Alternative Price Expectation Formulation And Information Access

By

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ABSTRACT

Access to information is pivotal to formulating price expectations included in acreage allocation decisions. Rationality coefficients imply coexistence of rational and naive expectations in the soybean market. Results confirm the “biased predictor” nature of naive expectations, suggesting that Extension Service resources should focus on programs that improve producers’ information access.

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Expectations play a very important role in economic decision making, especially in the areas of macroeconomics and financial economics. The response of aggregate supply to demand management policies; the behavior of components of aggregate demand, such as consumption and investment; the behavior of asset prices, such as interest rates and exchange rates, all depend on expectations about the future formed by economic participants in previous periods.

Motivated by concern for small-scale producers of agricultural commodities in an environment of reductions in public funding for information distribution, appropriate representation of the manner in which producers formulate price expectations may be pivotal to public budgeting decisions (Edward and Pertritz). Cooperative Extension Services are making definitive choices in allocating decreasing resources between large- and small-scale farmers. Smallholder farmers usually have limited resources to obtain information that could enhance their ability to make acreage allocation decisions. Agricultural economists have long recognized the importance of price expectations in decision making.

Much of the initial interest in price expectations in agriculture centered on instabilities highlighted by Ezekiel's use of the cobweb model. Nerlove subsequently introduced adaptive expectations to agricultural market modeling in response to evidence of misleading results from employing the cobweb model. The adaptive expectations formulation was inadequate because ad hoc restrictions on parameters did not reflect decision makers optimization process. To overcome these inadequacies, rational expectations was proposed as a method of examining economic agents' use of available information for decision making (Muth).

There are numerous agricultural applications of Muth's work, embodying the rational expectations hypothesis into a standard linear economic model (Huntzinger; Fisher; Goodwin and Sheffrin; and Shonkwiler and Emerson). More recently, Aradhyula and Holt, and Antonovitz and Green extended the rational expectations hypothesis to include higher moments.

Empirical agricultural research employing the rational or composite expectations concept has been dominated by minor crops and livestock production (Lopez; Shonkwiler; Shonkwiler and Emerson; Aradhyula and Holt; Goodwin and Sheffrin). In most of these studies, the centralized and concentrated nature of these markets is conducive to the use of rational expectations (DeCanio). Homogeneity of producers within a small area, facing similar economic and climatic conditions supports the implicit rational expectations assumption of an information set that is common to all decision makers.

Field crop production is less homogeneous, geographically, and spans the range of farm size and characteristics. Supply response models presented in Gardner and Chavas' articles, enriched by the use of commodity futures prices in describing price expectations, justify the use of advanced expectations framework, such as rational expectations. Additional information introduced when futures markets are included in commodity analysis, yields empirical results that are more consistent with Muth's rational expectations (Stein). Further, producers normally pay considerable attention to price development in related markets -- this is *prima facie* evidence that their information set is not limited to prices of a single commodity. It is reasonable to expect that the expanded information set of past and future prices, may influence producers' acreage decisions. Omission of an acreage behavioral equation ignores the planting decision on which overall production is based. Structural models of U.S. field crops, that employed rational expectations, lack explicit accounting of acreage allocation decisions (Holt; Holt and Johnson; and Shonkwiler and Maddala).

This study bridges the empirical gap by demonstrating how market participant expectations of price change from one extreme of lagged prices to another based on the rational expectations framework and acreage decisions. Individual or family farms account for 83 percent of 381,000 total number of farms that produce soybeans (U.S. Department of Commerce). The soybean model specified examines acreage, yield, exports, domestic use, and stocks, with total production derived as an identity.

RATIONAL EXPECTATION HYPOTHESIS

The rational expectations concept, first advanced in Muth's 1961 path-breaking article, suggests that economic agents use all available information when planning for the future. This forces the model builder to consider the data contained in decision makers' information set. Rational expectations for a particular variable are mathematical expectations conditional on available information. Assuming expectations about the value of endogenous variables are formed in a previous time period, the rational expectations specification is formulated as follows:

(1) $P^*_t = E_{t-1}[P_t|\Omega_{t-1}]$,

where E_{t-1} represents the expectation formed given all available information (Ω_{t-1}), and P_t is the price in period t. The information consists of all available observations on the variable in question and on related variables at the time the forecast is being made. According to Muth, since rational expectations are informed predictions of future events, they are essentially the same as the predictions of the relevant economic theory. For applied work, this means that the expectations must be consistent with the structure of the econometric model for the system under study.

The rational expectations hypothesis and other forms of expectations are not without criticisms, most of which already are well known in economics literature (Burton and Love; Chavas, Pope and Kao; Fisher; Muth; and Lucas). These criticisms and others call for an alternative method of examining the way producers formulate their expectations and provide a strong justification for advocating a composite price expectations rather than a singular expectations model. Lopez, and Tada have demonstrated separately that, indeed, composite price expectations models are superior to pure rational expectations or lagged response models, but these models have received little attention in agriculture.

ECONOMETRIC IMPLICATIONS

Significant contributions have been made in previous research regarding estimation techniques for econometric models employing rational expectations (Nelson; McCallum; and Wallis). This section briefly describes the procedures adopted, illustrating how composite and rational expectations can be imposed on a simultaneous equation model. The approach is similar to that of Wallis, extended later by Shonkwiler to include mixed expectations. Interested readers are referred to this material for a detailed exposition.

Consider the following model consisting of a system of simultaneous equations as in equation (2):

(2) $$Y\Gamma + Y^{*}A + JB = U,$$

where Y is a (T x g) matrix of g endogenous variables, and Y^{*} is a vector of expectations of endogenous variables formed in period t-1 given the information set Ω_{t-1}. This is equivalent to defining Y^{*} as $Y^{*}_{t} = E_{t-1}[Y_t|\Omega_{t-1}]$. J is a (T x l) matrix representing the partitioned matrix $[W \vdots J_1]$, where W denotes the matrix of exogenous variables and $_1J$ denotes the matrix of lagged endogenous variables appearing in the system. U is a matrix of structural disturbance terms which have mean zero and finite variance. The parameter matrices Γ, A and B are of dimensions (g x g), (g x g) and (l x g) respectively. Γ is nonsingular and B usually has one non-zero element in each of h columns when there are h equations requiring expectations.

The expected variable Y^* is a reduced form prediction of the relevant econometric model as shown in equation (3).

(3) $Y^* = -\hat{J}B(\Gamma + A)^{-1}$,

where $\hat{J}_t = [\hat{W}_t \vdots J_{lt}]$ and $\hat{W}_t = E_{t-1}(W_t|\Omega_{t-1})$. Thus, the rational expectation of Y^*_t depends on the parameters of the system and forecasts of the exogenous variables given Ω_{t-1}. Substituting equation (3) into (2) expresses the model in terms of observable variables:

(4) $Y\Gamma - \hat{J}B(\Gamma + A)^{-1}A + JB = U.$

The restrictions inherent in equation (4) imply that the information useful in forecasting shifts in the exogenous variables is incorporated in the model consistent with the economic structure. The forecasts of the exogenous variables are accomplished using a first-order vector autoregressive process given by

(5) $W_t = \Phi_0 + \Phi_1 W_{t-1} + \epsilon_t$,

where ϵ_t is a white noise process independent of the structural disturbance term (U). This implies that $\hat{W}_t = \Phi_0 + \Phi_1 W_{t-1}$ because $E(W_t|\Omega_{t-1}) = \Phi_0 + \Phi_1 W_{t-1}$. Note that equation (4) is highly nonlinear in parameters and is estimated using maximum likelihood or simultaneous nonlinear least squares procedures.

The composite expectations formulation is composed of expectations based on rational expectations and lagged response models. Different forms of lagged response models exist. For simplicity, it is assumed that the lagged response is one based on naive expectations. Thus, given any level of information, the expected value of a variable is a weighted average of rationally determined variables and variables observed in the previous period. In matrix notation, this is denoted as:

(6) $Y^o = Y^*K + Y_{-1}(I-K)$,

where K is a (g x g) matrix with non-zero diagonal elements. When K is an identity then expectations are rational; and if K equals the null matrix, expectations follow the lagged response model. The composite expectations model is formulated as in equation (7):

(7) $Y\Gamma + Y^oA + JB = U$.

Substituting equation (6) into (7) we get the reduced form prediction in equation (8).

(8) $Y^* = -Y_{-1}(I-K)A(\Gamma + KA)^{-1} - \hat{J}B(\Gamma + KA)^{-1}$.

Combining equation (6), (7) and (8) results in a complete composite model as shown in equation (9):

(9) $Y\Gamma - [Y_{-1}(I-K)A + \hat{J}B](\Gamma + KA)^{-1}KA + Y_{-1}(I - K)A + JB = U$.

Readers will notice that equation (9) reduces to equation (4) when K = I. Thus, if economic agents exploit all the available information efficiently, we should find the rational expectation assumption to be reasonable. On the other hand, if economic agents fail to exploit the information or such information is lacking or is cost-prohibitive, the lagged response model should be more reasonable.

MODEL DESCRIPTION

The structural model of the soybean market consists of six behavioral equations and four identities. The behavioral equations include planted acreage, harvested acreage, yield, export, domestic use, and import equations. Identities comprise production which is a product of yield and harvested acreage, total use which is the sum of exports and domestic use, and total supply which is the sum of production and imports. The model then is closed by letting total soybean supply equal total demand. For a more complete description of the model, interested readers are referred to Chembezi (1994) for detailed model documentation.

Given the influence of U.S. corn market on soybean production, a multi-market approach is most appropriate. However, a single-market framework was adopted to simplify the overall exposition. We assume producer price expectations are based on rational expectations as well as lagged prices as in equation (10).

(10) $P^*_{st} = [\beta(\Omega_{t-1})P^e_r + (1-\beta(\Omega_{t-1}))P^e_l]$, $0 \leq \beta(\Omega_{t-1}) \leq 1$, $0 \leq \beta \leq 1$, $0 \leq \Omega_{t-1} \leq \infty$.

P^*_{st} is the expected price for soybeans; P^e_r is soybean expected price based on rational expectations; P^e_l is soybean expected price based on naive expectations; and β is a rationality coefficient which is a function of the information input (Ω_{t-1}). The construction of expected price is based on a modified version of formulations by Lopez and Tada. Also, this specification is consistent with equations (6) and (9) which suggest that given any level of information input, ($0\leq \beta(\Omega_{t-1}) \leq 1$), the expected price is a weighted average of prices based on rational expectations and lagged response. As the information input gets infinitely large, the rationality coefficient approaches unity, and the expected price is determined largely on the basis of rational expectations. Lack of information implies that the expected price is primarily a function of lagged prices.

Following the procedure outlined previously, the reduced-form price based on rational expectations is determined as a function of expected values of all the predetermined variables in the model. The reduced-form price equation for the composite expectations requires some assumptions about the rationality coefficient and the availability of information. We assume the amount of information and its accessibility improves with time. Thus, the rationality coefficient is a function of time ($\beta = \beta_0 + \beta_1 T_t$). Substituting this function together with P_{st-1} and P^e_r into equation (10), the reduced-form composite price equation becomes a function of all predetermined variables in the model, the lagged price variables, and a time trend.

RESULTS AND DISCUSSION

The model was estimated using annual data for 30 years, 1965 to 1994. The data were obtained from publications by the U.S. Department of Agriculture. In this study, the structural coefficients are obtained using the nonlinear, three-stage least squares (N3SLS) technique. The N3SLS is a full information method and is more efficient than nonlinear two-stage least squares (N2SLS). The efficiency of N3SLS estimates depends on correct specification of the complete model. The naive expectations model was estimated using the generalized least squares technique. Table 1 presents estimated coefficients, their associated asymptotic standard errors and measures of fit. For lack of space, only acreage and yield equations are reported. This is necessitated also by the fact that the expectational variable occurs only in the acreage and yield equations. It is recognized, however, that since both the supply and demand blocks are estimated as a system, the structural parameters of other equations than acreage and yield also are expected to change.

In general, the composite and naive expectations models yield more statistically significant results than does the rational expectations model. The structural estimates display signs which are consistent with theoretical expectations. The explanatory power is reasonably high and the Durbin-Watson and h-statistics reveal no evidence of first order serial correlation. The expected price variables in all three models is significant at the 5 percent level or better, suggesting that both naive and rational expectations exist in the soybean market. The own-price estimate in the rational expectations model, however, is smaller than that in either the composite or naive expectations model; and the estimate for the price of corn, a competing crop, is statistically insignificant. Overall, the composite expectations model offers the best explanatory power and statistical fit, except for the soybean-stock equation, which is best explained by the naive expectations model. The short-run acreage elasticities with respect to the expected price under rational, composite, and naive expectations are respectively 0.141, 0.242, and 0.202. These estimates are all consistent with those reported in previous studies.

I. Test for Alternative Specification

In addition to the traditional discriminating techniques presented above, alternative hypotheses tests were conducted using the JA-test proposed by Fisher and McAleer. This test is used to test specification inadequacy of each price expectations formulation. The JA-test is designed for testing model specifications, not for choosing among competing models. The advantage of JA-test over the J-test proposed by Davidson and MacKinnon is that when hypotheses are linear and the error terms normal, the test is exact. That is, even for small samples it will produce tests of correct size (Doran). The J-test, on the other hand, is not exact, and in small samples tends to reject a true null hypothesis too often.

The results of the JA-test are presented in Table 2. Each of the test of the null hypothesis (H_0) in Table 2 rejects the alternative (H_1) for both acreage and yield. That is, no single H_0 is rejected against H_1. Thus, these results show no evidence of inadequacy in terms of specification, implying that the results fail to provide a basis for choosing one specification over the other. This is probably the most significant conclusion from this analysis. It suggests that no unique acceptable price expectations formulation can be advocated for the soybean market on the basis of these tests alone. These results do confirm the original assertion that expectations are a continuum, ranging from simple naive expectations to more advanced forms such as rational expectations.

II. Test of Rationality

If economic agents use all the information effectively, their expectations are identical to the mean of the distribution formed by the applicable economic theory given the relevant information set. Mathematically, this is denoted as:

(11) $E_{it-1}(Z_t|\Phi_{t-1}) = E_{t-1}(Z_t|\Phi_{t-1})$,

where Z_t is the economic variable in question. This implies that the difference between an agent's rational expectation and the actual value of the economic variable is zero:

(12) $E_{t-1}[Z_t - Z^e_t|\Phi_{t-1}] = 0$,

where Z^e_t is the expectation of Z_t. Thus, if Muth's definition of rationality is to hold, the agent's expectation should be the unbiased predictor of the actual value of an economic variable. This is normally referred to as the weak-form condition of rationality and is translated into the following relationship:

(13) $Z_t = \tau_0 + \tau_1 Z^e_t + \mu_t$.

Under the null hypothesis that the expectations are rational, the intercept (τ_0) should equal zero and the slope (τ_1) should equal one. The disturbance term (μ_t) should be uncorrelated, otherwise past forecast errors are not incorporated into the current forecast (Colling, Irwin, and Zulauf).

In both the acreage and yield equations, the rationality coefficient is significantly different from zero and/or one, rejecting the assertion of sole existence of either rational or naive expectations. These results are consistent with those presented in Table 2. That is, no unique acceptable price expectations specification can be advocated as the 'best' in the soybean market. Thus, these results confirm the assertion that when information collection and processing is costly, producers' optimal forecasts may involve simplistic rules, resulting in possibly biased and inefficient forecasts of future prices. With positive information costs, any number of expectations regimes may reflect the underlying price forecasting model used by producers. Indeed, when the cost of forecasting is positive, rational utility maximizing agents will choose to use a simpler expectations mechanism, like naive expectations, if the losses incurred due to the inaccuracies of the expectations are less than the expected net benefit from more accurate, but costly, expectations mechanisms (Evans and Ramey).

To test for the unbiasedness of the mean expectation of the alternative expectations, equation (13) was estimated using the ordinary least squares method. Individual t-tests (Table 3) of the estimated parameters were performed to test the null hypothesis that $\tau_0 = 0$ and $\tau_1 = 1$ for all the alternative forms of expectations. The results suggest that indeed τ_0 is not statistically different from zero, and τ_1 is not statistically different from one for the rational and composite expectations models. Thus, we fail to reject the null hypothesis. In the naive expectations model, τ_0 is significantly different from zero, and τ_1 is not statistically different from one, suggesting that bias exists in the mean value of the naive expectations. This implies, given the data used in the analysis, that naive expectations are not rational. An F-test of the joint hypothesis that $\tau_0 = 0$ and $\tau_1 = 1$ yielded similar conclusions. The estimated F-statistics were 2.57, 2.49, and 3.95 for rational, composite, and naive expectations, respectively. The critical F-value at the 5 percent level is 3.40. Thus, the null hypothesis is rejected only for the naive expectations, implying that the prices under naive expectations are biased and, therefore, not rational.

CONCLUDING REMARKS

This study examined the use of rational and composite expectations in the U.S. soybean market. These results may reflect the fact that the soybean market is less regulated than other commodity markets. Most importantly, the validity of both rational and naive expectations points to the significance of access to and cost of information. When the cost of information and forecasting is positive, rational producers will choose to use simpler expectations mechanisms. Thus, large-scale farmers, who can readily and cost effectively access information, determine their price expectations rationally. At the other end of the scale, small-scale farmers who have little or no access to information, base their expectations on a smaller, limited information set of past experience. To improve acreage decision making capabilities of small farmers, publicly available information is an important source of additional information to augment their past experience base.

Though the rational expectations model is appealing theoretically, there are problems in employing it in applied research (Burton and Love). The naive expectations formulation, on the other hand, is ad hoc and oversimplifies the way producers formulate their expectations. The composite expectations model offers a compromise and taps into the advantages of both rational and naive expectations.

While these preliminary results contribute to the discussion of linkages between public funding of market information, cost effective accessibility and farm size characteristics in field crops, implications from alternative expectations may be strengthened by allowing for interaction with other field crop markets. Further, re-specification of demand block to explicitly account for soybean crushing joint outputs, soyoil and soymeal, would improve the model.

Table 1: Empirical Estimates of the Structural Parameters[a]

Equations/Variables	Rational Expectation	Composite Expectation	Naive Expectation
Planted Acreage Equation			
Intercept	6.611	13.899**	13.510**
	(4.215)	(4.554)	(3.528)
INT77[b]	7.298**	3.749*	3.721**
	(2.091)	(1.964)	(1.553)
Soybean Price	101.633**	174.371**	158.136**
	(19.050)	(28.97)	(22.60)
Corn Price	-66.658	-339.253**	313.157**
	(72.640)	(95.650)	(69.090)
Lagged Acreage	0.710**	0.699**	0.712**
	(0.061)	(0.062)	(0.052)
Rationality Coefficient	-	0.114**	-
		(0.021)	
R-Square	0.934	0.965	0.958
D-W Statistic	2.125	2.401	2.306
h-Statistic	-0.335	-1.077	-0.809
Soybean Yield Equation			
Intercept	21.289**	21.258**	22.034**
	(0.494)	(0.440)	(0.645)
Soybean price	0.321**	0.333**	0.210**
	(0.052)	(0.051)	(0.065)
Weather Index	0.847**	0.875**	0.879**
	(0.076)	(0.077)	(0.093)
Time trend	0.208**	0.203**	0.253**
	(0.029)	(0.026)	(0.036)
Rationality Coefficient	-	0.039**	-
		(0.008)	
R-Square	0.934	0.933	0.891
D-W Statistic	2.661	2.347	2.229

[a]Figures in parentheses are standard errors.
[b]INT77 is an intercept shifter after 1977.
*Estimate significant at 10 percent level.
**Estimate significant at 5 percent level.

Table 2: JA-test for Alternative Hypotheses[@]

Null Hypothesis	Alternative Hypothesis: Rational Expectation	Composite Expectation	Naive Expectation
Rational Expectations			
Acreage Equation	-	1.213	1.207
Yield Equation	-	1.081	1.101
Composite Expectations			
Acreage Equation	1.039	-	1.092
Yield Equation	1.001	-	0.933
Naive Expectations			
Acreage Equation	1.412	1.379	-
Yield Equation	1.292	1.313	-

[@]Reported here are t-statistics. All values are statistically insignificant at the 10 percent level.

Table 3: Rationality Tests of the Mean Expectations

Variable	Rational Expectation	Composite Expectation	Naive Expectation
Intercept	0.052	0.016	1.597[**]
	(0.564)	(0.121)	(0.605)
Expected Price	0.958[**]	0.948[**]	0.763[**]
	(0.055)	(0.027)	(0.152)
R-Square	0.949	0.955	0.797
D-W Statistic	1.919	1.922	2.101
F-ratio ($\tau_0 = 0$ and $\tau_1 = 1$)	2.571	2.487	3.946

[**]Variables significant at 5 percent level. Figures in parentheses are standard errors.

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