QUANTIFYING LONG RUN AGRICULTURAL RISKS AND EVALUATING FARMER RESPONSES TO RISK

Proceedings of a Seminar sponsored by
Southern Regional Project S-232
"Quantifying Long Run Agricultural Risks and Evaluating
Farmer Responses to Risk"
Sanibel Island, Florida
January 28-31, 1990

Food and Resource Economics Department
University of Florida
Gainesville, Florida

April 1990

ISSUES IN FARM LEVEL MODELING

Peter J. Barry

This paper identifies major issues in the development of firm level models for use by multiple participants in a regional research project. Included among the issues are the choice of equilibrium analysis framework, measures of risk, modeling scope, optimization versus nonoptimization; status versus dynamics, risk attitudes, farm structure specifications, economic scenarios, and performance measures.

Key words: firm models, risk, policy analysis

The purpose of this paper is to identify some of the major issues involved in developing and implementing farm level models for use in accomplishing objective 2 of the S-232 project. At this point, the focus is largely on conceptual, empirical and methodological issues rather than administrative or organizational functions. Included are considerations of the appropriate equilibrium analysis framework to use, measures of risk, the scope of the farm level models, optimization versus nonoptimization, time specifications, risk attitudes, structural characteristics, and alternative economic scenarios. The issues are expressed in a highly tentative form in order to generate ideas and discussion, and eventually move toward some final decisions about the farm level modeling activity.

General Mission

Objective 2 of Regional Research Project S-232 is intended "to assess the risk implications of selected agricultural policies for both the risk environment of individual firms in various production regions and the risk characteristics of the agricultural sector". The basic procedures for achieving this objective are to utilize an aggregate model to indicate how the distribution of agricultural commodity prices will be influenced by selected agricultural policies, to evaluate the farm level implications of policy alternatives using a set of farm level models, and to consider the linkages between the micro and aggregative effects. One of the important parts of these procedures is to specify the farm level models and conduct the farm level analyses. The approach essentially involves equilibrium analysis at the firm level in which the firm's optimal responses to policy induced changes in risk are observed, in light of the risk attitudes of the decision makers and the empirical characteristics of the farm units.

Peter J. Barry is a professor, Department of Agricultural Economics, University of Illinois

Equilibrium Analysis Framework

Equilibrium analysis under risk allows observations of the firm's responses to policy induced changes in the risk characteristics of the firm's decision environment. Included are responses to changes in probability distributions, risk free rates of return, levels of wealth, and risk attitudes. A number of approaches have been developed for expressing the qualitative characteristics of these responses and for testing their effects in quantitative analyses.

The implications for the S-232 analysis are the need to draw upon an appropriate conceptual framework for designing the equilibrium policy analysis at the firm level and for qualitatively predicting the characteristics of possible firm level responses. Thus, the theoretical framework should provide general guidelines to consider in approaching the adjustment process. The specific form and magnitude of the portfolio adjustments will vary with the structural and operating characteristics of the firms involved, with the attitudinal characteristics of the investor, and with the possible responses of lenders, other financial claimants, and other agents external to the firm whose actions may in turn influence the firm's decision environment.

An example of the conceptual approach to these issues is provided by some of our own work involving adjustments in the firm's financial structure under risk. Using the mean-variance approach we have considered how the concepts of equilibrium analysis under risk (Robison and Barry, 1977, 1986) can be applied to analyze financial structure at the firm level. One application (Barry and Robison, 1987) shows how the distinction between business risks and financial risks enables an analyst to gauge the magnitudes of changes in business risk and/or financial risk that are needed to restore an equilibrium level of total risk, and thus assess the feasibility of accomplishing those changes with the managerial and policy instruments that are available. Similar applications have considered financial behavior under stress (Robison, Barry and Burghardt, 1987) and others (e.g., Featherstone, et al., 1988) have considered the relationship between farm policies, farm financial structure, and the firm's risk position. Clearly, this conceptual framework could be broadened to consider production and marketing responses to risk as well as financial response, and to evaluate combinations or trade offs among risk responses in these organizational areas, using the mean-variance model or some other analytical approach.

Measures of Risk

Risks in the farm level analysis are to be expressed in terms of probability distributions of gross margins on production activities, perhaps expressed by means, variances and covariances. The probability distributions are to be estimated from historic time series of commodity prices, production levels and costs that, in turn, are obtained from the results of objective 1 of the project and the first phase of objective 2. That is, objective 1 will yield an historic time series of yields, the initial phase of objective 2 will yield a comparable time series of prices given the yield results from objective 1, and the product of prices and yields in each historic year gives a time series of gross returns for each commodity or production activity. Subtracting estimates of operating costs (or operating plus fixed costs) yields a time series of gross margins (or net returns) for each commodity or production activity. These time series of returns then serve as the basis for estimating means and variances for the respective production activities, and covariances among the production activities.

The estimates presumably will reflect the case of a base scenario either free of policy effects or arising from policies in place over the historic period. The effects of alternative policy regimes then can be introduced either through modifications in the time series of production levels and prices, resulting from the aggregative analysis, or by direct modifications (e.g., truncation) of the estimated probability distributions.

Scope of the Farm Level Models

The scope of the farm level models should be broad enough to capture the major organizational areas in which decision making and risk responses may occur. Included are the firm's production alternatives, marketing choices, investment activities and asset holdings, financing methods and sources, consumption and taxation. Past research has shown that linkages among these respective areas are important and that trade offs in risk responses may occur depending on the sources of risk and the empirical characteristics of the farm business. That is, some types of firms may find it easier to respond to risk by adjusting their production activities (i.e., enterprise diversification, output levels, input levels), others may adjust marketing methods (i.e., use of government programs, inventory management, contracting), others may adjust the financial structure and liquidity positions, others may alter the pace of investment or disinvestment, and so on. In practice, a mix of such risk responses likely occurs, but the point is to have a model in which the organizational components are sufficiently rich to realistically depict the firm's choices in responding to risk. Clearly, all of the organizational components cannot be expressed in great detail, so some important decisions about degrees of detail will be needed.

Optimization Versus Nonoptimization

The modeling approach will need to reflect the objectives of the decision maker in some fashion. An optimization approach directly specifies the objectives stipulated for the decision maker, while a nonoptimization approach (e.g., simulation) leaves the objectives outside the model. In terms of risk analysis, an optimization approach will directly accommodate the risk attitudes (see below) of the decision maker and changes in risk attitudes, consistent with changes in the Arrow-Pratt measures. The optimization approach also offers the opportunity to observe firm decisions and performance that arise from the firm's efforts to push against its resource limits and operating requirements in order to maximize the stipulated objectives. Finally, an optimization approach provides a common model structure for project participants to use in tailoring the empirical specifications of the model to representative farms in their respective states. Thus, a risk programming type of formulation may have merit, although various simulation models (e.g., Richardson and Nixon) have also been employed in these types of farm level policy analyses under conditions of risk, and simulation models offer considerable flexibility in their basic design.

Single Versus Multiperiod; Static Versus Dynamic

Ideally, the modeling approach would account for intertemporal and dynamic properties of the firm's environment and characteristics. These properties would be consistent with the long run perspective developed for the S-232 project; they would accommodate the multiperiod effects of investment and financing decisions; and they would account for inter-period linkages in decision making, including the updating of the firm's information base. However, developing stochastic firm level models of sufficient organization breadth and depth, while also including intertemporal and dynamic properties is difficult at best for individual research projects, and it likely presents significant administrative problems for the kind of inter-state participation anticipated in this project. Thus, some sacrifices in these properties may be needed.

These issues may be closely related to the aggregative modeling efforts as well. Perhaps some type of sequential or recursive framework could be developed in which to combine both the micro and macro analyses with the stochastic and intertemporal properties; such an approach has a long history, going back to aggregative analyses in the 1960s. Its applicability here remains to be seen.

Risk Attitudes

The combination of an optimization and equilibrium analysis approach relies on a specific expression of the decision maker's risk attitude in order to evaluate the range of possible risk responses. While a policy induced change in a risk characteristic could be characterized in terms of a shift in a risk efficient set, the meaningful implications of equilibrium analysis are only developed when one considers how a decision maker will adjust from an optimal position on the original efficient set to a new equilibrium position on the revised efficient set. The theoretical framework shows the qualitative characteristics (i.e., willingness to accept greater variance and greater wealth) of the adjustment process for any location on the efficient set, but the empirical characteristics of such an adjustment path are based in part at least on the risk attitudes of the decision maker.

The key points, then, are that the firm level model apparently must be specified in a fashion to include an explicit characterization of the decision makers risk attitude (and possible changes thereof) and one or more levels of the risk attitude (e.g., risk neutral, low risk aversion, moderate risk aversion, high risk aversion) must be specified as a basis for the empirical analysis. The greater the number of levels, the broader is the prospective for understanding how the characteristics of the risk response will vary over the range of risk attitudes. However, using multiple risk levels may quickly complicate the analysis and add to the administrative tasks.

Structural Characteristics and Initial Risk Management Practices of the Farm Situations

The empirical specification of the farm level models by multiple project participants introduces a host of questions about the specific structural characteristics to use. Included are specifications of the following: 1) farm type (i.e., basic enterprise mix), 2) farm size, 3) tenure position, 4) rental arrangements, 5) asset structure (e.g., financial assets relative to business assets), 6) financial structure (leverage position), 7) legal form of business organization, and 8) demographic characteristics of the farm family or other personnel involved. In addition, specifications are needed about the availability and use of a wide set of risk management techniques available to the farm business. For example, do the farm's initial marketing activities include the use of hedging, forward contracting, inventory management and participation in government programs? In production, are preventative health and disease measures employed? Are excess capacities or reserves (i.e., buffer stocks) of various types of financial and non-financial assets held? Are crop insurance and other forms of insurance used?

The general point is that some specific decisions will be needed about the structural characteristics and risk management strategies employed by the farms portrayed in the farm level models. To illustrate, the farm level modeling of the financial stress activity of the S-180 project followed a dual approach for project participants to use in specifying the farm characteristics. The first approach required that all researchers followed a core set of guidelines in delineating the farm characteristics and in the range of risk responses to be evaluated. The second approach allowed the participants to elect other specifications for the farm characteristics and response options that would further generalize the analysis for their own state or region.

In the first approach, consideration was given to basing the farm specifications on previously established representative farms (as in the case of USDA). However, insufficient information was available, and it was clear that more confidence in the model could be generated by having the participants develop their own farm. Thus, each participant was asked to specify one type of farm based on the mix of major crop and core livestock enterprises--the suggested choice criteria were to use farm types that either were most economically meaningful in their respective states or that experience the most chronic economic problems. Each participant chose one size of unit for the representative farm, generally a moderate size commercial farm thus avoiding part-time farms and exceedingly large units. Each participant chose one tenure arrangement for the representative farm, specified by the ratio of acres owned to acres operated. For leased land, one rental arrangement (cash rent, crop share rent, or livestock share rent) was chosen for compensating the landlord. For the financial structure, each participant specified three beginning leverage positions for their representative farm, as measured by debt to asset ratios of 20%, 40%, and 70% with the asset structure roughly matching the liability structure. Other characteristics of the farm businesses were left to the discretion of the researchers. But, they were advised to utilize a non-corporate form of business and open market transactions for acquiring inputs and selling commodities. Other organizational characteristics and operating procedures (i.e., timing of transactions, integer specifications on investments, scale of relationships, linearities) were consistent with the specifications of the simulation model used in the analysis.

The S-180 activity placed heavy emphasis on managerial and policy responses to financial stress in agriculture. Thus, the financial components of the models were emphasized. Other components may have a greater role in the S-232 activity, although, as indicated above, the full set of organizational components needs careful consideration. Whatever are the areas of emphasis, some decisions will be needed about the degrees of uniformity and range of structural characteristics and risk response methods to include in the analysis.

Single or Multiple Economic Scenarios

Economic scenarios refer to the basic assumptions made about the states of nature in which the representative farms operate. Included could be assumptions about monetary policy and inflation conditions, international trade conditions, degree of government involvement in agriculture, and others. Presumably, probability distributions could be specified within each state of nature to portray the stochastic characteristics of major sources of risk, although the methods of measuring risk in this study may preclude such an approach.

The specification of multiple economic scenarios is typical in many types of aggregate and micro analyses. Perhaps, however, this issue will have a lower priority in the S-232 activity because of the focus on policy alternatives and their effects on the risk characteristics and operating performance of farm firms. That is, the range of agricultural policy alternatives considered and their effects on the probability distributions may themselves embody parts of alternative economic scenarios--although it is unlikely that the full set of conditions normally represented by "economic scenarios" would be affected much by alternative specifications of agricultural policies. Thus, the role of economic scenarios remains an issue to consider in the future.

Output Goals and Aggregative Consistency

Objective 2 has the dual aims of assessing the risk implications of selected agricultural policies for both the risk environment of individual farms in various production regions and the risk characteristics of the agricultural sector. Thus, the farm level models should be designed to provide output for both of these perspectives. At the farm levels, the focus presumably is on such characteristics as stability of profits, solvency, liquidity, and survivability--or, more generally, on the degrees of risk efficiency and attainment of expected utility or other stipulated goals.

At the aggregate level, the focus is less clear. It might include a supply response to risk, stability of aggregate performance measures, implications for aggregate financial structure, and so on. These aggregate characteristics and measures need further attention, and just as important, the consistency between the aggregate and farm level effects of public policies need careful attention both to insure the validity of the aggregate analysis and to guide the specifications of the farm level models.

References

Barry, P. J. and L. J. Robison. "Portfolio Theory and Financial Structure: An Application of Equilibrium Analysis." Agricultural Finance Review 47(1987):142-151.

Barry, P. J. Financial Stress in Agriculture: Policy and Financial Consequences for Farmers. Department of Agricultural Economics, University of Illinois, November 1986.

Featherstone, A., C. B. Moss, T. G. Baker and P. Preckel. "The Theoretical Effects of Farm Policies on Optimal Leverage and the Probability of Equity Losses." American Journal of Agricultural Economics 70(1988):572-579.

Richardson, J. and C. Nixon. The Farm Level and Policy Simulation Model: FLIPSIM. Department Technical Report No. 81-2. Texas A&M University 1981.

Robison, L. J. and P. J. Barry. The Competitive Firm's Response to Risk. McGraw Hill, New York, 1987.

Robison, L. J. and P. J. Barry. "Portfolio Adjustments: An Application to Rural Banking." American Journal of Agricultural Economics 59(1977):311-320.

Robison, L. J., P. J. Barry and W. Burghardt. "Borrowing Behavior Under Financial Stress by the Proprietary Firm: A Theoretical Analysis." Western Journal of Agricultural Economics 12(1987):144-151.