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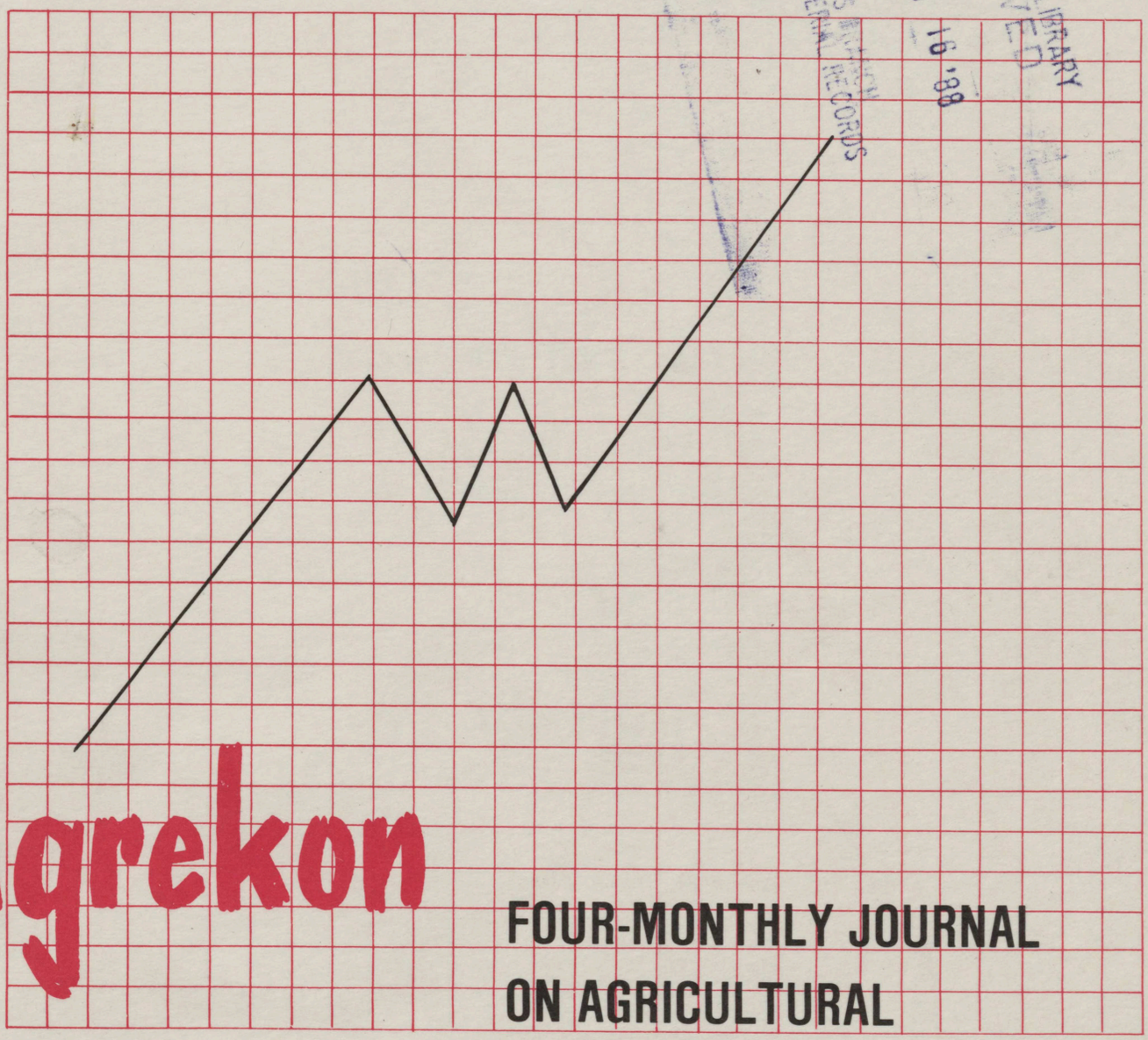

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THE INFLUENCE OF DROUGHT AND GENERAL ECONOMIC EFFECTS ON AGRICULTURE: A MACRO-ANALYSIS

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ABSTRACT

In this study the effects of drought and the weakening parity of agriculture owing to structural inflation are analysed using macro-information. Analyses of key variables over time are followed by multiple regression analyses with total farm debt as a dependent variable.

The drought hit the gross income from field crops the hardest; the value of field crop production was on average 45,3 per cent per annum lower for the period 1982-85 than predicted by the long-term trend. On the other hand, deviations in horticultural and animal production were on average smaller than 8 per cent per annum. Multiple regression shows that drought, general economic conditions and the effects of structural inflation influence the debt burden of the farming sector. Real gross domestic product, interest rates, the ratio of input to output prices and the drought index all had a significant influence on the real debt burden of agriculture in the period 1970-85. The influence of these factors was also, without exception, relatively elastic. This means that a change in any of these factors will result in a proportionally larger change in real total debt burden.

INTRODUCTION

The eighties was introduced by a period of apparent prosperity for South African agriculture. The years 1979-81 were characterised by record crops of maize, sunflowers, dry beans, buckwheat, peanuts, cotton, sorghum, cowpeas and dried peas; wheat production reached two successive records in 1981 and 1982. Drought subsequently set in and production levels declined in the succeeding years. In each of the years 1982/83 and 1983/84, the total maize crop was less than 30 per cent of the record level of 1980/81 (*Abstract*, 1986).

The years of drought were accompanied by serious recession and hyperinflation (stagflation) in South Africa (Janse van Rensburg and Groenewald, 1986). The process of deteriorating parity of agriculture in the seventies (Groenewald, 1986) also continued. Real values of margins over the majority of agricultural inputs were considerably lower for each year in the period 1981/82 to 1984/85 than in 1980/81, livestock and inventory values declined and the real value of farm debt increased by almost 50 per cent (*Abstract*, 1986).

In such a situation, a thorough analysis of the effect of drought and macro-economic trends on the financial situation of the agricultural sector is relevant. In this study the effect of drought and the deteriorating parity of agriculture owing to structural inflation (Groenewald, 1985; Van Zyl, 1986) are analysed with the use of macro-information.

PROCEDURE

A study of the behaviour of economic phenomena over time can be either descriptive or logically structural in nature (Du Toit, 1982:11). Traditional time series analyses are a good example of the first, while applied econometrics supplies examples of the structural approach.

In die "traditional" approach, change in a variable over time is divided into four different, but logical time components, namely a trend, a seasonal, a cyclic and a random component each with a repetitive nature differing from those of the others. This approach therefore tries to explain movements in economic time series by associating such movements with the underlying time patterns. Such movements, which are largely self-generating, therefore explain themselves (Wonnacott and Wonnacott, 1977). The accent therefore does not fall on the question why a particular trend exists, but merely on measuring its influence (Ferber and Verdoorn, 1967:127, 128).

The structural approach in time series analyses represents an attempt to bridge this gap. In this approach the accent falls on the analysis and interpretation of the above-mentioned systematic components of time series in logical or structural terms. The underlying approach is that fluctuations in a specific time series cannot be properly explained without taking into account movements in other time series and without reference to a structural model that indicates the relationship between the different time series (Du Toit, 1973).

In this study both approaches are utilised in an attempt to determine the effect of drought and macro-economic variables on the financial situation of the farming sector. The analysis was done by

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means of regression analysis (single and multiple) of macro-information. All information was obtained from the *Abstract of Agricultural Statistics* (1986) and unpublished information of the Directorate of Agricultural Economic Trends.

Analyses of key variables over time were done first and were followed by multiple regression analyses with total farming debt as dependent variable. Certain conclusions are offered eventually.

CHANGES IN KEY VARIABLES OVER TIME

It was hypothesised that the deviation from the long-term regression line could be ascribed to changes in climate and other macro-effects, among others the condition of the general economy. Regression functions were fitted on time series until before the drought and then extrapolated. It was argued that deviations between these extrapolated functions and actual results are the result of drought and macro-economic influences. This hypothesis is, however, subject to the assumption that historical trends would have persevered but for the effects of drought and macro-economic variables. Figure 1 depicts the situation graphically.

The gross income of the farming sector as measured by the total value of agricultural production was analysed first, followed by analyses of total assets, net assets and total farm debt.

Gross income

Linear, exponential, logarithmic and power functions were fitted on time series of the real value of total agricultural production and on its various components, namely the real values of field crop, horticultural and animal production.

Each variable was deflated with the corresponding producer price index. Time is the independent variable in each case.

The exponential function consistently produced the best fit. The results in Table 1 refer exclusively to the exponential function:

$$Y = aEXP(bX) \quad \text{..... (1)}$$

where Y = real value criterion
X = time (1960/61 = 1)
a = intercept
b = slope of regression coefficient

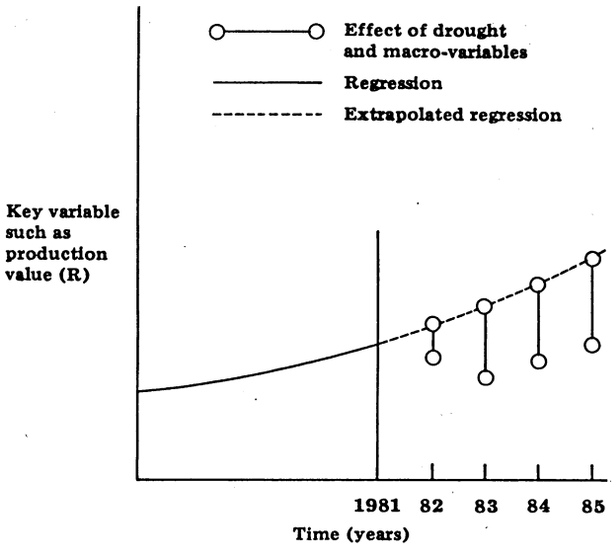

FIG. 1 Graphical representation of the determination of the effect of drought and macro-variables, for example, on production value

According to Table 1 all the functions produced highly significant fits. The coefficient of determination (R^2) exceeds 75 per cent in all cases, with the exception of animal production. The functions can therefore be utilised for the determination of the effect of drought and macro-variables on agriculture. The differences between estimated and actual production values for the drought years are shown in Table 2.

It appears from Table 2 that the actual value of total agricultural production was considerably lower in all the years than that predicted by the extrapolation of the pre-drought trend. Field crop production was hit the hardest. Animal production initially probably compensated by marketing more animals, but the lag effect of the drought also eventually exercised a negative effect. However, it must be remembered that the coefficient of determination (R^2) for animal production is low.

The information in Table 2 does not represent the total loss suffered by agriculture since 1982, but only the loss in gross income. Cost savings and escalations, inflation effects, the cost-price squeeze and the effect of interest obligations and deferred debts are not reflected in these figures. The amounts also cannot simply be added together to get the total loss in income over time; such a procedure would ignore the time value of money. The net asset value and total debt burden of agriculture should therefore be better criteria of the actual economic situation.

TABLE 1 - Results of single variable exponential regression with time as independent variable

Y	a	b	R^2	Durbin-Watson	t-value*
Real value of					
Total agricultural production	3,102	0,030	0,773	1,864	8,237
Field crop production	0,625	0,040	0,799	1,854	8,894
Horticultural production	0,365	0,034	0,953	1,331	20,058
Animal production	3,948	0,014	0,319	1,071	3,057

*All t-values are highly significant ($p < 0,01$)

TABLE 2 - Difference between estimated and actual gross production values, 1982-85

Item	Year			
	1982	1983	1984	1985
Gross value of total agricultural production				
a. Actual value (R mil.)	7 636,4	7 822,9	8 749,6	10 602,9
b. Estimated value (R mil.)	8 135,6	9 388,3	10 748,3	12 262,2
c. Difference (a-b) (R mil.)	(499,2)	(1 565,4)	(1 998,7)	(1 659,3)
d. Percentage difference	-6,5	-20,0	-22,8	-15,6
Gross value of field crop production				
a. Actual value (R mil.)	3 187,1	3 071,2	3 413,9	4 529,1
b. Estimated value (R mil.)	3 853,6	4 856,4	5 697,5	6 121,1
c. Difference (a-b) (R mil.)	(666,5)	(1 785,2)	(2 283,6)	(1 592,0)
d. Percentage difference	-20,9	-58,1	-66,9	-35,2
Gross value of horticultural production				
a. Actual value (R mil.)	1 237,8	1 306,0	1 487,0	1 678,7
b. Estimated value (R mil.)	1 153,9	1 263,5	1 281,6	1 777,1
c. Difference (a-b) (R mil.)	83,9	42,5	205,4	(98,4)
d. Percentage difference	+6,8	+3,9	+13,8	-5,9
Gross value of animal production				
a. Actual value (R mil.)	3 211,5	3 445,7	3 848,7	4 395,1
b. Estimated value (R mil.)	2 968,3	3 136,9	3 717,4	4 439,9
c. Difference (a-b) (R mil.)	243,2	308,8	131,3	(44,8)
d. Percentage difference	+7,6	+9,0	+3,4	-1,0

Total assets, net assets and total debt burden

Linear, exponential, logarithmic and power functions were also fitted on time series of the above-mentioned values. The variables were deflated with the combined producer price index for agricultural products. Time is the independent variable. The exponential function produced the best fit for the real total and real net assets, while the logarithmic function produced the best fit for the real total debt burden. The exponential function is the same as that in Equation 1, except that 1970 represents the beginning of the time series. The logarithmic functions are as follows:

$$Y = a + b \log X \quad \text{..... (2)}$$

where the symbols have the same meaning as in Equation 1.

According to Table 3 all the functions produced highly significant fits with relatively high coefficients of determination. The functions were consequently used for extrapolation. The prediction value is also confirmed by the small percentage differences between the actual and predicted values of 1,2 per cent, 0,9 per cent and 6,3 per cent, repectively, for the total and net asset value and total debt burden in 1981.

It is important to note that real values of total debt burden have declined from 1970 to 1981. On a percentage basis real debt burden showed the greatest and real net assets the smallest decline per annum. The declines resulted in improvements in solvency (assets/liabilities) for agriculture during this period. The improvement was, however, not significant at the 10 per cent level.

The actual and predicted total asset value, net asset value and total debt burden in 1985 are shown in Table 4.

It appears that the total and net asset value are, respectively, 19,5 and 32,4 per cent lower and total debt burden 80,2 per cent higher owing to the drought and continued macro-economic effects such as structural inflation.

The net capital ratio is, on the other hand, 55,3 per cent lower than the predicted value.

MULTIPLE REGRESSION

In the structural approach the real debt burden in agriculture was hypothesised as a function of the drought, the general economic state and the structure

TABLE 3 - Results of single variable regressions with time as independent variable, 1970-1981

Y	a	b	R^2	Form	Durbin-Watson	t-value*
Real value of						
Total asset value	730,486	-0,020	0,681	Exp.	1,826	4,620
Net asset value	568,224	-0,018	0,585	Exp.	1,683	3,753
Total debt burden	230,511	-48,339	0,739	Log.	1,318	5,320

*All t-values are highly significant ($p<0,01$)

TABLE 4 - Actual and predicted total asset value, net asset value and total debt burden in 1985

Variables	Actual	Predicted	Difference between actual and predicted values	
	R million		R million	% deviation
Total asset value (1)	43 045,0	53 448,4	(10 403,4)	-19,5
Net asset value	31 887,0	47 143,1	(15 256,1)	-32,4
Total debt burden (2)	11 158,0	6 192,4	4 965,6	80,2
Net capital ratio (1÷2)	3,86	8,63	(4,77)	-55,3

of inflation. The following functions were hypothesised:

RTS = f (VIA, RK, RBBP and IU) ..... (3)
and RTS = f (DI, RK, RBBP and IU) ..... (4)
and TS = f (VIA, RK, BBP, IU and PPI) ..... (5)

where
- RTS = Total debt burden deflated by producer price index
- TS = Total debt burden
- VIA = Index of volume of field crop production
- RK = Weighted mean interest rates in agriculture
- RBBP = Gross domestic product deflated by the consumer price index (this variable is an indication of the general economic condition)
- IU = Price index of farming requisites divided by the producer price index
- UI = Producer price index divided by the price index for farming requisites
- DI = Drought index - the deviation from the long-term trend in the index of volume of field crop production
- BBP = Gross domestic product at factor prices
- PPI = Producer price index

Several selections of the above-mentioned functions were fitted with linear multiple regression on time series data over 16 years (1970 until 1985). The variables were lagged separately and together in attempts to obtain better fits. Logarithmic transformations were also done and fitted. Results with lags and logarithmic transformations were less successful. Only a few selections representing some of the better fits are given and these do not include any lagged and logarithmic fits.

Another fit was done by omitting the intercept term. The real GNP as provided by the Reserve Bank (1986) was used, while the structure variable was redefined as input prices divided by output prices (UI), instead of the other way round as in Equation 8.

The fit is as follows:

$$RTS = -63{,}56\ VIA + 0{,}17\ RBBP + 452{,}47\ RK - 4{,}904\ UI \quad \ldots\ldots\ldots (9)$$
$$-4{,}22^{***} \qquad 3{,}39^{**} \qquad 4{,}62^{***} \qquad -4{,}25^{***}$$
$$R^2 = 0{,}984 \qquad F = 188{,}28^{***} \qquad DW = 1{,}98$$

Student's t- values according to the one-sided probability of exceedance table:

*** = 0,1%; ** = 1,0%; * = 5%

Significance of the F-values is indicated as follows:

*** = 0,1%; ** = 1,0%; and * = 5%

Equations 6, 7, 8 and 9 represent relatively good statistical fits: All the functions and individual regression coefficients are significant and the coefficients of determination (R^2) are relatively high. This implies that the equations explain 98,8 per cent, 82,1 per cent, 88,7 per cent and 98,4 per cent respectively, of the variation in total debt burden.

Equation 8 contains variables representing the drought, general economic conditions and the effect of structural inflation on the farming sector. The elasticities of RBBP, RK, IU and DI with regard to RTS were estimated at -1,896; 2,650; 1,406 and -4,236, respectively, from Equation 8. All the variables are thus relatively elastic; a change in any of the variables will result in a proportionally larger change in the total debt burden of agriculture.

Equation 9 contains the same variables as Equation 8, but in a different form. The real GNP coefficient is, however, positive in Equation 9, whereas it is negative in Equation 8. The difference

Selected fits:

$$TS = 1\,680{,}73 - 34{,}34\ VIA + 162{,}66\ RK + 22{,}62\ PPI \quad \ldots\ldots\ldots (6)$$
$$-5{,}47^{***} \qquad 2{,}43^{*} \qquad 9{,}77^{***}$$
$$R^2 = 0{,}988 \qquad F = 336{,}83^{***} \qquad DW = 1{,}46$$

$$RTS = 35{,}0009 - 0{,}126\ VIA + 0{,}689\ RK - 0{,}016\ RBBP \quad \ldots\ldots\ldots (7)$$
$$-4{,}10^{***} \qquad 3{,}88^{**} \qquad -1{,}92^{*}$$
$$R^2 = 0{,}8211 \qquad F = 18{,}31^{***} \qquad DW = 1{,}10$$

$$RTS = 9{,}39 - 0{,}025\ RBBP + 0{,}751\ RK + 17{,}068\ IU - 0{,}062\ DI \quad \ldots\ldots\ldots (8)$$
$$-2{,}66^{*} \qquad 2{,}97^{**} \qquad 1{,}99^{*} \qquad -1{,}86^{*}$$
$$R^2 = 0{,}887 \qquad F = 20{,}17^{***} \qquad DW = 1{,}21$$

is probably due to differences in the data base and the different variables used in the models. The different elasticities were estimated as follows from Equation 9: VIA = -2,68; RBBP = 1,21; RK = 2,81 and UI = -2,13.

Time was not included as an independent variable in any of the equations. The reason for this is the high correlation coefficient (r=0,91) that existed between time and the input/output variable (IU) and the output/input variable (UI) for the period 1970 until 85. The effect of time was therefore implicitly taken into account by the structure variable (UI or IU).

CONCLUSION

The drought hit the gross income from field crop production the hardest; the value of field crop production was on average 45,3 per cent per annum lower for the period 1982-85 than that predicted by the long-term trend. On the other hand, the deviations in horticultural and animal production were less than 8 per cent per annum on average. Value of total agricultural production is on average 16,2 per cent per annum lower than that predicted by the long-term trend for the period 1982 until 1985 (Table 2).

The initial increase in the value of animal production is probably ascribable to initial increased marketing of livestock by farmers because of the drought. It can also partially be caused by farmers who started milk production in periods of drought in order to generate extra cash revenue. The poor financial state of cattle farmers is therefore probably not the result of a smaller income, but probably the result of bigger expenditures on, among other things, feedstuffs and of interest on the resultant increased debt burden.

Even in the period 1970 until 1981 the position of agriculture deteriorated as a result of structural inflation. Real total and real net asset value, respectively, declined by 2,0 and 1,8 per cent per annum (Table 3). In the period 1982 until 1985 total asset value in agriculture - which should not be greatly influenced by drought - declined by 19,5 per cent or R10 403 million below what was predicted from the long-term trend in the period 1970 until 1981.

This reduction constitutes the difference between the actual and predicted total asset value in 1985 and is therefore mainly the result of macro-effects and more specifically structural inflation, which caused input prices in agriculture to rise faster than producer prices. On the other hand, the difference of 32,4 per cent or R15 256 million between the actual and predicted net asset value of agriculture in 1985 is the result of the combined effect of structural inflation and drought since 1982, as shown by the 80,2 per cent increase in the total debt burden of the agricultural sector (Table 4).

Multiple regression shows that drought, general economic conditions and the effect of structural inflation affect the debt burden of the agricultural sector. Real gross domestic product, interest rates, the ratio of input to output prices and the drought index all had a significant effect on the real debt burden of agriculture in the period 1970-1985: The elasticities of interest rates, drought index, volume of field crop production, real GNP and the ratio of input to output prices are relatively high. This means that a change in any of these factors will result in a proportionally bigger change in real total debt burden.

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