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A risk-programming analysis of alternative coordination arrangements in beef packing

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CHAPTER I. INTRODUCTION

A coordination arrangement is a mechanism for achieving coordination, i.e., for synchronizing economic activity. Forward price contracting, vertical integration, and direct purchases are viable coordination arrangement alternatives in the production and first-handler stages in agricultural subsectors. The choice between coordination arrangements in agriculture has gained importance due to increasing market risks. These risks are attributed to variations in prices or demand for a firm's output or variations in inputs with respect to price, quality, and quantity.

The Research Problem

Significant trends in the relative importance of various coordination arrangements have occurred in many agricultural subsectors causing substantial impacts on subsector participants. Even though this has been widely acknowledged, an operational model from which to investigate trends in coordination arrangements, and effects of changes, is lacking.

The purpose of this study is to provide an operational model from which to obtain explanations, predictions, and prescriptions of changes in coordination arrangements. In the model presented here, the choice of a coordination arrangement or combination of arrangements is viewed as a

decision problem facing firms at one or more stages in the subsector. For subsectors in which firms at a single stage are dominant in determining coordination arrangements, analysis of one firm decision model may be sufficient to determine trends in the relative importance of alternative coordination arrangements. For subsectors in which firms at two or more vertical stages participate in choosing coordination arrangements, however, two or more firm decision models may need to be developed. Analysis of these models should indicate what changes could be made that would benefit firms at all stages and what changes would cause conflict, i.e., benefit firms at one stage at the expense of those at another stage.

To be useful in analyzing agricultural producer - first-handler coordination arrangements, the formulation of the decision problem must provide for (1) varying attitudes toward risk, (2) price variations in inputs to and outputs from agricultural production and processing activities, (3) the multiperiod nature of most production and processing firms, (4) the short-term and long-term decisions concerning coordination arrangements, (5) differences in price variations associated with different input acquisition channels, and (6) selected financial and other constraints likely to effect firm decisions concerning choice of coordination arrangements.

In addition, the model must permit determination of the choice of coordination arrangements over a multiperiod planning horizon for given conditions and determination of changes in these results given changes in conditions.

The problem the firm faces in choosing among alternative coordination arrangements is formulated as a multiperiod risk programming model of a firm. A quadratic model was chosen over a linear model because a linear model takes no explicit account of the risk associated with a firm's income-producing activities. Solution of this parametric quadratic programming model will generate an E-V frontier. The specification of a particular utility function will give a static result. Comparative static results are investigated by successive changes in the utility function specified and changes in other parameters in the model. These results should provide useful information about firm choices among coordination arrangements in given situations, about changes in these choices given changes in certain characteristics of the firm or its environment, and about likely trends in the relative importance of alternative coordination arrangements in given subsectors.

Objectives

The principal objective of this study is to demonstrate the development and structure of a multiperiod programming model from which to (1) determine the optimal combination of coordination arrangements for a typical beef packing plant given its present position and how this optimal combination may change due to changes in the situation the firm faces and (2) identify trends which are likely to develop in relation to coordination arrangement choices in the meat packing industry. These are accomplished by evaluating the trade-offs between income and risk for a typical beef packing plant through the use of E-V frontiers.

Specifically, to achieve the objectives the following procedures will be employed: (1) estimate output prices, input costs, and resource requirements for alternative coordination activities, (2) develop gross margins (gross sales less variable expenses) for coordination alternatives, (3) estimate a variance-covariance matrix for coordination alternatives, (4) develop a decision-making model that generates an efficient boundary or E-V frontier reflecting combinations of coordination arrangements that minimize the variance of income for selected income levels, and (5) to apply the model in (4) above to derive efficient growth plans over the planning horizon.

The major thrust of this study is to develop a decision model and use it to prescribe optimal courses of action for decision-makers given the characteristics of the firm and its environment. In addition, the investigation of likely trends in the importance of alternative coordination arrangements is undertaken.

Outline of Remaining Chapters

In Chapter II the coordination arrangements available to the beef packer, previous research related to these, and outline of the general approach of the study are discussed. The analytical model, data sources and the specific data needed are discussed in Chapter III. In Chapter IV the results of the quadratic programming model are presented and a summary of the conclusions of the analyses is given in Chapter V.

CHAPTER II. LITERATURE REVIEW

Substantial variations in net income of meat packing plants have occurred during the early 1970's (2) as a result of wide variations in packer margins, which may be due to changes in the relation of wholesale to farm prices. This margin variability creates a serious need to evaluate relevant choices for reducing, shifting, or otherwise managing these risks (7). The choice of an optimal coordination arrangement or combination of arrangements is one option for risk management by a firm.

In this chapter, various coordination alternatives open to a firm and previous research and related statistical data are discussed. An overview of the mean-variance approach is also presented.

Alternative Coordination Arrangements

Four types of coordination arrangements were considered in this study. They were direct purchases, forward contracting, and vertical integration through custom feeding or feeding in a packer-owned feedlot.

In recent years, direct purchases have conveyed the bulk of fed cattle to meat packers; this is not likely to change suddenly. However, the increased profits or reduced risk or both that may be gained by use of forward contracting

and/or vertical integration could influence a trend towards more widespread use of these coordination arrangements. Already there have been studies to investigate various aspects of these coordination alternatives (3, 8, 35, 43) although their possible value with regard to the beef packing industry has not been emphasized.

Direct purchases

Direct purchases include the acquisition of fed cattle from privately owned farmer feedlots, commercial feedlots, or country markets through decentralized negotiations as opposed to purchases through public markets, i.e., terminals and auctions. Table 1 shows the percentage of total fed cattle which were acquired by each of these means in the United States from 1970 to 1975 (39). As the table indicates, direct purchases of fed cattle predominate (65.9 percent of all fed cattle). The trend toward declining relative importance of public markets for cattle during the past decade was halted in 1974 and the share through public markets increased again (by 3.7 percent) in 1975. Direct purchases of cattle fluctuated from 65.3 percent in 1970 to 73.0 percent in 1973, and back to 65.9 percent in 1975.

Table 1. Percent of fed cattle purchased by packers at public and other outlets, 1970-1975 (39)

Year	Public markets (%)	Direct purchases (%)
1970	34.7	65.3
1971	31.4	68.6
1972	27.8	72.2
1973	26.0	73.0
1974	30.4	69.6
1975	34.1	65.9

Forward contracting

A forward contract is defined here to consist of a producer's promise to deliver a specified volume of production at a designated time and place. The method to be used to determine price is agreed upon at the time the contract is entered. Of interest in this study, are forward-pricing contracts. These contracts involve an agreement between a packer and a single producer. At the time that the producer enters into the contract, a specific base price is guaranteed for the cattle to be delivered to the packer at a later specified date or time interval (31).

A forward-pricing contract eliminates the producer's uncertainty about the future product price for that time

period by transferring part of the price risk to the forward buyer. In turn, the forward buyer may hedge his position in the futures market to transfer the risk further (7). In any event, the risk bearing function may be transferred to others who can likely accept it at a lower cost due to their larger numbers, diversified portfolios, or risk preferences (27).

Vertical integration

Effective opportunities for reduction of income variability may be offered by vertical integration. While contractual agreements may be interpreted as being some degree of integration, probably the more common usage of the term is in reference to custom feeding or direct ownership of feeding facilities. Under these coordination arrangements, purchased feeder cattle are either custom fed in a commercial feedlot to a packer's specifications or fed in a packer-owned feedlot.

In general, all evidence points toward significant economies associated with vertical integration in beef production. In a theoretical discussion of vertical integration, Greenhut and Ohta (22) contend important benefits stem from vertical integration. Specifically, they proved a theorem which stated that "merger or collusion between input supplier and the final good producer brings about lower prices,

greater output and sales, and greater profits."[1] Relating this statement to a beef packer, it suggests that theoretically, a packer should gain increased profits and lower costs by custom feeding or owning and operating a feedlot.

Custom feeding The placement of feeder cattle into commercial feedlots which specialize in feeding cattle for custom clients is termed custom feeding. These feedlots are usually heavily dependent upon custom feeding as a major source of income (20). Feeder cattle may be purchased through the feedlot, dealers, or order buyers by specifying grade, weight, sex, and type of feeder cattle desired. The cattle are then fed to meet general specifications of the client as to weight.

Although custom feeding is a risky venture, clients of commercial feedlots are not faced with high investment costs as are other agricultural producers. In addition, clients are able to enjoy the advantages of feedlot economies of size and therefore may have relatively low production costs (20). The ease of entry and possibility of relatively high returns per working dollar has made custom feeding a potentially important coordination instrument.

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[1] Greenhut and Ohta (22, p. 268).

Neither Iowa nor federal law prohibits packers from having cattle fed in a commercial feedlot. Federal regulations, however, do not permit a packer to own, operate, or control a feedlot which custom feeds livestock for clients. This ruling is intended to prohibit packers from controlling a major marketing facility which in turn could lead to a monopolistic structure in the livestock industry, controlled prices, or otherwise restricted commerce (40).

Feeding in packer-owned feedlots A packer, after weighing all pertinent factors, may decide to invest in a feedlot. The supplying of fed cattle for slaughter from a packer-owned feedlot superficially appears certain to increase packer margins by including feeding profits. This may not be true primarily due to negative profits to the feeder. Fluctuations in feed costs and additional fixed and variable expenses generated by ownership may also inhibit anticipated margin increases. However, acquiring fed cattle from packer-owned lots eliminates the price risks which are associated with the other buying alternatives. The feeding of cattle to specifications may be directly managed as well, which may enable animals of quality more consistent with packer preferences to be produced. All these factors must be considered before a decision is reached regarding investment in a feedlot by a packer.

Federal law permits packers to feed their own livestock for their own slaughter purposes. Therefore, a packer may own a feedlot if the only cattle fed are owned by the packer. Under Iowa law, however, "it is unlawful for any processor of beef or pork . . . to own, control, or operate a feedlot in Iowa in which hogs or cattle are fed for slaughter."[2] This prohibits packers from taking advantage of this coordination arrangement in Iowa although other states may permit this practice.

Empirical studies have been lacking on the profitability of packers owning and operating a feedlot. Statistical data are also not available but data on the percentage of total cattle fed by and for packers are available and are shown in Table 2. The table indicates that there has been no consistent trend, up or down, in the feeding of cattle by and for packers since 1970. The percentage of all fed marketings from thirty-nine states that were fed by and for packers has varied between 6.2 and 6.9 percent during this period. This suggests that the profitability of custom feeding and feeding in a packer-owned feedlot is still in question.

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[2] Code of Iowa, 1977 (17).

Table 2. Number of cattle fed by and for meat packers compared with total fed marketings of cattle in thirty-nine states, 1970-1975 (39)

Year	Packer feeding as a percentage of fed marketings
1970	6.7
1971	6.3
1972	6.8
1973	6.2
1974	6.7
1975	6.9

Earlier Analyses of Alternative Coordination Arrangements

This study emphasizes the use of a firm-oriented model to analyze coordination alternatives of a typical beef packing plant. The basic approach is similar to that of Snyder and Candler (34) who formulated a firm-oriented linear model to investigate hog procurement, slaughter, processing, and product sales activities. This model was then used to consider the effect of forward contracting on hog procurement. Given this linear programming model, alternative data with respect to demand structure, supply variability, and quality were used and resulting solutions

were studied. Evaluation of these profit positions indicated that contracting represents one important way to increase the regularity of hog deliveries and improve hog quality while farmers and packers gain increased profit contributions.

Snyder and Candler found that an important motivation for some form of nonmarket coordination was the desire to balance live hog production and product marketing to the optimum level of slaughter and processing. Improved weekly scheduling of hog procurements constituted a major factor in short-run improvements in operational efficiency. To the extent that nonmarket coordination reduced procurement fluctuations, coordination payback was very high. Under the assumption that contracting will cause hog procurement at the level where all slaughter capacity is utilized, Table 3 shows the net profitability and return on investment improvement which was obtained.

The model in the present study draws heavily from Barry and Willmann's (8) work on financial and contract choices for producers. Risk was incorporated into this study by using a multiperiod quadratic programming model. This model was used by Barry and Willmann to evaluate forward contracting and other financial choices for farmers who are subject to market risks and credit rationing. The model

Table 3. Net profitability and return on investment improvement from nonmarket coordination (34)

Coordination contract volume (% annual kill)	Net profitability improvement ($)	Return on investment improvement (%)
31	508,447	3.6
39	620,147	4.4
52	877,578	6.2
62	1,030,460	7.2

utilizes mean-variance analysis to derive sets of E-V efficient growth plans reflecting the influence of contracting on income stability, levels of credit, and income growth. This mean-variance approach has been widely used as a framework for evaluating optimal levels of contracting (8, 27, 36) and determining risk minimizing levels of contracting (28).

Although there have been no empirical studies investigating vertical integration alternatives for beef packers, producers choices have received considerable attention in recent years (3, 43, 44). Two studies (43, 44) incorporated a quadratic programming model similar to that of Barry and Willmann. Whitson, Barry, and Lacewell (44) investigated the risk-return effects of selling produced

calves or holding them through subsequent stages of the production process. They concluded that vertical integration increases income expectations but also sharply increases risk. Thus, the form of vertical integration should be determined by the producer's willingness to accept risk, as well as constraints to the growth process such as borrowing capacity, cash flow requirements, and existing input-output product relationships. Nevertheless, consideration of vertical integration in farm planning appeared to be an effective way to manage risk.

The available research concerning meat packer's coordination arrangements is sketchy, at best. By application of techniques used in previous related studies, the four coordination arrangements available to a packer that were mentioned earlier will be investigated. It is anticipated that the results of this study will provide information firm managers can use in selecting an optimal combination of coordination arrangements and that these results, along with results of studies focusing on producer choices among alternative coordination arrangements, will provide information about likely future trends for each of the alternative arrangements considered.

Mean-Variance Approach and E-V Analysis

The financial components and other basic features of the model formulated in this study are generally similar to those used in previous studies (6, 8, 41, 44). Following the work by Barry and Willmann (8), the model is cast in terms of multiperiod quadratic programming with the addition of risk information expressed as variances and covariances. As indicated above, this mean-variance approach has been widely used in studies evaluating contracting (8, 27) and vertical integration (3, 44). A quadratic programming model can be used to develop E-V frontiers depicting, for various degrees of risk-aversion, efficient growth plans which prescribe levels of production, input procurement, and marketing activities for each period in the planning horizon.

The mean-variance approach taken in this study follows Markowitz's theory of portfolio selection. This approach includes risk and uncertainty in the traditional economic analysis. The firm's portfolio consists of the alternatives in production, acquisition, marketing, and investments to which the firm's resources may be committed. Markowitz (27) focused on means and variances of probability distributions of income. Thus, rather than basing a decision on a single income expectation, decisions are based on ranges of outcomes expressed as probability distributions. Once the

statistical properties of the choices in the portfolio are determined, an opportunity frontier is developed which is efficient with respect to expected return (E) and variance (V). The E-V frontier is considered efficient in that variance of income was minimized for alternative levels of income.

Criticisms of an E-V analysis

Critics (12, 24) of the E-V or mean-variance approach to decision-making contend that only under special circumstances is such an approach applicable. They assert that E-V analysis is relevant only when the decision-makers utility function reflects preferences toward the mean and variance of expected returns, i.e., third and higher derivatives of the manager's utility function are zero, or if distributions of the uncertain outcomes are all members of a two parameter family, i.e., third and higher moments of the distributions of returns are zero. Hazell (25) states that the principal assumptions associated with the development of the efficient E-V frontier and with its ultimate use in decision-making may be summarized as follows: (1) a producer develops a preference between alternative plans solely on the plan's expected income (E) and associated variance (V), (2) a producer is a risk averter, and (3) the total gross margin (total sales less variable costs) is approximately

normally distributed around the mean gross margin.

Many packer decisions are concerned with the maximization of income and the reduction of uncertainty. Thus, assumption (1) used in deriving efficient E-V pairs does not appear to be an unreasonable approximation of at least two important decision-making criteria (27).

The assumption that optimal plans are developed for managers who are risk averters adequately describes many decision-makers. Many firm managers rationally prefer a plan which produces a given level of expected income with minimum income variance (12, 43).

The requirement that gross margins of possible outcomes for a given firm be normally distributed is more difficult to accept. It is necessary to assume that the number of activities considered in this study is large enough such that the Central Limit Theorem may be applied. This will provide for a reasonable acceptance of the assumption.

In summary, the assumptions associated with an E-V analysis approximate the real world decision situation of a packing firm reasonably well.

Selection of an optimal plan

Once the efficient E-V frontier has been derived, it is desirable to determine the optimum "portfolio" from the total set for one or both of two reasons: (1) to provide a definite plan for a manager to follow and (2) to predict a

manager's actions. The selection of an optimal plan from the plans located along the E-V boundary is accomplished by introducing the concept of a utility function.

Three general types of continuous utility curves typically described include linear (acceptance of risk remains constant), diminishing (risk averter), and increasing (risk preference). As stated previously, one of the assumptions associated with an E-V analysis is that the manager be a risk averter. A utility function representing a risk averting manager is mapped on Figure 1. The optimum plan is identified at the tangency between the efficient E-V frontier (FF) and the manager's utility function (UU). The plan

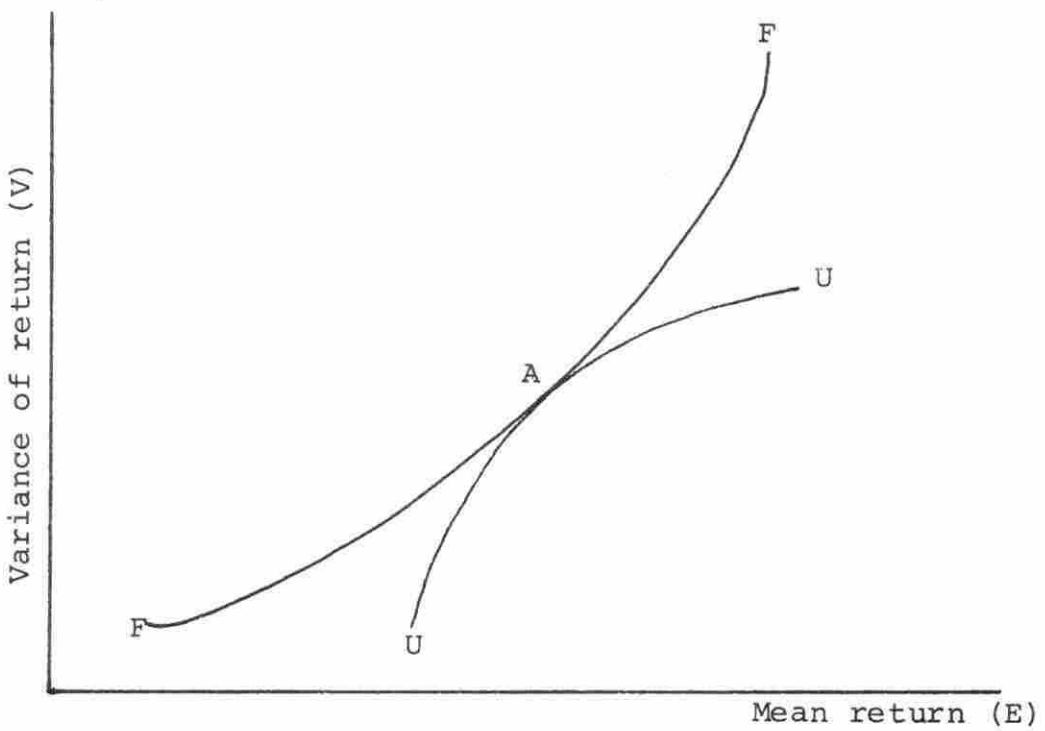

Figure 1. Graphic illustration of risk aversion on an optimal growth plan

located at point A represents a particular plan that produces maximum utility for an individual manager given his attitude towards risk.

Firm growth considerations

When time is an explicit variable in the decision-making process, a firm's optimal growth path may be considered. By jointly considering the firm's decision choices in production, marketing, and financial areas in a dynamic or firm growth setting, the decision-making framework is greatly expanded.

Considerable research efforts have been devoted to the topic of firm growth. Early studies, as reviewed by Irwin (26) involving the use of multiperiod linear programming, were primarily for investment choices and allocating internal capital (10). Later models included greater detail in financial investment, production, and marketing aspects of firm growth which resulted in improved understanding of how growth occurs and the result of financial management strategies on the firm growth process (6, 8, 43).

Multiperiod quadratic programming was selected for this study to develop an efficient E-V frontier which illustrates the feasible growth plans or portfolios. Portfolios, in this case, are composed of mixes of production, investment, financial, and marketing activities for each

period of a multiperiod planning horizon.

Risk management is an important consideration in the growth process because of interrelationships between cash and credit requirements for growth and cash or unused credit needed to counteract risk (6). Other important factors affecting the composition of the growth plans include coordination alternatives, capital constraints, credit evaluation, and resource indivisibilities (4, 5).

In summary, the alternative coordination arrangements considered in this study and related previous research were reviewed. The mean-variance approach was presented and criticisms and major assumptions of this analysis were discussed. Finally, the decision-making process and the expansion of the problem to one of firm growth were presented.

CHAPTER III. MODEL AND DATA

Of primary importance in this study is the selection of an appropriate research method and the development of the input data required by the research method. This research represents an application of quadratic programming to a beef packing plant. First the basic model used for the analysis will be presented. The discussion of the procedures followed will focus on (1) a discussion of the basic problem, coordination alternatives, financing, and investment alternatives available to the firm manager, (2) the data requirements for solution of the problem, and (3) sources of data to be utilized in the study.

The Quadratic Programming Model

A multiperiod quadratic program was used to model a representative packing firm and to derive a set of E-V efficient growth plans. The mathematical model is outlined below while its more detailed features will be discussed later in this chapter

$$\text{Maximize } U = \lambda \bar{C} X - X'DX$$

$$\text{Subject to: } AX \leq B$$

$$X \geq 0$$

where U = the value of the objective function, λ = a scalar to be parametrically increased from zero to unbounded to derive

the E-V frontier, $\overline{C}$ = a row vector of present values of mean returns, X = a column vector of activity levels for each time period, D = the variance-covariance matrix of present values of returns, A = a matrix of technical coefficients for activities and constraints defined over the different time periods, and B = a column vector of resource levels defined over the respective time periods.

The model was well-suited to this decision problem because it permits varying attitudes towards risk on the part of the decision-maker, a multiperiod planning horizon, inclusion of choice among alternative coordination arrangements, recognition of differences in prices associated with different coordination arrangements, and inclusion of financial and other constraints.

The Rand QP360 program was used to solve the problem (19). This quadratic program is designed to minimize quadratic objective functions subject to linear constraints. Therefore, the necessary adjustments had to be made to transform the problem from maximization to minimization.

Assumptions

A four-year firm growth model of a typical beef packing plant was constructed which allowed for joint consideration of alternative acquisition and investment (building a feedlot

and increasing slaughter facilities) activities. A decision period of one year was chosen because it enabled all coordination arrangement choices to be included. Although beef packers make decisions on a weekly basis, the use of a base period shorter than one year would not permit the consideration of custom feeding or feeding in a packer-owned feedlot as coordination instruments.

A planning horizon of four years was selected for this study because other research indicated that this approached the maximum planning horizon the QP program was capable of solving (43). Additionally, a four year planning period was considered to be adequate for analyzing choices regarding annual acquisition decisions as well as longer run investments such as building a feedlot and increasing slaughter capacity.

Specific assumptions made in constructing the model firm in this study include the following: (1) initial slaughter capacity was 180,000 head per year estimated as a midsize slaughtering facility (18), (2) packer-owned feedlot capacity was set at 10,000 head per year based on estimated cattle fed in a feedlot per year (11, 37), (3) all fed cattle bought for slaughter were choice steers weighing approximately 1,150 pounds which produce a 725 pound choice carcass with yield grade 3. These figures were assumed to be representative of

fed cattle available for slaughter and were determined in part from a budget study by the Iowa State Cooperative Extension Service (14), (4) custom feeding was limited to 50,000 head per year. A Texas study (20) suggested this figure as representative of most custom clients over a one year period. (5) The firm manager had $1,000,000 credit available. This figure was limited by the format of the QP program which prohibited a larger value to be specified. (6) The income tax rate was fifty percent as indicated by balance sheet data (2). (7) Feeder cattle bought for purposes of custom feeding or feeding in a packer-owned feedlot were yearlings weighing 635 pounds as estimated from budget data (14).

The model was developed to be used for prescribing future courses of action (as opposed to explaining what the firm manager should have done in a past time period). Hence, coefficients in the model were assumed to represent expected future values.

Price expectations were developed by using a simple price forecasting model. The chosen model assumed that the average of the past nine years (1968-1976) is the price expectation for the following year.

The costs of acquiring fed cattle by each of the coordination instruments considered were estimated from an

average of the nine years 1968-1976. The nine year period was selected principally because data were not available for some alternatives prior to 1968. Moreover, it was assumed for this study that the factors that caused costs to vary during the past nine years would produce similar variations in future time periods. The absolute quantity of the variations may change; however, the predictive ability of the model will not be drastically affected so long as the major factors causing variation in the past continue to be important in the determination of future variance.

Activities and Constraints

Fourteen activities were included for each year of the planning horizon. These activities were slaughter and marketing of fed cattle acquired through (1) direct purchases, (2) forward contracting, (3) feeding in a packer-owned feedlot, and (4) custom feeding, (5) addition of feedlot capacity, (6) addition of slaughter capacity, (7) borrowing, (8) repayment of debt, (9) transfer of debt to the next period, (10) transfer of cash to the next period, (11) withdrawal of cash for expenses, (12) payment of income taxes, (13) packer-owned feedlot capacity accounting, and (14) increased slaughter capacity accounting. These accounting rows kept

count of additional feedlot and slaughter capacity for depreciation adjustments each period and net worth computation in the final period.

Constraints were included for slaughter capacity, custom feeding, packer-owned feedlot capacity, cash, credit, minimum debt repayment, payment of income taxes, cash withdrawal for expenses, debt balances, and accounting rows for packer-owned feedlot capacity and increased slaughter capacity.

The activities and constraints are summarized in Tables 5a and 5b (pp. 38, 39) and will be discussed in more detail later in this chapter.

Objective Function

The objective function for the model included an income and a variance-covariance portion. To derive the E-V frontier, the income portion of the objective function (the linear portion) was parametrically increased until the maximum income solution was obtained. For each parametric increase in income, plans were developed which minimized variance of income given the constraints.

Empirical Procedures

For each income-producing activity available to the typical firm manager, an average gross margin was computed. These activities included the acquisition of fed cattle by direct purchases, forward contracts, custom feeding, and feeding in a packer-owned feedlot. These gross margins reflected nine-year averages, 1968-1976, and were coefficients in the linear portion of the quadratic program's objective function. The following procedures were utilized in the gross margin calculations (1) all costs were estimated for each of the nine years and (2) all feeder cattle, slaughter cattle, carcass, hide and offal prices were determined from Midwest quotations for the month of sale.

Estimation of objective function coefficients for acquisition activities

For each acquisition alternative it was necessary to compute the cost of the fed cattle and the price received for the carcass and byproducts to determine the gross margins. It was assumed that the carcass and byproducts from each steer were sold for the same price regardless of the way they were acquired. Carcass and hide and offal prices were obtained from the Livestock, Meat, Wool Market News Weekly Summary and Statistics (38) which summarizes weekly statistics on by-product and wholesale dressed meat prices. These data were

then averaged to obtain a monthly average for each month of the nine years, 1968-1976.

The direct purchase price of choice steers weighing 1000 to 1250 pounds was determined from data recorded by the Extension Economists at Iowa State University. These weekly prices were averaged for each of the years 1968-1976 after the gross margins were calculated.

To estimate the price offered a farmer on a forward contract for cattle to be delivered in seven months, the futures market prices were used as a starting point (16). The packer would then deduct some amount from the futures price to determine the offer of the cash price to be paid upon delivery. This figure was estimated by deducting the average actual basis calculated from 1965 to 1973 (32) for each contract delivery month. An additional $.15 was deducted each month as an estimated hedging cost. This procedure assumed that past actual basis values approximate those expected in the future. The estimated basis figure was approximately $1.20 for each contract delivery date. Consultation with an Iowa packing plant which engages in forward contracting showed this basis figure to be low and suggested perhaps a more reasonable figure might have been $2.00[3]. However, the original basis estimates were assumed

[3]Joseph Georgan, Wilson Foods, Inc., Cedar Rapids, Iowa, Private communication, 1977.

to be representative and were applied to the data to determine forward contract offers.

Costs associated with a packer feeding cattle for slaughter in a packer-owned feedlot were estimated from budget data compiled by the Cooperative Extension Service of Iowa State University (14). In this study cattle feeder's monthly costs per head of cattle fed were estimated. Fixed costs included labor, medical expenses, maintenance, waste handling, and feed processing. These expenses averaged $37.47 per head per month or $449.64 per head annually. Feed costs and the cost of purchasing a yearling steer were estimated from USDA estimates of average prices received by Iowa farmers and monthly average price of choice 600-700 pound yearling steers at the Sioux City, Iowa market, respectively. The cost of the facility and any interest and depreciation expenses were considered separately in the model.

Average custom feeding charges were established based on discussion with several owners of custom feedlots regarding their average charges[4]. It was determined that a representative figure would be $.10 per day for feeding in an open lot with shelter plus ten percent over the elevator

[4]Donald Budlong, Titonta, Iowa, Private communication, 1977 and John M. Greig, Estherville, Iowa, Private communication, 1977.

price for feed plus medical costs incurred. Because a yearling steer is on feed approximately seven months before slaughter, it was assumed that the cattle would be fed 210 days. Feed costs were estimated to be 110 percent of average prices received by Iowa farmers for feed ingredients. This seemed reasonable because many custom feedlot owners feed the cattle of their custom clients corn and hay produced in their own farming operations. Medical expenses were estimated to be $3.30 per head per month.

To enable a uniform carcass and byproduct price to be used in determining the gross margins, all costs were calculated from the perspective of when the cattle were ready for slaughter. Therefore, costs for forward contracting, custom feeding, and feeding in a packer-owned feedlot were measured from June of one year to May of the next. Any cattle put on feed in these months would be available for slaughter in the same calendar year. For example, cattle started on feed in September 1975 were ready for slaughter in April 1976 and all costs were calculated for this time period.

Variance-covariance determination

The annual gross margins for the acquisition activities (Table 4) were developed for two purposes. One purpose was to derive estimates of expected gross margins. Additionally, the annual gross margins, 1968-1976, were used to estimate

Table 4. Average gross margins associated with the alternative coordination activities, 1968-1976

Year	Direct purchases	Forward contracts	Fed in packer-owned feedlot	Custom fed
1968	28.24	44.33	29.71	33.83
1969	30.61	64.30	47.28	51.05
1970	28.67	32.09	13.43	16.87
1971	31.31	67.74	39.27	41.71
1972	29.78	78.75	68.69	72.17
1973	20.83	83.43	70.45	57.64
1974	42.60	-20.24	-43.44	-58.30
1975	54.69	112.41	98.54	88.42
1976	38.26	7.13	-23.55	-26.72
Average[a]	33.89	52.21	33.37	30.74

[a]Average of the nine years.

variances and covariances to be used for these activities in the objective function.

Variances and covariances for all coordination activities were determined by using standard statistical techniques. The principal reason for not adjusting gross margins for trend before computing the variances and covariances was that the limited number of observations prohibited determination of the trend (9 observations).

Investment activities

The investment alternatives available to the model beef packing plant were building feedlot capacity and increasing slaughter capacity by building an addition onto the present facility. The capital investment required to build feedlot capacity was estimated to be $226.32 per head capacity for an open lot with shelter. This figure was determined by taking twenty-five percent over the costs reported in 1974 (11). It was assumed that this would bring costs into line with present costs. Regretfully, no recent data were available and this arbitrary figure had to be applied to existing data.[5] This figure represents the capital requirements to design and construct a facility. Lot and shelter, waste handling, feed storage and handling, wells, sorting and handling, office, and miscellaneous equipment costs were included.

The total investment cost per head per year kill capacity to build a slaughtering facility was estimated to be $26.36. This figure includes estimates for holding corrals, kill floor, chill room, holding room, freezer, pollution control, office and administrative facilities, transportation, and land (18).

[5]Michael D. Boehlje, Associate Professor of Economics, Iowa State University, Private Communication, 1977.

A depreciable life of ten years was assumed for feedlot capacity (9). A straight line method was then used to determine annual depreciation costs. Slaughter facilities were assumed to depreciate at a rate of 5.5 percent per year. This was determined from balance sheets of several U.S. beef packers (29). Depreciation costs were computed each year of the model and net worth of investments at the end of the planning horizon reflected these costs.

Credit activities

Credit was established initially at $1,000,000. Credit was assumed to be generated in an equal proportion to gross income. Therefore, each dollar generated by the buying, slaughter, and marketing of carcasses and byproducts also generated one dollar of credit.

The principal use of credit was borrowing. Borrowing, at an eight percent rate, was possible each year of the planning horizon. The borrowing was for a period of five years only with at least one-fifth of the principal being repaid with interest in each of the five years. This is a reasonable assumption since a loan to finance the building of feedlot capacity is usually of this duration and the increasing of slaughter facilities is often heavily financed internally with short-term loans being used for inventories.

Activities to repay debt and transfer any remaining

debt from one year to the next were included. The mechanics of these activities have been presented in other research (41, 44); thus a detailed explanation will not be presented here.

Cash flow

The cash flow activities and constraints of the model allowed a reasonable consideration of sources and uses of funds between years. Sources of funds included gross margins received from packing operations and borrowing. Uses of funds included debt repayment, withdrawal of cash for expenses, income taxes, and cash remaining at the end of the planning year. Cash was permitted to be transferred from one year to the following year. Cash at the end of the planning horizon increased the objective function.

A fifty percent income tax rate was assumed. Tax row entries reflect deductable expenses associated with investments:interest on debt and depreciation.

Cash withdrawal for expenses was estimated to be approximately eighty-five percent of gross income. This figure was estimated from financial statements of U.S. meat packers (29) and from financial facts on the meat packing industry (18).

The Multiperiod Model

The full model contained 101 rows, 54 columns, and 293 matrix entries. The entire model is not presented due to its size, however, two years of the input-output relationships are presented in Table 5c.

The coordination activities were the same for each of the four years. Objective function values were discounted using a discount rate of eight percent (42, p. 139). Hence, the two years of the model given in Table 5c provide the framework for inter-year transfer of debt and cash. The variance-covariance matrices for the two periods are provided in Table 6. These values were appropriately discounted for each year in the four year model upon examination of the serial or autocorrelation coefficients (Table 7).

The serial correlations indicated that a general formula should be used to calculate the discounted variances since neither serial independence nor perfect autocorrelation could be assumed. Therefore, the following formula was applied where p is the autocorrelation coefficient, i is the discount rate, here assumed to equal eight percent, σ_τ and σ_θ are the standard deviations in the τth and θth periods, respectively, and σ_t^2 is the variance of the tth period (15).

Table 5a. Activities of the model

Activity name[a]	Description	Variance/covariance utilized in model
iDP	Fed cattle acquired through direct purchases	yes
iFC	Fed cattle acquired through forward contracts	yes
iFOF	Fed cattle acquired from feeding in a packer-owned feedlot	yes
iCF	Fed cattle acquired through custom feeding	yes
iBF	Build feedlot capacity	no
iISC	Increase slaughter capacity	no
iB	Borrow	no
iRD	Repay debt	no
iTD	Transfer debt	no
iTC	Transfer cash	no
iWC	Withdraw cash	no
iPT	Pay income taxes	no
iSA	Increased slaughter capacity accounting	no
iFA	Increased feedlot capacity accounting	no

[a] i refers to the year the activity appears. The value may be 1-4 depending on the year of the activity in question.

Table 5b. Constraints of the model

Relation[a]	Row name[b]	Description
N	OBJ	Objective function
L	iSC	Slaughter capacity
L	iCFC	Custom feeding limit
L	iPFC	Packer-owned feedlot capacity
E	iCFL	Cash flow
L	iCR	Credit
E	iDB	Debt balances
E	iCON	Withdrawal of cash
E	iPIT	Pay income taxes
E	iSCA	Increased slaughter capacity accounting
E	iFLA	Increased feedlot capacity accounting
L	iMDR	Minimum debt repayment

[a]N = nonconstrained, L = less than, E = equal to.

[b]The letter i will be replaced by the respective year, 1-4.

Table 5c. Input-output relationships for two years of the model[a]

	1DP	1FC	1FOF	1CF	1BF	1ISC	1B	1RD	1TD	1TC	1WC	1PT	1SA	1FA
OBJ	34	52	33	31				-.08	-.08				-1.44	-23
1SC	1	1	1	1										
1CFC				1										
1PFC			1											
1CFL	-34	-52	-33	-31	226	26	-1	1.08		1	1	1		
1CR	-34	-52	-33	-31	226	26	1	-1						
1DB							-1	1	1					
1MDR							.2	-1						
1CON	-29	-44	-28	-26							1			
1PIT	-2.5	-4	-2.5	-2			.08					1	1.44	23
1SCA						1							-1	
1FLA					1									-1
2SC						-1								
2CFC														
2PFC					-1									
2CFL										-1				
2CR									1					
2DB									-1					
2MDR							.2							
2CON														
2PIT														
2SCA						1								
2FLA					1									

[a]Some rounding was required to present the matrix. See Tables 5a and 5b for row and activity identification.

Table 5c (Continued)

	2DP	2FC	2FOF	2CF	2BF	2ISC	2B	2RD	2TD	2TC	2WC	2PT	2SA	2FA
OBJ	31	48	30	28				-.074	-.074				-1.34	-21
1SC														
1CFC														
1PFC														
1CFL														
1CR														
1DB														
1MDR														
1CON														
1PIT														
1SCA														
1FLA														
2SC	1	1	1	1										
2CFC				1										
2PFC			1											
2CFL	-34	-52	-33	-31	226	26	-1	1.08		1	1	1		
2CR	-34	-52	-33	-31	226	26	1	-1						
2DB							-1	1	1					
2MDR							.2	-1						
2CON	-29	-44	-28	-26							1			
2PIT	-2.5	-4	-2.5	-2			.08					1	1.44	23
2SCA						1							-1	
2FLA					1									-1

Table 6. Variance-covariance relationships for two years of the planning horizon

	Direct purchases	Forward contracts	Fed in packer owned feedlot	Custom fed
Year 1				
Direct purchases	98.95			
Foward contracts	-2.87	1679.72		
Fed in packer owned feedlot	-15.97	1854.80	2081.08	
Custom fed	-48.57	1890.39	2117.79	2216.50
Year 2				
Direct purchases	258.91			
Forward contracts	-6.55	2777.65		
Fed in packer owned feedlot	-30.84	2277.15	1849.71	
Custom fed	-89.31	2110.8	1674.47	1834.62

Table 7. Serial correlation coefficients

	Direct purchases	Forward contracts	Fed in packer owned feedlot	Custom fed
Direct purchases	.95			
Forward contracts	.77	.43		
Fed in packer owned feedlot	.58	.2	.017	
Custom fed	.53	.14	-.036	-.016

$$\sigma^2 = \sum_{t=0}^{n} \frac{\sigma_t^2}{(1+i)^{2t}} + 2 \sum_{\tau=0}^{n-1} \sum_{\substack{\theta=1 \\ \tau<\theta}}^{n} \frac{\rho\sigma_\tau\sigma_\theta}{(1+i)^{\tau+\theta}}$$

Note that when $\rho=0$, showing independence, the second summation term is equal to zero and the remaining term is the equation normally given for the discounted variance of independent cash flows. In this study, $\sigma_\tau = \sigma_\theta$ in the second summation term since the discounting concerns the variances and covariances of nine-year average gross margins which are autocorrelated between years.

E-V Analysis and the Selection of an Optimal Growth Plan

The emphasis of the model was to develop the optimal E-V firm growth frontier. The E-V frontier illustrates the trade-offs between alternative four-year growth plans and the variance associated with the growth plan. Thus, each point on the E-V boundary represented solutions of the four-year plan.

By applying the dynamic model, it was possible to evaluate the firm's decision choices in acquisition and investment considering the rate of firm growth in an uncertain environment. Therefore, alternative four-year growth plans were developed for alternative levels of risk.

To ascertain how different constraint levels affect the E-V frontier, the right-hand-side values were parametrized. Various levels of initial slaughter capacity, packer-owned feedlot capacity and custom feeding limits were substituted and the results were analyzed. Of particular interest was the elimination of initial packer-owned feedlot capacity to investigate the implications of Iowa law prohibiting ownership of feedlots by meat packers.

CHAPTER IV. RESULTS

The multiperiod model was used to estimate E-V frontiers which minimized variance for alternative levels of net income. The present value of net income streams was accomplished by investment and production. The emphasis of this analysis was the development of E-V frontiers.

In this chapter, the E-V frontiers and characteristics of various optimum solutions along the frontier are discussed and contrasted with results from assuming independent net incomes. Results from parametrizing the right-hand-side values are also presented.

Development of E-V Frontiers

Any specified point on the E-V frontier represents a separate four-year growth plan, i.e., each critical point included an annual operating plan for each year of the four-year planning horizon. The E-V frontier illustrated alternative four-year growth plans which were optimal in the sense that variance was minimized for total expected four-year income. Thus, through application of the dynamic model, alternative growth strategies were developed which illustrated the trade-offs between increasing net income and increasing risk.

The expected net income for the four-year model

represented the present value of expected income streams. The variance associated with the four-year model was the total of the annual variances of present values. The four-year total net income includes total gross income plus additional net worth less variable production expenses which included debt on borrowed funds. Income and variances were expressed as present values, not actual values.

The development of the E-V frontier generated a considerable number of optimal solutions (fifty-six E-V efficient solutions) in that each observation along the E-V curve represented annual plans for the four-year period. Therefore, only a sample of solutions was selected from the available plans along the E-V frontier to keep the discussion to manageable proportions and because the major results can be discerned by examination of only a few solutions.

Characteristics of Alternative Growth Plans

An E-V curve depicting the present value of net income and associated variance over the four-year planning horizon is presented in Figure 2. Selected four-year growth plans in Figure 2 are further described in Tables 8 and 9. The trade-offs between net income and stability of income are illustrated by the ratio, $\Delta Y/\Delta SD$, which quantifies the slope of linear segments composing the frontier graphed in Figure 2.

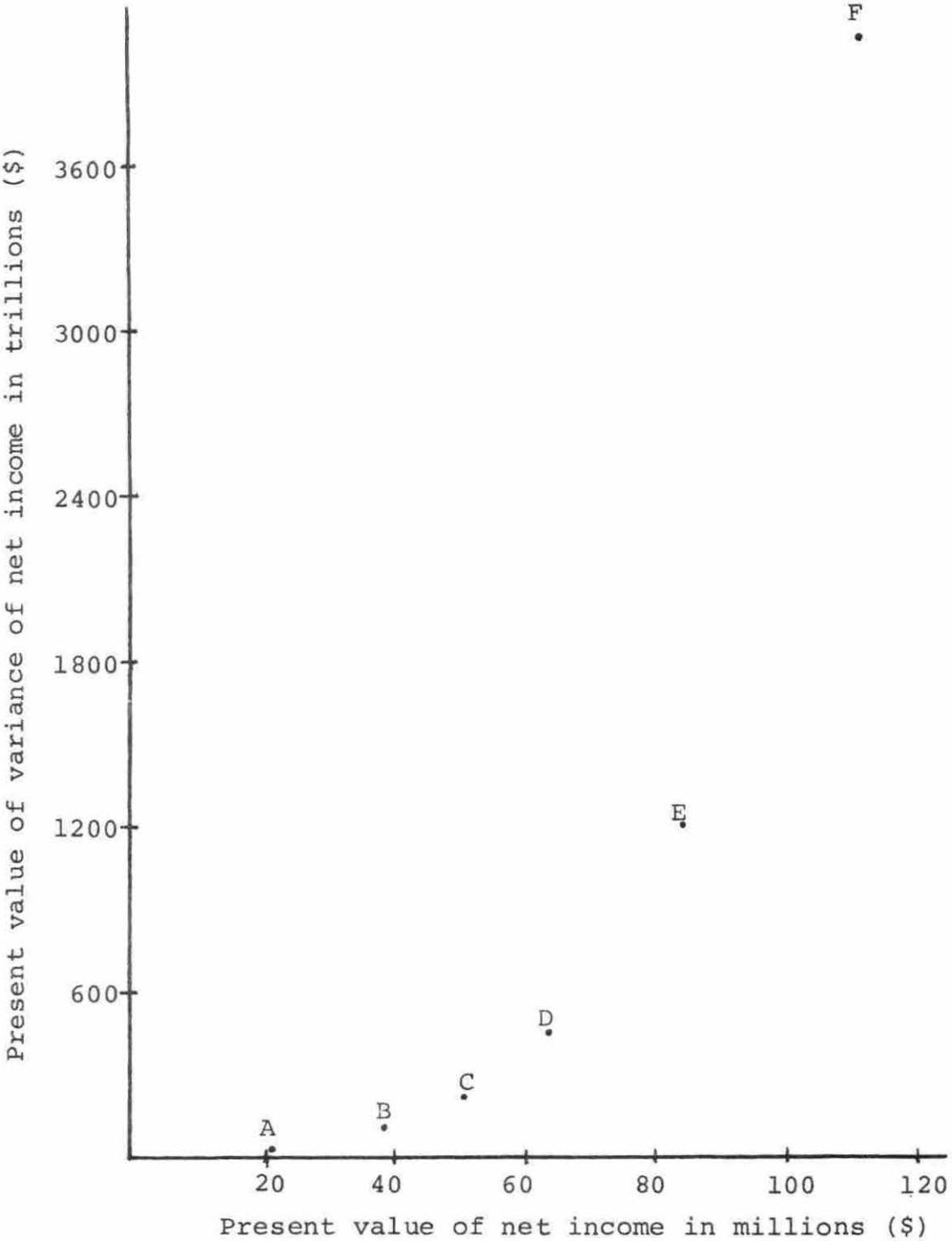

Figure 2. The relationship between level of net income and variance of net income on the E-V frontier, for six alternative four-year growth plans, auto-correlated net incomes

Table 8. Four-year net income and statistical characteristics of six alternative four-year firm growth plans, autocorrelated net incomes[a]

Firm[b] plan	Total[c] net income (Y) ($)	Standard[d] deviation (SD) ($)	$\frac{\Delta Y}{\Delta SD}$
A	20,609,709	4,416,908	4.67
B	38,692,302	10,023,279	2.99
C	50,476,614	14,706,866	2.52
D	63,889,425	21,018,987	2.12
E	84,601,937	33,091,152	.61
F	109,261,374	64,279,921	.79

[a]All values in the table are present values discounted at eight percent.

[b]The six alternative plans are presented in an E-V curve framework in Figure 2.

[c]Total net income represents total four-year income from carcass and byproduct sales plus additional net worth less cash expenses associated with production including interest on borrowed funds.

[d]Price variation was included for all coordination activities.

Table 9. Composition of six alternative four-year firm growth plans, autocorrelated net incomes[a]

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Financed by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
A	1	180,000	87	13					
	2	180,000	86	8		6			
	3	180,000	59		1	16			
	4	180,000	45		1	17			
B	1	180,000	68	32			169,400		Yes
	2	349,400	85	15					
	3	349,400	81	1	3[b]	15[b]			
	4	349,400	68	1	3[b]	15[b]			
C	1	180,000	43	57			187,000		Yes
	2	367,000	81	19			126,600		Yes
	3	493,600	82	8		10[b]			
	4	493,000	80	8	2[b]	10[b]			
D	1	180,000		100			216,400		Yes
	2	396,400	73	27			257,400		Yes
	3	653,000	84	16			24,700		Yes
	4	678,500	81	10	1[b]	8[b]			

[a] See Table 8 for net income and statistical characteristics of the alternative plans.

[b] All capacity available is utilized.

Table 9 (Continued)

Firm plan	Year	Slaughter capacity (Hd)	Fed cattle acquired through: Direct purchases (%)	Forward contracts (%)	Feeding in packer-owned feedlot (%)	Custom feeding (%)	Increase slaughter capacity (Hd)	Build feedlot (Hd)	Financed by borrowing
E	1	180,000		100			216,400		Yes
	2	396,400	24	76			331,700		Yes
	3	728,100	72	28			382,000		Yes
	4	1,110,100	80	16		4[b]			
F	1	180,000		100			216,400		Yes
	2	369,400		100			367,700		Yes
	3	764,100		100			610,700		Yes
	4	1,374,800	61	39					

Thus, differences in the rate of the present value of net income contribution per unit of standard deviation may be compared to gain insight into income stability. Here, as the present value of net income increased, the cost, in terms of variance, increased and then decreased slightly for the linear programming solution (Plan F). This decrease may be due to the large investment in slaughter capacity in solution F so that additional net worth, which is included in the net income computation, causes this ratio to be larger.

The annual acquisition alternative and investment decisions of each of the six growth plans are presented in Table 9. Each plan represents an optimal combination of activities required to produce the four-year total net income illustrated in Table 8 with minimum variance.

Plans A and B illustrated unusual characteristics. In Plan A, slaughter capacity remained at the initial level and total capacity was utilized only in Years 1 and 2 of the four-year planning horizon. Slaughter capacity was increased in Year 1 in Plan B but by Year 4, only eighty-seven percent capacity was used in production. This tendency towards idle capacity may be explained by the high serial correlation of net income from direct purchases and the low serial correlation of net income from the vertical integration activities (Table 7, p. 42). Therefore, to avoid in-

creasingly higher risk, at least at low levels on the E-V frontier, some capacity is left idle.

Plans C, D, and E illustrated the four-year plans where all slaughter capacity was used for production. The addition of slaughter capacity became more intensive for four-year growth plans that were located at higher levels on the E-V frontier, i.e., in Plan E slaughter capacity was increased by 930,100 head versus an increase of 498,500 head for Plan D, and 313,600 head for Plan C.

For years in any of the four-year planning horizons, increasing slaughter capacity occurred only in Year 1 in Plan B, in Years 1 and 2 in Plan C, and in Years 1, 2, and 3 in Plans D, E, and F. Because increased slaughter capacity was not available until the year following initial investment, it was unreasonable to engage in this activity in Year 4 of any growth plan.

Plan F represents the typical linear programming solution for the firm growth problem. Thus, maximum use was made of available credit and cash to increase slaughter capacity without regard to variance of income associated with the growth plan, i.e., the choice of activities was not a function of income variance but rather availability of physical resources. Plan F represents the greatest present value of net income and also produced the greatest income

variation of the six plans. Thus, uncertainty increased as level of present value of net income increased.

In the first year of each plan, increasing use was made of forward contracts. In Plans D, E, and F all cattle were supplied by using this coordination instrument. With the exception of Plan A, the same is true for the second year of each plan and in Plan F, 100 percent of the cattle were supplied through forward contracts. The third years of Plans D, E, and F also exhibit this property, again in the LP solution (Plan F) all fed cattle were acquired through forward contracts. This suggests that as degree of risk aversion decreases, the large gross margin associated with forward contracting becomes increasingly attractive as managers become more willing to accept the high risk associated with this coordination instrument.

Vertical integration (custom feeding and feeding in a packer-owned feedlot) becomes decreasingly intensive for four-year growth plans that were located at higher levels on the E-V frontier, i.e., Plan E used less vertical integration than Plan D, etc. Within annual organization of any of the five plans represented by Plans A, B, C, D and E, the later part of the four-year planning horizon made greater use of vertical integration than earlier years.

In Plans B, C, and D all available capacity for custom feeding and feeding in a packer-owned feedlot was utilized.

While all packer feedlot capacity in these plans was used, no investment was made in additional feedlot capacity. This result indicates that the costs associated with a packer-owned feedlot exceeded the benefits of a packer feeding cattle for slaughter. The investment costs of building a feedlot are relatively high per head and the returns from cattle produced in packer-owned feedlots are lower than returns from cattle purchased directly or through forward contracts. With the exception of Plan A, when cattle were custom fed or fed in a packer-owned feedlot, all capacity available was used.

Credit Requirements

Credit availability, credit use and cash flow requirements were of utmost importance in allowing for firm growth. Because the essence of firm growth is acquiring the control of resources which may be used for production and in turn generate more income exceeding the cost of the resource, growth may be accelerated by increasing the use of credit.

The total quantity of credit used increased as the six plans were compared moving up the E-V frontier (Plans A to F respectively). Additionally, the percentage utilization of credit also increased as the six plans were compared.

When considering the relationship of growth rates and the position that a given four-year plan occupied on the E-V

curve, it should be remembered that the total risk in the model was due to variation in prices paid to acquire fed cattle. Moreover, no aversion to debt was specified. Credit implicitly affected the riskiness of a particular firm plan in that the interest payments caused a reduction in income while leaving variance unaltered, i.e., as alternative firm plans required increased quantities of credit, variance per dollar of income was relatively greater compared to a plan requiring the use of less credit.

For each plan, all investments were financed by borrowing. As the plans move up the E-V frontier, more and more credit is used as investments increase dramatically.

Implications of the borrowing activities associated with the various plans presented along the E-V frontier may be briefly summarized as follows: (1) higher present value of net income required an increase in the use of credit, (2) credit was not a limiting element in firm growth except for the plan producing maximum growth (Plan F), and (3) firm plans used credit according to their position on the E-V frontier, i.e., an increase in the present value of net income resulted from movement up the E-V frontier; however, movement could occur only with increased use of credit.

Results from Solution of the Model with Serially Independent Net Incomes

Figure 2 and Tables 8 and 9 showed the results from the model when serial correlation between cash flows was considered in discounting the variances and covariances. Previous studies using quadratic programming models (8, 44) assumed independent net incomes when discounting the variances and covariances. Figure 3 and Tables 10 and 11 show the results when this assumption is applied to the present model.

Seven four-year growth plans are presented in Table 10 with Plan G representing the linear programming solution. The other plans were chosen to approximate the total net income of each plan in Table 8 (p. 48). Comparison of the two tables (8 and 10) indicate that variances associated with the results of Table 10 are almost one-half of those in Table 8.

The composition of the seven alternative four-year firm growth plans assuming independence of cash flows over time is presented in Table 11. Each plan represents an optimal combination of activities to produce the four-year total net income illustrated in Table 10 with minimum variance.

None of the plans utilize integration coordination activities (feeding in a packer-owned feedlot or custom feeding). This is due to their low return and associated

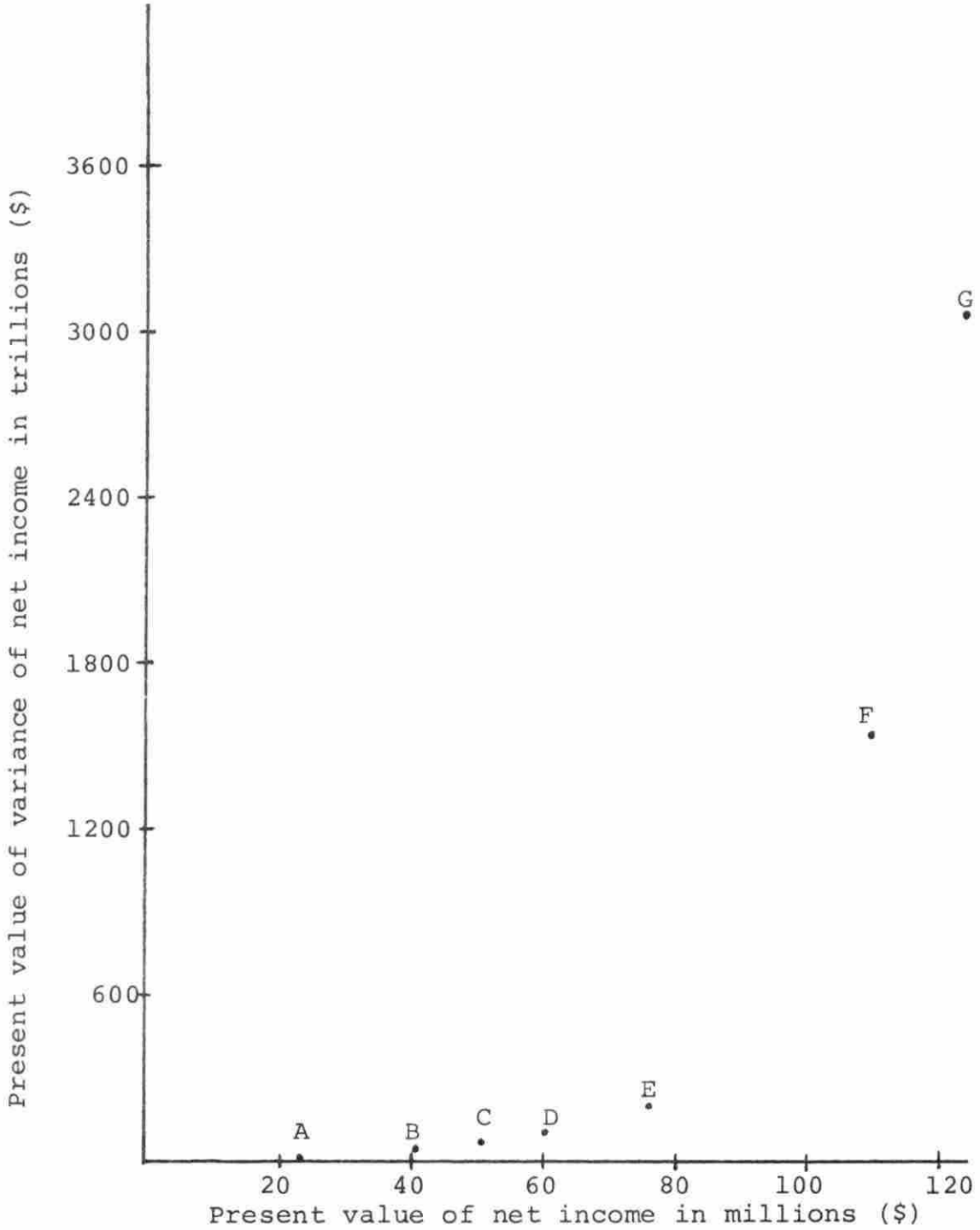

Figure 3. The relationship between level of net income and variance of net income on the E-V frontier for seven alternative growth plans, independent net incomes

Table 10. Four-year net income and statistical characteristics of seven alternative four-year firm growth plans, independent net incomes[a]

Firm[b] plan	Total[c] net income (Y) ($)	Standard[d] deviation (SD) ($)	$\frac{\Delta Y}{\Delta SD}$
A	23,276,619	2,993,326	7.78
B	40,388,681	5,422,914	7.04
C	51,219,949	7,203,471	6.08
D	60,248,503	8,986,657	5.06
E	76,387,004	14,349,216	3.01
F	110,797,237	38,031,566	1.45
G	123,742,778	55,510,359	.74

[a]All values in the table are present values discounted at eight percent.

[b]The seven alternative growth plans are presented in an E-V curve framework in Figure 3.

[c]Total net income represents total four-year income from carcass and byproduct sales plus additional net worth less cash expenses associated with production including interest on borrowed funds.

[d]Price variation was included for all coordination activities.

Table 11. Composition of seven alternative four-year firm growth plans, independent net incomes[a]

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Financed by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
A	1	180,000	78	7					
	2	180,000	84	8					
	3	180,000	92	8			15,350		No
	4	195,350	92	8					
B	1	180,000	89	11			154,850		Yes
	2	334,850	91	9			23,750		Yes
	3	358,600	91	9			11,500		No
	4	370,100	91	9					
C	1	180,000	85	15			157,850		Yes
	2	337,850	90	10			210,150		Yes
	3	548,000	91	9					
	4	548,000	91	9					
D	1	180,000	75	25			164,600		Yes
	2	344,600	86	14			217,430		Yes
	3	562,030	90	10			279,350		Yes
	4	841,380	91	9					
E	1	180,000		100			216,400		Yes
	2	396,400	61	39			274,730		Yes
	3	671,130	79	21			342,250		Yes
	4	1,013,380	86	14					

[a]See Table 10 for net income and statistical characteristics of the alternative plans.

Table 11 (Continued)

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Financed by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
F	1	180,000		100			216,400		Yes
	2	396,400		100			367,700		Yes
	3	764,100		100			613,740		Yes
	4	1,377,840	55	45					
G	1	180,000		100			216,400		Yes
	2	396,400		100			367,700		Yes
	3	764,100		100			637,730		Yes
	4	1,401,830		100					

high risk which remains the same relative to the risk of the other coordination instruments under this discounting technique.

Similar to the results shown in Table 9, direct purchases increase in later years of each four-year growth plan for all but the last three plans in each table. The final three plans of each table (Plans D, E, and F, Table 9 and Plans E, F, and G, Table 11) exhibit increasing utilization of forward contracts with plans in Table 11 using forward contracts more extensively and beginning at a lower level on the E-V frontier. The linear programming solution of Table 11 (Plan G) uses forward contracting exclusively.

Investments are also more extensively employed under the assumption of independent cash flows over time. Additionally, in the initial solution (Plan A) slaughter capacity increases slightly whereas no slaughter capacity investment was utilized in Plan A of Table 9. Internal financing of small slaughter capacity investments also appeared in Plans A and B of Table 11. All larger investments were financed by borrowing which is consistent with the plans of Table 8.

The results from the model assuming independent cash flows provides some insight into the reason for idle capacity seen in Plans A and B of Table 9. The first two years of Plan A in Table 11 also exhibit idle capacity. This is the opposite of Plan A in Table 9 where idle capacity appeared in

the final two years. This, therefore, can be explained by the difference in computing the discounted variances and covariances. Under the assumption of independent net incomes, variances and covariances decrease each year they are discounted (42, p. 140). However, with autocorrelated net incomes, the discounting process increases some variances and covariances over time and decreases others (Table 6, p. 42). This also helps explain the differences in choice of coordination alternatives between the two Tables 9 and 11.

In summary, solutions based on the assumption of serially independent net incomes over time include (1) greater investment, (2) an increasingly higher percentage of forward contracts at higher levels of the E-V frontier (Plans A to G, respectively), (3) some internally financed investment, and (4) no use of vertical integration coordination activities.

Results from Parametrization of Right-Hand-Side Values

The parametrizations of the right-hand-side values included setting (1) initial slaughter capacity equal to 100,000 head per year, (2) initial custom feeding capacity equal to 100,000 head per year, (3) packer-owned feedlot capacity equal to 25,000 head per year, and (4) packer-owned feedlot capacity equal to zero.

The results of the various parametrizations of the model are given in Tables 12 through 19. Comparison of Tables 12, 14, 16 and 18 with Table 8 of the general model shows no significant differences especially regarding the shape of the E-V frontier. A notable exception was when the initial slaughter capacity was reduced to 100,000 head per year. This change caused the E-V frontier to retain its shape but to be moved to the left of the curve in Figure 2. Therefore, everything else the same, changes in initial slaughter capacity affects the E-V frontier by shifting its position.

Additionally, Table 13 which shows results when slaughter capacity was set at 100,000 head per year, indicates that at lower initial levels of slaughter capacity, vertical integration is utilized to a lesser extent and forward contracting is used extensively. In Plan E, the LP solution, all fed cattle were acquired through forward contracts in every year of the planning horizon. Plans preceding Plan E indicate the clear trend towards the use of additional forward contracts as variance increased.

Investment in slaughter capacity was higher than in the original model for the lower initial slaughter capacity results. This may be explained by noticing the larger amounts of forward contracts used in the plans of Table 13 versus those of Table 9. Therefore, greater credit was

Table 12. Four-year net income and statistical characteristics of five alternative four-year firm growth plans, initial slaughter capacity equals 100,000 head per year, autocorrelated net incomes[a]

Firm plan	Total net[b] income (Y) ($)	Standard[c] deviation (SD) ($)	$\frac{\Delta Y}{\Delta SD}$
A	16,761,273	4,007,493	4.18
B	26,321,840	7,233,257	2.98
C	43,718,628	15,479,018	2.11
D	52,773,186	22,333,830	1.32
E	72,122,812	61,540,230	.49

[a]All values in the table are present values discounted at eight percent.

[b]Total net income represents total four-year income from carcass and byproduct sales plus additional net worth less cash expenses associated with production including interest on borrowed funds.

[c]Price variation was included for all coordination activities.

Table 13. Composition of five alternative four-year firm growth plans, initial slaughter capacity equals 100,000 head per year, autocorrelated net incomes[a]

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
A	1	100,000	81	19			49,600		Yes
	2	149,600	86	14					
	3	149,600	73		1	20			
	4	149,600	56		4	21			
B	1	100,000	52	48			109,000		Yes
	2	209,000	83	17			48,500		Yes
	3	247,500	78		3	19[b]			
	4	247,500	76		5[b]	19[b]			
C	1	100,000		100			128,900		Yes
	2	228,900	60	40			166,000		Yes
	3	394,900	81	19			201,400		Yes
	4	596,300	81	9	2[b]	8[b]			
D	1	100,000		100			128,900		Yes
	2	228,900		100			218,500		Yes
	3	447,400	67	33			243,900		Yes
	4	691,300	80	20					

[a]See Table 12 for net income and statistical characteristics of the alternative plans.

[b]All capacity available is utilized.

Table 13 (Continued)

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
E	1	100,000		100			128,900		Yes
	2	228,900		100			218,500		Yes
	3	447,400		100			378,000		Yes
	4	825,400		100					

Table 14. Four-year net income and statistical characteristics of six alternative four-year firm growth plans, initial custom feeding capacity equals 100,000 head per year, autocorrelated net incomes[a]

Firm plan	Total net[b] income (Y) ($)	Standard[c] deviation (SD) ($)	$\frac{\Delta Y}{\Delta SD}$
A	20,609,709	4,416,908	4.67
B	39,058,474	10,012,492	3.30
C	50,537,292	14,422,205	2.60
D	65,217,844	20,980,944	2.24
E	83,599,488	32,286,220	.62
F	109,261,374	64,279,921	.80

[a]All values in the table are present values discounted at eight percent.

[b]Total net income represents total four-year income from carcass and byproduct sales plus additional net worth less cash expenses associated with production including interest on borrowed funds.

[c]Price variation was included for all coordination activities.

Table 15. Composition of six alternative four-year firm growth plans, initial custom feeding capacity equals 100,000 hea per year, autocorrelated net incomes[a]

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
A	1	180,000	87	13					
	2	180,000	86	8		6			
	3	180,000	59		1	16			
	4	180,000	45		1	17			
B	1	180,000	71	29			167,700		Yes
	2	347,700	85	15					
	3	347,700	78		2	20			
	4	347,700	69		3[b]	28			
C	1	180,000	44	56			186,300		Yes
	2	336,300	81	19			156,750		Yes
	3	523,050	79		2[b]	19[b]			
	4	523,050	77	2	2[b]	19[b]			
D	1	180,000		100			216,400		Yes
	2	396,400	73	27			257,400		Yes
	3	643,800	84	16			61,400		Yes
	4	715,200	79	6	1[b]	14[b]			

[a] See Table 14 for net income and statistical characteristics of the alternative plans.

[b] All capacity available is utilized.

Table 15 (Continued)

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
E	1	180,000		100			216,400		Yes
	2	396,400	25	75			329,600		Yes
	3	726,000	72	28			379,000		Yes
	4	1,105,500	78	13		9[b]			
F	1	180,000		100			216,400		Yes
	2	396,400		100			367,700		Yes
	3	764,100		100			610,700		Yes
	4	1,374,800	61	39					

Table 16. Four-year net income and statistical characteristics of six alternative four-year firm growth plans, initial packer-owned feedlot capacity equals 25,000 head per year, autocorrelated net incomes[a]

Firm plan	Total net[b] income (Y) ($)	Standard[c] deviation (SDA) ($)	$\frac{\Delta Y}{\Delta SD}$
A	20,609,709	4,416,908	4.67
B	38,468,462	9,868,637	3.28
C	50,251,144	14,570,518	2.51
D	64,884,663	20,980,943	2.28
E	84,601,937	33,081,717	1.63
F	109,261,374	64,279,921	.79

[a]All values in the table are present values discounted at eight percent.

[b]Total net income represents total four-year income from carcass and byproduct sales plus additional net worth less cash expenses associated with production including interest on borrowed funds.

[c]Price variation was included for all coordination activities.

Table 17. Composition of six alternative four-year firm growth plans, initial packer-owned feedlot capacity equals 25,000 head per year, autocorrelated net incomes[a]

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
A	1	180,000	87	13					
	2	180,000	86	8		6			
	3	180,000	59		1	16			
	4	180,000	45		1	17			
B	1	180,000	69	31			168,500		Yes
	2	348,500	85	15					
	3	348,500	79		7[b]	14[b]			
	4	348,500	66		7[b]	14[b]			
C	1	180,000	43	57			186,850		Yes
	2	366,850	81	19			133,850		Yes
	3	500,700	81	4	5[b]	10[b]			
	4	500,700	79	6	5[b]	10[b]			
D	1	180,000		100			216,400		Yes
	2	396,400	73	27			257,400		Yes
	3	653,800	84	16			31,100		Yes
	4	684,900	81	7	4[b]	8[b]			
E	1	180,000		100			216,400		Yes
	2	396,400	24	76			331,700		Yes
	3	728,100	72	28			382,000		Yes
	4	1,110,100	80	16		4[b]			

[a]See Table 16 for net income and statistical characteristics of the alternative plans.

[b]All capacity available is utilized.

Table 17 (Continued)

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlot	Custom feeding	Increase slaughter capacity	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
F	1	180,000		100			216,400		Yes
	2	396,400		100			367,700		Yes
	3	764,100		100			610,700		Yes
	4	1,374,800	61	39					

Table 18. Four-year net income and statistical characteristics of six alternative four-year firm growth plans, initial packer-owned feedlot capacity equals zero, autocorrelated net incomes[a]

Firm plan	Total net[b] income (Y) ($)	Standard[c] deviation (SD) ($)	$\frac{\Delta Y}{\Delta SD}$
A	20,601,529	4,415,880	4.67
B	38,958,624	10,164,645	3.19
C	50,430,122	14,713,939	2.52
D	64,892,599	19,773,973	2.86
E	84,601,937	32,298,762	1.57
F	109,261,374	64,279,921	.77

[a]All values in the table are present values discounted at eight percent.

[b]Total net income represents four-year income from carcass and byproduct sales plus additional net worth less cash expenses associated with production including interest on borrowed funds.

[c]Price variation was included for all coordination activities.

Table 19. Composition of six alternative four-year firm growth plans, initial packer-owned feedlot capacity equals zero, autocorrelated net incomes[a]

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlots	Custom feeding	Increase slaughter	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
A	1	180,000	87	13					
	2	180,000	86	8		6			
	3	180,000	59			17		3789	No
	4	180,000	46		2[b]	18			
B	1	180,000	68	32			169,700		Yes
	2	349,700	85	15					
	3	349,700	82	4		14[b]			
	4	349,700	69	3		14[b]			
C	1	180,000	43	57			187,000		Yes
	2	367,000	81	19			126,200		Yes
	3	493,200	82	8		10[b]			
	4	493,200	82	8		10[b]			
D	1	180,000		100			216,400		Yes
	2	396,400	73	27			257,400		Yes
	3	653,800	84	16			20,400		Yes
	4	674,100	82	11		7[b]			

[a] See Table 18 for net income and statistical characteristics of the alternative plans.

[b] All capacity available is utilized.

Table 19 (Continued)

Firm plan	Year	Slaughter capacity	Fed cattle acquired through: Direct purchases	Forward contracts	Feeding in packer-owned feedlots	Custom feeding	Increase slaughter capacity	Build feedlot	Finance by borrowing
		(Hd)	(%)	(%)	(%)	(%)	(Hd)	(Hd)	
E	1	180,000		100			216,400		Yes
	2	396,400	73	27			331,700		Yes
	3	728,100	84	16			382,000		Yes
	4	1,110,100	82	11		4[b]			
F	1	180,000		100			216,400		Yes
	2	396,400		100			367,700		Yes
	3	764,100		100			610,700		Yes
	4	1,374,800	61	39					

available for managers with the plans of Table 13 because of the larger margin associated with forward contracts.

In Tables 18 and 19 six selected plans are given from results when packer-owned feedlot capacity was initially set to zero. Plan A was the only solution which included the building of feedlot capacity. This investment was financed internally possibly because of the relatively small capacity built. After the building of the feedlot capacity, all capacity was utilized in the next period (the first year it was available due to the lagged nature of this activity). Note also that investment in slaughter capacity and coordination choices were almost identical to those of the original model (Table 9) with the exclusion of feeding in a packer-owned feedlot.

The stability of the original model is indicated by the uniform E-V frontier which all results exhibited. The fact that for the same level of income, approximately the same variance was generated for all parametrizations indicated that the original model (Tables 8 and 9) was stable. Also note the identical LP solution and initial (Plan A) solution were found for each parametrization (excepting where slaughter capacity was changed and independence of net incomes was assumed). These factors contribute to the conclusion of the stability of the original model with regard to changes in the firm's environment.

The particular plan which is chosen from the wide range of solutions along the E-V frontier is determined by a firm manager's particular utility function. It is possible to conclude that significant increases in firm growth are feasible (considering preference towards risk) for all parametrizations given and the original model.

Summary

The results of the quadratic programming model with variances and covariances discounted considering serial correlation of net incomes over time, assuming serial independence, and parametrizing of right-hand-side values have been presented. Comparisons between these results were drawn and the stability of the original model was discussed.

CHAPTER V. SUMMARY AND CONCLUSIONS

A dynamic firm growth model was used to derive a firm's optimal growth path through time in an uncertain environment by jointly considering a firm's decision choices in coordination arrangements, investment, and other financial areas. The coordination arrangement choices of the firm growth model contributed to net income. The firm growth model evaluated the trade-offs in present value of net income and present value of variance of net income for a four-year planning horizon. The variances and covariances were discounted considering the autocorrelation of net incomes. Optimal four-year plans were developed which evaluated the present value of net income from coordination choices. Investment alternatives included increasing slaughter capacity and feedlot capacity.

Other financial considerations in the firm growth model included a detailed cash flow analysis, credit activities, withdrawal of cash for expenses, and income tax considerations. The limiting resources were slaughter capacity, custom feeding limit, packer-owned feedlot capacity, cash and credit.

As mentioned in Chapter I, the emphasis of this study was to provide an operational model from which to obtain explanations, predictions, and prescriptions of changes in

coordination arrangements. Although specific coordination arrangements have received considerable attention in literature concerning beef producers, the previous studies have not considered coordination arrangements of beef packers.

Objectives laid out in Chapter I included the following: (1) determination of the optimal combination of coordination arrangements for a particular firm given its present position and how this optimal combination may change due to changes in the situation a firm faces and (2) identification of trends which are likely to develop in relation to coordination choices for beef packers.

Results and Conclusions of Empirical Analysis

The principal result obtained from applying quadratic programming was the development of an efficient E-V frontier. The specific optimal plan chosen by a particular firm manager would depend on his utility function, his preference for risk.

Firm plans were developed for a four-year planning horizon which illustrated the trade-offs between increases in the present value of net income and resulting increases in variance. Increases in the present value of net income could occur from investment in slaughter capacity or feedlot capacity.

The firm growth model

Results from application of the dynamic model provided several implications for firm organization. First, the most stable four-year plan, providing minimum variation in net income, required no organizational changes in the firm, i.e., no investments. This plan produced the lowest four-year net income of all optimal growth plans examined. Second, the greatest growth in the four-year firm net income was approximately an eighty percent increase over the beginning income. This plan required slaughter capacity to be increased 6.6 times, and maximum use of forward contracting and credit. This plan was the most risky of all growth plans developed and represented the linear programming solution. Third, the extent that forward contracting was used in the growth plans depended on its relative position on the E-V frontier, i.e. higher growth plans utilized more forward contracting. Fourth, vertical integration activities (custom feeding and feeding in a packer-owned feedlot) were used in all growth plans except the LP solution and all plans utilized it to its fullest extent except in the first plan.

These results suggest that as firm managers become more willing to accept risk, forward contracting is utilized more extensively especially in early years of each four-year planning horizon. This result may be a little surprising.

Since forward contracting locks in the price of fed cattle in advance, it would seemingly be a less risky coordination instrument than direct purchases; the results suggest this is not the case. While forward contracting does determine the price of fed cattle, the price received for the carcasses of the contracted cattle varies until the day of sale. Therefore, the margin on forward contracted cattle is variable while direct purchased fed cattle margins are fairly stable since the time between acquiring the cattle and selling the carcasses is short. The existence of a futures market for beef carcasses may eliminate these differences because a packer who has forward contracted would be able to hedge in the carcass futures market to eliminate margin variability.

Additionally, in the later years of each horizon, vertical integration is usually employed to its fullest extent. Therefore, the trend over time is toward use of existing vertical integration capacity although additional investments in feedlot capacity do not occur.

Impact of cash and credit on growth Availability of credit was an extremely important factor in allowing present value of net income to increase, i.e., credit allowed increasing investment for movement up the E-V frontier. However, it is important to note that credit was a limiting

constraint only for the four-year growth plan providing maximum present value of net income (the LP solution). Credit aversion was not included in the model. The model illustrated the quantity of credit required for achieving a given firm growth plan. Hence, alternative risk-return firm plans indirectly considered the problem of credit allocations since large income producing plans required greater use of credit. Therefore, the level of credit useage could be viewed as being dependent on the firm manager's risk return preference for all plans except F (the LP solution).

The firm growth model with serially independent net incomes

Previous studies using quadratic programming models (8, 44) assumed serial independence of cash flows over time when discounting the variances and covariances. Therefore, a comparison between this assumption and the technique for discounting used in this study was made by assuming serial independence. Also the assumption was made to see how this simplifying assumption would affect results of the model.

The results from this analysis showed that for approximately the same net income, the variance was almost one-half the variance computed for the original model. Additionally, vertical integration activities do not appear in the solutions comprising the E-V frontier. Forward contracts and investment in additional slaughter capacity were used

more extensively when net incomes were assumed independent over time.

Most importantly, these results indicate that the idle slaughter capacity experienced in the first two plans of the original model was directly related to the discounting procedure. These results also show the possible hazards of assuming independence if autocorrelation does exist. If independence is wrongly assumed, the results will not be meaningful and the variances of the present value of net income streams will be understated.

Parametrization of the right-hand-side values

Results from parametrization of the right-hand-side show the stability of the model. The changing of these values did not affect the shape or position (except when initial slaughter capacity was reduced) of the E-V frontier. The combination of coordination activities and investment decisions were also very similar indicating that a change in the initial capacity constraints did not affect either the choice of coordination arrangements or the magnitude of the use of these arrangements.

One exception was when initial packer-owned feedlot capacity was set equal to zero. This assumption was chosen to investigate the effect of the Iowa law preventing packers from feeding cattle for their own slaughter purposes. The

results indicated that only at low levels of the E-V frontier was investment in feedlot capacity undertaken and, even then, the investment was small. These observations hypothesize that for managers who are very risk averse the Iowa law is limiting but for all other managers the law is not limiting since there is no desire for these managers to invest in feedlot facilities.

Limitations of the Research

Some limitations of the study are evident. First, the past nine years were used as a basis to project prices and therefore gross margins. Changes could occur in the future that could alter these projections. Second, estimates of variances and covariances were developed from a limited sample. As a result, the statistics obtained may not accurately reflect the true population parameters. Third, increased slaughter capacity had no effect on margins although increased competition for fed cattle would result. Fourth, no variance was assumed for management ability, investment, or other financial components in the model. Fifth, resources were assumed to be completely divisible. No disinvestment alternatives were included in the study; thus cash was not assumed to be available, if needed, from the sale of accumulated slaughter or feedlot capacity.

Additional Research

Suggestions for further research include the following. There is a need in further research to more fully investigate financial choices of a meat packer. Short-run as well as longer-run financing options should be available. Second, a coordination arrangement alternative could be included to investigate public markets, auctions and terminal markets as well as the alternatives included in this study. Third, a better estimation of expenses could be used to determine cash withdrawals. Fourth, quality, scheduling, and buying cost differences between acquisition alternatives could be considered. And fifth, different selling alternatives of carcass and byproducts could be included.

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