalkwyk has recently joined the staff of Standard Bank. The authors gratefully acknowledge financial assistance by the Institute of Research Development (IRD) of the Human Sciences Research Council (HSRC). Opinions expressed in this article are those of the authors and do not necessarily reflect those of the IRD or HSRC.

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