THE CATTLE CYCLE AND THE RANGE LIVESTOCK INDUSTRY

by

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STATEMENT BY AUTHOR

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ABSTRACT

This study was initiated to study the impact of the cattle cycle on the range livestock industry, in relation to policies for administration and development of public lands. Two hypotheses are tested by using econometric models. The first hypothesis holds that the output of the livestock industry is separable into two components, one produced by firms in response to longrun changes in the economy, and the other produced by firms responding to changes in shortrun price ratios. These components are called the stable and the unstable subsets. The second hypothesis is that the range livestock industry is not in that part of the livestock industry which is responsible for the cyclical behavior of prices and inventories in the industry as a whole. Statistical tests of models derived from these hypotheses result in accepting both of these hypotheses. This suggests that theoretical and applied studies of the cattle industry may be advanced by regional analysis of the industry, in place of the past practice of analyzing the industry in the aggregate. Since important concentrations of livestock in the West are in areas uninfluenced by federal land, this suggests that rigidities in federal grazing policies are not responsible for supply rigidities in livestock ranching. An important conclusion is that management decisions on federal lands need not take account of year-to-year changes in cattle markets.

CHAPTER ONE

INTRODUCTION

Important problems of economic theory and policy center about dynamic mechanisms producing cyclical fluctuations in industries and aggregates within the economy. These fluctuations are of direct practical concern for individuals and institutions in the industries affected. They also relate directly to public policy in the areas of income and employment stabilization, and aggregate efficiency of resource use in the economy. To the economic theorist, concerned with developing models for the purpose of explaining and predicting behavior within the economy, these cyclical movements are an important challenge. The task is to formulate dynamic models which embody the following elements: technical relations (production functions), expectations hypotheses (describing the formation of plans) and managerial response functions (describing how the industry reacts to conditions depicted by the above functions) plus actual market results derived from industry supply and consumer demand functions. Such a model will describe the time path of production, marketings, inventories, and prices and will illuminate the dynamic influences producing long run cyclical movements (Figure 1).

The phenomenon known as the cattle cycle is a periodic cyclical fluctuation in prices of beef cattle. Over six cycles, the average period has been roughly 11 years in breeding herd inventory and nine

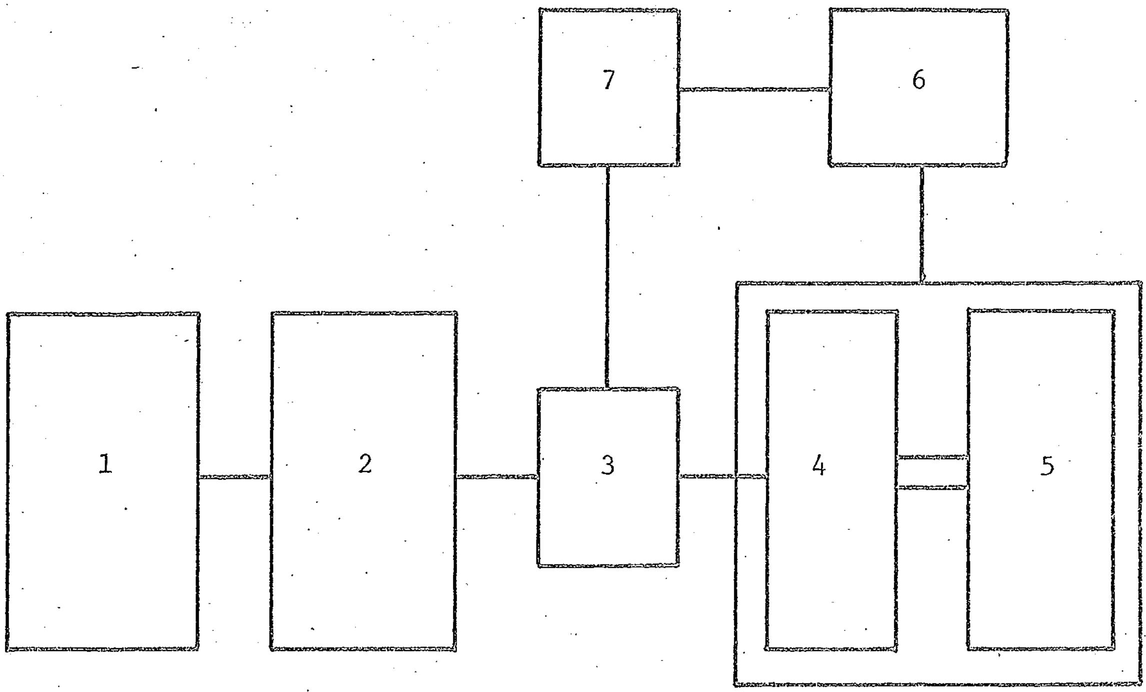

Figure 1. Structure of a General Model of the Livestock Economy.

Boxes in this flow sheet represent components of a general model of the livestock economy. Box 1 is the production function; Box 2 is the derived marginal cost function; Box 3 is the marketing decision; Box 4 is actual supply; Box 5 is market demand; interactions between (4) and (5) produce the market price which is input into the expectation function, Box 6; Box 7 is the managerial response function.

to ten years in prices. The cycles are roughly 180 degrees out of phase, that is, one cycle peaks when the other reaches its minimum. The cycle in inventory has been superimposed upon a general rising trend in numbers since the 1920's. There has been little trend in the general level of cattle prices since World War II. Variations from year to year are not large, but the overall amplitude of the price cycle at farm level was roughly $6.00 per hundredweight over the last full cycle. Indications are that the cycle is gradually shortening in period, and decreasing in amplitude. The term cattle cycle is used in this report to denote both of these cycles together. Detailed description of the cattle cycle may be found in Williams and Stout (1964) and in Ehrich (1966).

This study deals with the impact of the cattle cycle on the ranch livestock industry of the western United States. It grows out of an attempt to construct an econometric model of the cattle industry in the State of Arizona. After several attempts to avoid facing the problem of the cattle cycle, the writer realized that any model ignoring it would not be a model at all, but merely a flimsy rationalization of the data. It was also realized that if strong secular fluctuations tended to develop within the industry in response to price changes, certain generalizations important for resource administration could be made (Cromarty, 1967).

A fruitless search for a mathematical model that would capture the elements shown above, and at the same time be simple enough to be analytically tractable, was after a time abandoned in favor of a simpler approach to the problem. The following null hypothesis was proposed: The cattle cycle is a price and inventory cycle generated within some subset of the total livestock economy. This hypothesis will be tested by means of a simple model of the livestock industry. An important further question follows immediately: Which sector of the industry generates the cattle cycle? The second null hypothesis of the study is: The ranch livestock industry does not generate the cattle cycle.

There are several strong theoretical reasons for believing that the cattle cycle may be generated within the ranch livestock economy. There are also strong practical reasons for believing that it is not. We shall see that the evidence suggests that both null hypotheses be accepted.

The implications of accepting the null hypotheses for grazing policy are clear. If the ranching industry as a whole shows no strong tendency to expand and contract inventories in response to the cattle cycle, then lease policy can concentrate on range and weather conditions for stocking rate decisions, and ignore the market. Current marginal products of forage may then be approximated by some system of adjusting use fees to correspond to the level of prices received for marketed output in the current year.

Method of the Study

This short section describes the scientific philosophy underlying the methods used in this study. It is necessary in order that the tentative and conditional nature of the conclusions may be fully appreciated. It is also appropriate to indicate briefly the methodological outlook employed, since there is no clear agreement among social scientists as to a single theory of social knowledge.

This study is based upon the conviction that research in wildland economics must be relevant to the problems of men in society. This means confronting policy problems. It is also held that fruitful study of policy requires appropriate use of relevant theoretical constructs. This is necessary because in policy discussions it is often found that statements of theory are confused with statements of fact. This means that the first task is to begin with rigorously specified and tested theories and models, which simultaneously specify what is held to be theory and what is held to be fact. The statement that "ranchers maximize profits" has two dimensions: that of an empirical generalization and that of an *a priori* postulate. Careful use of theoretical concepts assures that policy discussion proceeds with a clear understanding of what is known and of what is being assumed.

The methodological approach used in this study is logical positivism, and more specifically, the hypothetico-deductive method of inquiry. The method is the well-known procedure of formulating a system of generalizations about behavior, deducing testable consequences, then judging the generalizations on the basis of their ability to predict (explain) the relevant facts. The core of the method is the null hypothesis: a testable generalization derived from *a priori* considerations, which is to be compared with facts by means of accepted procedures of inference. The acceptance or rejection does not close the issue, but merely allows one to place a greater or lesser degree of confidence in the underlying generalizations.

This study proceeds, then, "to employ questionable premises and use them to obtain questionable conclusions" (Baumol, 1967). The study will use models based on simplifying generalizations which depict the structure of the relationships under study. We begin with empirical generalizations because from postulates with no empirical content no empirical hypotheses can be deduced: ex nihilo, nihil fit. The logic of positive economics requires that these generalizations be tested by their capacity to preduct events, and not by their "realism". The postulates are used to deduce "meaningful theorems" in the sense of Samuelson (1965): hypotheses "about empirical data which could conceivably be refuted, if only under ideal conditions." These "ideal conditions," of course, are rare indeed in applied work.

This brings us to the role of econometrics in this study. Many workers employ tools of statistics and econometrics without being conscious of their role in science. The statistical method is simply a widely accepted body of conventions used for comparing data with hypotheses. The tools of statistics are deduced mathematically from quite general formal postulates. Hence, it is impossible to prove anything with statistics. Statistics provide merely an impersonal standard for agreement among research workers.

It will soon become apparent that this is not a piece of policy research in the usual sense; we shall wander far from policy and administration in the econometric work ahead. This is a study in the background for policy; not of policy itself, but of the economic regularities within the ranching industry which policy must recognize. We are only marginally concerned with the details of grazing policy. The primary result is a general statement of great importance for the theory of the cattle cycle. The secondary result is a statement relating to the specific arrangements used in leasing grazing rights on federal lands in the western United States.

Before describing the study and its results, it will be helpful to define some terms, to be used with standard meanings throughout. The _range livestock industry_ is assumed to be congruent with the beef-producing industry of the 11 western states, which is based upon the extensive exploitation of naturally growing forages. This definition naturally obscures quite a bit of diversity within the industry, but is necessary in an exploratory study such as this.

The term _livestock industry_ is used to denote the entire beef-producing industry of the nation, of which the range livestock industry is naturally a subset.

The two groups of firms defined by hypothesis I are termed the _stable set_ and the _unstable set_. The terms stable and unstable are not used here in the same sense as in the field of mathematical economics, wherein they refer to the characteristics of a mathematically defined equilibrium position. No statement is made about what parts of the livestock industry may eventually be found in these two sets; they are merely employed as a convenient analytical tool. The second hypothesis is a specific hypothesis about the range livestock industry relating to these concepts; it is not held that only one geographic division of the industry can occupy either set.

It will be noted that in speaking of supply response to prices, I never use the term elasticity, but rather some more general and vague term such as "degree of responsiveness" or "sensitivity" to prices. This is because I estimate no true elasticities in this report, and prefer to use the term elasticity in its mathematical sense.

Models Used in the Study

Two models are developed in this study, corresponding to the two null hypotheses suggested. Model I tests the first hypothesis, namely that regarding the separation of the industry into a stable and nonstable classification of firms. Model II tests the hypothesis that the range livestock industry is not in the unstable set.

CHAPTER TWO

MACRO MODEL

Agricultural economists have long recognized that fixed production lags in an industry may, even when connected with reasonable price expectation models, produce long run cyclical fluctuations in output and price. This concept was set forth in the 1930's in Ezekiel's paper, which grew out of studies of the hog cycle (1938). The area of cattle cycle analysis has been based mostly on heuristic descriptive models of how price changes induce shifts in breeding herd sizes which in turn produce lagged output effects. Recently, analytical work has proceeded to isolate causal mechanisms involved and to test theories about the causes of cyclical movements. Recent papers are those of Maki (1962, 1963), Reutlinger (1966b), and Egbert and Reutlinger (1965).

The problem of the cattle cycle is a special area of the general field of supply analysis. It is set apart from the rest of supply analysis by the fact that it is a dynamic process, requiring dynamic tools for its analysis. The dynamic character of the process is introduced by the fact of the interdependence of production possibilities through time, and by the lags in output results which allow for the expectations at planning time to be unrealized at marketing time. These facts mean that the industry supply function cannot be identified with the horizontal summation of the firm marginal cost functions.

Most studies of the livestock economy in the past have employed static demand-supply analysis concepts, coupled with simultaneous estimation of demand and supply functions, as called for by standard econometric practice. These studies have commonly focused on the consumer level, attempting to explain per capita consumption of meat in relation to the level of meat prices. In recent years, these studies have reached greater levels of sophistication, as investigators test specific hypotheses about market behavior. Important early studies of the static sort are Hildreth and Jarret (1955) and Fox (1958) and Working (1954).

Recent applications of the method are given by Reutlinger (1966b) who shows a negative elasticity of supply for cow beef, and by Feltner (1968), who studies the relation between feed grain policy and the livestock economy.

The model shown in Figure 1 suggests that while marginal costs affect production decisions in the short run, they affect marketing decisions only indirectly, by way of a constraint. The complete process must be described by a dynamic model of the type described in Figure 1.

Economists from the time of Malthus have concerned themselves with theoretical models of economic fluctuations. There is a vast literature on the subject which contains much that is of use for the study of the cattle cycle. One example is the Metzler inventory cycle model. Another related area is that of building cycles, which are in principle quite similar to cattle cycles. Business cycle theory is reviewed in texts such as that by Gordon(1952), and will receive no further comment here.

In the mid-fifties agricultural economists began to explore supply responses of farmers using new concepts. A leader in this movement was Marc Nerlove (1956, 1958a, 1958b), who experimented with distributed lag hypotheses and other concepts based upon price expectations and assumed adjustment paths. These advances are described in a series of important articles, and in Nerlove's 1958 book. The ideas contained in these publications were tantamount to abandoning the classical short run supply function and replacing it with a concept of a desired output based upon expected prices, and an adjustment equation.

These concepts were further advanced by Larson (1964, 1967) when he presented his important contribution to the theory of the hog cycle. Larson showed that under certain reasonable assumptions, the hog cycle can be viewed as a harmonic motion phenomenon. This model represents a crucial breakthrough from our viewpoint, for it takes the final step to a fully dynamic model. The harmonic motion model generates an infinite progression of uniform oscillations, starting from given initial conditions.

At first reading, the harmonic motion model seems hopelessly naive and mechanical. But that is not the point. The point is to explain the mechanism underlying the cyclical behavior of prices and quantities in terms of price expectations and production responses of farmers. The harmonic motion model is a fertile basis for further study, for it may be modified to include different price expectation hypotheses, supply responses, and stability conditions for all these cases may be derived. Ehrich has suggested that the Larson model may be applied to the cattle cycle, but he fails to make a convincing case for this in his bulletin. Another mathematical contribution analyzing hog supply is the paper of Meyers and Havlicek (1967) which presents a mathematical model of short-term hog supply.

Important advances in the construction and analysis of dynamic models have been made recently. The contributions of Crom and Maki (1965), Egbert and Reutlinger (1965), and Reutlinger (1966a) are significant. They point the way to a fruitful welding together of dynamic mathematical concepts and methods of statistical estimation that can be expected to revolutionize the science of predicting economic magnitudes in agriculture. The basic method is to make parameter estimates by regression in a dynamic model, then use the model to recursively generate future values of endogenous variables. This approach frees the projections from dependence on projected values of exogenous variables.

A word is in order here about the cobweb theorem and its relation to this problem. The cobweb theorem is a simple mathematical model based on supply functions which relate to the last period's price, instead of current price. Demand is a function of current price, and markets are cleared. Hence, if price escapes from equilibrium, there will be oscillations about the equilibrium price. The analysis can be reduced to a simple difference equation, from which may be deduced stability conditions and the shape of the path to equilibrium. This model, introduced to American economists by Mordecai Ezekiel, has been suggested as an explanation of the hog cycle; Cochrane (1958) gives several other applications. The workings of the model are analyzed graphically in the original 1938 paper, and mathematically in Allen (1965).

As a general concept, the cobweb theorem is valuable for its emphasis on the role of price expectations and supply responses. The cobweb is simply a dynamic model that uses a classical supply function for a response function. The Larson approach is thus a generalization of the cobweb theorem, obtained by dropping the clsssical supply function and using differential equations instead of difference equations. Economists have unfortunately been content to sit back and criticize the alleged naiveté and simplicity of the model, rather than explore its potential implications by developing more realistic formulations. Some of the few original attempts at generalizations of the model are found in Waugh (1964) and in Allen (1965). Applications may be found in Cochrane (1958).

This discussion of the general problem is necessary as background for this study, to show how its hypotheses contribute to the understanding of the cattle cycle. The studies cited have approached the problem by considering the industry as an aggregate over the entire nation. This ignores regional differences in resources and industry structure: Southern Coastal Plain and arid West are breeding grounds, the Corn Belt the great feeding and slaughtering region, and the Midwest and Northeast are major suppliers of cow beef and veal as by-products of dairying (Bray, 1966; Williams and Stout, 1964). These considerations suggest that as a prelude to model building, it would be worthwhile to see if the cattle cycle is generated within some subset of the total livestock economy. This done, the appropriate analytical tools and the relevant variables for the dynamic model shown in Figure 1 will be apparent. So the contribution to theory made by this study is to test two simple hypotheses about the cattle cycle. Econometric analysis suggests that both hypotheses be tentatively accepted. This suggests that the search for the driving mechanism of the cattle cycle will be a necessary preliminary to any fully general theory. A further conclusion is that the ranch livestock industry is probably not the locus of the dynamic forces producing the cattle cycle.

Hypothesis One: A Model

The first hypothesis under test involves the output of the livestock industry. One subset adjusts output to levels consistent with longrun expectations of basic market variables: prices and incomes. This subset is relatively insensitive to shortrun shifts in price ratios, and is called the stable subset. This subset is unlikely to be responsible for the cattle cycle, since it does not contain cyclically unstable breeding herds. The other subset, the stabe subset, produces in response to shortrun price ratios. This subset is the one in which are concentrated the breeding herd fluctuations and output changes which are responsible for cyclical fluctuations in prices and marketings in the industry. No attempt is made at this stage to identify these subsets with any particular groups of firms or geographic sectors of the industry.

To test the usefulness of this hypothesis, a statistical model is deduced from it. The hypothesis implies:

$$Q_t = S_t + U_t \tag{1}$$

where Q_t is total marketings of livestock during period t, S_t is marketings of stable subset, and U_t is marketings of unstable subset.

A basic issue is to define precisely the nature of the expectations used to determine S_t. We assume that price changes and income changes are the major planning variables, and seek a hypothesis which relates S_t to these variables. A preliminary model was developed using annual "expected prices" and "expected incomes" based on linear regressions against time. This approach, of course, produced almost perfect multicollinearity in all the variables relating to S_t, and it was impossible to test hypotheses regarding S_t. The solution to this conundrum is to introduce the expectations hypothesis directly into the model, thereby making time an explicit variable in the analysis. This has the advantage of reducing the number of variables in the final reduced form, and of rendering the expectations hypothesis testable by statistical means.[1] The model is then:

---

1. This approach was suggested by Professor B. J. Marks

$$
\begin{aligned}
S_t &= a_0 + a_1 \log\overline{Y}t + a_2\overline{P}_t \\
\overline{Y}_t &= de^{kt} \\
\overline{P}_t &= b_0 + b_1 t \\
U_t &= c_0 + c_1 P_t^* + c_2 F_t^* \\
P_t^* &= P_{t-1} + g\,(P_{t-1} - P_{t-2}) \\
F_t &= F_{t-1}
\end{aligned}
\tag{2}
$$

where $\overline{Y}_t$ is expected level of consumer disposable income in year t, $\overline{P}_t$ is expected level of output prices used in stable subset, P_t^* is expected price used in unstable subset, and F_t^* is expected price of feed in unstable subset. The model is completed by the identity in (1).

The construction of the model is fairly straightforward, calling for little comment. Marketings in the unstable subset are held to depend linearly upon the logarithm of income; this allows for incorporating constant percentage growth of income over time. Marketings in the unstable subset are thought to depend upon expected prices of outputs and inputs, as represented. To render this formulation operational, expectation models must be introduced into the model; these are the last two equations.

To derive the reduced form implied by this model, first notice that:

$$\log\overline{Y}_t = \log d + kt. \tag{3}$$

This is a happy result, since it allows us to employ time linearly in the reduced form. Replacing $\overline{Y}$ and $\overline{P}$ in the expression for S_t yields:

$$S_t = a_0 + a_1 \log d + a_1 kt + a_2 b_0 + a_2 b_1 t. \tag{4}$$

Similarly for U_t the derived expression is:

$$U_t = c_o^{`} + c_1 P_{t-1} + g(P_{t-1} - P_{t-2}) + c_2 F_{t-1}. \tag{5}$$

$$= c_0 + c_1 P_{t-1} + c_1 g P_{t-1} - c_1 g P_{t-2} + c_2 F_{t-1}$$

The identity in (1) instructs us to add (4) and (5); accordingly,

$$Q_t = B_0 + B_1 P_{t-1} + B_2 P_{t-2} + B_3 F_{t-1} + B_4 t. \tag{6}$$

Coefficients are renamed as follows:

$$B_0 = c_0 + a_0 + a_1 \log d + a_2 b_0$$

$$B_1 = c_1 (1+g)$$

$$B_2 = -c_1 g$$

$$B_3 = c_2$$

$$B_4 = (a_1 k + a_2 b_1)$$

It will be observed that (6) is indeed a reduced form, since all of the variables on the right side are predetermined as of time t.

Statistical Specification

We have in (6) a formal statement of an empirically testable relationship derived from our original hypothesis. We have now to specify a statistical model which will allow us to derive estimates of the B_i and to test hypotheses about them (Goldberger, 1964; Graybill, 1961). The statements in the literature about the minimum acceptable specification for such a model vary widely, depending upon the author chosen. Christ (1966) gives an exhaustive list of assumptions required for estimating a variety of models by a number of single-equation and system methods. Tintner (1965) and Graybill (1961), by contrast, begin with a very economical set of assumptions which are not adequate to cover all the pitfalls commonly found in econometric work. Commonly, biometrically inclined writers (such as Graybill) employ small lists of assumptions, where econometricians find it necessary to explicitly state a larger number. The reason for this is that the biometrician commonly analyzes controlled, planned experiments. These experiments are not subject to the estimation problems encountered when working with economic data. We shall employ the specification used by Johnston (1963, Ch. 4) and by Goldberger (1964, Ch. 4). The statistical model is:

$$Y - BX = u \qquad (7)$$

Y is a T X 1 matrix of T observations on the endogenous variable.

X is a T X K matrix of T observations on each of K predetermined variables.

B is a vector of K coefficients of predetermined variables.

u is a vector of disturbances.

The purpose of the statistical specification is to place appropriate restrictions upon the above vectors and matrices and thus to preserve the mathematically derived properties of the estimators of B and var (u). These properties are discussed in Johnston (1963) and in Goldberger (1964); Christ (1966) gives proofs of properties for several related model specifications. Valavanis (1959) gives a valuable discussion of the role of the statistical specification. The specification adopted here is as follows:

a. model linear in unknown parameters B and variables X

b. $E(u) = 0$

c. $E(uu') = \sigma^2 I$

d. X is a set of fixed numbers

e. rank of $X = 1 + K \leq T$

f. u is a vector of mutually independent normally distributed variables with common expectation and variance given by (b) and (c).

g. model identified

The specification is straightforward and calls for little comment. Assumption (a) allows the use of a linear model. Assumptions (b) and (c) assure that the expectation of the u's will be zero and that they have common variance σ^2 for all t, with zero covariances between periods. Assumption (d) says that X is fixed under repeated sampling, that is, it is a nonrandom matrix. This assures that the random variation in the model is concentrated in the u vector, and that the X's cannot be correlated with u. Assumption (e) states that the columns of X are linearly independent, and that the observations exceed in number the parameters to be estimated, thus assuring that (X'X) has an inverse.

Model I: Estimates

Data used to estimate parameters in Model I are from standard sources, as follows:

P_t = Beef cattle: Average price received by farmers, 40 states, weighted by quantity sold. Livestock and Meat Statistics 1962 p. 261 and supplements

Q_t = Beef cattle marketed. Agricultural Statistics 1967

F_t = index of cost of feed grains, Feed Statistics Through 1966. (USDA, 1967.)

Estimated coefficients and test statistics are given in Tables 1 through 3. The model explains 97% of the variance in marketings over the sample period. This figure is unusually high for an econometric model. Several reasons for this are the autocorrelation shown in prices (Table 3) and the strong time trend in marketings, which means that a large chunk of the variance of Q_t is accounted for by the time variable. The vonNeumann's ratio test indicates nonsignificant autocorrelation in the residuals. The intercorrelations shown are well within the range considered acceptable by many investigators (Fox,

Table 1. Parameter Estimates, Model I

Variable	P_{t-1}	P_{t-2}	F_{t-1}	t
Coefficient	-5.82	1.74	1.45	12.72
t	-5.28	1.62	2.39	14.92

Constant term 142.64 $R^2 = .97$

Table 2. Analysis of Variance, Model I

Source	DF	SS	MS	F
Regression	4	51950.69	12987.67	90.58
Residual	11	1577.24	143.39	
Total	15	53527.94		

Table 3. Highest intercorrelations, Model I

$F_{t-1} \times t$	-.63
$P_{t-1} \times P_{t-2}$	.58
$P_{t-1} \times F_{t-1}$	.51

von Neumann's ratio test (Ezekiel and Fox, 1959)

R = 2.245 U = .224

Nonsignificant autocorrelation is indicated. (alpha = .05)

1968; Goldberger, 1964; Farrar and Glauber, 1967). Predictions and actual values are graphed in Figure 2.

Conclusions: Model I

The statistical results shown for Model I lead to the conclusion that hypothesis I may be accepted. On the basis of the estimates presented, we can say that the hypothesis does not clash with the evidence presented. It is still possible, however, that other interpretations of this model may be correct. There is certainly nothing new in relating cattle output to lagged prices and the price of feed. But at least this model is a test of a specific hypothesis; it has logical foundation as well as empirical content. More has been accomplished than to rehash the familiar tautology that "output in period t is strongly correlated with cattle inventory on January 1 ", which tells us precisely nothing.

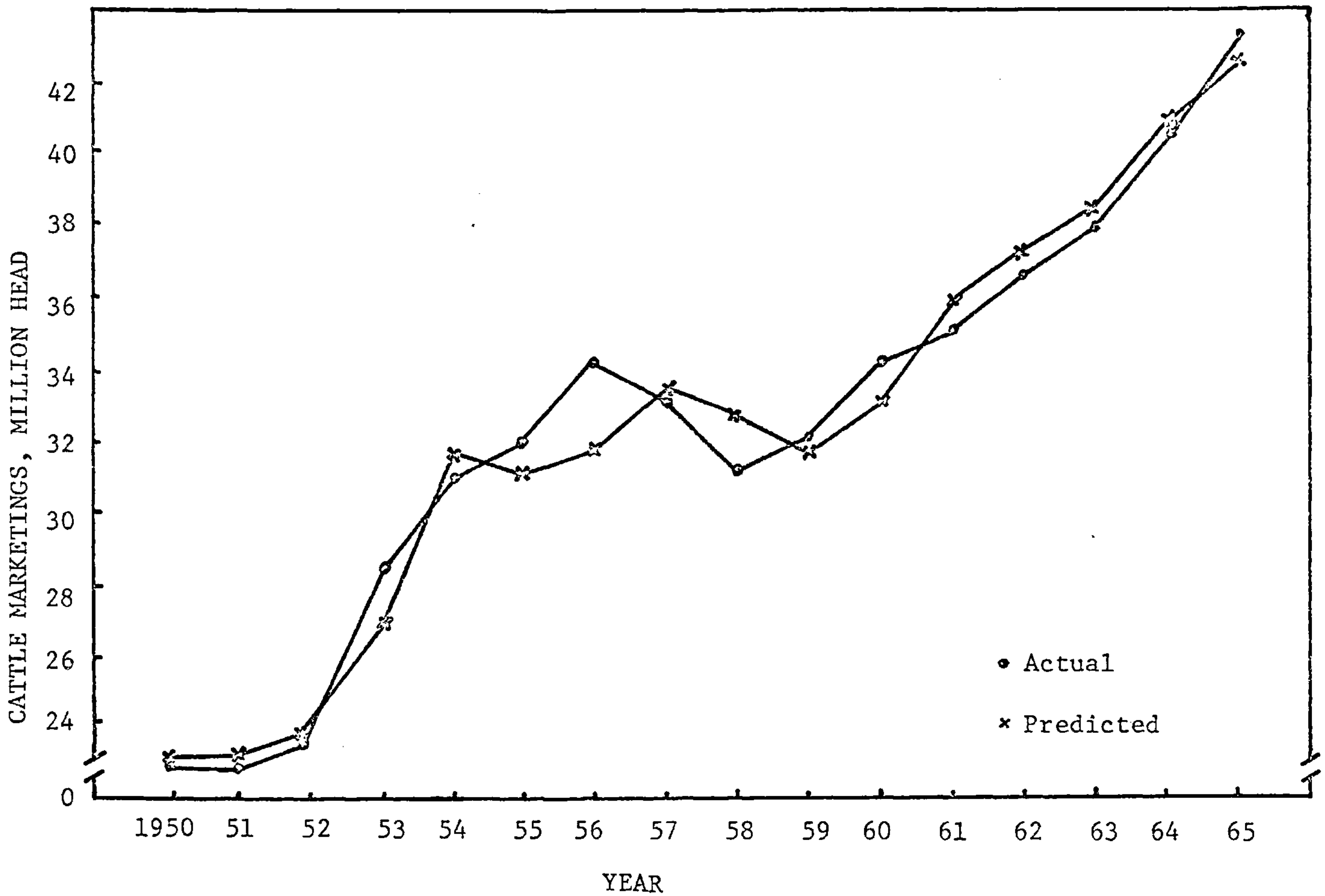

Figure 2. Calculated and actual values of Q_t, Model I.

CHAPTER THREE

MICRO MODEL: MODEL II

Work reported in the previous chapter has led us to accept the first null hypothesis of the study. It is now necessary to assure ourselves that the suggested interpretation of this behavior is correct. Then we desire to test the second null hypothesis, with a view towards identifying the unstable subset responsible for dynamical fluctuations.

We must first establish that the stable and unstable subsets developed above may be identified with actual geographic or functional divisions of the industry. We must be certain that these constructs do not in fact represent different aspects of the behavior of the same firms, i.e., of all firms in the industry. The model developed for this purpose will be referred to as model II. It is a model which attempts to depict the structural basis of marketing decisions within the ranch livestock industry. This model is also employed to test the second null hypothesis. This is possible since the acceptance of the null hypothesis implies that the above interpretation of model I is correct (the converse is not true). If the null hypothesis is rejected, we must seek another supplementary test for the proposed interpretation.

The second null hypothesis of this study is as follows: The ranch livestock industry is not the unstable subset. The test of this hypothesis will yield two useful results: it will narrow the area of search for the unstable subset, and it will provide implications for public land leasing policy.

The length of the cattle cycle suggests that the production lag between the time that a calf is retained for the breeding herd and the time that her offspring reach market is the crucial determinant of the length of the cycle. The length of the lag may be two to three years. This introduces a price expectations problem, since the decision to hold a calf or sell it depends upon expected prices for calves in the future. This situation produces the cobweb-like phenomenon of expectations being betrayed by market results, in turn producing an overreaction to the previous errors, which produces further disequilibrium in the market in the next period.

These considerations lead us to seek the unstable subset in some cattle breeding region of the nation. Arizona has been primarily a breeding area since the turn of the century (Wagoner, 1952), as has the entire Rocky Mountain range region. Another important breeding area is the Southern Coastal Plain; the Corn Belt is also a significant producer of young cattle (Williams and Stout, 1964; Fowler, 1961). The strong dependence of the western cattle industry on calf marketings suggests that it is a prime candidate for being the locus of the unstable subset.

Other considerations suggest another conclusion, however. It is true that a breeding area is likely to be in the unstable set, but there are other breeding areas in the country. It appears that many ranch operators, instead of basing output plans on price, base plans on their estimates of range carrying capacity in the coming year. This approach, in fact, has much to recommend it from the individual firm's point of view. Forage conditions are so unstable from year to year that the only rational basis for a continuing operation is a careful matching of stocking rates with forage condition.

Another fact of importance is the heavy dependence of the industry on public land for range feed. In grazing districts of Southwest Arizona, only very small amounts of land are privately owned. These public lands are grazed on a lease or permit basis using stocking rates determined by long range productivity of the resource. For many operators, then, alternatives for changing breeding herd sizes are narrow.

A detailed survey of literature has not been made, but indications are that breeding herds tend to be relatively stable. An example is found in a study of ranch adjustments to drought in eastern New Mexico: "The most stable element of ranch operations in eastern New Mexico is the breeding herd. Numbers of calves and yearlings in the inventory of a beef cattle ranch vary from year to year depending upon range forage conditions and upon price expectations, but the number of cows changes very little." (Boykin, Gray, and Caton, 1962 .)

The most persuasive evidence available for the analysis of behavior of the ranch industry is found in work reported by Martin and his co-workers (Martin and Gatz, 1968; Martin and Jefferies, 1966; Dickerman and Martin, 1967). Martin starts with the problem of explaining why ranch sale values are inconsistent with imputed values based upon beef production alone. He presents data which show very low or negative returns to management and capital. He finds that ranch prices in Arizona are nearly twice as high as can be reasonably explained by beef productivity. He concludes that a major output of the ranch industry comes in the form of consumption utility to the owners, rather than production (income) utility. He identifies ranch fundamentalism values and the desire for conspicuous consumption, and for the social position conferred by ranch ownership, as strong components of the motivation for investment in the industry.

The fact that ranch ownership itself is a very important consumption good in the western United States shows that ranches are in fact multi-product enterprises. Their value no longer depends exclusively on their economic productivity. It is possible that a wealthy man may lose a great deal of money on his ranch every year, and remain an important social and political figure. In any event, this evidence suggests that for the ranch industry as a whole it is not unreasonable to suspect that responses to shortrun changes in price may be weak.

A Model of the Ranch Economy

The cattle cycle is at bottom an investment cycle, produced by periodic overinvestments in breeding herds. It has been suggested above that strong price-induced fluctuations in breeding herds may not be important in the ranch industry. How can this claim be subjected to empirical test? The answer is to formulate a model that represents the structure of the industry, and apply the model to the data. The results should indicate whether the hypothesis is reasonable or not.

For our purposes we may distinguish two types of models that may help us in this problem. Normative models are logically derived models that describe what actions should be taken, given constraints and objective functions. In this class fall most operations research models such as linear programming and inventory control models. Several such models have been presented for firm decision-making in the livestock industry (Afzal, McCoy, and O'Razem, 1965; Allison, Amick, and Cummins, 1966; Halter and Dean, 1965). The other class of models may be termed positive models, which say, "firms act as if they tried to behave in the manner specified by this hypothesis." An example of this approach is the Friedman Permanent Income Hypothesis, which states that consumers base consumption decisions not on current or past income but on their own concept of their permanent, lifetime income. The positive hypothesis does not say that every consumer knows his lifetime income, and that he plans to spend some portion of it every year. The permanent income hypothesis merely claims that the consumer acts as if he did. This approach is in contrast to the firm-level budget studies, such as those by Caton (1965), and Boykin, Caton, and Rader, (1966), who use no models at all. They employ budget studies based upon surveys of sample ranches. This approach has the appearance of concreteness, but it is doubtful whether the accounting concepts used in the budgets are meaningful to the rancher himself. Thus, it is apparent that these studies are no less "abstract" and "unrealistic" than the approach used here, which is based on models of industry behavior.

The concept selected as a basis for Model II is a positive and not normative model. No suggestion is made that normative models are inappropriate; they are only beginning to be explored. But the model given here seems appropriate to the task, and it is, so far as I am aware, original.[2]

The hypothesis upon which this model is based may be simply stated: ranchers act so as to preserve a uniform age class distribution within their breeding herds. This hypothesis appears outrageous at first, but it must be remembered that it is a positive and not a normative concept. It also purports to represent only the behavior of the industry, not of any specific rancher. It does not deny, for example, that a man might buy Mexican steers and place them on his range during a good rainfall year.

The reason for adopting this model is that it enables us to obtain a simplified view of the structure of the industry, and to deduce qualitative predictions of the system's behavior in response to various stimuli. Thus, the primary advantage of the present model is workability. This model lends itself to analysis by means of Markov chains, although such analysis is not attempted here.

This model was proposed as a simple answer to the question: "How does one obtain stable output from a diversity of ages and types of

2. After developing this model I discovered that Maki has used a similar device several times. He did not, however, employ it in the present manner (Maki 1962, 1963).

animals?" The answer is obviously derived from the classical conception of sustained yield, developed in the field of forest management.

The structure of the model is illustrated graphically in Figure 4. The model allows us immediately to isolate the three decision points implied. They are: a) The division of current calf output between marketings and breeding herd replacement. This implies a decision as to the level of the future breeding herd, for replacements may exceed culls, equal culls, or be less than culls, b) A decision point of secondary importance is at the yearling stage, marked Y. The option always exists of selling these animals if conditions warrant. This of course is the primary decision point in a cow-yearling operation. In others, we may assume that the decisions made in (a) will hold, and that (b) is of slight importance. c) The decision to cull the breeding herd itself. The model shows that the normal cull rate is box 8, which contains by hypothesis 1/8 of the animals in the breeding herd. The rancher may always hold these animals for another year's calf crop, if he feels that price conditions warrant this.

In addition to isolating specific decision points in the firm, and thus specifying the important variables for analysis, the model allows the development of qualitative statements about the response of the system to changed prices. Three possibilities exist. Examine the response to a price rise:

1. The price rise is regarded as ephemeral.

The rancher may sell more of the current calf crop

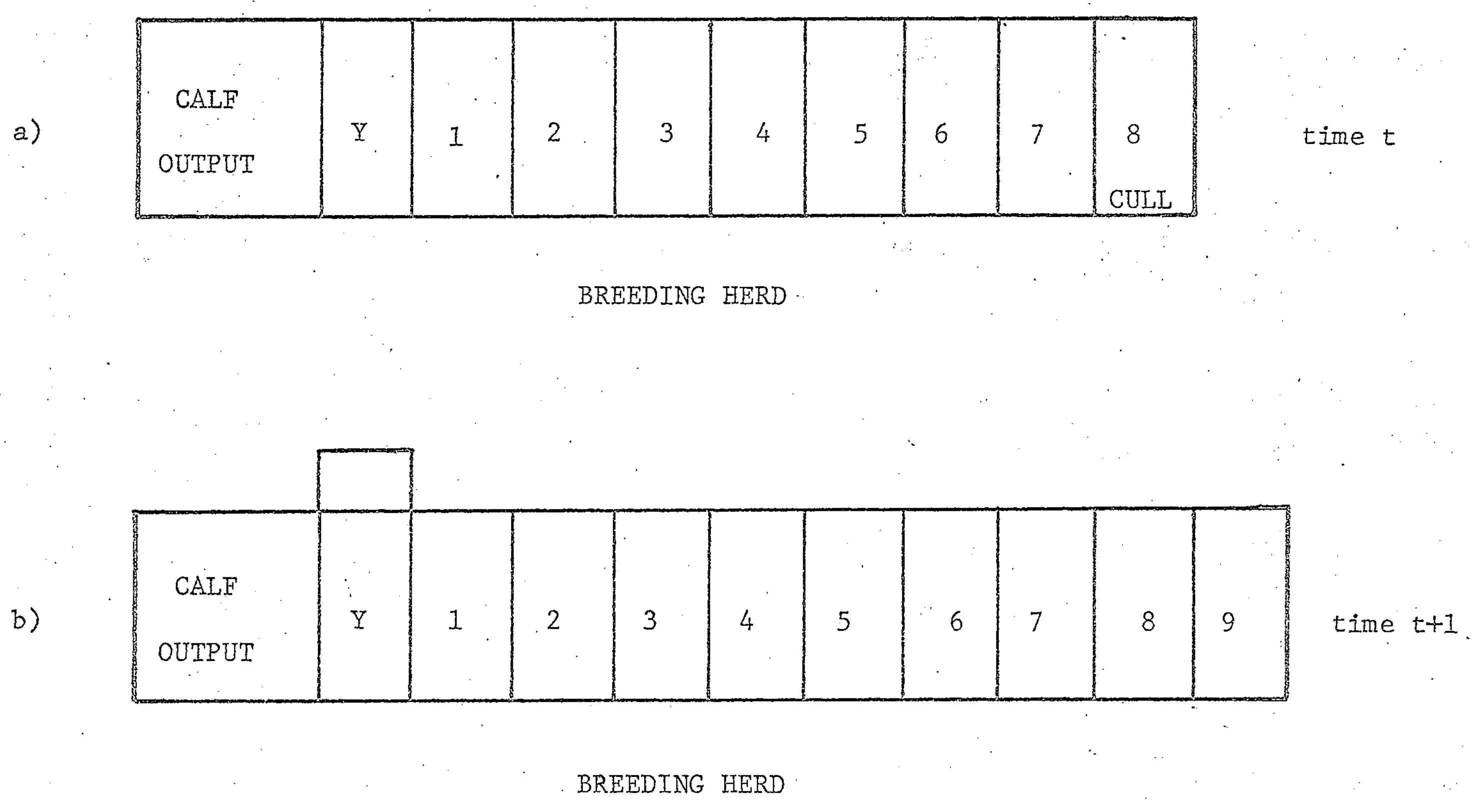

Figure 3. Structure of the Ranch Firm, Model II.

than the equilibrium replacement rate, cull the breeding herd more heavily, or do both.

2. The price rise is thought to be stable until the next marketing period.

   The rancher may retain his oldest age class for one more year's production. Normal plans for calves and yearlings may or may not be changed.

3. The price rise is thought to be permanent.

   The rate of calf retention will be increased, to allow greater calf output in two years.

Before testing the model, its assumptions are summarized as follows:

1. Ranchers tend to maintain a uniform distribution of breeding stock in breeding herds.
2. Shortrun calf-production possibilities, given breeding herd sizes, are fixed.
3. International and interregional trade are not considered.

Test of Hypothesis

The model is deliberately stated in very strong and restrictive form here. This is necessary to show its structure and its analytical usefulness. It is possible to extend the model to include these other complications, but this is not attempted here. The bare structure of the model is used to test the hypothesis stated at the beginning of this chapter, namely that the ranch industry is not in the unstable set.

A true test of this hypothesis using this model should embody all of the elements shown in Figure 1. The test given here is much more crude than that, but seems adequate.

Referring to Figure 4 suggests that certain prices may be correlated with certain output responses. That is, current calf marketings may be correlated with calf prices three years ago, since a planned increase in calf production takes roughly three years to materialize. Other correlations are also suggested. A total of eight variables are analyzed in this manner. The results are given in Table 3.

The variables are:

X_1 farm level price, lagged three years

X_2 farm level price, current year

X_3 change in breeding herd, eleven western states

X_4 calf marketings

X_5 marketing of all cattle

X_6 calf price, current year

X_7 calf price, lagged three years

X_8 price of feeder steers, all weights, at Chicago

Disappointingly, the data permitted the use of only 11 observations on each variable. This is because the breeding herd variable, of crucial importance in the analysis, was available in Agricultural Statistics only as far back as 1955.

The table shows only those correlations deemed particularly important for this analysis. More interesting entries are boxed. The data show a very low level of correlation between calf prices, current

Table 4. Model II Correlation Coefficients

	1	2	3	4	5	6	7	8
1	-		.17	.52	.54			
2		-	.57	-.48	-.48			
3			-			-.10	.27	.29
4				-		.99	-.81	-.93
5					-	.99	-.79	-.93
6						-		
7							-	
8								-

and lagged, and changes in size of the breeding herd. Price of feeder steers is similarly low in correlation with breeding herd changes. Calf marketings are most strongly correlated with current prices of calves and feeder steers. The results for farm level price of all livestock with marketings are similar.

On the strength of this admittedly crude test, it appears reasonable to accept hypothesis II, that the ranch livestock industry is not in the unstable set. The degree of responsiveness to price is so low that it is obvious that many other factors enter into output decisions than price. On the strength of this and the corroborating evidence presented above, we accept hypothesis II.

Some Additional Evidence: Calf Crops

Model II has been subjected to test and leads us to think that the breeding herds in livestock ranching are not sensitive to price changes. It is still not proven that supply itself is insensitive with respect to price. One source of output flexibility remains: calf crops. If calf crop, as percent of breeding herd, can respond to price in the aggregate, then price cycles will influence ranch marketings and rangeland use in a cyclical manner.

To study the relation of calf crops to prices, the calf crop decision was conceptualized as a standard output decision, subject to rising marginal costs. That is to say, it was thought that successive marginal increments in calf crop percentages are obtainable at rising costs per unit. This suggests using the theory of supply to analyze this problem. To fit a supply function, we include exogenous influences which might affect the level of the function, and input prices. A trend term is included to measure systematic changes in practice, since major changes in calf crop percentages are possible only with long-term programs of management and herd improvement. The function specified was:

$$CC_t = b_o + b_1P_{t-1} + b_2F_t + b_3RC_t + b_4t$$

CC_t = calf crop as percent of breeding herd

P_{t-1} = lagged calf price

F_t = current feed price

RC_t = USDA index of range condition

t = time

Several combinations of these variables were fitted, to study their independent effects. Data for the eleven western states were used to estimate parameters and test statistics. Results indicated nonsignificance for all prices, and for range condition also. It seems that range condition on the average exerts little effect on regional calf crops. But it is certain that prices exert little or no influence. Detailed discussion of these results, and a similar study for Arizona, are in the author's files.

This evidence on calf crops then allows us to conclude that the cattle cycle has slight effect on breeding herd and output decisions in the ranch livestock industry of the eleven western states. This means that range use and development policies do not need to cope with cyclical patterns of forage demand resulting from price cycles exogenous to the industry. It is entirely reasonable, then, to plan grazing use on the basis of ecologic and other technical factors alone, and omit consideration of year-to-year market changes.

By saying that the range livestock industry does not respond to the cattle cycle, we are also saying that it cannot, by reason of the feedback nature of the phenomenon, be a cause of the cattle cycle either. The locus of dynamic activity responsible for the cattle cycle must be sought elsewhere in the livestock industry.

CHAPTER FOUR

DISCUSSION AND CONCLUSIONS

The purpose of this study is to test two hypotheses concerning the relation of the cattle cycle to the range livestock industry. Statistical analysis indicates that they may both be accepted. They are restated here.

Hypothesis I. The output of the livestock industry is produced by two groups of firms, one which produces in response to perceived longrun movements in the economy and is insensitive to shortrun changes in price ratios. These are called the stable and unstable sets. Production lags cause the unstable set to generate secular periodic fluctuations in prices, outputs, and inventories.

Hypothesis II. The western range livestock industry (eleven states) is not in the unstable set.

The model used to test hypothesis I was deduced directly from the hypothesis, with the aid of several reasonable corolary assumptions regarding the form of lags and expectation functions. It produced very good explanations of the variance in marketings over the period 1950 to 1965. There is an important caveat to be recognized here. The model specification employed is a very simple and strangely familiar one. Indeed, it looks like a great many other functions used to explain livestock supply. It must be admitted, then, that the statistical result shown is in fact amenable to other interpretations than the one given in this study. But the important fact from the point of view of scientific method is that this model is deduced from the hypothesis, and that the hypothesis given does not conflict with the evidence.

The test of hypothesis II is admittedly considerably weaker. The test does not rest upon a carefully specified economic structure, such as that shown in Figure 1, but upon correlations deduced from a heuristic formal model. Still, the model allows us to deduce logically some reasonable hypotheses about industry response to price changes, and it is found that these responses are very weak. So, the second null hypothesis is also accepted.

The conclusions to be drawn from this work are several, both for theory and for policy.

First, the relevance of these conclusions for the theory of the cattle cycle. The results indicate that the search for a model of the cattle industry will have to focus upon characteristics of regional units of the industry. Due to differing resource conditions, firm structures, supply functions for inputs, and demands for outputs, the diverse regional components of the industry must be studied separately. When the specific contents of the unstable set are uncovered, it will be possible to model the cattle cycle very easily, since the relevant price variables and firm structure conditions will be obvious. The ranch industry is one of the occupants of the stable set. Including the stable set in the analysis of the cattle cycle merely obscures the forces at work and reduces the power of the analysis, without adding any meaningful degree of generality to the solution.

The results shown here would be consistent with the widespread occurrence of firms described by the Martin Hypothesis: multi-product, consumption oriented organizations whose primary purpose is not the production of income streams, narrowly defined in cash terms. It is plain however, that these results do not establish this in a direct way.

Inspection of livestock distribution maps (Williams & Stout, 1964) and summary data support the conclusion that a large number of livestock in the West are produced in areas free of influence of federal lands. Indeed, the major concentrations of livestock are the Central Valley of California, the Salt River Valley of Arizona, the plains of Northwest Colorado, and other irrigated river basins. This fact makes it possible to claim that, viewing the industry as a whole, federal grazing policy of using rigid long-term leases does not significantly affect supply response in the industry. The central factors are instead to be found in the structure of the ranch firm and in the limited range of physical production possibilities. On federal grazing policy see Clawson and Held (1957), Foss (1959), Foss (1960), and Roberts (1963).

A final implication of the study is in regard to management policy on public lands. The original purpose of the study was, in fact, to examine this question using general tools of analysis. The result shown is that in the West as a whole, periodic fluctuations in breeding herds and calf marketings in relation to price cycles are of slight importance. This means that substantive management decisions may correctly be based upon consideration of technical factors only, and not the state of the market. Pricing policy, however, should take account of the cyclical fluctuations in the marginal value product of forage brought about by changing output prices. There is nothing inconsistent about these two statements. Grazing district fees have long been adjusted to changes in cattle prices (Foss, 1959; Clawson and Held, 1957). These adjustments are made by reference to prices in the previous year. There is no reason why fees could not be assessed on the basis of regional average prices received in the current marketing year. Even in lease situations, such as those used on Forest Service lands, annual fees could be levied on the basis of shifts in prices received.

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