THE DECOMPOSITION OF PRICE AND SUPPLY CYCLES IN THE SOUTH AFRICAN BEEF INDUSTRY

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ABSTRACT

A composite model of moving averages and analysis of variance (MA-ANOVA) was used to estimate cyclical and seasonal patterns of supply and producer beef prices in South Africa. Significant seven year price cycles and eight and nine year cycles were isolated for female and male slaughterings respectively. These cycles depict a dependence on seven and 18 year rainfall cycles and a process of herd expansion/liquidating following the implementation of the controlled marketing policy. Turning points were forecasted with relative accuracy, while short term marketing strategies were successfully implemented by producers using the estimated seasonal indices.

1. INTRODUCTION

Prices are generally considered as signals for production, consumption and agricultural marketing intervention policies, but agricultural commodity prices are highly volatile and subject to excessive variation over the short, medium and long term. The reasons for this erratic price behaviour is the inflexibility and uncotrollability of agricultural production, production and supply dependence on rainfall and biological factors, price and market intervention policies and individual producer behaviour (Tomek & Robinson, 1981) Current agricultural prices are not responsible for current supplies, because of time lags between production decisions and the final outputs, while current supplies are the results of previous production decisions and prices as well as price expectations. This is especially true for the red meat industry, where production cycles of one to five years may exist (Farris, 1975; Du Toit, 1982).

The existence of deterministic price patterns over time had been well identified and reported (Thomson & Foote, 1952; Shepherd & Futrell 1969; Farris, 1975; Tomek & Robinson, 1981). Seasonality in prices and production had also been reported for meat products in South Africa (Adendorf, 1958; Louw, 1975; Lubbe, 1980 and Lubbe 1989). Price variation over time consists of long term trend movements in time, cyclical movements over several years, seasonal variation within one year and also irregular behaviour. Although

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the influence of female slaughterings on supply cycles had been identified (Du Toit, 1982), the isolation of beef supply cycles in South Africa had not yet been reported.

Price variation patterns are generally illustrated with descriptive methods such as moving averages or indices and analyzed with structural econometric methods (causal supply and demand analysis). This research is aimed at identifying, isolating and estimating seasonal, cyclic and trend components of beef producer prices and related supply cycles for the South African controlled market. Rainfall cycles were also estimated. The purpose of this paper is to develop a suitable basis for predicting cyclical price movements by isolating the components in the time domain, and also relating cycles in other variables, such as rainfall and supply, to these price cycles.

2. DATA, TECHNIQUES AND METHODS

2.1 Data

Trends and cyclic components of average (All Grades) beef prices (1970 - 1989) were isolated from yearly data, while monthly data (1970 - 1989) was used for the seasonal components. Supply cycles of total slaughterings, oxen and female animals were isolated from yearly data (1964 to 1989). Data from the Witwatersrand abattoirs are considered to be representative and were obtained from the Meat Board. Rainfall cycles were isolated from average yearly raintall figures for South Africa (1921 - 1989).

2.1 Techniques and methods

Trends were estimated as single predictor variable regressions in time, using single stage OLS methods (Draper & Smith, 1981). Transformations of non-linear functional forms (linear in parameters) were used. Cycles and seasonal patterns were estimated using a composite two stage model, MA-ANOVA, which combines the techniques of moving averages and analysis of variance (ANOVA) recursively. These techniques are described in Makridakis *et.al* (1983) and Steel & Tory (1960). The MA-ANOVA method is a refinement of the traditional moving average and index methods. The traditional ratio to moving averages (or trend) decomposition procedure was followed, and multiplicative models assumed (Makridakis *et.al.*, 1983).

The basic model is : $Y_t = (T_t.C_t.S_t).E_t$ (1)

where :

Y_t = price at time t,
T_t = trend at time t,
C_t = cycle index at time t,
S_t = seasonal index at time t,
E_t = random error or irregular component at time t and
t = the time range.

Observations correspond to monthly intervals for seasonal variation (months or quarters) models. The basic model was modified to include multiple cycles (amplitudes) at time t. This is specified as C_{it} with i = 1....N as different possible amplitudes at time t. Reduced models without the seasonal component were used with yearly data, while completely specified models were used to estimate seasonal indices. ANOVA models were used to estimate the most significant cyclical amplitudes (length of MA_t that will effectively eliminate the cyclic behaviour).

Trends were estimated and eliminated before the estimation of cycles and seasonal indices. Averages were used in the absence of significant trends (for rainfall). The model was adapted as follows for rainfall cycles:

$$Y_t = T_a . C_{it} . E_t \qquad (2)$$

with T_a the average rainfall (in the absence of a significant trend) and C_{it} multiple cycles of different lengths at time t.

Drawbacks of this method include loss of data at both ends of the data series (MA calculation) and the large number of observations needed for cycles with larger lengths. The statistical significance of this method was however significantly improved by introducing the ANOVA technique in estimating cyclical amplitudes. For any of the analyses the resulting model can be expressed in estimated parameters, which may be used for the prediction of future components. The model would be as follows:

$$Y'_t = t_t . c_{it} . s_t \qquad (3)$$

where i indicates different cycles and Y'_t is the predicted time series values. The computational form is then:

$$Y'_t = (B_0 + B_1 t)(U_i + Z_{ij})(U_s + V_j) \qquad (4)$$

where :

t	=	data range in time for which model was fitted - t = 70 ....89 for 1970 to 1989,
B_0 and B_1	=	is the estimated trend coefficients,
U_i and U_s	=	is the ANOVA ratio means and will always be unity with adjusted indices,

i	=	denotes the different cycle lengths (i = 1...N)
Z_{ij}	=	Is the ANOVA effect coefficients for cycle i at the time j. It is thus the difference between the mean of period j of the cycle and U_i.
j	=	1....Li, is the different periods within cycle i which is of length Li. For the seasonal component L equals 12. The formula j = ((t-1) mod Li) + 1) can be used to compute j in (4).
V_j	=	denotes the effect coefficients at period j within in the amplitude of the seasonal component.

Cycle adjustment coefficients between price cycles, rainfall cycles (Lubbe, 1990) and the isolated supply cycles were estimated using multiple regression analysis with distributed lags. The following model were adapted from Judge *et al* (1985).

$$Z_t = a + \Sigma b_i P_{t-i} + \Sigma c_i R_{t-i} + e_t \qquad (5)$$

where:

Z_t = supply cycle response value at time t,

P_t = price cycle index value at time t,

R_t = rainfall cycle value at time t,

b_i and c_i = coefficients of cycle adjustments pertaining to price or rainfall cycles at lag i,

i = lags in prices or rainfall cycle indices and

e_t = random error at time t.

Analyses were done using typical seven year rainfall and price cycles or specific stationary cycles filtered with moving averages.

3. RESULTS

Similar results were reported using time series of different lengths (Lubbe, 1983, 1989, 1990a, 1990b and 1990c). Although static forecasts were attempted, the main purpose thereof is to evaluate cyclical behaviour and not future values. Dynamic models provide more accurate forecasts of expected prices than the pure recombination of time series components.

3.1 Beef price time series components

Significant trends were isolated for beef prices from the yearly data. An exponential function fitted best and the derived estimates are as follows (in log transformation).

$T_t = 0.0063991 + 0.1259083 \quad R^2_{adj} = 96.53\ \%$

(11.58) (23.02)

(Absolute T-values in brackets, significant at 5% level)

The original beef price series and the fitted trend (extrapolated to 1996) are illustrated in Figure 1. Significant seven year price cycles were isolated and the derived cyclic indices and effect coefficients summarised in Table 1. The specific price cycle (before estimation of index coefficients) and typical cycle (extended to 1996) are illustrated in Figure 2. From Table 1 and Figure 2 it is evident that the price cycle is below the average trend for four years, (negative Zj's) and above the trend for three years. This implicates a downswing for four years followed by a sharp upswing (larger coefficients) of three years. Static forecasts of the cycles suggest that prices are at present in the increasing phase of the cycle. In reality, however, extended droughts and efforts by producers to discount these forecasts resulted in that the upswing was less noticeable as illustrated.

Significant seasonal components were isolated and the coefficients are summarised in Table 1. Seasonal indices are also illustrated in Figure 3. It must be noted that these seasonal cycles are averages over 20 years and that there is evidence that the pattern itself could be subject to variation.

3.2 Beef supply cycles

Significant seven year supply cycles for total, female and oxen slaughterings were found. The cycle coefficients are summarised in Table 1 and illustrated in Figures 4 and 5. The total supply (slaughterings) and price cycles (both seven years) are illustrated in Figure 5, demonstrating the interaction between directional adjustments of supply and prices as well as the regularity of shortages and surpluses at the controlled markets. It is apparent that the minimum of the supply cycle coincides with the maximum of the price cycle, while maximum of the supply cycle occurs in the year following the minimum of the price cycle. It is possible that this lagged response originates from ill-timed policy adjustments.

Table 1: Seven year cycle estimates for beef prices and supplies (slaughterings) and seasonal index estimates of beef prices.

	Seven year beef price cycles		Seven year beef supply cycles			Seasonal indices for beef prices		
Period (year)	C_j	Z_j	Total C_j	Female C_j	Oxen C_j	Period (month)	S_j	V_j
1	0.899	-0.101	1.026	1.158	0.958	1	1.027	0.027
2	0.831	-0.169	1.162	1.475	1.060	2	0.992	-0.008
3	0.862	-0.138	1.149	1.241	1.119	3	0.965	-0.035
4	1.064	0.064	0.875	0.686	0.944	4	0.980	-0.020
5	1.263	0.263	0.897	0.699	0.973	5	0.960	-0.040
6	1.093	0.093	0.933	0.767	1.004	6	0.968	-0.032
7	0.987	-0.013	0.957	0.973	0.940	7	0.976	-0.024
						8	0.985	-0.015
						9	1.002	0.002
						10	1.040	0.040
						11	1.048	0.048
						12	1.057	0.057
Statistics								
U_i	1.000		1.000	1.000	1.000		1.000	
F_{model}	36.240		2.610	6.630	6.160		15.180	
R^2_{adj} (%)	94.21		72.30	76.80	75.50		43.50	

Coefficients and parameters significant at the 5% level

3.3 Rainfall cycles

The main purpose for isolating probable rainfall cycles is not to forecast the weather patterns, but to investigate any similarities or explanatory behaviour towards meat price cycles. Seven year and 18 year cycles were sequentially isolated. The coefficients are summarised in Table 2 and the typical indices illustrated in Figure 6. It is evident from Figure 6 that the period from 1980 to 1989 represented years below the 18 year rainfall average, but 1981 and 1989 were also maxima of the seven year cycle. Rainfall for 1981, 1985 and 1989 were above average, although in the low phase of the 18 year cycle.

Table 2: Estimates of seven and 18 year rainfall cycles from average yearly rainfall figures.

Period (years)	Eighteen year cycle C_j	Seven year cycle C_j
1	1.074	0.974
2	1.082	1.103
3	1.066	0.927
4	1.043	0.925
5	1.004	1.115
6	0.967	0.944
7	0.970	1.010
8	0.963	
9	0.932	
10	0.934	
11	0.943	
12	0.949	
13	0.952	
14	0.974	
15	0.993	
16	1.026	
17	1.064	
18	1.064	
Statistics		
U_t	1.000	1.000
F_{model}	4.710	9.580
R^2_{adj} (%)	76.450	83.150

Significance at 5% level

3.4 Supply cycle adjustments

Cycle adjustment coefficients were estimated by regressing stationary seven year price and rainfall cycles on a stationary total supply cycle. These results are summarised in Table 3. Functions which contained only combinations of lagged rainfall cycle variables or short term lagged price variables were not significant.

It is thus apparent that adjustment of supply depends both on price and rainfall parameters. From Table 3 it is apparent that supply responds negatively to a one year lag in price movements and the current rainfall cycle level. The relatively short term inverse response to the price cycle is probably due to anticipations that prices will continue to increase (during the increasing price cycle) and vice versa. Positive supply cycle responses to a five year lag in real prices represents the herd expansion process, which links the maxima of the price and supply cycles, while one and two year rainfall lags pertain to medium term climatological-supply reactions. These analyses indicate that supply flexibility depend to a large extent on climatological influences, but is evidently distorted by price signals.

Table 3: Results of supply cycle adjustment coefficients from regression of price and rainfall cycles on supply cycles.

	Functions			
Variables	F_1	F_2	F_3	F_4
Intercept	2.259	1.255	1.796	1.227
$Price_{t-1}$	-0.023*	-0.707*	-0.453*	-0.335*
	(11.76)	(-8.59)	(-7.66)	(-8.38)
$Price_{t-5}$			0.237*	0.317*
			(3.86)	(8.30)
Rainfall	-0.636**		-0.582*	-0.519*
	(2.25)		(-7.74)	(-11.54)
$Rainfall_{t-1}$		0.45**		
		(2.87)		
$Rainfall_{t-2}$				0.310*
				(5.72)
F_{model}	96.08*	37.26*	121.43*	279.84*
R^2 (%)	91.9	81.4	95.8	98.7
DW	2.56	2.43	3.50	2.90
Df	19	19	19	19

Significance at the 5% level

4. DISCUSSION

From Figures 4 and 5 it is evident that the cyclical behaviour of the supply of beef is mainly due to the cyclical behaviour of the female slaughterings. Du Toit (1982) and Lubbe (1983) found empirically that controlled slaughterings can be estimated by three to four year lagged female slaughterings. This indicates a process of livestock expansion (which starts at the maximum of the cycle) and a process of livestock liquidation (which starts at about the minimum of the cycle). The expansion period thus continue for four years, while the liquidation period takes place over three years. One of the main incentives for the expansion is the high prices that prevail during the cycle maxima. The latter could be the result of maximum supply control during the previous two to three years and the consequence of the just completed liquidation period, which rendered a shortage in supply, the year before the maximum of the cycle. During a downswing this shortage is wiped out in two years by un-marketed stock and the supply of young animals (mainly feedlot action).

The effect of rainfall is evident from Figures 6 and 7. The maxima of the seven year rainfall and price cycles coincide, while the minima of the price cycles are followed by the minimum of the rainfall cycle. The rainfall maxima is followed by three years of relative average rainfall, then one year with extremely high rainfall (at the price cycle minimum), thereafter by two extremely low rainfall years, that also represent the minimum of the rainfall cycle. From this relation to the seven year rainfall cycle one can conclude that the combined effect of the rainfall, the variation in production capacity and price expectations produce an environment for relative stable price cycles. The livestock expansion and liquidation processes are fuelled by the rainfall cycle and rainfall expectations. The effect of the 18 year cycle is to modify the patterns of stock expansion and liquidation.

The total supply (slaughtering) and price cycles (both seven years) are illustrated in Figure 4, demonstrating the interaction between directional adjustments of supply and prices as well as the regularity of shortages and surpluses at the controlled markets. It is apparent that the minimum of the supply cycle coincides with the maximum of the price cycle, while maximum of the supply cycle occurs in the year following the minimum of the price cycle. It is possible that this lagged response originates from ill-timed policy adjustments.

These analysis confirm the cause and effect of cyclical production through a process of herd expansion and liquidation which simultaneously responds to price expectations and current prices. Female slaughtering cycle is more volatile than the oxen cycle probably because the latter is filtered by feedlot activities. It is apparent from Figure 5 that the cyclic behaviour of female slaughterings is the driving force of cyclical supply in the form of variation in production capacity. This state of affairs evidently indicates a distorted production process which amplifies climatological inflexibilities and distorted price signals. High prices during the upswing and maximum of the cycle are incentives for production capacity expansion. Female animals, which are in great demand, are thus kept from markets, while the excess production capacity results in a herd liquidation process during the decline of the price cycle.

5. CONCLUSION

Although producer prices of beef are erratic over the long medium and short terms, relative stable price patterns exist. These price patterns were successfully isolated as significant trends, seven year cycles and seasonal indices. Significant seven and 18 year rainfall cycles were also isolated. Cyclical production may thus be the result of the combined influences of price expectations, price guarantees, inadequate market access (due to supply control), other restrictive regulations, importation policies and the cyclical behaviour of rainfall.

The inherent inflexibility of supply from biological and climatological parameters is not compensated for, but exaggerated by the price cycle and regulative measures. High prices and progressive floor price increases provide incentives for livestock producers to expand production capacity, while increased production is met by low prices, supply control and continued importation of meat (or livestock). This will influence the farmers' ability to adjust their supply to climatological hazards in the long term, and render farmers subject to increased market and drought risks in the short term. The nett result is a distorted production process and the inability of farmers to stabilise their incomes.

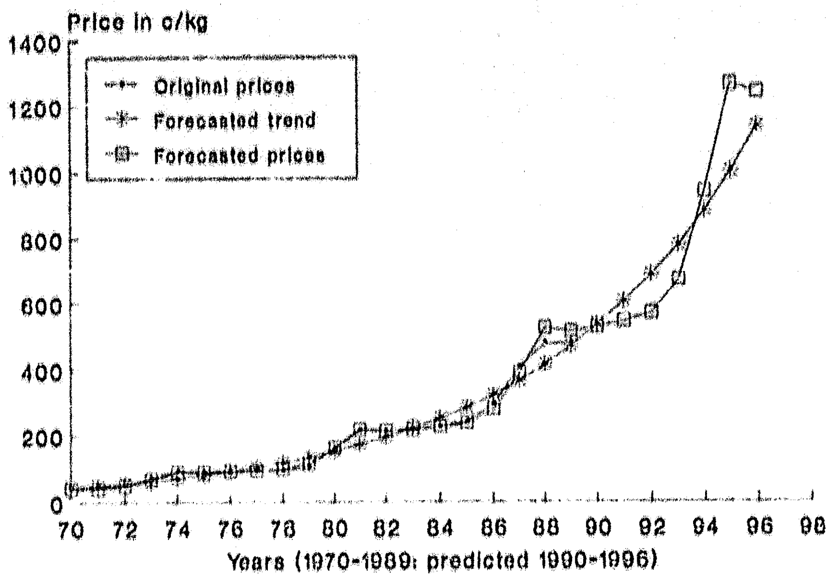

FIG. 1: Prices and trends (data & forecasted) for all grades beef.

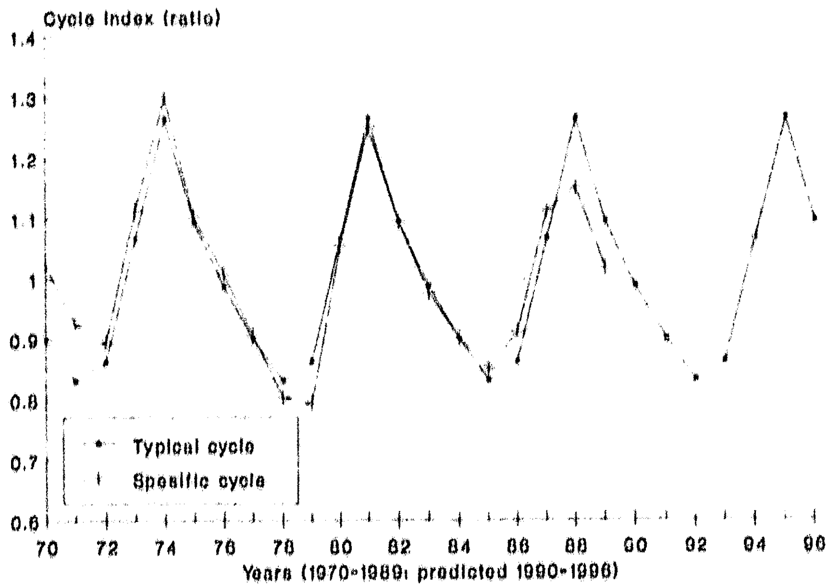

FIG. 2: Typical seven year cycles and specific cycles for beef prices

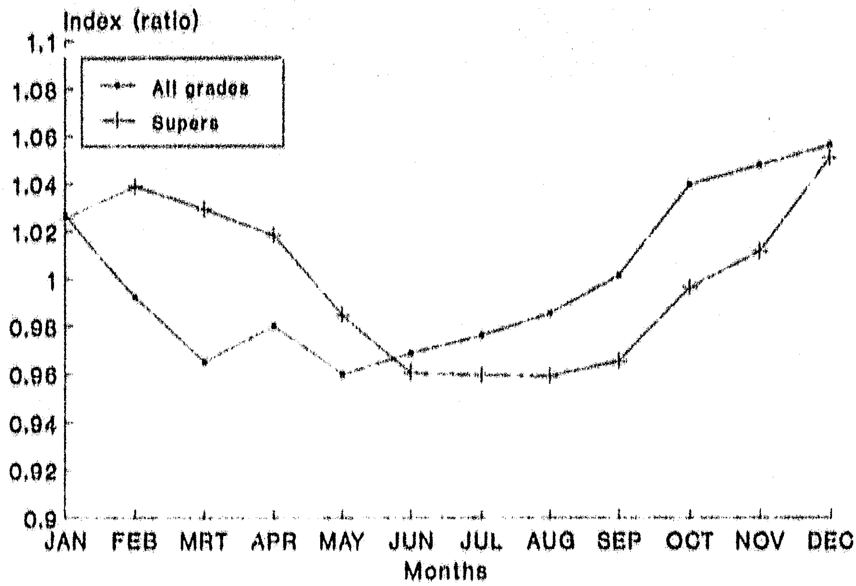

FIG. 3 Seasonal indices of beef prices
(averaged indices for 12 months)

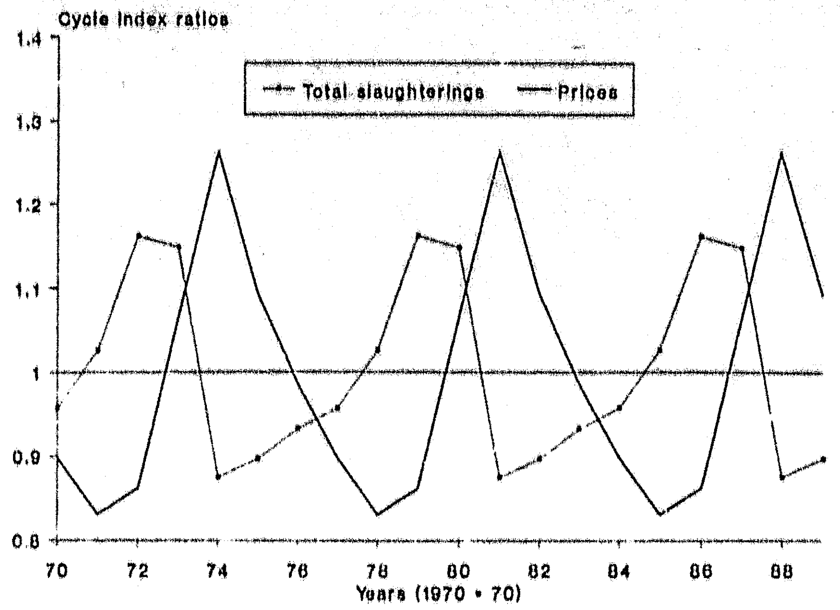

Fig. 4: Total supply and price cycles

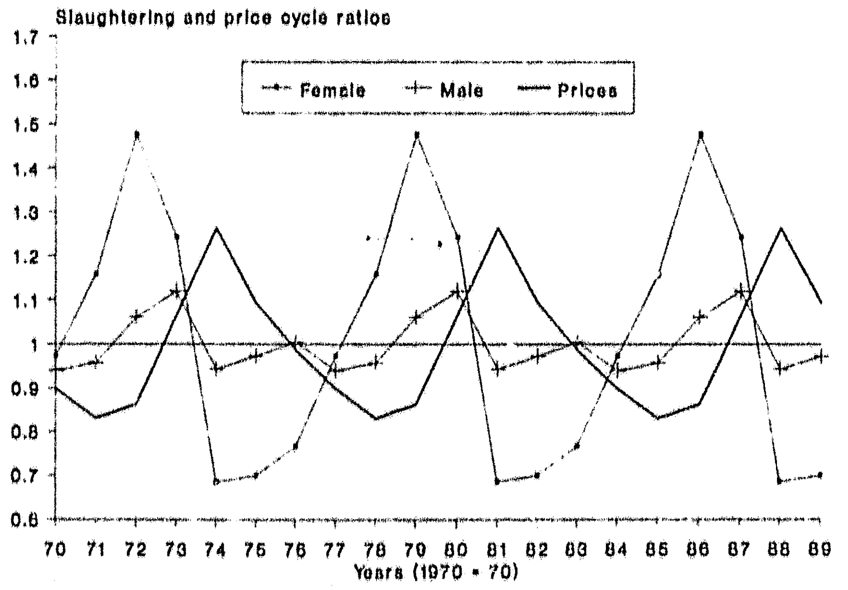

Fig. 5: Female and oxen supply cycles
and typical price cycles

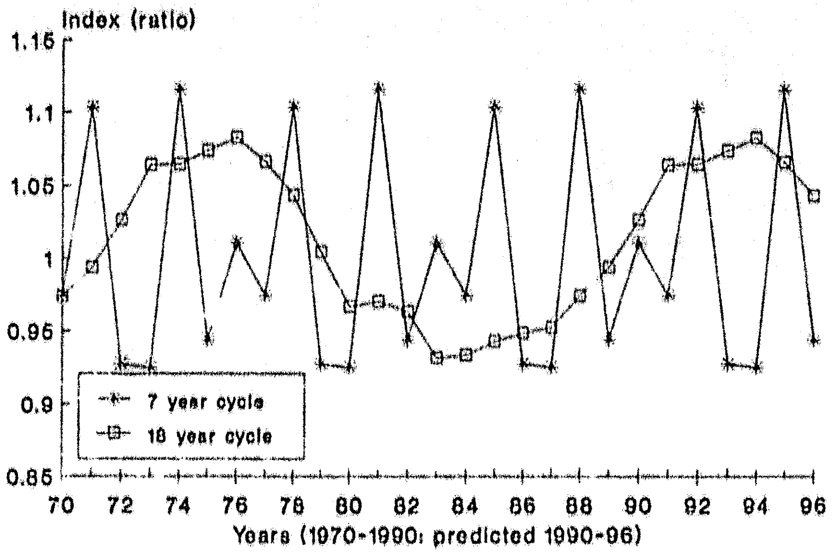

FIG. 6: Typical 7 year and 18 year rainfall cycles (averaged) for average rainfall of South Africa.

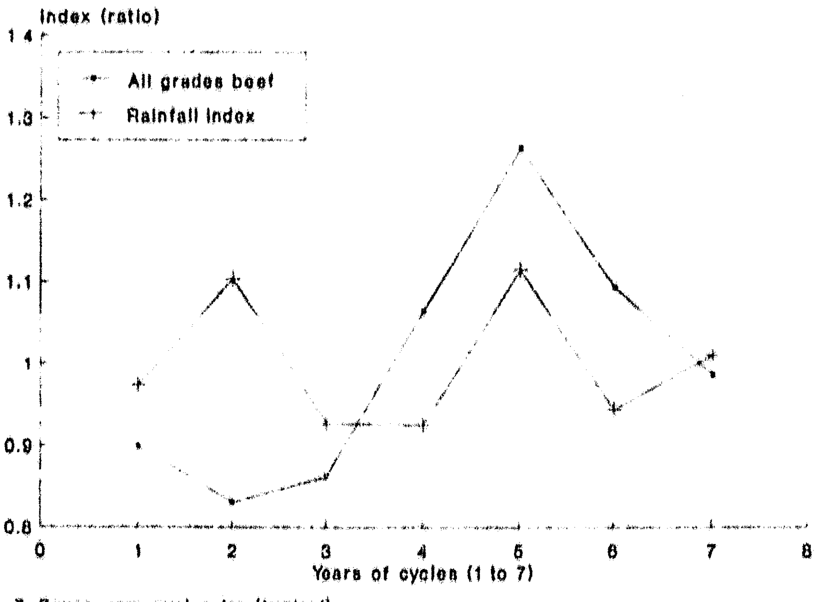

FIG. 7: Seven year cycles for (typical) for beef prices and average rainfall

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