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ALTERNATIVE REPRESENTATIONS OF RISK IN ECONOMETRIC MODELS OF SUPPLY: A CASE OF SOYBEANS IN THE SOUTHERN REGION

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Risk

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Agricultural economists have recognized that incorporating risk in supply analysis provides useful information for farm management. But, under the limited knowledge about uncertainty, measuring risk effects is one of the most difficult tasks.

Brennan made a summary of risk measures used in econometric studies. Given those measures, he classified them into two categories. One dealt with risk relating to the variability or instability of price, yield or return in recent periods. Moving standard deviation or moving weighted standard deviation is used to measure this type of risk. Behrman, Winter and Whittaker, Wilson, Arthur and Whittaker, and Ryan used this type of formulation in their econometric analyses.

Brennan's second category is based on the view that risk is generated from the difference between the expected and actual outcomes. Measures of expected outcomes were formed by using different distributed lags on past outcomes. Traill employed a polynomial (Almon) lag relationship in conjunction with an iterative procedure to estimate expected prices and formulate risk as the absolute deviations of expected and actual prices. Just utilized Klein's geometrical distributed lag model to develop a squared deviation of geometrically weighted production returns as a representation of the dynamic risk in an acreage response model of California field crops.

For reasons of simplicity and ease of approach, Brennan suggested that the moving standard deviation would be the more useful one to represent risk, and in fact, this approach is the most popular method. However, for this measure of risk, the best length of lag has to be found by measuring different ranges of moving standard deviation.

An alternative view of risk representation is proposed in this paper. That is, competing products play a very important role in farmers' decision making. Thus, a change in the expectation of one product relative to the expectation of its competing product can provide useful information to measure supply response relationships. Behrman used such a framework in his analysis of relative price variabilities by means of a moving standard deviation approach.

Given that economists viewed Just's study as providing a theoretical framework to evaluate expected outcomes and changes in risk, this study will utilize a variation of Just's model in terms of relative subjective means and variances instead of absolute levels as explanatory variables. This relative formulation will be used to analyze soybean supply response in the southern region with corn as the competing crop.[1] Furthermore, for the purpose of evaluating this relative risk model with the more highly utilized risk measuring approach, the moving standard deviation model is also estimated. The forecasts for the latest four years based on the two different risk measure models will also be compared.

Model

The model used differs from the Just's model in not only that relative expectations are used instead of absolute expectations as the explanatory variables but that price and yield effects are investigated separately instead of the total effect of return.[2] The return risk is separated into price risk and yield risk because the two components come from different sources. Since the production of soybeans and corn in the southern region is only a small part of the total U.S. soybean and corn, farmers who produce soybeans and corn in the southern region have very little, if any, affect on prices by changing their production decisions. Also, the price variability and yield fluctuation may offset each other to some degree in the returns variability. Thus, in order to approximate the real supply response behavior of soybean producers in the southern region under risk, price and yield should be considered separately.

While previous studies may not have incorporated weather, this study used three variables to represent weather in modeling the supply response. Average rainfall during the planting season was used since a wet season would shift planting from corn to soybeans. The other two variables represented a farmer's weather mean expectation and risk during the growing season.

The underlying model utilized in this study was a variation of Just's model by considering the relative form of the subjective expectations. Thus, the model is constructed as

$$\begin{aligned} A_t &= a_0 + a_1 (Z^*_{t1}/Z^*_{t2}) + a_2 (W^*_{t1}/W^*_{t2}) + a_3 (Z^*_{t3}/Z^*_{t4}) \\ &\quad + a_4 (W^*_{t3}/W^*_{t4}) + a_5 G_{t1} + a_6 G_{t2} + a_7 R_t + a_8 Z^*_{t5} + a_9 W^*_{t5} \\ &\quad + e_t \qquad t = t_o, \ldots, T \end{aligned} \tag{1}$$

where

A_t = the decision variable, soybean acreage planted in the southern region in period t (1,000 acres),

$Z^*_{tj} = \alpha \sum_{k=o}^{\infty} (1-\alpha)^k Z_{t-k-1,j}$ - decision makers' subjective expectation for the mean of soybean prices (j=1), corn prices (j=2), soybean yield (j=3), corn yield (j=4), and rainfall for the growing season (j = 5),

$W^*_{tj} = \beta \sum_{k=o}^{\infty} (1-\beta)^k (Z_{t-k-1,j} - Z^*_{t-k-1,j})^2$ - decision makers' subjective variance of soybean prices (j=1), corn prices (j=2), soybean yield (j=3), corn yield (j=4), and rainfall for the growing season (j = 5), regarded as an observation on risk,

Z_{t1} = price (dollars per bushel) of soybeans in period t,

Z_{t2} = price (dollars per bushel) of corn in period t,

Z_{t3} = yield (bushels per acre) of soybeans in period t,

Z_{t4} = yield (bushels per acre) of corn in period t,

Z_{t5} = average rainfall during the growing season in period t,

G_{t1} = relative support price per bushel of soybeans to corn in period t,

G_{t2} = payment in kind program, = 1 when program was in effect (1983) and 0 otherwise,

R_t = average rainfall during the planting season in period t, and

e_{tj} = a $N(0,\sigma^2)$ random variable.

The estimation procedure for this model is based on the approach taken by Klein and Dhrymes, in which the subjective mean and variance variables are broken down into observable and unobservable parts (see Just). The method of estimation follows the approach used by Just.[3]

The moving standard deviation model (MSD) used in this study is utilized as an alternative approach for comparing with the Just type risk approach. This model can be represented as

$$\begin{aligned} A_t &= b_o + b_1 (Z_{t-1,1}/Z_{t-1,2}) + b_2 (MSDZ_{t,1}/MSDZ_{t,2}) \\ (2) \quad &+ b_3 (Z_{t-1,3}/Z_{t-1,4}) + b_4 (MSDZ_{t,3}/MSDZ_{t,4}) + b_5 G_{t1} \\ &+ b_6 G_{t2} + b_7 R_t + b_8 Z_{t-1,5} + b_9 MSDZ_{t,5} + \varepsilon_t \quad t = t_o,\ldots,T \end{aligned}$$

where

A_t, Z_t's, G_{t1}, G_{t2}, and R_t = specified previously,

$MSDZ_{t,i}$ = n periods moving standard deviations of soybean price (i=1), corn price (i=2), soybean yield (i=3), corn yield (i=4), and rainfall for the growing season (i=5) as the measures of risk in period t,[4] and

ε_t = a $N(0, \sigma^2)$ random variable.

Data

The annual time series included for this study is the period 1965 to 1983. The government program variables were relative support price of soybeans to corn and a dummy variable capturing the effect of the PIK program. The annual planted acreage, support prices and average prices received and average yield data for soybeans and corn, by acres, were obtained from Crop Production Annual Summary, Agricultural Prices Annual Summary and U.S. Department of Agriculture, Agricultural Statistics.

Empirical Results

The relative price and yield risk are expected to have negative impacts on the planted acreage, while relative expected price and yield and government support price program are expected to have positive effects on planted acreage in the two models. The PIK program is expected to have a negative influence on soybean acreage since the program was aimed at corn production. An increase in rainfall during the planting season is hypothesized to have a positive effect on soybean acreage. A wet spring would shift planting from corn to soybeans. The expected rainfall during the growing season is hypothesized to have a negative effect on acreage since if farmers expect a good growing season they plant corn because of their expectation of higher returns per acre for corn relative to soybeans. If a farmer's weather risk increases, he would be expected to shift from corn to soybeans since corn is more sensitive to lack of rainfall. However, if the risk increases to a certain level, a farmer may shift from soybeans and corn to grain sorghum which is much more drought resistant. Thus, the sign for the weather risk is indeterminate.

The coefficients and statistics of soybean supply response in the southern region are shown in Table 1. The Just relative model explained over 99% of farmers' soybean supply response variation. All of the coefficients have the anticipated signs except for the relative

Table 1. Maximum Likelihood Coefficients and Their T-Ratios of Soybean Acreage Response in Southern Region, 1965-83

Explanatory Variable	Just Model Coefficient	Just Model T-Ratio	MSD Model Coefficient	MSD Model T-Ratio
Constant	55,008.00	11.31*	5,925.58	0.55
Relative subjective means in 1965	15,982.00	3.54*	–	–
Relative subjective mean of price	3,083.62	3.55*	3,933.80	1.75
Relative subjective mean of yield	18,142.00	4.35*	-11,874.70	-1.10
Relative subjective risk in 1965	-63,330.00	-10.06*	–	–
Relative subjective variance of prices	-209.89	-10.58*	-709.32	-0.98
Relative subjective variance of yields	-73,213.60	-6.61*	10,260.60	1.30
Relative support price	-306.13	-1.50	2,853.14	1.82
Payment in kind	-7,033.60	-14.38*	-1,247.52	-0.40
Rainfall for planting season	428.14	4.60*	777.29	1.11
Subjective mean of rainfall for growing season	-3,768.80	-4.63*	5.22	0.00
Subjective variance of rainfall for growing season	-1,671.26	-1.11	-2,366.46	-2.39*
Maximum likelihood estimated α	0.209			
Maximum likelihood estimated β	0.055			
R-Square	0.996		0.69	
F-Value	404.52		4.74	
Durbin-Watson Statistic	2.14		1.40	

*Significantly different from zero at 95 percent level.

support price, but it is statistically insignificant. One possible reason for the insignificance is that soybean's market price has generally exceeded the support price. The other insignificant parameter is the coefficient for the weather risk. The signs and significance of the coefficients further indicate that farmers' decision-making depends highly on the relative price and yield expectations and variabilities. Thus, these findings seem to support the assertion that returns should be separated into price and yield for empirical analysis.

The estimation of the moving standard deviation model with a three years moving length is also represented in Table 1.[5] There are no statistically significant coefficients except the weather risk variable. The MSD model explains only approximately 69% of the variation. Thus, the explanatory power of the MSD model is weaker than Just's.

Examination of the α and β parameters from the Just model further reveals significant difference between the two models as well as how farmers form their mean expectations and risk. The α and β parameters reveal a slow decay in a farmers weighting of past observations. For example, the results imply that a farmer uses 32 percent of an observation six periods back in forming his subjective mean and 77 percent in forming his subjective risk. On the other hand, the MSD model used in this study assumed that any information beyond three periods back is not used by a farmer in forming his subjective mean and risk. If the α and β parameters were large, the truncation of information would not have been significant for large parameter values would have implied that only recent information is relevant in the expectations.

Another interesting fact about the α and β parameters is the difference in magnitude. The values of these two parameters imply that farmers discount past information much faster in their formulation of subjective means than they discount of the same information in their formulation of subjective risk. In contrast, the MSD model used in this study gives equal weights to all periods.

Once a model has been estimated, one of the criteria used to compare alternative models is the forecasting capability. Four years of predictions of soybean planted acreage based on the two models from 1980 through 1983 are presented in Table 2. Data were included to the latest period for estimation before the next period forecast was made. This process was repeated three times.

For the purpose of evaluating the forecasting power of the two models, the mean square error (MSE) ex post for each model was calculated (Granger). Based on this approach, the Just model provided more favorable predictions for it had a relatively lower MSE ex post. The Theil U statistic was also used to evaluate the forecasting capability (Table 3). The value of this statistic implies that the Just model is better than a naive model while the MSD model was worse than the naive model.[6]

Conclusions

The major purpose of this study was to formulate a supply response model with relative risk factors for soybeans in the southern region

Table 2. Actual Soybean Supply Response for Southern Region and Predictions Based on Just Model and MSD Model, 1980-83

Year	Planted Acreage		
	Actual	Just Model	MSD Model
	(1,000 acres)		
1980	23,755	24,501.2	20,247.6
1981	22,255	22,320.5	21,807.8
1982	23,023	22,837.0	19,116.7
1983	19,060	21,670.6	19,411.1
MSE		1,852,733.2	6,971,072.7
Theil U		0.63	1.22

over the period 1965-83. The Just approach was used to formulate risk. However, given the ease of estimation and popularity of the moving standard deviation model to represent risk, this approach was also estimated for comparison purposes.

Several differences existed between the traditional Just model and the model employed in this study. First, the subjective mean and variance variables in the soybean supply response are in relative forms while Just dealt with the absolute terms in his study. Second, returns were separated into two components, price and yield, since their changes come from different sources.

According to the two models' abilities of explanation and forecasting power, the Just model seemed to fit much better than the moving standard deviation model in crop supply response. Thus, while the moving standard deviation model seemed superior when using an absolute model (based on previous studies), this assertion would not be totally correct when a relative model is utilized.

Another important finding is that the impacts of price and yield are not the same. The significance of these two terms supports the view that price and yield should be treated separately and not combined into a returns variable.

Since there is no standard form for representing risk in econometric models of supply, further studies should not disregard the Just formulation in favor of the highly utilized moving standard deviation model.

FOOTNOTES

[1]Southern region comprises North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Arkansas and Louisiana.

[2]A couple of reasons exist for utilizing relative terms. First, soybeans and corn compete for the same acre of land and input. Farmers consider both the risk of producing soybeans and corn for they are concerned about the relative risk change of soybeans to corn. Morzuch et al. also used relative price in their supply response model based on the theory of the firm which suggests that the function is homogeneous of degree zero in prices.

[3]Farmers are assumed to have the same adjustment process for soybeans and corn. Thus, only one α and β are needed in the estimation.

[4]The formula for the n period moving standard deviations of prices is

$$MSDZ_{t,i} = [\sum_{k=1}^{n} (Z_{t-k,i} - \bar{Z}_i)^2]^{1/2}$$

where

$$\bar{Z}_i = (\sum_{k=1}^{n} Z_{t-k,i})/n \quad \text{and } i=1,2,3,4,5.$$

[5]A three, four and five year moving length were examined in a similar fashion as Brennan with the three year period providing the best fit.

[6]If the U statistic lies between zero and one, the forecast is better than a forecast from a naive model. A value of one indicates equivalency in forecasting while a value greater than one implies a naive model's forecast is better.

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