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A SPECTRAL DECOMPOSITION OF SLAUGHTER STEER PRICES AND ITS FORECASTING IMPLICATIONS

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Introduction

The number of alternative ways to formulate stochastic models and the possible variations in data arrangements and transformations is overwhelming. Gaining information about the fundamental time-varying characteristics of an economic series is a central feature in the exploratory stages of econometric model selection and specification. The value of the much simplified and straight-forward algebraic and trigonometric models, for example, is directly ascribable to the extent and repeatability of underlying time patterns.

The objective of this manuscript will, therefore, be to (1) place the investigation of the time varying characteristics of slaughter cattle prices on a rigorous statistical foundation, and (2) critically examine the "usefulness" of any regular, recurrent cyclical patterns to building short-run price forecasting models. Although used extensively in the following analysis, no attempt will be made to formally present the mathematical and statistical properties of the power-spectrum or the cross-spectrum estimates. An excellent survey and bibliography are to be found in Dhrymes [2].

Power Spectrum Estimate - Actual Series

The power spectrum estimate for monthly slaughter steer prices, Chicago basis, from January, 1920, through December, 1970, is presented in Figure 1. Since it is generally advisable to use as many time lags k as possible -- only so long as k does not exceed one-third of the total observations -- 199 lags were used [4].

The most noticeable characteristic of the logarithm of this power spectrum is the importance of the low frequency components. Despite attempting several trend removing transformations, the frequency bands between 0 and .013 cycles per month still contributed a significant portion of the total variance. Granger [4] argues that even though a trend removal procedure has been applied, a characteristic of the estimating procedure, known as leakage, will still cause biases in the low frequency estimates. The failure of the estimated power spectrum to form a significant "spike" at these low frequency bands provides strong evidence for rejecting the hypothesis that actual slaughter cattle prices are characterized by a long-term cyclical component.

The power spectrum estimate does indicate the existence of a minor price cycle with a periodicity of approximately four years duration (frequency of .025 cycles per month). A formal explanation of this cycle is partially advanced by the theory of self-generation [1]; i.e., a coherency estimate of .57 between the four-year cycle in the price of slaughter cattle and the four-year cycle in the number of cattle slaughtered each month establishes that each phase in the price cycle partially generates its succeeding phase.

The power spectrum estimate is also characterized by a series of peaks corresponding to a period of 16 months and its harmonics. These peaks, although contributing little to the total variance of the series, are indicative of a slowly changing but stochastic seasonal pattern. As manifsted by a coherency estimate of .98 at .085 cycles per month, there is an extremely close correlation between the seasonality in cattle prices and the number of cattle slaughtered.

Power Spectrum Estimate - Deflated Series

A possible explanation for the long-run irregularity of slaughter steer prices is the intermittent influence of inflation, deflation, wars, weather, etc. Breimyer has suggested 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 "to produce cyclical curves of some regularity, it is necessary to deflate the reported prices" [1].

In order to examine the possibility that outside forces are obscuring the true cyclical nature of slaughter steer prices, a spectral analysis was made on the deflated series. The index of prices received by farmers for all farm products (1910-14 = 100) was used as

the deflator. The dashed line in Figure 1 illustrates the estimated power spectra of the undeflated series.

Most striking is the presence of a highly significant 10-year cycle in the deflated price series. The peak at .008 cycles per month completely substantiates the hypothesis that the time path of the deflated slaughter steer prices follows a relatively stable cycle that repeats itself at 10-year intervals.

The evidence poses three important questions. First, is the undeflated price series actually characterized by an unobserved 10-year cycle that is being obscured by the transitory factors mentioned by Breimyer? Second, in the process of deflating, is the deflator introducing a spurious cyclical component on the original series? Third, and most important, what inferences can be advanced concerning the applicability to forecasting of the deflated series?

A reconciliation of the first question is offered insofar as a 10-year cycle in cattle prices can be linked internally to a similar cycle in beef production. Since a coherency statistic is similar in concept and interpretation to the coefficient of determination in standard regression analysis, the coherency estimate of .67 at .008 cycles per month does establish some correlation between cattle prices and the supply of slaughter cattle.

The coherency (C_y^2), gain (G_y), and phase-shift (Φ_{yx}) statistics between the original and deflated series can provide the type of information necessary for investigating the possibility that the deflator is inadvertently influencing the low frequency components [2]. Accordingly, these three statistics were computed for the undeflated slaughter cattle price series in relation to the deflated series.

Examination of the coherency function in Figure 2 illustrates that the deflator does preserve the overall movement and general appearance of the original time series -- at least at frequencies corresponding to the 10-year cycle, 4-year cycle, and the seasonal and its harmonics. The gain estimate in Figure 3 also indicates that the deflator is not, at low frequencies, abnormally attentuating the amplitude of the original series. In fact, only an insignificant amount of dampening is recorded at .008 cycles per month. Finally, although rather violent phase-shifts were observed at extremely low frequencies (those below .008 cycles per month) the deflator does not abnormally influence the remainder of the power spectrum.

On the strength of the statistical evidence presented thus far it must be concluded that the slaughter cattle price series is characterized by an unobservable long-term cycle with a periodicity of 10 years. Even so, the real value of this cycle must be assessed in terms of its contribution to describing and forecasting cattle prices.

Franzmann [3] demonstrated that the time path of the average price of all slaughter cattle can be described by a mathematical function comprised of a 10-year cyclical component and a seasonal component fluctuation about a linear trend. He then concluded that "the stability of the period of the estimated cyclical variation holds forth the promise of increased forecasting reliability over rather long periods of time" [3].

From the foregoing analysis Franzmann's conclusion can not be disputed. Over a short planning horizon, however, where the actual prices received for specific classifications of cattle (e.g., Choice grade 900 to 1,100-pound steers) are required, it is believed that consideration of a long-term cyclical component only adds to the complexity of the problem. For example, in the following mathematical model, similar to the one considered by Franzmann, only 64 percent of the total variance in the series can be explained:

$$Y_t = \underset{}{.073} + \underset{(.000008)}{.00006T} + \underset{(.0006)}{.008\cos 3t^0} - \underset{(.0006)}{.00095\sin 7.5t^0}$$

$$+ \underset{(.0009)}{.0024\cos 7.5t^0} - \underset{(.0006)}{.0024\sin 30t^0} - \underset{(.001)}{.0016\cos 30t^0}$$

$$R^2 = .64$$

Where:

Y = deflated, 900 to 1,100-pound Choice grade slaughter steer prices by month, Chicago
T = trend (1920 = 1).

Moreover, in management problems requiring forecasts of the undeflated series, it necessarily follows that future values of the deflator must be known or at least forecastable. It is believed that the errors associated with forecasting future values of the deflator and converting the deflated series into estimates of the actual series would probably transcend the errors from a similar model using the undeflated series as the dependent variable.

Concluding Inferences

The second movement time varying properties of the slaughter steer price series, as visually portrayed by the lag of the estimated power spectrum is characterized by (1) an extremely irregular long-term fluctuation in the original series; (2) a highly regular long-term cycle of 10 years duration in the deflated series; (3) a slightly significant minor price cycle with a regular periodicity of approximately four years; and (4) nonconforming (trending) seasonal patterns.

In general the nature of the time patterns in the original price series is such that doubt is cast on the possibility of using a simple unobserved components model for forecasing future price movements. In fact, because of the trending nature of the high frequency components, price researchers should extend extreme caution when using seasonal dummy variables in forecasting models. It may be possible, if data are not readily available on the underlying economic mechanism which generates the four-year cycle, to include a sinusoidal function with a duration of four years in a behavioral model.

Some support was advanced for the possibility that, since outside forces are obscuring the true cyclical nature of the original series, a price deflator should be entertained. By deflating the original series, the task of estimation could be greatly simplified. However, the problems inherent in estimating the deflator makes it questionably acceptable for short-term forecasting.

Finally, it can be argued that apart from the irregular long-term cyclical behavior and the somewhat important minor cycle, the overall spectral configuration may contain useful information. That is, a realization from a low-order autoregressive process is represented by a relatively smooth spectrum with the predominance of power at low frequencies for a positive process and at high frequencies for a negative process. Examination of Figure 1 suggests that an autoregressive model may be worthy of further investigation.

REFERENCES

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3. Franzmann, John R., "Cattle Cycles Revisited," Paper presented to the Southern Agricultural Economics Association, Jacksonville, Florida, February 1-2, 1971.

4. Granger, C.W.J., in association with M. Hatanaka, Spectral Analysis of Economic Time Series, (Princeton N.J.: Princeton Un. Press, 1964).

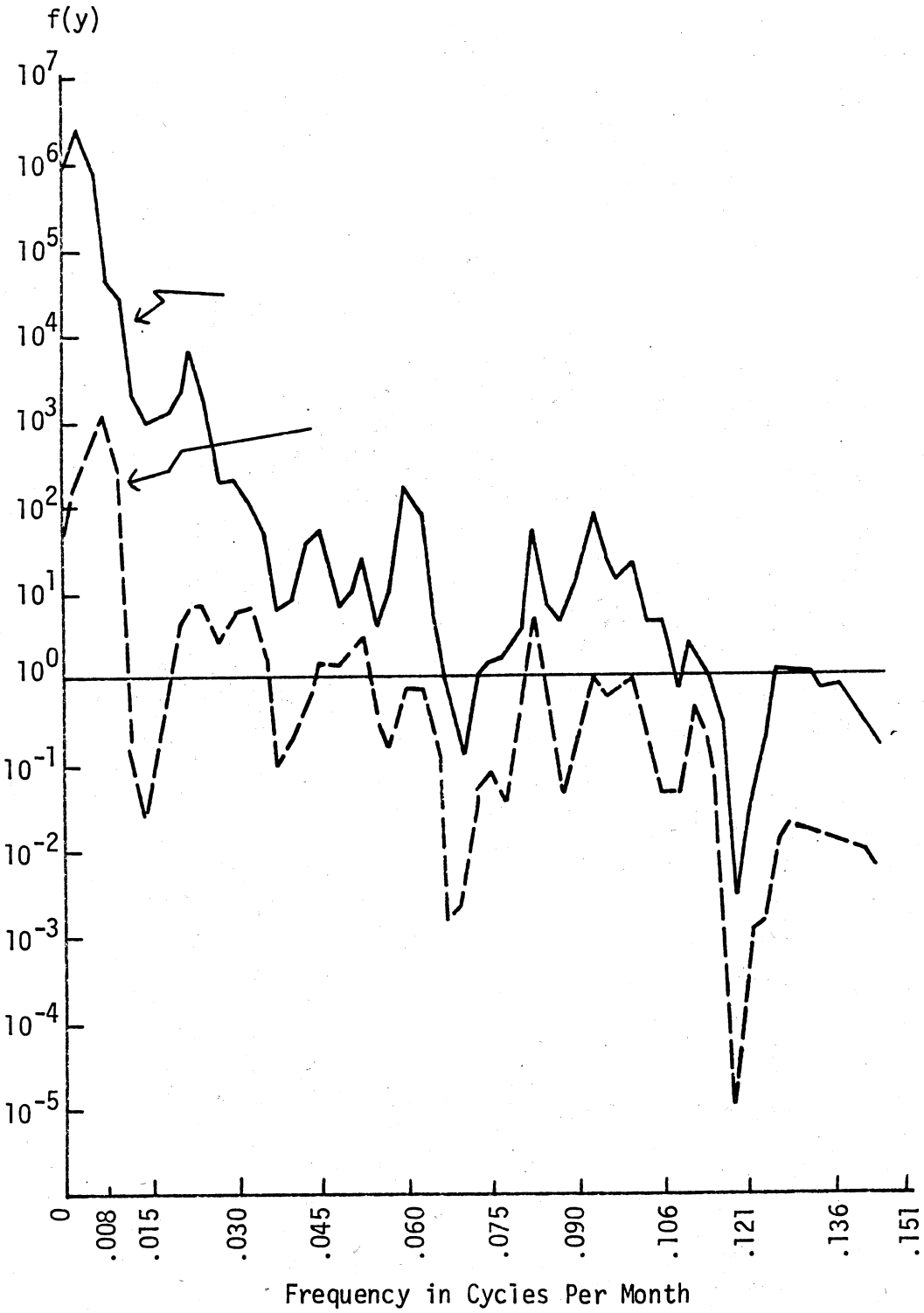

Figure 1. Log of Estimated Spectral Density Function
Actual and Deflated Slaughter Cattle Prices

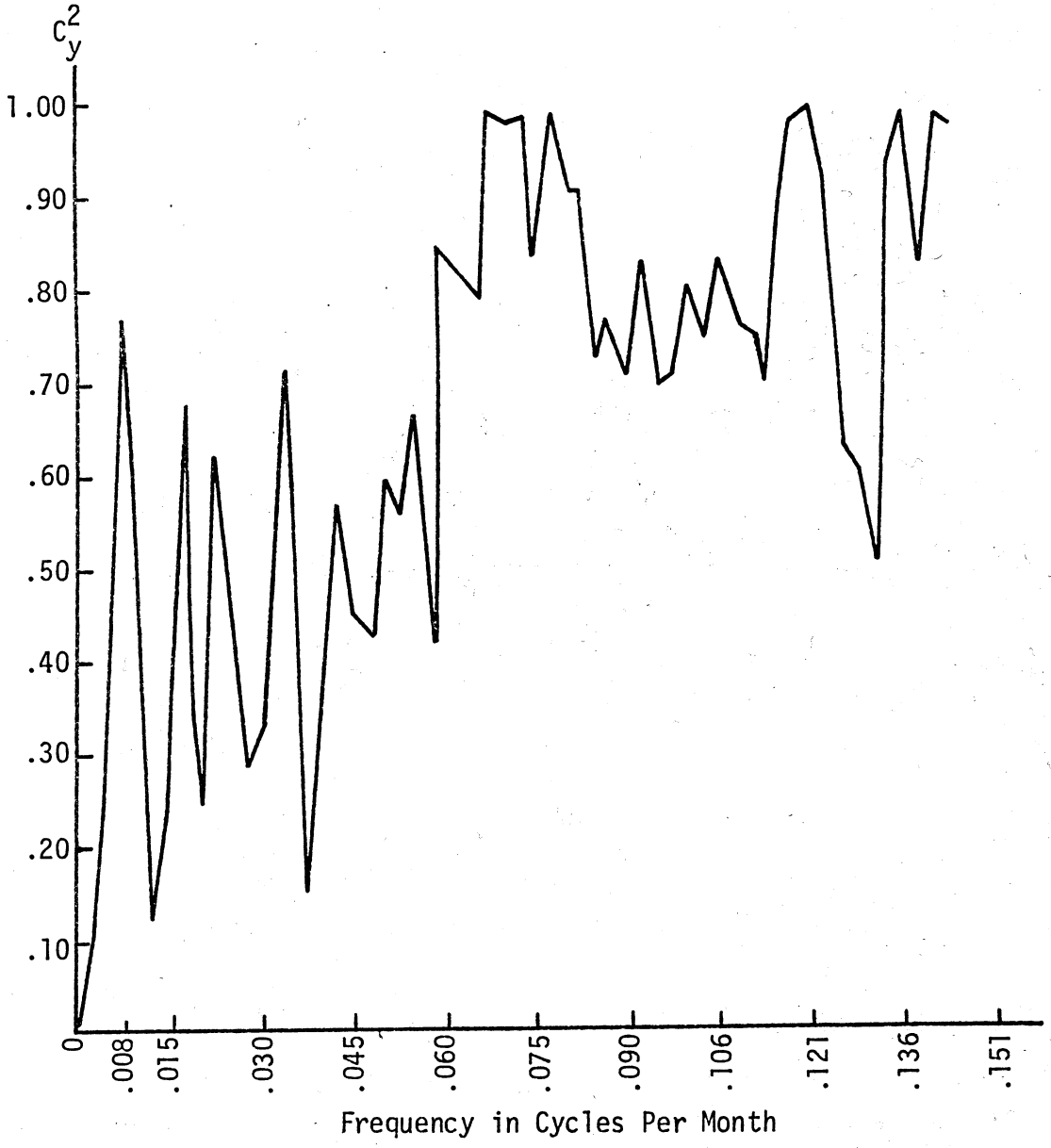

Figure 2. Coherency Function of Actual Slaughter Cattle Prices and Deflated Slaughter Cattle Prices

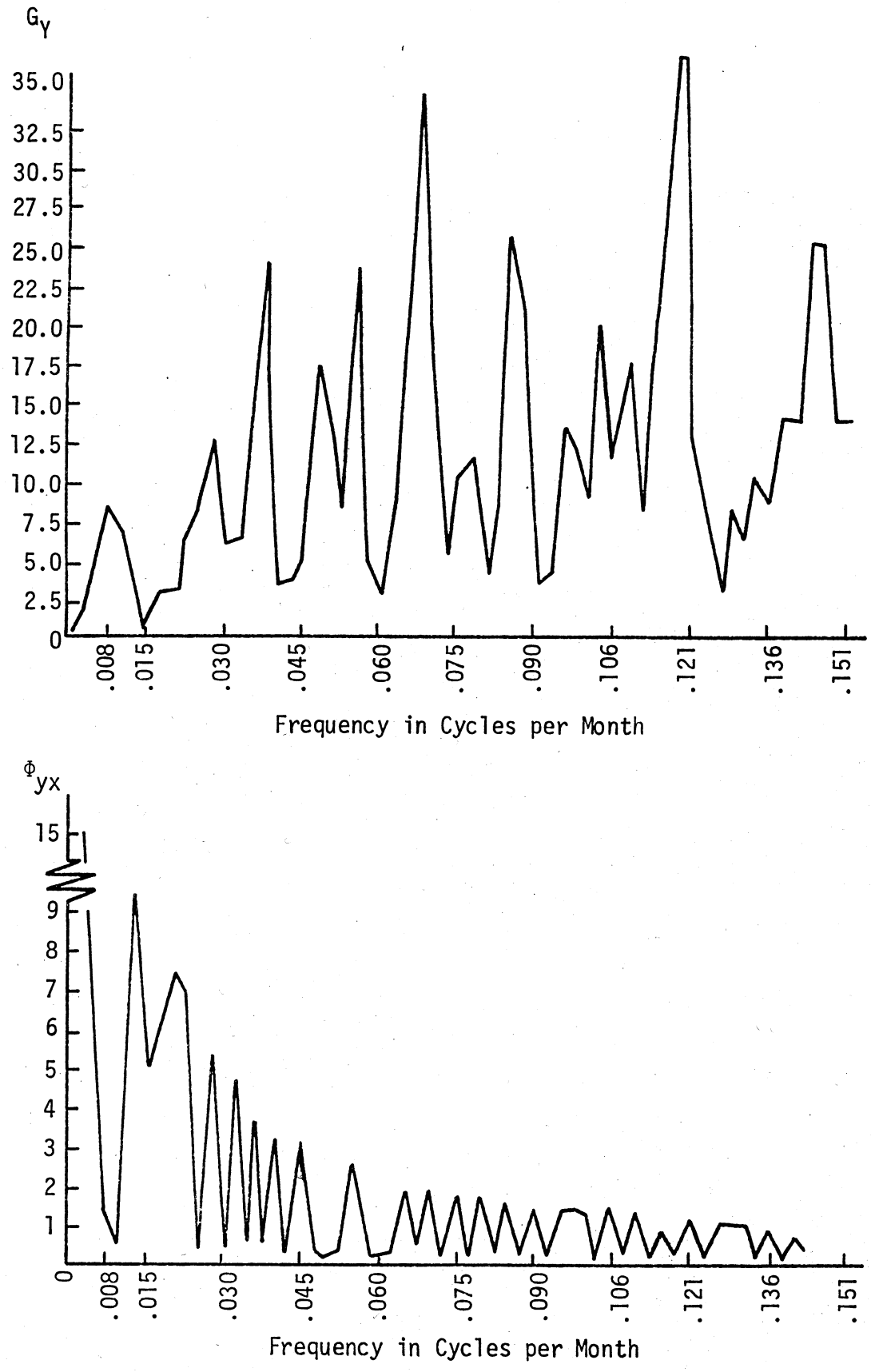

Figure 3. Gain and Phase-shift Diagrams for Actual Slaughter Cattle Prices and Deflected Slaughter Cattle Prices