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ESTIMATES OF THE ELASTICITIES OF SUPPLY
OF SELECTED AGRICULTURAL COMMODITIES

MARC NERLOVE
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This paper deals with the role that farmers' expectations of future
relative prices plays in shaping their decisions as to how many acres
to devote to each crop. Although the writer and most previous workers in
the field of supply response have concentrated on acreage decisions, it
should be recognized at the outset that acreage response to price is only
one facet of the much more complicated problem of obtaining a compre-
hensive supply function. Within this limited context I shall try to answer
two questions: First, why have such low elasticities of acreage to de-
flated price been obtained? Second, is it possible to obtain measures of
the elasticities that are more in line with what we know from studies
made on production functions and on farmers' reactions to the allot-
ment and price support programs? In connection with this second ques-
tion, I shall present a few tentative and preliminary estimates of the
elasticity of acreage to deflated price for cotton, wheat and corn, for
the period 1909-32.

I

Many fewer studies have been made on the response of supply to price
in comparison with the number of studies on demand. What little work
that has been done is mainly for agricultural products. The more im-
portant of these studies are those of Bradford Smith, Louis Bean, Robert
Walsh, and R. L. Kohls and Don Paarlberg.1 All these studies suggest that
farmers respond very little to price in planning their acreage. The most
intensively investigated commodity has been cotton. Walsh found that
the elasticity of acreage with respect to last year's deflated price, while

* Based on an investigation of the relationship of acreage to deflated price for
cotton, wheat and corn, during the period 1909-1932.

This paper is a preliminary report on research still in progress. Subsequent findings
may alter the conclusions reached.

** I wish to acknowledge the financial and computational assistance of the Social
Science Research Council, the Earhart Foundation, and the Department of Economics
at the University of Chicago. I am deeply grateful to Professors C. F. Christ and
A. C. Harberger, both of the University of Chicago, for many stimulating comments
and criticisms on earlier drafts of this paper and on the research upon which this
paper is based. I alone, however, am responsible for any errors that occur.

1 Bradford B. Smith, Factors Affecting the Price of Cotton, USDA Tech. Bul. 50
(Washington: 1928); L. H. Bean, "The Farmers' Response to Price," Jour. Farm
Econ., Vol. 11 (1929), pp. 368-85; Robert M. Walsh, "Response to Price in the
359-72; R. L. Kohls, and Don Paarlberg, Short-Time Response of Agricultural
Production to Price and Other Factors, Purdue Univ. Agri. Expt. Sta. Bul. 555
(1950).
significantly greater than zero, was of the order of only 0.2. Kohls and Paarlberg estimated an elasticity of acreage with respect to price of about 0.07 for corn and 0.2 for wheat. In a number of regressions of acreage on deflated price lagged one year and trend, for the period 1909-32, I have obtained similar results. The results of Smith and Bean cannot conveniently be summarized by a single numerical measure of elasticity.

These numerical estimates seem to be contradicted by experience under the support programs. In 1948, about 36% of the cotton crop, 28% of the wheat crop, and 15% of the corn crop was placed under loan. The estimates of the elasticities of demand for these three crops are quite low: between $-0.3$ and 0 for cotton and wheat, and less than $-1$ for corn. If the supply elasticities are as low as previous measurement would suggest, then support prices for cotton, wheat, and corn must have been greatly in excess of the equilibrium prices in 1948. On the other hand, somewhat higher elasticities of supply would not imply support prices that were greatly out of line with the equilibrium prices. It is difficult to believe that the supported cotton price was 70% above the equilibrium price, the supported wheat price 50-60%, and the supported corn price more than 15%. It seems far more reasonable that supply elasticities are higher than previous measurement would suggest.

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**These figures were crudely derived on the basis of the following considerations:**

Let $q =$ the quantity produced;

$P_0 =$ the equilibrium price;

$P + \Delta P =$ the support price;

$\frac{\Delta q}{q} =$ the quantity placed under loan as a percent of the total crop.

The elasticity of demand $\varepsilon$ is approximately equal to

$$\frac{-\Delta q/q}{\Delta P/P_0}.$$  

Therefore, if the elasticity of supply is close to zero, the excess of the support price over the equilibrium price is

$$\frac{\Delta P}{P_0} = \frac{\Delta q/q}{\varepsilon}.$$  

If the elasticity of supply is not zero but $\eta$, we have

$$\frac{\Delta P}{P_0} = \frac{\Delta q/q}{\varepsilon + \eta},$$

where all elasticities are measured from the disequilibrium quantity actually produced.
Estimates of farm production functions give additional reason to question previous estimates of the elasticities of supply. Heady has found that, on the individual farm, substitution among crops is relatively easy. This means that on typical farms small changes in the relative prices of crops may make large changes in the cropping practices profitable. Beneke and Howell have investigated Iowa farmers' reactions to corn acreage allotments. They find that farmers not participating in the allotment program increased substantially the acreage they planted to corn, at the expense of soybeans and other crops. Presumably these farmers shifted because they could anticipate that a combination of both the supports for corn and the existence of allotments would make it profitable for them to do so. Individual farmers, then, can and do shift when conditions make a shift profitable. This fact suggests that there may be substantial response to price in the production of individual crops.

One reason why such low estimates may have been obtained may be that the elasticity of supply has been identified with the elasticity of acreage with respect to price. The elasticity of acreage is probably only a lower limit to the supply elasticity. More important, though, is the fact that price lagged one year has been identified with the price to which farmers react, i.e., the price that they expect will prevail at some future time. Kohls and Paarlberg have pointed out that farmers would not be acting in their own interest if they did, in fact, take last year's price as an indication of what this year's price was going to be. I think we would all agree—after all, agricultural prices are among the most volatile in the economy. Farmers would probably find themselves with lower incomes if they extensively revised their production plans in response to the wide swings that take place in the relative prices of various crops. Surely farmers must base their decisions on some reasonable assessment of the supply and demand conditions for the commodities they produce. Farmers react, not to last year's price, but rather to the price they expect, and this expected price depends only to a limited extent on what last year's price was.

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6 High elasticities of substitution on individual farms do not, however, necessarily entail a high elasticity of supply for the industry as a whole. The extent of change of relative prices may have to be very great before any substantial number of farms will shift. The more diverse are the farms with regard to the suitability of their lands and managements for production of various crops, the lower will be the elasticity of supply. With high elasticities of substitution among crops, however, we must assume almost unreasonable diversity among farms in order that the observed elasticities of supply be as low as previous studies have indicated.
7 Kohls and Paarlberg, op. cit., p. 7.
II

In taking the position that we should not identify expected price with price lagged one year, we are letting ourselves in for trouble. In theory we can always find out what today’s expected prices are by asking farmers; but we cannot find out what expected prices were in the ‘twenties by asking the farmers of 1955. In practice, therefore, we cannot observe expected prices. If we do not identify expected price with last year’s price, with what, then, can we identify it? If you will grant that we can use the elasticity of acreage with respect to expected price as a measure of the elasticity of supply, then this question is really the second question posed at the beginning of this paper: Can we obtain more reasonable estimates of the elasticities of supply?

If more specific information is not available, it seems reasonable to assume that the price expected to prevail at some future date depends in some way on what prices have been in the past. Price expectations are, of course, shaped by a multitude of influences, so that a representation of expected price as a function of past price may merely be a convenient way to summarize the effects of these many and diverse influences. In some situations certain influences may be controlling, and in those situations we should utilize what knowledge we have of the controlling influence to take account of it directly. For example, it is difficult to believe that the operations of the Commodity Credit Corporation can have failed to exert an influence on price expectations far in excess of those factors whose influences may be summarized by past prices. Because of the special difficulties presented by the support programs and the acreage allotments, this discussion will be confined to the period before 1933.

How should we use past prices to represent expected price? Each past price represents only a very short-run market phenomenon, an equilibrium of those forces present in the market at the time. It is for precisely this reason that farmers may not react only to last year’s price. This does not mean, however, that the past has no relevance for the future. I think it can be said in general that more recent prices are a partial result of forces expected to continue to operate in the near future: the more recent the past price, the more it expresses the operation of those forces relevant to expectations. Hence, I assume that the influence of more recent prices should be greater than the influence of less recent prices. What could be simpler than to represent expected price as a weighted moving average of past prices in which the weights decline as one goes back in time?

The practice of representing expected price by price lagged one year is clearly a special case of this more general hypothesis. In the special case a weight of one is arbitrarily assigned to last year’s price and zero
weight to all other prices. In allowing for the possibility that the weights for prices other than last year’s price are not zero, we should use farmers’ behavior to help us decide on an appropriate weighting system. We clearly do not have enough observations on the acreages devoted to major field crops to permit us to include prices separately back to Adam and Eve in a multiple regression of acreage on past prices. The sensible procedure readily suggests itself: Why not restrict the form of the weighting system but allow the actual values of the weights to be determined by the data? Since, for any declining weight system, prices beyond a certain point in time exert only a negligible influence in total, we can economize the available degrees of freedom, estimate the elasticity of acreage with respect to expected price, and determine the number of past prices influencing expected price; and we can do these things all at the same time.

There are many forms we might give to a weighting system such as I have described. How can we settle on a particular form? We might obtain a sensible form for the weighting system by beginning a bit farther back with some very specific hypothesis about the way in which expectations are formed and then deriving the result that expected price may be represented by a weighted moving average of past prices. One such hypothesis that seems plausible to me, but which is by no means the only possibility, is that each year farmers revise the price they expect to prevail in the coming year in proportion to the error they made in predicting price this period. Let us denote the price expected this year by \( p_t^* \), the price expected last year by \( p_{t-1}^* \), the actual price last year by \( p_{t-1} \). Let the proportion of the error by which farmers revise their expectations be a constant, \( \beta \), which lies between zero and one. I shall call \( \beta \) the coefficient of expectation. The hypothesis just stated can be expressed mathematically as follows:

\[
(1) \quad p_t^* - p_{t-1}^* = \beta [p_{t-1} - p_{t-1}^*], \quad 0 < \beta \leq 1.
\]

Let me illustrate the meaning of this hypothesis with a numerical example. Suppose that farmers expected a price of $2.00 per bu. of wheat this year but that the realized price was only $1.90. Shall they now immediately reach the conclusion that their previous prediction had no value whatsoever, that the best they can do is to predict a $1.90 for next year? If we agreed with the procedure usually followed, namely that of arbitrarily assigning unit weight to last year’s price and zero weight to all other prices, we would have to say that farmers placed no faith at all in their previous predictions. Farmers as a group, however, are known

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8 Substantially the same hypothesis was originally developed by Phillip Cagan in *The Monetary Dynamics of Hyper-Inflations*, unpublished Ph.D. dissertation, the University of Chicago (March, 1954). Only minor modifications are necessary in order to apply Cagan’s formulation to the problems under consideration in this paper.
for the strength of their convictions. Some farmers might revise their expectation downward from $2.00 to $1.90, but I suspect that most farmers would revise their expectations down only, let us say, to $1.95. Some farmers might not revise their expectations at all. In this case the average expected price might turn out to be $1.94, so that the magnitude of the coefficient of expectation would be 60% for the group as a whole.

It can be shown that the hypothesis, stated in equation (1), that farmers revise the price they expect in proportion to the error they have made in prediction, is equivalent to one in which expected price is represented as a weighted moving average of past prices where the weights are functions solely of the coefficient of expectation. Mathematically the result is as follows:

\[ P_t^* = \beta P_{t-1} + (1 - \beta)\beta P_{t-2} + (1 - \beta)^2\beta P_{t-3} + \cdots \]

The variables have the same meaning as before. Since the coefficient of expectation, \( \beta \), is between zero and one the weights will decline toward zero as we go back in time. Although in theory all past prices must be included, the fact that the weights decline means that practically we can safely ignore prices in the very distant past. At just what point in the past we can safely begin to ignore all previous prices depends on the size of the coefficient of expectation: the closer is the coefficient of expectation to zero, that is, the greater the tenacity with which farmers cling to their previous expectations, the greater will be the number of past prices we cannot ignore. When the coefficient of expectation is 50%, we must include about the five past actual prices to come within 5% of the expected price. Taking account of five past prices is certainly quite different from taking account of only one past price.

We can use the hypothesis that farmers revise their expectations by a portion of the error they make in prediction to obtain estimates both of the elasticity of acreage to expected price and of the coefficient of expectation. Let us restrict ourselves to the simple case in which the acreage devoted to a crop is a linear function of the expected relative price of that crop alone. We might in practice wish to include a trend variable, but for the purpose of this exposition I shall leave it out. Let \( x_t \) be acreage this year, \( P_t^* \) be the price expected this year, and \( u_t \) be a random residual
then we can write the acreage response function as follows:

\[ x_t = a_0 + a_1 P_t^* + u_t. \]

We cannot observe \( P_t^* \) and so we cannot estimate equation (3) quite as we would any other simple equation. We must represent \( P_t^* \) in terms of variables we can observe. Equation (3) means that we can write any expected price, \( P_t^* \), as a linear function of acreage \( x_t \). In particular, last year's expected price, \( P_{t-1}^* \), can be represented by last year's acreage, \( x_{t-1} \). But this means that expected price this year is a function of last year's actual price and last year's acreage. Why? Because our expectation model, as expressed in equation (1), says that expected price this year is a function of actual price last year and expected price last year. We can replace last year's expected price in equation (1) by a linear function of last year's acreage. If we now substitute this new expression for expected price into the acreage response function, equation (3), we obtain a new relation between acreage this year and last year's actual price and last year's acreage. It is

\[ x_t = \pi_0 + \pi_1 P_{t-1} + \pi_2 x_{t-1} + v_t, \]

where \( v_t \) is a random residual different from \( u_t \). \( \pi_0 \) turns out to be equal to \( a_0 \beta \), \( \pi_1 \) equals \( a_1 \beta \), and \( \pi_2 \) equals \( 1 - \beta \).\(^{11}\) We cannot, in practice, observe expected price, but we can observe last year's price and last year's acreage. Hence, if acreage really does respond to expected price we should observe a correlation between acreage this year and actual price last year and acreage last year. The relationship between the \( \pi \)'s in equation (4) and the \( a \)'s and the \( \beta \) in equation (3) allows us to work back from equation (4) to the acreage response function expressed by equation (3).\(^{12}\)

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\(^{11}\) This method of transforming the original acreage response function was suggested by the work of L. M. Koyck on *Distributed Lags and Investment Analysis* (North-Holland Publishing Co.: Amsterdam, 1954), chap. II. Koyck, however, postulates the existence of a distributed lag, whereas equation (1) above explains its existence. The advantage of using two relationships, such as (1) and (3), to obtain (4) rather than obtaining (4) from a relationship such as

\[ x_t = a_0 + a_1 [\beta P_{t-1} + (1 - \beta) \beta P_{t-2} + \cdots] + u_t, \]

is that it is still possible to perform this same kind of transformation on the acreage response function when more than one expected price is included. When the coefficients of expectation for different crops are not restricted to be the same, however, it is necessary to transform the whole set of all related acreage response functions simultaneously. It is then also necessary to estimate all such transformed relations in order to estimate the coefficients in any one of the original response functions. A great advantage of this method is, however, the ease with which we can make the change in expected price depend on factors other than the error of prediction (i.e., past prices). For example we might wish to take account of the influence of anticipated changes in livestock numbers on the expected price of corn.

\(^{12}\) A major difficulty exists in interpreting the results of a regression of acreage on lagged price and lagged acreage: In the discussion in the text, a relationship between
At this point a parenthetical remark about the statistical properties of the estimates we obtain from an equation relating this year’s acreage to last year’s actual price and last year’s acreage should be inserted. Most economic time series are known to exhibit a great deal of serial correlation. Normally, in estimating an equation like (3), we would assume that the residuals \( u_t \) were not serially correlated. Suppose for the moment that we could observe \( P_t^* \) and we went ahead and estimated equation (3). If the residuals \( u_t \) were positively serially correlated our estimates of the coefficients in equation (3) would be biased and statistically inconsistent. The residuals \( v_t \) of equation (4) will be serially uncorrelated only if the residuals \( u_t \) are positively serially correlated. Hence, estimates of \( a_0 \) and \( a_1 \) derived from equation (4) may be better estimates than those we would obtain if we could observe \( P_t^* \) independently.

acreage and expected price, (3), and a relationship between expected prices and past prices, (1) or (2), are assumed: on the assumption that observed acreage represents desired acreage, equation (4) is derived. Alternatively, we might assume that expected price was equal to last year’s price, but that desired acreage was not the same as observed acreage. In order to make these hypotheses operational we would have to assume some relation between desired and actual acreages. For example,

\[
(1') \quad x_t^* - x_{t-1}^* = \gamma (x_t - x_{t-1}) ,
\]

where \( x_t^* = \) desired acreage, \( x_t = \) actual acreage, and \( \gamma = \) a constant. (1') states that the change in actual acreage is proportional to the difference between desired and actual acreage. If we assume the particular relation stated in (1'), we find that acreage is again a linear function of lagged price and lagged acreage, only \( \gamma \) now enters where \( \beta \) did before. Hence, estimation of equation (4) cannot distinguish between two cases: (1) actual acreage is equal to desired acreage, but expected price is not equal to last year’s price, and (2) desired acreage is not equal to actual acreage, but expected price is equal to last year’s price. The difficulty inherent in the interpretation of equation (4) of the text is common to all empirical work in economics. Theory does not always provide us with relationships between variables which can be observed. Further relations between the nonobserved variables and other variables that can be observed must be postulated. Only then can we test hypotheses concerning the theoretical relationship. Additional empirical evidence must be brought to bear on the problems of how strongly farmers react to actual prices in altering their expectations and how rapidly they react to expected prices in the adjustment of actual acreage to desired acreage.

\[2\] In order that the residuals \( v_t \) be serially uncorrelated, the residuals \( u_t \) must follow an auto-regressive scheme of the following sort:

\[
u_t = (1 - \beta) u_{t-1} + \varepsilon_t ,
\]

where \( \varepsilon_t \) is randomly and independently distributed and \( \beta \) is the coefficient of expectation. To assume that this is so, is no worse an assumption than to assume no serial correlation among the \( u_t \).

\[4\] If the residuals \( u_t \) are actually uncorrelated serially, the residuals \( v_t \) should be negatively serially correlated. Tests I have made, however, on the calculated residuals \( v_t \) do not indicate significant negative serial correlation. (See the table below.) Another method for estimating the coefficients in equation (3) and the coefficient of expectation is available. This method rests on the assumption that the residuals \( u_t \) are not serially correlated. An alternative way of looking at expected price is that it
In the table below some of the main empirical results are summarized and compared. The results obtained from the regressions of acreage on lagged deflated price and trend are summarized in column (2). These regressions were carried out for three crops, cotton, wheat and corn, for the period 1909-32. The estimates of the elasticities, coefficients of trend and the multiple correlation coefficients are comparable with such estimates that have been obtained by other workers in the field of supply

is a weighted moving average of past prices where the weights are determined by the coefficient of expectation. If we knew the coefficient of expectation we could calculate all the expected prices using past actual prices. If we tried a number of different values for the coefficient of expectation we could find a value that would yield the greatest correlation between acreage and expected price. In this way we could obtain estimates of both the coefficient of expectation and the elasticity of acreage response. By stepwise maximization of the likelihood function we can show that this iterative procedure yields maximum likelihood estimates, provided the residuals \( u_i \) are not serially correlated. Confidence intervals for the estimates would be very difficult to obtain, but any point hypothesis can be tested by means of the likelihood ratio.

This procedure has been used to obtain estimates of the elasticities of acreage with respect to expected price. The estimated elasticities, the multiple correlation coefficients and the estimates of \( \beta \) are presented in the table below.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Elastcity of acreage with respect to expected price</th>
<th>Coefficient of expectation ( \beta )</th>
<th>( R^2 )</th>
<th>Durbin-Watson Statistic for regression discussed in this footnote</th>
<th>Durbin-Watson Statistic for regression discussed in the text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>4.53</td>
<td>0.04</td>
<td>0.80</td>
<td>1.71*</td>
<td>2.34*</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.18</td>
<td>0.27</td>
<td>0.77</td>
<td>1.25*</td>
<td>2.19*</td>
</tr>
<tr>
<td>Corn</td>
<td>0.35</td>
<td>0.25</td>
<td>0.43</td>
<td>1.54*</td>
<td>2.04*</td>
</tr>
</tbody>
</table>

* Insignificant serial correlation at the .05 level.

b Durbin-Watson test inconclusive at the .05 level.

The values of the Durbin-Watson statistic, used for testing for the presence or absence of serial correlation, are given in column (5) for the results obtained by the iterative procedure under discussion. These values are given in column (6) for the results obtained by the procedure discussed in the text. The Durbin-Watson Test does not appear powerful enough to distinguish between the iterative and noniterative procedures: the statistic indicates insignificant negative serial correlation among the residuals \( v_i \) obtained by the noniterative procedure, but it also indicates that the hypothesis of no positive serial correlation among the residuals \( u_i \) cannot be rejected. It should be noted, however, that the estimates of the coefficients of expectation obtained by the iterative procedure are unreasonably low and also quite different from one another. The rather strange results obtained by the iterative procedure may be due in part: (1) to the presence of positive serial correlation among the \( u_i \); and/or (2) to the presence of a lag in the adjustment of actual to desired acreage in addition to the lag in the adjustment of expected to actual price; and/or (3) to the presence of additional variables that should have been, but were not, taken into account in the acreage response function. The estimates of the elasticities obtained by the iterative procedure are higher than those obtained by the noniterative (see the table in the text). These higher estimates correspond to the lower estimates of the coefficients of expectation.
response. I have called the procedure, which yields the estimates summarized in column (2), the "special" method, because it rests on the arbitrary assumption that the coefficient of expectation is one. Column (3) summarizes the results obtained from the regressions of acreage on lagged deflated price, trend, and lagged acreage. I have called the procedure, which yields these estimates, the "general" method, because it allows the data to determine the coefficients of expectation.

The main things we want to compare between the special and general methods are: (1) the magnitudes of the elasticities of acreage to expected price; and (2) the percentage of the variance of acreage explained, i.e., the R²'s. The squares of the multiple correlation coefficients are substantially higher using the general method than they are using the special method. Dropping the arbitrary assumption that the coefficient of expectation is 1 leads to an increase in the R² of .15 for cotton, .13 for wheat and .13 for corn. The general method also yields estimates of the elasticities of acreage to expected price that are two to three times as large as those yielded by the special method. See Table I. Earlier in the

<table>
<thead>
<tr>
<th>Crop and Magnitude Compared</th>
<th>Special Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Restricted β: (β=1)]</td>
</tr>
<tr>
<td>Cotton:</td>
<td>(1) (2) (3)</td>
</tr>
<tr>
<td>Elasticity</td>
<td>0.20 0.67</td>
</tr>
<tr>
<td>Coefficient of expectation (β)</td>
<td>1.0 0.51</td>
</tr>
<tr>
<td>R²</td>
<td>0.59 0.74</td>
</tr>
<tr>
<td>Trend</td>
<td>0.48 0.18</td>
</tr>
<tr>
<td>Wheat:</td>
<td>0.64 0.77</td>
</tr>
<tr>
<td>Elasticity</td>
<td>1.0 0.52</td>
</tr>
<tr>
<td>Coefficient of expectation (β)</td>
<td>1.0 0.52</td>
</tr>
<tr>
<td>R²</td>
<td>0.47 0.93</td>
</tr>
<tr>
<td>Trend</td>
<td>1.08 0.58</td>
</tr>
<tr>
<td>(± 0.10)</td>
<td>(± 0.11)</td>
</tr>
<tr>
<td>Corn:</td>
<td>0.99 0.18</td>
</tr>
<tr>
<td>Elasticity</td>
<td>0.09 0.18</td>
</tr>
<tr>
<td>Coefficient of expectation (β)</td>
<td>1.0 0.54</td>
</tr>
<tr>
<td>R²</td>
<td>0.22 0.35</td>
</tr>
<tr>
<td>Trend</td>
<td>0.21 0.16</td>
</tr>
</tbody>
</table>

(The figures in parentheses below the estimates are the standard errors of the estimates.)

15 These increases are all significant at the .05 level or better.
16 It should be noted that the results obtained by the general method are consistent
paper I indicated why I thought a higher estimate of the elasticity was preferable to a lower estimate. Qualitatively, at least, the estimates obtained by the general method are more reasonable than those obtained when the coefficient of expectation is arbitrarily assumed to be one.\textsuperscript{17}

It is also especially interesting to note the decrease in the significance of the trend variable in explaining acreage when we allow the coefficient of expectation to be determined by the data. The necessity of including a trend, that is to say the finding of a significant trend, is tantamount to an admission of ignorance, ignorance of either the relevant trend-causing factors or of the whereabouts of data by which to measure the force of these factors. To the extent to which the use of the general method leads to a reduction in the ratios of the trend coefficients to their standard errors, we have reduced our ignorance.\textsuperscript{18}

III

The explanation of changes in corn acreage is substantially poorer than the explanations of changes in the acreages devoted to cotton and wheat. It is sometimes said that the price of livestock products is more influential in determining corn acreage than corn prices are. Such a statement is, I believe, incorrect. The price of livestock products is a factor determining the demand for corn and not its supply. The expected level of future livestock prices would reflect itself in the expected price of corn. A large differential between the price at which a farmer can sell corn and the price at which he can buy corn to feed his livestock would tend to reduce the elasticity of supply of corn, but such a differential will not introduce a factor that is really in the demand function into the supply function as well. The difficulty with corn is probably due in large part to the fact that corn is harvested after or during the period when winter wheat is planted.

with those obtained by the special method. When we use the special method what we really estimate is the elasticity of acreage times the coefficient of expectation; hence, the estimates of the elasticities obtained by the general method should be about twice as large as those obtained by the special method, if the coefficient of expectation is about 50%.

\textsuperscript{17} The estimates of $\beta$ (none significantly different from 0.50) indicate that five or more past prices should be used to approximate expected price. A somewhat more restrictive approach would be to assume that expected price was a weighted moving average of the last two past prices where the weights are determined by including prices lagged one and two years in a regression with acreage. This restriction might be justified by the following model of expectation formation:

$$P_t^* - P_{t-1}^* = \alpha [P_{t-1} - P_{t-2}], \quad |\alpha| \leq 1.$$ 

As might be expected this model does less well in explaining acreage than the more general model.

\textsuperscript{18} The ratio of the trend coefficient to its standard error falls, in passing from column (2) to column (3), from 4.8 to 1.5 for cotton, from 6.0 to 3.1 for wheat, and from 2.1 to 1.5 for corn.
Elasticities of Selected Agricultural Commodities

Corn and winter wheat compete for acreage throughout the Corn Belt. When deciding how much acreage to plant to winter wheat, the farmer must also decide how much he will later plant to corn. In addition, he is restricted in his decision by the fact that it is difficult for him to plant acres on which corn is still standing. Corn price lagged one year appears to be less relevant to the determination of expected corn price than does the price lagged two years.\(^{19}\)

Another factor that may influence price expectations is the existence of the Commodity Credit Corporation, which has introduced an entirely new element into the problem of how farmers form their expectations of future prices. The loan rates on various crops are generally known by farmers before they make their final decisions on what to plant. Actual prices at harvest may, of course, be higher than the support level and they may even fall below it when sufficient storage facilities are not available in the immediate vicinity of farmers. In spite of this fact, it seems to me that the level of support will be the best available indication at planting of what prices will be at harvest. The Commodity Credit Corporation has probably been instrumental in raising the levels of expected prices for corn, cotton and wheat relative to price levels of other agricultural products not included in the support programs, or whose prices are supported at a lower percentage of parity.

In addition to raising the level of expected price, the Commodity Credit Corporation has probably reduced the price uncertainty that farmers face. Such a reduction in uncertainty would probably lead to decreased capital rationing and a better allocation of resources between agriculture and the rest of the economy, as Professor D. Gale Johnson has shown.\(^{20}\) Both the higher level of prices and reduced capital rationing would have the effect of speeding up the adoption of new and better techniques of agricultural production.\(^{21}\) Many economists have observed (1) a great increase in yields, when acreage has been restricted; and (2) an increase in acreage, when acreage has not been restricted. Those that believe that the elasticities of supply are low have argued that both these increases in yields and increases in acreage have been a result solely of shifts in the supply schedules caused by forces set in motion by the

\(^{19}\) When corn acreage is regressed on corn price lagged two years, corn acreage lagged one year, and trend, an \(R^2\) of 0.43 is obtained. Corn price is highly significant and its coefficient indicates an elasticity of acreage with respect to expected corn price of 0.23. These considerations indicate that it is highly important to take careful account of harvesting and planting times. The competition between corn and winter wheat will be more thoroughly investigated in future research.


policies of the Commodity Credit Corporation. The evidence presented in this paper suggests that the elasticities of supply are considerably higher than previous measurements indicate. If the elasticities of supply are higher, a large part of the alleged shifts in the supply schedules may be explained simply on the basis of the fact that the Commodity Credit Corporation has raised the levels of expected price and, thus, farmers have more or less moved along the original schedule that relates supply to expected price. Since shifts in the supply schedule due to decreased capital rationing and adoption of new techniques of production are likely to be largely irreversible, it seems worthwhile to find out how much of the alleged shift in the supply schedules is in reality due only to increases in the levels of expected prices. This means that analyses carried out for the period before 1933 should be applied to the period after 1933. Thus, in order to assess the effects of the Commodity Credit Corporation on capital rationing and technological change, we will first have to assess its effects on price expectation formation.

IV

At the beginning of this paper two questions were posed: First, why have such low elasticities of acreage with respect to price been obtained? And second, how is it possible to obtain elasticities of supply more in line with our experience with price supports and more compatible with the results of the studies on production functions and farmers’ reactions to the allotment programs? The answer given to the first question was that previous estimates of the elasticity of acreage response to price have been based on the arbitrary and possibly incorrect assumption that the expected price is last year’s price. The answer to the second question was that by making a more general assumption about price expectations it is possible to obtain higher elasticities of acreage response to price; and, insofar as the elasticity of acreage with respect to price represents a lower limit to the elasticity of supply, higher and more reasonable estimates of the elasticity of supply are implied.

Obviously the method presented in this paper is not a panacea for all problems connected with the estimation of supply functions for agricultural products. Good estimates of the elasticity of supply response to price can be obtained only from comprehensive supply functions. This means that at least the expected prices of alternative outputs and the expected prices of variable inputs must be taken into account. In addition, the responsiveness of yields to various prices must be investigated, and the role of technological change must be examined. The way in which farmers form their expectations of future prices is only one facet of the complex and interesting problem of measuring supply response, but I believe it is an exceedingly important facet. The method that has been
presented for obtaining expected price in an operational manner is only one of possibly many such methods. I do not want to assert that it is the best one. What I do assert is that consideration of the role that expectations of future price plays in shaping farmers' decisions is not a trivial nor an unimportant occupation. More sophistication in the matter of price expectations will help us greatly in estimating supply functions and will reduce the amount of sophistication necessary to the solution of the other problems involved in the development of comprehensive supply functions for agricultural commodities.

DISCUSSION: ESTIMATES OF THE ELASTICITIES OF SUPPLY OF SELECTED AGRICULTURAL COMMODITIES

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The paper presented by Marc Nerlove emphasizes the need for reconsideration of results obtained from statistical estimates of supply response from time series data. He has made a substantial contribution in the formulation and application of price expectations models to the estimation of supply, or acreage response for wheat, cotton and corn for the period 1909-32. His position is that many statistical estimates of supply response have been too low, for certain commodities, because of incorrect formulation of the price factor to which farmers react. More specifically, "farmers react, not to last year's price, but rather to the price they expect, and this expected price depends only to a limited extent on what last year's price was." The alternative formulation that he explores most fully is that "farmers revise the price they expect to prevail in the coming year in proportion to the error they made in predicting price this period."

I fully agree with the conclusions as to the importance of the role of expectations of future prices in farmers' supply response; not only the price of that single commodity, but the prices of alternative outputs, the factor costs of the alternative enterprises, and the alternative employment possibilities of the factors, including the operator himself. In brief, the comprehensive supply response study requires knowledge of the production functions underlying various enterprises, factor and product prices, and the conditions and rapidity with which farmers will react to seemingly more profitable production, as well as the ever present problem of technological change. This problem of trying to predict probable supply response has been tackled by various methods, such as budget analysis of modal-type farms, linear programing, and analyses of farm records, as