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Crop Selection in High-Risk Agriculture

By C. V. Moore and J. H. Snyder

Farmers the world over have long recognized and adjusted to problems of risk and uncertainty in crop production. Agricultural economists have also recognized the problem but have been somewhat frustrated in their attempts to find satisfactory solutions and techniques of analysis. Heady (4, ch. 17)[1] developed a logical framework for combining variances and for diversification of crop enterprises. Others (2) have made empirical estimates of price, yield, and income variability of crops and cropping systems for wide geographic areas based on this framework. Stovall (7) proposed use of quadratic programming to develop a rational expected income-variance surface from which farm managers can choose cropping plans depending on their propensity or aversion for risk. Alternative formulations of the problems have been within the framework of the theory of games (3). This paper suggests an additional formulation in which the objective is maximization of long-term expected gains. The results may conflict with many of the past formulations and suggested solutions which have emphasized short-term gains.

The Problem Setting

The Salinas Valley of California is an important contributor to the national market for summer head lettuce and other high-risk fresh vegetables (6). The local vegetable industry is highly vertically integrated, with only two marketing cooperative associations and several large packer-shippers contracting with a large number of small growers. A variety of open price contracts or "deals" link the packer-shippers and the growers. Depending on the contractual agreement made, a grower can transfer all or part of the risk of income variability to a packer-shipper. The contract can also be a source of operating capital to the grower through advances from the packer as well as assuring the grower a guaranteed market outlet for his produce. The marketing cooperatives provide their members only with an assured market outlet--they do not provide operating capital or accept any of the income risk due to price or yield variability. They also require that the member have sufficient financial backing to survive 3 poor crop years in succession.

The Problem and an Analogy

The problem is to select cropping programs for high-risk crops that maximize long-term expected gain, taking into account the operators' capital position and the variability of income from alternative crops.

A close analogy can be drawn between selection of cropping plans and investment portfolio analysis. Each crop enterprise is analogous to a marketable security--a stock share, a bond, or a savings certificate. The proportion of a particular crop enterprise to total crop acres is equivalent to the proportionate value of any one security to total investment portfolio value. Investors in securities (farmers) desire a portfolio (crop program) with the highest expected return. However, this is usually not the portfolio (crop plan) with the lowest income variance. Likewise, the portfolio (crop plan) with a low variance may have an unacceptably low expected return.

Any crop plan A, with the same expected income as crop plan B but a smaller variance than B, is superior if the objective of the investor is to achieve the highest expected immediate gains. If A had the same variance as B but a higher expected return, A would also be considered

[1] Underscored numbers in parentheses indicate items in the References, p. 97.

superior. Stovall terms superior crop plans as "efficient" on the basis of expected immediate returns (7). Thus, if the only criterion for selection of portfolios was maximizing immediate returns, all inefficient crop plans could be eliminated from consideration. But under a criterion of maximizing long-term gains, this may not always be the case.

Most studies of portfolio or cropping program selection under uncertainty implicitly assume that the investor or manager is constrained only by propensity or aversion to risk. We argue that this is in fact not the case, but that the investor's capital limitations impose real restrictions on his admissible alternatives. For example, unless purchase of fractional shares is allowed, a small individual investor with limited capital could not purchase expensive portfolios. A diversified portfolio with 10 different securities, each valued at $500, could not be purchased by an investor with only $3,000 to invest. Similarly, a farmer may also be limited in the choice of alternative efficient cropping plans. First, on technical considerations alone, the proportion of a single crop in the efficient cropping plan may be too small to make it economically feasible to grow. Second, a grower with limited capital may be excluded from certain cropping plans or even contractual agreements to grow certain crops. For example, the membership requirement in the marketing cooperative of sufficient financial resources to withstand 3 poor years excludes any grower without access to large amounts of liquid assets.

Five marketing arrangements for head lettuce, two for carrots, and one each for dry beans and sugarbeets were analyzed. Dry beans and sugarbeets were included to represent the low-income, low-variability field crop alternatives. Marketing arrangements for head lettuce and carrots are as follows:

LETTUCE

1. Marketing through a cooperative. All operating capital is furnished by the grower, who bears all of the risk and receives all proceeds from the crop.

2. A joint venture with a packer-shipper, the packer advancing one-half of the cultural costs to purchase a 50 percent share in the crop. Returns are split equally from the first carton harvested, and the balance of the operating capital is furnished by the grower.

3. A contract with a packer who advances $135 per acre in addition to furnishing one-half of the cost of pesticides and fertilizer. Proceeds from the crop are shared equally after deducting the cost of the packer's share of pesticides and fertilizer.

4. A minimum income guarantee contract with the packer advancing $135 per acre plus all hoeing and thinning costs. Proceeds are shared equally after the $135 advance has been repaid to the packer.

5. A flat fee of $300 per acre, paid to the grower to produce an acre of lettuce. There is no sharing of profits or losses by the grower.

CARROTS

1. A minimum guarantee of $135 per acre advanced by the packer plus one-half of the pesticides and fertilizer. Proceeds are shared from the first crate.

2. A payment of $275 per acre by the packer to grow a crop to maturity. Profits or losses are not shared.

Dynamic Programming

Dynamic programming, a mathematical extension of Markov process, has been developed by Belman (1), Howard (5), and others. The salient characteristics of Markov process are the state of the system and the transition from one state to another. A system occupies a state when it is completely described by the variables which define the state. A system makes a transition from one state to another usually over time, either discrete or continuous.

A simple example might make this approach more clear. Suppose a flower breeder has developed a variety which, in a given year, found a great demand in the market. Let a successful flower variety be defined as state 1. The flower breeder's competitor markets an improved variety the following year and sales of our breeder's variety fall off drastically. Let us define state 2 as an unsuccessful variety. If successful and unsuccessful varieties are the only possible states for the flower breeder, then these two states completely describe the system. Suppose further that when the flower breeder is in state 1, his variety has a 50 percent change of finding favor with his customers in the following year (state 1). By the same token, it has a 50 percent chance of being out of favor with his customers, thus moving him to state 2. When the breeder is in state 2, assume that he has a two-thirds chance of having an unsuccessful variety in the following year (remaining in state 2) and a one-third probability of coming up with a successful variety and making the transition back to state 1. Schematically, these transitions can be shown as in figure 1.

In matrix form this can be stated as a transition matrix

$$P = \left[P_{ij} \right] = \begin{bmatrix} 1/2 & 1/2 \\ 1/3 & 2/3 \end{bmatrix}$$

A state probability can be defined as $\pi_i(n)$, which is the probability that the plant breeder will occupy the ith state after n transitions if the state at N = 0 is known. Since

$$(1) \qquad \sum_{i=1}^{n} \pi_i(n) = 1 \text{ and}$$

$$(2) \qquad \pi_j(N+1) = \sum_{i=1}^{N} \pi_i(n) P_{ij} \quad n = 0, 1, 2,$$

then,

$$(3) \qquad \pi(n) = \pi(0)\, p^n$$

Using this relation, it is possible to find the probability that the plant breeder occupies each state in the system after n transitions by post-multiplying the initial state probability by the nth power of the transition matrix.

Rewards for each transition may be included by defining a value $V_i(n)$ as the expected total earnings in the next n transitions if the system is now in state i and defining r_{ij} as the amount the system will earn if it makes the transition from state i to state j. The total expected earnings can be expressed as:

$$(4) \qquad V_i(n) = \sum_{j=1}^{N} p_{ij} r_{ij} + \sum_{j=1}^{N} p_{ij} V_j(n-1)$$

$$i = 1, 2, ..., N$$
$$n = 1, 2, 3, \ldots$$

In words, total expected returns equal the probability starting in state i of making a transition to state j times the reward earned for making the transition plus the expected reward from starting in state j with one fewer time period remaining.

In our example of the flower breeder, rewards or net returns for each possible transition can be assumed such that if he makes a transition from state 1 to state 1 the flower breeder earns 10 units of reward. If he remains unsuccessful for two periods in succession (transition from state 2 to state 2), his loss would be -6. If he changes from successful to unsuccessful or vice versa, he earns 4 units. Thus the reward matrix is:

$$R = \left[r_{ij} \right] = \begin{bmatrix} 10 & 4 \\ 4 & -6 \end{bmatrix}$$

and since $P = \begin{bmatrix} 1/2 & 1/2 \\ 1/3 & 2/3 \end{bmatrix}$

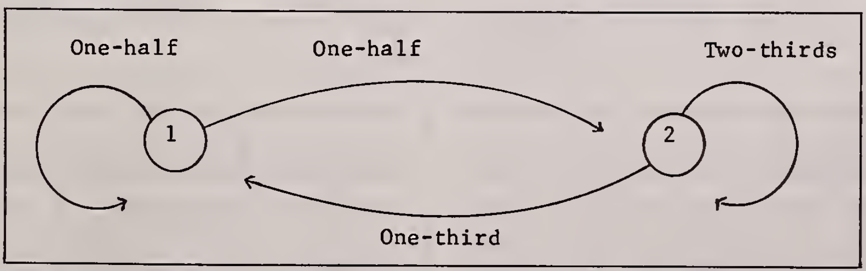


Figure 1.--Schematic diagram of transition probabilities.

immediate expected returns,

$$q_i = p_{ij}\ r_{ij} = \begin{bmatrix} 7.0 \\ -2.7 \end{bmatrix}$$

where

(5) $$q_i = \sum_{j=1}^{N} p_{ij}\, r_{ij} \qquad i = 1, 2, \ldots, N$$

then equation 4 reduces to

(6) $$V_i(n) = q_i + \sum_{j=1}^{N} p_{ij}\, V_j(n-1) \qquad \begin{matrix} i = 1, 2, \ldots, N \\ n = 1, 2, \ldots \end{matrix}$$

(5, p. 18).

Suppose the flower breeder knows his greenhouses will be taken over by a subdivision at the end of 5 years and he wishes to know the amount of money he will make in that time depending on whether or not he now has a successful variety. Assuming that the business will have a zero salvage value at the time of urbanization, V_i (0) can be set equal to zero.

Equation 4 can be used to calculate V_i (n) for each state, for several values of n (see table 1). From table 1, if the flower breeder is 5 years from going out of business, he can expect to make 12.825 units in the time remaining if he now has a successful variety and only 1.14 units if he now has an unsuccessful variety for his customers.

Suppose the flower breeder is not restricted to chance alone as to whether or not he has a successful variety this year. In years of an unsuccessful variety, he has the alternative of investing additional funds and effort in research to find a more acceptable variety. During the year, when he has a successful variety, he can expend additional funds on advertising in order to keep the variety from losing acceptance. Therefore, in each state, the flower grower would have two alternatives. Associated with these additional alternatives would be a new set of transition probabilities and rewards.

A sequential decision problem involving one or more alternatives can be solved with a slight modification of equation 6 from Howard (5). Defining q_i^k as the expected reward from a single transition from state i following alternative k, then

(7) $$q_i^k = \sum_{j=1}^{N} p_{ij}^k\ r_{ij}^k$$

Howard (5, p. 28), redefines $V_k(n)$ as "the total expected return in n stages starting from i if an optimal policy is followed." Thus, equation 6 can be rewritten as

(8) $$V_i(n+1) = \max_k \left[q_i^k + \sum_{j=1}^{N} p_{ij}^k\ V_j(n) \right]$$

The problem becomes one of making the optimum decision in each time period in order to maximize long-term expected income. If each combination of decisions over the n time periods is defined as a policy, then the optimal policy would be one that maximizes total expected returns over the planning period. Howard (5) has developed an efficient algorithm which can be used to determine the optimum decisions in each stage, assuming that an optimum policy had been followed up to that stage. This algorithm can be used for any number of states, alternatives, and time periods up to the storage capacity of the computer.

Table 1.--Total expected reward for flower breeder by state and number of years remaining

n =	0	1	2	3	4	5
$V_1(n)$	0	7.0	9.15	10.475	11.662	12.825
$V_2(n)$	0	-2.7	-2.20	-1.15	-0.013	1.14

The lettuce growers' sequential decision problem was defined for a single farm size, 240 acres of irrigated land with a typical line of machinery and an assumed equity of 55 percent in machinery and equipment. For this single-size of farm, 10 states were defined representing 10 different gross operating capital levels or supplies. Within each state different cropping plans were defined as alternatives that could be selected by the grower. Lower numbered states contained alternatives (crop plans) with a high proportion of low-risk field crops and low-risk contractual arrangements for growing vegetables. In the higher numbered states, high-risk crop plans were specified requiring larger amounts of operating capital to be furnished by the grower. One state (state 1) was defined as a proxy for bankruptcy. For each alternative in each state there is an associated farm income. From this income must come funds to pay family living expenses, machinery loan payment, and personal income tax. The residual is a net addition to the operating capital supply.

Transition probabilities were determined by asking the question for each alternative, how many standard deviations of income (converted to areas under the normal curve) would be required from this crop plan to cover expenses and provide sufficient operating capital to move the system to the next state (operating capital supply)? Standard deviations were based on the total variance of net income for each crop plan.

Net income variability was estimated from a statistical time series of gross income less a series of cost data deflated by an index of prices paid for inputs in the vegetable industry. Tintner's variate difference method (8) was applied to this series to determine variances and correlation coefficients. Total variance of crop plans was determined using the well-known procedures for combining variances outlined by Heady (4).

A total of 10 states were defined, each with a set of alternative crop plans. Each time the grower makes a transition, either to another state or to the same state, he earns a reward. If the transition is to a lower numbered state, the reward is negative, reflecting a loss in operating capital. The reward for making a transition from one state to another was defined as the difference in operating capital used in defining the two states. For example, the reward for moving from state 5 to state 6 was $7,500. To move from state 5 to state 4 was -$5,000. Data used to calculate the transition probabilities are shown in table 2 and the estimated transition probabilities are shown in table 3.

Results

In contrast to the usual solution of farm management problems which attempts to maximize immediate expected income, dynamic programming not only takes into account immediate expected income for any starting state but also the income received if subsequent transitions cause a grower to land in a different state from whence he started. That is, the program calculates the rewards from starting state 3 plus the rewards the grower would receive by following an optimal policy if he lands in state 4, times the probability of making the transition to state 4.

Although the expected immediate income from a given alternative (crop plan) within a state may be lower than another alternative, the probability of making a transition to a higher state may be greater because of a higher variance of net income. Therefore, the policy which maximizes expected immediate gains may not maximize the long-term expected gains if we consider a large number of time periods.

Figure 1 shows expected incomes from each alternative plotted against its standard deviation. The solid lines indicate the restrictions imposed by the supply of operating capital used in defining the state. Since some alternatives were repeated in more than one state, these lines show the lowest state in which an alternative first appeared. The dashed curve represents the efficiency frontier. The policy iteration method defines an optimal policy as that set of alternatives (decisions) which maximizes the present value of income in all states. That is, the solutions indicate, for each gross operating capital level (state), the crop plan and contractual arrangement a grower should follow if his objective is to maximize long-term income. The optimal alternative in each state is indicated by the circled dots in figure 2.

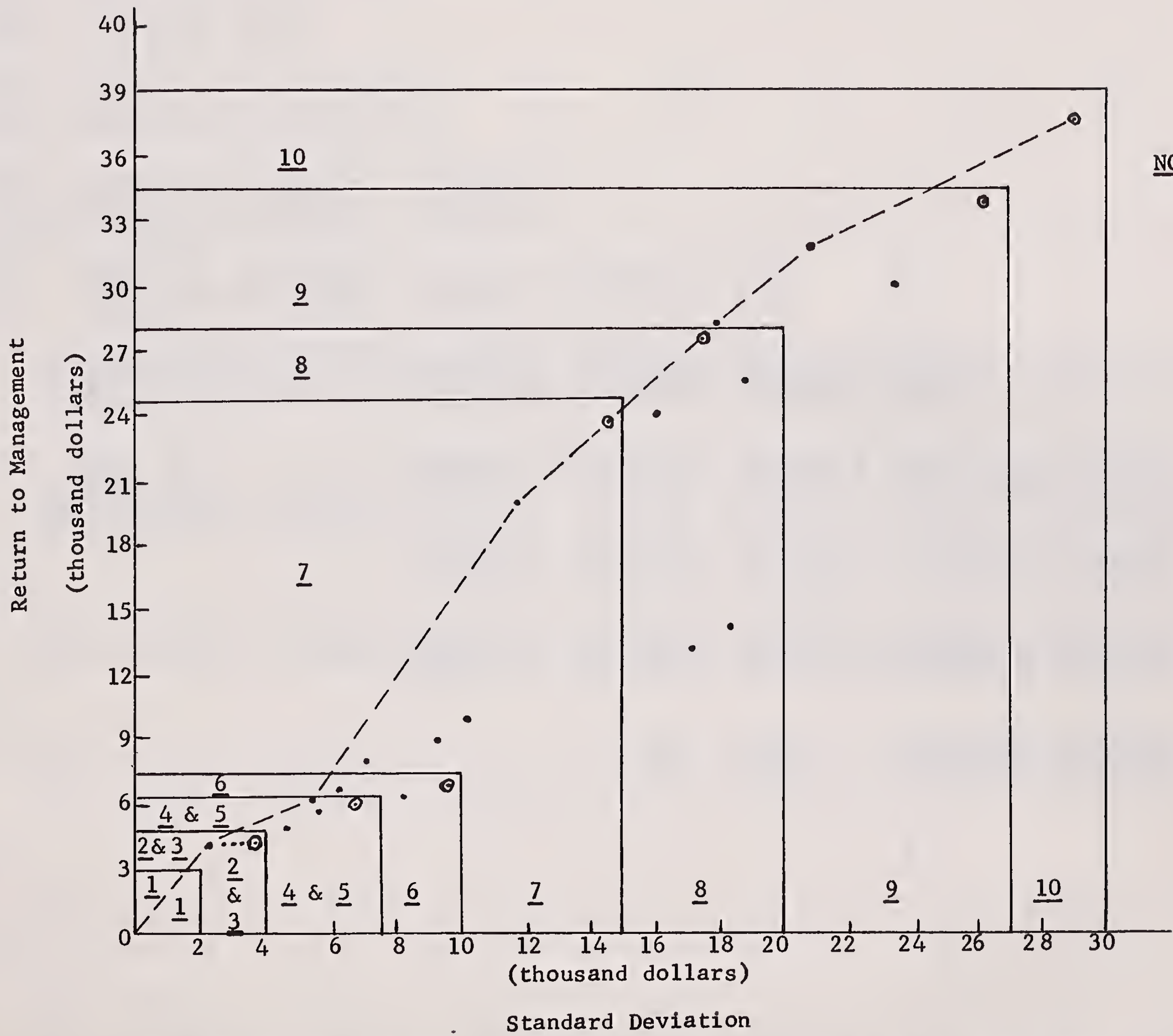
The optimal strategy for growers with very low operating capital supplies is not to follow

Table 2.--Income, family withdrawals, loan payments, marginal tax rates, and standard deviation about net income by state and alternative, Salinas Valley, Calif.

State	Operating capital	Alternative	Return to labor and management	Taxable income	Family withdrawal	Loan payment	Marginal tax rate	Standard deviation
	dollars		dollars				percent	dollars
1	0	1	0	0	0	0	0	0
2	7,500	1	9,556	8,556	5,200	1,845	22	3,497
		2	9,561	8,561	5,200	1,845	22	3,227
		3	9,566	8,566	5,200	1,845	22	2,974
		4	9,572	8,572	5,200	1,845	22	2,740
		5	9,582	8,582	5,200	1,845	22	2,168
3	11,250	1	9,556	8,556	5,200	1,845	22	3,497
		2	9,561	9,561	5,200	1,845	22	3,227
		3	9,566	8,566	5,200	1,845	22	2,974
		4	9,572	8,572	5,200	1,845	22	2,740
		5	9,582	8,582	5,200	1,845	22	2,168
4	15,000	1	9,566	8,566	5,200	1,845	22	2,974
		2	9,572	8,572	5,200	1,845	22	2,740
		3	9,582	8,582	5,200	1,845	22	2,168
		4	10,417	9,417	5,200	1,845	22	4,589
		5	10,852	9,852	5,200	1,845	25	5,587
		6	11,288	10,288	5,200	1,845	25	6,830
5	20,000	1	9,566	8,566	5,200	1,845	22	2,974
		2	9,572	8,572	5,200	1,845	22	2,740
		3	9,582	8,582	5,200	1,845	22	2,168
		4	10,417	9,417	5,200	1,845	22	4,589
		5	10,852	9,852	5,200	1,845	25	5,587
		6	11,288	10,288	5,200	1,845	25	6,830
6	27,500	1	11,288	10,288	5,200	1,845	25	6,830
		2	11,723	10,723	5,200	1,845	25	8,210
		3	12,164	11,164	5,200	1,845	25	9,675
		4	11,438	10,438	5,200	1,845	25	5,153
		5	11,840	10,840	5,200	1,845	25	6,276
		6	13,330	12,330	5,200	1,845	28	7,581
7	35,000	1	12,164	11,164	5,200	1,845	28	9,675
		2	13,330	12,330	5,200	1,845	28	7,130
		3	14,276	13,276	5,200	1,845	28	8,988
		4	15,228	14,228	5,200	1,845	32	10,228
		5	25,127	24,127	5,200	1,845	36	11,705
		6	29,008	28,008	5,200	1,845	39	14,586
8	55,000	1	14,276	13,276	5,200	1,845	28	8,988
		2	15,288	14,288	5,200	1,845	28	10,228
		3	25,127	24,127	5,200	1,845	36	11,705
		4	29,008	28,008	5,200	1,845	39	14,586
		5	32,923	31,923	5,200	1,845	42	17,542
		6	30,642	29,642	5,200	1,845	42	18,717
9	75,000	1	18,478	17,478	5,200	1,845	32	17,056
		2	19,296	18,296	5,200	1,845	36	18,216
		3	33,194	32,194	5,200	1,845	45	17,826
		4	36,962	35,962	5,200	1,845	48	20,714
		5	35,354	34,354	5,200	1,845	48	23,457
		6	39,122	38,122	5,200	1,845	50	26,283
10	100,000	1	35,354	34,354	5,200	1,845	48	23,457
		2	39,122	38,122	5,200	1,845	50	26,283
		3	42,889	41,889	5,200	1,845	53	29,167

Table 3.--Transition probabilities by state

State	Alter- native	1	2	3	4	5	6	7	8	9	10
1	1	.9999	.0001								
2	1	.0020	.8666	.1237	.0077						
	2	.0010	.8611	.1330	.0049						
	3	.0006	.8804	.1164	.0026						
	4	.0001	.8998	.0989	.0012						
	5	.0001	.9462	.0536	.0001						
3	1		.0384	.8054	.1539	.0023					
	2		.0287	.8334	.1368	.0011					
	3		.0217	.8593	.1186	.0004					
	4		.0116	.8881	.1002	.0001					
	5		.0037	.9426	.0536	.0001					
4	1		.0006	.0211	.9773	.0010					
	2		.0001	.0115	.9570	.0314					
	3		.0001	.0036	.9869	.0094					
	4		.0089	.0605	.7544	.1749	.0013				
	5		.0217	.0668	.6727	.2326	.0062				
	6	.0024	.0412	.0989	.5525	.2884	.0163	.0003			
5	1			.0006	.0072	.9896	.0026				
	2			.0001	.0031	.9956	.0012				
	3			0	.0003	.9996	.0001				
	4		.0003	.0086	.0240	.9156	.0514	.0001			
	5		.0017	.0200	.0353	.8479	.0941	.0010			
	6		.0071	.0336	.0602	.7380	.1540	.0071			
6	1			.0013	.0058	.0336	.7982	.1611			
	2		.0013	.0051	.0119	.0511	.7129	.2177			
	3		.0047	.0092	.0205	.0695	.6360	.2601			
	4			0	.0033	.0071	.8928	.0968			
	5			.0004	.0026	.0226	.8275	.1469			
	6			.0013	.0055	.0276	.9632	.0024			
7	1			.0023	.0025	.0131	.0825	.8921	.0075		
	2			0	.0003	.0023	.0318	.9640	.0016		
	3			.0004	.0008	.0056	.0437	.9406	.0089		
	4			.0006	.0024	.0086	.0648	.9057	.0179		
	5			.0002	.0004	.0017	.0123	.7877	.1975	.0002	
	6			.0003	.0006	.0015	.0099	.6505	.3356	.0016	
8	1							.0012	.9899	.0089	
	2							.0030	.9791	.0179	
	3							.0006	.8017	.1977	
	4							.0009	.6619	.3370	.0002
	5						.0012	.0032	.6059	.3877	.0020
	6						.0037	.0062	.6709	.3169	.0023
9	1						.0003	.0005	.0321	.8936	.0735
	2					.0001	.0004	.0015	.0364	.8852	.0764
	3						0	.0001	.0047	.7243	.2709
	4						.0001	.0003	.0083	.6828	.3085
	5					.0002	.0004	.0012	.0179	.6788	.3015
	6					.0005	.0007	.0019	.0207	.6017	.3745
10	1								.0009	.0107	.9884
	2								.0017	.0133	.9850
	3							.0003	.0025	.0155	.9817



NOTE: The points circled are the optimum alternatives in each state.

Figure 2.--Management income and standard deviation of income by supply of operating capital (states), Salinas Valley, Calif.

the alternatives which give the highest immediate income. Under this situation, a grower would accept a slightly lower farm income plan but one which has a higher variance. This means that to maximize long-term income, the alternative with the greater variance has a better chance of moving to a higher state. Sacrificing a higher current income for a crop plan with a lower income but higher probability of making a transition to a higher state in the future was found to be optimal in states 2 through 6. The optimal policy in states 7, 8, and 10 indicates that long-term income can be maximized by a crop plan on the efficiency frontier. In state 9, the optimal plan was very close to the frontier (see table 4).

Conclusions

These results would indicate that alternatives not located on the efficiency frontier must be included in an analysis when the objective is maximization of long term income. Second, analysis of problems in the Expected Income - Variance space must include capital explicitly as a third variable. Failure to include capital as a variable leads to unrealistic solutions. For instance, in the problem just described, failure to include capital supplies in the definition of the states would have resulted in always selecting an alternative that utilized the largest amount of capital possible as long as the return per unit of capital was positive. Third, as the supply of capital approaches the point where its MVP is near the marginal factor cost, less current income need be sacrificed to achieve a reasonable probability of making transitions to higher states.

References

(1) Belman, R. Dynamic Programming. Princeton Univ. Press, 1957.

(2) Carter, H. O., and G. W. Dean. Income, Price and Yield Variability for Principal California Crops and Cropping Systems. Hilgardia, Vol. 30, 1960.

(3) Eidman, V. R., G. W. Dean, and H. O. Carter. An Application of Statistical Decision Theory to Commercial Turkey Production. Jour. Farm. Econ., Vol. 49, No. 4, Nov. 1967. p. 852-868.

(4) Heady, Earl O. Economics of Agricultural Production and Resource Use. Prentice-Hall, 1952.

(5) Howard, R. A. Dynamic Programming and Markov Processes. MIT Press, Cambridge, Mass., 1960.

(6) Moore, C. V., and J. Herbert Snyder. Risk and Uncertainty in Lettuce Production in Salinas Valley, California. Calif. Agr. Expt. Sta. Res. Rpt. 300, Jan. 1969.

(7) Stovall, J. G. Income Variation and Selection of Enterprises. Jour. Farm Econ., Vol. 48, No. 5, Dec. 1966, p. 1575-1579.

(8) Tintner, G. The Variate Difference Method. Cowles Found. Monog. 5, Principia Press, Evanston, Ill., 1940.

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Table 4.--Optimal policy by state, 240-acre farm

State	Operating capital level	Alternative	Cropland
	dollars		percent
1	0	Bankruptcy	
2	7,500	Carrots (2)[a]	30
		Sugar beets	20
		Small white beans	30
		Lettuce (5)	
		$300 flat rate	20
3	11,250	Carrots (2)	30
		Sugar beets	20
		Small white beans	30
		Lettuce (5)	
		$300 flat rate	20
4	15,000	Carrots (2)	20
		Sugar beets	20
		Small white beans	20
		Lettuce (2)	
		$135 guarantee	40
5	20,000	Carrots (2)	20
		Sugar beets	20
		Small white beans	20
		Lettuce (3)	
		$135 guarantee	40
6	27,500	Carrots (2)	15
		Sugar beets	15
		Small white beans	10
		Lettuce (3)	
		$135 guarantee	60
7	35,000	Carrots (2)	15
		Sugar beets	20
		Small white beans	15
		Lettuce (1)	
		Cooperative	50
8	55,000	Carrots (2)	15
		Sugar beets	15
		Small white beans	10
		Lettuce (1)	
		Cooperative	60
9	75,000	Carrots (1)	20
		Sugar beets	10
		Lettuce (1)	
		Cooperative	70
10	100,000	Carrots (1)	20
		Lettuce (1)	
		Cooperative	80

a/ Number in parentheses indicates contract number.

The U.S. Supply of Soybeans: Regional Acreage Functions

By James P. Houck and Abraham Subotnik

Some recent analytical and empirical work on regional supply relationships for U.S. soybeans is described in this paper. This work is part of an ongoing research project sponsored jointly by the U.S. Department of Agriculture and the Agricultural Economics Department of the University of Minnesota.[1]

Of particular interest here are (1) the manner in which support prices and acreage restrictions for competing crops have been introduced into the regional supply relations for soybeans and (2) the estimated effects of changes in the soybean price support rate on acreage. With the estimates presented here, it is possible to investigate the implications on soybean acreage of policy changes in both soybean price support procedures and in price supports and acreage restrictions for other competing crops. It is anticipated that, ultimately, supply relationships for U.S. soybeans can be combined with the simultaneous demand model developed earlier (3).[2] This modification will give the system a dynamic dimension it now lacks.

First, a theoretical model of the "effective support price" is developed. This involves combining into one quantitative measure the support price and acreage restrictions which jointly represent Government policy for several crops. Second, a distributed lag estimation model is presented which incorporates both actual prices and effective support prices in a soybean acreage supply function. Third, empirical estimates of this model, based on annual data for 1946-66, are presented for the major soybean-growing regions of the Nation. Finally, an application of this model shows the net impact over several years of a specified decrease in the soybean support price.

Theoretical Model of Effective Support

Price support programs for a number of important crops in U.S. agriculture involve a guaranteed minimum support price in return for which participating farmers agree to reduce acreage relative to some historically established base. The guaranteed minimum price may include several elements--the basic price support loan rate, a direct payment based on participation level, and a direct payment based on production from permitted acreage under the program. It is clear, therefore, that supply analyses which utilize only the basic support rate for several competing commodities will be less useful than those into which the mandatory or voluntary acreage restrictions imposed on farmers can be incorporated.

One approach to this question of incorporating both price support and acreage restrictions in a supply analysis involves the weighting or "normalization" of announced support rates by means of the acreage restrictions imposed on participating farmers. For this discussion, a rather simple analytical framework is developed. A more complete treatment of these ideas is contained in the appendix.

Let a simple acreage supply function be represented by

$$(1) \qquad A = a_0 + a_1 P$$

where A is the harvested acreage and P is the relevant supply-inducing price. All other supply shifters are held fixed and incorporated in a_0.

[1] Technical advice and consultation are provided by the Economic Research Service through the Economic and Statistical Analysis Division. Robert M. Walsh, deputy director of this division, serves as technical coordinator for the project and chairman of an informal advisory committee consisting of USDA personnel. Responsibility for the material in this article is clearly that of the authors.

[2] Underscored numbers in parentheses indicate items in the References, p. 107.

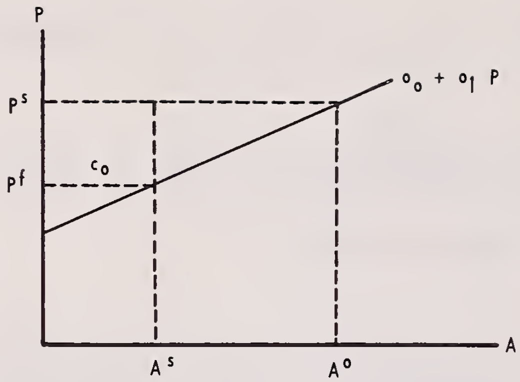

Figure 1

Assume now that a support price p^s is offered to the farmers only if they are willing to reduce acreage to A^s, compared to A^o which would be harvested without restriction at p^s. This is shown in figure 1. The price p^f is that which would induce farmers to hold acreage at A^s without restrictions. For this discussion, p^f is called the "effective support price" and is the alternative cost of committing A^s to this commodity. This effective support rate is the variable which will be taken into account by farmers in planning production patterns among alternative crop enterprises.

The announced support rate p^s may be higher than p^f because policy makers wish to maintain farm income above the level which would occur under p^f (area c_0 in figure 1). This added income is only available to farmers when their acreage is held at A^s.[3]

For analytical purposes, it is useful to find a function which transforms p^s into p^f by normalizing or deflating the announced support rate. Consider equation (1) evaluated at two points, p^s and p^f. At each of these points

(2) $$a_1 = \frac{A^o - a_o}{p^s} = \frac{A^s - a_o}{p^f}$$

This relationship implies that

(3) $$p^f = \frac{A^s - a_o}{A^o - a_o} p^s$$

If $a_o = 0$ or is small relative to A^s and A^o, then

(4) $$p^f \cong (A^s/A^o)\ p^s$$

[3] For additional discussion of this general topic, see (1).

In this case, the effective support rate can be expressed as a function of announced support rate and a ratio of the permitted to the desired acreage. Where no acreage restrictions are employed, p^s and p^f are identical since $(A^s/A^o) = 1$.

The Estimation Model

Since World War II, the farm price of soybeans has been supported, but no acreage restrictions have been attached to these supports (5). In most years, average market prices have been above support levels. However, crops which compete for soybean acreage have been influenced not only by support prices but also by acreage restrictions of one sort or another. These competitive crops are mainly corn, oats, wheat, and cotton.

Under these conditions, it is hypothesized that the expected prices of various crops which effect the soybean acreage supply in year t are

(5) $$P^*_{it} = w_{i1}\ P_{i\ t-1} + w_{i2}\ p^f_{it}\,,$$

where P^*_{it} is the expected price in year t for crop i, P_{it-1} is actual farm price in year (t-1) for crop i, and p^f_{it} is the effective support price in year t for crop i. As mentioned previously, the effective support rate is equal to the announced support rate when no acreage compliance is required to obtain the announced rate. This formulation of price expectation also is assumed to be appropriate for both mandatory and voluntary acreage control programs.

The basic model for acreage supply response used in this analysis is

(6) $$A_t = b_0 + b_1\ A_{t-1} + b_2\ P^*_{1t} + b_3\ P^*_{2t} + u_t$$

where A is acreage harvested, P^*_{1t} is the expected price for the crop in question, P^*_{2t} is the expected price for a competing commodity, and u_t is a random, mean-zero disturbance with finite variance. Although the expected price for only one competing commodity is included in equation (6), the method can easily be extended to incorporate numerous others. Notice that the model is of the lagged adjustment type developed by Nerlove (4). Substituting in equation

(6) for the values of P_1^* and P_2^* from equation (5):

$$(7) \quad A_t = c_o + c_1 A_{t-1} + d_1 P_{1t-1} + e_1 P_{1t}^f + d_2 P_{2t-1} + e_2 P_{2t}$$

where

$c_o = b_o$ $\qquad e_1 = b_2 w_{12}$

$c_1 = b1$ $\qquad d_2 = b_3 w_{21}$

$d_1 = b_2 w_{11}$ $\qquad e_2 = b_3 w_{22}$

In equation (7), there are two variables that cannot be observed--P_{1t}^f and P_{2t}^f. Using the relationships developed in the previous section and elaborated in the appendix, the effective support prices for the relevant commodities can be calculated and used in the estimation process. They are

$$P_{1t}^f = (A_1^s/A_1^o)\, P_{1t}^s \quad \text{and}$$

$$P_{2t}^f = (A_2^s/A_2^o)\, P_{2t}^s.$$

Effective support prices for several commodities--wheat, corn, oats, and cotton--were calculated for 1945-66 and used in the empirical analysis (table 1). No special calculation was needed for soybeans since effective and announced support prices were equivalent during this period, no acreage restrictions having been imposed. Other methods of computing the A^s/A^o ratios for the various commodities surely could be developed and used in the formulation of effective support prices. The series shown in table 1 indicate the underlying concepts.

In the table, there are three columns of figures for each of the four commodities. The first column is simply the announced support price. In recent years, this announced price also includes direct payments to program participants. The second column is an estimate of the A^s/A^o ratio. This estimate is based on the ratio of permitted acreage for program participants relative to some actual or historical allotment base. It is designed to reflect the ratio of the acreage desired by policy makers to the acreage desired by farmers at the announced support rate. These ratios are to be regarded as estimates of A^s/A^o and not the precise calculation of A^s or A^o.[4] Finally, the third column is the product of the first two. It is the announced support rate weighted or "normalized" by the estimate of A^s/A^o. It is the effective support price.

Empirical Results

Supply functions in terms of harvested soybean acreage were estimated by least squares for six regions of the United States: the Lake States, the Corn Belt, the Plains States, the Delta States, the Atlantic States, and all other States grouped together. These correspond to the soybean-producing regions identified by the Economic Research Service in recent statistical series (6, p. 69). Crop year data for 1946-66 were used. The Nerlove distributed lag model was used in each region except the Atlantic States. The specification of individual equations differed from region to region because of the differing importance of alternative crops. A number of different specifications were tested for each region. In each case, the inclusion of the effective support price series described earlier yielded markedly better results than similar equations without the adjustment of support rates. One seemingly most appropriate equation for each region was selected for presentation here. In virtually all cases, the choice among estimated equations was not difficult--one specification seemed to stand out clearly in each region.

The regression equations are presented here in a standard format. The t-values appear in parentheses directly below the estimated coefficients. (None of the t-values for the estimated intercepts were absolutely larger than 1.0.) There was no evidence of serial correlation in any of the residuals. The variables used are identified below each equation. An aggregate national supply equation and a summary of direct and cross elasticities of acreage response are presented following the regional results.

[4] Further refinements of these ratios could be developed to account for trends in yields among several crops as well as the cross-compliance features of some past and present programs. In the case of corn and soybeans, some adjustments could be made to allow for the provision that, in some years, soybeans could be grown on permitted corn acreage without forfeiture of the direct support payments for corn.

Table 1.--Announced support prices and effective support prices

Year	Corn			Oats			Wheat			Cotton		
	Support price[a]	A^s/A^o	Effective support price	Support price[a]	A^s/A^o	Effective support price	Support price[a]	A^s/A^o	Effective support price	Support price[a]	A^s/A^o	Effective support price
	Dol./bu.		*Dol./bu.*	*Dol./bu.*		*Dol./bu.*	*Dol./bu.*		*Dol./bu.*	*Dol./bu.*		*Dol./bu.*
1945	1.01	[b] 1.00	1.01	0.48	1.00	0.48	1.38	1.00	1.38	0.20	1.00	0.20
1946	1.15	[b] 1.00	1.15	0.53	1.00	0.53	1.49	1.00	1.49	0.23	1.00	0.23
1947	1.37	[b] 1.00	1.37	0.63	1.00	0.63	1.84	1.00	1.84	0.26	1.00	0.26
1948	1.44	[b] 1.00	1.44	0.70	1.00	0.70	2.00	1.00	2.00	0.29	1.00	0.29
1949	1.40	[b] 1.00	1.40	0.69	1.00	0.69	1.95	1.00	1.95	0.27	1.00	0.27
1950	1.47	[b] 0.44	0.65	0.71	1.00	0.71	1.99	[e] 0.85	1.69	0.28	[h] 0.63	0.18
1951	1.57	[b] 1.00	1.57	0.72	1.00	0.72	2.18	[e] 0.90	1.96	0.30	1.00	0.30
1952	1.60	[b] 1.00	1.60	0.78	1.00	0.78	2.20	1.00	2.20	0.31	1.00	0.31
1953	1.60	[b] 1.00	1.60	0.80	1.00	0.80	2.21	1.00	2.21	0.31	1.00	0.31
1954	1.62	[b] 0.57	0.92	0.75	1.00	0.75	2.24	[f] 0.79	1.77	0.32	[h] 0.76	0.24
1955	1.58	[b] 0.62	0.98	0.61	1.00	0.61	2.08	[f] 0.70	1.46	0.32	[h] 0.65	0.21
1956	1.50	[b] 0.54	0.81	0.65	1.00	0.65	2.00	[f] 0.70	1.40	0.29	[h] 0.62	0.18
1957	1.40	[b] 0.51	0.71	0.61	1.00	0.61	2.00	[f] 0.70	1.40	0.29	[h] 0.63	0.18
1958	1.36	[b] 0.53	0.72	0.61	1.00	0.61	1.82	[f] 0.70	1.27	0.31	[h] 0.63	0.20
1959	1.12	[b] 1.00	1.12	0.50	1.00	0.50	1.81	[f] 0.70	1.27	0.30	[h] 0.62	0.19
1960	1.06	[b] 1.00	1.06	0.50	1.00	0.50	1.78	[f] 0.70	1.25	0.29	[h] 0.63	0.18
1961	1.20	[b] 1.00	1.20	0.62	1.00	0.62	1.79	[f] 0.70	1.25	0.32	[h] 0.66	0.21
1962	1.20	[c] 0.90	1.08	0.62	[c] 1.00	0.62	2.00	[f] 0.84	1.68	0.32	[h] 0.65	0.21
1963	1.25	[c] 0.84	1.05	0.65	[c] 1.00	0.65	2.00	[f] 0.84	1.68	0.32	[h] 0.58	0.19
1964	1.25	[d] 0.84	1.05	0.65	[d] 1.00	0.65	1.73	[f] 0.71	1.23	0.33	[h] 0.58	0.19
1965	1.25	[d] 0.84	1.05	0.60	[d] 0.84	0.50	1.69	[f] 0.63	1.06	0.33	[h] 0.58	0.19
1966	1.30	[d] 0.65	0.85	0.60	[d] 0.80	0.48	1.84	[f] 0.61	1.12	0.30	[h] 0.58	0.17

[a] From Agr. Handb. 345(5).
[b] Allotment acreage/Actual acreage.
[c] Based on data in Feed Situation, U.S. Dept. Agr., Aug. 1963.
[d] Based on data in Feed Situation, U.S. Dept. Agr., Feb. 1966.
[e] Allotment acreage/Actual average acreage 1948-49.
[f] Allotment acreage/Actual average acreage 1952-53.
[g] Based on data in Wheat Situation, U.S. Dept. Agr., May 1965 and Nov. 1967.
[h] Allotment acreage/Actual average acreage 1951-53.

THE LAKE STATES

This region contains Minnesota, Wisconsin, and Michigan. Soybean acreage harvested was expressed as a linear function of the previous year's acreage, the average market price for soybeans in the previous year, the soybean support rate, market prices of alternative crops in the previous year, and effective support prices for alternative crops. In the Lake States, corn and wheat emerged as the most significant competitors for acreage which can be devoted to soybeans.

The estimated function is

$$A_t^L = -244.3531 + \underset{(7.1)}{0.6611}\, A_{t-1}^L + \underset{(2.2)}{826.9820}\, p_{t-1}^s$$

$$- \underset{(1.7)}{820.0772}\, p_{t-1}^c + \underset{(2.3)}{899.9078}\, p_t^{ss}$$

$$- \underset{(3.5)}{877.7295}\, p_t^{sc} - \underset{(1.5)}{496.8078}\, p_t^{sw}$$

$$\bar{R}^2 = 0.95$$

where

A_t^L = soybean acreage harvested in the Lake States (1,000 acres)

p_{t-1}^s = lagged soybean price (dollars per bushel)

p_{t-1}^c = lagged corn price (dollars per bushel)

p_t^{ss} = effective support price of soybean (dollars per bushel)

p_t^{sc} = effective support price of corn (dollars per bushel)

p_t^{sw} = effective support price of wheat (dollars per bushel)

The estimated coefficients are reasonable in sign and magnitude. A given change in either market or effective support prices for soybeans or corn seems to have a similar impact on Lake States acreage, with corn appearing as a strong competitor. The competitive impact of changes in the wheat support rate is less strong. About 95 percent of the regional variation in soybean acreage is associated with changes in the specified independent variables.

THE CORN BELT

This region contains Illinois, Iowa, Indiana, Ohio, and Missouri. The same general specification was utilized for this region as for the Lake States, and a variety of equations were tested. In this region, corn was found to be the only significant crop alternative within the context of the model.

The estimated function is

$$A_t^{cb} = 2{,}781.764 + \underset{(10.3)}{0.7792}\, A_{t-1}^{cb} + \underset{(2.3)}{2{,}767.006}\, p_{t-1}^s$$

$$- \underset{(3.1)}{5{,}019.287}\, p_{t-1}^c + \underset{(1.1)}{1{,}010.428}\, p_t^{ss}$$

$$- \underset{(2.7)}{1{,}623.752}\, p_t^{sc}$$

$$\bar{R}^2 = 0.97$$

where the price variables are same as used previously and

A_t^{cb} = soybean acreage harvested in the Corn Belt (1,000 acres).

Again the estimated coefficients are reasonable in sign and magnitude. The impact of changes in corn prices or corn support rate relative to those for soybeans is much stronger in the Corn Belt than in the Lake States, as one might expect. About 97 percent of the regional variation in soybean acreage in the Corn Belt is associated with variation in the specified independent variables.

THE PLAINS STATES

This region contains Kansas, Nebraska, North Dakota, and South Dakota. Equations similar to those for the Lake States and Corn Belt were tested. However, in the Plains States, oats emerged along with corn as significant competitors for acreage in soybeans.

The estimated equation is

$$A_t^p = -189.6314 + \underset{(3.1)}{0.5644}\, A_{t-1}^p + \underset{(2.5)}{834.4143}\, p_{t-1}^s$$

$$- \underset{(2.8)}{1{,}239.135}\, p_{t-1}^c + \underset{(1.6)}{563.3366}\, p_t^{ss} - \underset{(1.4)}{243.5887}\, p_t^{sc}$$

$$- \underset{(1.4)}{1{,}056.619}\, p_t^{so}$$

$\bar{R}^2 = 0.92$

where the variables are as indicated before and

A_t^p = soybean acreage harvested in the Plains States (1,000 acres)

p_t^{so} = effective price support rate for oats (dollars per bushel)

Here again, appropriate direct and competitive relationships emerged. The net impact of changes in the oats price support variable seem to be quite large, although the coefficient is not highly significant in comparison with the coefficients on lagged market prices of soybeans and corn. About 92 percent of the variation in Plains States soybean acreage is accounted for in this equation by the specified independent variables.

THE DELTA STATES

This region contains Arkansas, Mississippi, and Louisiana. Using the same general specification as before, corn fell away as a significant alternative, but cotton and oats emerged.

The estimated equation is

$$A_t^d = 747.3894 + \underset{(10.8)}{0.8713}\, A_{t-1}^d + \underset{(1.6)}{831.9335}\, p_{t-1}^s$$

$$- \underset{(1.4)}{2{,}702.658}\, p_{t-1}^o + \underset{(1.3)}{749.1897}\, p_t^{ss} - \underset{(1.4)}{1{,}565.446}\, p_t^{so}$$

$$- \underset{(1.4)}{4{,}214.172}\, p_t^{s\,ct}$$

$\bar{R}^2 = 0.98$

where the variables that have not appeared before are:

A^d = soybean acreage harvested in the Delta States (1,000 acres)

p_{t-1}^o = lagged price of oats (dollars per bushel)

$p_t^{s\,ct}$ = effective price support of cotton (dollars per pound)

Reasonable direct and cross relationships emerged for the variables involved. The very rapid growth of soybean production in this region is reflected in the large and highly significant coefficient associated with lagged acreage. Changes in market prices of soybeans and oats have relatively more impact on acreage than do their respective support rates. An extremely large proportion--about 98 percent--of the variation in Delta soybean acreage is captured by the specified variables.

THE ATLANTIC STATES

This region contains North Carolina, South Carolina, Virginia, Maryland, and Delaware. In this region, the distributed lag model did not produce useful results.[5] Therefore, the lagged acreage variable was dropped from the function. Among the several other specifications tested, two emerged as potentially useful. In the first, oats and cotton emerged as significant alternative crops. In the other, oats and corn appear as alternatives.

The two equations are

(I) $$A_t^a = 1{,}483.435 + \underset{(1.4)}{939.9202}\, p_{t-1}^s$$

$$- \underset{(1.4)}{3{,}464.083}\, p_{t-1}^o + \underset{(1.9)}{1{,}434.114}\, p_t^{ss}$$

$$- \underset{(2.0)}{2{,}637.900}\, p_t^{so} - \underset{(1.7)}{6{,}761.531}\, p_t^{s\,ct}$$

$\bar{R}^2 = 0.70$

(II) $$A_t^a = 1{,}424.855 + \underset{(3.4)}{1{,}843.204}\, p_{t-1}^s$$

$$- \underset{(4.4)}{2{,}995.110}\, p_{t-1}^c + \underset{(1.1)}{647.4396}\, p_t^{ss} - \underset{(2.2)}{2{,}565.618}\, p_t^{so}$$

$$- \underset{(1.1)}{356.3632}\, p_t^{sc}$$

[5] The estimated coefficient on lagged acreage in the region was consistently larger than +1.0. This suggests instability in the adjustment processes assumed by the Nerlove-type model. Hence, other specifications of the acreage response for this region were investigated.

$\bar{R}^2 = 0.76$

where all of the variables have been introduced before except

A_t^a = soybean acreage harvested in the Atlantic States (1,000 acres)

The weakest of the estimated coefficients in equation (I) is stronger than the weakest in equation (II). However, the coefficient of multiple determination ($\bar{R}^2$) in equation (II) is larger than in equation (I). Moreover, the market price coefficients on soybeans and corn are stronger in equation (II) and larger than the coefficients estimated for their effective support rates. Because of the omission of lagged acreage in the estimated equations, the $\bar{R}^2$ for both equations is substantially lower in this region than is typical for the other States.

OTHER STATES

This grouping includes all other States that produce soybeans in any quantity: New York, New Jersey, Pennsylvania, West Virginia, Georgia, Florida, Kentucky, Tennessee, Alabama, Oklahoma, and Texas. In this widely dispersed grouping, corn and oats appeared as significant competitors.

The estimated equation is

$$A_t^m = 92.9566 + \underset{(10.3)}{0.9248}\, A_{t-1}^q + \underset{(1.8)}{255.3745}\, p_{t-1}^s - \underset{(1.4)}{275.9034}\, p_{t-1}^c + \underset{(1.9)}{248.4233}\, p_t^{ss} - \underset{(1.1)}{66.5647}\, p_t^{sc} - \underset{(3.8)}{1{,}043.640}\, p_t^{so}$$

$\bar{R}^2 = 0.98$

The only new variable here is

A_t^m = soybean acreage harvested in other States (1,000 acres)

The strong upward trend in acreage in this region is captured by the lagged acreage variable whose estimated coefficient is large and highly significant. The estimated relationship of the effective support rate for oats with soybean acreage is surprisingly strong. About 98 percent of the variation in acreage for this region is associated with variation in the specified independent variables.

AN AGGREGATE FUNCTION

A national acreage supply function can be developed by summing the six regional functions and collecting terms where appropriate (equation (II) for the Atlantic States was used). This function is

$$A_t^T = 4{,}612.99 + 0.8713\, A_{t-1}^d + 0.6611\, A_{t-1}^L + 0.7792\, A_{t-1}^{cb} + 0.5644\, A_{t-1}^p + 0.9248\, A_{t-1}^m + 7{,}358.913\, p_{t-1}^s - 10{,}349{,}512\, p_{t-1}^c - 2{,}702.658\, p_{t-1}^o + 4{,}118.723\, p_t^{ss} - 3{,}168.588\, p_t^{sc} - 6{,}231.326\, p_t^{so} - 4{,}214.172\, p_t^{s\ ct} - 496.808\, p_t^{sw}$$

$\bar{R}^2 = 0.96$

where

A_t^T = total soybean acreage harvested in the United States (1,000 acres)

This aggregate $\bar{R}^2$ was derived by weighting the computed $\bar{R}^2$ for each region by the proportion of that region's acreage variance to the total acreage variance for the Nation. This aggregate function reflects the total direct and cross supply relationships associated with market prices and effective support rates for soybeans, corn, oats, wheat, and cotton.

SUPPLY ELASTICITIES[6]

For a clearer comparison of the relative sizes of price effects on soybean acreage, the relevant direct and cross short-run elasticities of supply were computed at the data means. They are shown in table 2. The estimated supply elasticities for the national aggregate function are displayed along the bottom row of the table.

[6] It can be easily shown that the theoretical model used in this analysis implies that the acreage elasticity with respect to the announced support price is equal to the acreage elasticity with respect to the effective support price.

Table 2.--Short-run acreage supply elasticities for soybeans, estimated from regional functions, 1946-66

Regional function: Elasticity of--	With respect to--							
	p^{s}_{t-1}	p^{ss}_{t}	p^{c}_{t-1}	p^{sc}_{t}	p^{o}_{t-1}	p^{so}_{t}	p^{sw}_{t}	$p^{s\ ct}_{t}$
A^{L}........................	0.91	0.87	-0.49	-0.44	--	--	-0.35	--
A^{cb}........................	0.50	0.17	-0.50	-0.13	--	--	--	--
A^{p}........................	2.10	1.20	-1.70	-0.27	--	-0.69	--	--
A^{d}........................	0.75	0.64	--	--	-0.81	-0.31	--	-0.38
$A^{a}(I)$....................	1.70	2.40	--	--	-1.70	-1.30	--	-1.14
$A^{a}(II)$....................	3.30	1.10	-3.00	-0.28	--	-1.28	--	--
A^{m}........................	0.69	0.62	-0.41	-0.10	--	-0.75	--	--
A^{T}........................	0.84	0.43	-0.65	-0.17	-0.09	-0.19	-0.04	-0.04

The aggregate direct short-run price elasticity for the Nation as a whole is similar to some earlier estimates made by Vandenborre (7) and to several national estimates developed by Heady and Rao (2, p. 1054). However, it is higher than the estimates made by Houck and Mann (3, p. 47). None of these other studies included price supports and acreage restrictions for substitute crops jointly in the analysis. The independent variables were mostly acreages of competing crops and various price ratios.

The relationships among the elasticities in table 2 are reasonable, with market price elasticities generally exhibiting larger values than effective support price elasticities. Long-run elasticity estimates can be computed for each region except the Atlantic by dividing the short-run estimates by $(1-\hat{c}_1)$ where $\hat{c}_1$ is the estimated coefficient on lagged acreage, equation (7) (4, p. 309). Since most of the regions display substantial upward trend in soybean acreage, the estimates of $\hat{c}_1$ are fairly large, making the long-run elasticity estimates much larger than those for the short run.

An Application of the Results

As carryover stocks of soybeans continue to grow and as market prices continue to hang on support levels, the impact of lower soybean support prices is being analyzed and debated. One crucial problem is to estimate the change in soybean production which would follow any given change in the support price. The regional supply equations presented here can be used to estimate the impact of contemplated support rate changes.

As an illustrative example, consider the estimated impact of the recent drop in the soybean price support loan rate for the 1969/70 crop year. On March 6, 1969, the national average price support for No. 2 grade soybeans to be harvested in the fall of 1969 was reduced

Table 3.--Estimated regional and national decreases in harvested soybean acreage annually following a $0.30/bu. decrease in the soybean price support rate for the 1969 crop, 1969-73[a]

Region	1969	1970	1971	1972	1973
	1,000 acres				
Corn Belt......	270	426	281	185	122
Lake States....	303	1,066	831	648	505
Plains States..	169	345	193	108	60
Delta States...	225	445	387	337	293
Atlantic States	194	553	--	--	--
Other States...	75	146	134	123	113
Nation.........	1,236	2,981	1,826	1,401	1,093

[a] Based on No. 2 grade soybeans.

from the 1968/69 level of $2.50 per bushel to $2.20--a 30-cent decrease.[7] Further assume that market prices drop during the 1969/70 crop year, to the new loan rate as the large carryover indicated for September 1969 is worked off. The impact of these assumed conditions within the framework of this supply model would be as follows: First, the support rate decrease of 30 cents per bushel would discourage some plantings for the 1969 crop; second, the drop in the 1969/70 market price would continue to discourage production in 1970; third, the lagged adjustment feature for each region, except the Atlantic States, would continue to operate causing further but decreasing acreage drops in subsequent years. The data in table 3 show the annual adjustments that would occur in soybean acreage in 1969-73 if nothing else in the system changed and the market price remained at $2.20. Since other things will undoubtedly be changing during this period, these figures can be viewed as the net downward pressure annually on soybean acreage due to the specified support rate change, and not as a prediction of what will in fact occur. If a yield of 25.5 bushels per acre is assumed, the national production decrease each year would be as follows:

	Million bushels
1969	31.5
1970	76.0
1971	46.6
1972	35.7
1973	27.9

This exercise is only one of many that could be investigated with these estimates. It is suggestive of the kinds of analyses that are possible. Changes in support levels and acreage restrictions attached to other commodity programs also can be evaluated in terms of their impact on soybean acreage and production.

Concluding Comments

The regional supply functions presented and discussed here are of interest not only because of the empirical estimates but also because of the apparently successful application of the effective support price idea. Time series supply analyses of several U.S. crops have been limited because of the operation of supply-restricting acreage controls. Hence, wider application of the effective support price concept might prove useful in analysis for crops other than soybeans.

The method of calculating effective support rates suggested here might well be modified and improved. But, given the method used in this analysis, the empirical results were clearly superior to results using only announced support rates. Moreover, the estimates provide a means of evaluating acreage responses given changes in market price, announced support prices, and nonprice restrictions for soybeans and related crops.

References

(1) Brandow, G. E. Direct Payments as Instruments of Farm Policy. United States Agricultural Policy: Foreign and Domestic, G. L. Capel, ed., Agr. Policy Inst., N.C. State Univ., Raleigh, Jan. 1968, p. 103-109.

[7] The 1968-69 average price support loan rate was $2.50 per bushel applied to No. 2 grade soybeans. The 1968-70 loan rate is $2.25 per bushel applied to No. 1 grade soybeans. The price discount for No. 2 grade soybeans relative to No. 1 is about 5 cents per bushel. Hence the support rate decrease for all soybeans is approximately 30 cents per bushel.

(2) Heady, Earl O., and V. Y. Rao. Acreage Response and Production Supply Functions of Soybeans. Iowa Agr. and Home Econ. Expt. Sta. Res. Bul. 555, Sept. 1967.
(3) Houck, J. P., and J. S. Mann. An Analysis of Domestic and Foreign Demand for U.S. Soybeans and Soybean Products. Univ. Minn. Agr. Expt. Sta. Tech. Bul. 256, 1968.
(4) Nerlove, Marc. Distributed Lags and Estimation of Long-run Supply and Demand Elasticities: Theoretical considerations. Jour. Farm Econ., Vol. 40, No. 2, May 1958, p. 301-310.
(5) U.S. Department of Agriculture. Farm Commodity and Related Programs. Agr. Handb. 345, 1967.
(6) U.S. Department of Agriculture. U.S. Fats and Oils Statistics, 1909-1965. Statis. Bul. 376, 1966.
(7) Vandenborre, R. J. An Econometric Analysis of the U.S. Soybean Sector. Univ. Ill., unpublished Ph.D. thesis, 1964.

Appendix

The transformation of announced support prices into effective support prices can be generalized to a supply function including both market and support prices for several competing crops.

For example, let

(A1) $A_1 = a_0 + a_1 P_1 + a_2 P_1^f + a_3 P_2 + a_4 P_2^f$

where P_1 and P_2 are supply-affecting market prices, and P_1^f and P_2^f are effective support prices which cannot be observed directly if acreage restrictions are involved. More competing commodities can be introduced if desired, but one is sufficient for illustration. Then

(A2) $$a_2 = (A_1^o - a_o - a_1 P_1 - a_3 P_2 - a_4 P_2^f) / P_1^s \text{ and}$$

$$-a_2 = (A_1^s - a_o - a_1 P_1 - a_3 P_2 - a_4 P_2^f) / P_1^f$$

where A^o, A^s, and P^s are as defined in the text of the paper (see equation (2)). From the equations in (A2) it follows that

(A3) $$P_1^f = (A_1^s / A_1^o)(P_1^s) + (a_o + a_1 P_1 + a_3 P_2 + a_4 P_2^f)(P_1^s - P_1^f) / A_1^o$$

Let A_1^n be the acreage intercept in equation (A1) when $P_1^f = 0$. Then

(A4) $$P_1^f = (A_1^s / A_1^o)(P_1^s) + (A_1^n / A_1^o)(P_1^s - P_1^f)$$

If a supply equation for commodity 2 comparable to equation (A1) is assumed then with a similar line of reasoning it follows that

(A5) $$P_2^f = (A_2^s / A_2^o)(P_2^s) + (A_2^n / A_2^o)(P_2^s - P_2^f)$$

Substituting (A4) and (A5) into (A1) and collecting terms

(A6) $$A_1 = a_o + a_1 P_1 + a_2 \left[(A_1^s / A_1^o) P_1^s\right] + a_3 P_2 + a_4 \left[(A_2^s / A_2^o) P_2^s\right] + a_2 \left[(A_1^n / A_1^o)(P_1^s - P_1^f)\right] + a_4 \left[(A_2^n / A_1^o)(P_2^s - P_2^f)\right]$$

Consider the last two terms in equation (A6). First A^n / A^o is less than + 1.0, and if the commodities are sensitive to support price changes, the ratio will be much less than + 1.0. The expression $(P^s - P^f)$, though unobserved, is positive and smaller than P^s in the other expressions with the coefficients of a_2 and a_4. Finally, a_2 and a_4 will be of opposite sign if the commodities are substitutes in production. Hence, A_1 is approximated by

(A7) $$A_1 \cong a_o + a_1 P_1 + a_2 \left[(A_1^s / A_1^o) P_1^s\right] + a_3 P_2 + a_4 \left[(A_2^s / A_2^o) P_2^s\right]$$

This is the basic function fitted by least squares in this supply study of soybean acreage. The most difficult empirical problem, of course, is the estimation of A^s/A^o for several crops over a period of years in which support programs have changed markedly.

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A Model for Decision Making Under Uncertainty

By J. Bruce Bullock and S. H. Logan

Decision theory usually is partitioned according to whether the decision is made under conditions of (a) certainty, (b) risk, or (c) uncertainty. These areas are defined as follows:

(a) Certainty if each action taken by the decision maker is known to lead invariably to a specific outcome.

(b) Risk if each action leads to one of a set of possible unknown outcomes, but each outcome occurs with a known probability distribution.

(c) Uncertainty if each action leads to one of a set of possible outcomes, but the probability of a particular outcome is not known to the decision maker.

Luce and Raiffa (11, p. 13)[1] suggest that we add a fourth classification (d), a combination of risk and uncertainty in the light of experimental evidence--the area of statistical inference.[2]

Decision making in the realm of certainty poses no particular problems since each action has a single-valued or known outcome. The decision maker simply selects the action with the most favorable outcome. However, decision problems under risk and uncertainty have several possible outcomes associated with each action. A set of decision rules, consistent with the decision maker's objective (utility) function, is needed to select the course of action that maximizes utility.

This paper presents one method of developing decision rules when the outcome of alternative actions cannot be specified with certainty. The model presented is applicable to a wide range of decision problems (1, 2, 5, 6).

[1] Underscored numbers in parentheses refer to items in the References, p. 114.

[2] Classifications a, b, and c are similar to those specified by Knight (10).

Decisions Under Uncertainty

The problem of decision making under uncertainty can be characterized as a decision maker faced with choosing the optimal course of action, A_i, from a set of m possible actions. The outcomes of these various actions are dependent on the occurrence of alternative states of nature θ_j, j = 1, 2, ..., n. The states of nature are values of one or more exogenous factors that directly affect the outcome of a particular action but cannot be controlled with certainty by the decision maker. For example, if the set of actions represent different fertilizer applications for corn, the states of nature might be alternative levels of rainfall.

For each possible action $A_1, A_2, ..., A_m$, there are n potential outcomes, one for each state of nature. Uncertainty implies that the individual has no information about the likelihood of occurrence of any particular state of nature θ_j. Thus, the decision maker is faced with a set of unknown outcomes. Each outcome, λ_{ij}, can be represented as a point in an action-state plane, $\lambda_{ij} = (A_j, \theta_j)$, as shown in table 1.

For example, the outcome (profits) of a decision to feed high-quality steers will depend on the price of slaughter cattle at the end of the feeding period. Thus θ_1 may represent high slaughter cattle prices, θ_2 average prices, and θ_3 low prices. The outcome of decision A_1 (feed high-quality steers) and A_2 (feed low-quality steers) will depend on which value of θ occurs (cost per pound of gain is assumed to be known with certainty in both cases). We can represent this decision problem as shown in table 2, where λ_{12} is the profit per head from feeding high-quality steers when average prices are received at the end of the feeding period.

Table 1--Matrix representation of outcome plane

Action	States of nature									
	θ_1	θ_2	.	.	.	θ_j	.	.	.	θ_n
A_1	λ_{11}	λ_{12}	.	.	.	λ_{1j}	.	.	.	λ_{1n}
A_2	λ_{21}	λ_{22}	.	.	.	λ_{2j}	.	.	.	λ_{2n}
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
A_i	λ_{i1}	λ_{i2}	.	.	.	λ_{ij}	.	.	.	λ_{in}
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
A_m	λ_{m1}	λ_{m2}	.	.	.	λ_{mj}	.	.	.	λ_{mn}

Table 2.--Representation of a decision problem

Action	States of nature		
	θ_1 (high prices)	θ_2 (average prices)	θ_3 (low prices)
A_1 (feed high-quality steers)	λ_{11}	λ_{12}	λ_{13}
A_2 (feed low-quality steers)	λ_{21}	λ_{22}	λ_{23}

To make rational and consistent decisions relative to the action-state-outcome combinations, a utility index or some sort of preference ordering must be assigned to the set of outcomes. If the decision maker's preferences among the outcomes are consistent with von Neumann-Morgenstern utility axioms (14, p. 26; 11, p. 22-31), it is possible to define a utility function, $u_{ij} = u(\lambda_{ij})$, that will map the outcomes into a utility plane.

Von Neumann and Morgenstern show that there exists a utility function u on the set of prospects if:

A. the individual has a complete and transitive preference ordering over the set of all possible prospects, that is,

(1) for any two prospects u and v, one and only one of the following relations holds:

$u = v, u > v, u < v$[3]

(2) $u > v, v > w$ implies $u > w$

B. $u < w < v$ implies the existence of an α such that $\alpha(u) + (1-\alpha)v < w$, and $u > w > v$ implies the existence of an α such that $\alpha(u) + (1-\alpha)v > w$, where $0 < \alpha < 1$, and

C. it is irrelevant whether a combination of two prospects is obtained in two successive steps--first the probabilities α, $1-\alpha$, then the probabilities β, $1-\beta$; or in one operation with the probabilities γ, $1-\gamma$ where $\gamma = \alpha\beta$. (That is, complex choices can be partitioned into simpler choices to facilitate evaluating preferences.)

(1) $\alpha u + (1-\alpha)v = (1-\alpha)v + \alpha u$

(2) $\alpha[\beta u + (1-\beta)v] + (1-\alpha)v = \gamma u + (1-\gamma)v.$

In other words, for each prospect P_i there exists a number $u_i = u(P_i)$ which is called utility of P_i. This function has the following properties (4, ch. 4):

(1) $u(v) > u(w)$ if and only if the individual prefers v to w.

(2) If P_k is a prospect of receiving v with probability α or w with probability $(1-\alpha)$ then $u(P_k) = \alpha u(v) + (1-\alpha)\, u(w)$.

However, the derivation of such a utility function is no small undertaking. Thus, as a matter of practical application, it is usually assumed that the utility function is linear with respect to money over the relevant range. Consequently, maximization of monetary gain is equivalent to maximizing utility.

Thus the decision problem can be stated as follows: Given a set of possible actions, A, the set of alternative states of nature, θ, and the utility index u_{ij}, associated with the selection of action A_i and the occurrence of θ_j (outcome λ_{ij}),[4] select the action that is in some sense optimal--where optimality is defined by the particular decision criterion used. Possible decision criteria include maximizing the minimum gain (maximin), minimizing the maximum regret (minimax), and the "principle of insufficient reason."

The Maximin Criterion. Each action is appraised on the basis of its security level (i.e., its lowest possible utility payoff). In the example below, action A_1 has a minimum possible utility (security level) of one whereas A_2 has a security of two. The maximin criterion is to select the action associated with the maximum of these minimum values (maximin). Thus, action A_2 is selected:

Utility Payoff Matrix

Action	State		Security level
	θ_1	θ_2	
A_1	1	5	1
A_2	3	2	2

The Minimax Criterion. Each action is appraised on the basis of its "regret index." Regret is the utility foregone as a result of selecting a nonoptimal action, given θ_j as the true state. The regret index for each action is its maximum "regret" value or lost utility.

In the above example, there is no regret if action A_1 is selected and θ_2 is the true state nor if action A_2 is selected and θ_1 is the true state. However, three utility units are foregone (regret = 3) if action A_2 is selected when θ_2 is the true state. The regret payoff matrix for the above example is:

Regret Payoff Matrix

Action	State		Regret index
	θ_1	θ_2	
A_1	2	0	2
A_2	0	3	3

[3] Where: = implies indifference between prospects
$>$ is read as "is preferred to"
$<$ is read as "is not preferred to"

[4] The matrix formulation of the decision problem is obtained by replacing λ_{ij} with u_{ij} in table 1.

The minimax criterion is to select the action that minimizes maximum regret. This criterion defines A_1 as the optimal action since it has the lowest regret index.

The "Principle of Insufficient Reason." This criterion asserts that if the decision maker has no information about the relative frequencies of the states of nature, then the occurrence of each state should be considered as equally likely. The criterion is to select the action that has the highest expected utility index.

$$\bar{u}_i = \frac{u_{i1} + u_{i2} + \ldots + u_{in}}{n}$$

Each of these decision criteria has serious shortcomings (11, p. 278-286; 3; 13). Moreover, few decision problems fall into the category of complete uncertainty, i.e., where the decision maker has no knowledge of the likelihood or distribution of θ. Given the volume of public and private information currently available, most well-informed decision makers will have at least a subjective[5] estimate of the distribution of θ, particularly for decisions of a recurring nature.

Bayesian Decision Theory

Generally some a priori information regarding the relative frequency of θ in the past will be available. Thus, emphasis in decision theory has shifted to the estimation of Bayesian strategies (7, 9, 12, 15), i.e., the selection of optimal actions based on some a priori information (either objective or subjective) about the probability distribution of the states of nature, $P(\theta)$.

The Bayesian approach to decision making can be stated as follows: Given a set of m possible actions, the set n of alternative states of nature, and the utility index associated with each outcome (table 1), along with a vector of a priori information about the relative frequency of θ,

$$P(\theta) = \begin{bmatrix} P(\theta_1) \\ P(\theta_2) \\ \cdot \\ \cdot \\ \cdot \\ P(\theta_j) \\ \cdot \\ \cdot \\ \cdot \\ P(\theta_n) \end{bmatrix}$$

where $P(\theta_j)$ is the a priori probability that state θ_j will occur, select the action A_I for which expected utility $\hat{u}_i = \sum_j u_{ij} P(\theta_j)$ is a maximum.

The a priori information can be any information that the decision maker has about the relative frequency of θ. This information is expressed in the form of a probability distribution $P(\theta)$ that provides some indication of the likelihood of a particular value of θ (states of nature) occurring. It may be nothing more than a subjective evaluation of the probabilities by the decision maker, or it may be derived from a histogram showing the relative frequencies of θ in the past.

In addition to the a priori knowledge of the probability distribution $P(\theta)$, it may be possible for the decision maker to gain additional information about the likelihood of a particular state θ by performing an experiment Z (with results Z_k, k = 1, 2, ..., n) that serves as a predictor of θ. That is, it may be possible to construct a conditional probability distribution $P(\theta|Z)$ which incorporates the a priori information, $P(\theta)$, with information about the past performance of Z as a predictor of θ. The a posteriori probability distribution, $P(\theta|Z)$, is calculated using Bayes' formula (8),

$$(1) \qquad P(\theta\ Z) = \frac{P(Z|\theta)\ (P\theta)}{P(Z)}$$

where P(Z) is the probability of observing a particular experimental result.

[5] For an analysis using subjective probability estimates, see Carlson (2).

Table 3.--Matrix of a posteriori information

States	Experimental results									
	Z_1	Z_2	.	.	.	Z_k	.	.	.	Z_n
θ_1	$P(\theta_1 \mid Z_1)$	$P(\theta_1 \mid Z_2)$	.	.	.	$P(\theta_1 \mid Z_k)$	.	.	.	$P(\theta_1 \mid Z_n)$
θ_2	$P(\theta_2 \mid Z_1)$	$P(\theta_2 \mid Z_2)$	.	.	.	$P(\theta_2 \mid Z_k)$	.	.	.	$P(\theta_2 \mid Z_n)$
.	.	.	.	.	.	.	.	.	.	.
.	. .	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
θ_j	$P(\theta_j \mid Z_1)$	$P(\theta_j \mid Z_2)$	.	.	.	$P(\theta_j \mid Z_k)$	.	.	.	$P(\theta_j \mid Z_n)$
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
θ_n	$P(\theta_n \mid Z_1)$	$P(\theta_n \mid Z_2)$	.	.	.	$P(\theta_n \mid Z_k)$	.	.	.	$P(\theta_n \mid Z_n)$

The experiment, Z, can be anything that is used as an estimator of θ. It may consist of simply observing the current state of nature θ_j and assuming that the value of θ at the time of payoff will also be θ_j. The experiment may consist of an elaborate model used to project future values of θ. For example, if the states of nature are future prices, the experiment would consist of some price forecasting mechanism.

The experimental information expands our knowledge about the likelihood of θ from the $P(\theta)$ vector to an (nxn) matrix of conditional probabilities (table 3). $P(\theta_j \mid Z_k)$ is the probability of θ_j occurring given Z_k as the experimental result (prediction of θ).[6] If the experiment Z is a perfect predictor of θ, table 3 will consist of ones along the diagonal and zeros elsewhere.

With data provided by the experiment, the Bayesian strategy becomes: Given a projection of θ (for example, Z_k) select the action A_i for which the expected utility

$$\hat{u}_i^k = \sum_j u_{ij} P(\theta_j \mid Z_k) \quad (2)$$

is a maximum. Thus the Bayesian strategy consists of a set of optimal actions, at least one for each experimental result.[7]

Value of the Data

The derivation of Bayesian decisions by using only the a priori probability distribution $P(\theta)$ is referred to as the "no data" problem. Decision problems using a posteriori distribution are called "data" problems. The difference in expected incomes resulting from using the "data" strategy bundle relative to the "no data" strategy can be interpreted as the value of the data, i.e., the value of the information provided by the experiment.

[6] $P(\theta_j \mid Z_k)$ is estimated by the relative frequency over the historical period with which θ occurred as the true state of nature when Z_k was the experimental result. For applications of this procedure see (6, 5, 1).

[7] It is possible that two or more actions could have the same expected utility for a given experimental result.

The expected value of the "no data" strategy is defined above as $u_i = \sum_j u_{ij} P(\theta_j)$. The expected value of following the "data" strategy is calculated by multiplying the expected value of the optimum action for each experimental result by the probability of observing the appropriate experimental result, P(Z), and summing over all possible results.

$$(3) \qquad \sum_k [\sum_j u_{ij} P(\theta_j|Z_k)] P(Z_k)$$

The expression in brackets was defined in equation 2 as $\hat{u}_i^k$ (expected utility of action A_i given Z_k as a prediction of θ). Thus equation 3 reduces to $\sum_k \hat{u}_i^k P(Z_k)$. Therefore, the value of the data is defined as

$$(4) \quad V = \sum_k [\sum_j u_{ij} P(\theta_j|Z_k)] P(Z_k) - \sum_j u_{ij} P(\theta_j)$$

$$V = \sum_k \hat{u}_i^k P(Z_k) - \hat{u}_i.$$

The value of the data can then be compared with the cost of performing the experiment to evaluate the net contribution of the experimental information to expected income.

The Bayesian decision model presented above provides a framework for developing decision criteria for problems characterized by uncertain outcomes. The model incorporates the available objective and/or subjective information into the decision process. Data requirements are modest; a priori information is generally available from past experience and published information. Additional information can be obtained from experiments such as econometric forecasting models.

Few decision problems do not contain at least some element of uncertainty. This is particularly true of production and marketing decisions in the agricultural sector. The outcome of alternative actions depends on such factors as rainfall, yield, feedlot performance, and future prices. The Bayesian decision model is a method of systematically incorporating available information about the frequency distribution of these factors directly into the decision process.

References

(1) Bullock, J. B. Cattle Feedlot Marketing Decisions Under Uncertainty. Unpublished Ph.D. thesis, Univ. Calif., Berkeley, 1968.

(2) Carlson, G. A. A Decision Theoretic Approach to Crop Disease Prediction and Control. Unpublished Ph.D. thesis, Univ. Calif., Davis, 1969.

(3) Chernoff, H. Rational Selection of Decision Functions. Econometrica, Vol. 22, 1954, pp. 422-443.

(4) Chernoff, H., and L. E. Moses. Elementary Decision Theory. John Wiley and Sons, Inc., New York, 1969.

(5) Dean, G. W., A. J. Finch, and J. A. Petit, Jr. Economic Strategies for Foothill Cattle Ranches. Univ. Calif. Agr. Expt. Sta. Bul. 824, 1966.

(6) Eidman, V. R., G. W. Dean, and H. O. Carter. An Application of Statistical Decision Theory to Commercial Turkey Production. Jour. Farm Econ. Vol. 49, No. 4, Nov. 1967, p. 857.

(7) Hadley, G. Introduction to Probability and Statistical Decision Theory. Holden Day, San Francisco, 1967.

(8) Hoel, P. G. Introduction to Mathematical Statistics. John Wiley and Sons, Inc., New York, 1962.

(9) Jeffrey, R. C. The Logic of Decision. McGraw-Hill, New York, 1965.

(10) Knight, F. H. Risk, Uncertainty, and Profit. Sentry, New York, 1957.

(11) Luce, R. D., and H. Raiffa. Games and Decisions. John Wiley and Sons, Inc., New York, 1965.

(12) Raiffa, H., and R. Schlaifer. Applied Statistical Decision Theory. Harvard Univ. Press, 1961.

(13) Thrall, R. M., C. H. Coombs, and R. L. Davis (eds.). Decision Processes. Ch. V by R. Radner and J. Marschak. John Wiley and Sons, Inc., New York, 1954.

(14) Von Neumann, John, and Oskar Morgenstern. Theory of Games and Economic Behavior. Princeton Univ. Press, 1947.

(15) Weiss, L. Statistical Decision Theory. McGraw-Hill, New York, 1961.

Book Reviews

Systems Simulation for Regional Analysis: An Application to River-Basin Planning

By H. R. Hamilton, S. E. Goldstone, J. W. Milliman, A. G. Pugh III, E. B. Roberts, and A. Zellner. The Massachusetts Institute of Technology Press, Cambridge. 407 pages. 1969. $15.

Public-spirited citizens have been suggesting for years that development of our natural resources is the means to attaining increased general business activity and an improved quality of life. In a paper presented before the Birmingham meeting of the British Association for the Advancement of Science in 1913, C. R. Enock maintained that the economic problems before the world called for a comprehensive and constructive science whose aim would be to evolve and teach the principles under which economic equilibrium in the life of communities might be attained. He asserted, by way of solution to the economic and social problem, that the congestion of the population in towns, the desertion of the countryside, the high cost of living, low wages, and unemployment are related phenomena, intimately connected with the conservation and development of natural resources.

During the past decade, analysts have continued to ask the same question, but are developing a different answer. An application to river-basin planning of a system simulation for regional analysis suggests that prospects for income and employment for residents of the Susquehanna River Basin are independent of natural resource development in the basin. Rather, appraisals of economic development in the 49-county area, covering parts of three States, are based on simulations of markets, transportation of products and materials, industrial organization, labor force participation, education, and migration patterns. The simulations reflect general business activity in each of nine functional economic subregions in the river basin. This book demonstrates the power of simulation models in comprehensive, multi-county area planning as an alternative to base studies, input-output, and linear programming. Simulation has arrived, and readers of this journal must needs be familiar with its techniques.

The book was written by a committee of six as a report on the research of a larger committee of 15 whose members lived in different cities and who worked over an extended period of time. For the beginner and graduate student, your reviewer recommends chapters 3 and 4. Chapter 3 gives a concise and meaningful statement of what regional analysis is and why we need it. Chapter 4 reviews several recent regional analyses and compares their relative strengths and weaknesses. Chapter 2 doesn't have anything to do with the rest of the book, but makes interesting reading. It deals with the role of mathematics underlying economic theory as used by Cournot, Walras, Marshall, and others as a system of logic. But the committee did not use their mathematics that way. And it deals with the role of mathematics and statistics as used by the Cowles Commission and others as a system of estimating parameters for econometric models. But the committee did not get their parameters that way. Other chapters describe and explain the model, sometimes brilliantly and sometimes incoherently. The chapters often fail to relate either to each other or to the illustrative program listed in the appendix. This is taken by the reviewer to be a fault of the committee approach to book authorship rather than a reflection on the research stature of committee members.

The overall approach of the committee to the problem of economic development in a river basin is sound. They delineate the basin into functional economic areas. For each area they work out a detailed simulation of three sectors: Demographic, employment, and import/export. With these sectors linked together and behaving properly for each subregion, it then became a relatively easy matter to extend the model with an educational sector, requirements for water and other natural resources, prospective water pollution, and various interregional relationships. Further extensions to reflect social goals, decision processes, and political and social institutional constraints might be incorporated in future versions of the model

The method of model construction used by the committee was far simpler than the microanalytic approach suggested by Orcutt. Consequently the model is cheaper to run. To the extent that it reaches its goals, it is therefore more efficient. The committee worked with aggregates whereas Orcutt worked with individuals. For example, Orcutt keeps track of everyone's birthday every year; the committee moves one-sixth of the people aged 14 to 19 into the next age bracket with a single equation. Even with these shortcuts, the committee keeps track of far more detail than they find use for in their summaries of the system. One wonders if further efficiencies might be achieved with further aggregations without destroying the usefulness of the aggregative results.

The weakness of the simulation research derives not from difficulties in the overall approach but rather in the handling of some of the details. This is symptomatic of a common ailment among simulators. Simulations need not follow the mathematical beauty of the Walrasian system; parameters need not have the elegance of the maximum likelihood estimates of the Cowles Commission. Simulation models are patched together one equation at a time. If the logic is sound and the data reliable, then the simulation is useful. But in the interests of operationalism, one can easily incorporate dubious logic and shaky data. The user will have difficulty telling the difference simply by scanning a listing of the computer program. For example, the treatment of migration in the model appears to be entirely inadequate and misleading while some of the equations for handling exports show a spark of genius. But when converted to DYNAMO language and listed in an appendix, they all look equally impressive.

Researchers already interested in applications of simulation to multicounty development planning will want to be aware of this book and will find parts of it helpful to them in suggesting not only meaningful ways to build some subsectors of a model but also pitfalls to avoid in building other subsectors. Other researchers need to be aware of the importance of the problem tackled by the committee and of the approach used, but this may not be the best book from which to learn.

Clark Edwards

The Agrarian Transition in America

By Wayne C. Rohrer and Louis H. Douglas. The Bobbs-Merrill Company, Inc., Indianapolis-New York. 197 pages. 1969. $8.

Rohrer and Douglas, a span of scholarly professors from Kansas State University, have created a book which carries a considerable impact. The prospects are that it will be read primarily by professors of agricultural economics and rural sociology and by graduate students in these disciplines. It is not a primer for beginners.

The authors take us on a guided tour along the sunlit paths, shady lanes, and dark defiles of agricultural development in this country with innumerable stops to present a capsule lecture or to sketch a fine-line vignette of incidents, organizations, and forces that had an impact on our agrarian transition. In this fashion, they narrate accounts of the "Agrarian Tradition," "Modern Agriculture and Organized Rural Life," "The Public Sector of Rural Life," and "Social Contexts of American Agriculture." A summary chapter titled "Conclusions and Interpretations" is followed by an appendage dealing with "Foreign Adventures of United States Agriculture."

At the outset Rohrer and Douglas legitimize the origins of the agrarian concept by citing Jefferson's familiar statements concerning "rules for the good society." The authors agree that in a nation where the vast majority of the population was on farms or shortly removed, it was understandable that the notion prevailed that "the farmer pays for all," that his work was noble, and that the farm was the homesite of virtue. The thing of continuing astonishment to them is the persistence and pervasiveness of the agrarian myth. Despite the surge of industrialization and the corollary decline of the agricultural sector, the agrarian dream remains. Rohrer and Douglas account for this phenomenon by recording its acceptance and support by nonfarm elements. Teachers, preachers, and politicians so inculcated the agrarian idea in myriad ways that even today legislation to aid the commercial farmer gets preferential treatment and almost everybody agrees that the "farm is a good place to raise a family."

The authors did not mention one very significant factor in the promotion of the agrarian theme and that was the role of artists such as George Durrie who painted nostalgic farm scenes idealizing country life. Such sentimental pictures were reproduced by Currier and Ives, hung in thousands of homes across the Nation, and are now collectors' items. However, if you are of the opinion that (1) the farmer is independent, (2) farming is our fundamental industry, and (3) the agricultural life is good and natural--the basic tenets of agrarianism--you may not relish this book. The authors have different ideas and make a persuasive case for their point of view. The agrarian concept is not only a myth, according to Rohrer and Douglas, but its widespread acceptance has been harmful in such areas as perpetuating obsolete farm and marketing practices, poor rural schools, inept local officials and State legislators, and in staving off reapportionment proposals.

The authors delineate two agricultural structures: (1) Commercial or "venture" agriculture and (2) low-income, part-time "refuge" agriculture. The former is depicted as enlightened, aggressive, and supported by "federal bureaus that are concerned with agricultural production problems, the commodity organizations, producers and marketing cooperatives, the American Farm Bureau, the bulk of the farm credit grantors, and a majority of the professional workers of the land-grant universities. . . [constituting] an aggregation of agencies and groups that regard the problems of commercial agriculture as the farm problem." As to the latter type of agriculture, Rohrer and Douglas state: "On the other hand, some social scientists of the land-grant system and of the federal government, the National Farmer's Union, some of the consumers cooperatives serving farmers, and probably a majority of the rural life officials of the religious denominations constitute the aggregation of agencies and groups who attend to the problems of the refugists." Thus we are confronted with two quite distinct societies: one affluent, and geared to a sophisticated infrastructure, the other poverty-laden and with a relatively weak and uncoordinated support structure. The term "refuge agriculture" seems somewhat harsh and unfair for, as Rohrer and Douglas point out, whether such farmers "are refugists or trapped is a moot question." Perhaps, within the context of intellectual honesty, it is just as well to use the stark expression, although this reviewer recognizes that to refer to an illegitimate child as a "woodscolt" softens the reality without invalidating the fact. In any event, the void that exists in our dualistic agriculture is sharply revealed by Rohrer and Douglas and their presentation represents an important contribution to considerations of current and prospective rural problems.

The writers sense an urgency in solving the problems of refuge agriculture--"a paramount concern in America today"--that is not generally appreciated. They doubt that the three generations or so used in evolving an infrastructure for commercial agriculture will be allowed for the development of organizations, systems, and practices needed to relieve refuge agriculture. It is their judgment that it will take more than "'conversation' legislation" to meet the worsening situation. The authors have undergirded their statements with carefully contrived and judiciously used regional studies and statistical comparisons. The research palpably was done diligently and in depth. Anyone inclined to differ with the authors' major findings had better have his facts well in hand.

Rohrer and Douglas conclude with the hope "that this work will become a part of the social science fund of knowledge and that the total will be used by busy legislators, agency administrators, and social researchers." It seems to this reviewer that the authors' hope would have a better chance of achievement if they had restrained their bent for unusual words and complex sentences. It is not an easy book to read. In order to obtain an objective appraisal of the book's readability, a Fog Index was computed based on much more data than usual, 266 sentences and 5,138 words. A 10 percent random sample of the pages of text was selected, the average number of words per sentence derived, a count made of words of three syllables or more per 100 words and the sum of these multiplied by a constant factor. The result was a

Fog Index of 17, the highest recognized by the system. As a basis of comparison, the Atlantic Monthly has been rated at 12.

The use of the precise word can be a joy and it is expected that a book intended for an educated and knowledgeable audience will be couched in scholarly terms. In this instance, however, the objective of the publication has been blunted by an overuse of abstract terms. Other impediments to easy reading include irregular right-hand margins and the lack of paragraph indentations and distinct headings. These criticisms should not be allowed to obscure the fact that Rohrer and Douglas have written a useful book.

Emerson M. Brooks

Measures of the Quality of Agricultural Credit: Technical Paper 19

By George K. Brinegar and Lyle P. Fettig. National Bureau of Economic Research, New York. 51 pages. 1968. $2.25.

Agricultural credit should be an object of extensive economic study, mainly because its history to date has been so checkered. This technical paper is the National Bureau's fifth publication on the quality of credit in a number of sectors of our economy; the study concentrates on the quality grading systems of the Production Credit Associations and the Federal Land Banks.

In essence the findings reveal that (1) there is a close relationship between credit ratings placed on loans by the PCA and the final disposition of these loans; (2) with respect to the Federal Land Bank loans, there is little connection between loan collateral groups and loan experience; and (3) the quality of credit offered at both the PCA and the Land Banks appears to have been declining since 1932.

Although the Brinegar-Fettig research project is primarily a methodological study and does not purport to evaluate a cross section of U.S. agricultural credit, it records valuable information about Federal farm lending agencies for analyzing secular trends in farm credit quality.

Jack Ben-Rubin

Science and Technology in Developing Countries

By Claire Nader and A. B. Zahlan. Cambridge University Press. 588 pages. 1969. $16.

The title of this book is misleading: it might have more accurately read "Science and Technology in the Middle East." The format, however, is well expressed by the subtitle: "Proceedings of an international conference held [in December 1967] at the American University of Beirut."

Conference proceedings are usually a smorgasbord and this one is no exception. Although nominally divided into three main sections--"Links with National Goals," "Institutional and Organizational Resources," and "Aspects of a Support System; Impact of Cultural Factors"--the papers show no particular logical order or progression.

Altogether there are 24 articles, each with appended references and edited discussion. Most refer to individual nations. Only three are specifically devoted to agriculture (although others do touch on the subject): Afif I. Tannous, "Organizing Science and Technology for Agricultural Development"; Gordon H. Ward, "Integrating Research, Extension and Cooperatives for Agricultural Development"; and Edward A. Mason, "An Analysis of Nuclear Agro-Industrial Complexes."

Tannous covers a number of development questions in his paper, but I found his comments on agricultural education in the Middle East of special interest. He suggests that progress in this area has been slow: while the American University of Beirut (of which Tannous is a graduate) was established in 1866, a School of Agriculture was not established until 1950. Among the Middle Eastern nations, Egypt appears to be in the forefront.

Ward reviews, in part, professional staffing problems in the Middle East. He indicates that in one country, 16 Western-trained Ph.D.'s left the research department of the Ministry of Agriculture because they were unable to carry out research; they joined the Faculty of Agriculture at a local college only to find no budget for research. He notes that in some countries the administrative structure in extension provides little incentive to get into the field.

Mason's paper, while of particular relevance to the Middle East, is now somewhat dated. Readers interested in his subject might better start with the article by Marion Clawson and others on "Desalted Seawater for Agriculture: Is it Economic?" in the June 6, 1969, issue of Science.

Elsewhere, John L. Simmon notes that one of the problems of introducing labor-intensive technologies such as handicrafts and public works is that they ". . . do not sound like technologies associated with the 1960's." He suggests that afforestation projects are a particularly promising venture but acknowledges that ". . . the Gallup poll of development projects favors impressive dams."

In a similar vein, Claire Nader indicates that from 1962 to 1967, Pakistan spent 10 times as much money on nuclear research as on two of its major sources of foreign exchange: jute and fishery resources. He does on to add that Pakistan spends over $100 million annually for foreign consultants, "a figure representing over 1% of its entire national income."

Aside from these papers, there are not many other articles which would be of interest to the general agricultural economist. If, however, one is faced with a bid to do scientific work in the Middle East, the book would be a useful background reference.

Dana G. Dalrymple

The Agricultural Development of Mexico, Its Structure and Growth Since 1950

By Eduardo L. Venezian and William K. Gamble. Frederick A. Praeger, New York. 281 pages. 1969. $15.

This study of Mexico is the first of a series of benchmark studies of Latin American countries projected by the publisher. The data used are taken mostly from published materials in the Spanish language. The research was completed in 1966 and although there is some updating to 1968 in the text, there is no title in the bibliography with a date later than 1966. Works in English are notable by their absence. For example, although a chapter is devoted to research, education, and extension, Stackman's "Campaigns Against Hunger" is not cited.

Every author has problems of organization. The organization of materials in this book follows the pattern of survey, exposition, and summary in separate chapters. This results in a great deal of overlapping and repetition. In general, the data presented are on a macro level. There are no examples of specific projects--such as colonization in the tropics or irrigation projects--although such case studies are cited in the bibliography.

This book is valuable as a reference work for its statistical data, much of which is not otherwise readily available in the English language. The two final chapters, which are devoted to factors limiting agricultural development in Mexico, alternative opportunities for agricultural development, and the author's conclusions, are particularly interesting since they seem to represent a Mexican viewpoint on the state of development and prospects for the future.

Jane M. Porter

Agricultural Policy in an Affluent Society

Edited by Vernon W. Ruttan, Arley D. Waldo, and James P. Houck. W. W. Norton and Company, New York. 321 pages. 1969. $2.50 (paper).

The editors have drawn upon varied sources, including this journal, for readings centered around the topic indicated by the title.

Readings in Agricultural Policy

Edited by R. J. Hildreth. University of Nebraska Press, Lincoln. 463 pages. 1968. $3.95 (paper).

The readings were selected from the proceedings of the National Agricultural Policy Conferences, which have been held annually since 1951 for extension specialists concerned with agricultural policy and public affairs.

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