To the Graduate Council:

I am submitting herewith a dissertation written by Virgil Parker Culver entitled "A Growth Analysis of a Typical Farm Firm in Western Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

Luther H Keller

Luther Keller, Major Professor

We have read this dissertation and recommend its acceptance:

John R Brooker

Robert Gafford

Neal Walker

Accepted for the Council:

L Evans Roth

Vice Chancellor
Graduate Studies and Research

A GROWTH ANALYSIS OF A TYPICAL FARM FIRM IN WESTERN TENNESSEE

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee

Virgil Parker Culver

June 1982

ACKNOWLEDGMENTS

The author wishes to extend his appreciation to the faculty and staff of the Department of Agricultural Economics and Rural Sociology for their support during the graduate studies. Special appreciation is extended to Dr. Joe Martin for his patience and the opportunities which he made available toward the completion of this study. Special appreciation is also extended to Dr. Luther Keller for his patience, guidance and encouragement, both academically and non-academically, during the course of this study.

Special appreciation is also extended to the author's family and friends who, many times and in many ways during the graduate program, have expressed their love and concern.

For the patience, understanding and sacrificial fortitude of my wife, Jan, and the love of she and our children, Rachel, Julie and Philip, I remain expressionless.

Above all, to Him to Whom all glory and honor is due, Who is in all and through all and All in All, thank you Jesus.

ABSTRACT

The general objectives of the study were: 1) the development of a firm growth model consistent with economic theory and which approximated technological production possibilities faced by farmers in a given area, 2) to develop an analytical framework sufficient for quantitative investigation of both the decision-making and the planning processes and 3) to examine the effects of changes in selected growth variables, viz., equity levels, interest rates, land values, off-farm investment opportunities, land acquisition methods, crop yield variability and risk preference levels held by the farmer on the growth process of a typical farm firm in Western Tennessee.

A typical farm firm was synthesized from available data applicable for the Deep Loess Soils Area of Tennessee. The typical farm as defined had an initial land base of 350 total acres with 252 acres or 72 percent classified as openland. The farm operator was assumed to supply approximately 2,500 hours of labor annually, hiring additional seasonal or part-time labor as needed. Capital could be borrowed for land purchase by amortized loan with restrictions based on equity ratios of either 40 or 60 percent. Operating capital could be borrowed without limitation. Additions to the land base could be made using credit and an amortized loan, by outright cash purchase or by cash rental.

Firm growth was measured by changes in net worth and total acres operated. Growth in net worth could occur as increased equity in land and machinery, investment in an off-farm savings alternative or as cash on hand at the end of the planning horizon. The growth variables analyzed were: two rates of interest on the off-farm investment alternative, two equity ratios, three rates of interest on borrowed operating capital, three rates of interest on amortized land purchases, six time sequences of yield variability and three risk preference levels.

When an off-farm investment alternative earning eight percent interest was included net worth accumulation increased by 33 percent over an eight-year period. No additional land was acquired and all net worth growth accrued through the off-farm investment. When the off-farm investment option was eliminated, growth in net worth over the eight-year period was 29 percent and involved substantial expansion by land.

A reduction in interest charges on borrowed operating capital resulted in a 22 percent increase in total openland acreage. Reducing the interest charge on amortized land purchases resulted in an increase in total openland acreage of 26 percent from the initial level of 252 acres.

A reduction in per acre land values from $1111 to $833 per acre resulted in an increase in total openland acreage of 68 percent. Associated net worth increased 31 percent.

The effects of year-to-year yield variability were, in general, of little consequence. Net worth increased 28 percent and total openland acreage increased 22 to 27 percent among the six time sequences of yield variability investigated.

Net worth accumulation over an eight-year period was 28 percent for the high risk preference as compared to 21 percent for the risky and low risk preference levels. At the high risk level, acreage operated increased by 19 percent over the eight-year period. No expansion of land occurred at the risky and low risk preference levels.

From this study, it would appear that farmers in this particular area of West Tennessee would experience highest potential for farm expansion through purchase of land, either by outright cash purchase or by amortized loan and specialization of soybean production. Off-farm returns on capital funds also seem to yield higher returns than on-farm investments.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Research in the area of farm firm growth in the last two to three decades has been encouraged by an agricultural economy characterized by technological improvement, structural change and greater volatibility in market prices of farm products. The need to achieve size economies arising from new technology and lumpy investments in machinery and equipment has stimulated the growth of the farm firm.

Numerous studies of firm growth, employing various empirical techniques, have appeared in the literature. Walker and Nelson(40) and Irwin(19) have categorized and compared the various analytical techniques used. Of the techniques used, multiperiod linear programming(MLP) or some modification of MLP has been used the most often(2, 3,7,20,22,24,31). Simulation procedures also have been used in studying firm growth(18,28). Although lacking the versitility of MLP, recursive programming(RP) is another technique that has been used in growth studies(8,14,15,33). Another approach that has recently received widespread attention is the use of various types of risk programming models designed to model firm growth in an uncertain environment. Separable programming, maximin decision theory, marginal risk constraint linear programming, and minimization of total absolute deviations from expected income(MOTAD) were used, respectively,by Thomas, et al.(36), Maruyama(25), Chen and Baker(6), and Hazell(11, 12).

Research approaches and analytical techniques for studying firm growth will likely continue to expand as improved techniques or combinations of techniques, more reliable data, more efficient algorithms, and more sophisticated computer facilities are made available.

I. Problem

Penrose(29, p.1) has defined growth as follows:

> The term 'growth' is used in ordinary discourse with two different conotations. It sometimes denotes merely increases in amount; for example, when one speaks of 'growth' in output, export, or sales. At other times, however, it is used in its primary meaning implying an increase in size or an improvement in quality as a result of a process of development akin to natural biological processes in which an interacting series of internal changes leads to changes in the characteristics of the growing object.

Irwin(19,p.82) postulated a more pragmatic view by defining growth in terms of using controlled resources to achieve profitability goals.

> In its simpliest terms, the principle of growth is to acquire control of the services of additional productive resources by paying a price less than they will earn. The process of growth is, at its core, obtaining funds to purchase these resources, either internally or from external sources. All the other variables we might name--family consumption levels, profitability of the business, price and yield variability, lender attitudes, tax management, etc.--are merely the bounds within which the process can operate.

However defined, it is now widely recognized that farm firm growth is a dynamic concept which cannot be fully explored within a strictly static environment. Within a static model framework there exists limited possibility of adjusting for changes in available capital over time or for variations in product prices and yields. Also ascertaining the impact of uncertainty on the decisions made by the farmer in determining which enterprises he selects and the changes he makes or expects to make over time, can be done only in a limited way.

Relevant questions about decision-making and growth patterns must be considered. Several relevant questions are: 1) what would be the firm growth potential under different capital costs? 2)what impact on firm growth could be expected from variability in such factors as prices and yields? and 3) how is growth influenced by risk attitudes of the decision-maker?

The problem addressed in this study was that of aligning theoretical knowledge with reality in such a way that the interrelationships of enterprise selection decisions and investment planning decisions could be approximated with a descriptive model. Within this context, the problem, specifically, was to determine the impact of selected variables on the growth process of a typical farm firm in the Deep Loess Soils Area of West Tennessee. Variables hypothesized to have a significant impact on the growth process were defined as "growth" variables.

II. Objectives of the Study

The primary objectives of this study dealt with the quantitative techniques of model building and implementation, while the secondary objective dealt with the practical application. The primary objectives were:

1. To construct a firm growth model which was consistent with economic theory and, to the extent possible, approximated technological production possibilities faced by farmers in a given area.
2. To construct an analytical framework that was sufficient for quantitative investigation of the firm growth process within a nonstatic environment, while flexible enough to incorporate the decision-making process as well.

Given this framework, it then became necessary to demonstrate the applicability of the model in analyzing the firm growth process. The secondary objective was:

3. To examine the effects of changes in selected growth variables, viz., equity levels, interest rates, land values, off-farm investment opportunities, land acquisition methods, crop yield variability and risk preferences held by the farmer on the growth process of a typical farm firm in Western Tennessee.

III. Research Procedure

The modelling process in this study was divided into three phases. The first phase was the systhesis of both the resources and technical production relationships for a typical farm firm to be used in analyzing the growth process. The second phase was the model development phase which included three models; 1) a multiperiod linear programming model, 2) a monoperiod linear programming model and 3) a monoperiod MOTAD model incorporating yield variability factors. The last phase in the study was the actual computer analysis using the appropriate models to determine the effect of systematic variation in particular variables on farm firm growth over an eight-year period.

Typical Farm Firm

A typical farm firm situation was sythesized from data derived for a 10-county area in West Tennessee. This area, commonly referred to as the Deep Loess Soils Area, included Crockett, Dyer, Fayette, Gibson, Hardeman, Haywood, Lauderdale, Madison, Shelby and Tipton Counties. Characteristics of the typical farm firm are detailed in the Resource Assumptions section of Chapter III.

Model Development

The overall purpose of each of the three models was to analyze growth in terms of changes in net worth and total acres operated. This was accomplished differently in each model. The multiperiod maximization model(MLP) was developed as an eight-period model and solved once resulting in simultaneous solutions for all eight periods. The solutions were estimates of the maximum return to land, labor, management and owner equity in a riskless environment over the eight years of the planning horizon.

The monoperiod linear programming model(RLP) was developed and used recursively to analyze growth under conditions of year- to -year crop-yield fluctuations. Six series of simulated crop yields were used to determine the influence on firm growth of 1) randomly fluctuating yields, 2)ordered best-to-worst yield fluctuations and 3) ordered worst-to-best yield fluctuations. The best production plan for each year of an eight-year planning horizon was determined by obtaining solutions for the model successively for eight years, adjusting resource conditions to simulated outcomes between runs. More detail on this model is presented in the model delineation section of Chapter III.

The monoperiodMOTAD model(RM) was developed and used recursively to examine the influence on growth of risk aversion preferences held by the farmer. Three preference levels were used. Like the RLP model, the best production plan for each year of an eight-year planning horizon was determined by obtaining solutions for the model successively for eight years, adjusting resource conditions between runs. A more detailed explanation of the operation and rationale of the RM model is presented in section IV of Chapter II.

CHAPTER II

THEORETICAL FRAMEWORK

I. Introduction

This chapter was devoted mainly to the development of the analytical framework through which the growth process was examined. A brief discussion of theoretical considerations pertinent to firm growth was used to lay the base upon which this framework rests. In particular, the notion of statics versus dynamics were discussed. The last two sections of this chapter describe the development of the three models used in this study, i.e., the multiperiod linear programming model, the monoperiod linear programming model and the monoperiod MOTAD model.

II. Theoretical Considerations

The static theory of the firm is a well established concept in economic theory. The basis and need for the distinction between "statics" and "dynamics" have been identified particularly by Hicks and Dorfman. Hicks(16,p.115) has argued that the dating of factor employment and product completion distinguishes between statics and dynamics.

> I call Economic Statics those parts of economic theory where we do not trouble about dating; Economic Dynamics those parts where the quantity must be dated. For example, in economic statics we think of an entrepreneur employing such-and-such quantities of factors and producing by their aid such-and-such

> quantities of products; but we do not ask when the factors are employed and when the products become ready. In economic dynamics, we do ask such questions; and we even pay special attention to the way changes in these dates affect the relations between factors and products.

Dorfman(10,p.109) carried the discrepancies of statics and dynamics into the programming realm to more fully describe the relationship of inputs, outputs and time.

> Economists are familiar with the way in which a dynamic model of analysis may be developed from a static one, and the usual procedure applies in linear programming. Static linear programming rests on the relationships by which quantities of homogeneous goods and services(inputs) are transformed into other homogeneous goods and services(outputs), as we have seen. If we consider a production program as continuing over a number of periods of time, specify the quantity of each input that becomes available at the begining of each period as a function of activities in earlier periods, and seek to determine the level of each process in each period, the framework of a dynamic analysis results. A genuine dynamic quality is imparted to the analysis when the limitations on the activities of any period are expressed in terms of the results of previous periods. In this way a feedback is introduced into the system, and the successive periods are linked together by a set of linear difference equations which determine the maximum rate of growth of the system, the level of operation of each process during each period, and any inherent tendency to cyclical behavior.

Confronted with the same difficulties, S. R. Johnson(20) chose to analyze firm growth in an economic classification he called "non-static" as opposed to dynamics. His idea stems from the notion that economic activity actually takes place in an intermediate position between statics and dynamics. Given a spectrum with pure statics(no change) on one end and dynamics(all variables are functions of time in an irreversible way) on the other end, non-statics occurs at some intermediate point.

III. Monoperiod and Multiperiod Linear Programming Models

Although linear programming techniques have become one of the basic tools in the study of firm growth, it serves a useful purpose to review the basic formulation.

The mathematical formulation of the standard linear programming model can be illustrated with a profit maximizing objective criterion and resource constraints as follows:

$$(1) \quad \text{Max } Z = \sum_{j=1}^{n} c_j x_j \qquad j=1, \ldots, n$$

subject to the constraints:

$$(2) \quad \sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad i=1, \ldots, m$$

$$(3) \quad x_j \geq 0$$

where,

c_j = net price of the jth activity

x_j = level of the jth activity

a_{ij} = amount of the ith resource required to produce one unit of the jth activity

b_i = level of the ith resource available

This formulation was extended to a multiperiod framework by adding resource constraints and production activities for each additional production period and linking successive periods as illustrated in Figure 1. Linkage between periods was established by using transfer activities. These activities were used to allow capital funds generated in one production period to be used in any of several ways in the next period.

IV. Monoperiod MOTAD Model

The development of appropriate algorithms and new and more efficient computing facilities has stimulated the use of combinatorial techniques in firm growth research. In particular, farm firm growth studies have utilized various mathematical programming techniques in conjunction with nonoptimizing procedures(6,18,23). Recent research by Mapp,et al.(23), employed simulation in conjunction with a risk programming framework called MOTAD(minimization of total absolute deviations from expected income). This framework was developed by P.B.R. Hazell(11) in 1971 as an alternative to the more complex quadratic programming algorithm.

The basic difference in standard linear programming and MOTAD is that standard linear programming models usually have a profit maximizing or cost minimizing objective criterion, while MOTAD has an objective criterion of minimimizing the total absolute value of the negative

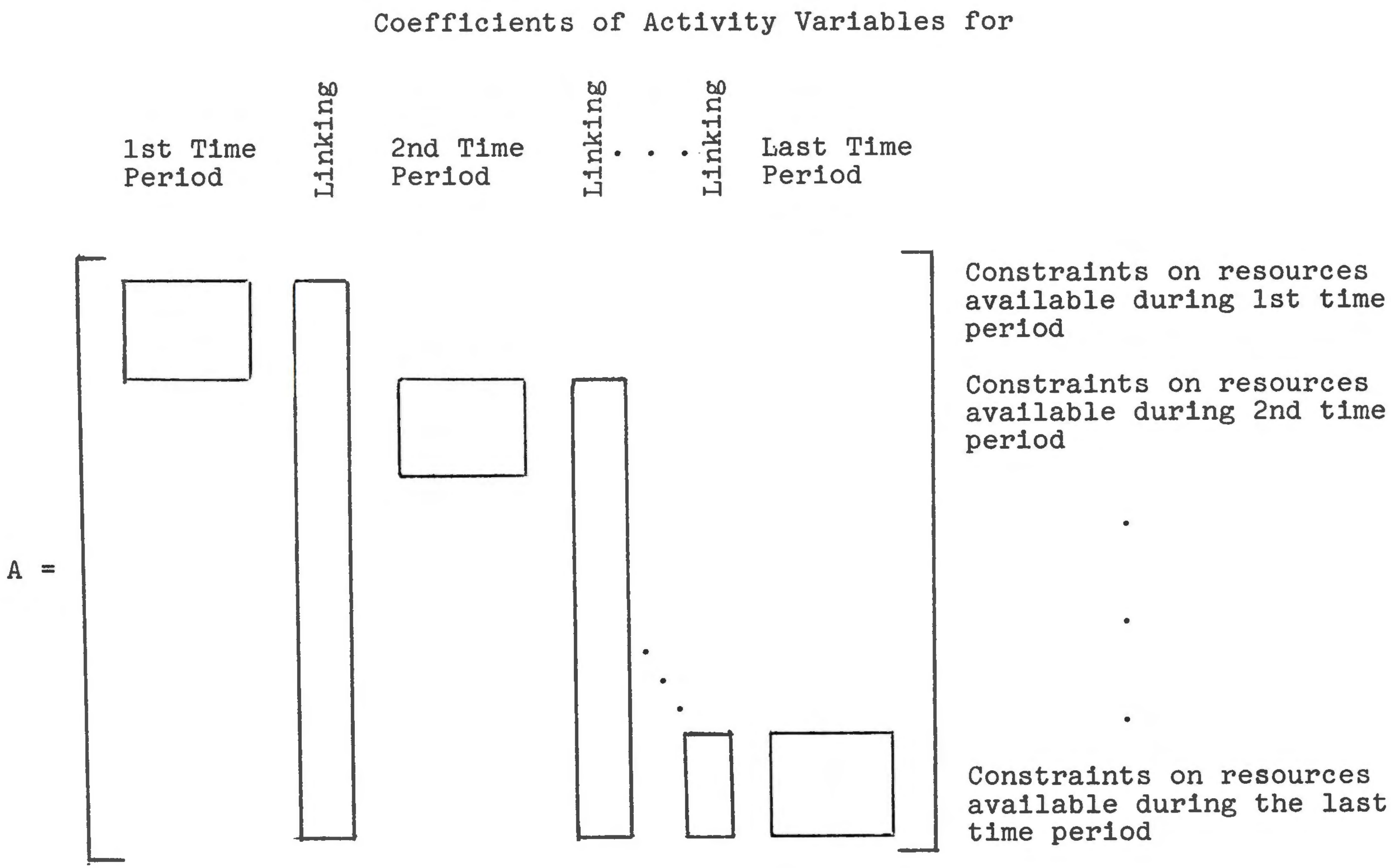

Figure 1. Constraint Coefficients for Multiperiod LP Model

Source: Hillier and Lieberman, <u>Operations Research</u>, p. 147.

deviations from expected income. For standard linear programming approaches the parametric options are normally employed only post-optimally, while the income-income variance relationships usually sought in MOTAD models are generated by parametric operations.

In contrast to the static linear programming model, the MOTAD model is based on the rationale of the farmer in restricting his choice among alternative farm plans for which minimum income variations are achieved for given levels of income(11,p.53). Mathematically, the MOTAD formulation can be expressed as:

$$(1) \quad \text{Min} \sum_{j=1}^{n} y_{h}^{-}$$

such that:

$$(2) \quad \sum_{j=1}^{n} (c_{hj} - g_j)x_j + y_h^{-} \geq 0 \qquad \text{(all } h, h=1,\ldots,n)$$

$$(3) \quad \sum_{j=1}^{n} g_j x_j = \lambda \qquad \lambda \geq 0$$

(4) $\sum_{j=1}^{n} a_{ij}x_j \leq b_i$ (all i,i=1,...,m)

(5) $x_j, y_h^- \geq 0$

where,

y_h^- = negative total gross margin deviations of the hth sample observation

a_{ij} = technical requirements of the jth activity for the ith resource or constraint

b_i = the ith constraint level

g_j = average or expected gross margin for the jth activity

c_{hj} = actual gross margin for the hth observation on the jth activity

λ = scalar (value of expected total gross margin)

x_j = level of the jth activity

An illustrative linear programming tableau for a MOTAD model using six years of yield deviation data is shown in Table 1(11, p.6). The coefficients relating T1-T6 to X1-X4 are deviations from mean gross margins in each respective year. The solution to the MOTAD model generates a set of production activities which yield "the sum of the absolute values of the negative total gross margins" for each specified level of gross margin to be attained(11,p.57).

Table 1. Tableau in MOTAD Format

Row and Unit	X_1	X_2	X_3	X_4	Y_1^-	Y_2^-	Y_3^-	Y_4^-	Y_5^-	Y_6^-	Constraint
A (dollars)					1	1	1	1	1	1	MIN
b_1 (acres)	1	1	1	1							$\leq$ 200
b_2 (hours)	25	36	27	87							$\leq$ 10,000
t_1[a] (dollars)	39	-571	136	63	1						$\geq$ 0
t_2 (dollars)	-74	117	-97	123		1					$\geq$ 0
t_3 (dollars)	-139	205	82	-137			1				$\geq$ 0
t_4 (dollars)	-6	101	-35	408				1			$\geq$ 0
t_5 (dollars)	173	-261	38	-511					1		$\geq$ 0
t_6 (dollars)	6	407	-125	53						1	$\geq$ 0
E[b] (dollars)	253	443	284	516							= λ

[a] $t_i = (c_{hj} - g_j)$

[b] $E = g_j$

Source: Hazell, American Journal of Agricultural Economics, 53:53-62, 1971, p. 61.

Implicit in the use of negative objective function values is the assumption that the farmer places a high value on avoiding negative income levels. The distribution obtained by pairing the sum of deviations value with each respective income level is the E-A boundary or production possibilities frontier. The set of all feasible farm plans and the efficient E-A boundary derived from the MOTAD model and the iso-utility curves estimated external to the model are illustrated in Figure 2. The optimal plan under this formulation is obtained at the point of tangency between the farmer's utility preference function and his production possibilities frontier(point C).

Although the estimation of iso-utility curves as shown in Figure 2 was not an integral function of this study, some attention was given to farmer preferences in relation to optimal plans in section VIII of Chapter III.

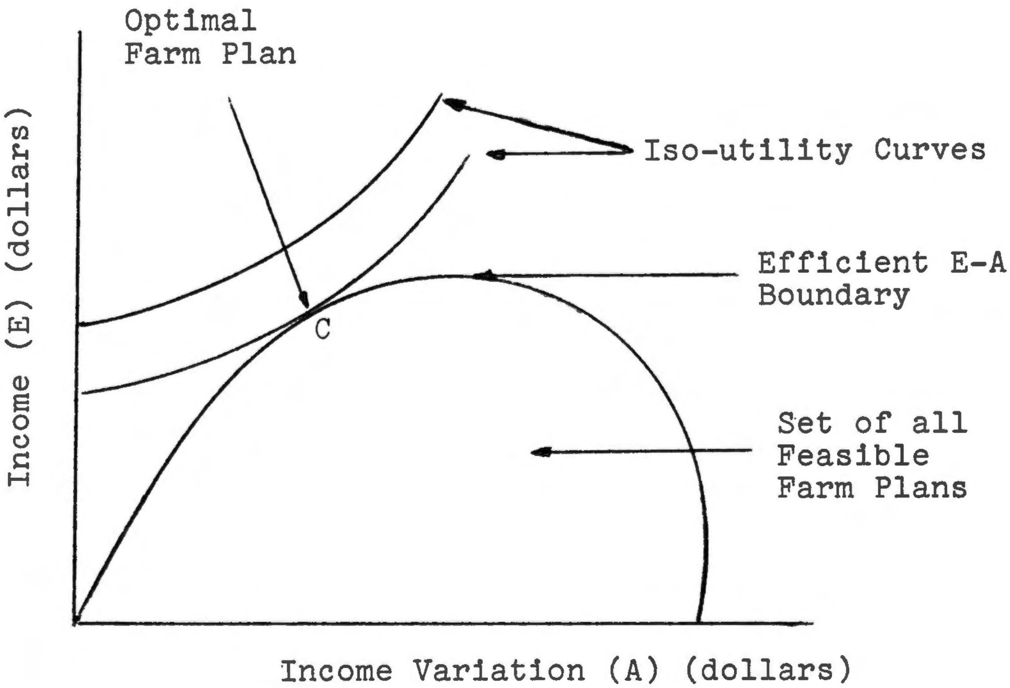

Figure 2. The Optimal E-A Farm Plan

Source: Hazell, American Journal of Agricultural Economics, 53:53-62, 1971, p. 54.

CHAPTER III

MODEL SPECIFICATION AND DELINEATION

I. Introduction

In order to make the models as realistic as possible while restricting them to a manageable size, several assumptions were necessary in synthesizing the typical farm firm and in the development of the three models. It was assumed that the farm operator possessed above average management skills and the ability and willingness to acquire additional resources with current income in excess of needs for consumption and debt servicing and that the operator had 100 percent equity in initial land holdings and in an initial complement of machinery valued at $26,942. A fixed quantity of family labor was assumed to be available throughout each production period. Both availability and requirements of labor were specified in two-month periods. Additional resources, particularly land and labor could be hired or purchased as justified in terms of the growth and risk aversion goals.

Capital withdrawals were made annually from current income for family consumption needs. Overhead costs such as charges to fixed capital, insurance, utilities, property taxes and other miscellaneous costs were also accounted for annually. Both operating and investment-capital borrowing activities were included in the analysis.

II. Resource Assumptions

Land Availability and Acquisition

The initial land base of the typical farm consisted of 350 total acres with approximately 72 percent or 252 acres in openland acres. Use of openland acreage was further restricted by soil capability classes determined on the basis of use suitability and potential yields. The classification of soils into groups was adapted from earlier work by Atchison(1, p.13). Each soil group comprised a specified percent of total openland acreage of the farm, i.e., Group I--48%; Group II--11%; Group III--19%; and Group IV --22%.

Additional land resources could be acquired by three methods: 1) cash purchase; 2) cash down payment plus an amortized loan; and 3) cash rental. The rental option was included because of its prevalence in the study area. The annual rental rate was assumed to be six percent of the average per acre land value for the ten-county area.* Buying land with an amortized loan required a down payment equal to the specified equity level (60 percent initially) followed by equal annual installments over a 40-year amortization period.

---

*According to estimates by Farm Real Estate Market Developments(39, per acre rental rates as a percent of land value in Tennessee were 6.0, 5.5 and 5.5 percent, respectively ,for the years 1978-80. Research by Tweeten(37, p. 28) using ten Midwest states indicated per acre rental rates ranging from 5.3 to 8.1 percent of land value for the years 1961-1978.

Purchasing land with cash required a cash payment in the full amount of the purchase price at the beginning of the period. Both alternatives used the same face value per acre for land and both required payment of property taxes of $3.68 per acre(39). All land acquisitions were assumed to be made at the beginning of a production period. If the credit option was used the first installment was due at the end of the period of purchase. Funds for land acquisition were transferred from the previous period's net revenue with the exception of land rental which was funded through operating capital which could be borrowed or transferred from net revenue.

Average per acre values of land and buildings were obtained from Tennessee Agricultural Statistics(35) for the ten study counties were summed and averaged for 1978. Using the index of land values for Tennessee(39) the estimated 1980 land value for the area was $1,111 per acre. This value was used in the analysis and remained constant throughout the planning horizon. Appreciation in land values over time due to inflation was not considered since the real rather than nominal rate of interest for amortized land purchases was used(37,p.28). Since land values over the ten-county area at any given point in time could differ significantly, land values approximately 25 percent lower than the base level were examined to determine the impact of land value differences on growth.

Capital Availability

In determining the growth potential of a farm firm, capital normally becomes the effective constraint. Firm growth can occur from either internal or external capital, or both. However, the effective constraint in the present study was farm income, since growth as measured by changes in net worth occurred primarily from internal generation of income. Limits on quantities of external capital available were based on required equity ratios.

Capital borrowing activities for land were subject to limits built into the land buying activities. The maximum debt allowable was determined by an equity ratio of either 60 or 40 percent. No borrowing restrictions were placed on operating capital. Operating capital was assumed to be repaid at the end of the production period in which it was borrowed.

Interest rates of 10 percent for investment capital and 11 percent for operating capital were charged initially. These rates were those charged by the Federal Land Bank Association and the Production Credit Association, respectively, in the State of Tennessee for mid-1980. Interest rates on operating capital were varied upward and downward by approximately 27 percent as part of this analysis to examine their impact on growth. The rate of interest received on an off-farm investment alternative was also varied from its initial eight percent level to determine the significance of the off-farm investment alternative on the flow of internally generated investment funds.

Labor Availability

The typical farm was characterized as an owner-operator type farm with the farm operator supplying a maximum of 2,500 hours of labor annually, distributed by two-month periods. Additional labor was provided by family members with the largest share coming in the summer months as shown in Table 2. Additional seasonal and/or part-time labor was assumed to be available at a wage rate of $3.50 per hour.

Machinery and Equipment

The synthesis of the typical farm necessitated the estimation of an equipment and machinery complement using dollar values in lieu of physical units. The equipment complement initially was valued at $26,942. This value was generated for a monoperiod farm plan of the typical farm firm as the amount necessary to maximize returns to land, labor, management and owner equity with all variables used in this study at base levels.

Equipment charges were handled in the analysis by developing an investment constraint that would charge off amounts in each production activity to maintain the existing complement, allowing machinery to be treated as a completely divisible resource available in annual increments so that exact amounts needed for each period could be purchased.

Table 2. Family Labor Availability by Two-Month Periods

Family Member	Jan.-Feb.	March-April	May-June	July-Aug.	Sept.-Oct.	Nov.-Dec.	Total
	Labor Periods						
	- - - - - - - - - - - - hours - - - - - - - - - - - - - -						
Operator	415	415	425	415	415	415	2500
Wife	60	60	45	45	60	60	330
Son			200	415			615
Total	475	475	670	875	475	475	3445

Annual Overhead and Family Consumption

Annual overhead costs and family consumption expenditures were assumed to be fixed for each production period. An annual withdrawal of $6,590 was made for family consumption based on estimated poverty level thresholds for a four-member farm family with a male head-of-household in the U.S. in 1980(32).

An annual overhead charge of $4,067. was also made to account for annual cost not accounted for in individual enterprise budgets. The components of annual overhead costs are shown in Table 3.

Objective Criteria

One of the major objectives of this study was the development of a modelling framework through which farm firm growth within a non-static environment could be analyzed while simultaneously allowing changes in the enterprise mix between production periods. The development of such a framework enabled the accomplishment of another objective, which was to examine the effects of changes in selected growth variables on the growth process of a typical farm firm. Taken together, these objectives imply that the farm operator should be in a position to chart out his intended route of expansion over some future time span as well as change his mix of production alternatives from year to year over that same time span.

Table 3. Estimated Annual Overhead Costs for the Typical Farm Firm in the Deep Loess Area of West Tennessee

Item	Cost New	Cost Avg.[a]	Salvage Value	Years Life	Annual Deprec.	Annual Repair	Int. @10%	Taxes and Ins.	Fuel and Other	Annual Total
	-dollars-									
Machine shed	2400.	1200.		20.	120.	12.	120.	12.		264.
Truck(one ton)	6000.	3300.	600.	10.	540.	360.	330.	400.		1630.
Auto(farm share)[b]									288.	288.
Liability ins.								65.		65.
Farm tools		800.				96.	80.			176.
Bookkeeping, legal fees, misc.									230.	230.
Telephone									90.	90.
Electricity[c]									36.	36.
Land								1288.[d]		1288.
Total					660.	468.	530.	1765.	674.	4067.

[a]Average cost was computed by adding salvage value to initial cost and dividing by two.

[b]Farm share, 1600 miles @ $0.18 per mile

[c]Monthly rate assumed to be $5.

[d]Property tax @ $3.68 per acre of land.

Options open to the decision-maker operating under the situation described above include; 1) assuming that the next few production periods will not differ significantly from the average of the last few production years so that he can operate on these expectations without taking specific precautions against uncertainties and 2) incorporating risk and uncertainty factors into his decision-making/planning process. Both options were explored in this study. Expected outcomes were used in analysis of the growth variables in the MLP model, while "actual" versus "expected" outcomes via simulated yield factors were used with the RLP model. The RM model incorporated risk and utility factors to determine the impact of risk aversion preferences on growth.

The objective criteria used is of significant consequence to the overall growth of the farm firm. Two objective criteria were used. In the monoperiod and multiperiod linear programming models an objective criterion of maximizing net returns to land, labor, management and owner equity was used. In analyzing growth in a risky setting an objective criterion of minimizing total absolute deviations from expected income in order to achieve a specified income level was used.

Growth Measures

Although growth measures are many and varied by study type, the growth measures used in the current study were (1) change in net worth and (2) change in total acres operated. These measures are defined more explicitly in Chapter IV.

Investment Process

All investment funds flowed from a net revenue(NR) accounting row in the form of capital available for investment. Total capital available for investment for any one period was equal to total net returns less allowances for fixed farm overhead, family consumption, property taxes on land acquisitions and debt payments. Debt payments included annual installments on land purchases and repayment of borrowed operating capital.

Capital generated in one production period could be transferred to the next production period. Transfers could be made to operating, machinery or land capital. Capital also could be transferred to an off-farm investment alternative(savings) earning interest in each period. All savings funds could be held and transferred in savings or transferred to operating, machinery or land capital in the next time period.

III. Crop Enterprises

The alternative crop enterprises considered included corn, cotton, wheat, soybeans, double-cropping of wheat and soybeans, red clover-timothy hay and fescue-ladino clover permanent pasture.

Estimated yields per acre for these enterprises are shown by soil management group in Table 4. Labor requirements for these same alternatives are shown in Table 5 by time periods. Cotton, corn, wheat, and soybeans were revenue producing enterprises, while hay and pasture could be used as intermediate products to produce beef cattle. Prices received for commodities sold and inputs purchased were adapted from prices used by Walch and Ray as 1981 projections in Farm Planning Manual(30). Product prices used were \$2.61 per bushel for corn, \$.63 per pound of lint for cotton, \$2.80 per bushel for wheat and \$6.50 per bushel for soybeans. Prices used for major farm inputs included in the crop budgets are shown in Table 6.

IV. Livestock Enterprises

Because the study area is predominantly a row-crop producing area in which few livestock activities occur, a beef cow-calf backgrounding enterprise was the only livestock enterprise considered. A 90 percent calf crop, spring calving and a 20 percent replacement rate for heifers were assumed for the beef enterprise. All calves would be grazed on permanent pasture over an eight-month grazing period and fed hay over a four-month winter period.

Steers and heifers(other than replacements) would be sold in late spring at 700 pounds and 655 pounds, respectively. Prices assumed were \$50 per hundredweight for steers and \$42 per hundredweight for heifers(30). Net

Table 4. Estimated Per Acre Yields for Crop Enterprises by Soil Management Group

Crop Enterprise	Unit	Soil Management Group 1	2	3	4
Corn	bu.	90	75	60	-
Cotton	lbs.	450	375	275	-
Wheat	bu.	40	35	30	-
Wheat straw	bale	40	35	30	-
Soybeans	bu.	35	32	26	-
Double-cropping					
Soybeans	bu.	28	24	20	-
Wheat	bu.	40	35	30	-
Red Clover-Timothy Hay	ton	2.5	2.25	2.0	-
Fescue-Ladino Clover Pasture	CAD[a]	180	160	140	110

[a]Cow acre days.

Source: Adapted from Alvin A. Bedel, "A Study of Potential Farm Growth and Survival For Representative Farms in West Tennessee", unpublished Ph.D dissertation, The University of Tennessee, Knoxville, Tennessee, June, 1975, p. 31.

Table 5. Labor Requirements for Each Crop by Two-Month Periods

Crop	Periods						
	Jan.-Feb.	March-April	May-June	July-Aug.	Sept.-Oct.	Nov.-Dec.	Annual
	- - - -	- - - -	- - - -	hours	- - - -	- - - -	- - - -
Corn	-	.99	.98	.37	.74	.26	3.34
Cotton	-	1.68	2.22	1.48	1.63	.81	7.82
Wheat (straw baled)	-	-	1.30	1.70	2.20	-	5.20
Soybeans	-	.54	1.64	.74	.50	.32	3.74
Wheat-Soybeans (double-cropped)	-	-	1.99	.74	1.94	.50	5.17
Red Clover-Timothy Hay	-	-	2.61	3.12	-	-	5.73
Fescue-Ladino Clover Pasture	-	.52	-	.72	-	-	1.24

Source: Robert M. Ray and Herbert N. Walch, "Farm Planning Manual", Publication EC622, Agricultural Extension Service, The University of Tennessee, Knoxville, Tennessee, (Revised), April, 1978, p.13.

Table 6. Major Farm Input Prices

Item	Unit	Price($)
Seed		
Corn	bu.	50.00
Cotton(acid delinted)	lb.	.37
Wheat	bu.	8.25
Soybeans	lb.	.17
Fescue	lb.	.45
Ladino Clover	lb.	3.00
Red Clover	lb.	1.22
Timothy	lb.	1.33
Fertilizer		
N	lb.	.25
P_2O_5	lb.	.12
K_2O	lb.	.22
Lime(app.)	ton	10.50
Boron	lb.	1.35
Weed Control		
Atrazine(80% W.P.)	qt.	2.28
Dual 6E	pt.	3.54
Bascagran	pt.	7.81
Sencor	pt.	8.70
Treflan	pt.	3.50
Cotoran	lb.	5.17

Source: Tennessee Farmer's Cooperative

returns to farm-produced feed, land used for feed production, labor, management and owner equity was $165.05 per cow.

V. Capital Requirements

Requirements for both operating and investment capital for the various crops by SMG and the livestock alternative are shown in Table 7. The required operating capital for each activity was assumed to be used for six months. Operating capital was somewhat lower on some SMGs due to the lower level of use of some variable inputs such as seed and fertilizer.

Investment capital for crops was defined as the prorata share of machinery investment necessary to produce one acre of a particular crop. Investment capital for the livestock activity was defined as the amount of capital necessary to produce one livestock unit(cow plus replacement).

Machinery investment for crops was calculated by estimating average annual investment for each machinery input, dividing by expected hours of annual use and multiplying by the machine hours required to produce a particular crop. Machinery investment per crop activity was assumed to remain constant for all SMGs.

Investment capital for the beef cow-calf activity was calculated as the total of capital charges attributable to one cow-calf unit and associated replacement and breeding

Table 7. Operating and Investment Capital Requirements Per Unit of Crop and Livestock Activities[a]

Capital Type	Enterprise					
	Corn	Cotton	Soybeans	Wheat	Wheat-Soybeans	Cow-Calf
	- - - - - - - - - - - - - - - dollars - - - - - - - - - - - - - - -					
Operating capital on SMG1	48.80	65.97	37.46	36.26	63.38	409.90
Operating capital on SMG2	44.80	55.97	30.71	34.51	56.62	
Operating capital on SMG3	40.80	45.97	23.96	32.76	49.88	
Investment capital	92.48	214.95	136.76	142.19	174.95	982.60

[a]Crop activities were specified in one-acre units. The cow-calf activity was specified in units of one cow plus a share of her replacement.

stock($648), one backgrounded calf($225) and buildings and equipment per livestock unit($328.80) or a total of $982.60.

Of the crop activities, cotton required the highest per acre investment capital($214.95) followed by double-cropping of wheat and soybeans, wheat, soybeans and corn. Cotton was also highest in operating capital requirements at $65.97 per acre followed by wheat-soybeans, corn, soybeans and wheat.

VI. Net Returns

Returns to land, labor, overhead costs, management and owner equity differed by SMG for each of the crop activities due to differences in the amount of operating capital required and the per acre yields on different SMGs. Expected(mean) and actual net returns(gross margins) for the various production alternatives are shown in Table 8. Mean gross margins were defined as the net returns to land, labor, capital management and overhead cost using the yield levels shown earlier. Actual gross margins were estimated for each year from average annual yield data for the ten-county area adjusted to achieve a mean yield over the 1972-79 period equal to the yields used for the base budgets.

Assuming that the gross margins indicated are reflective of the base level of all growth variables, expected gross margins on SMG1 were highest for wheat-soybeans at $127.78 followed by soybeans at $127.49, corn at $115.29, cotton at $109.99 and wheat at $37.43. Hay

Table 8. Expected and Actual Gross Margins for Various Production Alternatives

Production Activity	Budgeted Gross Margin (Mean)[a]	Actual Gross Margins by Years[b]							
		1972	1973	1974	1975	1976	1977	1978	1979
	- - - - - - - -	- - - -	- - - -	- - - -	dollars	- - - -	- - - -	- - - -	- - - -
Corn									
CRN1	115.29	109.	106.	95.	102.	140.	109.	120.	136.
CRN2	84.14	80.	77.	69.	75.	102.	80.	87.	100.
CRN3	52.99	51.	49.	45.	48.	65.	51.	56.	63.
Cotton									
COT1	109.99	139.	136.	85.	97.	85.	117.	139.	102.
COT2	81.24	97.	95.	59.	68.	59.	82.	97.	71.
COT3	36.24	45.	44.	27.	31.	27.	38.	45.	33.
Wheat									
W1	37.43	35.	34.	31.	33.	42.	40.	40.	37.
W2	23.18	23.	22.	20.	21.	27.	26.	25.	23.
W3	8.93	8.	8.	8.	8.	11.	10.	10.	9.
Soybeans									
SOY1	127.49	120.	127.	116.	138.	120.	120.	127.	146.
SOY2	121.49	117.	121.	109.	132.	117.	117.	121.	143.
SOY3	108.99	101.	109.	98.	117.	101.	101.	109.	125.
Wheat-Soybeans									
WSOY1	127.78	125.	125.	123.	129.	130.	128.	130.	134.
WSOY2	121.24	99.	100.	97.	102.	100.	102.	102.	106.
WSOY3	74.78	73.	75.	72.	77.	74.	73.	77.	79.

[a]Estimated net returs to land, labor, capital, management and overhead costs and crop yields shown in Table 4.

[b]Budgeted gross margins adjusted for variations in average annual county yields.

and pasture had negative values indicating production costs rather than returns. Net returns to the cow-calf enterprise and associated feed enterprises was $165.05 per cow plus a share of her replacement.

VII. Yield Variabiliity

Heady(11, p.449) contends that when farmers speak of risk, they are referring to uncertainty. He defines several types of uncertainty important in formulating production and investment plans. These are price uncertainty, yield uncertainty, technological uncertainty, and institutional and sociological uncertainties. Although the farm operator is confronted by various types of risk and uncertainty it is difficult to account for several types in one study. There is some justification for assuming that although prices probably will change over time they change in relatively constant proportions across all production alternatives. Taking this into consideration along with the necessity of price forecasting models to predict future prices, no attempt was made to account for risk and uncertainties associated with price changes. Only yield variability occurring within a specific technique of production was of concern in this study. Variability in yields may be caused by weather fluctuations, disease, insects and other biological factors.

The effect of yield variability on decision-making was incorporated through the MOTAD framework as part of the modelling process to account for risk and uncertainty which the farmer faces in the planning process. This was accomplished by deriving deviation coefficients for each of the major crop activities.

The derivation of yield deviation coefficients involved several steps. First, annual per acre yield data for the crop production alternatives under consideration were obtained for each of the ten counties in the Deep Loess Soils Area for 1972-1979. The county data were then averaged resulting in an average per acre yield for each of the crop alternatives for each year. Since above average management skills were assumed in cost-returns budgets developed for the various crops, it became necessary to adjust estimated per acre yields for the ten- county area to reflect these higher levels of management skills. For example, a yield of 40 bushels per acre was used for wheat budgets developed for SMG1, while the estimated yield for the ten counties over the 1972-1979 period was only 33 bushels per acre. In order to equate the two, a yield factor of +1.22 was used on each of the yearly averages to bring conformity to the data and the crop budgets. A different yield factor was necessary for each crop activity. When used in conjunction with 1980 prices the adjusted yields resulted in gross margin values which were equal to net returns shown in Table 8. Average yearly gross margins for any one crop alternative became the mean gross margin which in this case was identical to the net returns to land, labor, management and owner equity per unit of each activity. Mean(expected) and actual gross margins for the various crop alternatives are those indicated in Table 8 for each of the years 1972-1979.

The differences between the yearly gross margins and the mean gross margin were entered into the MOTAD model as yield deviation coefficients. 'Deviation', as used here, does not imply a statistical measure, but rather the absolute change from the mean value. All deviations were weighted equally since there was no way of knowing whether the farmer would face a good or bad production year. It should be noted that the procedure used to derive deviation coefficients actually understated the range of possible outcomes since deviations in yields occurring on individual farms would likely be greater than deviations derived from average county yield data. Deviation coefficients for the various crop enterprises are shown in Table 9. Gross margin variability was highest for cotton and lowest for double-cropping of wheat and soybeans. The variation in cotton gross margins ranged from a negative 23 percent to a positive 21 percent of the mean value. The range in variation for the other activities in percentage terms was corn(-16 to +22), soybeans (-9 to +15), wheat(-8 to +13) and wheat-soybeans(-4 to +5). Again, these values were understated due to the aggregation of county data. Individual farm data would exhibit wider fluctuations in yields and correspondingly wider gross margin variability.

Table 9. Gross Margin Deviations From the Mean for the Various Crop Activities[a]

Year	Corn	Cotton	Soybeans	Wheat	Wheat-Soybeans
	- - - - - - - - - - - -		dollars	- - - - - - - - - - - -	
1972	-6	23	-6	-2	-3
1973	-8	21	0	-3	-3
1974	-18	-25	-11	-3	-5
1975	-13	-13	11	-3	1
1976	25	-25	-6	5	2
1977	-6	5	-7	3	0
1978	5	21	0	3	2
1979	21	-8	19	0	6

[a]Only gross margin deviations for SMG1 are shown

Another aspect of yield variability was addressed with the RLP model. In order to determine the influence of year to year fluctuations in yields on the growth process, six series of yield data were used. Differences in budgeted yields and actual yields for the years 1972-1979 were reflected by the gross margins of each crop activity for each individual year. The gross margins of soybeans were used to order the eight years under consideration from best-to-worst and vice versa in addition to four random series.

VIII. Model Delineation

The three models used to examine growth are described more fully in this section with reference to specific structure and the purpose and use of each. A description of the row(constraint) and column(activity) codes is given in Table 10.

In addition to the usual production activities(corn, cotton, soybeans, etc.) and fixed activities(overhead and family consumption), the acquisition and transfer activities were the channels for farm expansion in all three models. Acquisition activities included two methods of buying land(BLN1 and BLN2), a rent land option(RLAND) and operating capital borrowing activities (BOPCAP and BOPCAPL).

The transfer activities allowed capital available for investment to move freely from period to period. Through transfers, capital available for investment could be used in

Table 10. Description of Matrix Rows and Column Codes

Rows	
MAX	Objective criterion--maximization of returns to land, labor, management and owner equity
MIN	Objective criterion--minimization of total absolute deviations from expected income
SMG1	Soil Management Group I--34% of total land acreage
SMG2	Soil Management Group II--8% of total land acreage
SMG3	Soil Management Group III--14% of total land acreage
SMG4	Soil Management Group IV--16% of total land acreage
LAB1-LAB2	Labor availability in two-month periods
OPCAP	Operating capital
RCAP	Machinery capital
LCAP	Land capital
NR	Net revenue--accounting row
SAVE	Off-farm investment alternative
FIXED	Fixed overhead expenses
CONS	Family consumption expenditures
SLOPE	Equality to fix slope in RM model
INTCEPT	Equality to set extreme income level in RM model
CARRY	Accounting row used for capital transfers in the RLP and RM models
T21-T28	Deviation coefficients for cropping activities

Table 10. (continued)

Columns	
Production Activities:	
CRN1-CRN3	Grow and sell corn on SMG1-SMG3
COT1-COT3	Grow and sell cotton on SMG1-SMG3
W1-W3	Grow and sell wheat on SMG1-SMG3
SOY1-SOY3	Grow and sell soybeans on SMG1-SMG3
WSOY1-WSOY3	Grow and sell double-cropped wheat and soybeans on SMG1-SMG3
HAY1-HAY3	Grow hay on SMG1-SMG3
PAS1-PAS4	Grow pasture on SMG1-SMG4
BEEF	Beef cow-calf backgrounding activity
Fixed Activities:	
OVERHD	Fixed overhead charges
FAMCONS	Family consumption expenditures
Acquisition Activities:	
HLB1-HLB6	Hire labor by two-month periods
BLN1	Buy land on a 40-year amortization with cash downpayment
BLN2	Buy land with cash
RLAND	Rent land
BORCAP	Borrow operating capital
Transfer Activities:	
INVEST	Transfer capital available for investment to an off-farm investment alternative
TSAVE23	Transfer capital already in savings to the next period

Table 10. (continued)

TSAV23O	Transfer savings to operating capital in the next period
TSAV23R	Transfer savings to machinery capital in the next period
TSAV23L	Transfer savings to land capital in the next period
TNR23O	Transfer net revenue to operating capital in the next period
TNR23R	Transfer net revenue to machinery capital in the next period
TNR23L	Transfer net revenue to land capital in the next period
Y21-Y28	Absolute values of the negative total gross margin deviations around the expected return based on sample mean gross margins

subsequent periods as operating, machinery or land capital or it could be used for off-farm investments. Transfer activities were also available to allow capital invested off-farm to re-enter the on-farm capital flow as operating, machinery or land capital.

Monoperiod and Multiperiod Linear Programming Models

The RLP model was used to examine the impact on growth of year to year crop yield fluctuations by comparing results obtained by the use of simulated "actual" yields with results obtained using "expected" or budgeted yields. The model was used recursively making annual adjustments in resource restriction levels between runs to reflect changes in capital, machinery and land availability due to differences in actual and expected outcomes. Although this study was not expressly concerned with the question of survival, the effect of random and ordered yield fluctuations on growth was examined by using six series of simulated yield data. In addition to four random series, yields ordered from worst-to-best and best-to-worst, as defined in section VII, were used to determine growth changes when several favorable and/or unfavorable production years followed in succession.

The MLP model was developed by extending the RLP formulation to a multiperiod framework. Returns to land, labor, management and owner equity were maximized simultaneously over an eight-year planning horizon(MAX).

The addition of several activities (columns) and constraints(rows) for each production period were necessary for the multiperiod model. Linking activities between periods are indicated as transfer activities in Table 9.

The purpose of the MLP model was two-fold: 1) to determine the optimum growth pattern when returns to land, labor, management and owner equity were maximized in a riskless setting and 2) to evaluate the effect on the growth process of changes in the level of selected growth variables in a static environment. The latter was accomplished by isolating individual growth variable changes while holding all other growth variables at their base levels.

Monoperiod MOTAD Model

The purpose in using the MOTAD formulation was to evaluate the effects of different risk aversion preferences on the growth of the farm firm. However, since the estimation of iso-utility curves was beyond the scope of this study, an alternative method of defining points of tangency was needed. Theoretically, it can be shown that the optimal solution can be derived if only the slope of the line passing through the point of tangency is known. The modified MOTAD procedure is illustrated in Figure 3.

Using this model income and associated income variation for any level of risk aversion could be estimated by defining the slope of a line as a proxy for the iso-utility curve. With zero slope maximum income and income variation

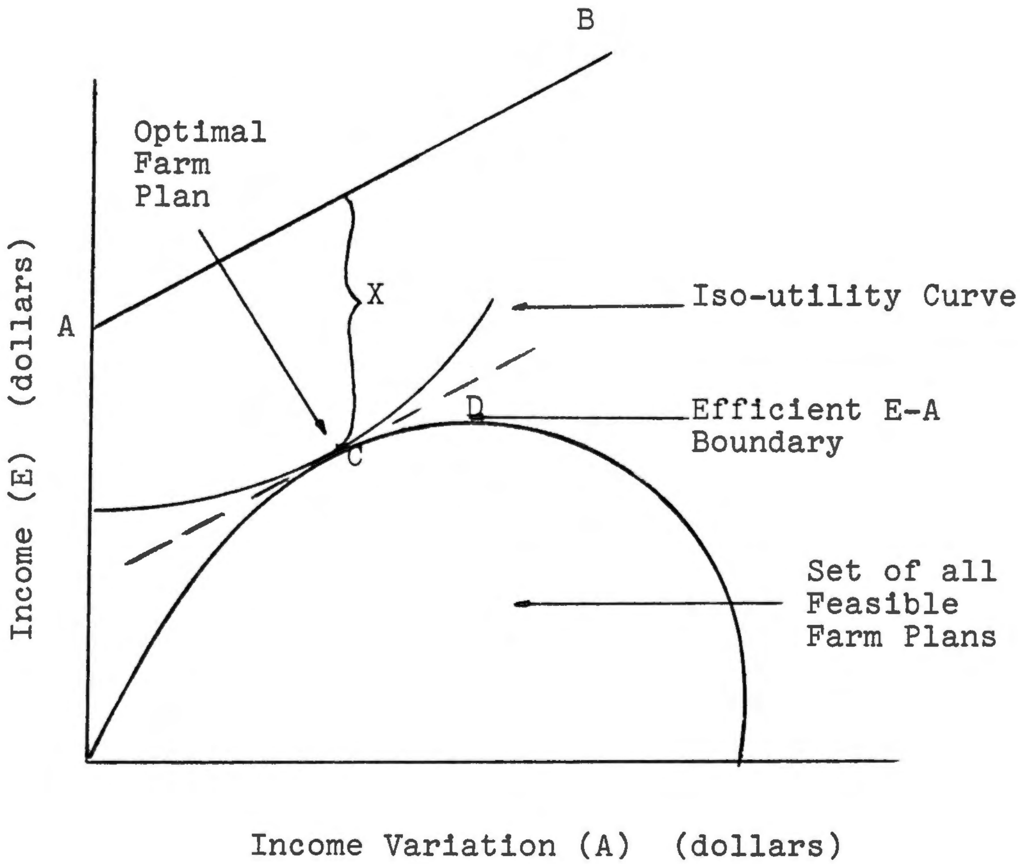

Figure 3. Income-Income Variation Tradeoff for Specific Risk Preference Levels Using the RM Model

would correspond identically to that of standard maximizing procedures(point D). For analytical purposes, the maximum income point was chosen as one risk preference level. By arbitrarily choosing some percentage of the maximum and parameterizing slope values for small increments of income around this value, a slope value for a particular point on the production possibilities frontier was estimated. The three slope values used in this study were 1.94, 1.86 and 0, corresponding to 73 percent, 85 percent and maximum income, respectively.

The objective criterion of minimizing total absolute deviations from expected income was modified to also include minimizing the distance X in Figure 3. An intercept value(A) was used with a line of appropriate slope(B) so that forcing tangency between the production possibilities frontier and the line B resulted in the desired risk preference level of income and associated income variation at point C.

Having determined the appropriate slope values, the RM model was used recursively to trace the growth of typical farm firm for the three risk aversion levels. Resource conditions were updated between production periods to reflect changes in capital availability, and machinery and land acquisitions.

IX. Computer Analysis

Though distinct in purpose and somewhat different in structure each of the models used were solved with the IBM Programming Package, Mathematical Programming System Extended(MPSX). The MLP and RLP models were solved by standard maximization procedures. The RM model was solved as a minimization model.

The various computer runs made for each of the three models are shown in Table 11. Runs one through nine were made using the MLP model. Runs one through three were used to test the significance of an off-farm investment alternative on the flow of internally generated capital available for investment by decreasing the interest rate earned on savings from eight to four to zero percent. Runs four and five were used to evaluate the effect on growth of changes in interest rates on operating capital. Runs six and seven were made to determine the influence on growth of changes in interest charges on amortized land purchases. Run eight was used to examine the influence of changes in per acre land values on growth. The rate of interest on land purchase indicated by Table 11 is in terms of the estimated real rate of interest on land investment, i.e., the mortgage rate minus the rate of inflation. The last run made with the MLP model(nine) was made to examine the influence of variation in equity levels on the growth process.

Table 11. Computer Analysis by Type of Model and Level of Selected Growth Variables

Model Type	Computer Runs	Equity Level	Interest Rate on Land Investment	Interest Rate on Operating Capital	Interest Rate on Savings	Land Value	Land Rental rate	Preference Level
		-percent-				-dollars-		
Multiperiod maximization (MLP)	1	60	5	11	8	1111	67	
	2	60	5	11	4	1111	67	
	3	60	5	11	0	1111	67	
	4	60	5	14	0	1111	67	
	5	60	5	8	0	1111	67	
	6	60	3.75	11	0	1111	67	
	7	60	6.25	11	0	1111	67	
	8	60	5	11	0	833	50	
	9	40	5	11	0	1111	67	
Monoperiod maximization (RLP)	(10-57)	60	5	11	0	1111	67	
Monoperiod MOTAD (RM)	(58-65)	60	5	11	0	1111	67	High risk
	(66-73)	60	5	11	0	1111	67	Risky
	(74-81)	60	5	11	0	1111	67	Low risk

The monoperiod RLP model was run successively for eight runs for six different sets of simulated outcomes. The first runs(10-41) were made with four series of random simulations. The second and third series of runs(42-49 and 50-57) were made to examine the effect of yield variability on growth when several favorable years are followed by several not-so-favorable years and vice-versa.

The RM model was run successively for eight runs for three different risk aversion preference levels. Runs 58-65 were made to analyze a high risk preference, while runs 66-73 and 74-81 were made to evaluate growth changes for two levels of increasingly risk averse preferences.

CHAPTER IV

RESULTS OF THE ANALYSIS

The results of the analysis are discussed in this chapter in five sections. The focal point of discussion in each section is growth in farm size over an eight-year period in terms of 1) change in net worth and 2) change in acres operated. Section one contains a discussion of the growth of the typical farm firm when all growth variables are constrained to their base levels using the MLP model. Growth in a riskless environment using the MLP model is discussed in section two. The growth variable changes made were: 1) the interest earned on an off-farm investment alternative(savings) was reduced from eight percent to four percent and finally zero percent, 2) the interest charged on operating capital was reduced from 11 percent to eight percent and increased to 14 percent, 3) the interest rate used for amortized land purchases was reduced from five percent to 3.75 percent and increased from five percent to 6.25 percent, 4) the equity level was reduced from 60 percent to 40 percent, and 5) the per acre land value was decreased from $1,111 to $833. These changes were made individually holding all other factors constant at their base levels.

Growth changes arising from yield fluctuations between production periods are discussed in section three. The RLP model was used recursively to analyze yield variability factors by incorporating simulated yield factors to derive "actual" versus "expected" yields. Six series of yield data, four random and two ordered, were used in this analysis. All growth variables were held at their base levels with the exception of the off-farm investment alternative which was eliminated.

The monoperiod MOTAD model(RM) was used recursively to generate results discussed in section four. This part of the study dealt with changes in growth attributable to risk preferences held by the farm operator. Again, all growth variables were held at their base levels and the off-farm investment alternative was eliminated.

In section five a brief discussion on model adequacy and applicability is presented.

I. Base Level Growth Variable Analysis Using the MLP Model

The initial farm situation for the typical farm firm assumed ownership of 350 total acres of land and an equipment and machinery complement valued at $26,942. The assumed initial net worth was $415,792, consisting of 350 acres of land valued at $1,111 per acre($388,850) and $26,942 invested in machinery and equipment. Increases in net worth could occur from reinvestment of net farm returns in machinery and/or land purchase, off-farm investment in a savings account and use of capital for annual farm operating expenses. Cash on hand at the end of the planning horizon was also added to net worth.

In the base model for the typical farm the selected growth variables were set at 60 percent equity, 11 percent interest on operating capital, eight percent interest on the off-farm investment alternative, five percent interest on amortized land purchases, $67 per acre land rental rate and $1,111 per acre land values. Land rental was restricted in any one production period to the amount held initially or 350 acres.

With the growth variables set at these levels, the farm organization that would maximize returns to land, labor, management and owner equity over an eight-year period was obtained. Soybeans was the only crop activity in the optimal farm organization. All available land acreage in SMGs one, two and three were devoted to soybean production. Since SMG four included land suitable only for pasture, this acreage was not utilized.

The flow of investment funds and annual and cumulative changes in net worth are shown in Table 12 for each of the eight years. The annual change in net worth was equal to net returns minus family consumption expenditures. This value was also equal to the amount of capital available for investment in any one production period.

A simple production scheme evolved when the base model growth variables were used. All available acreage was devoted to soybean production because of the relatively low requirements of both operating and investment capital per acre and the relatively high returns per acre. All

Table 12. Net Worth Changes and Flow of Capital Available for Investment by Period for the Base Situation Using the MLP Model

Period	Annual Change in Net Worth[a]	Cumulative Change in Net Worth	Transfer Inv. Cap. to Operating Capital	Transfer Inv. Cap. to Off-farm Investment	Transfer Savings to Savings	Transfer Savings to Oper. Cap.	Transfer Savings to Mach. Cap.
	- - -	- - -	- - -	dollars	- - -	- - -	- - -
1	12682.	12682.		12682.			
2	13697.	26379.		13697.	12682.		
3	14793.	41172.		14793.	26379.		
4	15976.	57149.		15976.	41172.		
5	17254.	74403.		17254.	57149.		
6	18635.	93037.		18635.	74403.		
7	20125.	113163.	6543.	13583.	93037.		
8	21946.	135109.					

[a]Annual change in net worth(which equals capital available for investment) was also equal to net returns minus family consumption ($6590)

available investment capital was funneled into the off-farm investment alternative. No additional land was acquired because the internal rate of return on on-farm investments was lower than the eight percent return on the off- farm investments.

All invested capital was carried in savings from period to period earning interest in each period. Net worth increased by 32.7 percent or $135,109 over the eight periods, bringing ending net worth to $550,902.

II. Growth Variable Analysis in a Riskless Environment Using the MLP Model

In all the optimal solutions resulting from the various growth variable changes discussed in this section, soybeans was the only crop activity. Since all available openland acreage other than that in SMG4, which was suitable only for pasture, was devoted to soybean production, all subsequent reference to openland acreage denotes soybean activity.

The Effect on Growth of Changes in Interest Rates on the Off-Farm Investment Alternative

Since the present study was concerned with the growth, i.e., the accumulation of assets of the farm firm from internally generated capital funds, an evaluation of the off-farm investment alternative was made prior to analyzing the other growth variables. With all other growth variables at their base levels, the interest rate on savings was reduced from eight percent to four percent and finally, zero percent. A comparison of annual changes in net worth at these three interest rates is shown in Table 13.

Results with the eight percent interest rate were as shown in the previous section(the base situation). All available capital was invested in the off-farm savings alternative. No additions were made to either machinery or land. When the interest rate was reduced to four percent, the off-farm investments again were the dominant factor; however, slightly over nine acres of land were added in the final period utilizing the amortized land purchase option.

With the off-farm investment alternative eliminated(zero percent), the overall percentage increase in net worth over the eight-year period was 29 percent, only 3.6 percent less than for the eight percent level and 0.3 percent less than for the four percent level including the savings option. Without the savings option additions were made to both machinery and land investment over the eight-year period. Machinery assets were increased by $21,454 or 80 percent. Cash purchases of 65 acres of land increased total openland acreage by 18 percent or 46 acres. Since no land purchases were made at the eight percent or four percent interest levels, acquisitions at the zero percent level are presented in later tables. The inclusion of the savings alternative dominated all other growth variables in the use of available capital funds to the extent that the effects on growth of changes in other growth variables could not be evaluated. This led to the

Table 13. Change in Net Worth by Period Using the MLP Model and Three Interest Rates on an Off-Farm Investment Alternative (Savings)

	Annual Increase in net worth		
	Interest Earned on Capital		
Period	8%	4%	0%
	- - - - - - - - - dollars - - - - - - - - - -		
1	12682.	12682.	12682.
2	13697.	13190.	13351.
3	14793.	14245.	14012.
4	15976.	14287.	14665.
5	17254.	14859.	15310.
6	18635.	15453.	15948.
7	20125.	16071.	17001.
8	21946.	20711.	17253.
Total	135109.	121498.	120222.
% increase	32.7	29.2	28.9

elimination of the off-farm investment alternative as an option in the MLP model for all subsequent analysis.

Effect on Growth of Changes in the Interest Rate on Operating Capital

The results which follow were generated by varying the interest charge on operating capital from the initial 11 percent rate upward to 14 percent and downward to eight percent.

The effects of varying the interest charge on operating capital on changes in net worth over the eight year period are shown in Table 14. Only slight changes in overall net worth accumulation occurred with changes in the interest charges on operating capital. These interest rate changes were reflected in the amount of interest paid on borrowed operating capital. Net worth increased 0.4 percent over the period when the interest rate was reduced from 11 to eight percent and decreased 0.4 percent when the interest rate was increased from 11 to 15 percent. At all three interest rates the total increase in net worth was approximately 29 percent. Total ending net worth was $537,516, $536,014, and $534,462, respectively for interest charges on operating capital of eight, 11 and 14 percent.

The flow of capital funds available for investment at an eight percent interest charge on operating capital is shown in Table 15. A large part of available capital in each production period was used for cash purchase of land with just enough additional machinery investment to support

Table 14. Change in Net Worth Using the MLP Model and Three Interest Rates on Operating Capital

	Change in Net Worth		
	Interest on Operating Capital		
Period	8%	11%	14%
	- - - - - - - - dollars - - - - - - - - - - - -		
1	12879.	12682.	12486.
2	13574.	13351.	13139.
3	14241.	14012.	13783.
4	14910.	14665.	14419.
5	15572.	15310.	15048.
6	16193.	15948.	15669.
7	16780.	17001.	16935.
8	17574.	17253.	17190.
Total	121724.	120222.	118670.
% increase	29.3	28.9	28.5

Table 15. Flow of Capital Available for Investment Using the MLP Model With an 8 Percent Interest Charge on Operating Capital

Period	Capital Available For Inv.	Capital Transfers to Oper. Cap.	Mach. Cap.	Land Cap.
	- - - - - - - - - -	- - - dollars	- - - - - - - -	- - - - - -
1	12879.		830.	12048.
2	13574.		1651.	11912.
3	14241.		2463.	11778.
4	14910.		3266.	11644.
5	15572.		4534.	11039.
6	16193.		5734.	10458.
7	16780.	8007.	6047.	2726.
8	17574.			

crop activities on the additional land. Operating capital was borrowed in all periods except the last. Operating capital requirements for period eight were met by transfers from net returns in period seven.

A 14 percent interest charge on operating capital generated a similar capital flow as shown in Table 16. Again a large part of available capital was used for cash purchase of land and supporting machinery. Because of the higher cost of borrowing, operating capital requirements for both periods seven and eight were satisfied by transfers from net returns in the previous period.

The effect of variations in the interest charge for operating capital on acres operated in each time period is summarized in Table 17. Total openland acreage is used here to more accurately depict the farm organization and operation since only 72 percent of the total acreage was suitable for cropping. All acquisitions at each interest level were made with the cash purchase option with the exception of four acres at the eight percent level, which were purchased with the amortized loan option. Total openland acreage increased from 252 acres to 309, 298 and 298 acres, respectively for interest charges on operating capital of eight, 11 and 14 percent. The eight percent interest charge on operating capital led to the purchase of 11 additional acres over the 11 and 14 percent interest charges.

Table 16. Flow of Capital Available for Investment Using the MLP Model With a 14 Percent Interest Charge on Operating Capital

Period	Capital Available For Inv.	Capital Transfers to Oper. Cap.	Mach. Cap.	Land Cap.
1	12486.		805.	11681.
2	13139.		1601.	11538.
3	13783.		2386.	11397.
4	14419.		3162.	11257.
5	15048.		3929.	11120.
6	15669.	7597.	4355.	3716.
7	16935.	7719.	4856.	4361.
8	17190.			

Table 17. Total Openland Acreage and Acquisition by Period Using the MLP Model With Three Interest Rates on Operating Capital and no Savings Option

	Cash Purchase			Total Openland Acreage		
	Interest on Operating Capital			Interest on Operating Capital		
Period	8%	11%	14%	8%	11%	14%
	acres					
1				252.0	252.0	252.0
2	10.8	10.7	10.5	259.8	259.7	259.6
3	10.7	10.6	10.4	267.5	266.9	267.1
4	10.6	10.4	10.3	275.2	274.8	274.4
5	10.5	10.3	10.1	282.7	282.2	281.7
6	16.6	10.2	10.0	294.6	289.6	288.9
7	15.7	5.8	5.6	305.9	293.8	292.9
8	a	6.5	6.5	308.9	298.4	297.7
Total change				56.9	46.4	45.7
% increase				22.6	18.4	18.1

[a]The amortized loan option was used to obtain an additional 4.1 acres.

<u>Effect on Growth of Changes in the Interest Rate On Amortized Land Purchases</u>

The amortized land purchase option involved a cash down payment of 60(or 40) percent dependent on the equity level in effect. The remaining 40(or 60) percent of the purchase price of an acre of land was borrowed and repaid in equal annual installments. A change in the interest rate used in the amortized loan would affect net worth and acres operated only if that option was used to acquire land.

A comparison of the land acquisitions by period and the change in total openland acreage is given in Table 18. At an interest rate of five percent all land acquisitions occurred by cash purchase. When the interest rate was reduced to 3.75 percent, the amortized land purchase option was used in all periods. The increase in openland acreage was eight percent greater for the 3.75 percent interest rate. The overall increase in openland acreage was 67 acres and 46 acres with interest rates on amortized purchase at 3.75 and five percent, respectively. Since no land purchases by amortized loan occurred at the five percent interest level, no upward adjustment in interest charges was made.

Even though total openland acreage increased an additional eight percent when the amortized loan purchase option was used at an interest rate of 3.75 percent, the overall change in net worth at the two different interest rates was approximately the same. A comparison of net worth

Table 18. Total Openland Acreage and Acquisitions by Period Using the MLP Model With Two Interest Charges on the Amortized Land Purchase Option

	Method of Acquisition		Total Openland Acreage	
	Amor. Loan	Cash Purchase		
	Interest Rate		Interest Rate	
Period	3.75%	5%	3.75%	5%
	- - - - - - -	- - - - - - - acres	- - - - - - -	- - - - - - -
1			252.0	252.0
2	17.1	10.7	264.3	259.7
3	16.2	10.6	276.0	266.9
4	15.5	10.4	287.1	274.8
5	14.7	10.3	297.1	282.2
6	14.0	10.2	307.2	289.6
7	13.4	5.8	316.8	293.8
8	1.6	6.5	318.0	298.4
Total change			66.4	46.4
% increase			26.4	18.4

changes at the two interest rates is shown in Table 19. Net worth at both interest rates increased approximately 29 percent. This can be accounted for by the fact that the cash purchase option required the full purchase price of an acre of land ($1,111) from available investment capital. For each acre purchased, additions had to be made to machinery to support crop activity on that acre. With the cash purchase option a balance had to be maintained between acreage purchased and investments in machinery. This was also true of the amortized land purchase option. Under this option, however, less on-hand capital was required for the purchase of an acre of land($667) allowing for the purchase of more acreage while acquiring additional machinery resources to support the additional crop activity. This made a positive difference in acres acquired, but in examining the overall change in net worth, annual debt payments offset any advantage of this option.

Effect on Growth of a Change in Equity Levels

A 60 percent equity level was used initially. This level was reduced to 40 percent to determine its impact on net worth accumulation and land acquisitions. A slight increase occurred in total acreage with the 40 percent equity level as compared to the 60 percent equity level. Changes in equity levels did not result in a change in ending net worth. A summary of land acquisitions by period and total openland acreage changes is given in Table 20.

Table 19. Change in Net Worth Using the MLP Model and Two Interest Rates on Amortized Land Purchases

	Change in Net Worth	
	Interest on Amortized Purchase	
Period	3.75%	5%
	- - - - - - - - - - dollars - - - - - - -	
1	12682.	12682.
2	13384.	13351.
3	14052.	14012.
4	14688.	14665.
5	15294.	15310.
6	15871.	15948.
7	16420.	17001.
8	19652.	17253.
Total	122043.	120222.
% increase	29.4	28.9

Table 20. Total Openland Acreage and Acquisition by Period Using the MLP Model With Two Equity Levels

	Equity Level			Openland Acreage	
	40%		60%	Equity Level	
	Method of Acquisition				
Period	Amortized Loan	Cash Purchase	Cash Purchase	60%	40%
	acres				
1				252.0	252.0
2		10.7	10.7	259.7	259.7
3		10.6	10.6	267.3	267.3
4		10.4	10.4	274.8	274.8
5		10.3	10.3	282.2	282.2
6		10.2	10.2	289.6	289.6
7	8.2		5.8	293.8	295.5
8	8.7		6.5	298.4	301.8
Total increase				46.4	49.8
% increase				18.4	19.8

The major point of interest here was the shift from cash land purchases to amortized land purchases toward the end of the planning horizon at the 40 percent equity level. This shift was attributed to the reduction in capital outlay for downpayment on land in each production period with a 40 percent equity level.

Net worth changes resulting from the change from 60 percent to 40 percent equity are shown later in comparison with per acre land value changes.

Effect on Growth of a Change in Per Acre Land Values

The initial per acre land value was $1,111. This value was reduced to $833 to determine the influence of land value on net worth accumulation and acres operated. Because the land rental rate was determined as a percentage of the land value(six percent), the land rental rate decreased from $67 to $50 per acre with the reduction in land value.

The reduction in land value from $1111 to $833 per acre resulted in an increase in acres operated. A summary and comparison of land acquisitions and total changes for both levels of land values are given in Table 21. At $1,111 per acre all additions to land were made by cash purchases and the increase in openland acreage over the eight-year period was 18 percent. When the per acre land value was set at $833, total openland acreage increased 68 percent, from 252 acres to 424 acres. Although the absolute reduction in land value resulted in the purchase of an additional 48 acres in

Table 21. Total Openland Acreage and Acquisition by Period Using the MLP Model and Two Per Acre Land Values

Period	Per Acre Land Value			Openland Acreage	
	$833		$1111	Per Acre Land Value	
	Method of Acquisition				
	Amortized Loan	Rental	Cash Purchase	$833	$1111
	- - - - - - - - - - - - - - acres - - - - - - - - - - - - - -				
1				252.0	252.0
2	25.4		10.7	270.3	259.7
3	19.5		10.6	284.3	266.9
4	19.4		10.4	298.3	274.8
5	18.3		10.3	311.5	282.2
6	17.2		10.2	323.8	289.6
7		122.2	5.8	411.8	293.8
8		139.4	6.5	424.2	298.4
Total increase				172.2	46.4
% increase				68.3	18.4

the first six periods, the most significant change was in acres of land rented. When land value was set at $1111 per acre($67 per acre land rental rate) all land acquisitions were by cash purchase. With land value set at $833($50 per acre land rental rate) land rental reached a level of 139.4 acres in period eight.

The shift to land rental resulted in a substantial increase in acres operated and a 31 percent increase in ending net worth. Change in net worth is shown in Table 22. Total net worth with an $833 per acre land value increased $126,045 bringing ending net worth to $541,837 compared to $536,014 with a $1,111 per acre land value.

III. Effects on Growth of Simulated Yield Fluctuations

Results presented in this section were obtained by using only the monoperiod RLP model. All growth variables were assigned their base level values. No off-farm investment alternative was included in this analysis. Again the only crop which was included in the optimal solutions was soybeans.

The focus of the RLP model was the examination of the effect of yield variability on growth. Adjustments in machinery, operating and land capital could occur due to differences between expected(budgeted) and actual yields. A series of annual yields was used to arrive at actual outcomes in terms of realized net returns and capital available for investment over an eight-year planning

Table 22. The Effect of Varying the Per Acre Land Value and Equity Ratio on Net Worth Using the MLP Model

Period	Change in Net Worth		
	Equity Level/Per Acre Land Value		
	60%/$1111	40%/$1111	60%/$833
	-dollars-		
1	12682.	12682.	12682.
2	13351.	13351.	13190.
3	14012.	14012.	14625.
4	14665.	14665.	15465.
5	15310.	15310.	16256.
6	15948.	15948.	17002.
7	17001.	16988.	18320.
8	17253.	17354.	18505.
Total	120222.	120309.	126045.
% increase	28.9	28.9	30.8

horizon. Any positive difference in actual net returns(actual greater than expected) was used to supplement capital available for operating expenses or additional investment in machinery or land for the next production period. If returns were lower than expected(expected greater than actual) the amount of capital available for investment in the next period was reduced.

Six series of yield data were analyzed; four series using randomly simulated yields and two series of ordered yield simulations. Four random series were used to reflect several possible yield distributions. These four series were determined by random drawings with replacement from the years 1972-1979. The ordered series were ordered on the basis of soybean yields from best-to-worst and worst-to-best outcomes. Gross margins for soybeans for each of the years 1972-1979 and each series by year are shown in Table 23. Capital available for investment in each period was determined by solving for expected outcomes and calculating the difference in expected and actual returns minus family consumption expenditures.

The extreme for soybean production in gross margin values in any one series could range as low as \$116 and as high as \$146 around the expected value of \$127 on SMG1; from \$109 to \$143 with an expected value of \$121 on SMG2; and from \$98 to \$125 with an expected value of \$109 on SMG3. It was recognized that random drawings with replacement from a limited number of observations probably would not lead to

Table 23. Yield Variability Series and Associated Gross Margins for Soybeans by Soil Management Group

	Soybean Gross Margins			Yield Varability Series					
	Soil Management Group			Best to	Worst to	Random			
Year	SMG1	SMG2	SMG3	worst	best	1	2	3	4
	- - - - dollars - - -			- - - - - - - - - - - - years - - - - - - - - - - - -					
1972	120	117	101	1979	1974	1975	1977	1977	1972
1973	127	121	109	1975	1976	1978	1972	1973	1976
1974	116	109	98	1978	1977	1978	1975	1972	1976
1975	138	132	117	1973	1972	1974	1979	1976	1975
1976	120	117	101	1972	1973	1977	1976	1973	1976
1977	120	117	101	1977	1978	1975	1977	1973	1972
1978	127	121	109	1976	1975	1973	1978	1976	1974
1979	146	143	125	1974	1979	1975	1974	1973	1974

appreciable differences among the four randomly drawn series. However, the main purpose here was a comparison with the ordered series.

Enterprise organizations that would maximize net returns to land, labor, management and owner equity were derived for each time period using expected gross margins as objective function values. In the optimal systems, all available acreage in SMGs one, two and three was devoted to soybeans. No other crops were included in any of the optimal systems used in this analysis. For all six sets of simulated yield fluctuations all additions to land acreage were made by the amortized land purchase option with accumulated debt carried throughout production periods subsequent to the period of purchase.

Ordered Yield Simulations

Normally it would be expected that farm expansion would occur more rapidly with larger amounts of capital available at the beginning of the planning horizon and decreased amounts in later periods than vice versa. Results of this analysis supported these expectations, both in terms of acres operated and net worth changes. A comparison of the accumulation of total openland acreage for all six series is shown in Table 24. Of each acre of land acquired only 72 percent was openland acreage. Of the 72 percent in openland acreage an additional 16 percent was suitable only for pasture, leaving 56 percent of each acre for crop

Table 24. Total Openland Acreage by Period Using the RLP Model With Random and Ordered Yield Variability

Period	Total Openland Acreage					
	Ordered Series		Random Series			
	Best to Worst	Worst to Best	1	2	3	4
	- - - - - - - - - -	- - - - - - - -	acres	- - - - - - - -	- - - - - - - -	- - - - - - - -
1	252.0	252.0	252.0	252.0	252.0	252.0
2	264.8	257.1	262.6	258.2	258.2	258.2
3	276.8	264.3	271.9	265.5	267.4	265.5
4	286.5	273.0	281.4	277.5	274.8	277.6
5	296.4	280.6	288.0	292.3	282.5	290.0
6	304.5	290.3	295.9	300.3	289.0	298.0
7	312.7	300.4	309.0	308.4	299.0	306.1
8	321.1	313.6	319.5	318.9	307.2	313.1
Total change	69.1	61.6	67.5	66.9	55.2	61.1
% increase	27.4	24.4	26.8	26.6	21.9	24.3

production. When viewed in these terms, no appreciable difference in total acres operated resulted between the two ordered series, although the best-to-worst series showed a slight advantage over the worst-to-best series.

These results were somewhat misleading in that a limited number of observations led to a smaller range of variation than might actually occur. In the years 1973 and 1978 actual outcomes were equal to expected outcomes, thus no adjustment was necessary in capital available for investment. However, the order of years in these series did not affect ending net worth. In both the best-to-worst and worst-to-best series ending net worth increased approximately 28 percent as shown in Table 25.

Random Yield Simulations

Four randomly selected yield series were used to depict actual yield fluctuations between production periods. Referring again to Tables 24 and 25, it can be seen that very little variation occurred in ending net worth and total openland acreage among the random series and between the random and ordered series.

The percent increase in total openland acreage for the four random series ranged from 22 percent to 27 percent, while the same series had a range of 25 to 28 percent increase in net worth. Although it would be expected that the random series would lead to increases at least as good as the worst-to-best series, this did not hold true in this

Table 25. Annual Change in Net Worth by Period Using the RLP Model With Random and Ordered Yield Variability

	Change in Net Worth					
	Ordered Series		Random Series			
Period	Best to Worst	Worst to Best	1	2	3	4
	- - - - - - - - - - - - - - - - -		acres	- - - - - - - - - - - - - - - - -		
1	16293.	10415.	14633.	11267.	11267.	11267.
2	15922.	12164.	13816.	12201.	13644.	12201.
3	14367.	13356.	14178.	15951.	12522.	16005.
4	14744.	12718.	12090.	18266.	12783.	16489.
5	13534.	14516.	13242.	13391.	12125.	13312.
6	13816.	14896.	17305.	13671.	14847.	13590.
7	14105.	17499.	15622.	15602.	13630.	12892.
8	14568.	20881.	15387.	14318.	14759.	14080.
Total	117350.	116444.	116273.	114667.	105577.	109836.
% increase	28.2	28.0	28.0	27.6	25.4	26.4

particular case. Referring back to Table 23(page 74), notice that for the random series three, the year 1973 was used four times. This year was a zero change year, i.e., actual returns were identical to expected returns. In addition, the remaining years of series three, 1972, 1977 and 1976, all had actual returns of $120(on SMG), less than expected returns of $127(on SMG). In comparison, only the first year of the worst-to-best series had returns less than $120(1974=$116). Beginning with the second year in the worst to best series the returns ranged from $120 to $146, a distinct advantage. A similar situation exists with random series four in that the highest returns were $138 for year 1975 and the final two years' returns were only $116.

IV. The Effects of Risk Preferences on Growth

Three risk preference levels were analyzed using the monoperiod MOTAD model(RM) to determine their impact on the optimal growth pattern of the typical farm firm. Preference levels were defined in percentage terms initially to estimate appropriate slope values as indicated in Chapter III. The three levels were 100, 85 and 73 percent of the maximum attainable income with standard maximizing procedures. The slope values estimated from incremental changes in income and income variation for these percentages were 0, 1.86 and 1.94, corresponding to high risk, risky and low risk preferences, respectively. The base levels for all growth variables, excluding the off-farm investment alternative, were used in this analysis. The objective criterion was one of minimizing gross margin variations for given gross margin levels while restricting the optimal solution to comform to the specified risk preference level.

The effects on net worth accumulation of the level of farmer risk preferences are summarized in Table 26. In general, the effect of changing risk preferences from levels of high risk to levels of low risk caused an overall decrease in net worth. Net worth increased on the average 3.5 percent per year at the high risk level, 2.7 percent per year at the risky preference level and 2.7 percent per year at the low risk level. The total net worth changes from the initial level of $415,792 were increases of 28 percent, 21 percent and 21 percent, respectively for the high, risky and low risk preference levels. Total net worth rose to $533,349 for the high risk level, $505,121 for the risky preference level and $504,972 for the low risk preference level. Annual and cumulative changes in net worth are further illustrated by Figures 4 and 5, respectively. These results indicate that there exists a risk preference level beyond which a change to a slightly more risk averse preference would not lead to changes in income variation.

Only at the high risk preference level was additional acreage acquired. All acquisitions utilized the amortized purchase option. An average of 6.8 acres of openland were added in each of the periods two through eight for a total increase in openland acreage of 47.7 acres or 19 percent.

Table 26. Annual and Cumulative Changes in Net Worth Using the RM Model and Three Risk Preference Levels

	Annual Change in Net Worth			Cumulative Change in Net Worth		
	Preference Level			Preference Level		
Period	High Risk	Risky	Low Risk	High Risk	Risky	Low Risk
	- - - - - - - -	- - - - - - - -	- - - - - - - - dollars	- - - - - - - -	- - - - - - - -	- - - - - - - -
1	12682.	8813.	8680.	12682.	8813.	8680.
2	13716.	10597.	10582.	26398.	19410.	19262.
3	14075.	11574.	11573.	40473.	30984.	30835.
4	14443.	11665.	11665.	54916.	42649.	42500.
5	14822.	11670.	11670.	69738.	54319.	54170.
6	15211.	11670.	11670.	84949.	65989.	65840.
7	15610.	11670.	11670.	100559.	77659.	77510.
8	16998.	11670.	11670.	117557.	89329.	89180.
% increase				28.3	21.4	21.4

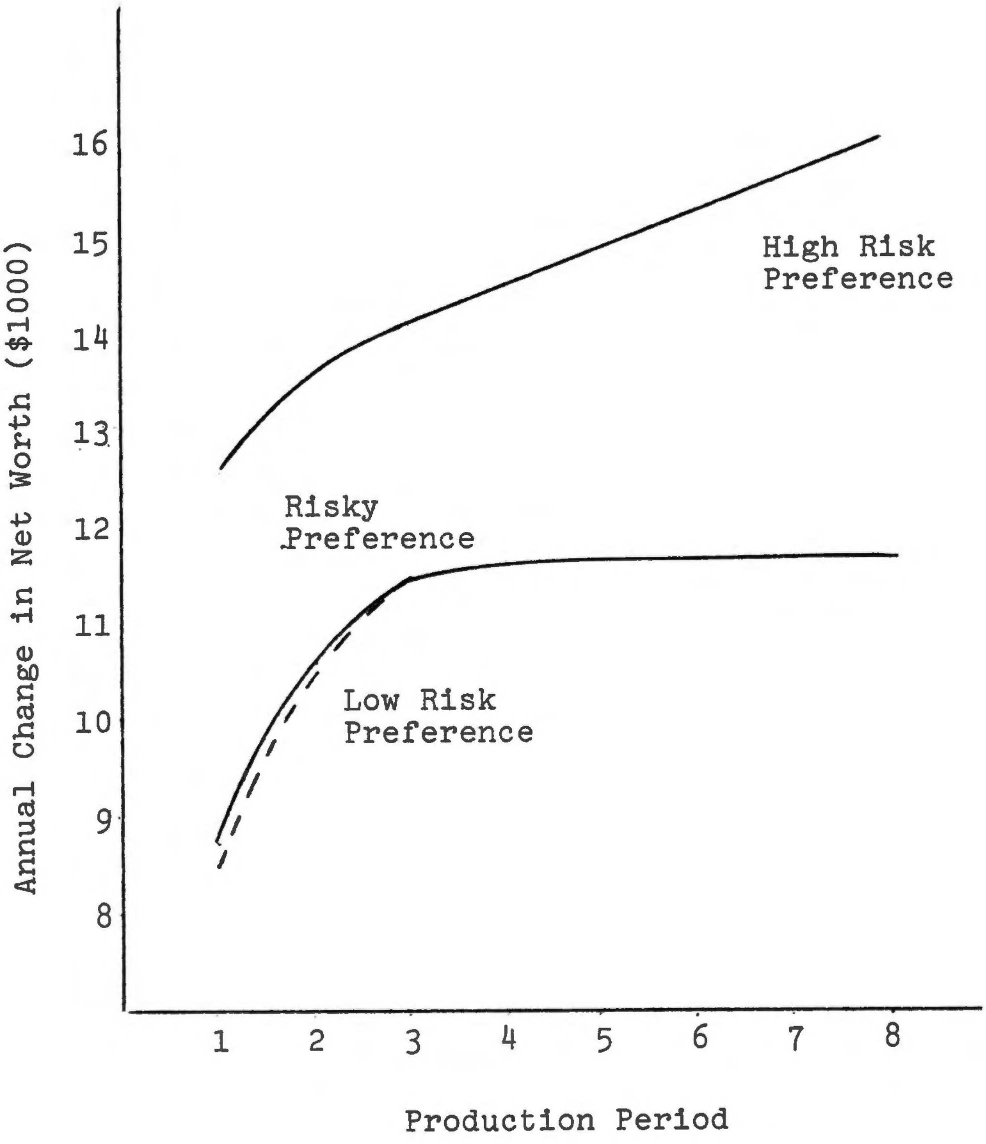

Figure 4. Annual Change in Net Worth for Three Risk Preference Levels

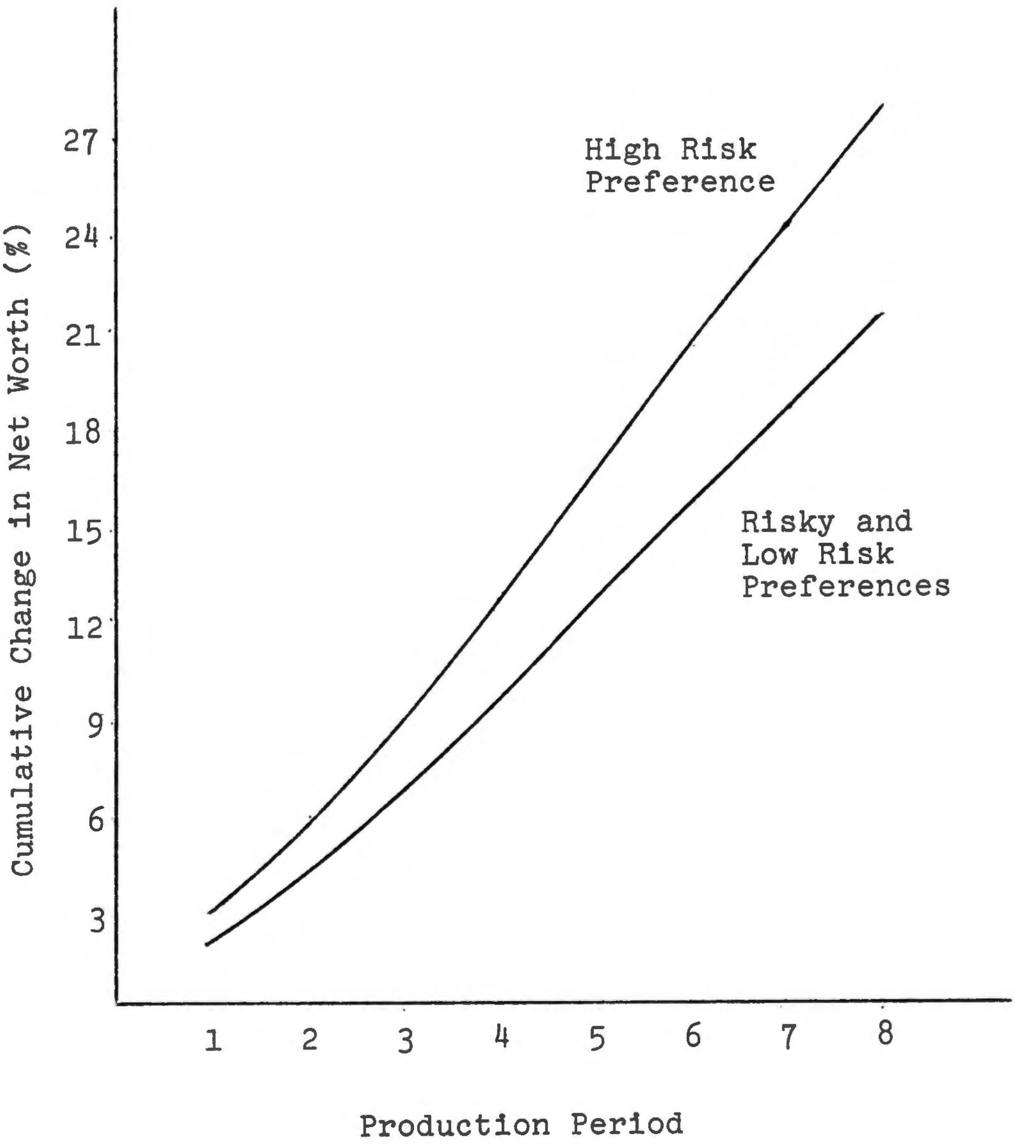

Figure 5. Cumulative Change in Net Worth for Three Risk Preference Levels

Allowing the farmer a tradeoff between income and income variation resulted in a diversity of production among the various crop alternatives. The crop activities included in the optimal solutions obtained for each risk preference level are shown in Table 27. All solutions were generated using expected returns for each crop activity.

At the high risk preference level, soybeans was the only crop included in the optimal solutions. These results were in line with previous discussions pertaining to the relationship of standard linear programming procedures using a maximizing criterion to the MOTAD procedure at the point of zero slope. The MLP model and the RM model at the high risk level resulted in increases in net worth of 29 and 28 percent, respectively.

At the risky and low risk preference levels, soybeans, double-cropping of wheat and soybeans and cotton were included in the optimal solutions. At both preference levels, crop activities and acreage devoted to each activity were identical for all periods except the first. Capital available for investment increased steadily over the first four periods and remained constant over the last four periods at both preference levels. Capital funds generated were not sufficient to allow for purchase or rental of additional acreage. All available capital was used either as machinery capital, leading to crop diversity, or as operating expenses to alleviate capital borrowing.

Table 27. Crop Activity by Period Using the RM Model and Three Risk Preference Levels

Preference Level	Period	Crop Activity: Soybeans	Wheat-Soybeans	Cotton
		- - - - - - - acres - - - - - - -		
Low Risk	1	39.8	122.9	
	2	13.7	181.0	2.6
	3	13.7	181.0	2.6
	4	13.7	181.0	2.6
	5	13.7	181.0	2.6
	6	13.7	181.0	2.6
	7	13.7	181.0	2.6
	8	13.7	181.0	2.6
Risky	1	42.6	120.4	
	2	13.7	181.0	2.6
	3	13.7	181.0	2.6
	4	13.7	181.0	2.6
	5	13.7	181.0	2.6
	6	13.7	181.0	2.6
	7	13.7	181.0	2.6
	8	13.7	181.0	2.6
High Risk	1	197.0		
	2	201.5		
	3	206.7		
	4	212.0		
	5	217.4		
	6	223.0		
	7	228.7		
	8	234.1		

The largest share of available acreage was devoted to double-cropping of wheat and soybeans at the risky and low risk preference levels due to relatively high returns and low yield deviation coefficients as compared to other alternatives.

V. Model Adequacy and Applicability

Three different models were used in this growth study basically because the objectives of the study could not be fulfilled with a single model structure. Each model was used to examine distinct aspects of the growth process of the typical farm firm. The MLP model was used to analyze the impact of individual growth variables on the optimal growth pattern in a static environment. A profit maximizing criterion was used and results were generated simultaneously over all periods of an eight-year planning horizon. The objective associated with the use of the MLP model was one of isolating the effects on growth of changes in individual growth variables, holding all others constant at their base levels.

Yield variability was another consideration in the current study. Johnson(18) has shown that yield variability can be handled using a stochastic linear programming approach. A less complex alternative was employed in this study by using a monoperiod linear programming model recursively(RLP) and making adjustments in resource conditions between model runs by external manipulation.

A third aspect of this particular growth analysis was consideration of the effect that risk preferences held by the farmer have on the optimal growth pattern. This necessitated the development of yet another model structure, i.e., the recursive MOTAD model(RM).

Since three models were used, the obvious question is which approach would be most useful in understanding growth processes or predicting likely patterns of growth. The most useful model can only be defined in terms of some relative criterion. The MLP model would appear to be the most useful in determining the effects of individual growth variables. The RM model would appear to be most useful in the evaluation of the effects of risk preferences held by the farmer on growth. The effect of variability in yields on growth can be handled adequately with the RLP model. In a relative sense, all three models make unique contributions toward understanding the growth process.

Given a set of resource constraints and production alternatives, all three models are capable of generating similar results in terms of a growth measure such as net worth as shown in Table 28. Values shown in Table 28 were generated using the base levels of all growth variables, excluding the off-farm investment alternative, for all three models. Soybeans was the only crop activity included in the optimal solutions for each of the models for the particular results indicated.

Table 28. Change in Net Worth by Period for the MLP, RLP, and RM Models With No Off-Farm Investment Alternative and All Growth Variables at Their Base Levels[a]

	Annual Increase in Net Worth		
	Model Used		
Period	MLP	RLP[b]	RM[c]
	- - - - - - - - - - dollars - - - - - - - - - - -		
1	12682.	16293.	12682.
2	13351.	15922.	13716.
3	14012.	14367.	14075.
4	14665.	14744.	14443.
5	15310.	13534.	14822.
6	15948.	13816.	15211.
7	17001.	14105.	15610.
8	17253.	14568.	16998.
Total	120222.	117350.	117557.
% increase	28.9	28.2	28.3

[a]Although the same variables and variable levels were used in each of the three models, results shown are not comparable among models due to different model structure and objective criteria.

[b]The best-to-worst series was used.

[c]The high risk preference level was used.

CHAPTER V

SUMMARY AND CONCLUSIONS

I. Summary of the Study

Farm firm growth has been analyzed in many ways and with various empirical techniques. The purpose of this study was to identify and evaluate significant variables that affect the growth of a typical farm firm in Western Tennessee using linear programming techniques.

The general objectives of the study were: 1) the development of a firm growth model consistent with economic theory and which approximated technological production possibilities faced by farmers in a given area, 2) to develop an analytical framework sufficient for quantitative investigation of both the decision-making and the planning processes and 3) to examine the effects of changes in selected growth variables, viz., equity levels, interest rates, land values, off-farm investment opportunities, land acquisition methods, crop yield variability and risk preference levels held by the farmer on the growth process of a typical farm firm in Western Tennessee.

A typical farm firm was synthesized from available data applicable for the Deep Loess Soils Area of Tennessee. The typical farm as defined had an initial land base of 350 total acres with 252 acres or 72 percent classified as openland. The farm operator was assumed to possess above average management skills and to supply approximately 2,500 hours of labor annually. Additional labor could be supplied by family members or by hiring seasonal or part-time labor as needed. Capital could be borrowed for land purchase by amortized loan with restrictions based on equity ratios of either 40 or 60 percent. Operating capital could be borrowed without limitation. Additions to the land base could be made using credit and an amortized loan, by outright cash purchase or by cash rental.

The crop alternatives considered were corn, cotton, soybeans, wheat, double-cropping of wheat and soybeans, red clover-timothy hay and fescue-ladino clover permanent pasture. The only livestock enterprise considered was a beef cow-calf backgrounding enterprise.

Firm growth was measured by changes in net worth and total acres operated. Net worth could be indicated by increased equity in land and machinery, investment in an off-farm savings alternative or by cash on hand at the end of the planning horizon. The growth variables analyzed were: two rates of interest on the off-farm investment alternative, two equity ratios, three rates of interest on borrowed operating capital, three rates of interest on amortized land purchases, six time sequences of yield variability and three risk preference levels.

II. Summary of Results

Results of the analysis were presented in three main sections; 1) growth in a riskless environment with growth changes attributable to changes in growth variables, 2) the effect on growth of yield variability using "actual" versus "expected" outcomes and 3) the impact of risk aversion on the optimum growth pattern. The models used were the multiperiod linear programming model(MLP), the recursive linear programming model(RlP) and the recursive MOTAD model(RM).

The base levels of the growth variables were: 60 percent equity, 11 percent interest on operating capital, eight percent interest on the off-farm investment alternative, five percent interest on amortized land purchases, $67 per acre land rental rates and $1,111 per acre land values.

MLP Model Results

Using the base level of variables and the MLP model, net worth increased by $135,109 or 33 percent over the eight year planning horizon. No additional land or machinery was acquired and all capital available for investment was invested in the off-farm savings alternative earning eight percent interest.

When the off-farm investment alternative(savings) was eliminated total openland acres operated increased from 252 to 294 acres or 17 percent by the last production period.

Soybeans was the only revenue producing activity in the optimal solution(profit maximizing plan).

Net worth increased 29 percent from $415,792 to $536,014 with the savings alternative eliminated, four percent less than with the savings option included in the analysis. All subsequent analysis were performed with the savings opportunity excluded.

The rate of interest charged on operating capital was also varied to determine its growth influence. Varying the interest charge from 11 percent to eight percent resulted in an overall increase of only .4 percent in net worth and no change in the optimum farm organization. Using an interest charge of 14 percent on operating capital resulted in a 28 percent overall increase in net worth, one percent less than for the 11 percent interest level. Over the eight year planning period land increased by 18 percent for both the 11 and 14 percent interest charge levels. At the eight percent interest charge level the land base increased by 22 percent over the period.

Changes in interest rates used on amortized land purchases from five percent to 3.75 percent. resulted in no change in overall net worth accumulation. At each interest charge net worth increased approximately 28 percent. Changes in interest rates on land purchase loans did affect the growth rate in acreage operated. Total openland acreage increased by 26 percent at a 3.75 percent interest rate and 18 percent at an interest rate of five percent.

When land values were reduced from $1,111 to $833 per acre and the land rental rate from $67 to $50 per acre, expansion of acreage operated included both land rental and land purchases. Total openland acreage increased 97 percent at the lower land price and rental value compared to an 18 percent increase at the higher value. The cash purchase option was used exclusively to acquire land with a $1,111 per acre value. Both the amortized land purchase and the land rental option were used at the $833 per acre land value.

Increases in net worth were also greater at the $833 land value. The total change in net worth was $120,222(29 percent) and $153,490 (37 percent) for the $1,111 and $833 per acre land values, respectively.

RLP Model Results

The monoperiod linear programming model(RLP) was used recursively to determine the effects of year to year yield variability on the optimum growth pattern. Six series of yield data were used: four random series and two ordered series. In all six series the only crop activity included in the optimal solution was soybeans and only the amortized land purchase option was used to secure additional land.

No appreciable difference was found to exist among the six series in terms of net worth accumulation. The two ordered series, best-to-worst and worst-to-best, and one of the random series had overall increases in net worth of 28 percent. The smallest increase for any of the six series was 25 percent.

When the best-to-worst series was used a slightly higher increase(three percent) in total openland acreage occurred than with the worst-to-best series. The range of increases in total openland acreage for the four random series was 22 to 27 percent.

RM Model Results

The monoperiod MOTAD model(RM) was used recursively to trace the optimal growth pattern for three different risk preference levels. Maximum returns to land, labor, management and owner equity with a corresponding level of income variation was defined as the high risk level, while two levels of constrained income variation were used for risk levels defined as risky and low risk preferences. In general, use of the high risk preference level resulted in a greater percentage increase in net worth than did the use of the other, lower risk, preference levels. The total change in net worth for the high risk level was 28 percent, while both the risky and low risk preference levels experienced a 21 percent increase.

Purchase by amortized loan was the only method of acquiring additional land for this part of the analysis. At the high risk level this option was a contributing factor to net worth accumulation. Total openland acreage increased to 300 acres over the eight-year period, a 19 percent increase.

No additional acreage was acquired at either the risky or low risk preference levels.

III. Conclusions

The general purpose of this study was to simulate the growth of a typical farm firm in West Tennessee in terms of changes in net worth and acres operated. An indirect result of the growth analysis was an examination of the enterprise selection in maximizing net returns to land, labor, management and owner equity. From the results generated, it would appear that for farmers in the Deep Loess Soils Area of West Tennessee who are strictly profit maximizers, specialization in soybean production would maximize those returns. As risk preferences change, however, other crops such as corn, cotton and double-cropping of soybeans and wheat are likely to be grown to keep income levels within acceptable ranges.

Farmers must also weigh reinvestment alternatives against off-farm investment opportunities to make the best use of available capital resources. This has been an increasingly important decision in recent years as farm input prices have tended to rise at a faster rate than the prices received at the farm level for commodities produced. With few exceptions results of this study indicated a higher rate of return for the off-farm investment opportunities than for on-farm investments. With increasing interest rates, land accumulation by purchase has become more difficult without initial capital investments to hold down interest payments although appreciation in land values have offset these charges somewhat. Problems arising from either rental or purchase of non-contiguous land holdings were not accounted for in this study.

Another aspect of this study was the examination of risk aversion preferences held by the farm operator on growth. Results generated using a profit maximizing(high risk) goal for the farm operator showed a higher gain in ending net worth and total acres operated than when operator goals were restricted to more conservative risk preferences.

Further research should concentrate on yield variability factors and risk preferences analysis to better explain the impact these factors have on the growth process. Emphasis should be placed on identifying the influence that the inate characteristics of the owner-operator has on the optimum growth pattern of the farm firm.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Atchison, James A., "A Study of Optimum Resource Use on Part-Time Farms in the Brown Soil and Delta Areas of Tennessee," unpublished Master's thesis, The University of Tennessee, Knoxville, Tennessee, August, 1972.

2. Bedel, Alvin A., "A Study of Potential Farm Growth and Survival for Representative Farms in West Tennessee," unpublished Ph.D dissertation, The University of Tennessee, Knoxville, Tennessee, June, 1975.

3. Boehlje, Michael D., and T. Kelley White,"A Production-Investment Decision Model of Farm Firm Growth," American Journal of Agricultural Economics, 51(1969):546-563.

4. Brink, Lars, and Bruce McCarl, "The Tradeoff Between Expected Return and Risk Among Cornbelt Farmers," American Journal of Agricultural Economics, 60(1978):259-263.

5. Burney, Robert w., "Minimum Capital Requirements for Specified Income Levels in the Delta and Brown Soils Areas of Tennessee," unpublished Ph.D dissertation, The Universsity of Tennessee, Knoxville, Tennessee, March, 1976.

6. Chen, J.T., and C.B. Baker, "Marginal Risk Constraint Linear Program for Activity Analysis," American Journal of Agricultural Economics, 56(1974):622-627.

7. Chien, Y.I., and G.L. Bradford, "A Multiperiod Linear Programming-Simulation Model of the Farm Firm Growth Process," Research Report 21, Agricultural Experiment Station, The University of Kentucky, Lexington, Kentucky, September, 1974.

8. Day, Richard H., Recursive Programming and Production Response, Amsterdam: North-Holland Publishing Company, 1963.

9. Doll, John P., and Frank Orazem, Production Economics: Theory With Applications, Columbus, Ohio: Grid, Inc., 1978.

10. Dorfman, R., Application of Linear Programming to The Theory of the Firm, Berkeley: University of California Press, 1951.

11. Hazell, P.B.R., "A Linear Alternative to Quadratic and Semi-variance Programming for Farm Planning Under Uncertainty," American Journal of Agricultural Economics, 53(1971):53-62.

12. Hazell, P.B.R., "The Economic Significance of Risk in Agricultural Planning: A Case Study in Mexico," unpublished paper, World Bank, July, 1974.

13. Heady, Earl O., Economics of Agricultural Production and Resource Use, Englewood Cliffs: Prentice Hall, Inc., 1952.

14. Heidhues, T., "A Recursive Programming Model of Farm Growth in Northern Germany," Journal of Farm Economics, 48(1966):668-684.

15. Henderson, J.M.,"The Utilization of Agricultural Land: A Theoretical and Empirical Inquiry," Review of Economics and Statistics, 41(1959):242-260.

16. Hicks, J.R., Value and Capital, London: Oxford University Press, 1946.

17. Hillier, Frederick S., and Gerald J. Lieberman, Operations Research, California: Holden-Day, Inc., 1974.

18. Hutton, R.F., and H.R. Hinman, A General Agricultural Firm Simulator, Bulletin No. 72, Agricultural Experiment Station, Pennsylvania State Universtiy, University Park, Pennsylvania, December,1969.

19. Irwin, George D., "A Comparative Review of Some Firm Growth Models," Agricultural Economics Research, 20(1968):82-100.

20. Johnson, S.R., K.R. Tefertiller, and D.S. Moore, "Stochastic Linear Programming and Feasibility Problems in Farm Growth Analysis," Journal of Farm Economics, 49(1967):908-919.

21. Knight, F.H., Risk, Uncertainty and Profit, New York: Kelley and Millman, Inc., 1957.

22. Loftsgard, Laurel D., and Earl O. Heady, "Application of Dynamic Programming Models for Optimum Farm and Home Plans," Journal of Farm Economics, 41(1959):51-67.

23. Mapp, Harry P., Jr., Michael L. Hardin, Odell L. Walker and Tillar Persaud, "Analysis of Risk Management Strategies for Agricultural Producers," American Journal of Agricultural Economics, 61(1979):1071-1077.

24. Martin, J.R., and J.S. Plaxico, Polyperiod Analysis of the Growth and Capital Accumulation of Farms in the Rolling Plains of Oklahoma and Texas, Technical Bulletin 1381, Washington: Government Printing Office, September, 1967.

25. Maruyama, Yoshihiro, "A Truncated Maximin Approach to Farm Planning Under Uncertainty, with Discrete Probability Distributions," American Journal of Agricultural Economics, 54(1972):192-200.

26. Modigliani, F., and K.J. Cohen, "The Role of Anticipations and Plans in Economic Behavior and Their Use in Economic Analysis and Forecasting," Studies in Business Expectations and Planning, Bureau of Economics and Business Research, University of Illinois, Urbana, 1961.

27. Nieuwoudt, W.L., J.B. Bullock and G.A. Mathia, "An Economic Evaluation of Alternative Peanut Policies," American Journal of Agricultural Economics, 53(1976): 485-495.

28. Patrick, G.F. and L.M. Eisgruber, "The Impact of Managerial Ability and Capital Structure on Growth of the Farm Firm," American Journal of Agricultural Economics, 50(1968):491-506.

29. Penrose, Edith T., The Theory of the Growth of the Firm, New York: John Wiley and Sons, Inc., 1959.

30. Ray, R.M. and H.N. Walch, Farm Planning Manual, Publication EC 622, Agricultural Extension Service, The University of Tennessee, Knoxville, Tennessee, April, 1978, April, 1981.

31. 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," Research Bulletin 249, Agricultural Experiment Station, The University of Georgia, Athens, Georgia, January, 1980.

32. Saupe, William E., William R. Garland and Deborah Streeter, "Changes in Farm Poverty in Wisconsin," Research Division, College of Agricultural and Life Sciences, University of Wisconsin-Madison, University of Wisconsin- Extension (Resource Report R2052).

33. Schaller, W.N., and G.W. Dean, "Predicting Regional Crop Production," United States Department of Agriculture Technical Bulletin 1329, Washington: Government Printing Office, April, 1965.

34. Simmons, Richard C. and Carlos Pomareda, "Equilibrium Quantity and Timing of Mexican Vegetable Exports," American Journal of Agricultural Economics, 57(1975): 472-479.

35. Tennessee Department of Agriculture, Tennessee Agricultural Statistics, Annual Bulletins, 1972-1980.

36. Thomas, Wayne, Leroy Blakeslee, LeRoy Rogers and Norman Wittlesey, "Separable Programming for Considering Risk in Farm Planning," American Journal of Agricultural Economics, 54(1972):260-274.

37. Tweeten, Luther, "Farmland Pricing and Cash Flow in an Inflationary Economy," Research Report P-811, Agricultural Experiment Station, Division of Agriculture, Oklahoma State University, Stillwater, Oklahoma, June, 1981.

38. U.S. Bureau of the Census, Census of Agriculture, Volume 1, Part 42, Tennessee State and County Data, Washington, D.C.: Government Printing Office, 1974, 1978.

39. U.S. Department of Agriculture, Economic Research Service, Farm Real Estate Market Developments, Publications CD64 (August, 1963), CD76 (August, 1971), CD83 (July, 1978) and CD84 (Supplement No. 2, May, 1980): Government Printing Office, Washington, D.C.

40. Walker, Odell L., and A. Gene Nelson, "Agricultural Research and Education Related to Decision-Making Under Uncertainty: An Interpretative Review of Literature," Research Report P-747, Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, March, 1977.

VITA

Virgil Parker Culver, son of Arthur Levan and Dorothy Jean Culver, was born in Troy, Alabama, on December 9, 1951. He attended Montgomery County Schools in Ramer, Alabama, until moving to Auburn, Alabama, in 1967 where he attended Auburn High School for three years, graduating in June, 1970. He entered Auburn University in September, 1970 and was graduated with a Bachelor of Science Degree in Agricultural Economics in August, 1974. In September, 1974, he entered the Graduate School of Auburn University as a graduate student in Agricultural Economics. He was graduated with a Master of Science Degree in Agricultural Economics in December, 1975. In September, 1976, he entered the Graduate School of The University of Tennessee, Knoxville as a graduate student in Agricultural Economics. He was graduated with the Doctor of Philosophy Degree in Agricultural Economics in June, 1982. Virgil is married to the former Nancy Janette Carroll of Birmingham, Alabama. They have four children, Rachel Catherine, Julie Rebecca, Philip Gregory and Karen Ruth.