CATTLE CYCLES REVISITED

John R. Franzmann*

In general, investigations of the cattle cycle have concentrated on the cyclical fluctuations in inventories based on the number of head of cattle on farms as of January 1. The emphasis in studies of the cycle in numbers appears to be on providing a system of logic to explain why a cycle could or even should exist. Very little attention has been given to describing in any precise manner, the characteristics of "the cycle."

In 1926, Hopkins [5] argued that the cycles in cattle have a periodicity of 12 to 15 years, "apparently due to forces outside of the cattle industry." He associated minor cyclical fluctuations with the general business cycle, but concluded that the major cycles were not associated with any phenomena of a regular recurrent nature. He, also, concluded that cattle price cycles are irregular in length and in amplitude.

Burmeister [2] did not explicitly provide an estimate of the period of the cycle, but, from the estimates he gives of the length of each upswing and each downswing over the period 1867-1945, he implies a period of 10 to 16 years.

Thomsen and Foote [7] attribute the cyclical fluctuations to the behavior of producers with regard to breeding and marketing decisions. According to these analysts, "The cattle cycle in the past has averaged about 15 years in length, with the upswing in cattle population requiring approximately 7 years, and the downswing 8 years. The length of individual cattle cycles has varied from 12 to 20 years, partly because of the episodic, or chance, occurrences. . .". These authors also state that, "The cycle of beef cattle prices is even less regular than the cycle of market receipts" [7, p. 38].

According to Lorie [6], business cycles have a relatively minor effect on the cattle cycle. He places the length of the cycle at 14 to 16 years with almost no irregularities, and attributes the length of the cycle primarily to the time required for gestation and the average age at which marketing takes place.

More recently Breimyer suggested the length of the inventory cycle varies between 10 and 16 years and its amplitude varies between 23 and 35 percent. In addition to the inventory cycle, Breimyer discussed cyclical variation in slaughter, price ratios, and price levels, noting that "actual prices in dollars conform only roughly to cycles because they reflect not only the supply of cattle but also the general level of all commodity prices" and that "to produce cyclical curves of some regularity it is necessary to deflate the reported prices" [1].

SOME PROBLEMS

Each analysis of the cattle cycle was based principally on the cycle in inventories and, hence, employed data on an annual basis. Where the analysis was extended to other series related to the cattle industry, annual data were employed again. In an analysis of inventories, there is, of course, no alternative. Where the cycle in cattle prices is being investigated, the use of annual data is not required if the analysis is confined to the period 1921 to 1969.

Deflating the annual average cost of cattle slaughtered under federal inspection yields the picture portrayed in Figure 1. The existence of cyclical variation is strongly suggested. Peaks are suggested for 1932, 1939, 1951, 1959, and 1969 (?). Troughs are suggested for 1925, 1934, 1944, 1953, and 1964. If the peaks and troughs are so identified, then the

*Associate professor of agricultural economics, Oklahoma State University. Journal Article 2207 of the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma. This research was conducted under Hatch 1269.

periods 1925-32, 1934-39, 1944-51, 1953-59, and 1964-69 (?) can be classified as upswing phases of the price cycle; the periods 1932-34, 1939-44, 1951-53, and 1959-64 can be classified as downswing phases of the price cycle.

Using the foregoing classification for the phases of the cycle, the length of the cycle may be estimated. Beginning with 1925, the length of successive cycles are, 9, 10, 9 and 11 years for an average length of cycle of 9.75 years. Alternatively, beginning with 1932, the length of successive cycles can be estimated as 7, 12, 8 and 10 (if 1969 were a peak in the cycle) for an average of 9.25 years.

If the foregoing analysis is accepted, then the price cycle is quite irregular in terms of the length of the cycle, and particularly in terms of the duration of upswing and downswing phases. Moreover, the irregularities are serious enough so as to cast serious doubt on the possible predictive value of cyclical variation.

The method employed to identify the peaks and troughs of the cycle and thenceforth to estimate the period of the cycle, is open to question. The price series under analysis includes components of variability other than that associated with the cycle. Variability resulting from unusual events occurring in a year, near but not at a peak, may cause a distortion great enough to result in a realized peak at a point other than where a cycle with a regular stable period would place it. Thus, over the span 1925-34 there appear two peaks. The peak in 1932 is higher, to be sure, but this does not necessarily justify a claim that this constitutes the "true cyclical peak." Again, in the period 1959-64, there appear two peaks. Can the peak in 1959 be designated as the correct cyclical peak merely because the average annual price was greater in 1959 than in 1962?

Thomsen [8, p. 264-266] has noted that monthly data may be used in analyses of cyclical fluctuations particularly "if it is desired to locate as exactly as possible the turning points at the peaks and troughs of the cycle or if it is necessary to bring the cycle up to date from month to month." Thomsen goes on to suggest the use of either a 12-month moving average or the use of an index of seasonal variation to eliminate the trend and seasonal components but concludes that:

"Regardless of which of these methods is used, the monthly residuals or percentages will be composed of the cyclical movement, irregular or episodic fluctuations, and seasonal fluctuations that do not conform with the typical or normal as represented by the seasonal indices. Thus the monthly deviations will be very irregular, and the principal objective – to show the cycle by itself–will not have been realized. For this reason in addition to considerations of con-

FIGURE 1. AVERAGE ANNUAL COST PER 100 POUNDS OF CATTLE SLAUGHTERED UNDER FEDERAL INSPECTION, DEFLATED, 1921-1969

venience, it is desirable to use either annual data or the moving average method of eliminating seasonal fluctuations. . ."

The problem of confounding the cyclical component with irregular fluctuations and non-conforming seasonal fluctuations arises if the analyst seeks to discover the nature of the cycle by removing the seasonal variation. But recourse to annual data, or the use of the moving average technique, suffers the drawback that some information concerning the market for cattle is eliminated. If the interest is solely in the nature of the cycle, there is some merit in such an approach.

SOME HYPOTHESES

An alternative approach is to employ the Fourier Theorem to develop an expression describing the cyclical variation and the seasonal and trend variation. Under this approach, each of the three components (cycle, seasonal, or trend) can be examined in isolation from the others.

The Fourier Theorem, in its simplest form, states that any periodic variation fulfilling certain conditions regarding continuity can be considered as the sum of a number of sinusoidal variations whose periods exhibit a simple relationship.[1]

If the monthly series of slaughter cattle prices are deflated, rather marked cyclical and seasonal patterns of "uniform" period are revealed (Figure 2). In addition to the cyclical and seasonal variability, there is suggested a long term linear trend. The hypothesis may then be advanced that the deflated price series may be described by an expression such as:

$$P = \beta_o + \beta_1 t + \sum_k \beta_k \sin(\omega t + \theta_k) + \varepsilon \qquad (1)$$

$$k = 2, 3, 4, \ldots..$$

where P represents the average cost per hundred pounds of cattle slaughtered under federal inspection deflated by the Index of Prices Received by Farmers for All Farm Products, 1910-14 = 100, t represents the month from the origin, t_o = January 1921; ω represents the angular velocity equal to 2Π times the frequency of the fundamental; the β's represent parameters to be estimated, and ε represents an error associated with each observation of P.[2] All harmonics from the second through the ninth and above the tenth are assumed to be absent on the grounds there exists no logical basis for expecting them and the lack of any pronounced visible evidence of them in the data.

There exists the possibility that a damping effect, i.e., a progressive diminution in amplitude, may exist. Incorporation of a damping term such as $e^{-\alpha_k t}$ in equation (1) would lead to:

$$P = \beta_o + \beta_1 t + e^{-\alpha_k t} \sum_k \beta_k \sin \left[\sqrt{(2\Pi f_k)^2 - \alpha_k^2}\, t + \theta_k \right] + \varepsilon \qquad (2)$$

The inclusion of a damping term makes estimation of the parameters tedious, particularly if k is large. Inspection of the series does not strongly suggest the existence of a damping effect. Therefore, it is hypothesized, initially at least, that $\alpha_k = o$.

Then since the relationship in equation (1) is of the form

$$\hat{Y} = \Sigma_i \hat{\beta}_i X_i \qquad (3)$$

where $\hat{Y}$ is a dependent variable, the X_i are independent variables and the $\hat{\beta}_i$ are parameter estimates, least squares procedures may be employed to provide estimates of the $\hat{\beta}_i$.

SOME RESULTS

Quantification of equation (1) over the period January 1921 to December 1969 produced the following results:[3]

$$\hat{P} = \underset{(50.42)}{5.2564} + \underset{(23.22)}{.00720\, t} + 1.11827 \sin$$

[1]The original variation need not be regarded as a series of sinusoidal variations. From a given set of period continuous functions, a set of normal orthogonal periodic functions can be constructed and any given arbitrary periodic function can be expanded as the sum of a number of the derived orthogonal function. The Fourier series of sine and cosine functions is a particular example of such an expansion.

[2]For a given set of empirical data, fixing the point of origin simultaneously fixes the θ_k for a deterministic relationship. For stochastic relationships $\hat{\theta}_k$ becomes subject to sampling variation.

[3]Numbers in parentheses under the estimated coefficients are the Student "t" statistics.

$$(\omega t + 154^{o}1^{1}) + .4556 \sin (10\omega t - 53^{o}57^{1}) \quad (4)$$
$$(9.52)$$

The coefficient of determination, R^2, was estimated as .8701. The coefficents associated with linear, cyclical, and seasonal trends were all significant at better than the one percent level.

Over the time span investigated, the model hypothesized cyclical peaks in 1929, 1939, 1949, 1959, and 1969; and cyclical lows in 1924, 1934, 1944, 1954, and 1964. A comparison of the cyclical pattern specified by the model with the actual data (Figure 3) provides strong support for a conclusion that the deflated average price of slaughter cattle varies cyclically with a uniform period of ten years. It is obvious that cattle prices at times reached values at levels greater than were realized at the specified cyclical peaks such as in 1931-32 and the period 1950-52. Further examination indicates that in the two instances where prices were maintained above the cyclical trend for a sustained period, prices ultimately broke rather sharply to resume the trend, producing the "normal" cyclical low and proceeding into the upswing phase of the price cycle.

Such periods may be interpreted as temporary aberrations of the cycle, and on the basis of the historical evidence imply that prices will likely break sharply before the expected cyclical low is due to appear. The period 1962-63 provides an additional example of this type of phenomenon. During 1962, prices departed markedly from the cyclical pattern. By 1963, however, prices broke sharply, attempted a recovery by midyear, then broke sharply again to produce the 1964 cyclical low.

The expected cyclical peak in 1969 appears to have been formed. The available data for 1970 appear to be producing a seasonal peak in a manner indicative of a normal entry into the downswing phase of the cycle which would be expected to end with the formation of a cyclical low in 1974. All of the cyclical lows conformed to the lows as hypothesized in the model.

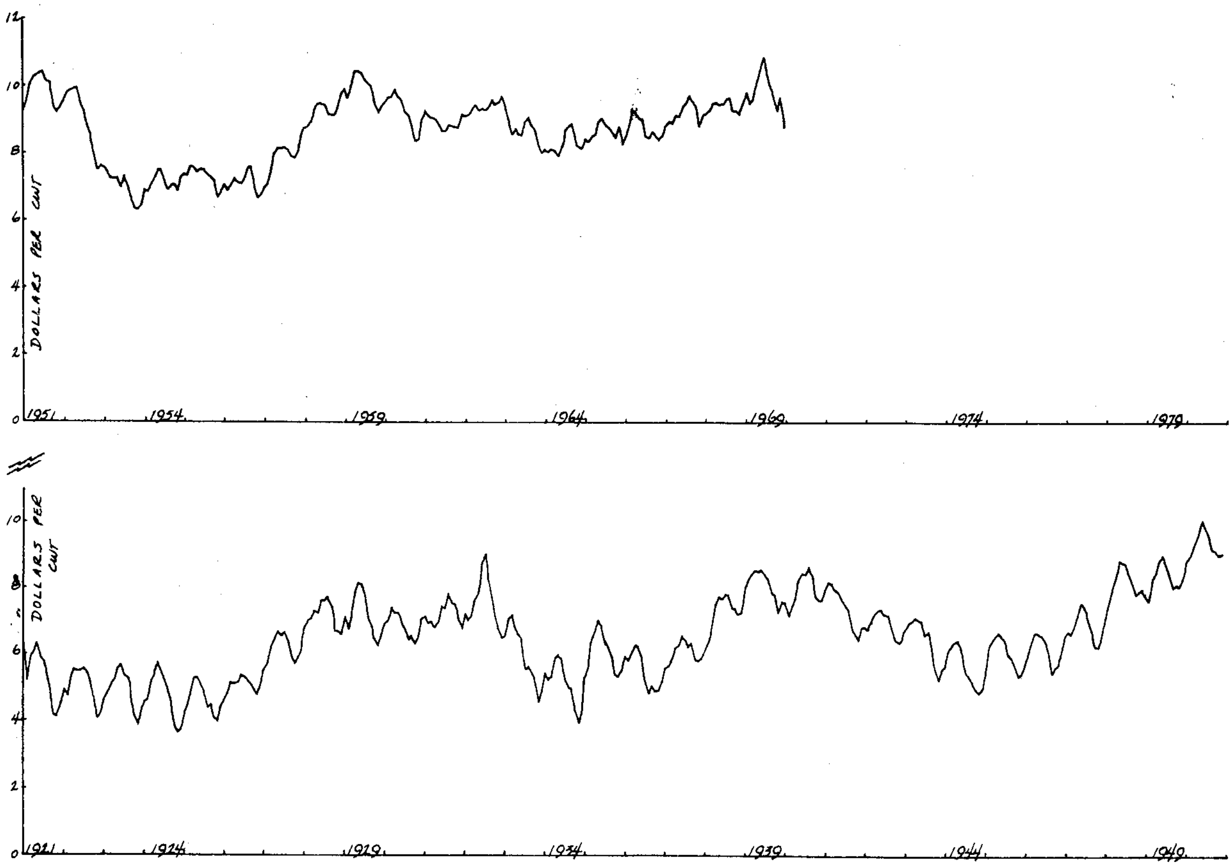

FIGURE 2. AVERAGE MONTHLY COST PER 100 POUNDS OF CATTLE SLAUGHTERED UNDER FEDERAL INSPECTION, DEFLATED, JAN. 1921 – DEC. 1969

It is tempting to offer explanations regarding why prices departed from the cyclical trend in 1931-32, 1950-52, and more recently in 1962-68. Such explanations, however, have a tendency to be based on rather loose generalizations and conjecture rather than on any empirical evidence. Hence, despite the tentative nature of the conclusions, such explanations will be deferred until further analysis of the empirical evidence surrounding this and other market levels of the livestock and meat industry currently under way can be completed.

A number of other tests are employed by analysts of cyclical phenomena including: (1) cycle dominance, (2) regularity of timing, (3) number of repetitions, (4) constancy of period, (5) re-establishment of phase, (6) persistence after discovery, and (7) wave shape [3]. The dominance test needs little comment. In cattle prices, the cycle is obviously the most dominant of fluctuation.

In addition to the dominance of the cycle, the regularity of the timing and the constancy of the period provide additional evidence of the non-randomness of this element of variation. Over the time span covered, there appears no marked evidence that the period of the cycle is changing.

For the data under consideration, the number of repetitions does not provide a strong test. The series is only long enough to examine five full cycles with a ten-year period. The meager evidence available, however, does not refute a cyclical pattern with a ten-year period.

A stronger case for the cycle can be made on the basis of the re-establishment of phase following "disturbance." In the early 1930's, slaughter cattle prices departed markedly from the trend pattern. Within two years, however, prices had "returned to pattern" and produced the 1934 cyclical low. With the onset of the Korean War, prices again departed markedly from the trend only to drop sharply within two years to produce the 1954 cyclical low. And again, in the early 1960's the departure from trend was quickly

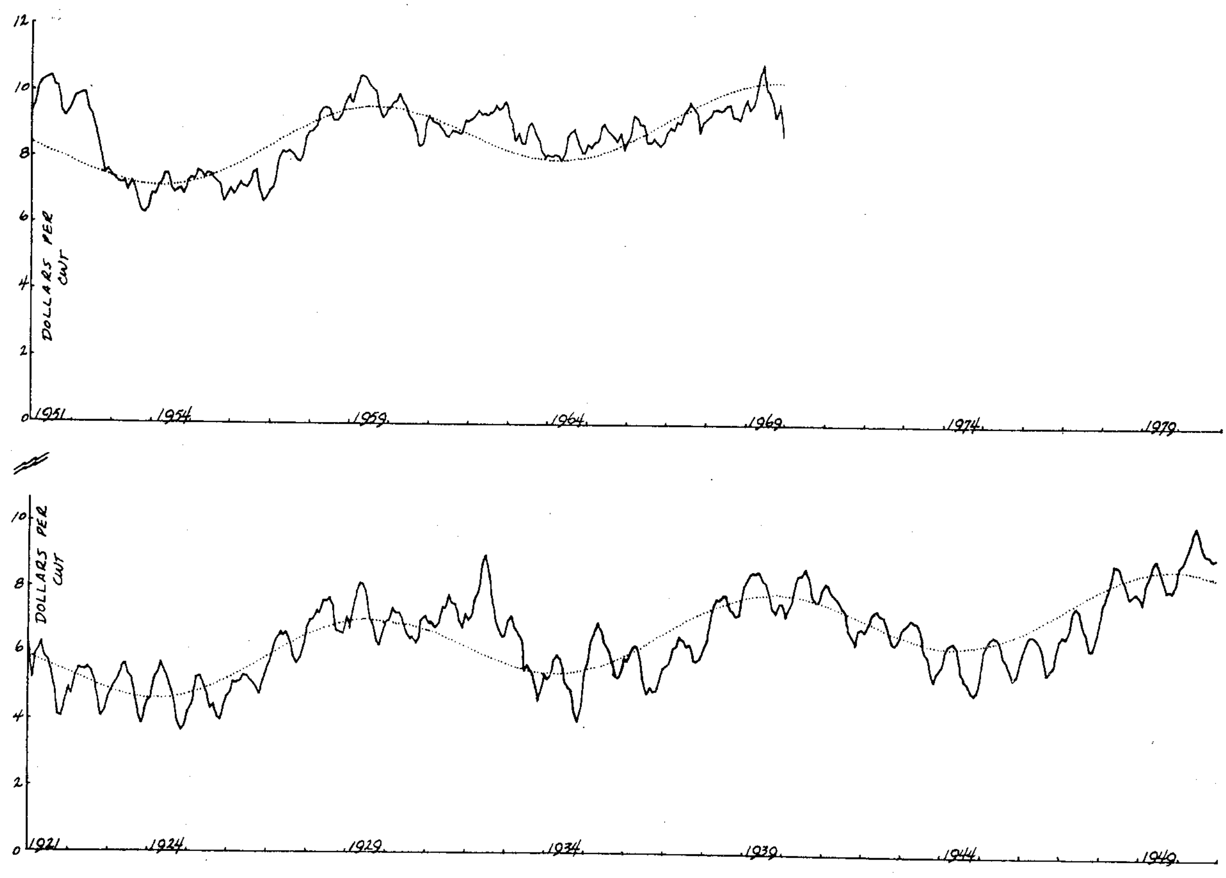

FIGURE 3. AVERAGE MONTHLY COST PER 100 POUNDS OF CATTLE SLAUGHTERED UNDER FEDERAL INSPECTION, DEFLATED, JAN. 1921 – DEC. 1969 AND ESTIMATED CYCLICAL TREND

followed by a drop in prices, producing the 1964 cyclical low.

Cattle prices also successfully meet the challenge of persistence through changed conditions. Over the time span examined, there has occurred the nation's worst depression, World War II with rationing and price controls, the Korean War, Viet Nam, several periods of severe drought, and important changes in technology throughout the entire livestock producing and marketing sector. In addition, important institutional changes have occurred and important shifts in tastes and preferences may well have evolved. Despite the wide array of important changes that have occurred and the timing of their appearance, the cycle has persisted for five complete revolutions.

The evidence concerning the persistence after discovery is extremely limited. The price cycle was originally quantified in the manner presented here in 1963 [4]. The sinusoidal model was fitted to the period January 1921 to December 1960 with the following results:

$$P = 5.2658 + \underset{(36.35)}{.00718}t + \underset{(24.08)}{1.2729} \sin (\omega t + 153^{\circ}43^{1}) \ \underset{(9.98)}{.52219} \sin (\omega t - 54^{\circ}49^{1}) \tag{5}$$

The coefficient of determination was estimated as .8571. The estimate of the cycle in equation (4) includes data covering nearly one additional cycle and provides, perhaps, the first objective evidence that the nature of the cycle may be undergoing a profound change. Most noticeable is the decrease in the coefficients of both the cyclical and seasonal terms. The relatively larger decrease in the coefficient connected with the cyclical term is of particular interest in that it suggests a reappraisal of the hypotheses concerning the lack of any damping effects.

The residuals may provide a rough indication of the presence of damping. If damping of any significant degree is present, then a plot of the residuals from a function with a fixed amplitude can be expected to increase in a progressive manner over time. The residuals from equation (4) are presented in Figure 4.

The residuals from equation (4) do not present convincing evidence that a damping effect is present in slaughter cattle prices. The residuals do not display any tendency to increase progressively over time. Periods of maximum overestimation occurred in 1936, 1946, 1956, and 1969 at values around $1.50 per hundredweight. Periods of maximum underestimation occurred in 1932, 1951, and 1962 at values around $2.75, $2.25, and $1.75 per hundredweight, respectively.

Rather than a damping effect, the plot of the residuals is more suggestive of additional sinusoidal components. The most logical components to expect would probably be a four-year fluctuation reflecting interdependence of the beef and hog markets and fluctuations of 3 or 4 months duration reflecting feedlot activity in the beef sector.

In the work reported in 1963, an estimate was made of the trend in slaughter cattle prices over the period January 1921 through December 1960, with the periods June 1931 through December 1935 and June 1950 through July 1953 omitted from the analysis. The results reported were:

$$P = 5.1987 + \underset{(41.26)}{.00675}t + \underset{(22.80)}{1.04589} \sin (\omega t + 145^{\circ}30^{1}) \ \underset{(10.00)}{.44210} \sin (10\omega t - 57^{\circ}3^{1})$$

$$R^2 = .9071 \tag{6}$$

Estimates were also made for the period January 1921 through December 1969, with the periods June 1931 through December 1935 and June 1950 through July 1953 omitted from the analysis for comparative purposes. The results were:

$$P = 5.1264 + \underset{(58.53)}{.00725}t + \underset{(27.46)}{1.21013} \sin (\omega t + 142^{\circ}11^{1}) \ \underset{(11.94)}{.51968} \sin (10\omega t - 58^{\circ}11^{1})$$

$$R^2 = .9070 \tag{7}$$

The differences in the results of equations (6) and (7) are similar to the differences in the two equations estimated over the uninterrupted time span.

SOME INFERENCES

In summary, it has been demonstrated that the time path of slaughter cattle prices can be described by a mathematical function comprised of a cyclical component and a seasonal component fluctuation about a linear trend. The cyclical component appears to possess a stable period of approximately ten years duration. Cyclical peaks have occurred at ten-year intervals beginning with 1929. Departures from the cyclical trend have occurred on several occasions at or soon after the appearance of a cyclical peak. However, prices subsequently fell sharply to resume the cyclical patterns providing additional evidence that a

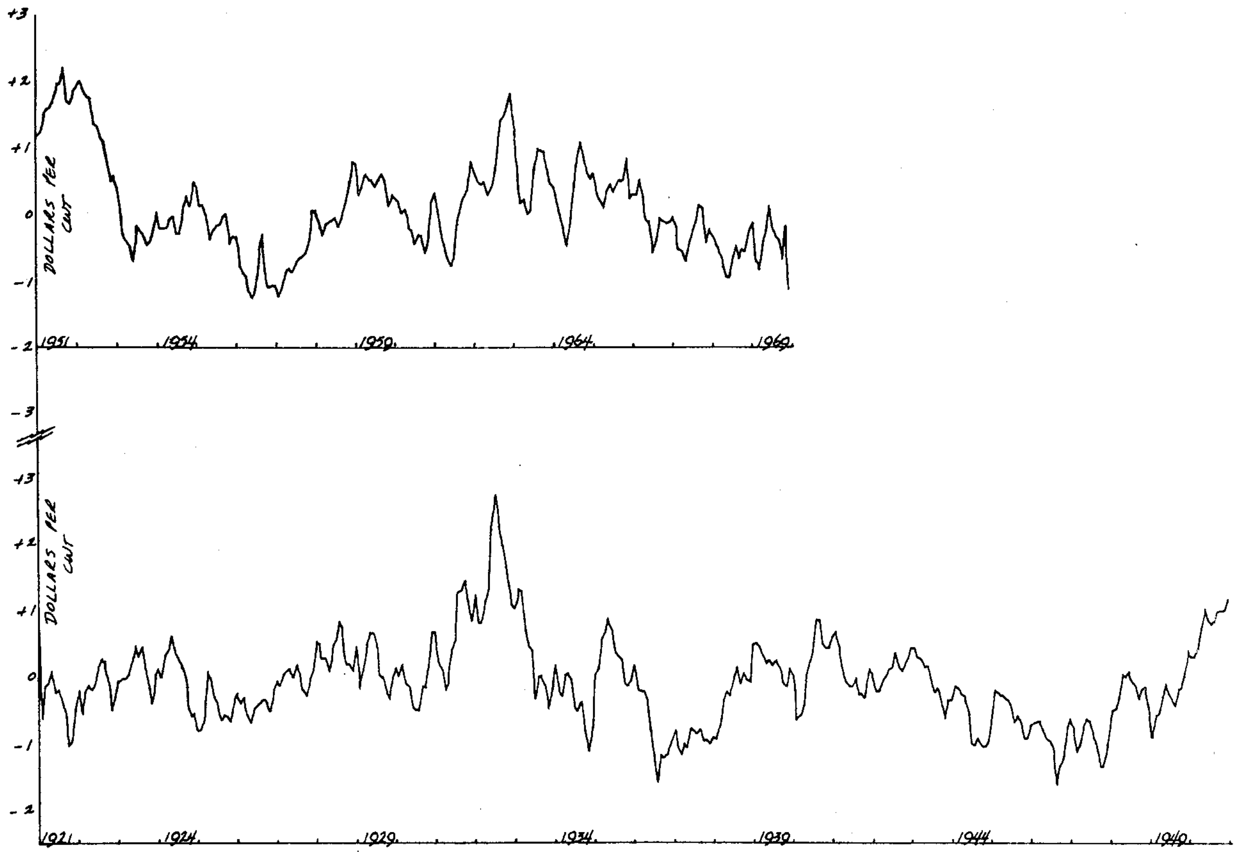

FIGURE 4. OBSERVED, DEFLATED PRICE OF SLAUGHTER CATTLE MINUS THE DEFLATED PRICE OF SLAUGHTER CATTLE ESTIMATED FROM EQUATION 4

cycle with a stable period does, in fact, underlie the data.

An examination of the residuals did not reveal any clear evidence of damping effects on the cyclical pattern. The time path of the residuals are more indicative of additional components perhaps identifiable with the hog sector or feedlot activities.

The stability of the period of the estimated cyclical variation holds forth the promise of increased forecasting reliability over rather long periods of time. Although precise estimates of the absolute levels of price may not be obtainable with the present trend model, the turning points may be identified more accurately providing useable information for investors in the cattle industry. However, the real value of the trend model may be that the number of terms, their amplitude, and their phase relationship may provide analysts with insights leading to improved economic models with which to describe and forecast cattle prices.

REFERENCES

1. Breimyer, Harold F., "Observations on the Cattle Cycle," *Agr. Econ. Res.*, Vol. VII, No. 1, pp. 1-11, Jan. 1955.

2. Burmeister, C. A., "Cycles in Cattle Numbers," *Livestock and Meat Situation – 25,* p. 10, U.S. Bureau Agr. Economics, March 1949.

3. Dewey, Edward R., "The Case for Cycles," *Cycles,* Vol. XVIII, No. 7, pp. 164-174, July 1967.

4. Franzmann, John R., "Forecasting the Average Monthly Cost of Cattle Slaughtered Under Federal Inspection," proceedings of Southwestern Social Science Assoc., San Antonio, Texas, April 11-13, 1963.

5. Hopkins, John A., Jr., *A Statistical Study of the Prices and Production of Beef Cattle,* Res. Bul. 101, Iowa State College, Ames, Iowa, Dec. 1926.

6. Lorie, James H., "Causes of Annual Fluctuations in the Production of Livestock and Livestock Products," *J. of Business,* Vol. 17, No. 1, Part 2, April 1947.

7. Thomsen, F. L. and R. J. Foote, *Agricultural Prices,* pp. 38, 386-389, McGraw-Hill, New York, 1952.

8. Thomsen, F. L., *Agricultural Prices,* pp. 264-266, McGraw-Hill, New York, 1936.