RISK TRANSFER, INFORMATION AND PRODUCTION CONTRACTS: A SUGGESTED ANALYTICAL METHODOLOGY

by

David A. Bessler and Charles V. Moore

Risk 1975

Paper presented at AAEA annual meeting, Columbus, Ohio Aug. 1975.

David A. Bessler is a Research Assistant, Dept. of Agricultural Economics, University of California, Davis; Charles V. Moore is an Agricultural Economist, Economic Research Service, U.S. Dept. of Agriculture stationed at the University of California, Davis.

Session Number XII Session Title Risk and Uncertainty in Agricultural Production

Risk Transfer, Information and Production Contracts: A Suggested Methodology

David Bessler and Charles V. Moore, University of California and Economic Research Service, USDA

Production contracts can be used to reduce or transfer risk but at a cost to the producer. The degree of risk transfer and its implicit cost can be determined using a Bayesian framework. The value of additional information is hypothesized as a function of the structure of the commodity market.

RISK TRANSFER, INFORMATION AND PRODUCTION CONTRACTS:
A SUGGESTED ANALYTICAL METHODOLOGY

Agricultural production is a risky endeavor. It involves committing dollars at some point in time for inputs which generate dollars at a future point in time from outputs. This flow from inputs to outputs is not deterministic. Output levels and output prices are distributed over some range of values; the specific value of each is unknown at the time the decision is made to commit the resources. The producer must guess the specific value (or at least a range of values) that these random variables take on. To reduce the variability in output prices they face, producers often enter into production contracts with first-handlers (processors or shippers). These contracts can be viewed as devices to reduce or transfer risk, for which producers may pay a price. In this paper, we will suggest a procedure to analyze the risk-transfer potential of various agricultural commodity contracts and hypothesize the effect of market structure on producers' flexibility, i.e., market conduct.

We are concerned with contracts that face a producer at the beginning of every production cycle. For many commodities, a producer has the option to (1) produce independently, (2) enter into a cost-revenue sharing agreement with a shipper or processor, (3) enter into a guaranteed price agreement with a shipper or processor, or to (4) sell at the beginning of the production cycle and serve as labor-manager in producing the commodity. For other commodities, the set of alternatives available to the producer are few or none. In California, Moore and Snyder [8, p. 16] have identified at least three types of contractual arrangements open to lettuce growers, and Eidman et al [4, p. 852] considered three alternative contracts for turkey growers. Field crops such as barley, sorghums, wheat, etc., have not experienced the same degree of contract variability, although contract activity has increased markedly in the past three years.

The objective of this paper is to develop a theoretical framework for testing the hypotheses that (a) risk can be transferred through production and marketing contracts, and (b) the value of additional information to the producer is negatively correlated with the degree of concentration in the market for agricultural commodities.1/ We suggest that the ability of a producer to transfer risk can be determined through a Bayesian analysis of expected returns under each alternative contract specification. In particular, we propose that knowledge of expected returns under each contract alternative and the "value of additional information" will define the risk structure of a particular commodity within a given region.

The heterogeneous nature of crop contracts with respect to price and input obligations by each party indicates that one might use unit profit as a standard of comparison. For example, a farmer may consider a number of alternative commodities (corn, wheat, barley, etc.), each of which has a number of alternative contractual arrangements.

1/ By additional information, we mean data series such as inventories held by processors prior to the start of the production cycle, price forecasts, or planting intentions of growers.

If we consider n possible commodities, each with m possible alternative contracts, the producer can be said to make his decision in the mn space. Defining each m x n alternative as a separate activity, the producer will seek that commodity-contract combination which maximizes expected net returns subject to input and acceptable variance constraints. Each crop will, in general, present the decision maker a unique array of expected net returns and variances (one for each possible contract). Analytically, these can be derived from crop budget data, expected prices, and yields. To simplify the analysis, we will only consider decisions made in the m space. That is, we will consider expected returns of each crop, and not of various crop combinations.

Price and yield expectations should, we think, represent the farmer's decision-making process, and not necessarily reflect scientific uniqueness. Bayesian decision theory is amenable to this end. The farmer can be thought of as having two sources of information when making expectations -- past time series on observed prices and yields, and present "state-of-the-industry" information. Calculation of expected net revenues can be made with or without this extra industry information. The increase in expected net revenue from using this extra information, rather than merely the past time series, has been called the "value of additional information" [5, p. 67]. In particular, one source of additional information that has been used in the past has been the level of inventories held by processors or shippers at the beginning of the production cycle [4, p. 858]. Including this additional information in price and yield expectations will change the expected net revenue and variance associated with each commodity-contract combination, and thus potentially change the optimal contract selection.

Our hypothesis is that the value of information varies directly with the level of price risk associated with each commodity, and inversely with the level of concentration in each commodity buyer market. That is, a farmer can expect to gain more from correct prediction with those commodities which have high net income variance than from those which have a low variance. This is indicated in Figure 1 for two commodities characterized by different variances but similar means.

Correct prediction of net income for commodity 2 will offer a greater payoff, as a greater density of income lies in the tails of the distribution. The frequency of extremely high or low net incomes is greater under commodity 2 than under 1. The value of additional information associated with commodity 2 should, in turn, be greater. Whereas the statistician would call density C_1 more informative, the economist would say C_2 has a potentially higher value of additional information (see Hirshleifer [6, p. 31]).2/

We further hypothesize that the value of additional information is also related to the degree of concentration in the buyer market (see Arrow [1] for a closely related development). Those crops for which elements of oligopsony or monopsony power exist, should yield lower levels of value for additional information. This can be demonstrated by comparing producer surplus under monopsony and pure competition. A monopsonist facing many suppliers will purchase an amount of input where his marginal

---

2/ Value of information as defined by Theil [9] will a priori increase with the number of alternative contracts and thus no testing is required. Value of information as we have defined it follows Gould, [5] and will, in general, not vary with the number of alternatives.

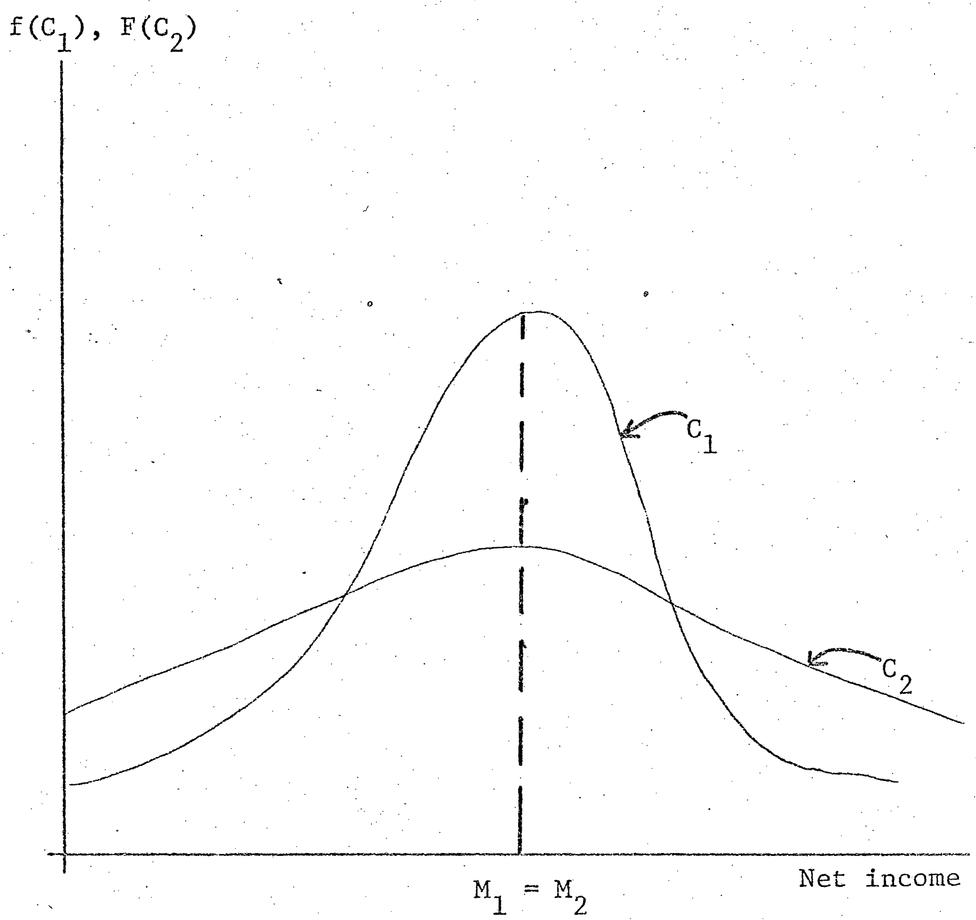

FIGURE 1: Net Income Densities from Two Hypothetical Contracts

expenditure equals the marginal revenue product of the input, and will pay a price which is just acceptable to suppliers.

In Figure 2, the monopsonist purchases Q_m units at a unit price of P_m by equating marginal expenditure (MM') to demand (RR') and pricing this quantity at the producer's supply schedule (SS'). The pure competitor purchases Q_c at price P_c. Now consider a shift (up or down) in the quantity of product demanded by consumers. An increase will shift the marginal revenue product (RR') up. The resulting price and quantity under this new derived demand will result in a greater amount of producers' surplus to suppliers selling under pure competition than under monopsony. Conversely, a shift down in demand will result in greater losses of producers surplus to producers selling in pure competition. Thus, correct prediction of demand has more potential value to producers selling in less concentrated industries. Both net income variance and concentration level are related to the value of additional information in Figure 3.

A farmer's ability to transfer risk is thus related to the degree of concentration of the market in which he sells. This may be validated by empirically noting the alternative ways in which a producer can produce his commodity (open market, cost/revenue sharing contracts, etc.). Those commodities offering the producer more "real" alternatives should possess a greater value of additional information and should possess lower level of buyer market concentration.[3/] For example, the value of additional information for sugar beets prior to 1975 should be rather

---

3/ Gould [5] gives the conditions for which increases in alternatives result in higher value of information. These are: the increase in variance must be mean-preserving and the payoff function must be linear in information.

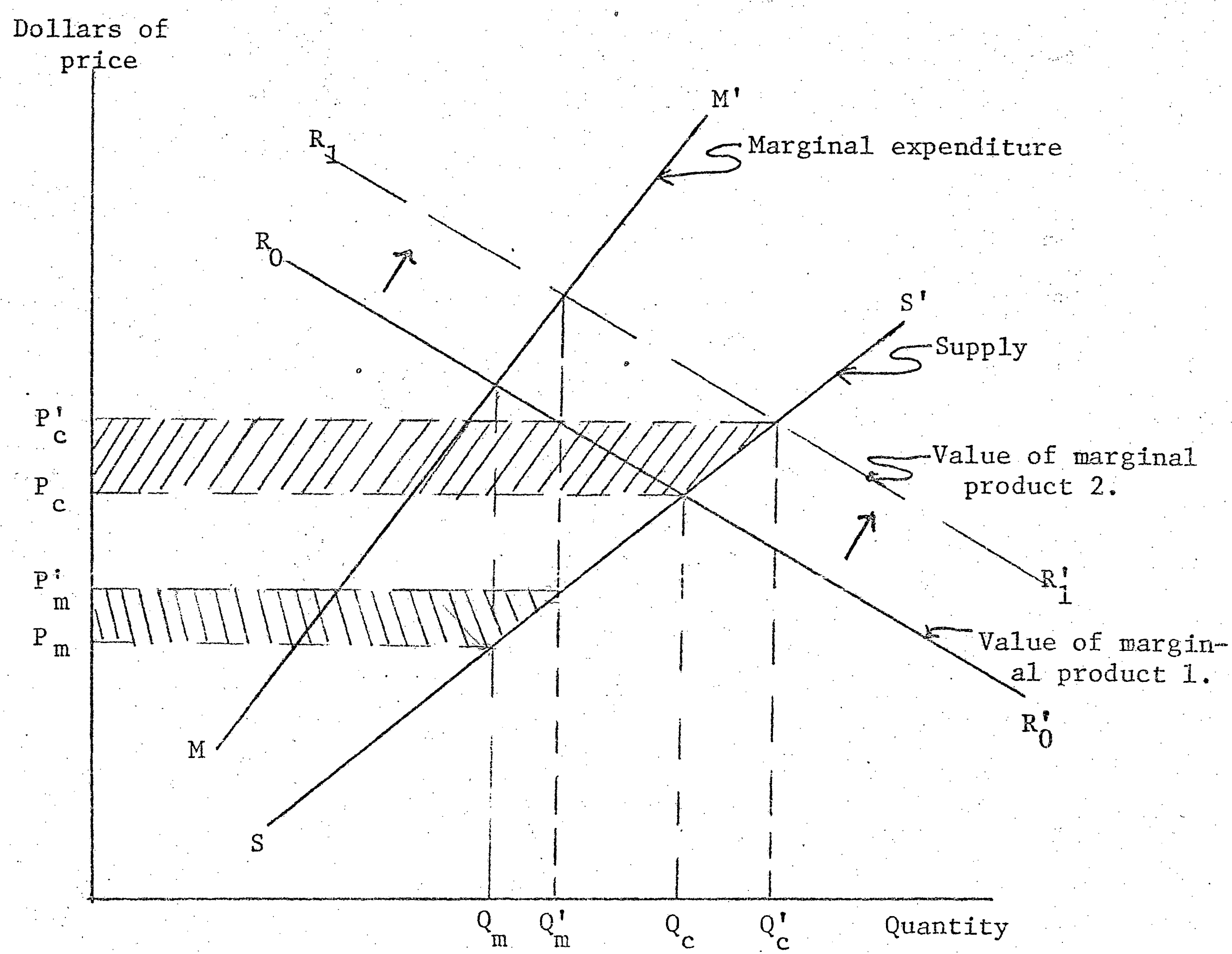

FIGURE 2: Producers' Surplus Under Pure Competition and Monopsony

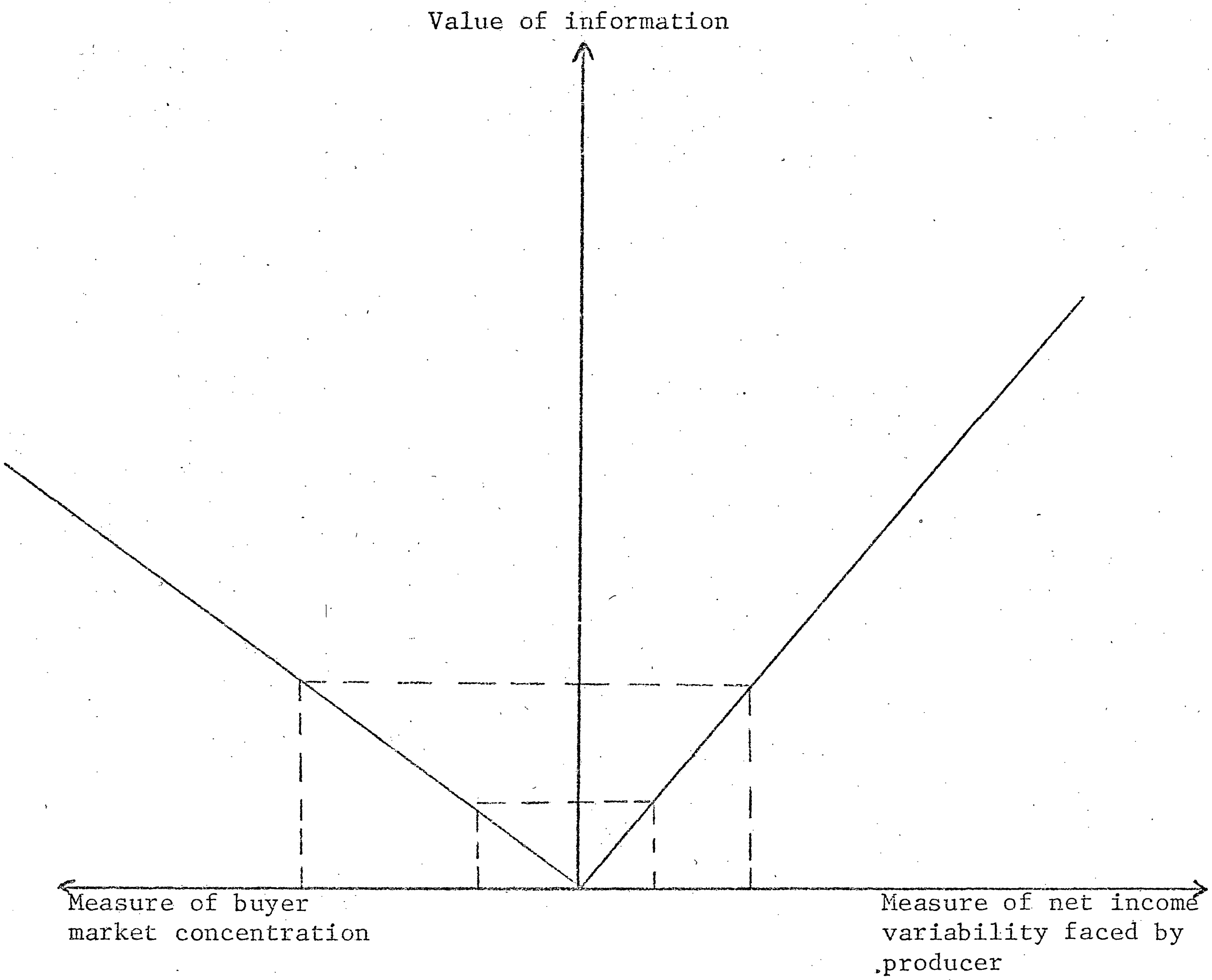

FIGURE 3: Model Depicting the Three Variables[a/]

a/ The measure of buyer market concentration is taken as the number of firms buying 70 percent of the crop grown in a particular region.

low (or zero) due to the nature of controls and the lack of real market alternatives open to growers. The value of information to lettuce growers, however, should be rather high, as there are three or four distinctly different ways in which to grow and sell lettuce. If the above are true, then can we infer that the concentration in the sugar beet buying industry is greater than in the lettuce buying industry?

The remainder of this paper will not answer the above question, but it will outline an empirical procedure for testing for the validity of our hypothesis.

The empirical test of this idea will involve the following steps:

1. Estimate the mean and variance of expected gross revenue using prior information (time series) on alternative crops.
2. Estimate the value of additional information for each crop.
3. Estimate the degree of market concentration present in each crop market.
4. Estimate the degree of correlation between 2 and 3, and 1 and 2 above.

To estimate the value of information, the researcher must calculate expected net revenues under each possible contract for each crop, both with and without the "state-of-the-industry" information. The "no information" case involves calculating price expectations and yield expectations from a time series of data. This assumes that the farmer will consider, as his best source of information, past time series. One might use a simple average of the past few years, or assume some distributed lag price and yield adjustment model. Alternatively, one can allow the decision maker to form his prior expectation from subjective knowledge (nondata based). Some type of interview process must be undertaken if this second approach is used. Both expected gross revenue and gross revenue variability will be given by the above. The use of aggregates on prices and yields will undoubtedly present some aggregation bias in terms of the size of the variance estimates. Although the extent of the bias will generally be unknown, aggregate measures will, in general, underestimate the variance faced by individual farmers (see Carter and Dean [2, p. 217]).

The "state-of-the-industry" information can be added to the above by revising the initial "no information" estimates through Bayes' theorem. A price-forecasting model which includes information other than just time series can be estimated. Level of inventories held by processors, or weather conditions in competing supply regions, are possible sources of additional information. The prior and additional information are combined through Bayes' theorem to obtain a posterior mean and variance. The posterior density function is given as $p(\theta/y)$:

$$p(y,\theta) = p(y/\theta)p(\theta)$$

$$= p(\theta/y)p(y)$$

$$p(\theta/y) = \frac{p(y/\theta)p(\theta)}{p(y)}$$

where $p(\theta)$ is the prior density associated with the parameter vector θ and $p(y/\theta)$ is the likelihood. In our case, the prior density will be given by the initial time series and the likelihood by the price forecasting model. The posterior mean and variance are a weighted average of the means and variances of the prior and the likelihood.

Expected net returns can be calculated for both the prior and the posterior densities for each alternative contract. This requires knowledge of the specific terms of each identified contract alternative. The prior and the posterior estimates will each give one "best" alternative which maximizes our assumed criterion function. Eidman et al. [4, p. 863] assume the decision maker maximizes net income subject to the constraint that the probability of net income falling below some specified level is less than 5 percent.

The value of information per unit of commodity can be determined by subtracting expected net income associated with the commodity-contract found using no additional information from the expected net income associated with the commodity-contract found using the additional information.

Market concentration for each crop can be measured as the number of buyers who together handle 70 percent of the crop grown in a particular region (the percentage 70 may be changed upon further analysis). For example, California almond growers sold 80 percent of their 1974 crop to three processors. Estimation of the degree of market concentration is complicated by governmental intervention. Commodity price support programs, allotment levels, and diversion programs, to the extent to which they reduce income variance, can be looked upon as substitutes for contracting. As such, a model must be developed to take governmental effect on structure into account. A rough measure may be the proportion of the commodity purchased under or supported by governmental programs [7, p. 445].

To test our hypothesis that the value of information to the producer varies directly with the level of price risk associated with each commodity, and varies inversely with the level of concentration in each commodity buyer market, two regression equations can be estimated. The value of information ($x per acre) can be regressed upon the concentration ratio and the measure of variability. Two separate equations of the forms:

$$(1) \quad V = a_0 + a_1 C + e_1$$

$$(2) \quad V = b_0 + b_1 S + e_2$$

can be estimated where V represents dollars of additional information, C represents concentration index, and S represents variability coefficient. The test of the hypothesis expressed in each equation is given as:

$$H_{01}: a_1 = 0$$

$$H_{02}: b_1 = 0$$

That is, the regression coefficients, a_1 (for the concentration index) and b_1 (for the variability of net income) are not significantly different from zero.

No causation is implied by equations (1) and (2). Their purpose is to begin to identify relations which may hold in describing the structure of a particular industry. The structure-conduct-performance theory suffers from its inability to identify relevant performance measures. Based on the structure's implied effects on growers behavior, we suggest another measure.

The following alternative signs on the concentration coefficient will suggest different policies: (1) a significant positive sign on the concentration would suggest that the value of information increases as seller-buyer competition increases, (2) a sign not significant from zero would indicate that there is no correlation, i.e., market structure and information are unrelated, and (3) a significant negative sign would indicate that value of information increases with reduced competition.

For subsectors with a high value of information, it would be beneficial for a data collection agency to accumulate and make available specific information on contract provisions, state of the industry, and price forecasts for the use of commodity growers.

REFERENCES

[1] Arrow, Kenneth J., "Vertical Integration and Communication," The Bell Journal of Economics, 6:173-183, Spring, 1975.

[2] California Crop and Livestock Reporting Service, California Vegetable Crops, August, 1970.

[3] Carter, H.O., and G.W. Dean, "Income, Price, and Yield Variability for Principal California Crops and Cropping Systems," Hilgardia, 30 (6):75-218, 1960.

[4] Eidman, V.R., G.W. Dean, and H.O. Carter, "An Application of Statistical Decision Theory to Commercial Turkey Production," Jour. of Farm Econ., 49:852-868, November, 1967.

[5] Gould, John P., "Risk, Stocastic Preference, and the Value of Information," Jour. of Econ. Theory, 8:64-84, 1974.

[6] Hirshleifer, J., "Where are We in the Theory of Information," Am. Econ. Rev., 63:31-39, May, 1973.

[7] Just, R.E., "A Methodology for Investigating the Importance of Government Intervention in Farmers' Decision," Am. Jour. of Agric. Econ., 55:441-452, August, 1973.

[8] Moore, C.V., and J.H. Snyder, Risk and Uncertainty in Lettuce Production in Salinas Valley, California, Giannini Foundation Research Report No. 300, 1969.

[9] Theil, Henri, Economics and Information Theory, North-Holland, Amsterdam, 1967.