Rational Expectations Estimation of Georgia Soybean Acreage Response

Nicolas B. C. Ahouissoussi, Christopher S. McIntosh and Michael E. Wetzstein*

Abstract

The general method of moments procedure is used for estimating a soybean acreage response function assuming that producers hold rational expectations. Results indicate that soybean, corn, and wheat futures prices, lagged acreage, and government programs are significant factors for determining soybean plantings. Implications of the results are that crop acreage selection by Georgia producers is not very responsive to demand shocks. Thus, producers in other regions are more likely to absorb impacts from these shocks on crop acreage selection.

Key Words: soybeans, rational expectations, GMM, elasticities

From 1950 through the late 1980s, soybeans were planted extensively in Georgia along with corn and wheat. This interest in soybeans is partially explained by its relative drought tolerance and compatibility with double cropping (Shapiro *et al.*). In 1982, soybeans were the second most valuable crop in Georgia, with 35 percent of available acreage planted in soybeans. However, soybean acreage has since declined. By 1990, only 20 percent of the total planted acreage was in soybeans, resulting in soybeans dropping to eighth in the ranking of the most valuable Georgia crops. One hypothesis for this acreage decline is a fall in soybean price. However, estimates of soybean acreage response are required for accepting or rejecting this hypothesis and calculating the magnitude of this responsiveness.

Although recent studies have dealt with supply response for wheat (Bailey and Womack) and cotton (Duffy *et al.*), current information on supply elasticity for soybeans is limited at the regional level. In terms of other commodities, studies by Whittaker and Brancroft, and Morzuch *et al.* are examples of acreage supply analysis using state data. Morzuch *et al.* argue that spatial heterogeneity and the opportunity for measuring variables with greater precision may make disaggregation to the state level worth the extra costs of data collection and analysis.

Estimates of the responsiveness of agricultural commodity supplies are valuable for individual farmers and agribusiness firms' decision calculus. Also, government domestic policy and policies for the General Agreements on Trade and Tariffs (GATT) rely on supply estimates in predicting both commodity and intercommodity effects of changing programs and in anticipating their consequent social benefits and costs.

For example, consider the federal regulatory policies resulting from implementation of the Clean Air Act Amendments of 1990 and the National Energy Policy Act. These acts will encourage the adoption and use of alternative fuel mixtures aimed at reducing emissions of volatile organic compounds, nitrogen oxide, and particulate matter as a means of controlling urban ozone. One alternative is biodiesel fuel. Soybean is a promising

*N. B. C. Ahouissoussi is a graduate research assistant, C. S. McIntosh is an associate professor and M. E. Wetzstein is a professor, Department of Agricultural and Applied Economics, University of Georgia.

J. Agr. and Applied Econ. 27 (2), December, 1995: 500-509

crop for biodiesel fuel, because it is a legume and its production and use is part of the natural carbon cycle. Its use for biodiesel fuel is among the best fuels at stabilizing greenhouse gas emissions. When soybean producers practice sustainable agriculture, no till/minimum till, the soil becomes a carbon "sink;" it builds up organic matter. This places soydiesel fuel at the top of the fuels list in terms of stabilizing the build-up of carbon dioxide in the atmosphere (Merrill, 1993).

The use of soybeans as a major input into biodiesel fuels will have an impact on price, and the magnitude of this impact depends on producers' supply response. If the hypothesis of price response for the soybean acreage decline is correct, then Georgia producers will potentially have a large acreage response to demand shocks such as biodiesel fuel adoption. If not, there may be limited effects of the program on Georgia agriculture.

Investigating this hypothesis requires a suitable formulation of price expectations. Muth proposes a rational expectations model which provides a consistent method of incorporating expectations into economic models. However, the rational expectations hypothesis generally is not employed for supply response analysis given the difficulties encountered with empirical applications (Shideed and White). Rational expectations requires the discrepancy between the expected value of a variable and its eventual realization, the estimation errors, be uncorrelated with relevant information contained in an information set at the time expectations are formulated. An instrumental variables technique developed by Hansen and Singleton and Hansen and Sargent, called Generalized Method of Moments (GMM) estimator, accounts for this requirement.

Elasticity estimates of regional soybean supply response are reported in this paper based on a rational expectations model and estimated by GMM. Implications of these elasticity estimates on the regional agricultural effects of programs such as biodiesel are discussed.

Rational Expectations

Previous studies on supply response used both naive and adaptive schemes with lagged variables as substitutes for expectations (Shumway and Chang). These expectations are taken to be extrapolations of past values of the variables concerned. On such expectations, Muth (1961) argues that "although this assumption helps make the equations identifiable and the parameter estimates easy to compute, there is little evidence that it is economically meaningful."

Rational expectations is an improvement where expectations for a particular variable are mathematical expectations conditional on available information. The rational expectations framework provides an appropriate way for incorporating the effects of uncertainty about future prices. Typically, this assumes that producers wish to maximize discounted expected profit subject to technology constraints (Fisher). It is well documented that producers have diverse price expectations (e.g., Bessler). However, the effect of diverse price expectations (compared to the case where all expectations are equal to the average) is to reduce (increase) total supply if the supply function is strictly concave (convex) in expected price. When the supply function is linear, diverse expectations have no impact (Pope). Also, averages of expectations in an industry are more accurate than naive models and as accurate as elaborate equation systems, although there are considerable cross-sectional differences of opinion (Muth).

Rational expectations implies an orthogonality condition between the estimated error terms and the information set at the time expectations are formulated. The orthogonality principle states that forecast errors associated with best linear predictors must be orthogonal to all random variables in the information set used in constructing the forecast (Hansen and Sargent). The GMM estimator minimizes sample error of the objective function by applying instrumental variables estimation techniques directly to this orthogonality condition implied by rational expectations. Implementing the technique of instrumental variables in estimating the components of soybean acreage provides a congruous means of accounting for price expectations. This overcomes any biases resulting from the fact that soybean acreage and those factors that affect soybean acreage may be jointly determined. Moreover, the use of lagged endogenous variables as instruments provides an appropriate means of incorporating dynamics into the analysis.

Model

The rational expectation model employed in this study relates soybean acreage to expected levels of its determinants, assuming profit maximizing, price-taking producers. The objective function of a given grower is the maximization of expected profits from a set of three alternative crops

$$\max\ \pi^e_{t+1} = \sum_{i=1}^{3} P^e_{i,t+1} Q^e_{i,t+1} - \sum_{i=1}^{3}\sum_{j=1}^{n} W_{ij,t} X_{ij,t} \qquad (1)$$
$$s.t.\ \sum_{i=1}^{3} A_{i,t} = L,$$

where π^e_{t+1} is expected profit in time t + 1, i is the index of crops, j denotes the index of inputs; $Q^e_{i,t+1}$ and $P^e_{i,t+1}$ represent expected production function of crop i and its expected price in time t + 1, respectively; $X_{ij,t}$ and $W_{ij,t}$ are quantity and price of input j used in production of crop i in time t, respectively; $A_{i,t}$ is planted acres of crop i; and L represents total planted acres of the three crops.

Estimation of the soybean acreage response function requires that expected production function, $Q^e_{i,t+1}$, be represented as a function of planted acres and expected yields of the different concurrent crops

$$Q^e_{i,t+1} = A_{i,t} Y^e_{i,t+1} = A_{i,t} f^e_i(X_{i1,t}, X_{i2,t}, \ldots, X_{\epsilon,t}), \qquad (2)$$

where $Y^e_{i,t+1}$ represents the yield function which is equivalent to $f^e_i(\ .\ )$. The first order conditions for (1) determine the following soybean acreage response function

$$SA_t = g(SP^e_{t+1}, CP^e_{t+1}, WP^e_{t+1}, W_{1,t}, W_{2,t}, \ldots W_{n,t}, L), \qquad (3)$$

where SA_t is planted soybean acreage in time t, SP^e_{t+1}, CP^e_{t+1}, and WP^e_{t+1} represent respectively soybean, corn, and wheat expected prices in time t + 1. Corn and wheat are chosen because they are the major related crops for soybeans in terms of planted acreage. Single-equation estimates generally are not expected to fully maintain or test all restrictions imposed by economic theory of the firm (Shumway, 1986). While the satisfaction of all the theoretical properties requires a full systems approach with nonlinear constraints, such models may not be tractable or even if tractable, data may not exist for estimation. Whereas, simpler models such as (3) can yield tractable relationships among variables, resulting in valuable policy implications.

Theory postulates that relative profitability influences enterprise selection. In order to obtain more detailed information, variables that represent underlying components should be included in the model. Five major factors, physical production of the crop, expected crop price, expected prices of related crops, changes in relative input prices, and government commodity programs, may influence field crop acreage response. Government intervention through various commodity programs plays an important role in forming producers' price expectations. Support prices influence field crop production decisions, because they represent a guaranteed minimum price regardless of market conditions (Duffy *et al.*). Fisher argues that it is naive to build a supply response model containing price expectations generated by past prices alone when a government agency is known to be altering the future course of prices. Thus, the model relates expected soybean acres to expected own and related crop expected prices (wheat and corn); a lagged dependent variable; government programs; and time trend

$$SA_t = g(SP^e_{t+1}, CP^e_{t+1}, WP^e_{t+1}, SA_{t-1}, GP_t, T), \qquad (4)$$

where SP^e_{t+1}, CP^e_{t+1}, WP^e_{t+1}, SA_{t-1}, GP_t and T are expected prices for soybeans, corn, and wheat; lagged soybean acreage; effective support price for soybeans; and time trend; respectively.

The effective support price is the loan rate for soybeans. As mentioned by Houck and Subotnick, the effective support price is equal to the announced loan rate when no acreage compliance is required to obtain the announced rate. Over the study period no acreage control, diversion, or set-aside programs were instituted for soybean production. The lagged planted acreage variable indicates that a partial adjustment approach is hypothesized. This assumption is used in recognition of the fixed costs of switching out of or into soybean production (Duffy *et al.*). Also, this assumption implies that a period of more than one year is required to complete the acreage adjustment process in response to exogenous shocks. The use of a time trend variable implicitly models the effects of technological changes on soybean acres. For consistency with firm-level assumptions, supplies of quasi-fixed inputs are assumed perfectly inelastic, and thus, do not enter the equation.

Expected prices are generally unobservable, resulting in different methods used for its specification in supply analysis. An appropriate price in the present case is the post-harvest price expected by producers at the time production decisions are made. Futures prices may not reflect correctly expectations of future local prices to which Georgia growers respond, because they are aggregate or group judgements on expected prices. Similarly, the timing of the futures contracts may not coincide with the timing of planting or harvest decisions of Georgia producers. Empirical work by Tomek and Gray and by Stein raises questions about whether futures prices are appropriate price forecasts. Specifically, Stein states that prior to four months to maturity, the futures price is biased and yields poor estimates of price maturity.

Alternatives for projecting expected prices are the instrumental variables techniques developed by Hansen and Sargent and Hansen and Singleton. These procedures represent expected values of endogenous variables in rational expectations models. Following this method, parameters of rational expectations models may be estimated by projecting ex-post realizations of endogenous variables on a set of appropriate instruments drawn from producers' information set.

Assuming that the relationships given in (4) represent the optimal determination of soybean acreage through the combined actions of optimizing buyers and sellers in the soybean market, the expected acres can be replaced by their realizations. Thus, the error defined in implicit form is

$$e_{t+1}(\xi) = SA_t - g(SP^e_{t+1}, CP^e_{t+1}, WP^e_{t+1}, SA_{t-1}, GP_t, T), \tag{5}$$

where ξ are parameters implicit in g(.) that relate expected acres to their theoretical determinants. Rational expectations require that the error function be uncorrelated with any variables in the information set that could be used by optimizing agents to forecast SA_t. An appropriate vector of instruments, z_t, drawn from the information set, could be used to form the orthogonality condition $E_t[e_t(\xi^0)z_t]$, where ξ^0 are the true, but unknown, values of the parameters, and E_t is the conditional expectations operator. According to Sargent, the law of iterative projections implies that

$$EE_t[e_t(\xi^0)Z_t] = 0, \tag{6}$$

Thus, it can be defined as a random variable, m_t, using this orthogonality condition as

$$m_t = [e_t(\xi^0) \otimes z_t], \tag{7}$$

Rational expectations theory indicates that the first moment of this variable is zero. Thus, GMM techniques can be used to estimate the parameters relating soybean acreage to its determinants by forcing the sample mean of m_t to its population moment of zero, as given by (5). Specifically, the model that relates soybean acreage to its determinants is a log-linear representation of (4)

$$\begin{aligned} LSA_t = \alpha_0 + \alpha_1 lnSP^e_{t+1} + \alpha_2 lnCP^e_{t+1} + \alpha_3 lnWP^e_{t+1} \\ + \alpha_4 GP_t + \alpha_5 lnSA_{t-1} + \alpha_6 T, \end{aligned} \tag{8}$$

According to Muth, expectations are informed predictions of future events, and thus are essentially the same as predictions from economic theory. Thus, the expected variables can be replaced by their futures prices and appropriate instruments are selected to form the orthogonality condition implied by (7). These instruments should be predetermined and useful to agents in formulating expectations of the endogenous variables. Lagged values of the endogenous variable, an index of agricultural production expenses, lagged market prices, and a linear time trend are used as instruments for obtaining orthogonality and cleansing the parameters in (8) of simultaneity. More precisely the following instrument set is used in the application of GMM

$$z_t = (1, lnMSP_{t-1}, lnMCP_{t-1}, lnMWP_{t-1}, lnAPE_t, lnSA_{t-1}, lnGP_t, T), \quad (9)$$

where MSP_{t-1}, MCP_{t-1}, and MWP_{t-1} represent lag market prices for soybeans, corn and wheat, respectively; APE_t represents an agricultural production expenses index. The use of an agricultural production costs index implicitly models the effects of production costs on soybeans acres.

For comparison purposes, the naive expectations and futures price models are considered. The naive expectations model specifies that the expected price is the same as the market price in the previous year.

$$LSA_t = \alpha_0 + \alpha_1 \ln MSP_{t-1} + \alpha_2 \ln MCP_{t-1} + \alpha_3 MWP_{t-1} + \alpha_4 \ln GP_t + \alpha_5 \ln SA_{t-1} + \alpha_6 T, \quad (10)$$

Whereas, in the futures price model the price associated with a futures contract is used for price expectations. This corresponds to (8) without the incorporation of the instrument set (9).

These three supply response models will render empirical estimates on the responsiveness of soybean acreage to changes in prices and government programs. This will provide evidence on the strength of the hypothesis that acreage decline is in response to a fall in soybean price. It is further hypothesized when government support prices are high relative to market prices, acreage should be positively related to support price. When support prices are low relative to market prices, it would be expected that producers should respond, at least in part, to market prices. However, risk-averse producers may respond to the guaranteed minimum price, even given relatively low support prices.

Agriculturally, Georgia is divided into a number of loosely defined crop mix regions. The boundaries of the regions are not well defined, with crop mixes blending into one another rather than distinct agricultural sectors. Thus, disaggregating the state into regions would be arbitrary. However, considering state level analysis diverse crop mix makes it difficult *a priori* to sign the cross price coefficients. Corn as a substitute for soybeans is generally true for the southwestern part of Georgia where base program crops (cotton, peanuts, and tobacco) predominate. In this region, after acreage is allocated to these base program crops the total acreage allocation is completed with a number of other crops. These crops are mainly soybeans and corn but also some producers will plant vegetables. The expected market prices of these commodities will generally determine acreage allocation. In contrast, other regions of the state, particularly in the southeast and middle-eastern regions, corn is a component in crop rotation with soybeans. In these regions corn complements soybean production in a rotation system. Corn is a relatively host-free crop, and thus is in the crop rotation for disease control.

Within Georgia approximately 60 percent of soybeans are doubled crop with wheat. This occurs predominately in the middle-eastern region of the state. Whereas, full-season soybeans are grown in the southeastern part of the state. Thus, depending on the region, wheat can be either a complement or traditional substitute for soybeans.

Data

Annual data for the period 1951-1990 were used for estimating soybean acreage response. Soybean acreage data were obtained from Georgia Agricultural Statistics Service and Georgia Cooperative Extension Service. U.S. Department of Agriculture estimates of variable costs of producing selected field crops are considered the best available estimates for production costs for corn and soybeans (Shideed and White). The index of prices paid by farmers for production items, interest, taxes, and wage rates was used to adjust the cost values for the study period.

An average of futures price observations was used, given uncertainty concerning what date the futures price should be observed and for averaging out short-term price fluctuations (Gardner). These averages are closing Chicago weekly contract prices for corn from March to May, and prices of soybeans and wheat during the planting period from May to July. Government policies designed to support incomes and stabilize prices of commodities were included in the form of effective support prices for soybeans.

Results

Estimated coefficients of the three models are presented in table 1. Similar coefficients of determination for the three models, R^2, indicate approximately 97 percent of the variation in soybean-planted acreage are explained by all three models. In addition, all three models have F statistics exceeding the one percent significance level. Strong collinearity among the variables is not evident, given a condition number of only 29. In contrast to the other models, all explanatory variables in the GMM model are significantly different from zero at the five percent level.

All coefficients in the GMM model are consistent in anticipated sign. Specifically, Soybean Expected Price, Effective Support Price, and Lagged Acreage have positive significant signs. The coefficient on Lagged Acreage is significant at the one percent level and positive, suggesting a response to exogenous shocks of over a year is required for Georgia producers to fully adjust their planting decisions.

In terms of the cross-price effects, the significant positive coefficient associated with expected corn price indicates the complementary relation between soybean acreage and corn price in crop rotation. The significant negative relation of expected wheat price and soybean acreage implies soybeans are a substitute for wheat, despite the relatively high amount of double-cropping of soybeans with wheat.

Although elasticity estimates from previous studies vary because of differences in estimation methods, model specification, time period, type of data (quarterly or annual), and quality of available data (Arnade and Davison), it is still of interest to compare the cross-price elasticities with earlier studies. Penn and Irwin reported a cross-price elasticity of 0.09 for soybean and corn for the southern United States, while Reed and Riggins reported -1.00 for the same area. McIntosh and William reported an elasticity of soybean output supply of -0.251 and -0.232 with respect to corn and wheat prices for Georgia. This comparison indicates that corn and wheat can be either complements or substitutes for soybeans in the Southeast.

Of particular interest is the own-price elasticity of soybean acreage. Results indicate a short-run inelastic acreage supply response (0.578). Thus, at least for Georgia producers in the short-run, soybean acreage is not very responsive to own-price changes. This implies that any future use of soybeans from demand shock programs such as biodiesel fuels will require a relatively large impact on soybean prices to result in a major impact on Georgia soybean acreage. The Georgia inelastic acreage supply response is slightly higher than the elasticities reported by Shideed and White. For example, they estimated a U.S. soybean acreage supply response of 0.410 under the futures price expectations model.

Long-run elasticities were calculated as $a/(1-g)$ where a is the estimated price elasticity and g is the elasticity of lagged acreage (Duffy *et al.*). These estimates are presented in table 2. The divergence between the short-run and long-run elasticities depends on the value of the corresponding coefficient of adjustment. The long-run are greater than the short-run elasticities in absolute value. Such results provide evidence that asset fixities would become less restrictive in influencing the planted acreage of soybean in the long-run. Shideed and White, with futures prices, estimated long-run own-price elasticity for U.S. soybean acreage of 1.576. The futures price model for Georgia results in a slightly higher estimate of 1.977. This indicates a relatively responsive acreage effect to a change in own-price. However, assuming rational expectations, the GMM results in a smaller elasticity of only 1.205. Assuming producers base their acreage decisions on other factors indicated in (9) rather than solely on futures price, their responsiveness to own-price changes is dampened. They tend to be more conservative in their acreage response when taking other factors into account. This difference in responsiveness is important when assessing the impact of price changes. Considering the five percent confidence interval in table 2, the long-run own-price GMM

Table 1. Estimates of Georgia Acreage Response Model Under Three Alternative Price Expectations, 1951-90

	Price Expectations[a]		
Variables	Naive Expectations	Futures Price	Generalized Method of Moments
Constant	-0.099 (-0.135)	-0.599 (-0.584)	-1.399 (-1.301)
Expected Corn Price	0.731 (2.571)*	0.111 (0.449)	0.874 (5.151)*
Expected Soybean Price	0.197 (0.549)	0.561 (2.900)*	0.578 (2.489)**
Expected Wheat Price	-0.664 (-3.133)*	-0.447 (-2.105)**	-1.015 (-3.210)*
Support Price	0.297 (1.987)**	0.344 (2.083)**	0.361 (2.141)**
Lagged Acreage	0.690 (6.871)*	0.716 (6.521)*	0.520 (4.319)*
Trend	0 002 (0.244)	0.002 (0.265)	0.210 (2.074)**
R^2	0.976	0.971	0.971
F-Statistic	223 377*	186.527*	186.142*
Durbin h-Statistic[b]	1.126	1.575	0 122[c]

[a] Numbers in parentheses are *t*-statistics. Significance levels are ** for 0.05, and * for 0.01.
[b] The critical h value is 1.645 at the 0.05 level.
[c] H-Statistic is N~(0,1) (Bowden and Turkington).

Table 2. Estimates of Georgia Long-run Elasticities Under Three Alternative Price Expectations, 1951-90

	Price Expectations[a]		
Variables	Naive Expectations	Futures Price	Generalized Method of Moments
Expected Corn Price	2.358 (0.189, 7.620)	-	1.819 (0.301, 4.466)
Expected Soybean Price	-	1.977 (0.818, 23.545)	1.205 (0.389, 2.764)
Expected Wheat Price	-2.141 (-6.00, -1.103)	-1.573 (-0.028, -7.228)	-2.113 (-4.721, -0.812)

[a] Number in parentheses are five percent significance interval.

price elasticity is within a narrow range of unitary elasticity, compared with the elasticity for the futures price model (Pindyck and Rubinfield).

For the GMM model the cross elasticities are also in the elastic range. This indicates that soybean crop acreage selection by Georgia producers is not as responsive to demand shock programs compared with cross-price effects. Given this response, other regional acreage supply elasticities may be more elastic. Thus, producers in non-Georgia regions may be more responsive to price changes from demand shock programs and absorb more of the programs impacts on crop acreage selection.

Conclusions

Soybean acreage response functions were estimated for Georgia based on rational expectations theory using the GMM model. The results indicate that wheat is a substitute for soybeans in terms of land use, whereas corn is a complement, and government support price programs increased Georgia soybean acres.

Without knowledge of regional acreage response elasticities, caution is required in assessing the impact of programs such as biodiesel fuels. Results indicate soybean acreage has a greater both short and long-run response to changes in the price of wheat and corn compared with the own-price change. Programs affecting soybean prices may not have as large an effect on Georgia crop acreage compared with other regions with relatively more elastic response. If demand for soybeans increases due to the potential development of soydiesel fuels for meeting clean air requirements, the impact on Georgia agriculture may not be as large as compared with other regions.

References

Arnade, C. A. and C. Davison. "Testing for Aggregation and Simultaneous Bias in U.S. Soybean Export Export Equations." S. J. Agr. Econ. 21(1989):129-137.

Bailey, K. W., and A. W. Womack. "Wheat Acreage Response: A Regional Econometric Investigation." *S. J. Agr. Econ.*, 17,2(1985):171-80.

Bessler, D. "Foresight and Inductive Reasoning of Economic Variables with California Field Crop Farmers." Ph.D. thesis, University of California, Davis, 1977.

Bowden, R. J. and D. A. Turkington. *Instrumental Variables*. Economic Society Monograph in Quantitative Economics, Cambridge University Press, 1990.

Chicago Board of Trade. Statistical Annual: Chicago Board of Trade, selected annual series.

Cho, D. G. "Estimation of A Wheat Acreage Response Function For Kansas." *Selected Paper,* American Association of Agricultural Economics Annual Meeting Baltimore, Maryland August 1992.

Cumby, R. E., J. Huzinga, and M. Obstfed. "Two-Step Two-Stage Least Squares Estimation with rational Expectations." *J. Econometrics,* 21(1983):333-55

Duffy, P. A., J. W. Richardson, and M. K. Wohlgenant. "Regional Cotton Acreage Response". *S. J. Agr. Econ*, 19(1987):99-109

Fisher, B. S. "Rational Expectations in Agricultural Economics Research and Policy Analysis. *Amer. J. Agr. Econ*, 64(1982):260-265.

Fomby, T. B., R. C. Hill and S.R. Johnson. *Advanced Econometric Methods*. Springer-Verlag, New York, 1984.

Gardner, L. B. "Futures Prices in Supply Analysis". *Amer. J. Agr. Econ.*, 58(1976):81-84.

Georgia Agricultural Statistics Service. *Agricultural Facts*. Selected Issues.

Hansen, L. P. "Large Sample Properties of Generalized Method of Moments Estimators." *Econometrica*, 50(1982):1269-86.

Hansen, L. P., and T. J. Sargent. "Instrumental Variables Procedures for Estimating Linear Rational Expectations Models." *J. Monetary Econ.*, 9(1982):263-96

Hansen, L. P., and K .J. Singleton. "Instrumental Variables Estimators of Non-linear Rational Expectations Models." *Econometrica*, 50(1982):1269-86.

Hocking, R. R., and O. J. Pendleton. "The Regression Dilemma." Communications in Statistics: Theory and Methods 12(1985):497-527.

Houck, J. P. and A. Subotnick. "The U.S. Supply of Soybeans: Regional Acreage Functions." *Agricultural Economics Research*, Vol. 21, Number 4, Oct. 1969:99-108.

Lee, D. R., and P. Helmberger. "Estimating Supply Response in the Presence of Farm Programs." *Amer. J. Agr. Econ.*, 67(1985):193-202.

Marra, M. C. and G. Carlson. "Double-Cropping Wheat and Soybeans in the Southeast: Input Use and Patterns of Adoption." *Economic Research Service*, Agricultural Economic Report, 552(1986):1-18.

McIntosh, C. S. and A. William. "Multiproduct Production Choices and Pesticide Regulation in Georgia." *S. J. Agr. Econ.*, 24(1992):135-141.

Merrill, N. "Biodiesel Alert." Publication Vol 1, No. 8, July-August 1993.

Morzuch, B. J., R. D. Weaver, and P. D. Helmbergher. "Wheat Acreage Supply Response Under Changing Farms Programs." *Amer. J. Agr. Econ.* 62(1980):29-37.

Muth, J. F. "Rational Expectations and the Theory of Price Movement." *Econometrica*, 29(1961):315-35.

Nerlove, M. "Estimates of the Elasticities of Supply of Selected Agricultural Commodities." *Amer. J. Agr. Econ.*, 38(1956):496-509.

Nerlove, M. "Adaptive Expectations and Cobweb Phenomena." *Quart. J. Econ.*, 72(1958):227-40.

Penn, J. B. and G. D. Irwin. "A Simultaneous Equation Approach to Production Response: Delta Region." *S. J. Agr. Econ.* 3(1971):115-121

Pindyck, R. S. and D.L. Rubinfeld. *Econometric Models & Economic Forecasts*. McGraw-Hill, Inc, third ed., 1991

Pope, R. D. "Supply Response and the Dispersion of Price Expectations." *Amer. J. Agr. Econ.* 63(1981):161-163.

Reed, M. R. and S. K. Riggins. "A Disaggregated Analysis of Corn Acreage Response in Kentucky." Amer. J. Agr. Econ. 63(1981):708-711.

Shapiro, B.I., B.W. Brorsen, and D.H. Doster. "Adoption of Double-Cropping Soybeans and Wheat." *S. J. Agr. Econ.*, 24(1992):33-40

Shideed, K. H., Fred C. White. "Alternative Forms of Price Expectations in Supply Analysis for U.S. Corn and Soybean Acreages." *W. J. Agr. Econ*, 14(1989):281-292.

Shumway, C. Richard and A. A. Chang. "Supply Response of Texas Field Crops: An Evaluation of the CET Linear Supply Model." *W. J. Agr. Econ.* 5(1980):149-64.

Shumway, C. R.. "Supply, Demand, And Technology in a Multiproduct Industry: Texas Field Crops." *Amer. J. Agr. Econ.* 65(1983):748-60.

Tomek, W. G., and R. W. Gray. "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles." *Amer. J. Agr. Econ.* 54(1970):372-80.

Tegene, A., W. E. Huffman, and J. A. Miranowski. "Dynamic Corn Supply Functions: A Model With Explicit Optimization." *Amer. J. Agr. Econ.* 70(1988):103-111.

Whittaker, J. K., and R. L. Brancroft. "Corn Acreage Response-Function Estimation with Pooled Time-Series and Cross-Sectional Data." *Amer. J. Agr. Econ.* 61(1979):551-3.