FARM FIRM DECISIONS MODELING: A METHODOLOGICAL EVALUATION OF ALTERNATIVE FARM GROWTH MODELING APPROACHES

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ABSTRACT

Because decision makers have bounded rationality, modeling approaches should reflect such behavior. An application of the conventional multiperiod linear programming (MPLP) and recursive strategic linear programming (RSLP) models to an analysis of farm firm growth suggests that the MPLP model, lacking behavioral contents, biases upward the "true" possibility of growth.

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Surpassed only by the experiences of inter-war years, the recent financial crisis in the United States agricultural sector has risen to a staggering dimension, resulting in delinquent debts, asset liquidations and farm foreclosures. While the problem has attracted attention from the press, from the legislature and also from economic analysts, farmers that have not been "shaken out" still face an uncertain future. Given the prevailing economic conditions, no better time could the expertise of the agricultural economics profession be crucially needed in remedying farmers' problems by providing adjustment strategies. However, requisite intelligence for the advisory roles of economic analysts is gained by building relevant models of the contemporary world.

One approach to investigating the adjustment process in farming has been through the use of farm growth models. Farm growth modeling became popular in the 1960s as an empirical means of analyzing farm firm adjustments towards larger sizes and increased output. However, farm growth analysis is not exclusively a study of farm size and output but also a study of evaluating the complex financial structure characteristic of today's farm environment. According to Bailey, "Without growth, financial management of the farm is a one-time budgeting of debt and of income flows; with growth, debt becomes a powerful management strategy. Thus, the concept of growth of the firm puts meaning into the term 'financial management'."

There is no universal modeling approach to analyzing farm growth. In his review of firm growth models, Irwin has classified the most commonly used models into three categories, depending on how each characterizes the decision-making process of the farm firm, namely multiperiod linear programming (MPLP), recursive linear programming (RLP) and simulation models. These modeling techniques have had extensive exposure in the agricultural economics literature.

The objectives of this study are (1) to propose an alternative farm firm growth modeling technique called recursive strategic linear programming (RSLP) model, and (2) to compare the results of RSLP model to those obtained from the conventional MPLP model. The two objectives have some methodological implications. The main criticism of the RLP approach is that it solves each production period's problem independently, thereby assuming the decision maker to have an extremely myopic expectation about future resource uses and production outcomes. The RLP approach is thus analogous to what Hicks termed as the "primitive growth model," because each period is self-contained. As stated by Hicks, "Proper dynamic theory, even at its single period stage, must take account of the fact that many activities that go on within the period are oriented outside the period; so that what goes on, even within the period, is not only a matter of tastes and resources but also of plans and expectations..." (p. 32). An RLP model becomes an RSLP model once it incorporates the desirability and consistency of future effects on current and interperiodic actions. The sequential optimizing nature of the RSLP utilizes learning which makes it compatible with the behavioral literature. The study by Muller and Day first applied the RSLP to the hog cycle.

The conventional MPLP model, unlike the sequentially solved RSLP model, derives its optimal solution over an entire planning horizon simultaneously. Given the same set of empirical data, it will be informative to see which one of the models more nearly approximates reality. It is hypothesized that because the MPLP model does not allow for deviations of expectations from realizations, the trajectory of growth it describes biases its results upward. By empirical rule, if expectations are not fully realized, some costs would be entailed. The traditional MPLP model does not account for such costs; whereas the RSLP model, through its period-by-period revision of expectations, acknowledges that decision makers are boundedly rational and that time and information modify behavior.

METHODOLOGICAL IMPLICATIONS

The implications of comparing MPLP and RSLP models with each other are methodological. The ensuing methodological implications from using either one of the models as an alternative technique for analyzing farm firm growth can be explained from four points of view:

(1) Linear programming problems generally have in common the assumptions of linearity, additivity, proportionality, nonnegativity, divisibility, and fixed technical coefficients. The most critical assumption in the comparison here is that of fixed technical coefficients. While the MPLP depends on a large forecasting effort in order to obtain necessary coefficients, no allowance is given for probability of errors in the forecasts. This implies that expectations are always fulfilled. The certainty assumption in the MPLP model precludes any possibility of bankruptcy. Since expectations may not be realized, the RSLP model, on the other hand, ascertains the congruity of expectation to realization through a feedback mechanism.

(2) Another methodological problem with the MPLP model relates to the lack of recourse during the planning horizon. The simultaneous process of the MPLP model is inconsistent with empirical observations. Although production decisions, especially in agriculture, are based on a multiperiod setting, input choices are not made simultaneously. Prescott has found that this procedure is reasonable only when uncertainty in the unknown parameters forecasted is small. Moreover, simultaneous optimization overlooks learning from feedback information and associated linked effects. The RSLP model, however, solves a submodel of the MPLP model sequentially, using expectational estimates as a prototypical model of farmers' behavior.

(3) Many agriculturally related MPLP models have maximized the net present value (Merrill; Vandeputte and Baker, Boehlje and White) or the net worth at the end of the planning horizon (Boussard; Reid et al.; Kinnucan et al.)

as the objective function. The objective function maximized, using the MPLP model, is limited to the extent that forecasting errors are not accounted for.

(4) Since many programming approaches are applied to decision making or to answering normative, policy questions, operational models must not be globally optimal. These models must rather permit some behavioral characteristics.

PROCEDURE

The method of analysis employed in this study is an ex post approach. As pointed out by Day, if one conceives of an economizing decision agent in the traditional neoclassical sense, one can investigate what parameters actually rationalize histories. Similarly, Penrose also has indicated that any hypothesis purporting to explain the theory of firm growth can be useful from two grounds: (1) if it can logically reproduce a model yielding comparable conclusions to actual events leading to firm growth, and (2) if it can vividly explain the underlying actions that led to a specific historical event, or if it is validated by data.

Since farm growth modeling requires a large amount of data for a number of years, data availability dictates the choice of a case study for executing these study objectives. According to Hayek, however, "... it is to the individualistic method that we owe whatever understanding of economic phenomena we possess..." Data covering a period of 8 years from a crop farm in North Alabama provide the benchmark data for developing the theoretical models used. Space limitation prevents a formal presentation of the RSLP and MPLP models here. The objective function of both models was to maximize cumulative expected net worth of the farm at the end of an 8-year planning horizon subject to price, yield and financial constraints.

Resource Availability and Assumptions

The case farm contains 1,243 acres with 600 acres under cultivation. For purposes of this study, it is assumed that the farm operator owns the tillable tract of

600 acres, with a chance for expansion by buying the remaining tract at prevailing market prices at the time of purchase. Historical land value per acre in Alabama and the Federal Land Bank effective annual interest rate on new farm loans apply to land purchase financing.

Machinery assumptions with respect to the farm characteristics are made. Machinery endowment at the beginning of the planning horizon has a limited capacity as follows: the tractors and machinery complement are sufficient for timely operations covering 600 acres for the first five years and for only 300 acres for the next five years; specialized harvesting equipment could only allow 200 acres of cotton annually for eight years and 400 acres of soybeans, or corn, or wheat, or a combination thereof (not exceeding 400 acres) for the first five years, and a half of this capacity in subsequent years. The straight line depreciation method and accelerated cost recovery system for tax depreciation apply to all machinery assets.

Three types of debts are allowed: short-term, intermediate, and long-term. Short-term, unsecured loans may not exceed 50 percent of expected returns at any production period, and they are paid back in full after harvesting. Machinery assets at the beginning of each period serve as collateral for an intermediate loan, and the Production Credit Association's annual rates of interest apply to such loans. Intermediate loans are set to be paid back with interest costs within a five-year period. Long-term loans are extended for a 20-year period.

The actual enterprises being grown on the case farm are considered: cotton, soybeans, wheat, and corn. Costs and returns budgets developed for each enterprise are reflective of the farm situation. These budgets are complemented by technical coefficients representative of the North Alabama crop production region.

Taking macroeconomic policy as given, farmers formulate expectations on product prices and yields in carrying out their annual production plans. Thus, variability in prices and yields serves as the main source of risk in farming. Yield expectations are assumed to follow a 5-year moving average of past yields and

with adjustments for erratic variations and for management level.

Two price expectational schemes are evaluated. The first is here referenced as the supply-based expectations (SBE), is derived from a synthesis of the USDA's information on aggregate production and the fundamental approach to price forecasting in commodity markets (which is based on applied theoretical underpinnings of supply and demand for determining prices). The second price expectational approach is similar to the "naive," cobweb-type of expectation here referred to as the adaptive expectation (ADE). A decision maker may be conceived to resort to this form of static expectation as a result of lack of confidence in alternative forms of expectations. Muller and Day have demonstrated the latter expectation to be a useful first approximation. Thus, three return streams are obtained: two represent alternative expected returns and the third corresponds to ex post farm returns.

Using the 1985 tax rules as a basis, this analysis includes the impact of the progressive income tax structure, the social security self-employment tax, the investment tax credit, Alabama income tax, and the alternative minimum tax structure in the description of the growth process. In spite of the effective tax reform in 1987, the results here are useful for further evaluation.

Given that the marginal propensities to consume and save vary among individuals, growth rates from farm to farm can also be expected to be variable as well. In farm growth analysis, however, there is no standard approach yet for specifying consumption function for the farm family. Consumption withdrawal is set at $10,000 per year, adjusted for inflation, plus 25 percent of the annual after-tax expected income in year t. Inflation adjustment is made by using the average inflation rates for food and services.

RESULTS

While economists usually do not disagree about theory, discrepant results and interpretations arising from the choice of method of applying theoretical concepts are prevalent in economic analyses. Given the same sets of data, results of both the

MPLP and the RSLP models are presented in Figures 1-6. With no initial debt, the farm operator was assumed to have started the planning year in 1978 with total assets (or net worth) of $402,951. The farm firm's trajectories of growth were evaluated through the end of 1985 with respect to net worth under three financial leverages and two expectational schemes. The three leverage situations were designated as low, medium, and high, corresponding to debt-to-asset ratios of 25, 40, and 70 percent, respectively. According to the principle of increasing risk, each debt-to-asset ratio represents alternative farm firm responses to financial risk. Analyses were based on SBE and ADE explained earlier.

Figures 1-3 compare the growth paths of the farm over the eight-year period under low, medium, and high leverage situations, given the alternative modeling techniques and the assumption of the SBE. Given the situations described in Figure 1, the ending net worth for the RSLP model was $672,788, while it was $638,660 for the MPLP model. However, in physical terms, the farm grew from the initial 600 acres in 1978 to 704 acres using the RSLP model and to 768 acres using the MPLP model at the end of 1985. Given the medium leverage condition in Figure 2, the growth path described by the MPLP model consistently overstated that of the RSLP model. The terminal net worth in the former was $721,155 and $777,116 in the latter. As in the low leverage case, land purchases in the MPLP model were completed in the first 2 years because of its "hindsight." Figure 3 illustrates the growth paths in the high leverage situation. In six out of eight years, the net worth growth path described by the MPLP model exceeded that of the RSLP model. The terminal net worth of the MPLP model was higher than that of the RSLP model by roughly $50,000.

Figures 4-6 compare the growth paths of the farm over the eight-year period under low, medium, and high leverage conditions, given the RSLP and the MPLP models and the ADE assumption. Disparities in the terminal net worth protrayed by both models were much more pronounced when the decision maker formulated expectations on the ADE rather than on the SBE. The patterns of growth in all

situations evaluated were reflective of changes in land values. The difference in the terminal net worth under the low leverage case, Figure 4, was well over $100,000. In Figure 5, the MPLP model shows a smoother and relatively higher growth path compared to the RSLP model. Similar to the low leverage case, terminal net worth difference between both models was close to $100,000. In Figure 6, comparable growth paths are described by both models in the first two years, with a wide divergence afterwards. By the net worth criterion, the terminal net worth of $672,003 and $781,522, respectively, was attained in the RSLP and the MPLP models.

As illustrated in Figures 7-9, the RSLP model indicates that alternative expectational schemes would result in different level of growth under different leverage conditions. Enterprise choices under the ADE scheme were more diversified than in the SBE scheme. The net worth growth indicated by the two expectational schemes shows the ADE scheme to be more conservative. Given the patterns of growth described, the ADE scheme also tracked better the actual farm growth situations of the study period.

CONCLUDING REMARKS

A major emphasis is placed on comparing the results of the MPLP and the RSLP models, as alternative modeling approaches for analyzing farm firm growth. Comparison of the results of both models is an attempt to demonstrate the methodological flaws of using the conventional MPLP models as a farm decision planning model over time. While the coefficients of the MPLP model are meant to approximate "general expectations" of some ex ante decision variables, actions based on the model results are limited to the extent that such expectations coincide with realizations. On the other hand, the RSLP model does not optimize the objective function simultaneously but sequentially over the planning horizon.

Under the same expectational scheme, the MPLP model results consistently overstated farm growth as compared to the RSLP model results. Since deviations of

expectations from realizations usually are the rule rather than the exception, plans are required to be revised as information changes. Thus, the RSLP model appears to be a more relevant analytical technique for the contemporary environment in farming. Farm plans are better formulated in a multiperiod setting but subject to continual revisions with respect to available resources and informational changes. The implied assumptions of the MPLP model do not allow for behavioral decision-making under uncertainty.

A cautionary interpretation of the study results must put into consideration the assumption that the farm had no outstanding or initial debt at the beginning of the planning period. The results indicated that major expansions took place in 1978 and 1979. Therefore, farm net worth growth substantially benefitted from the capital gains from land that immediately followed the expansions. For example, farm land values rose by 73 percent in Alabama from 1978 to 1981 and declined by only 15 percent between 1981 to 1985. Thus, purchase of land earlier in the planning horizon provided a financial cushion which resulted in near doubling of farm net worth in the high leverage situation. It may then be inferred that, predominantly, the higher leveraged farms with initial debt outstanding were perhaps trapped in financial stress over the study period.

With the same beginning asset, farm growth may follow divergent paths, depending on the level of financial risk the farmer can assume. The results presented above illustrate the importance of credit availability in facilitating farm growth. The critical problems associated with farm indebtedness are lack of asset diversification and unstable returns. The overall credit needs for farm survival and growth have some policy implications. The positive relations between debt and farm growth indicate the dependency of agriculture on financing for liquidity management and for long-term capital requirements. Thus, the government can control national farm growth by constraining the aggregate level of farm debts.

REFERENCES

Bailey, W. R. "Necessary Conditions for Growth of the Farm Business Firm." Agricultural Economics Research 19(1967): 1-6.

Boehlje, M. D. and T. K. White. "A Production-Investment Decision Model of Farm Firm Growth." Amer. J. Agr. Econ. 51(1969): 546-63.

Boussard, Jean-Marc. "Time Horizon, Objective Function, and Uncertainty in a Multiperiod Model of Firm Growth." Amer. J. Agr. Econ. 52(1971) 467-77.

Day, Richard H. "Discussion." Amer. Econ. Rev. 68(1978): 333.

Hayek, F. A. Prices and Production, 2nd ed.. New York: Augustus M. Kelley, 1976.

Hicks, John R. Capital and Growth. London: Oxford University Press, 1972.

Irwin, George D. "A Comparative Review of Some Firm Growth Models." Agr. Econ. Res. 20(1968): 82-100.

Kinnucan, Henry, Oscar Cacho, and Gregory D. Hanson. "Effects of Selected Tax Policies on Management and Growth of a Catfish Enterprise." So. J. Agr. Econ. 18,2(1986): 215-25.

Merrill, William C. "Alternative Programming Models Involving Uncertainty." Jo. of Farm Econ. 47(1965): 595-610.

Muller, Gerriet P. and Richard H. Day. "Cautious Rolling Plans with Forecasting and Market Feedback." In Modelling Economic Change: The Recursive Programming Approach. ed. Richard H. Day and Allexandro Cigno. New York: North-Holland Publishing Company, 1978.

Penrose, E. T. The Theory of the Growth of the Firm. Oxford: Oxford University Press, 1959.

Prescott, Edward C. "The Multi-period Control Problem Under Uncertainty." Econometrica 40(1972): 1,043-58.

Reid, D. W., W. N. Musser, and N. R. Martin, Jr. "A Study of Farm Firm Growth in the Georgia Piedmont with Emphasis on Intensive Growth in Hog Production." The University of Georgia, College of Agriculture Experiment Stations, Res. Bull. 249; January, 1980.

Vandeputte, J. M. and C. B. Baker. "Specifying the Allocation of Income Among Taxes, Consumption, and Savings in Linear Programming Models." Amer. Jo. Agr. Econ. 52(1970): 521-7.

NET WORTH GROWTH UNDER A LOW LEVERAGE CONDITION AND SUPPLY–BASED EXPECTATIONS––A COMPARISON OF MPLP AND RSLP MODEL RESULTS

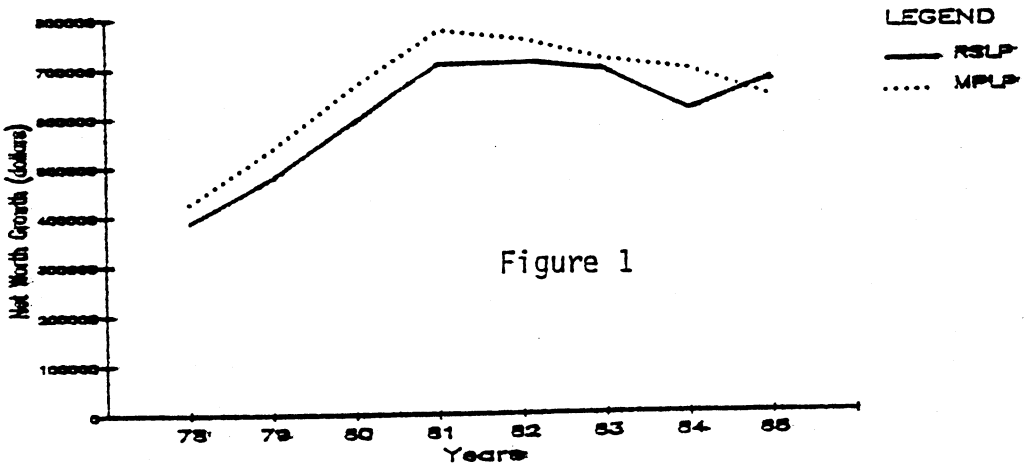

Figure 1

NET WORTH GROWTH UNDER A MEDIUM LEVERAGE CONDITION AND SUPPLY–BASED EXPECTATIONS––A COMPARISON OF MPLP AND RSLP MODEL RESULTS

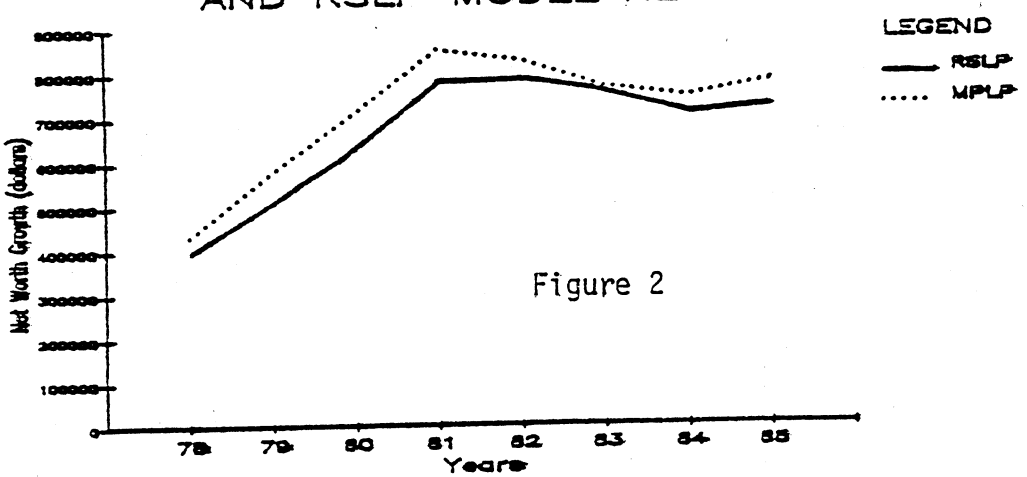

Figure 2

NET WORTH GROWTH UNDER A HIGH LEVERAGE CONDITION AND SUPPLY–BASED EXPECTATIONS––A COMPARISON OF MPLP AND RSLP MODEL RESULTS

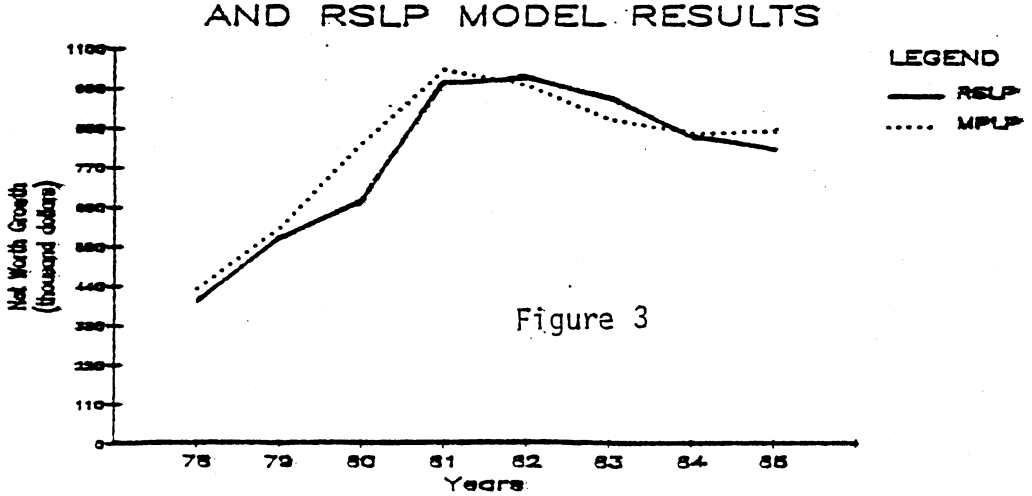

Figure 3

NET WORTH GROWTH UNDER A LOW LEVERAGE CONDITION AND ADAPTIVE EXPECTATIONS--A COMPARISON OF MPLP AND RSLP MODEL RESULTS

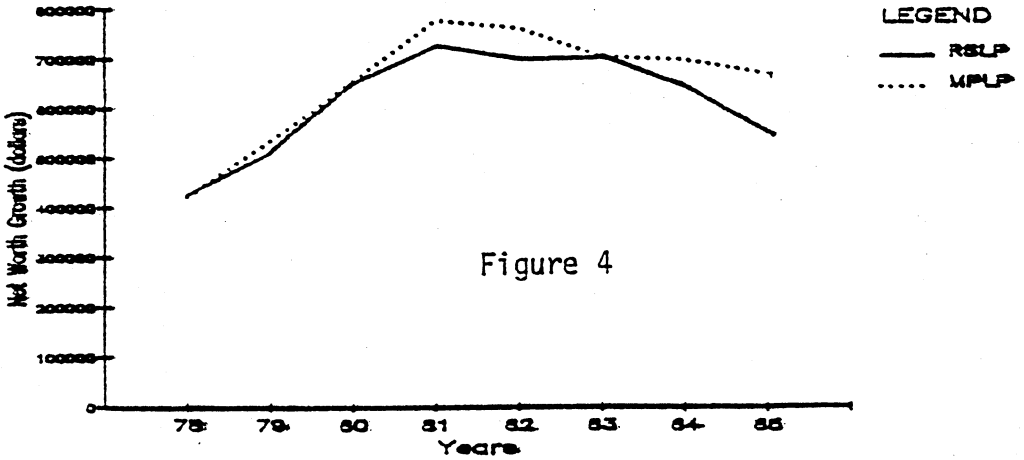

Figure 4

NET WORTH GROWTH UNDER A MEDIUM LEVERAGE CONDITION AND ADAPTIVE EXPECTATIONS-- A COMPARISON OF MPLP AND RSLP MODEL RESULTS

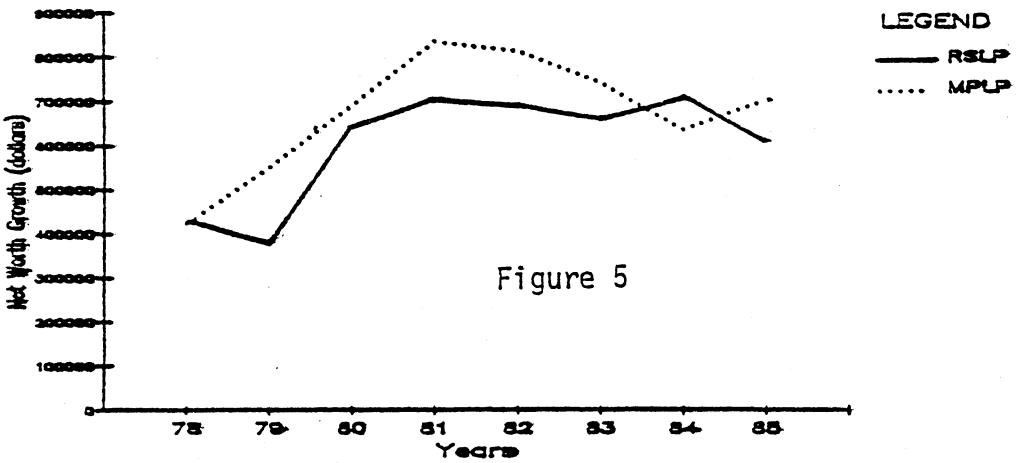

Figure 5

NET WORTH GROWTH UNDER A HIGH LEVERAGE CONDITION AND ADAPTIVE EXPECTATIONS--A COMPARISON OF MPLP AND RSLP MODEL RESULTS

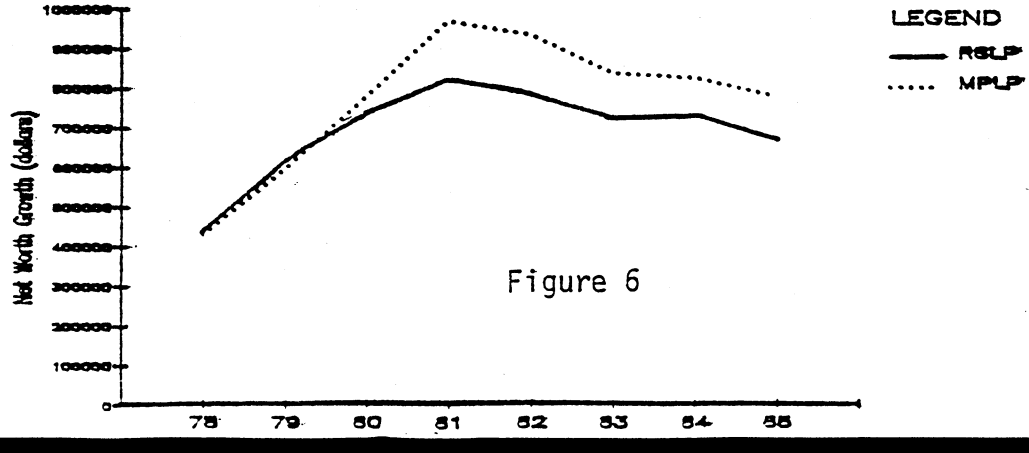

Figure 6

COMPARISONS OF NET WORTH GROWTH UNDER A LOW LEVERAGE CONDITION GIVEN SUPPLY–BASED AND ADAPTIVE EXPECTATIONS ––THE RSLP MODEL RESULTS

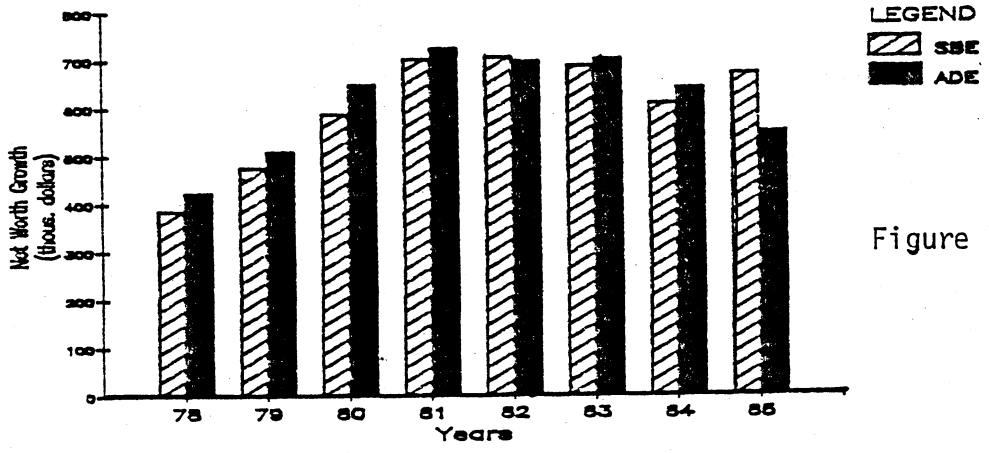

Figure 7

COMPARISONS OF NET WORTH GROWTH UNDER A MEDIUM LEVERAGE CONDITION GIVEN SUPPLY–BASED AND ADAPTIVE EXPECTATIONS–– THE RSLP MODEL RESULTS

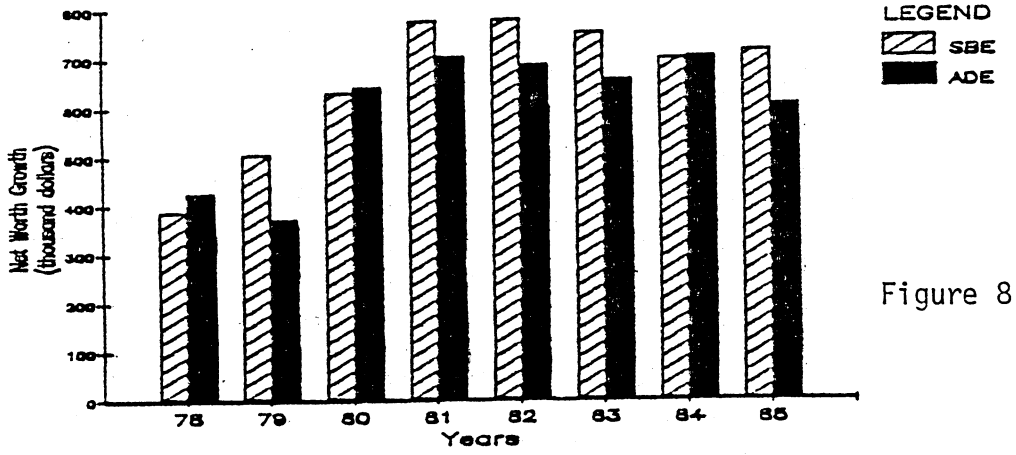

Figure 8

COMPARISONS OF NET WORTH GROWTH UNDER A HIGH LEVERAGE CONDITION GIVEN SUPPLY–BASED AND ADAPTIVE EXPECTATIONS –– THE RSLP MODEL RESULTS

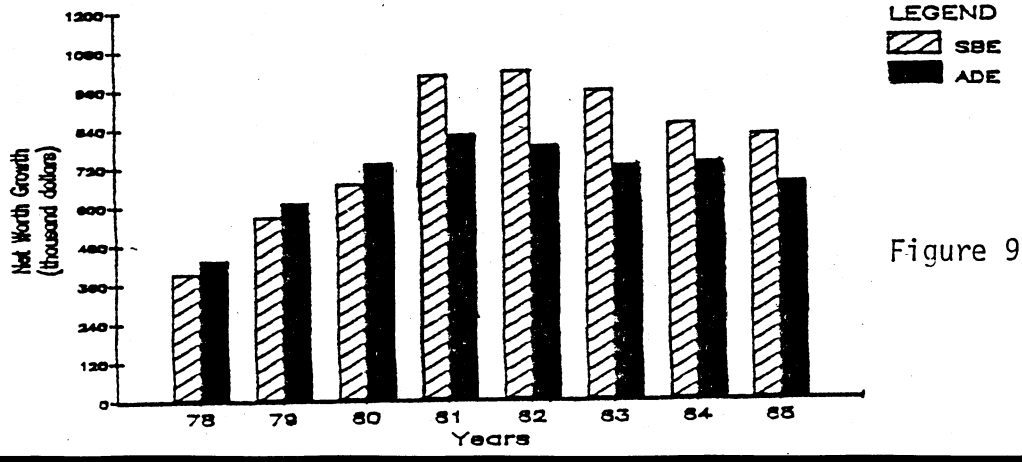

Figure 9