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HOG CYCLES AND COUNTERCYCLICAL PRODUCTION RESPONSE

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"In competitive markets there is a buyer for every seller. If one could be sure that a price will rise, it would have already risen."

P. A. Samuelson

". . . advance and decline in the value of hogs to be for twenty years past as alternatively certain as the diurnal revolutions of the earth upon its axis."

S. Brenner

I. INTRODUCTION

Can hog cycles exist? If livestock producers know in advance that meat prices follow a predictable cycle, they should expand and contract their herds in a countercyclical manner. This type of behavior should lead to a diminution and eventual elimination of such cycles; yet, the concept of predictable price movements remains alive in the literature and in the advice proffered by Agricultural Extension agents [Beale et al. (1983); Breimyer (1959); Meadows (1970); Larie (1947); Harlow (1960); and Larson (1960)].

Discussions of the above paradox center around two main arguments. The oldest and, until recently, most commonly held view is that producers ignore publicly available information and base production decisions and price expectations on the behavior of recent prices. Using this logic and the relatively long time period needed to increase livestock herds, cycles may be explained as the overall effect of many individual producers, each irrationally ignoring the production decisions made by the rest of the industry.

With the advent of organized futures markets and professional price forecasters, a second explanation became common. Proponents of this school argue that predictable movements in agricultural prices have never existed. The phenomena noted by cycle watchers are said to have been the result of random trends in both demand and supply which appear ex post to have been predictable. They point to the differences in wavelength and amplitude in what appear to have been cyclical price patterns that nullify any predictive power contained therein. This school of thought maintains that markets are efficient in the sense that it is impossible to profit consistently from publicly available information.

The purpose of this paper is to reconcile the two fields of thought represented above. We argue that predictable movements in hog prices can and have occurred in the presence of rational producers but that, because of lower information costs and larger herd size which increased the profitability of information collection, cycles eventually were eliminated as some producers responded in a countercyclical manner. While our study focuses only on the U. S. hog industry, the methodology presented can be applied to any industry where predictable cycles are said to exist.

The first part of this paper shows that historically hog cycles did exist. Secondly, we model the behavior of a rational agent in the presence of predictable price movements. We then model the influence of many such producers on the profitability of the strategy in question. The two theoretical models are then combined and tested empirically. The results are consistent with the hypothesis that countercyclical producers eliminated the cycle.

II. PREDICTIVE POWER OF CYCLES

Countercyclical production behavior is predicated on the existence of a predictable cycle. Predictable price movements exist when the profits accruing to hypothetical producers making use of such information are consistently greater than for those who ignore it. It is important in our model that, if a meaningful cycle exists, it must have predictive power for an actual hog producer. Our test for the existence of predictable cycles is, therefore, based on the profits such a producer would have earned had he, in fact, followed a production pattern consistent with the information contained in the strategy. This profit will be compared with that which would have occurred had the information content in the cycle not been acted upon. In the terminology of the efficient market literature, we will compare an active buy/sell strategy with a passive buy/hold strategy.

A total of seven different cyclical based strategies will be compared. The information required and decision rules emanating from each of these strategies are presented in Appendix 1 where the strategies are arranged in order of complexity. All decisions are assumed to be ex ante; hence, once begun, no deviation from any strategy is allowed. Also, the degree to which producers change their herd size does not depend on the strength of the signal. This was necessary to enable cross-strategy comparisons.

For instance, the rule used by producers using strategy E is to estimate the average per capita hog slaughter. If the actual slaughter is above average for two consecutive years, herd size is increased; if slaughter is below average for two years, herd size is reduced. The motivation here is clear:

large slaughter figures are typically associated with low prices and a liquidation of the breeding herd. If the demand curve for pork is unchanged, prices rise in subsequent years and is accelerated as procyclical producers rebuild their breeding stock by retaining mature hogs.

The relative size of the production change induced by the strategy will influence the size of the profit or loss. In the section dealing with individual producer behavior, the magnitude of this change will be treated explicitly. For purposes of determining whether such opportunities exist, an arbitrary figure is used. The production change used to test for the existence of these cycles is to sell all stock when prices are expected to fall, to maintain herd size when the expected price change cannot be determined, and to double output in periods when prices are expected to rise. That is, the hypothetical producer in an ex post analysis is assumed to regret carrying any stock into periods when prices fall; in periods when prices rise, we assume for symmetry that he wishes he had doubled production. Producers who make less drastic changes in production would obtain different profit levels, but they would arrive at the same evaluation of strategies.

With inflation, the absolute level of price changes will increase through time. To avoid favoring strategies that were profitable in periods of high inflation, we have deflated all profits by the wholesale price index (WPI) for the year in which they occurred. The period of the study is 1902-1981. Ample evidence of the existence of cycles prior to 1902 exists [Brenner (1895)]. It would have been possible for an informed agent to begin to use Brenner's buy/sell rule from that date. The comparisons were undertaken for the entire period as well as the subperiods--1902-1941, 1942-1981, 1942-1961, and 1962-1981.

The method used to determine whether profits, π, could be made from countercyclical behavior is given in equation (1) where P is the price of a typical ready-for-market hog and WPI is the wholesale price index (WPI = 100 in 1969) [U. S. Department of Agriculture (various years) and U. S. Department of Commerce (various years)]. The variable, I, takes on values of 2, 1, or 0 depending on whether the strategy emitted a buy, hold, or sell signal, respectively.

The method of construction of equation (1) is such that, for strategies following decision rules opposite those proposed, profits or losses of the same magnitude and opposite in sign will occur. The results for the seven strategies are presented in table 1. In addition, the profits made by using a passive strategy (i.e., the control) as well as those from the optimal strategy (i.e., using perfect foresight) are included.

$$\pi_s = \frac{\sum_{n=1}^{T}\left[\sum_{t=1}^{n} I(P_t - P_{t-1})\,(100/WPI_t)\right]}{T} - \frac{\sum_{n=1}^{T}\left[\sum_{t=1}^{n} (P_t - P_{t-1})\,(100/WPI_t)\right]}{T} \quad (1)$$

The results clearly support the hypothesis of a predictable cycle. Under the null hypothesis of a random walk or martingale, the expected relative profit for all but the perfect foresight strategy is zero. This is so because the profits made by the control have been subtracted from the profits for each strategy as outlined in equation (1).

With the exception of the 1962-1981 period, all profit figures are positive. It would, therefore, have been possible to profit from countercyclical behavior for most of the period. At first glance, the data indicate that producers were behaving irrationally. This is especially true of the

TABLE 1.--RELATIVE PROFITABILITY OF COUNTERCYCLICAL PRODUCTION STRATEGIES UNITED STATES, 1902-1981

Strategy[a]	Relative Profits				
	1902-1981	1902-1941	1942-1981	1942-1961	1962-1981
	dollars per hog				
A	68.8	41.2	37.4	23.3	16.3
B	40.2	25.1	17.8	4.8	17.8
C	28.6	16.0	19.6	18.5	- 1.7
D	43.0	28.0	12.4	4.2	6.4
E	48.0	37.3	13.0	8.4	- 3.0
F	63.2	42.6	28.9	15.4	20.4
G	82.6	44.9	24.6	21.3	3.5
Optimal	147.7	74.7	76.0	27.8	31.7
Control	35.1	25.5	42.0	27.8	37.0

[a]Defined in the Appendix.

data for the first part of the century. The large potential profits accruing to all strategies in the 1902-1941 period are due, in large part, to the assumption that producers could double the herd size or get out of production in a short period of time. Nevertheless, even if producers had made a fraction of these changes, they would have consistently outperformed the buy/hold strategy.

The results for the perfect foresight strategy are similar for the 1902-1941 and 1942-1981 periods. This indicates that the opportunities were similar in both periods; yet, in all cases but one, the relative profits declined in the latter period. The low or negative profits for the post-1962 period suggest that the predictive power of cycles was declining through time. It is interesting to note that producers following production decisions exactly opposite to strategies C and E would have made money in this period. This apparent decline in the profitability of countercyclical behavior has two possible explanations. Those agreeing with the efficient market hypothesis would argue that the strategies were initially picked because they proved profitable, i.e., the concept of a two-year price cycle exists because it would have, by chance, produced profits for at least some of this period. The decline in relative profitability would, therefore, be seen as a return to random price movements. A second possible explanation is that, as more and more producers noticed and reacted to the price cycle, their combined countercyclical production eventually eliminated the cycle. This phenomenon is modeled in the following sections.

III. THEORETICAL CONSIDERATIONS

A. Individual Agent Behavior

Consider an agent contemplating changes in his production based on some countercyclical strategy. The only information available to him with which to evaluate the strategy will be its relative performance in the recent past. It seems plausible that the agent will compare the price moves predicted by the strategy with those which actually occurred and that such comparisons will be based on the level of profitability he would have achieved had he used the strategy. If x_t^* is his subjective evaluation of a strategy at time t and he updates this evaluation in a manner similar to the adaptive expectations framework, then

$$x_t^* - x_{t-1}^* = \rho(\pi_{t-1}^r - x_{t-1}^*). \tag{2}$$

The variable, π^r, in equation (2) will involve some comparison of the profit accruing to the strategy relative to that which would have occurred had he used the perfect foresight strategy. He will be either sorry he did not use the strategy earlier or happy that he ignored it. We have defined π^r as the divergence between the profits accruing to the strategy in question and those of the optimal strategy, divided by the profits of the optimal strategy.

$$\pi_t^r = \frac{\pi_s - \pi_o}{\pi_o} \tag{3}$$

where π_o are the profits accruing to the optimal strategy.

Strategies performing close to optimum will be viewed favorably, while those with a large divergence from the optimal will be viewed less favorably.

Strategies that accurately predict large price movements will be preferred to those which are accurate only in times of relative stability.

If we allow Y_t^* to be the desired degree of correlation between the output of the producer and that dictated by the strategy and assume a linear relationship between this and his subjective evaluation of the strategy, then

$$Y_t^* = a + b\, x_t^* \tag{4}$$

where Y_t^* is his desired use of the strategy and x_t^* is his subjective evaluation of the strategy.

If he decides to adopt the production rules of a profitable strategy, it is unlikely that he will achieve the changes in herd numbers required to achieve the profits portrayed in table 1.

$$Y_t - Y_{t-1} = \gamma(Y_t^* - Y_{t-1}). \tag{5}$$

Equation (5) allows for such partial adjustment. This is Nerlove's (1958) partial adjustment model, Y_t^* is the desired correlation, while Y_t is the correlation achieved. Waud (1968) proposed a method of estimating models where both partial adjustment and adaptive expectations occur.

Substitute for Y_t^* from (4) into (5).

$$Y_t = \gamma a + \gamma b\, x_t^* + (1 - \gamma)\, Y_{t-1}. \tag{6}$$

Substitute for x_t^* from (2):

$$Y_t = \gamma a + \gamma b \rho\, \pi_{t-1}^r + \gamma b(1 - \rho)\, x_{t-1}^* + (1 - \gamma)\, Y_{t-1}. \tag{7}$$

Substitute for x^*_{t-1} in (6) and rearrange:

$$Y_t = \rho\gamma a + \gamma b\rho\ \pi^r_{t-1} + [(1 - \rho) + (1 - \gamma)]\ Y_{t-1} - (1 - \gamma)\ (1 - \rho)\ Y_{t-2}. \quad (8)$$

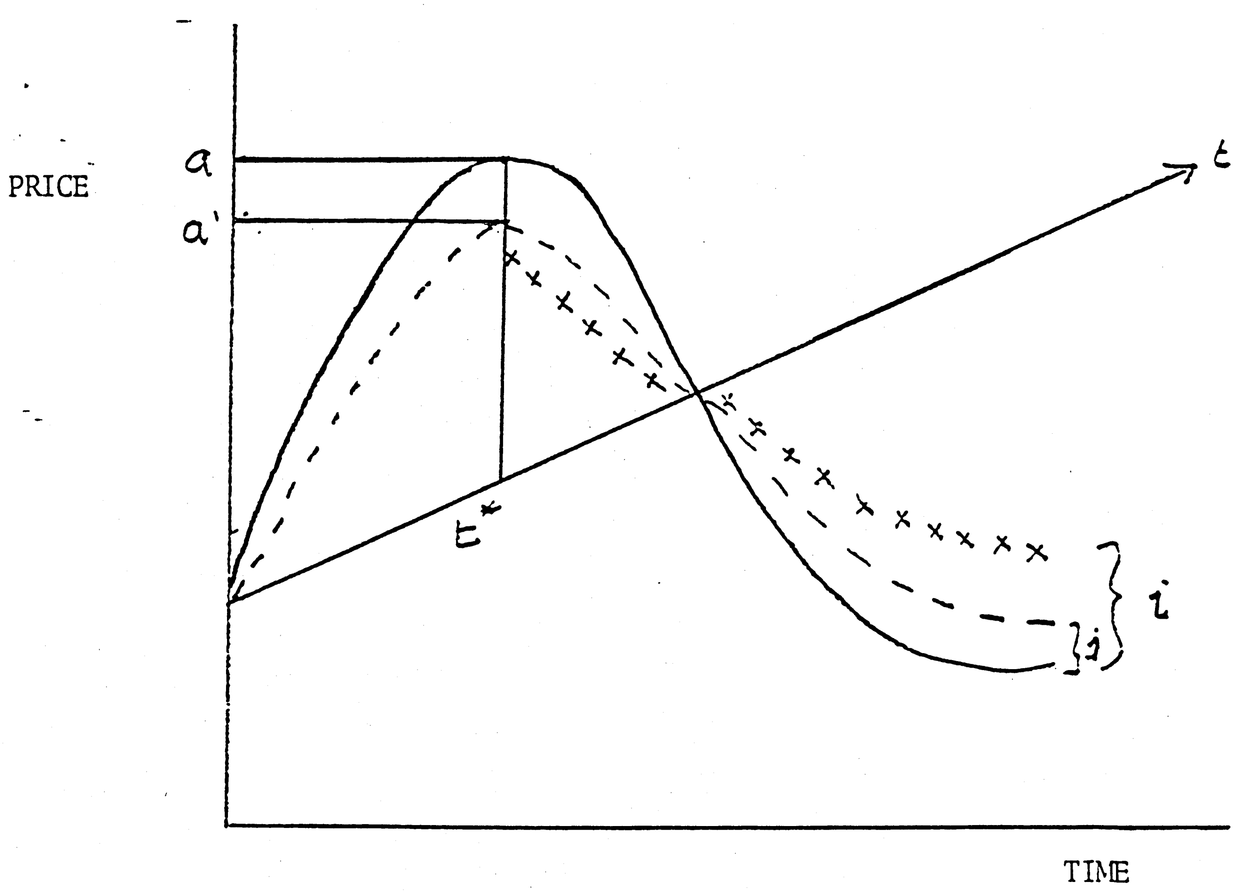
Waud (p. 216) states that "Only if the estimated regression coefficient associated with Y_{t-2} is not significant is it possible that 'partial adjustment or adaptive expectations' alone is the correct specification." In livestock production, it is very unlikely that all required adjustments are made instantaneously. Thus, the significance of the Y_{t-2} variable in equation (8), if it could be estimated, would be an indication whether this producer evaluated the strategy using the adaptive expectations framework outlined in equation (1).

B. <u>Aggregate Producer Behavior</u>

To derive some measure of the degree of countercyclical behavior for the market as a whole, we need some method for determining how the actions of an agent, behaving in the manner suggested by equation (8), affects the profits accruing to other users of that strategy. For this, we must aggregate over all producers, dropping the assumption that the behavior of an individual does not affect the profitability of the strategy. When aggregating across producers, it is essential to weight them by their output rather than by numbers. This weighted output, rather than actual numbers of agents, will be used for the remainder of the paper.

There will not be a one-for-one reduction in the profitability of a strategy as more and more producers adopt it (see figure 1). The solid line is the behavior of prices in the absence of any counter-cyclical production behavior. The dotted line is the price path once a certain proportion of the producers adopt the strategy. The reduction in price at time t*

FIGURE 1.--INFLUENCE OF COUNTERCYCLICAL PRODUCERS ON THE SIGNALS REACHING OTHER AGENTS.



from a to a' will alter the signals from which the procyclical producers operate. The price reduction will weaken the expansion signal to procyclical producers; hence, the subsequent fall in price will be even less. This new price path is shown with the starred line. It is not necessary for the new line to lie above the dotted line. The relative placement of these lines depends on the original cause of the cycle. It is possible, however, to obtain an estimate of this multiplicative effect. If we define j as the initial shift and i as the total one, then a measure of the multiplier effect, λ, is i/j.

If we define μ as the correlation between the production changes of producers using the strategy and the change in the weighted output of all agents, we can say

$$\frac{\partial \mu}{\partial N} > 0 \qquad (9)$$

$$\frac{\partial \pi_s}{\partial \mu} < 0. \qquad (10)$$

where N is weighted output of producers using the strategy. That is, as more producers use the strategy, the correlation between the actual price movements and those predicted by the strategy will tend toward -1. This change in μ will reduce the profits accruing to the strategy.

Equation (11) shows the relationship between the profitability of the strategy and that of the control. If there is no relationship between the strategic rules and actual prices, then the expected profits of the strategy will equal those of the buy-and-hold strategy. A positive correlation will imply a loss-making strategy. This loss will depend on the degree of correlation and the multiplier effect mentioned above.

$$\pi_s = \phi\ \pi bh - \lambda\mu\ \pi bh \tag{11}$$

where $E(\phi)$ is 1 and πbh is the profit accruing to the buy-and-hold strategy.

The graph in figure 2 shows this relationship. The first agent to notice the strategy will operate in the extreme left-hand region. As more and more people begin using it, the profits will follow a similar path to the one shown. In a year where a sufficiently large number of people use the strategy, the profits will be less than the control ($\mu > o$) or even negative ($\mu > s$). The problem facing any potential user is that μ cannot be determined until the production decision is made.

If we assume that all potential countercyclical producers behave in a manner similar to that depicted in equation (8), it is possible to obtain an estimate of their number by the change in u resulting from their decisions. From (11),

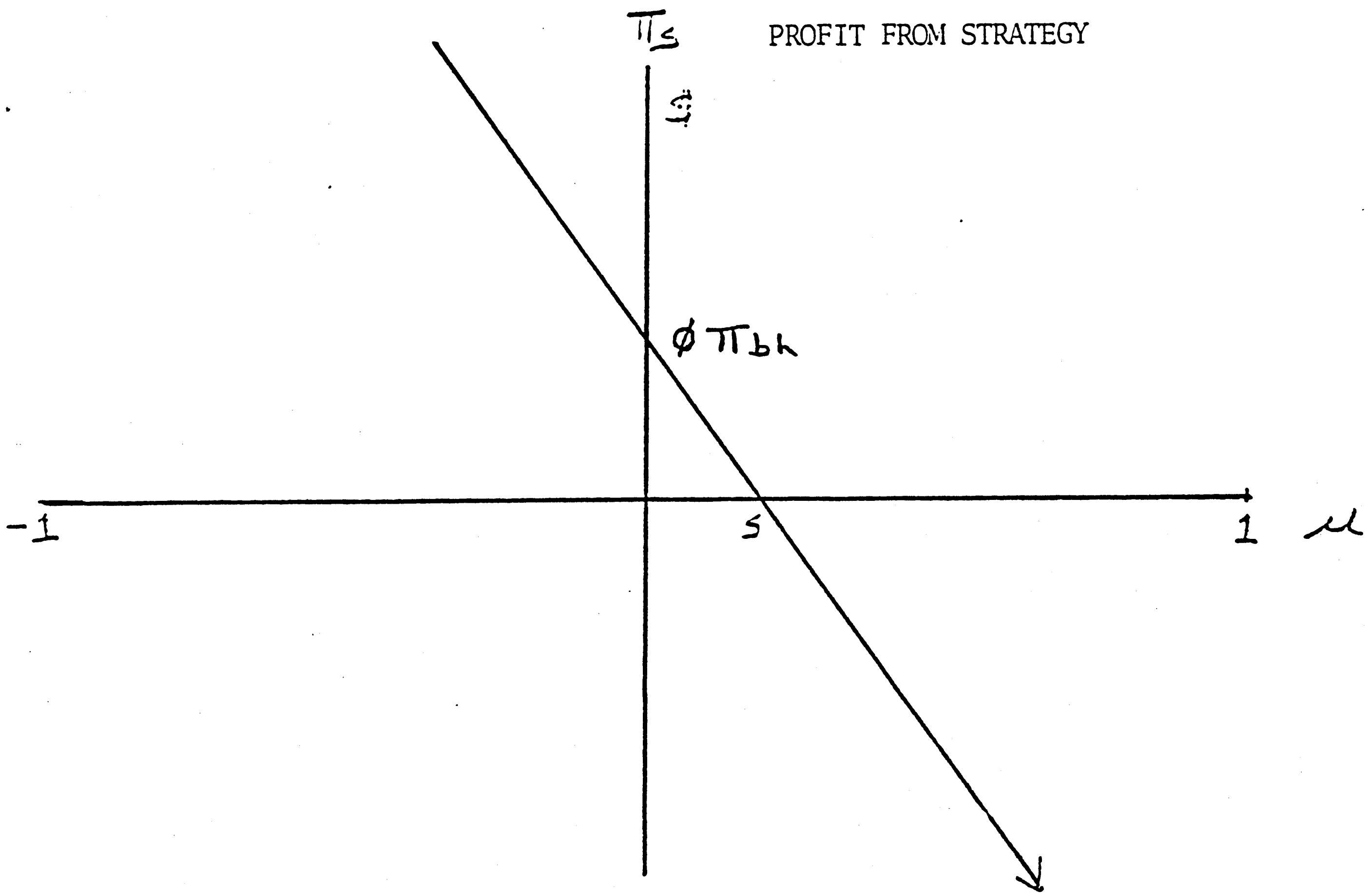
$$\mu = -\frac{\left(\pi_s/\pi bh - \phi\right)}{\lambda} \;. \tag{12}$$

Substituting μ for y in equation (8),

$$-\frac{\left(\pi_s/\pi bh - \phi\right)}{\lambda} = \rho\gamma a + \gamma b\rho\ \pi^r_{t-1} - [(1 - \rho) + (1 - \gamma)] \left(\frac{\pi_s/\pi bh - \phi}{\lambda}\right)_{t-1}$$

$$+ (1 - \rho)\ (1 - \gamma) \left(\frac{\pi_s/\pi bh - \phi}{\lambda}\right)_{t-2} \tag{13}$$

FIGURE 2.--RELATIONSHIP BETWEEN πs AND μ.



$$\Longrightarrow \left(\frac{\pi_s}{\pi bh}\right)_t = (\rho\gamma a + \phi)\ \lambda - \gamma b\rho\lambda\ \pi^r_{t-1} + [(1 - \rho) + (1 - \gamma)]\left(\frac{\pi_s}{\pi bh}\right)_{t-1} \tag{14}$$

$$- (1 - \rho)\ (1 - \gamma)\left(\frac{\pi_s}{\pi bh}\right)_{t-2}.$$

Equation (14) allows for estimates of the coefficients, $\rho\gamma$, $\rho + \gamma$, and λ (assuming $b = 1$). For γ, $\rho < 1$ and > 0, the expected signs are:

$$-\lambda\ \gamma\rho b \leq 0$$

$$0 \leq \overbrace{[(1 - \rho) + (1 - \gamma)]} \leq 2 \qquad -1 \leq -\overbrace{(1 - \rho)\ (1 - \gamma)} \leq 0.$$

Estimation of the variable, λ, allows us to determine the multiplier effect mentioned above; hence, some understanding of the production strategies followed by procyclical producers can be gained ($\lambda > 1$ implies a cobweb model behavior).

A significant sign on the Y_{t-2} variable is evidence in favor of both the adaptive expectations framework and partial adjustment hypotheses. All of the above discussion is predicated on the ability of the model to explain the behavior of profitable strategies. Thus, the overall performance of the model can be taken as a test of equations (8) and (14).

IV. EMPIRICAL RESULTS

Equation (14) was estimated using ordinary least-squares regression for the periods 1902-1981, 1902-1941, 1942-1981, 1942-1961, and 1962-1981. The results are displayed in tables 2, 3, 4, 5, and 6, respectively.

TABLE 2.--REGRESSION RESULTS: U. S. HOG PRODUCERS OPERATING IN A COUNTERCYCLICAL FASHION 1902-1981

Strategy[a]	Intercept	$\lambda\gamma\rho b$	$(1 - \rho) + (1 - \gamma)$	$(1 - \rho)(1 - \gamma)$	R^2 Adjusted	F
A	0.55 3.49	-0.94 -2.66	1.11 10.73	-0.41 -3.91	0.79	102.7
B	0.31 2.58	-0.46 -2.08	1.16 11.25	-0.42 -4.05	0.80	104.9
C	0.34 3.39	-0.36 -2.21	0.97 8.69	-0.26 -2.41	0.76	86.6
D	0.29 2.47	-0.47 -1.78	1.22 11.87	-0.45 -4.39	0.83	129.4
E	0.46 3.28	-0.14 -0.68	1.17 11.13	-0.39 -3.66	0.77	89.6
F	0.59 3.92	-0.42 -1.71	1.14 10.81	-0.40 -3.78	0.78	96.0
G	0.29 1.33	-0.27 -0.45	1.25 11.60	-0.35 -3.40	0.87	181.7

[a]Defined in the Appendix.

TABLE 3.--REGRESSION RESULTS: U. S. HOG PRODUCERS OPERATING IN A COUNTERCYCLICAL FASHION 1902-1941

Strategy[a]	Intercept	$\lambda\gamma\rho b$	$(1 - \rho) + (1 - \gamma)$	$(1 - \rho)(1 - \gamma)$	R^2 Adjusted	F
A	0.59	-1.49	1.12	-0.47	0.80	53.6
	2.75	-2.37	7.58	-3.09		
B	0.30	-1.00	1.15	-0.49	0.81	57.3
	1.87	-2.36	7.96	-3.36		
C	0.38	-0.48	0.97	-0.34	0.74	38.1
	2.70	-1.92	5.90	-2.09		
D	0.17	-1.78	1.15	-0.54	0.85	77.4
	1.06	-2.58	7.47	-3.62		
E	0.62	-1.39	1.13	-0.51	0.81	55.4
	3.16	-2.41	7.69	-3.40		
F	0.84	-1.54	1.09	-0.52	0.81	57.9
	3.64	-2.55	7.39	-3.43		
G	0.23	-0.49	1.31	-0.44	0.87	88.9
	0.71	-0.47	7.99	-2.51		

[a]Defined in the Appendix.

TABLE 4.--REGRESSION RESULTS: U. S. HOG PRODUCERS OPERATING IN A COUNTERCYCLICAL FASHION 1942-1981

Strategy[a]	Intercept	$\lambda\gamma\rho b$	$(1 - \rho) + (1 - \gamma)$	$(1 - \rho)(1 - \gamma)$	R^2 Adjusted	F
A	0.25	-0.08	0.77	0.09	0.83	68.7
	2.19	-0.43	4.72	0.58		
B	0.07	-0.04	0.78	0.17	0.88	104.8
	0.68	-0.34	4.80	1.03		
C	0.27	0.11	0.58	0.27	0.76	43.7
	2.49	1.45	3.61	1.78		
D	-0.02	-0.33	0.62	0.27	0.95	245.5
	-0.39	-1.79	4.16	1.94		
E	0.22	-0.30	0.50	0.22	0.64	25.3
	1.70	-1.23	3.42	1.37		
F	0.21	-0.17	0.78	0.08	0.87	94.5
	2.39	-0.74	5.14	0.55		
G	0.77	-0.02	0.67	-0.16	0.35	8.3
	4.19	-0.19	4.20	-1.11		

[a]Defined in the Appendix.

TABLE 5.--REGRESSION RESULTS: U. S. HOG PRODUCERS OPERATING IN A COUNTERCYCLICAL FASHION 1942-1961

Strategy[a]	Intercept	$\lambda\gamma\rho b$	$(1 - \rho) + (1 - \gamma)$	$(1 - \rho)(1 - \gamma)$	R^2 Adjusted	F
A	0.31 1.56	-0.98 -0.48	0.87 3.69	-0.06 -0.25	0.68	15.7
B	0.20 0.87	0.01 0.09	0.81 3.33	0.14 0.21	0.60	11.9
C	0.76 4.42	-0.59 -2.80	0.17 1.01	0.21 1.22	0.86	44.9
D	-0.54 -0.55	-0.28 -1.14	0.64 2.99	0.32 1.54	0.90	66.6
E	0.73 4.07	-0.21 -1.25	0.61 3.41	-0.18 -0.98	0.45	6.7
F	0.09 0.47	-0.35 -0.88	0.47 2.37	0.35 1.49	0.63	13.4
G	0.19 0.69	-0.05 -0.24	0.42 1.80	0.35 1.53	0.27	3.6

[a]Defined in the Appendix.

TABLE 6.--REGRESSION RESULTS: U. S. HOG PRODUCERS OPERATING IN A COUNTERCYCLICAL FASHION 1962-1981

Strategy[a]	Intercept	$\lambda\gamma\rho b$	$(1 - \rho) + (1 - \gamma)$	$(1 - \rho)(1 - \gamma)$	R^2 Adjusted	F
A	0.45	0.24	0.37	0.39	0.50	8.8
	1.99	0.89	1.54	1.70		
B	0.36	0.30	0.41	0.41	0.70	15.3
	1.86	0.78	1.78	1.79		
C	0.38	0.11	0.53	0.11	0.52	0.8
	1.64	1.03	0.46	0.46		
D	0.06	-0.27	0.59	0.29	0.86	39.8
	0.57	-2.08	2.80	1.32		
E	0.09	-0.38	0.57	0.32	0.42	5.7
	0.40	-1.95	2.54	1.38		
F	0.30	0.15	0.60	0.26	0.84	35.9
	2.17	0.41	2.50	1.09		
G	0.74	0.05	0.68	-0.31	0.24	3.0
	2.57	0.26	2.68	-1.32		

[a]Defined in the Appendix.

All significant coefficients are of the expected magnitude and sign. The construction of the dependent variable is such that it would behave randomly were the efficient market hypothesis to hold. There was a great deal of consistency in the decision rules of almost all the strategies. Any concerted attempt by producers to use any of the strategies would result in a reduction in the profitability of almost all strategies.

The figures in table 7 are the estimated values of λ assuming $b = 1$. They indicate that the reason for the pre-1941 cycle in prices was an overreaction by procyclical producers to price changes, i.e., the original cycle was caused by some form of cobweb behavior. The change in amplitude of the price cycle, caused by countercyclical agents, was strengthened via its effect of the signals used by procyclical agents ($\lambda > 1$).

By 1962, the estimated values of λ are negative in all but two cases. The proportion of producers behaving in the manner predicted by the cobweb model had become insignificant by the 1960s. When one considers the large losses suffered by procyclical producers prior to this date, the demise of such production rules is understandable.

The estimated intercept term $\widehat{(\rho\gamma a + \phi)}\,\lambda$ is with one exception in the region bounded by zero and one. The term, $\rho\gamma$, is positive. The expected value of ϕ is one. If λ is greater than one, then the intercept can only be less than one if a is negative. To see why this might be the case, consider equation 4, where the a is the intercept term in the relationship between his subjective evaluation of the strategy and his desire to adopt the production changes emanating from it. A potential countercyclical producer can only evaluate a strategy based on its past performance. If he considers the effect

TABLE 7.--ESTIMATED VALUES OF THE MULTIPLIER EFFECT λ FOR EACH TIME PERIOD

Strategy[a]	λ 1902-1981	1902-1941	1942-1981	1942-1961	1962-1981
A	3.13	4.25	0.05	5.15	-1.00
B	1.77	2.94	0.80	0.20	-1.66
C	1.24	1.41	-0.73	0.95	-0.30
D	2.04	4.81	3.00	7.00	2.25
E	0.63	3.56	1.08	0.37	3.45
F	1.61	3.58	0.56	1.94	-1.07
G	2.70	3.77	0.57	2.26	-0.08

[a]Defined in the Appendix.

on prices of other similar agents in a manner similar to figure 2, he may be biased against adoption. In this case, a will be negative, i.e., some countercyclical agents may decide that, because such information is public, the profitability of the strategy cannot continue.

The question remains as to why the relative number of countercyclical producers remained so small, i.e., why did the cycle persist through to the second half of the century? It is obvious that a large group of producers was behaving procyclically despite the large losses this entailed. A rational explanation for this behavior can be made by introducing the concept of a market for information.

Information is not a free good. There are costs involved in assimilating and utilizing all information. This includes data that are publicly available. Costs that should be included in acquiring information needed to predict cycles include the effort required to collect data on past cycles, current livestock births and slaughters, and the relationship between these data and meat prices. These costs seem irrelevant today but must have seemed enormous at the turn of the century when national livestock statistics and relative prices were difficult, if not impossible, to obtain.

The expected benefits accruing to the owners of such information would depend on their confidence in their price predictions; the magnitude of output changes, if any, resulting from its use; and the expected increase in profits arising from such behavior. These profits will depend, in turn, on the magnitude of the price cycle. Also, the average size of hog-producing units was relatively small in the early part of the century. For many of the smaller producers where hog production was a sideline activity, the magnitude of any countercyclical response could never be large enough to compensate them for collecting and using the volume of data required.

As with any good, rational agents will continue to purchase information until the expected benefits of the last unit purchased equal the cost. Thus, when information is expensive, little, if any, will be purchased. Under these conditions, it is possible for predictable cycles to exist. This can occur when agents expect prevailing prices to continue or because they are forced to base their herd size on the profitability of the enterprise.

V. FUTURES MARKETS

Futures market trading in pork bellies began in the early 1960s. This market made it feasible for a group of traders to specialize in predicting hog prices. Their combined estimate of future cash prices is available in daily price quotations. This represented a large drop in the price of information to producers and would be expected to influence countercyclical behavior.

In table 8, the results of models which allow for this information are presented. The variable Futures Volume is the combined yearly trading volume (in tens of thousands) for both pork bellies and live hogs [Chicago Mercantile Exchange (1961-1982)]. The implicit assumption here is that producers' evaluation of such information was proportional to the liquidity of these markets. The negative sign on this variable is consistent with the hypothesis that these markets contributed to the elimination of the cycle. The small t statistics may be due to the relatively short duration of these price forecasts (less than one year) or because the impact of this new information was insufficient to speed up the rate at which cycles were being eliminated.

TABLE 8.--THE INFLUENCE OF FUTURES MARKETS ON HOG CYCLES OPERATING IN A COUNTERCYCLICAL FASHION 1902-1981

Strategy[a]	Intercept	$\lambda\gamma\rho b$	$(1 - \rho) + (1 - \gamma)$	$(1 - \rho)(1 - \gamma)$	Futures Volume	R^2 Adjusted	F
A	0.55	-1.02	1.11	-0.41	-0.38	0.79	76.8
	3.49	-2.77	10.65	-3.91	-0.81		
B	0.31	-0.46	1.16	-0.42	0.00	0.80	77.6
	2.55	-2.05	11.17	-4.02	0.01		
C	0.36	-0.51	0.93	-0.28	-0.39	0.77	68.0
	3.64	-2.84	0.44	-2.58	-1.87		
D	0.28	-0.57	1.21	-0.46	-0.28	0.84	96.99
	2.38	-1.98	11.78	-4.43	-0.89		
E	0.49	-0.28	1.17	-0.40	-0.53	0.77	68.04
	3.43	-1.19	11.09	-3.81	-1.23		
F	0.60	-0.47	1.13	-0.40	-0.02	0.78	71.56
	3.94	-1.82	10.75	-3.80	-0.65		
G	0.23	-0.59	1.24	-0.35	-0.54	0.87	136.0
	0.96	-0.85	11.56	-3.37	-0.88		

[a]Defined in the Appendix.

VI. SUMMARY AND CONCLUSIONS

Predictable movements in hog prices have existed. This does not imply that all producers were behaving irrationally. There is evidence that the costs involved in acquiring and using the necessary information were higher in the early portion of the century than today and that, as the cost of information fell, a proportion of producers noticed and began reacting to the predictive power contained in hog cycles. However, the effect of these producers on the profitability of countercyclical behavior was not immediate. Two possible reasons for this inertia are supported by the data. The first is the time needed to evaluate a strategy and the decision to begin implementing it. The second is the difficulty involved in adjusting herd size at the speed required to utilize fully the concept of predictable price movements. One factor that tended to mitigate these effects and speed the dampening process was the change in the signals used by procyclical producers, caused by the early countercyclical ones. The results show that a significant portion of producers eventually noticed the cycle and acted to eliminate it.

These results have interesting implications for cycles in other industries. In 1976, beef slaughter reached what appeared to be a cyclical peak. Since then, the advice of many Extension Agents has been for producers to remain in the industry. Their adivce was based on the concept that, when enough procyclical producers have left, production will fall and profitability return. This has not occurred; the industry has never returned to a profitable level. It may well be that the ratio of countercyclical to procyclical producers has reached the point where the cycle has been eliminated or reversed.

APPENDIX I

STRATEGIES USED

(A) Beginning in 1902, expand for two years; then contract for two years. This is an application of Brenner's (1895) advice. The four-year hog cycle is standard [Breimyer (1959) and Meadows (1970)].

(B) Beginning in 1903, expand for one year; maintain herd size; and then contract for one year.

(C) As in (B), but starting in 1904; the motivation for either of these strategies is to avoid intrayear turnarounds in the price as the cycle reaches peaks and troughs.

(D) Expand whenever hog slaughter per capita increased in the previous year.

(E) Expand if hog slaughter was above trend for two previous years. The motivation for both (D) and (E) is that large slaughter figures can indicate a reduction in the breeding herd.

(F) Expand if the average nationwide price paid for fat hogs fell for two consecutive years; contract if the price rose. This is similar to strategy (A) but allows producers to get back in phase when exogenous events disrupt the cycle.

(G) Contract if the nationwide price fell. Red meat supply is defined as five times the total number of hogs slaughtered plus the total number of cattle slaughtered. The motivation for this strategy is that high beef prices will cause an increase in demand for its substitutes, namely, pork.

FOOTNOTES

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