THE DECOMPOSITION OF PRICE TIME SERIES COMPONENTS OF THE RED MEAT INDUSTRY FOR EFFICIENT POLICY AND MARKETING STRATEGIES

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Abstract

Prices are the signals for production, consumption and policy formation. Producer prices are volatile and a considerable amount of variation exists over the short, medium and long term, but there are also, however, stable price variation patterns. Producers and policy makers can use these price cycles to adopt efficient production and marketing policy strategies. This research was aimed at identifying, isolating and estimating seasonal, cyclic and trend components of beef prices for the Witwatersrand controlled market. The traditional decomposition approach in combination with analysis of variance and regression techniques were used. Statistical significant typical price components were isolated and estimated for all grades and super prices. These components were used to create static forecasts in order to predict a general change in the movement of prices. Although this research was primarily aimed at the identification and isolation of cycles, explanatory elements in the form of rainfall and supply indicators were added. This research indicated that beef price cycles are relative stable and are partly self generating processes, depending on price expectations, supply cycles and rainfall cycles.

Uittreksel

Die ontleding van prys-tydreeks komponente in die rooivleisbedryf vir effektiewe beleids- en bemarkingstrategieë.

Pryse dien as seine vir produksie, verbruik en beleidsvorming. Produsente pryse is onderhewig aan hewige variasie oor die lang, medium en korttermyn. Daar bestaan egter stabiele pryspatrone oor tyd. Produsente en beleidsmakers kan hierdie pryssiklusse gebruik vir die opstel van effektiewe produksie- en bemarkingsstrategieë en vir effektiewe beleidsformulering. Hierdie navorsing het ten doel om seisoenale, sikliese en tendens komponente van beesvleispryse vir die Witwatersrandse beheerde mark te identifiseer, isoleer en te skat. Die tradisionele tydreeks ontledingsmetode, tesame met variansie analise en regressie analise tegnieke, is gebruik vir die ontleding van die komponente. Daar is suksesvol daarin geslaag om statisties betekenisvolle prys-tydreekskomponente vir beesvleis te isoleer en te skat. Die komponent patrone is aangewend vir statiese voorspellings met die doel om veranderings in die algemene prysbewegings te identifiseer. Alhoewel die navorsing in hoofsaak die isolering en skatting van die betrokke pryskomponente ten doel het, is verklarende veranderlikes soos reënval en aanbod ook betrek. Hierdie navorsing het aangetoon dat die rooivleis pryssiklusse suksesvol geisoleer kan word en dat die relatief stabiele siklusse gedeeltelik self-genererend is, as gevolg van die invloed van prysverwagtinge, aanbodsiklusse en reënval siklusse.

1. Introduction

Consumer and industrial prices are fairly stable and deterministic, contrary to agricultural commodity prices which are highly volatile and subject to excessive variation in the short, medium and long term. The main reason for this erratic price behaviour is the inflexibility and uncontrollability of agricultural production, due to climatological and biological dependence (Rees, 1979:29-49; Tomek and Robinson, 1981:18-20). Current agricultural prices are not responsible for current supplies, as there are considerable time lags between the production decisions (price signals) and the final outputs (Farris, 1975). This is especially true for the red meat industry, where production cycles of one to five years may occur (Farris, 1975; Du Toit, 1982). The current supply, however, influence the current price and future production. This results in the cyclic behaviour of agricultural prices, of which one probable explanation could be the "Cobweb" theorem (Moore, 1917; Tomek and Robinson, 1981).

The existence of deterministic patterns in price variation over time had been well identified and reported on (Thomson and Foote, 1952; Shepherd, 1963; Shepherd and Futrell 1969; Farris, 1975; Dahl and Hammond, 1977 and Tomek and Robinson, 1981). Seasonality in prices and production had also been reported for meat products in South Africa (Adendorf, 1958; Louw, 1975; Nel, 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.

These price variation patterns had been well illustrated and analysed, mostly by descriptive methods such as moving averages and indices. Analysis of price behaviour was, until recently, mostly done by structural econometric methods. The variation in prices is explained by causal factors (demand and supply analysis). This type of analysis is useful for identifying the causal relationships and elasticities concerning supply and demand, but lack the predictive ability for forecasting and identifying cyclical components.

The reason for this is that the predictor variables themselves are subject to variation and can only be estimated with error before they can be used to forecast prices. Another related problem is identifiability, which implicates uncertainty whether a supply or demand curve had been fitted (Harvey, 1981a:8-10). Time series and related spectral methods concentrate on identifying, isolating and estimating the deterministic price variation patterns, in the time or spectral dimensions, without considering the causal factors. These methods are well documented in literature (Nelson, 1973; Harvey, 1981b).

This research is aimed at identifying, isolating and estimating seasonal, cyclic and trend components of beef producer prices for the Witwatersrand controlled market. This area was chosen because it's price levels tend to serve as a barometer for beef prices on the controlled markets in South Africa. The purpose of this paper is neither explanatory in nature, concerning the source of the price time series components, nor aimed at exploring scientific analysis techniques. The purpose 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 the predictive base. The isolated price patterns can be used to promote efficiency in production and related agricultural policies.

2. Data, techniques and methods

Data

The trends and cyclic components of beef prices (1970 - 1989) were isolated from yearly data, while monthly data (1970 - 1989) was used for the seasonal components. The price data is for the Witwatersrand controlled market and had been supplied by the Meat Board. Rainfall cycles were isolated from average yearly rainfall figures for South Africa (1921 - 1989), which were obtained from the Weather Bureau.

Techniques and methods

Trends were estimated as single predictor variable regressions in time, using the single stage OLS estimating method (Draper and Smith, 1981). Transformations to nonlinear functional forms (still linear in parameters) were used. Cycles and seasonal patterns were estimated using a combined two stage method which incorporates the techniques of moving averages and analysis of variance (ANOVA). These techniques are well described in Makridakis *et al* (1983) and ANOVA models in Steel and Tory (1960), Huitson (1971) and Draper and Smith (1981). This two stage method, developed by the author, is a refinement of the robust traditional moving average and indices methods.

The traditional ratio to moving averages (or trend) time series decomposition method was used, assuming the multiplicative model (Makridakis *et al*, 1983:137 - 182).

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 value range.

Observations must be taken at intervals corresponding to units of the seasonal variation (months or quarters).

A modification of the basic model was used in the sense that the cyclical component could be of multiple amplitudes at time t. This is specified as C_{ti} with i = 1....N different cycles of different possible amplitudes.

Reduced models without the seasonal component, where yearly data was involved, were used for the isolation of trends and cycles of beef prices and rainfall. The seasonal components were isolated from complete specified models (monthly data). Analysis of variance models were used to estimate the most significant cyclic amplitudes (length of MA_t that will effectively eliminate the cyclic behaviour), of cycles and seasonal components.

The sequence of component isolation comprises that the trends were first estimated from the initial data, then eliminated before estimating the cycles. In the case of rainfall, the model :

$$Y_t = T_a.C_{ti}.E_t \quad (2)$$

was fitted with T_a the average rainfall (in the absence of a significant trend) and C_{ti} multiple cycles of different lengths at time t. The moving average method has a few drawbacks (Makridakis *et al*, 1983) of which the lost of observations in each tail of the series, and the dependence on a large number of observations, to significantly isolate cycles with large amplitudes, are the most severe ones. The statistical significance of this method was however significantly improved by introducing the ANOVA technique in estimating the cyclical amplitudes. For any of the analyses the resulting model can be expressed as estimated parameters, which can be used for the prediction or forecasting of future components:

$$y^\bullet_t = t_t . c_{ti} . s_t \quad (3)$$

where i indicates different cycles and $y^\bullet$ is the predicted price (or time series values).

The computational form is expressed as:

$$y^\bullet = (b_0 + b_1t)(u_i + z_{ij})(u_s + v_j) \quad (4)$$

Where :

t = time data range (years) for which model was fitted, for instance t = 70 ....89 for the beef models.
b_0 and b_1 = is the estimated coefficients of the trend.
u and u = the ANOVA ratio means and will always be unity as the indices were adjusted.
i = denotes the different cycles (i = 1...N)
z_j = is the effects coefficients (ANOVA) for cycle i at the time j within the amplitude of cycle i. Thus z_{ij} is the difference between the mean for period j of the cycle and u_i.
j = 1....L_i, is the different periods within cycle i which is of length L_i. For the seasonal component L equals 12. To compute j in (4) the following formula can be used: j = ((t-1) mod L_i) +1) (5)
v_j = denotes the effect coefficients at period j within in the amplitude of the seasonal component.

3. Results

Some of these and similar results were reported on different occasions, but not yet published (Lubbe, 1983, 1989, 1990a, 1990b and 1990c). Although some static forecasts were produced, the main purpose thereof is to evaluate cyclical behaviour and not future prices. Dynamic models provide more accurate forecasts of expected prices than the pure recombination of time series components. Graphical representation will be extensively used to explain the results.

3.1 Beef prices

Significant trends were isolated for all grades and super beef prices from the yearly data. The exponential functional form provided the best fit for both series. The derived estimates are summarised in Table 1.

The original all grades beef price series and the fitted trend (extrapolated to 1996) are illustrated in Figure 3.

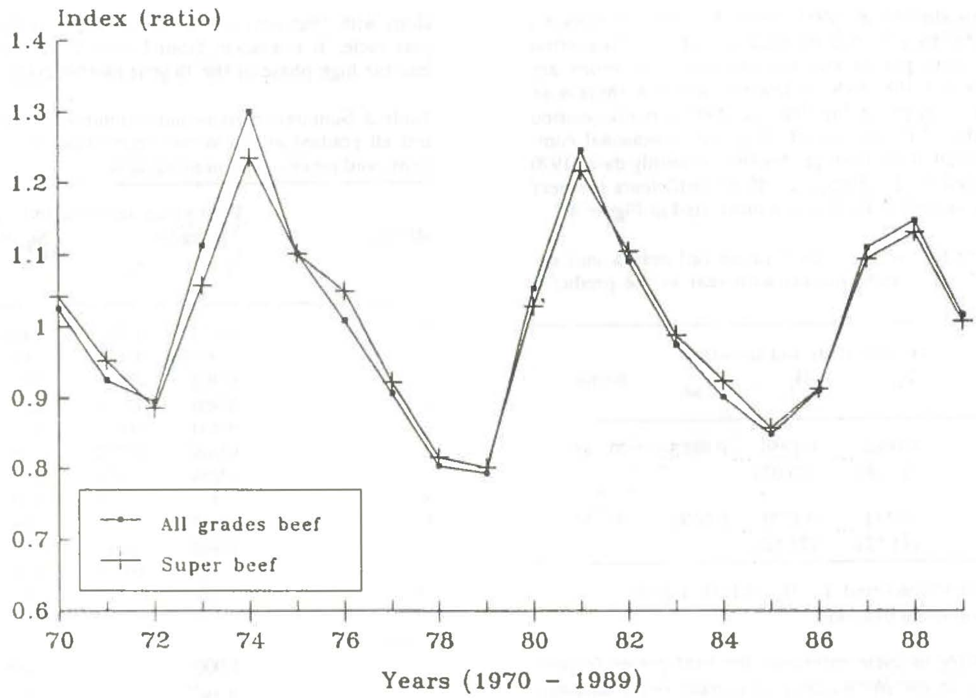

Figure 1: Specific cycle indices for super and all grades beef prices at the Witwatersrand controlled market

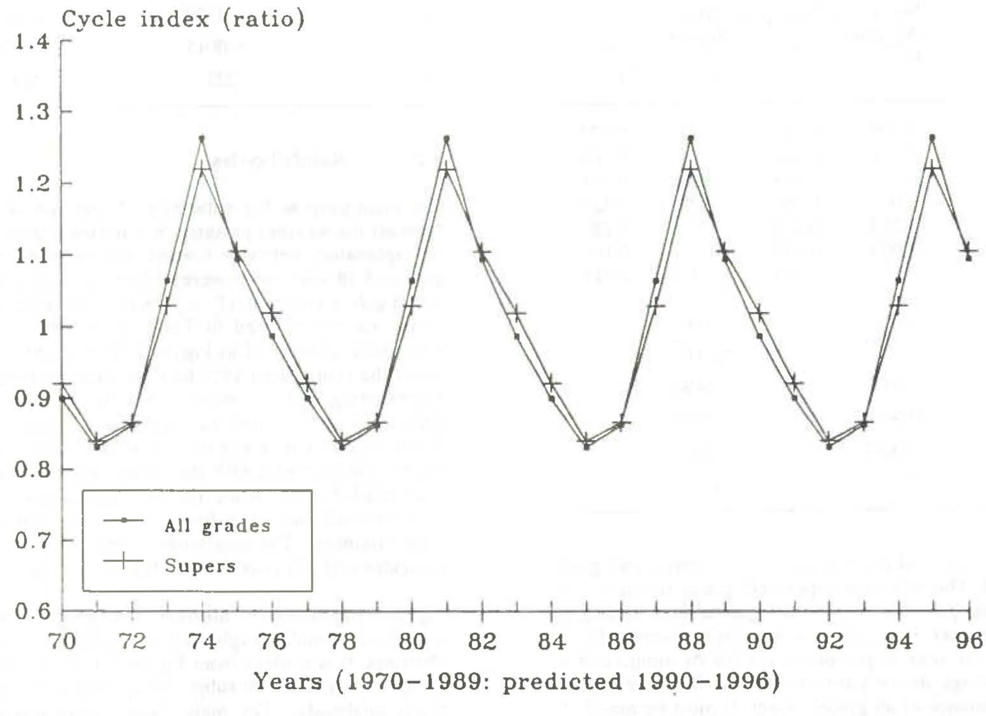

Figure 2: Typical seven year cycles for all grades and super beef prices at the Witwatersrand controlled market (predicted 1990 - 1996)

The all grades and the super beef prices follow nearly the same pattern, with the latter seemingly higher by a variable margin. Significant seven year price cycles were isolated for all grades and super beef, which follow exactly the same pattern, but with marginal differences in the absolute values of the individual index ratios. The derived cyclic indices and effect coefficients are summarised in Table 2 and the specific cycles illustrated in Figure 1.

The estimated beef price cycles for both grades (typical cycles), over the time range estimated (1970 to 1989) and extended to 1996 (predictions from 1990 onwards), are illustrated in Figure 2. From Table 2 and Figures 1 and 2, it is evident that the all grade's cycle is below the average trend for four years, (negative z's), opposed to super's cycle, which is below the average trend for only three years. Static forecasts of the cycles show that we are currently in the declining phase of the cycle and that the next upswing could probably be expected in 1992 (between 1992 and 1993). The next downswing is expected in

1996 (beginning already in 1995). Static forecasts of nominal prices from 1990 to 1996 for all grades beef, the forecasted trend for the same period and the original price series are shown in Figure 3. If the model is assumed accurate, there is an indication that lower prices for 1988 and 1989 actually realised than were predicted by the model. Significant seasonal components were isolated for both grades from monthly data (1970 to 1979). The seasonal indices and effect coefficients for beef prices are summarised in Table 3 and illustrated in Figure 4.

Table 1: Trend functions for beef prices (all grades and supers) at the Witwatersrand market with year as the predictor variable.

Series	Coefficients and statistics			Range
	B_0	B_1	R^2_{adj}	
Beef all grades	0.0064 (11.58)***	0.1259 (23.02)***	0.9653	70 - 89
Beef supers	0.0111 (11.52)***	0.1202 (24.52)***	0.9693	70 - 89

1) Exponential function fitted $Y_t = B_0.EXP(B_1.T_t) + E_t$.
2) Absolute T-values in brackets.

Table 2: Summary of cycle estimates for beef prices (supers and all grades) at the Witwatersrand market (with adjusted coefficients and means).

Year	Seven year beef price cycles			
	All grades		Supers	
	C_j^{**}	z_j^{**}	C_j^{**}	z_j^{**}
1	0.899	-0.101	0.921	-0.079
2	0.831	-0.169	0.840	-0.160
3	0.862	-0.138	0.866	-0.134
4	1.064	0.064	1.029	0.029
5	1.263	0.263	1.220	0.220
6	1.093	0.093	1.105	0.105
7	0.987	-0.013	1.019	0.019
Parameters:				
U_i	1.000		1.000	
F_{model}	36.24***		22.44***	
R^2	0.9421		0.9082	
R^{2}_{adj}	0.9688		0.9506	
S^2	0.0013		0.0016	
df	13		13	

Quite different seasonal price index patterns exist for all grades and super beef. The index for super beef prices seems to have an advantageous position over the all grades index during the first half of the year, however, this position is reversed for the second half of the year. Super prices are for six month's of the year above average in comparison with the five month above average performance of all grades prices. 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. According to the literature this is a well recognised fact (Thompson and Foote, 1952:328-331; Shepherd, 1963; Tomek and Robinson, 1981:171-176). Preliminary results of current research on this topic suggest that pattern variations can be related to different stages within the seven year cycle.

It is evident from Figure 5 that the period from 1980 to 1989 represent years below the 18 year rainfall average, but 1981 and 1989 were also maxima of the seven year cycle. Those years, along with 1985 were still above average for the combined 7x18 year cycle. It is evident from Figure 5. that were are moving into the high phase of the 18 year rainfall cycle.

Table 3: Summary of seasonal estimates for beef prices (supers and all grades) at the Witwatersrand market (adjusted coefficients and means with monthly data).

Month	Beef prices seasonal indices			
	All grades		Supers	
	S_j^{**}	V_j^{**}	S_j^{**}	V_j^{**}
1	1.027	0.027	1.025	0.025
2	0.992	-0.008	1.039	0.039
3	0.965	-0.035	1.029	0.029
4	0.980	-0.020	1.018	0.018
5	0.960	-0.040	0.985	-0.015
6	0.968	-0.032	0.961	-0.039
7	0.976	-0.024	0.960	-0.040
8	0.985	-0.015	0.959	-0.041
9	1.002	0.002	0.965	-0.035
10	1.040	0.040	0.996	-0.004
11	1.048	0.048	1.012	0.012
12	1.057	0.057	1.051	0.051
Parameters:				
U_i	1.000		1.000	
F_{model}	15.18***		8.423***	
R^2	0.4062		0.2646	
R^{2}_{adj}	0.4350		0.3002	
S^2	0.0015		0.0025	
df	227		227	

3.2 Rainfall cycles

The main purpose for isolating probable rainfall cycles is not to forecast the weather patterns, but to investigate any similarities or explanatory behavior towards the meat price cycles. Seven year and 18 year cycles were isolated sequentially. Both cycles are highly significant ($P < 0.001$). The coefficients of both cycles are summarised in Table. 4 and the typical indices of both cycles illustrated in Figure 5. The illustrations in Figure 5 cover the range from 1970 to 1996, with the range 1990 to 1996 representing static forecasts. The seven year cycles of beef prices (all grades) and the rainfall are illustrated in Figure 6. From Figure 6 it is apparent that the lowest year within the price cycle coincides with the second highest year of the seven year rainfall cycle, while the two lowest years of the rainfall cycle coincide with the first and second year after the price cycle minimum. The maximum of the seven year rainfall cycle coincides with the maximum of the price cycle.

Figure 7 illustrates the absolute numbers of female, male and total beef animals slaughtered at the Witwatersrand controlled abattoirs. It is evident from Figure 7 that the total and female slaughterings are both subject to cyclical behaviour (not statistically analysed). The male slaughterings follow a very weak cyclic pattern, but the cycle is most probably smoothened out by feedlot activities. Figure 8 illustrates the seven year price cycle of all grades beef and the indices of female and male slaughterings (computed as the ratio to their averages). From Figure 8 it is evident that female slaughterings reaches a maximum in the first year of the price upswing, and a minimum when the price cycle is at it's maximum. Breeding herds are thus expanded at the top of the price cycle and destocking really starts at the minimum of the price cycle.

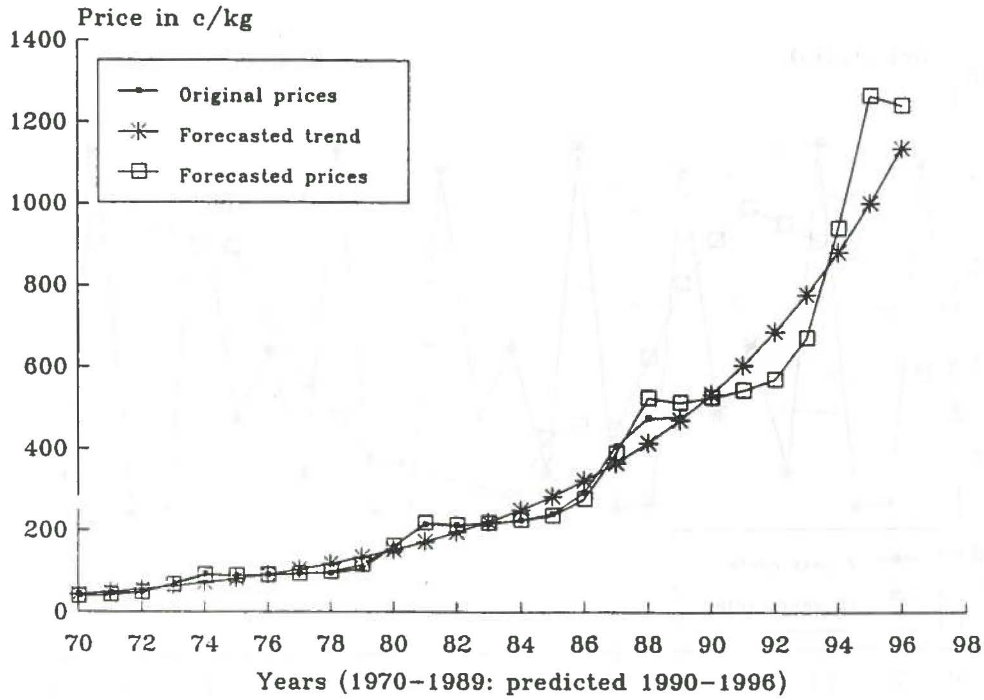

Figure 3: Prices and trends (data and forcasted) for all grades beef at the Witwatersrand controlled market

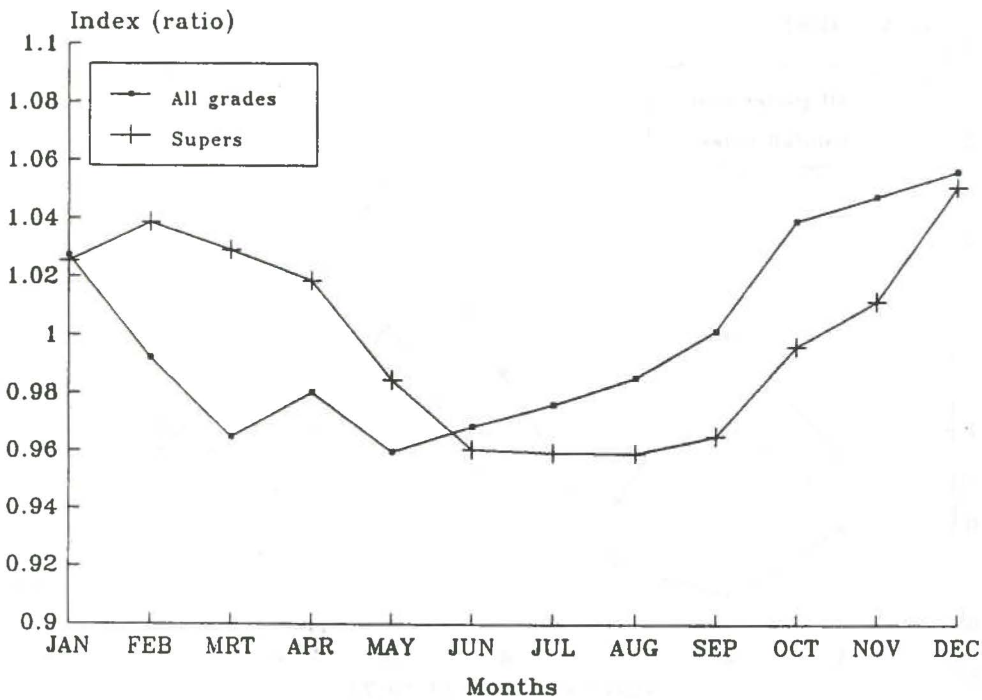

Figure 4 : Seasonal indices of beef prices for the Witwatersrand controlled market (averaged indices for 12 months).

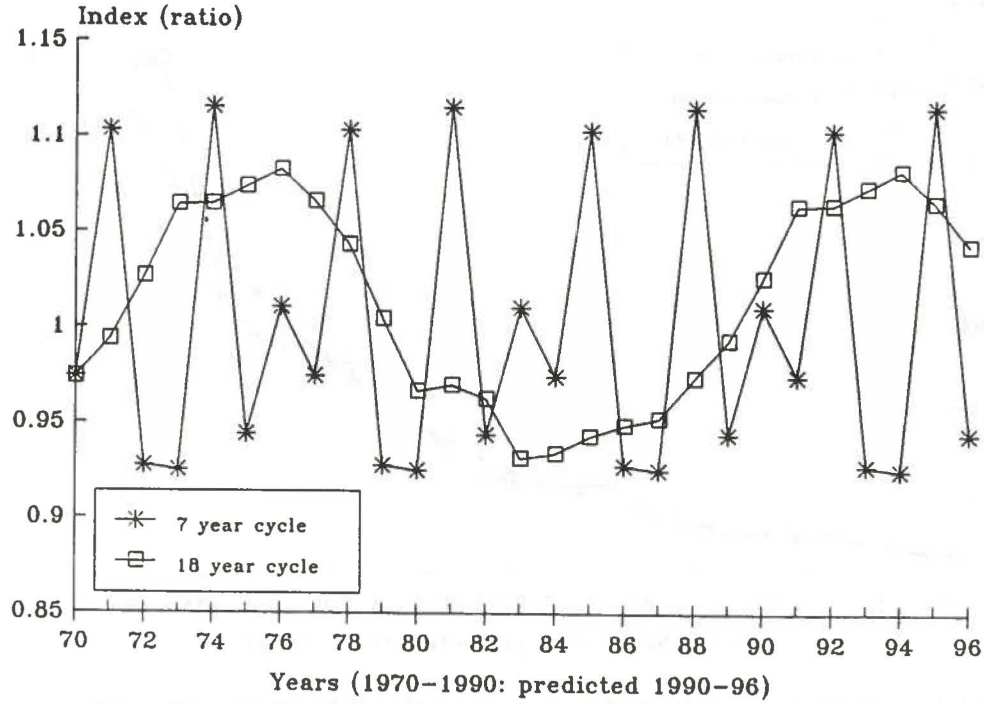

Figure 5 : Typical 7 and 18 year rainfall cycles for average rainfall of South Africa.

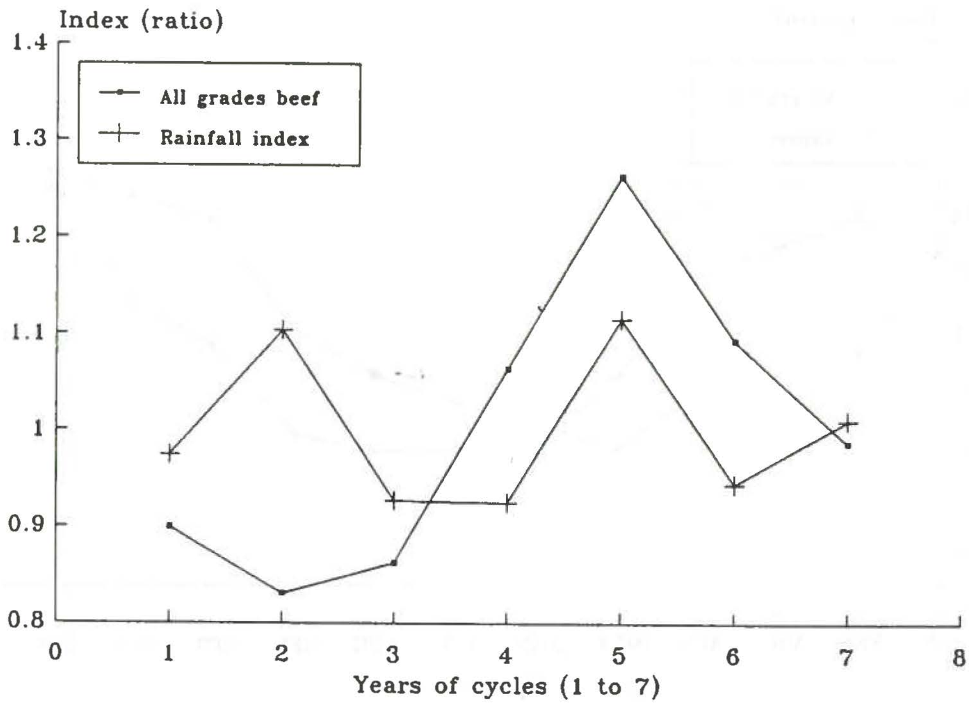

Figure 6 : Seven year cycles (typical) for all grades beef prices and average rainfall.

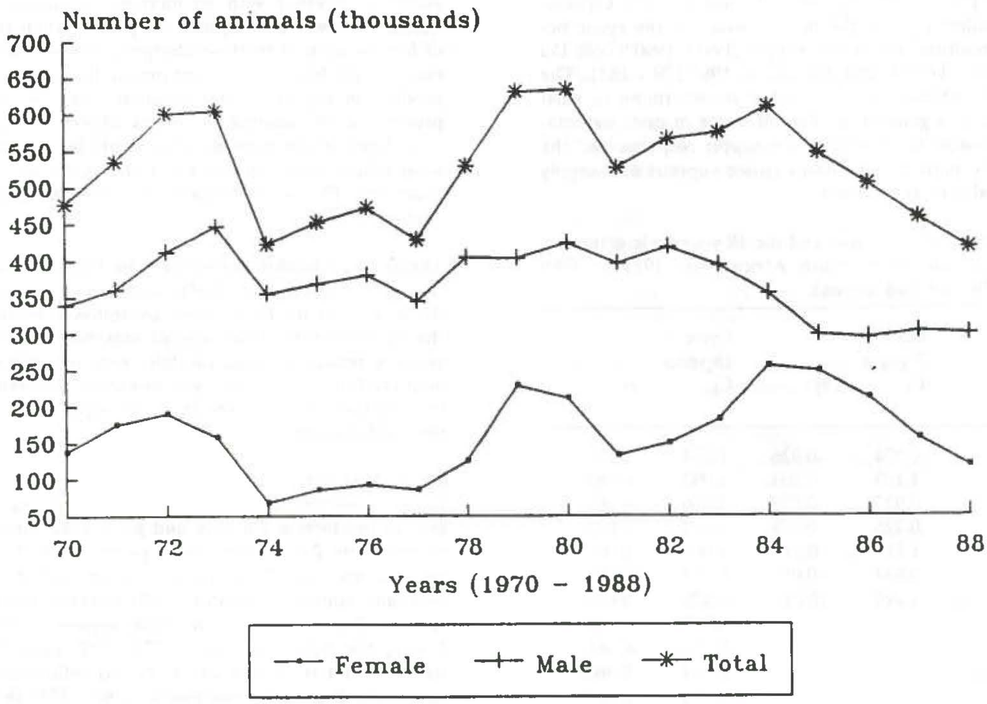

Figure 7 : Slaughterings of male, female and the total number of cattle at the Witwatersrand controlled area for 1970 to 1989.

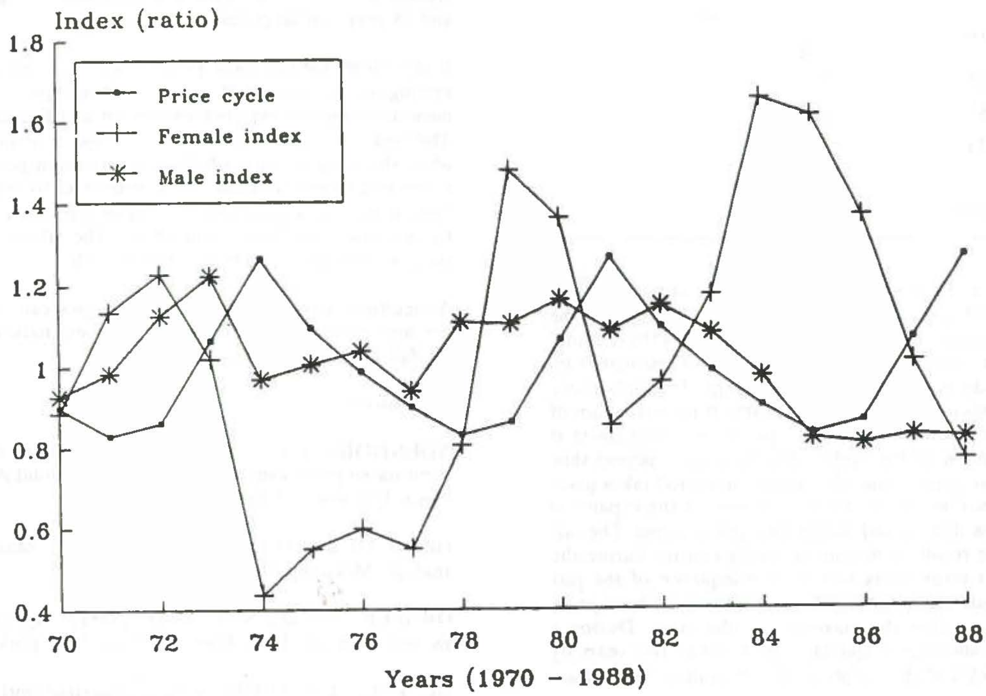

Figure 8 : Indices of male and female slaughterings and the seven year all grades beef price cycle (Witwatersrand controlled market).

4. Discussion

The inflexible production and the influence of price expectations are considered to be the main causes for the cyclic behaviour of agricultural prices and supply (FAO, 1960:97-98; Du Toit, 1982:68-88; Tomek and Robinson, 1987:178 - 182). The estimated cycles should be investigated to determine to what extend are they self generating. The influence of price expectations, external variables (rainfall), the supply response and the influence of the market regulations (price support and supply control) must also be considered.

Table 4: Summary of the 7 year and the 18 year cycle estimates for the average rainfall in South Africa from 1921 to 1989 (adjusted coefficients and means).

Year		Cycle 1 7 years Cj	zj*	Cycle 2 18 years Cj	zj*
1		0.974	-0.026	1.074	0.074
2		1.103	0.103	1.082	0.082
3		0.927	-0.073	1.066	0.066
4		0.925	-0.075	1.043	0.043
5		1.115	0.115	1.004	0.004
6		0.944	-0.056	0.967	-0.033
7		1.010	0.010	0.970	-0.030
8				0.963	-0.037
9				0.932	-0.068
10				0.934	-0.066
11				0.943	-0.057
12				0.949	-0.051
13				0.952	-0.048
14				0.974	-0.026
15				0.993	-0.007
16				1.026	0.026
17				1.064	0.064
18				1.064	0.064
Parameters:					
U_i		1.000		1.000	
F_{value}	4.71***		9.58***		
R^2adj	0.2645		0.7447		
R^2	0.3357		0.8315		
S^2	0.0123		0.0008		
df	62		50		
Data-range	21-89		21-89		

From Figures 7 and 8 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 quickly wiped out in two years by unmarketed stock and the supply of young animals (feedlot action mainly).

Prices therefore are declining (in Figure 3. it represents the constant part of the price step) and the slaughtering of male animals, together with an increase in supply control consequently follows. The liquidation phase (when the slaughtering of female animals increase sharply), follows soon, partly as the result of the lower prices that prevail but also due to the excess production capacity, that resulted from overreaction to the previous cycle maxima. Farmers expected that the previous price levels at the cycle maxima would be maintained or would soon follow again. In this sense the cycles are self generating processes. Farris (1975) came to the same conclusions about beef cycles in the USA.

The effect of rainfall is evident from Figures 5 and 6. 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 these price relations 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 fueled by the rainfall cycle and rainfall expectations. The effect of the 18 year cycle is to modify the patterns of stock expansion and liquidation. During the high cycle phase (1971 - 1979 in fig. 8), stock liquidation is not so severe and is mainly influenced by the seven year cycle. During the low phase, (1980 - 1988 in fig. 8), the liquidation of female animals is more intense in absolute numbers and in length of the liquidation process.

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.

It is evident that the cyclic price behaviour is partially self generating by the reaction of supply to price expectations. This behaviour comprises livestock expansion and liquidation periods. The cycle maximum consequently follows a liquidation period, while the cycle minimum follows a expansion period. Both the seven and 18 year rainfall cycles contribute to the cyclical price behaviour as it strengthens the expansion incentive and effectively enforce the liquidation phase. The effect of the 18 year cycle is to lengthen or shorten this periods.

Agricultural policy and farmer's strategies can be more effective and more efficient if the existence and nature of price and rainfall cycles are known.

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