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MEASURING AGGREGATE SUPPLY RESPONSE UNDER INSTABILITY*

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In spite of the strong interests that agricultural economists have had in measuring aggregate supply response in the past there are only a few studies that explicitly introduced the risk element into the models (e.g. Behrman, Just, Traill). Behrman quantified both yield and price variabilities by using three-year moving average standard deviations about a simple moving average of yield and price. Just formulated a risk response model by assuming that decision makers would form their risk expectations by geometrically weighting past observations of risk similar to the way in which price and yield expectations are formed. The risk variable was taken to be the square of the difference between the actual explanatory variable (such as gross return) and the expected values. Each lag variable was then divided into observable and unobservable parts similar to the approach suggested by Klein. Assuming the disturbance term follows a normal distribution, an iterative procedure was undertaken to derive the maximum likelihood estimates of the regression coefficients, given values of the lag parameters and the internally generated risk observations. Results obtained from Just's multivariate adapative expectations model often indicated risk to be significant in acreage response.

Traill attempted to use a polynomial lag to measure onion acreage response at the national level. He utilized an iterative procedure to first estimate the distributed lag effects of the past price variables, then formulated the risk observations by quantifying the absolute deviations of the actual and expected prices. Expected risk is then specified as a distributed lag function of past observations of risk. He found that a simple two-year moving average standard deviation of past actual prices performed at least equally as well as the iterative procedure.

The remainder of this paper proceeds as follows. First, a polynomial lag wheat acreage response model in Kansas will be estimated. Second, estimated results, elasticities and implications are discussed. Third, future research directions are sketched. Some specific methodological procedures are also suggested to deal with these research problems.

The Polynomial Lag Model

The use of geometric, Pascal or polynomial lag in supply response studies is a matter of choice depending on the researchers' view of the relative importance of past values on expectations. A convenient feature of the geometric declining lag is that once the coefficient of expectation is determined the lagged response pattern will follow smoothly. The "price" which researchers pay to use geometric lag, however, is its restrictive lagged response pattern arising from the use of a constant coefficient of expectation. It is due to this restrictive assumption that we turn to the polynomial lag model (Almon). It will be shown later that the polynomial lag is flexible enough to obtain a lagged response pattern similar to that implied by geometric lag.

Empirical Results

In the past, risk response models typically were estimated for a small geographic area. Traill recently attempted to estimate an onion acreage response model at the national level for the first time, but found the risk variable only moderately significant. At the national level, one encounters not only the aggregation problem suggested by Just, but also the difficulty of including competing crops price variables in the acreage response equation. At the state or regional level (perhaps California is an exception), the price or profitability of the second best alternative crop can be effectively incorporated and the aggregation problem becomes more manageable.

Preliminary empirical results of wheat acreage response in Kansas during the 1950–75 period are given in Table 1. A second degree polynomial function is employed since a higher degree polynomial appears to commit a larger specification error. Variables included in the equation are defined as follows:

PW_{t-n} = wheat price received by farmers in Kansas state, lagged by n years

ESR = effective support rate

EDPR = effective diversion payment rate

AA = acreage allotment

PS_{t-1} = price of sorghum, lagged by one year

T = time trend variable (1950=1.0)

IC = index number of prices paid by farmers for production expense items, excluding livestock and poultry sectors

Table 1--Empirical results of wheat acreage response in Kansas: 1950-75 *

Explanatory variables	Conventional	Length of lag 3	4	5	6	7	8
Constant	11,335.17 (1.87)b/	7,144.85 (1.47)c/	10,446.81 (1.89)b/	9,085.59 (1.63)c/	7,503.29 (1.21)	4,564.13 (0.63)	735.96 (0.07)
PW_{t-1}	1,616.29 (2.29)b/	1,736.52 (2.06)b/	2,120.22 (2.94)b/	2,050.65 (3.04)a/	2,059.56 (3.05)a/	2,154.54 (3.00)a/	1,985.95 (2.41)b/
PW_{t-2}	1,153.68 (3.04)a/	1,434.19 (2.13)b/	1,500.31 (3.34)a/	1,413.58 (3.85)a/	1,443.14 (3.95)a/	1,606.88 (3.89)a/	1,652.26 (3.69)a/
PW_{t-3}	730.10 (1.62)c/		793.57 (1.79)b/	859.45 (2.09)b/	928.97 (2.40)b/	1,134.65 (2.75)b/	1,335.22 (2.34)b/
PW_{t-4}	345.54 (0.94)			388.26 (1.17)	517.06 (1.25)	737.85 (1.53)c/	1,034.85 (1.36)c/
PW_{t-5}					207.40 (0.70)	416.47 (0.91)	751.15 (0.91)
PW_{t-6}						170.52 (0.57)	484.10 (0.67)
PW_{t-7}							233.72 (0.52)
ESR_t	3,490.09 (2.78)b/	3,349.23 (2.99)a/	3,834.27 (3.61)a/	3,136.94 (2.74)b/	2,835.34 (2.28)b/	2,689.36 (2.06)b/	2,299.02 (1.46)c/
$EDPR_t$	-2,584.81 (-3.30)a/	-2,779.18 (-3.17)a/	-3,185.64 (-3.97)a/	-3,281.03 (-4.14)a/	-3,189.30 (-3.95)a/	-2,747.44 (-2.91)b/	-2,289.59 (-1.68)c/
AA_t	0.247 (1.94)b/	0.280 (2.08)b/	0.365 (2.89)b/	0.337 (2.72)b/	0.323 (2.52)b/	0.321 (2.41)b/	0.303 (2.11)b/
PS_{t-1}	-2,907.35 (-2.07)b/	-2,081.27 (-1.41)c/	-2,335.78 (-1.73)c/	-2,168.72 (-1.64)c/	-2,247.35 (-1.59)c/	-2,962.13 (-1.64)c/	-3,034.27 (-1.48)c/
T_t	580.72 (3.71)a/	447.22 (4.49)a/	667.59 (4.58)a/	654.78 (4.47)a/	672.02 (4.38)a/	750.25 (4.26)a/	848.11 (3.18)a/
IC_t	-154.68 (-2.60)b/	-102.60 (-2.78)b/	-177.88 (-3.19)a/	-162.08 (-3.02)a/	-153.77 (-2.76)b/	-149.58 (-2.64)b/	-146.48 (-2.45)b/
SDR_t		-58.98 (-1.03)	-95.05 (-1.84)b/	-97.29 (-1.94)b/	-99.36 (-1.92)b/	-94.86 (-1.81)b/	-82.49 (-1.37)c/
R^2	0.802	0.883	0.876	0.853	0.856	0.869	0.873
$\bar{R}^2$	0.681	0.808	0.790	0.742	0.738	0.750	0.745
σ_u	710.2	724.00	661.29	640.65	655.36	659.34	688.41
D.W.	2.49	2.37	2.20	2.34	2.43	2.53	2.28

* Figures in parentheses are t-ratio; σ_u is the standard error of estimate, and D.W. is the Durbin-Watson statistic.

a/ Significant at 1 percent

b/ Significant at 10 percent

c/ Significant at 20 percent

SDR = three-year moving average standard deviation of past actual returns per acre

t = the time period

Variables of PW_{t-n}, ESR, EDPR, PS_{t-1}, IC, and SDR are all deflated by the index number of prices paid by farmers for family living and production expense items.

Following previous developments in incorporating governmental policy variables into supply response analysis (Houck, et al; Just), we included "effective" support rate, "effective" diversion payment rate, and acreage allotment as three governmental policy variables. Price of sorghum lagged by one-year is used as the expected price of sorghum. Time trend variable is included to capture the upward trend of wheat yields as well as the effects of wealth increases over time. To bring the input cost variable as relevant as possible to wheat production decisions, the livestock and poultry sectors were excluded from the index number of prices paid by farmers for production expense items. The ending lag coefficient or weight is restricted to zero since a marked difference from zero would imply an unreasonably sharp discontinuity in the lagged response.

The estimated results are reasonably satisfactory. All coefficients have expected signs and most of them are significant at 10% level when a 5 year lag is chosen as the "best" length of lag. The choice of the "best" length of lag can be subject to a more rigorous test suggested by Harper. According to the minimum residual-variance criterion, (Theil) we found that a five-year lag appears to be the "best" length of lag, either including or excluding the risk variable, SDR, in the model. Inclusion of the risk variable only improves the explanatory power moderately, although some coefficients are altered to some degree. Further exploration on the measures of risk variable is needed to reach firmer conclusions of the effects of risk on acreage response.

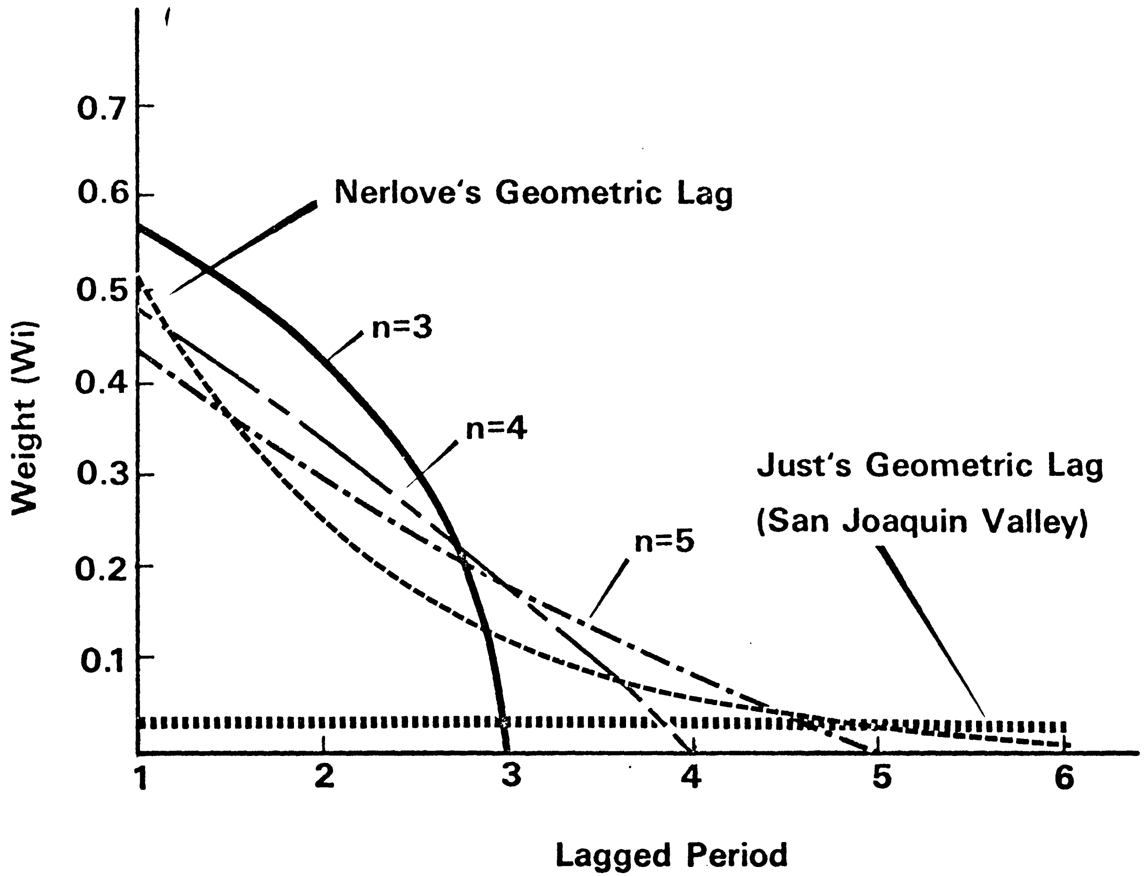
Elasticities, Lagged Response and Implications

The short-run price elasticity of acreage response with respect to the lagged market price (PW_{t-1}) was computed as +0.37 at the sample mean--virtually the same as that reported earlier by Houck, et. al. (+0.39) and close to +0.47 reported by Nerlove for the 1910-32 period. The long-run cumulative price elasticity for all N lagged periods was computed as +0.84; again, very similar to what was reported by Nerlove (+0.93). The empirical results also imply that a 1 percent decrease in instability, defined in terms of the three-year moving average standard deviation of gross returns, would lead to an increase of 0.06 percent in wheat planted acreage. Had the expected risk in 1975 been reduced from the actual $21.19 per acre to the historical trend of $4, some additional 622,000 acres of wheat would have been planted in Kansas.

The lagged response patterns for three, four and five years lags were shown in Fig. 1, of which the five-year lag appears to be the most plausible. This lagged response surface is convex toward the origin, not totally different from the geometric lag response obtained by Nerlove. In fact, Nerlove's previous finding suggests that the lagged

Fig. 1

POLYNOMIAL LAG RESPONSE FOR KANSAS WHEAT PLANTED ACREAGE



responses beyond the past sixth year become negligible; a response pattern resembling that suggested by our results. Our lagged response pattern, however, represents a dramatic departure from the pattern obtained from Just's previous work in California which implies that wheat farmers would take 20 years in San Joaquin Valley and 35 years in Sacramento Valley just to complete one-half of the total lagged response using "Model 3" results. As evidenced in Fig. 1, Nerlove reported a coefficient of expectation of +0.52 for the United States, compared to +0.035 in San Joaquin Valley and +0.02 in Sacramento Valley reported by Just.

Contrary to results reported earlier by Just in California, instability estimated for each point in time during the 1950-75 period suggests that instability of wheat return was considerably stabilized for the period approaching 1970, compared to the early 1950's (Lin).

Future Research Directions

There are numerous research areas that need to be pursued further if the effects of instability on supply are to be adequately measured. The remainder of this paper focuses on some of these research needs and possible procedures.

Normative Risk Response Studies

In spite of calls for normative risk response studies the published aggregate risk response studies all follow the positive approach wherein the supply function is estimated directly using historical time series. Yet, the positive approach cannot effectively account for the effects of changes in the decision-making environment as is theoretically possible with the normative approach. The major obstacle to the normative approach, in my judgment, are problems associated with the estimation of an aggregate utility function for producers, capital rationing by lenders and resource fixity.

To the extent that the aggregate utility function or the trade-off between mean and variance of return can be measured, then a regional E-V analysis would be an appealing approach to measure aggregate supply response under instability. A recent theoretical work of Keeney suggests that it is possible to derive such an aggregate utility function, provided interpersonal comparison of preference is allowed. Questions related to capital rationing by lenders can be pursued in several ways. Farmers' loan borrowing capacities for farm operation can directly be added into the resource constraint vector. Alternatively, lenders' attitudes toward risk can be incorporated into the E-V analysis by imposing a "safety-first" constraint to the E-V frontier. Thirdly, lenders' utility functions, in addition to producers' utility functions, may be needed if the lenders possess some control on farmers' planted acreage decisions. With regard to resource fixity, there is a need to extend the static E-V analysis to a dynamic analysis so that the process of resource adjustment over time can be captured by the model.

Expectation and Decision Theory

Expectation models, such as adaptive expectation, are predicated on the premise that expected price is a function of past historical prices, "if more specific information is not available" (Nerlove 1956).

Yet, casual observations remind us that producers may partly rely upon other market indicators, such as futures market price and outlook information, to form their price expectations. Recent empirical evidence suggested by Gardner that futures price, as an expected price, performs equally well as the lagged price in explaining crop acreage response further confirms our observations. This raises a question: How should we incorporate futures market or outlook information, in addition to historical prices, into the expectation model? One possibility is to convert the prior subjective probability distribution of historical prices, taken to be the weights of past prices in the estimated expected price equation, into the posterior probability distribution by integrating the expectation model with Bayesian decision theory.

Specification of Functional Form

An important application of risk response studies is to assess the distribution of welfare gains and losses from stabilization. Recently, Turnovsky (1976) has shown that when the assumptions of linear demand and supply equations and additive disturbances are dropped the allocation of welfare gains between consumers and producers tend to become indeterminate. Thus, specification of the demand and supply functions becomes an important issue in assessing stabilization policies.

To the extent possible, specification of functional form should be guided by economic theory. In the absence of a priori theoretical basis, existing few risk response studies have all relied upon the linear specification. Recent developments in the area of transformation of variables (Box and Cox), however, greatly widens the choice of functional forms and makes it possible to determine the "best" form in a more rigorous and formal manner.

Implications for Farm Structure

Economic uncertainty tends to induce farmers to favor diversification over specialization; the former generally is associated with small economic units and the latter is commonly identified with large commercial farms. Earily empirical studies concluded that stable prices encourage large-scale farming and some agricultrual economists begin to doubt whether the small family farms are able to survive in high-technology and high-risk phases of agricultural production. Is there any basic contradiction? To answer the above question, one would have to quantify the differential risk effects on farms of various scales of operation. Supply response under instability, if it can be broken down by farm size, certainly offers an important aspect of the risk effects on farms of various scales. Implications of instability on farm structure can further be drawn from this type of study.

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