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Existing crop selection models do not satisfy the needs of Willamette Valley farmers. The reasons are mainly that these decision models are based on abstract concepts often confusing for the common user, and they are not readily available to concerned growers. When decision models are in a form suitable for extension education, they do not address such questions as how the risk element inherent to a set of crops varies as the crop combination changes.

The main objective in this thesis was to provide farmers in the Willamette Valley with a decision model and management information to help in making crop decisions. Secondary objectives were to derive probability distributions from past data series for prices and yields, and assess relationship among prices, among yields, and between prices and yields of selected crops; then update production costs, and finally develop and test a model which computes profit margins and risk indices

associated with alternative crop combinations.

Price data were collected for the period 1959-1980. These price data were detrended using the Exponentially Weighted Moving Average procedure. Similarly, a yield index was constructed to detrend the yield series. The resulting adjusted prices and yields were used to derive the probability distributions for each crop. Histograms of crop prices were positively skewed in most cases, as opposed to the crop yield histograms which exhibited a slightly negative skewness. The adjusted prices and yields were also used to derive the relationships among crop prices, crops, yields, and between crop prices and yields. The R^2 for most empirical equations was very low; nevertheless, the relationship between crop prices, and between crop yields was taken into account into the proposed model.

Beta and triangular distributions were fitted to adjusted crop prices and yields, and to residuals of the regression equations used to interrelate crop prices and the crop yields.

The inputs of the model are: price and yield probability distributions, regression coefficients, production costs (adjusted), living expenses, and withdrawals, loan repayment, capital expenses, and the tax rate schedule. The model uses the specified price and yield probability distributions to generate random values for crop prices and yields, and computes lowest, highest, and average cash balances, and probabilities of being below specified cash balances.

The simulation model was run for a case farm with 400 acres of cropping land, and for which five crop combinations were defined. The results indicated that the crop combination comprising snap beans, sweet corn wheat and strawberries was the most attractive, in terms of risk indices and returns, of all five combinations defined. Results also indicated that the cropping system including snap beans, sweet corn, and wheat was associated with higher returns and lower risk indices than were the crop combinations involving only snap beans and wheat, or sweet corn and wheat.

Consideration of Risk in Crop Selection for Willamette Valley Farms

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L. G. D.

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CHAPTER I

INTRODUCTION

General Situation

Crop selection is a topic which has been discussed by many authors (Heady (1952); Hazell, Yahya and Adams). It is a critical aspect of the planning process in which farmers are engaged each year. Bristol conducted a survey in the Willamette Valley in which farmers were asked "how important is crop selection in the overall management of the farm?" Ninety percent of them answered that it was "one of the most important decisions"; five percent answered it was "an important decision," and five percent replied it was "not an important decision." The result of the survey expresses the significance of the crop selection decision, which has for a long time attracted farmers and economists' attention.

Prior to growing period, the farm manager[1/] faces a difficult choice among alternative courses of action available to him. In the decision process, managers are guided by objectives (business

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1/ The farm manager may be the owner of the farm business, or may be an employee hired for the purpose of managing the farm. It is understood throughout the thesis that the terms farmer, farm manager, farm decision maker refer to the person who has the power to make decisions on the farm. These terms are used interchangeably.

survival, growth, family life-style, etc.) which differ from one individual to another. In Bristol's survey, when farmers were asked about their management objectives, 55 percent answered that profit was their primary goal; 45 percent answered that profit was one of their primary management objectives. The survey showed that security and then life-style were also significant objectives for 60 percent of the farmers surveyed.

The choice of a farm plan is rendered difficult by the fact that the impact of a decision taken at planting time will not be realized until the crop is harvested. At that time there is no opportunity for correction. What will happen in the future cannot be predicted with accuracy. For example: events that can occur include bad weather (yield is reduced), government action (grain embargo on a buyer country); hence, there always exists a certain level of uncertainty regarding a course of action.

The crop selection decision is complex, due to the stochastic nature of the production factors among which are yields, input and output price levels. Clearly, these factors are not fixed, and may vary from year to year; and the decision maker doesn't know in advance what their exact values will be in the future.

Another aspect of the crop selection problem is that different crops require different levels of investment: on one side, crops such as bush beans and sweet corn require costly field operations;[2/]

[2/] Costly field operations relate to heavy and light land preparation for which crawler and wheel tractors, with a power range varying from 35 to 120 HP, are used.

on the other side, crops such as wheat need relatively less of such operations. Yet, the input cost level of a crop is not necessarily related to the corresponding returns.

The characteristics of alternative agricultural activities are diverse, and that makes the task of the farm manager a complex one.

Area of Study

The area of study is the Willamette Valley in Oregon. It is also known as Agricultural District I, one of six districts that comprise the state's agricultural map (see Figure 1). The Willamette Valley lies between the Cascade and the Coast Mountains. The soils in the Willamette Valley are fertile. They include silty to clayey Willamette, Malabou, Woodburn, Amity, and Dayton soils on terraces; on flood plains, they include loamy to clayey Newberg, Chehalis, Waldo, and Bashaw soils. The climate in the valley is mild, humid, and equable, with a long growing period. Precipitation falls during the cool period, whereas summer remains dry. Extreme temperatures and snow blizzards which pose a threat for crops in some other areas of the nation are rare in the Valley. As a result of these favorable natural factors, the production of a wide variety of crops, such as grains, legume seeds, field crops, vegetables, tree fruit and nuts, small fruit and berries, Christmas trees, etc., is possible (Miles, 1977). Apparently, the Willamette Valley seems to be a "blessed" land for agriculture; however, it becomes appropriate to inquire about what presently is the role of agricultural activity in the Oregon economy, especially the importance of the Willamette Valley agricultural production to Oregon agricultural output as a whole. In

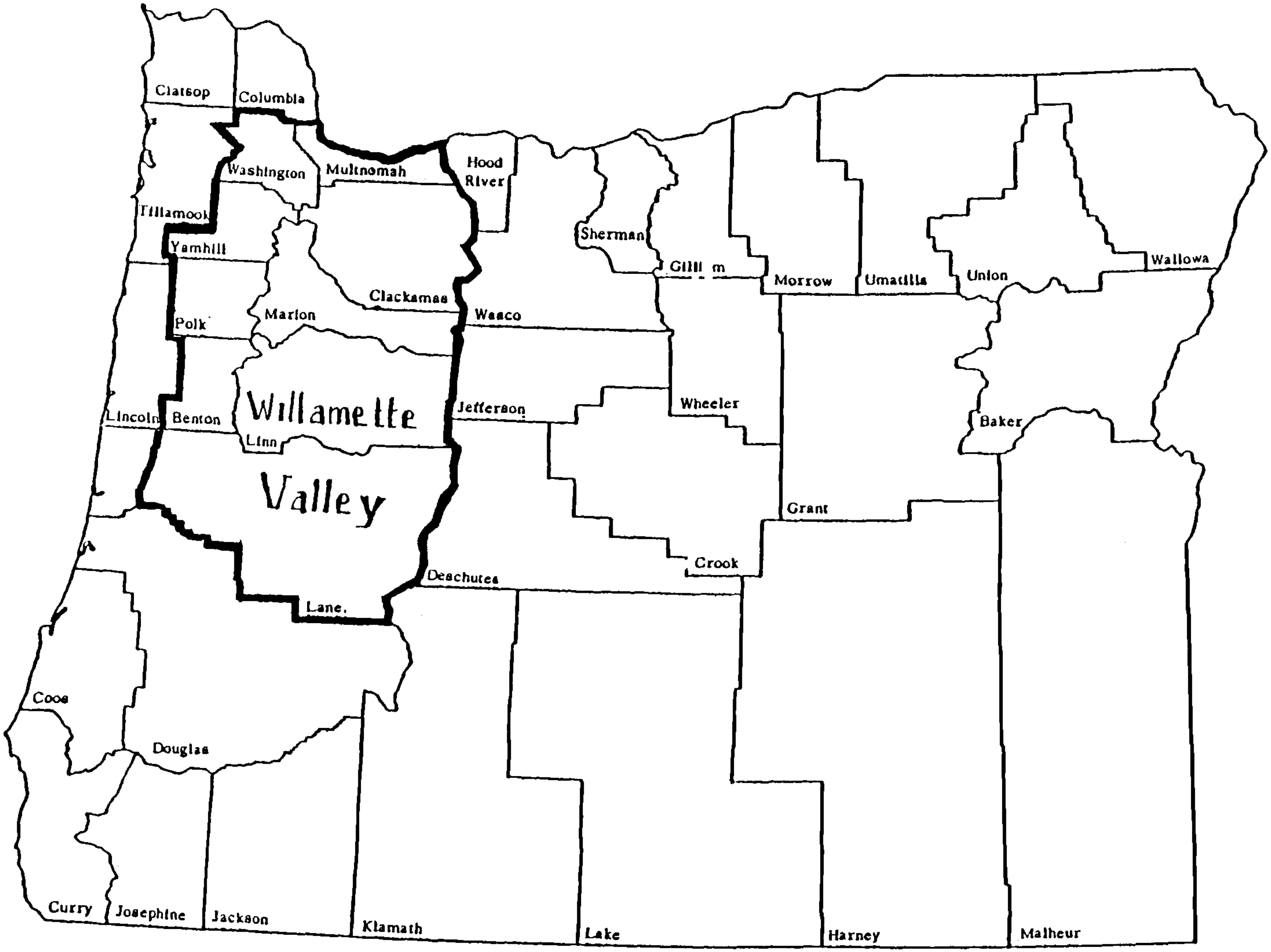


Figure 1. The Willamette Valley in Oregon.

the following, we try to provide an answer to that inquiry.

The estimates for Oregon Farm Gross sales amounts to $1.74 billion (Miles, 1981), which in turn generates an extra economic activity through the multiplier effect. The share of the Willamette Valley output is estimated to be $.71 billion, or about 41 percent of Oregon's total gross farm sales.

Tables 1-1 and 1-2 show the statewide distributions of harvested acreage and gross farm sales, respectively. These tables are derived from preliminary estimates established by the Oregon State University Extension Service. Their purpose is to indicate the relative importance of the Willamette Valley compared to the other agricultural districts in the state. Figures at the bottom of each column in Table 1-1 show the percent of harvested acreage related to each enterprise. Grain acreage accounts for the biggest portion with nearly 46 percent. The last figure in each row indicates the share of harvested acreage pertaining to each district. District 4 has the largest share of harvested crop acreage: 33 percent followed by District 1 with about 28 percent.

In Table 1-2, the last figures in each column indicate the percent of sales accrued to each enterprise. Again, grains dominate all the other crops with about 20 percent, but comes behind livestock, which account for 35 percent of total sales. Reading Table 1-2 by row reveals that nearly 41 percent of gross sales originates from District 1, which, as I mentioned, accounts for about 28 percent of harvested acreage.

Besides its agricultural production, District 1 (the Willamette Valley) is the home of about 70 percent of the population in the

TABLE 1-1

Distribution of Harvested Acreage 1980[P]

	Grain	Hay & Forage	Grass & Legume Seed	Field Crops	Tree Fruit & Nuts	Small Fruit & Berries	All Vegetable crops	Others	Total
				%					
District 1	8.69	5.17	8.85	1.02	1.07	.40	2.41	.06	27.67
District 2	.13	1.16	.01	.01	-	.04	-	-	1.35
District 3	.43	2.56	.02	.04	.38	.01	.03	-	3.47
District 4	27.37	4.01	.09	1.26	.72	-	.97	.01	34.43
District 5	5.23	7.16	.54	.96	.03	-	.34	-	14.26
District 6	3.87	13.56	.47	.94	-	-	.02	-	18.86
Total	45.72	33.62	9.98	4.23	2.20	.45	3.77	.07	100.04

Source: 1980 Oregon County and State Agriculture Estimates Special Report 607, March 1981, Oregon State University Extension Service.

P Preliminary

TABLE 1-2

Distribution of Gross Sales 1980[P]

	Grains	Hay & Forage	Grass & Legume Seeds	Field Crops	Tree Fruit & Nuts	Small Fruit & Berries	All vegetable Crops	Others	All Livestock	Total
				%						
District 1	4.71	.63	4.53	2.06	1.76	1.49	4.13	9.56	11.80	40.67
District 2	.06	.03	-	.01	-	.20	.01	1.02	4.40	5.74
District 3	.18	.13	.03	.08	1.08	.02	.08	.74	2.63	4.97
District 4	10.99	1.22	.06	2.75	3.24	.01	.71	.43	3.45	22.86
District 5	2.34	.76	.47	1.93	.09	-	.90	.11	5.79	12.39
District 6	1.55	2.48	.35	1.96	.02	-	.04	.19	6.78	13.37
TOTAL	19.83	5.25	5.44	8.79	6.19	1.72	5.87	12.05	34.85	100.00

Source: 1980 Oregon County and State Agriculture Estimates, Special Report 607, March 1981, Oregon State University Extension Service.

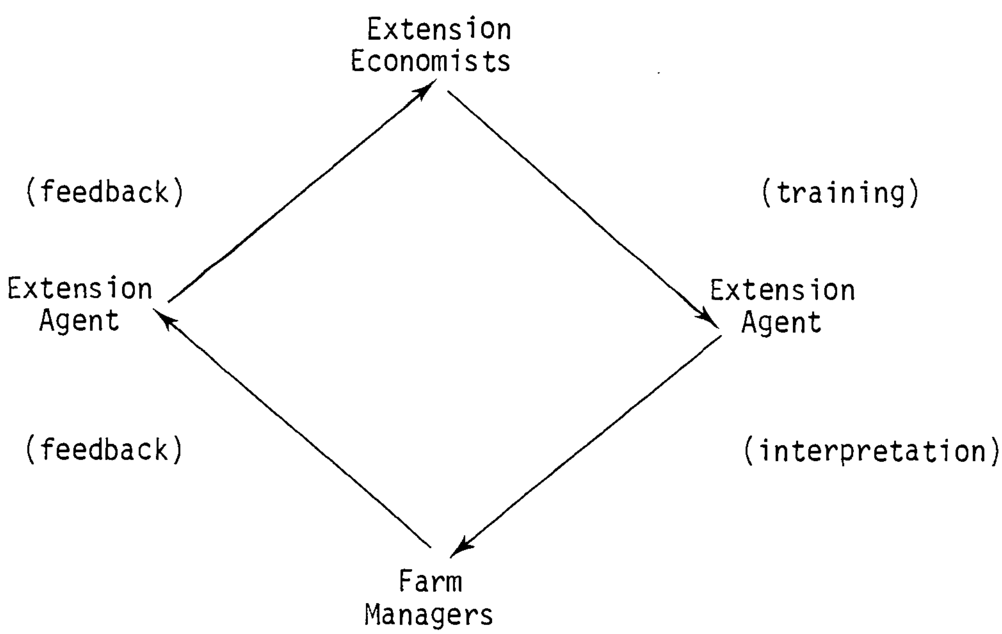
P Preliminary

state. Following that, it is easy to understand that the valley is often called the "heartland" of Oregon.

Problem Statement

Economic information and management techniques have been developed by agricultural economists, to be used by farm decision makers. The "know how" required to use these techniques is communicated to the extension agents who in turn guide the farm managers in the decision process. These extension agents maintain contacts with both the economists and the farm decision makers. The connection between economists, extension agents, and the interested growers can be summarized by the following diagram.

Model Development and Testing



Model Application

Despite the availability of existing management tools and information systems, the selection of a crop plan is still a major concern for farmers in the Willamette Valley. The relevance of this situation can be made explicit by quoting Bristol who wrote:

> "This situation may be the result of a combination of several factors. First, farmers may not be adequately aware of the appropriate information and analysis techniques available to them for making crop selection decisions. Second, this information and these techniques may not be in a form or presented at a level usable by the average farmer. Third, much of the information and/or analysis techniques are not appropriate or practical for use by farmers in making actual crop selection decisions...." (Page 7).

In light of the above observations, we can conclude that farmers need simple and easily applied management tools, as well as price, yield, and cost information, to aid them in solving the complex decision problems.

Research Objectives

This work has one major objective, which is to provide farmers in the Willamette Valley (and in other areas) with a set of decision tools and management information to aid in making crop selection decisions. The decision aids should not be too naive to violate economic and statistical theories, but they should be simple enough to guarantee their practicality. To achieve that goal, some subobjectives must be satisfied, which are to:

a) Estimate probability distributions from past data series for prices and yields, and derive correlation relationships among prices, yields, and among prices and yields.

The crops to be considered will be designated later.

b) Determine and update production cost for the crops to be selected. Such costs are compiled by the extension economists, but very often they (the costs) pertain to previous years. Thus, they need to be adjusted to reflect current figures.

c) Develop and apply a model to compute profit margins, and assess the risk associated with the alternative crop combinations. These measures are based on the information about production costs and the probability distributions of prices and yields referred to above.

It is apparent here that no probability distribution will be derived for production cost. This quantity generally includes several items which are affected differently by technological developments, oil prices, and government regulations. The difficulty of adjusting every item's cost for the period of study is prohibitive. The cost problem has been discussed by Carter and Dean, Pope, and Bristol. All authors unanimously recognized the difficulty of obtaining cost series. The fact that these figures are not readily available for all relevant years precludes considering costs as stochastic variables.

Crops in the Study

Table 1-3 shows a partial listing of the commodities grown in the Willamette Valley. As stated earlier, one sub-objective of this study is the derivation of the risk associated with certain

Table 1-3

Partial Listing of Agricultural Commodities
Grown in the Willamette Valley.
1980 Estimates

	Acres	Percent of State Total	Production	Percent of State Total	Value of Production ($000)	Percent of State Total
Wheat	254,300	18.84	17,915,300 Bu	23.15	72,932	23.68
Alfalfa	26,400	6.20	113,000 T	6.65	10,151	6.82
Annual Ryegrass Seed	122,000	100.00	204,000,000 lbs	100.00	22,440	100.00
Perennial Ryegrass Seed	65,230	95.93	59,687 000 lbs	94.44	22,846	93.92
Peppermint for oil	21,600	48.00	1,240,510 lbs	45.94	11,337	46.65
Snap Beans	30,000	96.46	156,580 T	97.57	24,356	97.91
Sweet Corn	29,920	88.78	259,250 T	88.63	16,458	90.31
Strawberries	4,715	90.67	42,429 000 lbs	91.64	14,011	91.37

Source: Office of Economic Information, Department of Agricultural & Resource Economics, Oregon State University.

crops. The following commodities are the focus of interest: annual ryegrass, peppermint for oil, snap beans, strawberries, sweet corn and wheat. The selection of these commodities was based on four issues: a) their importance, in terms of acreage and gross farm sales, to Willamette Valley farmers; b) the crop combination patterns common to the Valley, for example, farmers producing snap beans also usually grow sweet corn; c) the relative proportion of Willamette Valley production compared to the state's total output; and d) the availability of yield data. Following are more details about the relevant crops.

Annual Ryegrass. Annual ryegrass is one of the various seed crops grown in the Willamette Valley. Oregon 1980 total production of annual ryegrass seed originated in the Willamette Valley; the crop covered 122,000 acres, and generated about $22 millions in revenues in that same period. Less than 10 percent of the seed produced is shipped to other states, or exported overseas (predominantly to Europe and Japan).

Peppermint Oil. The Willamette Valley is a major producing area in Oregon. Its share of the state's total production varied from 90 percent in 1957 (see Matzat) to an estimated 46 percent in 1980. The planting period depends essentially on the current climatic conditions; it can take place in fall or spring. Harvesting activities occur from the beginning of July to late September.

Snap Beans. In Oregon, Willamette Valley producers grow the majority of the snap beans. This output accounts for about 98 percent of the state's total. The area planted with snap beans covers 30,000 acres, representing about 96 percent of the state's total. Most of the beans are canned and frozen by processors, and then marketed nationwide. The cultivation period occurs late winter or early spring. Harvest operations take place early summer.

Strawberries. From all small fruits grown in the Willamette Valley, strawberries emerge as the most important. Precipitation (40 inches), coastal winds, and the length of the growing period (estimated to be 195 days) are all factors making the Willamette Valley especially fit for small fruit production. About 92 percent of Oregon's strawberry production originates in the Valley. Cultivation activities cover the period from February to June, and harvest operations take place from late May to mid October.

Sweet Corn. Sweet corn is produced on 29,920 acres in the Willamette Valley. Sweet corn production reached 259,250 tons in 1980, which represented about 89 percent of the state's total. Planting operations take place in May through June; and the produce is harvested in late summer (August to September). A large portion of Oregon's corn is canned and frozen, then sold throughout the United States; it has a reputation of superior quality.

Wheat. Willamette Valley production for wheat accounts for about 23 percent of the state's total, making the Valley, after the Columbia Basin, the second wheat producing area in the state. Winter wheat is the predominant wheat grown in the Valley. Because of favorable weather conditions, irrigation is not required. Harvest operations take place in July and early August.

CHAPTER II

LITERATURE REVIEW

Choice Under Certainty

Microeconomic Models

In the short run, when technology is fixed, the amount of input used to produce a certain good governs the magnitude of the output; but, how much of the input to use, thus how many units to produce depends on the input and output prices. The situation becomes more complex when two or more inputs are used in the production of several commodities, as is the case on a farm where fertilizers, chemicals, and labor are the production factors for beans, corn, and wheat. The purpose of the microeconomic models is to determine the quantities of input and output adequate for the goal set by the business manager.

Consider the case of a farm business which sells its products on a competitive market, and which faces fixed input and output prices. It is assumed that the business utilizes one input to produce two commodities, say corn (Y_1) and wheat (Y_2). Its production function can be implicitly formulated as $F(y_1, y_2, x)$ where y_1 and y_2 and x represent quantities of Y_1, Y_2, and X, respectively. Solving explicitly $F(y_1, y_2, x)$ for x yields the product transformation curve $x^* = h(y_1, y_2)$.[3/] Using $h(y_1, y_2)$, we can derive a family of

3/ Jacobian = 0.

concave product transformation curves.[4/] Figure 2-1 illustrates a case with such a curve corresponding to a particular value of x*. The line EF represents an isorevenue line with P_1 and P_2 as prices for Y_1 and Y_2, respectively. The rational farm manager desires to maximize revenue given a certain cost level x*. He may also choose to minimize cost for a certain revenue level; but for this analysis let's assume that maximizing revenue is the goal. Thus it is important to find the amount of X to use and the respective quantities of Y_1 and Y_2 to produce.

For that purpose, the manager's Lagragian function W is established as:

$$W = P_1 y_1 + P_2 y_2 + \mu [x^* - h (y_1, y_2)]$$

where μ is the Lagragian multiplier; then setting the first derivatives of W, with respect to y_1, y_2, and μ, to zero we get:

$$\frac{\partial W}{\partial y_1} = P_1 - \mu h_1 = 0 \qquad (2\text{-}1)$$

$$\frac{\partial W}{\partial y_2} = P_2 - \mu h_2 = 0 \qquad (2\text{-}2)$$

$$\frac{\partial W}{\partial \mu} = x^* - h (y_1, y_2) = 0 \qquad (2\text{-}3)$$

Using equations (2-1) and (2-2) to solve for P_1 and P_2 gives:

$$\frac{P_2}{P_1} = \frac{h_2}{h_1}$$

4/ $h (y_1, y_2)$ is assumed quasi-convex.

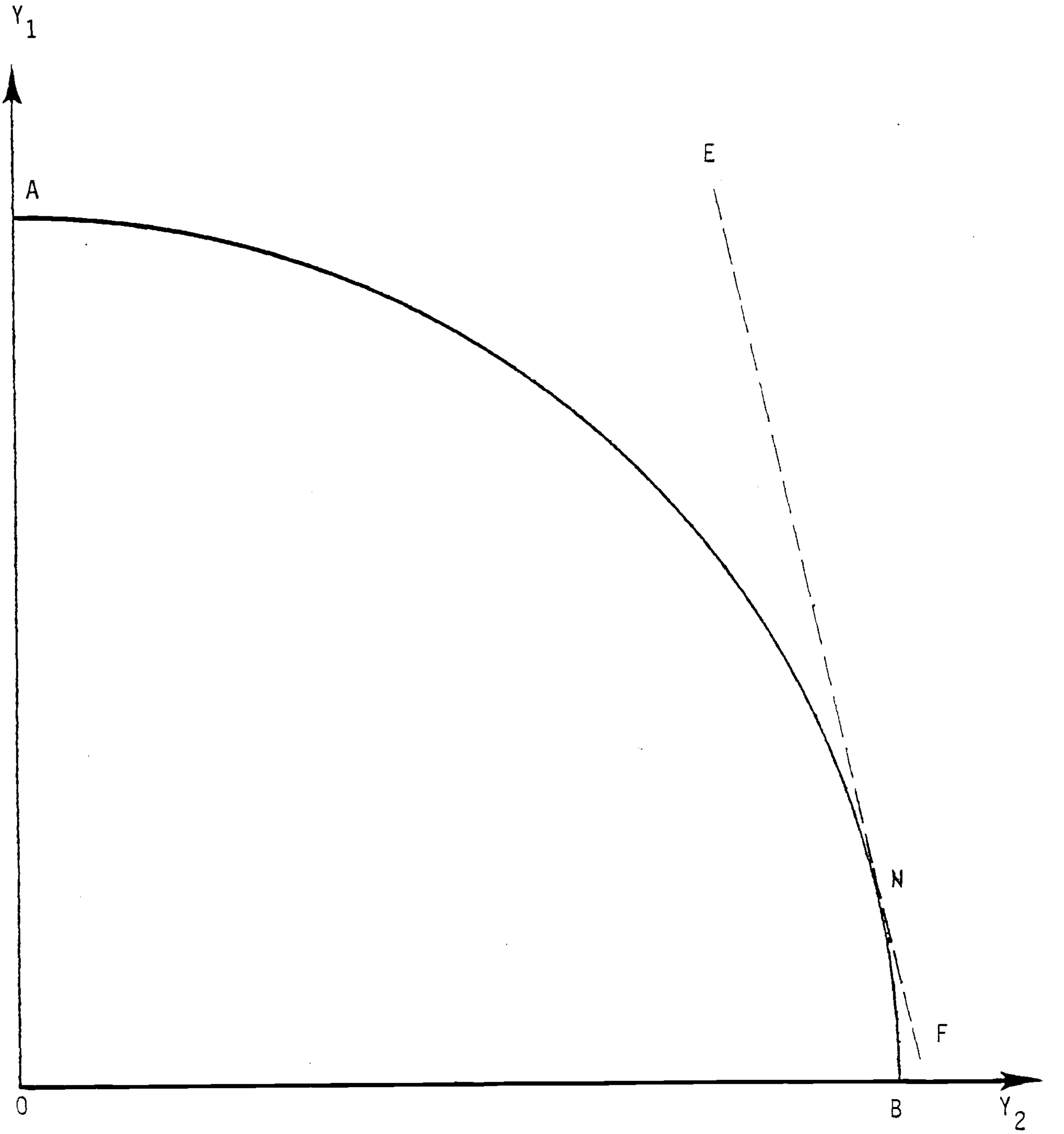


Figure 2-1 A Product Transformation Curve.

where $\frac{h_2}{h_1}$ = RPT, the rate of product transformation.

In other words, the fixed price ration P_2/P_1 has to equate the rate of product transformation. In geometric terms, maximum revenue is attained when isorevenue line EF is tangent to the product transformation curve (point N on Figure 2-1).[5/] To summarize, the price ratio is a key element in deciding in which proportion Y_1 and Y_2 should be produced.

Each price ratio defines an isorevenue line. In the following analysis, two cases involving different price ratios are presented: in the first one, the ratio of Y_1 and Y_2 prices are assumed equal to P_2/P_1; this price ratio corresponds to isorevenue line AC which is shown in Figure 2-2. In the second case, the ratio of Y_1 and Y_2 prices is assumed equal to P_2'/P_1', this latter price ratio corresponds to isorevenue BD which is also presented in Figure 2-2. If the decision maker's price ratio expectation is P_2/P_1, he maximizes revenue by specializing in the production of Y_1; the reason being that the product transformation curve is tangent to the isorevenue line AC at point A, where no Y_2 is produced (Figure 2-2). Likewise, if the decision maker's price ratio expectation is at a level equal to P_2'/P_1', he maximizes revenue by specializing in the production of Y_2; since the product transformation curve is tangent to the isorevenue line BD at point B, where no Y_1 is produced.

5/ For more details, see Henderson and Quandt (Chapter 4).

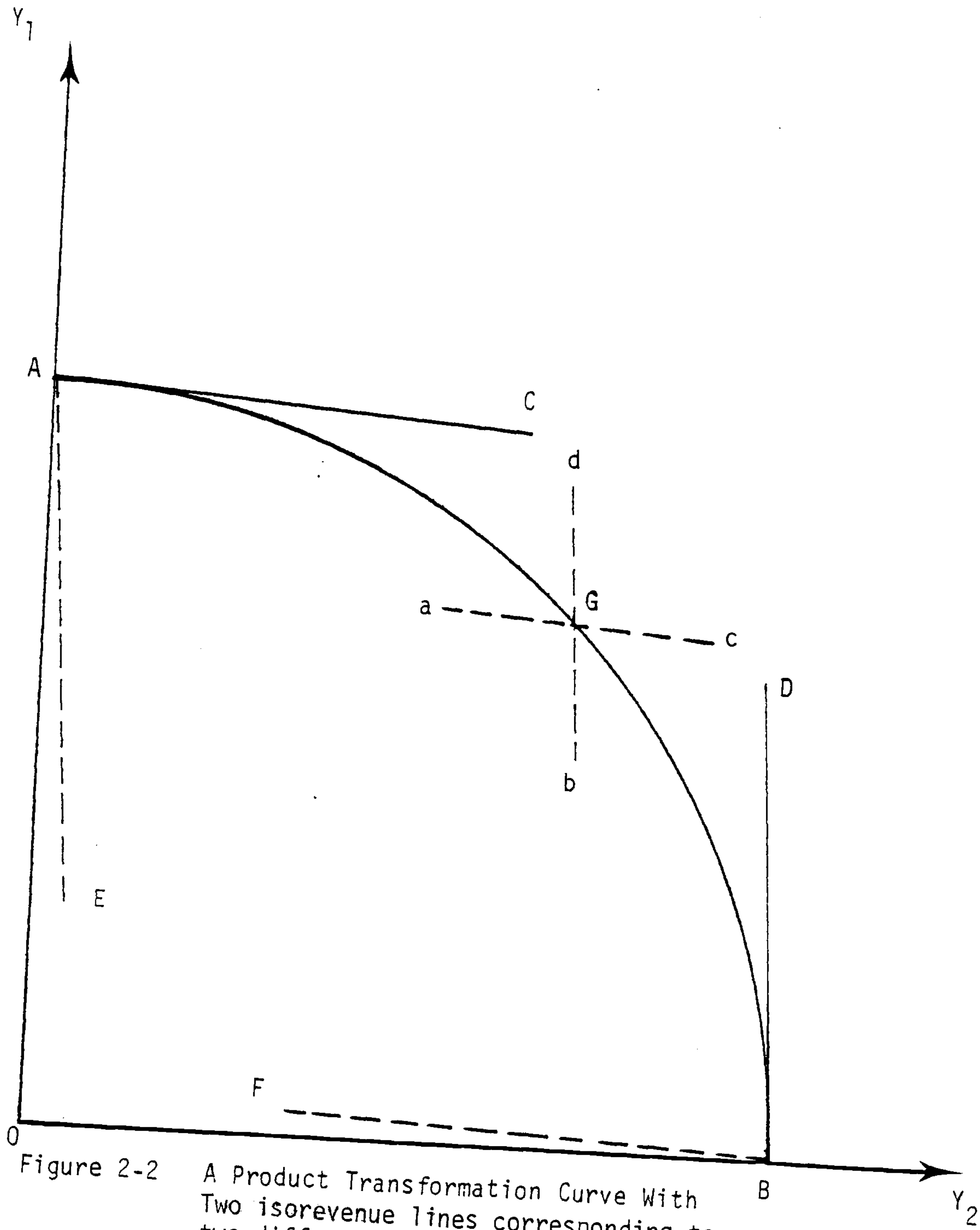


Figure 2-2 A Product Transformation Curve With Two isorevenue lines corresponding to two different price ratios.

As most farm managers know, price certainty is not the case in agriculture. At harvest time, commodity prices may turn out to be at unexpected levels. In the following discussion based on Figure 2-2, an aspect of the consequences of commodity price movements is presented.

Assume that the manager's price ratio expectation is P_2/P_1. He maximizes revenue by specializing in the production of Y_1; but he is worse off if the realized price ratio is P_2'/P_1', since his revenue line becomes BF, which corresponds to P_2'/P_1' and to specialization in the production of Y_1, instead of AC. Similarly, assume that the decision maker's price ratio expectation is P_2'/P_1'. He maximizes revenue by specializing in the production of Y_2; but he is worse off if the realized price ratio is P_2/P_1, for his revenue line becomes AE, which corresponds to P_2/P_1 and to specialization in the production of Y_2, instead of BD.

The price for specialization is high, especially when price expectations don't come true. An alternative to these two extreme single commodity production cases (points A and B) is the choice of point G on the product tranformation curve AB. At point G, both commodities are produced, and that offsets the effect of a price change; for, increased revenue from one commodity compensates the revenue shortfall from the other one (Heady 1952 (a)).

Enterprise Budgets

Budgeting is a technique used by businessmen to evaluate projects. As Castle, et al. explained it, the budget is a way of testing alternatives by means of "organized arithmetic." To farmers, budgeting relates to defining the contribution margin to net income for each crop candidate for inclusion in a cropping system. But, the contribution margin alone is not an ideal criteria to select an enterprise mix; some other factors, including contribution to insect, weed, and disease control, soil fertility and conservation could be as important. Nevertheless, the analysis in this section will focus on how a budget's development can aid to choose the elements of a cropping system. Two types of budgets are presented; mainly, the partial and the cash flow budgets.

The Partial Budgeting

Partial budgeting is appropriate when a contemplated change in the business organization is "marginal"; that is, if most of the enterprises remain unchanged (Castle, et al.). Partial budgeting requires estimates of crop yields and prices to calculate farm revenues, which serve as a basis for comparison between the existing organization of the business and the proposed change. The decision criterion centers on four items: the added costs resulting from the acquisition of extra production factors, the added revenues accrued to the added activity, the reduced costs pertaining to the reduced enterprise (if there is one), and the reduced revenues related to the reduced activity. For the decision rule, the reduced revenues and the added costs are substracted from the sum of the added revenues and reduced costs:

Net change = (added revenues + reduced costs) - (added costs + reduced revenues)

A positive net change indicates a total net revenue or net income enhancement as a result of the proposed business organization. Thus, the decision maker can proceed to further analysis.

The Cash-Flow Budget

This budget summarizes monthly and/or quarterly cash inflow generated from sales receipts and money borrowed, and the cash outflow resulting from capital investments, operating expenses, loan repayments, family living expenses, and withdrawals. The cash-flow budget is typically established for a twelve month period. It shows the monetary timing of purchases and sales related to activities on the farm, and determines cash surpluses or deficits. A cash deficit in a given period of time (outflows outweigh inflows) means that borrowing is necessary to finance the activities in that period. A cash surplus (inflows outweigh outflows) means money is available for current needs or carry over. One other figure which appears on the cash-flow budget is the ending balance, which is the cash available to the business at the end of the operating period. This latter value, together with the periodic cash surplus or deficit, constitutes another basis for comparison between different alternatives.

Enterprise budgets are useful tools of decision making. They provide information about the profitability of individual enterprises. However, their limited insight in prices and yields affects the quality of the information they provide. Thus, crop selection decisions should not solely be based on enterprise budget analysis. There is a need to consider the variability of the decision variables, to be consistent with the "real world" situations. Sensitivity analysis is a way to answer that need. With this approach, different cases involving various price and yield levels are explored; that allows the decision maker to measure the importance of a change in any of the decision variables, and thus raises his awareness about potential financial difficulties related to possible outcomes.

Linear Programming

The development of computers as a computation tool had a favorable impact on the use of linear programming (LP). According to Hillier and Liebermann, LP relates to "the problem of allocating limited resources among competing activities in the best possible (i.e., optimal) way" (p. 16). In other words, LP refers to planning activities with net revenue optimization as a goal. The LP technique makes use of mathematical models to describe the decision problem. For the purpose of this section the general standard form of the LP model will be presented. The reader may find an illustration of the model in existing publications, among which are Hillier and Liebermann, and Bauer.

The decision problem is generally a linear objective function to maximize, subject to some linear resource constraints. Symbolically, the standard LP model appears as:

$$\text{Maximize } Z = C_1q_1 + C_2q_2 + \ldots\ldots C_nq_n, \qquad (2\text{-}4)$$

$$\text{subject to } kQ \leq B$$

and

where Z = farm income

C_i = unit value (parameter)

K = m*n matrix of technical coefficients

Q = column vector of activity levels

q_i = activity level for enterprise i

B = column vector of resource constraints

$q_i \geq 0$ is a positivity constraint

The model so specified is coded on computers; when the parameters C_1 and the resource constraints are determined and fed into the computer, it outputs the value of the q_i's for which Z is maximum, given the constraints. In the agricultural context, when crop prices are specified as well as the land, water, and labor constraints (to cite only these), the computer outputs the quantity of each crop to produce for a maximum value of gross income Z. Net income can be maximized by the same algorithm if a cost function is defined and included into the objective function.

The LP model makes an assumption of price certainty, in the sense that the relevant variable is deterministic in the model. This assumption reduces the usefulness of the LP model, for in "real world" situations, price stochasticity is eminent. Probabilistic models are often referred to when dealing with the stochastic nature of decision variables such as crop prices.

Choice Under Risk and Uncertainty

Characterization and Assessment of Risk

Risk vs. Uncertainty. The terms risk and uncertainty are commonly found in the literature. According to Deaton and Muelbauer, risk and uncertainty are relevant whenever there exists a time space between an action and its consequences. To further use these terms more adequately, it appears necessary to assess their difference, if any.

Knight mentions an important distinction between risk and uncertainty. He suggests that risk refers to a situation where the probabilities of occurrence of events are known. For example, assume that one can win or lose five dollars if the toss of a fair coin showed head or tail. The probability of occurrence of both events is known to be one half and one half; this situation is one involving risk. Knight also argues that uncertainty refers to a case where the probabilities of occurrence of events cannot be easily defined. For example, the probability to have one half of all Willamette Valley corn producing farms converted into Christmas tree farms, two years from now, is rather unknown. In the latter case, uncertainty is relevant.

The distinction between risk and uncertainty depends pretty much on the subject matter. In the area of agriculture business, the farmer is not totally ignorant about the chances of the possible outcomes, as far as crop prices and yields are concerned. The farmer, even the beginner, can almost always get some information about past input, output prices, and yields levels for a particular crop. This reality leads to the question of whether the farm decision maker is in a situation of risk or uncertainty. To answer that question let's state that for agricultural business analysis, previous crop price and yield information is available in most cases; also, some farmers who have grown a crop for a fairly long period of time have become familiar with the factors which influence the price and yield of that particular crop. Based on these observations, uncertainty can be considered as irrelevant when we refer to the two variables named above. Risk, as defined by Knight cannot be relevant either, for the probabilities of all possible outcomes for crop prices and yields are not known.

However, based on the fact that proxies for risk measures, related to selected decision variables can almost always be derived from past and current information, the author believes that for agricultural decision analysis, risk can be considered as relevant.

Concept of Risk in Agriculture. Risk is the main component of the discussion in this thesis. The aim at the present stage is to bring the reader closer to the situation on a farm, thus widening his understanding of the remaining part of this work.

It was written in the preceeding section that there is risk whenever an action and its consequences occur at different periods, and when these consequences can't be known *ex ante*. This observation is a perfect match for agriculture enterprises where capital has to be committed at the beginning of the growing period; it is impossible to grow a crop before financial commitments are made on the land and equipment. These elements are rented and/or purchased.

Yet, nothing guarantees that crop prices and yields will reach the levels expected by the farm manager. Nelson, et al. define risk as "the chance of adverse outcomes associated with an action." Some authors use a different concept; among them Young refers to the variability concept, and suggests that risk can be defined as the second moment about the mean of the manager's probability distribution of the variable of interest; that is, risk can be measured by:

$$V(Y) = E\,[Y - E(Y)]^2$$

Both of these definitions refer to different aspects of risk. The first definition relates to the chance of a low value for Y, whereas the second definition indicates how variable Y is. Basically, the consideration each farmer gives to the chance of a "disasterous outcome" varies among farmers. For each individual, the financial leverage is an important factor which plays a key role. A farm business with a large proportion of assets over liabilities can easily survive a noticeable price fall and/or crop failure. The manager of such a business will be much more interest in how variable yields and prices (for the relevant crops) are, rather than in the probability of "bad events." At the opposite side stands the farm business with a high debt to asset ratio. In this case, the probability of meeting financial commitments will get more consideration. It seems reasonable to think that not all farm units are maintaining a secure equity portion on their operation. There certainly exists "marginal" type farms for which "safety first" is a rule. Therefore, it doesn't appear appropriate to choose only one risk concept for extension education purposes. Both concepts of risk are useful and, as a result, a consistent extension program should consider them altogether. It may not be easy to derive net income variability measures common to production areas where production costs differ significantly; however, this goal can be achieved at the regional level where farming practices and costs are similar among farms.

Up to now, the discussion has been directed to the definition of risk. The following provides some information about potential sources of risk for a farm business.

Sources of Risk in Agriculture. Risk is an important part of the decision making process, for it is related to the production and marketing activities. Clearly, crop prices and yields can take very low values, therefore generate low revenues which endanger the very survival of the farm unit. Also, government regulations and human loss are factors which can have a negative impact on farm revenues. Nelson, et al. sorted out seven sources of risk which are:

1. Production and Yield Risk: It is a consequence of the variability of yield and production due to such factors as weather conditions, diseases, pests, genetic variation, and timing of practices.
2. Market and Price Risk: Derives from the variability of input prices which determines the cost of production. Output prices may vary according to economic factors (law of supply and demand), speculation, and government programs.
3. Business and Financial Risk: Refers to the solvency of the business. The business will be doomed to bankruptcy

if it cannot meet its financial obligations; and that may happen in a low price (or low yield) season.

4. Technology and Obsolenscence: The development of a new technology can render the piece of equipment the farmer has just purchased obsolete; rival businesses will be using more efficient production means by comparison to what he has.
5. Casualty Loss Risk: Relates to the loss of assets, theft, and a series of natural factors such as wind, hail, and flood.
6. Social and Legal Risk: Government regulations are not always blessed by farmers, for controls on chemicals and feed often prohibits the use of the ones they (the farmers) feel are more efficient.
7. Human Risk: This source is inherent to human nature. The risk involved can be of several types from which a few are presented: a) Personal loss (death, injury, illness) at a crucial stage of the production period, b) change in family needs and goals.

The preceeding paragraphs have provided some background about the conceptual forms of risk. In the following sections, the concept of probability will be reviewed, and interest will be focused on how the farm manager determines his strategies in the light of the information on the various sources of risk. For simplicity reasons, yield and crop prices will be considered as the prevailing sources of risk in this thesis.

Various Types of Probabilities. In the agricultural decision process, the derivation of risk measures is subject to debate among economists; some of them advocate subjective risk indices, whereas some others favor objective indices. In this section, three concepts of probabilities are presented, among them are:

1. Local Probabilities: Relate to the toss of a fair coin. The laws of physics and the characteristics of the coin are known. So, the probability of obtaining tail or head when such a coin is tossed is one half. Unfortunately, the laws that influence the occurrence of events in agriculture are not known exactly, and that leads us to discard logical probabilities in deriving risk measures.
2. Objective Probabilities: Are derived from successive measurements. The quantity of rain, for example, is recorded every day, at the end of the year the probability of obtaining X inches of rain can be computed as the relative frequency of obtaining X inches of rain. Generally, the concept of objective probabilities is based on an infinite number of trials, and the probabilities are viewed as limits of relative frequencies (Anderson, Dillon, and Hardarker). Whether crop prices or yields are being considered, the frequency of having the variable in a certain interval is commonly used.
3. Subjective Probabilities: Represent the strength of conviction an individual has about the occurrence of a particular event. A farmer who has just learned about

an OPEC[6/] oil price increase will have a strong belief about high fertilizer prices in the next upcoming season. The probability which such an individual attaches to future input prices may be significantly different from that of an uninformed one. This example, typically, characterizes the subjective concept of probabilities.

The choice between risk measures computed from historical data series and subjective beliefs is a major issue. Proponents of the subjective probability approach such as Anderson, Dillon, and Hardaker, Lin, Dean and Moore argue that the changing markets, developments of new varieties, and the appearance of new diseases put historical data in a dubious position for computing a risk index. They also indicate that probability distributions derived from past data series are based on a relative frequency approach, whereas the repeatability of events in agriculture is questionable. The authors state that the decision maker is the only one responsible for the consequences of each action he takes, and therefore, his subjective judgement should weigh more than anything else.

However, many authors (Young, Moscardi and DeJanvry, Brink and McCarl) favor the objective concept of probabilities. Among them, Young affirms that the cost to get and update all manager's subjective judgement will limit the applicability of the approach favored by Anderson, et al. Roumasset, as quoted by Calvin, joins

6/ Organization of Petroleum Exporting Countries.

Young to observe that subjective probabilities restrict normative analysis to information available to the decision maker, who appears to be in a doubtful scientific position. An intermediary approach presented by Young is to provide raw data to the managers, to help them establish their own subjective judgements. As the author wrote it, that method would require from the manager the capability of processing the raw input. Unfortunately, that condition is not satisfied in most cases.

The debate between proponents of subjective probabilities on one side and proponents of objective probabilities on the other side is still relevant. The arguments for and against each of the two methods of measurement for risk are more or less convincing; the selection of any procedure, therefore, depends on the judgement of the researcher.

In this thesis, no attempt is made to derive subjective risk measures; both cost and time constraints being the main reasons. The intention here, is to derive risk measures from past data series. It is expected that these measures will be good proxies for risk for the farms in the Willamette Valley.

Theoretical Concepts Dealing With Risk

The Expected Monetary Value and "Safety First" Rules. These two concepts are grouped, for they are built on the same conceptual framework. Their purpose is to serve as a guide for the farm manager facing risky decisions. The following analysis is based on the table below called an outcome (or payoff) matrix.

	Action	
State	A1	A2
S_1	\$200	\$300
S_2	\$500	\$400

The hyopethetical figures on this table illustrate dry and wet weather conditions which are two states of nature designated by S_1 and S_2. Also presented are two alternative cropping strategies "grow corn" and "grow wheat", which are called actions, and symbolized by A_1 and A_2, respectively. Each pair of action and state is associated with a specific consequence expressed in terms of cash value. The farmer may choose action A_1 or A_2; but he does not know *a priori* which one of states S_1 and S_2 will occur after the cultivation period. Depending on his choice, he may be better or worse off if S_1 or S_2 occurs. In the following, the use of the expected monetary value (EMV) and "safety first" rules in decision making will be illustrated.

The Expected Monetary Value is based on the assumption that the farmer has some subjective knowledge about the chance of occurrence of S_1 and S_2. Empirically, that chance can be defined as .3 for S_1, and .7 for S_2; then, the respective EMV's for actions A_1 and A_2 equal:

$$(.3)\ (220) + (.7)\ (500) = \$416$$

$$(.3)\ (300) + (.7)\ (400) = \$370$$

According to Nelson, et al., the farmer is risk neutral if he chooses the action that maximizes EMV, i.e., A_1.

One of the farm decision maker's goals is to maintain the safety of the business. That is, any action capable of resulting in a revenue shortfall will be avoided. Businesses generally borrow to finance capital requirements, and a certain amoung of that debt has to be retired each year; thus, failure to meet the financial obligation can mean liquidating some farm assets, which leads to the end of the business. To illustrate the application of the "Safety First" rule we will go back to the prespecified actions A_1 and A_2, and states S_1 and S_2. It was found earlier that A_1 had the highest expected monetary value; however, when the "safety first" rule prevails, it may not be chosen by the farmer, because it is associated with the lowest payoff, \$220. If the grower sets \$300 as a critical income value, action A_1 will be rejected to insure the safety of the business, and A_2 would be chosen. If the critical income value is \$200, A_1 remains a valid choice under the "safety first" rule.

The two concepts presented in this section offer a great deal of simplicity; meanwhile, they tend to minimize the assessment of the risk element used in the calculation of the EMVs. Furthermore, the ability of these techniques to satisfy cases where two or more crops are grown, and where the interaction between activities may be eminent, is questionable.

The Expected Utility Concept. The computation of the expected utility (EU) follows the same procedure as the calculation of the EMV; but utility values are used in this case in place of the dollar gains in the latter case.

Consider that α_i represents action i, S_j a state of nature, and associate to each combination of action i and state of nature j a consequence γ_{ij}. This relationship enables us to construct the outcome matrix below.

Action

State	$\alpha 1$	$\alpha 2$
S_1	γ_{11}	γ_{12}
S_2	γ_{21}	γ_{22}
S_3	γ_{31}	γ_{32}

The actions here represent different enterprises which the farmer can choose to run for a particular period. The states may stand for any factor influencing production and/or profit, but in this case they relate to quantity of rainfall. Let's assume that a farmer is facing two production possibilities which can be identified as "grow corn" and "grow wheat". The issue at stake is to determine how the farmer in such a situation selects one alternative among the two available to him. The relevance of this question arises as a result of the uncertainty around the consequences of each action.

Prior theories emphasized on the maximazation of the expected value. Then Bernouilli explaining the St. Petersburg Paradox[7/] applied the concept of the expected utility. He showed that in a situation of choice involving risk, expected utility, as defined then, was being maximized, but not the expected value. Challenging the opponents of the expected utility maximization concept, Von Neumann and Morgenstern established a set of axioms of choice, which explain the behavior of the individual facing a risky choice. These axioms, as presented by Schoemaker, are:

1. The complete ordering axiom: "For any two lotteries L_1 and L_2, the decision maker prefers either L_1 to L_2 or L_2 to L_1, or else is indifferent. Furthermore, if L_1 is preferred to L_2 and L_2 to a lottery, L_3, then L_1 is also preferred to L_3 (called transtivity).
2. The continuity axiom: "If $X dollars is preferred to $Y and $Y to $Z, there must exist some probability P (between 0 and 1) so that the decision maker is indifferent between a sure amount $Y and a lottery offering $X or $Z with probabilities P and (1-P), respectively.
3. The independence axiom: "If the decision maker is indifferent between alternatives X and Y, then he should also be indifferent between two lotteries offering X and Z in the first lottery and Y and Z in the second, with probabilities P and (1-P) in each lottery for Z and P value.
4. The unequal probability axiom: "If X is preferred to Y, then lottery L_1 should be preferred to L_2 when both lotteries contain only the outcomes X and Y and when the probability of winning X is greater in L_1 than in L_2.
5. The axiom of complexity: "If two lotteries, L_1 and L_2, offer outcomes X and Y for L_1 and produce two new lotteries, L_3 and L_4, as the outcomes for lottery L_2, with L_3 and L_4 offering only X and Y, and then the decision maker should be indifferent between L_1 and L_2 if, and

[7/] The St. Petersburg Paradox appears as follows: Peter agrees to pay Paul one ducat if the first toss of a coin shows "heads", two ducats if he gets "heads" on the second toss, and 2^{n-1} ducats if he gets "heads" on the n^{th} toss. Although Paul's classical expectation is infinite, he is unwilling to pay a relatively small amount of money to play the game (see Bernouilli).

only if, the expected values of L_1 and L_2 are identical."[8/]

Recalling the definitions of actions and states as previously formulated, and assuming that the decision maker's utility function is relevant, we write that function as:

$$U = g\ [\gamma(\alpha_1, s_1),\ \gamma(\alpha_2, s_2), \ldots,\ \gamma(\alpha_n, s_m)] \qquad (2\text{-}5)$$

where n indicates the number of actions, m the number of states, and γ a vector of consequences.

The above expression in a simpler form appears as:

$$U = g\ (\gamma_1, \gamma_2, \ldots, \gamma_k)$$

where k is the dimension of the vector γ.

Consider now that we assign a known probability $\P_i$ to any of the possible outcomes; then we can derive an expression of the expected utility which writes:

$$EU = F\ [\P_1\ V(\gamma_1),\ \P_2\ V(\gamma_2), \ldots,\ \P_k\ V(\gamma_k)]$$

where $V(\gamma)$ is a subutility function within (2-5).

With the acceptance of the Von Neumann and Morgenstern axioms, we conclude that the farm decision maker behaves in such a way as to maximize his expected utility EU.

Not every decision maker is ready to embrace risky decisions; the willingness to select high risk alternatives depends on each farmer's financial leverage, and his expectation of the future. The concept of utility function introduced above seems

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8/ This axiom guarantees that probabilities are calculated in accordance with probability calculus.

useful in providing a measure of risk aversion. The difference between what we call risk takers and risk averters will be illustrated by pointing out the distinction between the utility of the expected value on one hand, and the expected value of utility on the other hand. For that purpose, let's examine Figure 2-3.

What is shown on this diagram is a concave utility function. Utility, here, is expressed in terms of wealth. The straight line represents the expected value of utility, and the arc represents the utility of expected value. When the decision maker is offered a lottery paying different amounts of wealth, W_1 and W_2, with probabilities, P_1 and $(1-P_1)$, respectively, the decision making process is indeed a case involving risk. A decision maker is risk neutral in relation to a lottery with a dubious payoff (W_1 or W_2), if the utility of the expected value of the lottery equals the expected utility of the lottery; that is, if:

$$U[P_1(W_1) + (1-P_1)(W_2)] = P_1\ U(W_1) + (1-P_1)\ U\ W_2.$$

The decision maker is said to be risk averter relative to the lottery if the utility of the expected value of the lottery is greater than the expected value of its utility; that is, if:

$$U[P_1W_1 + (1-P_1)(W_2] > P_1\ U(W_1) + (1-P_1)\ U(W_2).$$

This inequality statement is identical to saying that the utility function is strictly concave, with the quantity $d^2\ U/dw^2$ less than 0 (portion AB of Figure 2-3). The decision maker is said to be a risk lover if the above inequality is reversed; which means that the utility function is strictly convex, the with quantity $d^2\ U/dw^2$ greater than zero (Henderson and Quandt). However, it is observed

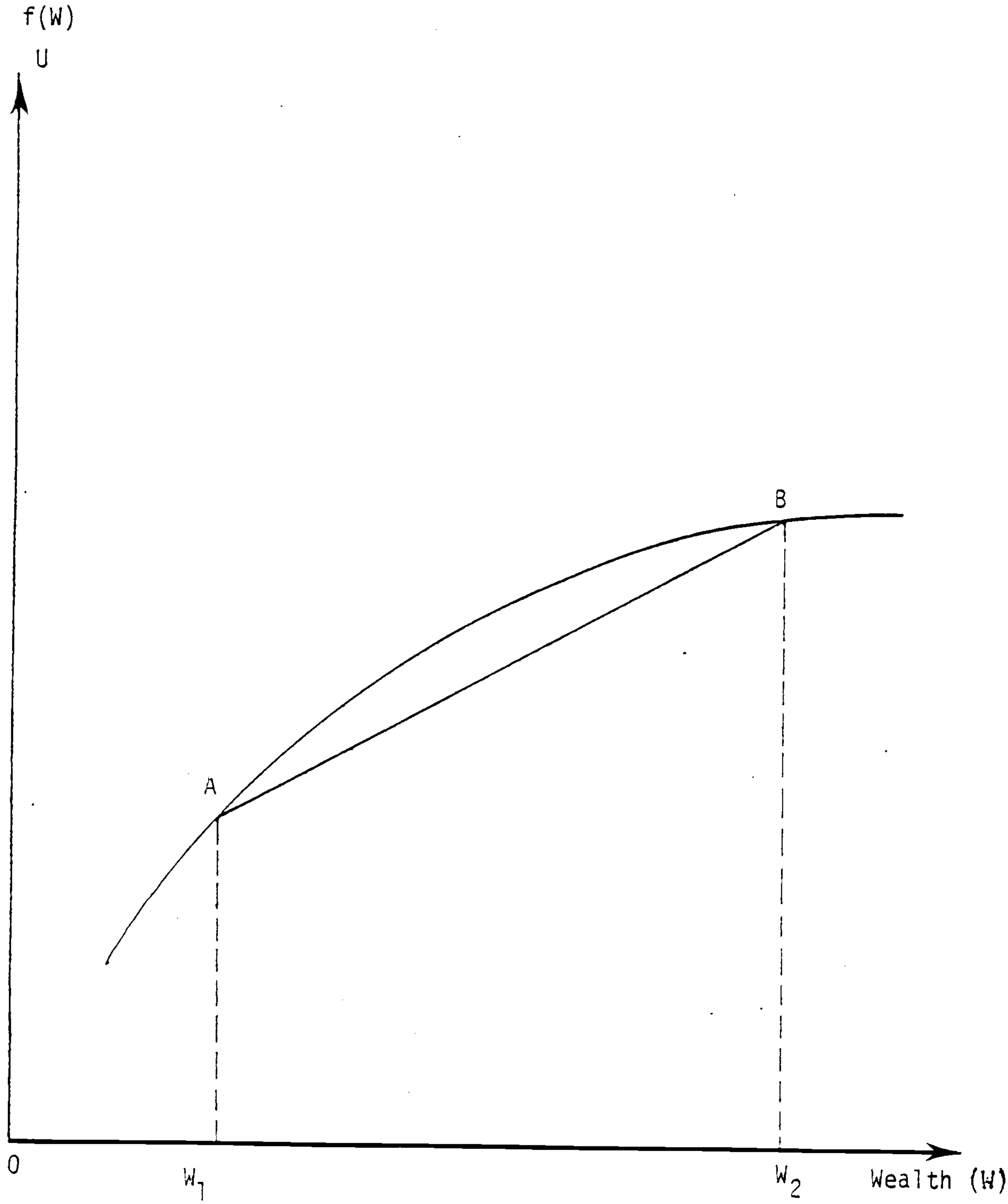

Figure 2-3. A Concave Utility Function.

that in current life, the same individual may behave both as a risk lover and a risk averter. That is what prompted Friedman and Savage to propose an hypothesis aimed at rationalizing such a behavior. In relation with their hypothesis, they proposed what is commonly referred to as the Friedman Savage utility function (Figure 2-4). The decision maker will be a risk averter and risk lover over the poritons AB and AC, respectively. Given the Friedman Savage utility function, how do we define risk aversion? The negative of the second derivative of the utility function cannot be used as a measure of risk aversion (Pratt, Deaton and Muelbauer). The derivation of a risk aversion coefficient is due to the work of Pratt and Arrow. Pratt defines the risk aversion coefficient by:

$$r = \frac{U'' (W)}{U' (W)} = - \frac{d \log U' (W)}{dW}$$

where U' (W), U" (W) stand for the first and second derivatives of the utility function, respectively, dW its first differential with respect to W.

Diversification on the Farm. There is a strong relationship between diversification and crop mix selection. Pope presented diversification in its relation with crop configuration (number of crops grown on a farm), farm size, inputs and intraseasonal factor demands, and finally with risk. Heady (1952b) presented diversification as a "mean of handling uncertainty", on the basis that in the long run, prices vary and the farm manager has no knowledge or control of future events. As Heady (1952b) wrote, farmers are advised to "get away from high risk, one-crop farming," and that

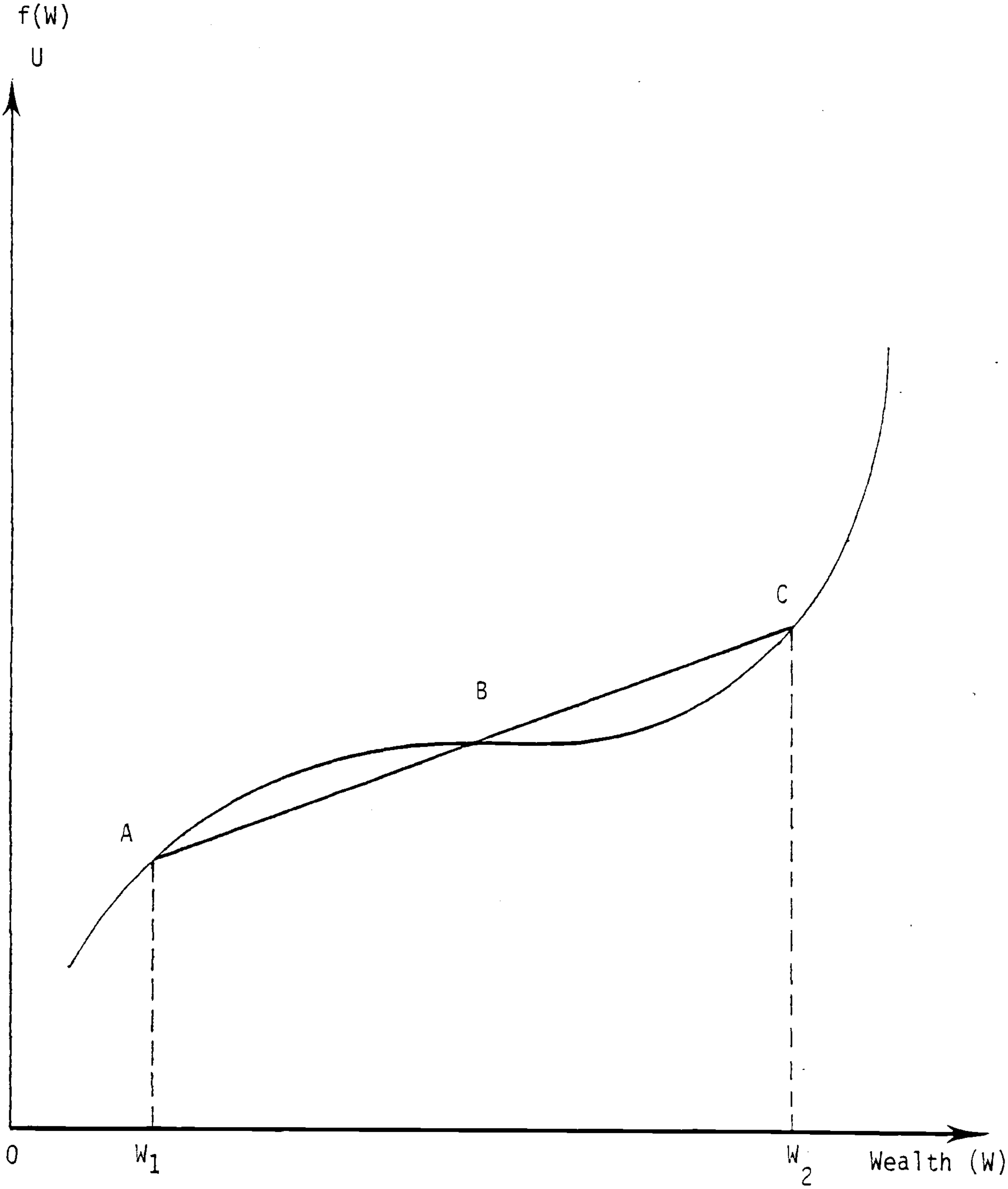

Figure 2-4. A Friedman Savage Utility Function.

one often reads that "diversification, not putting all you eggs in one basket, often is a wise procedure for a farmer who is not in a position to undertake great risks." These statements, although interesting, fail to demonstrate the "how" and "why" of diversification. According to Heady (1952a), there are two aspects involved in the practice: a) planning under perfect knowledge of future events. In that case, the firm maximizes profit by equalizing the marginal rate of product transformation with the price ratio (this point was made with the presentation of the microeconomic model), and b) the manager may consider the entire horizon as a population of cropping periods for which he wants to minimize income variability; or else, he may choose to minimize the probability of going bankrupt. Basically, there are two ways to implement diversification, which are: plentiful resources are accessible to the manager so that the farm size can be increased at will, and limited resources force the manager to the redistribution of resources among enterprises. In the next paragraphs, we will discuss each of the diversification methods, and in the process demonstrate why it is generally believed that the technique reduces risk.

To illustrate diversification by added resources, consider a firm which runs a corn enterprise with the possibility of adding a wheat enterprise to it. Denote the income variance of the corn enterprise by σ_C^2 and that of the wheat enterprise by σ_W^2; further, designate the correlation coefficient between the incomes of both enterprises by P_{CW}. At this point the question which arises concerns the behavior of the total variance of income σ_T^2 when the wheat enterprise is added to the already existing corn enterprise. To answer this question, we will refer to the expression below.

$$\sigma_T^2 = \sigma_C^2 + \sigma_W^2 + 2\ P_{CW}\ \sigma_C\ \sigma_W$$

In general terms, this equation reads:

$$\sigma T^2 = \sum_{\substack{i=1 \\ j=1}}^{n} \sigma_{ij}^2 + 2 \sum_{\substack{i,j=1 \\ i>j}}^{n} P_{ij}\ \sigma_i\ \sigma_j \quad i,j=1,\ldots,n \qquad (2\text{-}6)$$

From the examination of expression (2-6) it appears that a) if the correlation coefficient P_{CW} is zero, then the covariance term becomes null; however, σ_T^2 increases by σ_W^2. Thus, adding wheat to the corn enterprise will only increase variability, b) If the correlation coefficient P_{CW} is positive, there is less grounds to diversity activities with respect to the proposed configuration. c) If the correlation coefficient P_{CW} is less than zero, σ_T^2 becomes:

$$\sigma_T^2 = \sigma_C^2 + \sigma_W^2 - 2\ P_{CW}\ \sigma_C\ \sigma_W$$

In this case, the total variance of income can take a value less than σ_C^2 with the condition that the absolute value of the covariance $2\ P_{CW}\ \sigma_C\ \sigma_W$ be greater than σ_W^2; otherwise, σ_T^2 will be increased by some quantity equal to the resultant of σ_W^2 and the covariance.

The analysis, now, turns to the case of diversification with fixed resources. The assumption of the precedent paragraph are still relevant here, except that resources are limited. Diversification under these circumstances requires an allocation of a share of the resource endowment to the wheat enterprise; then, the total income variance of the new crop mix is summarized in the equation below:

$$\sigma_T^2 = k^2\sigma_C^2 + (1-k)^2\,\sigma_W^2 + 2k\,(1-k)\,P_{CW}\,\sigma_C\,\sigma_W \qquad (2\text{-}7)$$

where k and (1-k) are the proportions of resources devoted to the corn and wheat enterprises, respectively. In general form, expression (2-7) becomes:

$$\sigma_T^2 = \sum_{i=1}^{n} k_i\,\sigma_i^2 + 2\sum_{\substack{i,j=1\\ i>j}}^{n} K_iK_j\,\sigma_i\,\sigma_j$$

where k_i = proportion of resources assigned to enterprise i.

$\Sigma k_i = 1$

n = number of enterprises

To illustrate the behavior of total variance of income σ_T^2, consider the simple case of the previous two enterprises (corn and wheat) with three of four resource units devoted to the corn enterprise, and the remainder allocated to the wheat enterprise. Given these conditions, expression (2-7) can serve in deriving σ_T^2, which reads:

$$\sigma_T^2 = (3/4)^2\,\sigma_C^2 + (1/4)^2\,\sigma_W^2 + 2\,(3/4)(1/4)\,P_{CW}\,\sigma_C\,\sigma_W$$

$$\sigma_T^2 = \frac{9}{16}\,\sigma_C^2 + \frac{1}{16}\,\sigma_W^2 + \frac{6}{16}\,P_{CW}\,\sigma_C\,\sigma_W \qquad (2\text{-}8)$$

The analysis of expression (2-8) generates three possibilities for σ_T^2, which are:

a) if P_{CW} equals zero, σ_T^2 will be equal to the sum of the first two terms of (2-8). Mathematically σ_T^2 takes the form

$$\sigma_T^2 = \frac{9}{16}\,\sigma_C^2 + \frac{1}{16}\,\sigma_W^2.$$

The reduction of σ_T^2 requires that $\frac{1}{16}\,\sigma_W^2$ be less than $\frac{7}{16}\,\sigma_C^2$, or that the ratio $\frac{(7/16)\ \sigma_C^2}{(1/16)\ \sigma_W^2}$ be greater than one. Symbolically, that can be written as:

$$\frac{\frac{7}{16}\ \sigma_C^2}{\frac{1}{16}\ \sigma_W^2} > 1$$

or

$$\frac{7\ \sigma_C^2}{\sigma_W^2} > 1$$

which is equivalent to $7\ \sigma_C^2 > \sigma_W^2$

Clearly, σ_T^2 decreases as long as the income variance of wheat does not have seven times the income variance of corn.

b) If the correlation coefficient P_{CW} is positive, σ_T^2 will be increased if the following condition is satisfied:

$$\frac{1}{16}\ \sigma_W^2 + \frac{6}{16}\ P_{CW}\ \sigma_C\ \sigma_W > \frac{7}{16}\ \sigma_C^2$$

which is the same as:

$$\frac{\sigma_W^2 + 6\ P_{CW}\ \sigma_C\ \sigma_W}{7\ \sigma_C^2} > 1$$

c) If the correlation coefficient is negative, σ_T^2 becomes:

$$\sigma_T^2 = \frac{9}{16}\ \sigma_C^2 + \frac{1}{16}\ \sigma_W^2 - \frac{6}{16}\ P_{CW}\ \sigma_C\sigma_W$$

In this case diversification will lead to a reduction in total variance of income, unless $\frac{1}{16}\ \sigma_W^2$ is greater than $\frac{7}{16}\ \sigma^2 + |\frac{6}{16}\ P_{CW}\sigma_C\sigma_W|$.

We have discussed the impact of diversification in a fixed resource and in an add-on cases. The situation at stake is that where the manager desires to minimize variance over his planned horizon. Once again we will denote k and (1-k) as the amount of resources allocated to corn and wheat, respectively. From Equation (2-7), we deduce that k is the factor that we can shape at will to influence the total variance of income σ_T^2. By taking the first derivative of Equation (2-7), and setting it equal to zero, we get:

$$\frac{d\,\sigma_T^2}{dk} = 2k\,\sigma_C^2 - 2\,(1-k)\,\sigma_W^2 + 2\,P_{CW}\,(1-2k)\,\sigma_C\,\sigma_W = 0$$

The solution of this equation yields a value of k equal to:

$$k = \frac{\sigma_W^2 - P_{CW}\,\sigma_C\,\sigma_W}{\sigma_C^2 + \sigma_W^2 - 2\,P_{CW}\,\sigma_C\,\sigma_W} \qquad (2\text{-}9)$$

which minimizes σ_T^2.

Diversification as we have established it, can reduce risk. Both the situation of the farm with limited resources, and that of the farm which can diversify its activities by the acquisition of additional resources have been discussed, as well. Yet, one should be careful in approaching diversification. The reason is that many factors on the farm play an important role in determining the quality and quantity of farm products. Those factors include: a) agronomic factors: the adaptability of crops to the environment on the farm may preclude a well intentional diversification scheme; simply because on an improper soil type, for example, a crop will bear a lower yield than on a more appropriate soil type. b) human factors: the farm manager may not have the expertise required by the new crop(s). In case of an add-on, he may not devote sufficient effort to each enterprise, as may be required. c) Finally, the law of diminishing returns mentioned by Zenger and Schurle in their study on 128 Kansas state farms may be relevant on a specific farm.

Previous Crop Selection Studies

Gross Margin Analysis

This approach was presented by Carkner, and by Bristol as a useful tool in comparing relative profitability among crops. Carkner developed a progarmmable calculator program for the TI-59, which calculates gross margins. In the situation of a single crop selection, the gross margin formula appears as:

$$GM_i = P_i Y_i - VC_i$$

where GM = gross margin

P = crop price

Y = crop yield

VC = variable cost

i = crop designation

This model allows the decision maker to rank different crops with identical investment costs. It can also be accomodated to answer the situation where the selection of crop pairs are the goal. After ranking all individual alternatives, a breakeven analysis is performed, to find out how sensitive that ranking is to a change in price and/or yield. Practically, the breakeven analysis considers the gross margin of one crop, and computes the price and/or yield variation needed for a second crop to yield the same gross margin. In the empirical context, suppose that the best ranking crop generates

$400 for the gross margin value; then the farmer's objective will be to determine the change in each price-yield pair which would bring the remaining crop gross margin closer to the best ranking one. The case where little change is needed constitutes a logical choice among the remaining alternatives, unless important variations in price-yield pairs (due to new technology, marketing strategies, etc.) for a given crop are obvious. The breakeven analysis model uses the gross margin equations to establish the breakeven prices and yields. For the case of two crops, those equations are:

$$GM_1 = P_1Y_1 - VC_1$$

$$GM_2 = P_2Y_2 - VC_2 \qquad (2\text{-}10)$$

by setting $GM_1 = GM_2$ we obtain:

$$P_1Y_1 - VC_1 = P_2Y_2 - VC_2$$

Equation (2-10) can be solved for P_2 (or Y_2). The solution is:

$$P_2 = \frac{P_1Y_1 - VC_1 + VC_2}{Y_2}$$

$$\text{or} \quad Y_2 = \frac{P_1Y_1 - VC_1 + VC_2}{P_2}$$

P_2 (or Y_2) is the price (or yield) required for Crop 2 to yield the same gross margin as Crop 1, given P_1 and Y_1. This optimal mix selection is performed with respect to biological, financial, and management constraints.

The breakeven analysis model is a very simple management aid, which may readily receive the attention of the farmer with little interest in the sophisticated crop selection methods that exist to date. Raising the question of the stochasticity of input and output prices, and yield in the breakeven analysis model is equivalent to inquiring about how risk averse (or risk preferring) the farmer is. Theoretically, a risk taker is not worried about "putting all his eggs in one basket." To that farmer, Carkner's model may have brought a desired answer. The situation, however, looks different if the farmer is not a risk taker. The breakeven analysis model fails to provide for risk, and may not prove adequate for a risk averse farmer. It, nevertheless, can be the basis of a simulation approach which assesses the gross margin probabilities.

Quadratic Programming

Assume that a farmer has m resources and n possible enterprises. For the actual growing period he needs to select a set of enterprises, given the uncertainty that characterizes the revenue from each of them. This situation corresponds to the Markowitz's portfolio selection analysis, in the sense that the farmer has many proposals with different degrees of risk to choose from. Hence, the theoretical expected income-variance (E-V) approach of portfolio analysis can be effectively used to solve the farmer's problem. The quadratic programming risk-aversion model incorporates variances and covariances of all possible enterprises; it is, therefore, particularly attractive to agricultural economists faced with a crop selection case (Scott and Baker, Woolery and Adams). This model assumes that the farmer's iso-utility curves are convex, that means, he is risk averse. The expected income-variance criterion derived by quadratic programming also assumes that a farmer's preferences are defined in terms of expected income and the corresponding income variance only; which is true if he has an E-V utility function (Markowitz).

Using quadratic programming, one develops a set of feasible farm plans such that variance (V) is minimum for associated expected income level (E) (Hazell). Such plans form an efficient frontier which Anderson, et al. call "efficiency locus" or "efficient set." Figure 2-5 illustrates the efficiency locus (OM) of a farmer whose iso-utility curves are represented by U_0, U_1, U_2.

The points which lie on and below the curve OM constitute the feasible farm plans; however, any point on the curve OM yields a greater utility by comparison to points below the curve. Symbolically, the E-V approach is characterized by:

Expected Net Revenue $E = \sum_{n} q_i \, e_i$

Variance of Net Revenue $V = \sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{ij} \, q_i \, q_j$

$$= \sum_{i=1}^{n} \sum_{j=1}^{n} P_{ij} \, \sigma_i \, \sigma_j \, q_i \, q_j$$

Constraints $q_i \geq 0$ and $\sum_{i=1}^{n} q_i \leq Z$

where q_i = level of the ith activity

e_i = expected net revenue per unit for the ith activity

σij = covariance of the per unit net revenue from activities i and j

P_{ij} = correlation coefficient between per acre net revenue from activities i and j

Z = total units of resource i available (i = 1 to m).

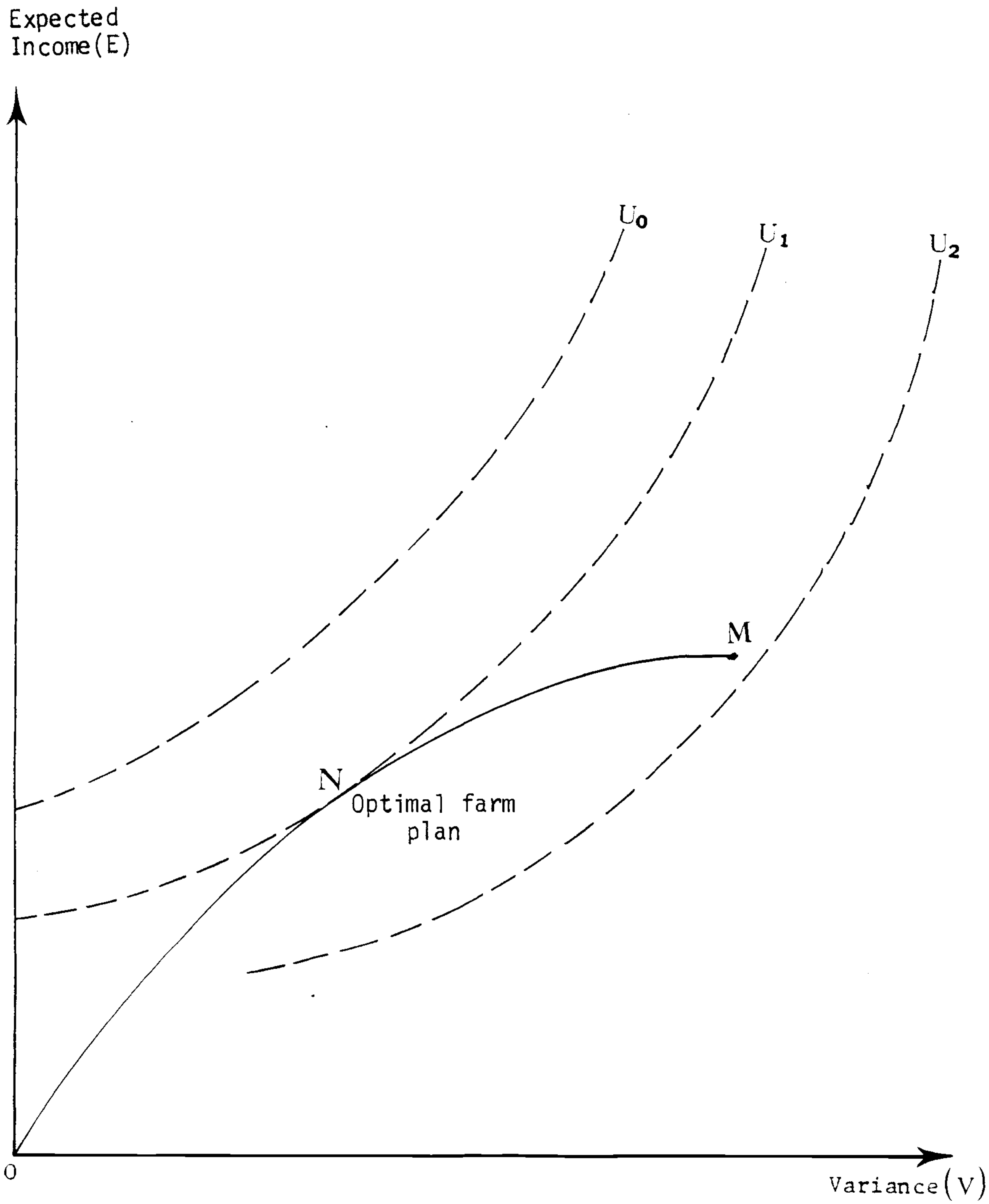

Figure 2-5. An Efficiency Locus.

The calculation to determine the efficient farm plans if performed by hand would require a tremendous amount of time and effort, which would be a major setback. Currently, a computer algorithm does exist, and it wipes out the computation difficulties. The general formulation of the quadratic programming model written in matrix form is:

$$\text{Maximize } Z = q'H - qRq$$

$$\text{subject to} \quad q_i \leq B$$

$$q'H = L$$

$$q_i \geq 0$$

where q = vector of enterprise levels

H = vector of expected income (e_i) from the relevant enterprises

R = variance-covariance matrix of revenue from the relevant enterprises

L = parameter (0 to unbounded).

The parameter L is progressively increased to reach the highest maximum value for variance and total gross margins; that point corresponds to the linear programming solution for gross margin under the actual set of constraints (Scott and Baker, Hazell).

The quadratic programming method has been widely used (Scott and Becker, Hazell, Woolery and Adams). The input data in all cases are: variance-covariance matrix of activity revenues, vector of input-output coefficients, and vector of resource constraints. Variance-covariance matrices can be built with available historical data, which may be adjusted according to subjective arguments.

The quadratic programming expected income-variance criterion is the type of tool needed for agricultural consultants, and for extension purposes, because it provides a set of expected income possibilities from which the interested farmer can select one, according to his own attitude toward risk. However, the fact that the computer packages (needed to ease computation) are not readily available will have an adverse effect on potential users.

The MOTAD Model

The quadratic programming algorithm presented in the precedent paragraph has one important drawback which is the limited availability of computer codes. The Minimization of Total Absolute Deviations (MOTAD) model was presented by Hazell as an alternative to quadratic programming. The mean absolute deviation (A) is defined by:

$$A = \frac{1}{s} \sum_{k=1}^{s} \sum_{i=1}^{n} \left| (C_{ki} - g_i)\, x_i \right| \qquad i=1 \text{ to } n$$

where s = sample size (number of gross margins observed)

n = number of activities

g_i = sample mean for activity i

x_i = activity level

C_{ki} = observed gross margin activity for the k^{th} observation.

According the Hazell, one can select an efficient E-A farm plan such that A is minimum for associated expected income level E. The E-A criterion bears some common properties with the quadratic programming E-V criterion. Both approaches require normality of the gross margin observations (which is guaranteed by reference to the Central Limit Theorem), and both allow the incorporation of probabilities in the model. However, the key departure (and its raison d' être) of the MOTAD model from quadratic programming is that the E-A efficient farm plans are derived by the usual linear programming codes. To arrive at the linear model, we must first define the new variable Y_k equal to:

$$Y_k = \sum_{i=1}^{n} C_{ki}\, x_i - \sum_{i=1}^{n} g_i\, x_i \qquad k=1 \text{ to } s$$

such that $Y_k = Y_k^+ - Y_k^-$

and $\quad Y_k^+, Y_k^- \geq 0.$

Then, the objective function can be formulated in terms of the absolute mean deviation A, and the unconstrained (in sign) deviations Y_k^+, and Y_k^-.

$$\text{Minimize } sA = \sum_{k=1}^{s} (Y_k^+ + Y_k^-) \tag{2-11}$$

$$\text{such that } \sum_{i=1}^{n} (c_{ki} - g_i)\, x_i - Y_k^+ + Y_k^- = 0 \text{ for all } k,\ k = 1 \text{ to } s \tag{2-12}$$

$$\text{and} \quad \sum_{i=1}^{n} e_i\, x_i = L \quad (L=0 \text{ to unbounded}) \tag{2-13}$$

$$\sum_{i=1}^{n} a_{ti}\, x_i \leq b_t \text{ for all } t,\ t = 1 \text{ to } m \tag{2-14}$$

$$x_i, Y_k^+, Y_k^- \geq 0 \quad \text{for all } k,i \tag{2-15}$$

e_i = expected gross margin of the i^{th} activity

a_{ti} = technical coefficient for the i^{th} activity for the t^{th} resources

We have stated the Y_k^+ and Y_k^- are the deviations from the expected return defined by the sample mean gross margins g_i; it follows that the sum of the positive deviations Y_k^+ must equal the sum of the negative deviations Y_k^-; hence Equations (2-11) and (2-12), in the Model (2-11) to (2-15), can respectively be replaced by the linear programming model:

$$\text{Minimize} \sum_{k=1}^{s} Y_k^-$$

such that

$$\sum_{i=1}^{n} (C_{hi} - g_i)\, x_i + y_k^- \geq 0 \text{ (for all k, k=1 to s)}$$

and

$$\sum_{i=1}^{n} e_i x_i = L \text{ (L = 0 to unbounded)}$$

$$\sum_{i=1}^{n} a_{ti} x_i \leq b_t \text{ (for all t, t = 1 to m)}$$

$$x_i,\, y_k^- \geq 0 \text{ (for all k, i)}$$

The MOTAD model offers a great computation ease. It generates a set of efficient E-A farm plans with the assumption that the farmer has an E-A utility function. Like in the case of the E-V criterion model, the client has the possibility of choosing the alternative which seems more attractive to him. However, the quadratic programming results are more reliable, because that model uses the most efficient estimator of V, the variance (Hazell).

Despite its relatively less efficient results, the MOTAD model will still be a first choice in many cases because of its practicality.

The Monte Carlo Technique

The Monte Carlo technique is one of the existing methods that becomes more apparent as investment analysis problems become more complex. The Monte Carlo procedure requires random variates as inputs; the distributions of such variates can be subjectively or objectively defined. Random values are drawn from the specified distributions and are used in the decision model to mimic the "real world" situation. As such, the Monte Carlo simulation is also called stochastic simulation (Anderson, et al.). In the agricultural context, stochastic simulation allows the farmer to appraise each investment alternative; mainly, it explores all possible consequences capable of occurrence over the planned horizon, and offers some estimates of expected payoff, and the degree of riskiness of a particular alternative.

The choice of the probability distribution depends on the nature of the problem; usually, a plot of historical data series (if available) serves as a guide. For stochastic programming, the inverse function of the cumulative probability distribution must be known, so that random prices and yields can be generated using random numbers between 0 and 1. Some distributions have a known inverse easily accessible; that is the case of the triangular distribution which was used by Knox. Other probability distributions have an inverse function which usually requires the use of a complicated algorithm; that is the case of the normal, Beta, and Gamma functions. The ease to compute the inverse of the cumulative function, thus to generate random yields and prices, is a key factor which may affect the choice of a distribution.

Knox used the triangular distribution to study the riskiness of crops in the Willamette Valley. This distribution is completely defined by the specification of three values, namely the mode m, the lowest possible value a, the highest possible value b. The mathematical form of the cumulative distribution function (CDF), as presented by Anderson, et al., reads:

$$F(x) = (x-a)^2/[(b-a)(m-a)] \qquad a \leq x \leq m$$

$$= 1 - (b-x)^2/[(b-a)\ (b-m)] \qquad m \leq x \leq b$$

Given a uniform variate u, F(x) can be solved for x; the solution gives:

$$x = a + [u(b-a)\ (m-a)]^{.5} \qquad 0 \leq u \leq (m-a)/(b-a)$$

$$= b - [(1-u)\ (b-a)\ (b-m)]^{.5} \qquad (m-a)/(b-a) \leq u \leq 1$$

Knox used this approach to derive the breakeven probabilities for farmers with respect to a variety of crops in the Willamette Valley. Practically, 100-200 trials were performed for each year. At the end of the planned horizon, the breakeven probability (PBE) was calculated. It was defined as the number of trials generating a positive cash flow over the total number of trials. Symbolically, the PBE writes:

$$PBE = \frac{n}{N}$$

with n = number of trials generating a positive cash flow

N = total number of trials

Bristol used a simpler form of the true simulation technique described above. He divided the range, for the price series in his study, into ten intervals. Following that, he computed the probability for each of the ten intervals. Similarly, the yield series were divided into ten intervals, the probabilities of which were calculated. The breakeven probability, then, was defined as the sum of the probability products of all price and yield pairs (P_i, Y_j) in the trials, for which revenue exceeded direct costs. Mathematically written, the PBE, in this case, takes the form:

$$PBE = \sum_{i=1}^{n} \sum_{j=1}^{n} P_{ri} P_{rj} \text{ for all } P_i{*}Y_j \geq \text{direct costs}$$
$$i=1,2,\ldots,10$$
$$j=1,2,\ldots,10$$

with P_{ri} = probability for price to be included in interval i

P_{rj} = probability for yield to be included in interval j

$P_i{*}Y_j$ = gross receipts

Knox's work focused on the riskiness of land investment decisions for two case farms. On one farm only wheat was grown; and on the second farm bush beans, sweet corn, and wheat comprised a cropping system in the proportion of one-third for each crop. Bristol, essentially, considered a certain number of crops, for which he determined the risk factor inherent to growing each of them individually.

The risk measures derived by both authors (Knox and Bristol) constitute a useful information for farm decision makers. These measures were computed using models based on elements familiar to the farmers. Namely, these elements are: lowest, most likely, and highest variable values for the probability distributions, production costs, and finally price and yield means. Most farmers can provide this information; and consequently, the on-the-field practicality of the specified models is very high, compared to some other existing schemes.

However, two aspects of the risk analysis which the authors failed to address deal with a) how the risk measure varies as a crop mix is considered in place of individual crops, b) how it (the risk measure) moves as the crop combination changes. The usefulness of the proposed information systems reviewed in this section will be widely enhanced if the farmers are presented different cropping systems, along with the respective risk measures.

CHAPTER III

DERIVATION OF PRICE AND YIELD PROBABILITY DISTRIBUTIONS

Theory on Expectation Models

Introduction

Time series are made of two basic components designated as a) the expected component which can be predicted, and b) the random element which is subject to chance variation. As defined, the random component cannot be predicted. To derive risk measures from historical data series there is a need to separate the expected and random components which comprise the observations. At this point, the inquiry is about the theoretical and empirical issues involved in how the expected components (in each observation) are to be computed, and what the variability measure should be.

Young suggests that for normative purposes, the computation of risk indices should follow the same pattern the farmers use in forming their expectations about future values. Farmers usually put more weight on recent events, and discard information prior to a certain period (which they evaluate using their own experience). Young established seven criteria which should serve as guides to agricultural economists dealing with historical data series:

1. The variability measure should be defined as the mean square deviation from a series of one step-ahead forecasts. Each mean square deviation should be weighted by a coefficient α_t. Mathematically, we can write:

$$V = \sum_{i=1}^{n} \alpha_t(x_t - \hat{x}_t)^2$$

with: V = variability measure

α = coefficient

x_t = actual observation of X

$\hat{x}_t$ = prediction of x in period t-1

t = period

n = number of periods

2. The expectation formulated for each period should be based on data available at that time only.

3. Managers consider information prior to a certain point in time obsolete and irrelevant. It is not taken into account in the formation of the subjective judgments. Based on the same argument, the computation of the expected component should involve data from a limited number of periods.

4. The most recent piece of information should carry more weight than the preceding ones. However, it should be noticed that this idea may be misleading in case the current conditions are just a response to a very rare event.

5. The expected component and variability measure should be subject to change any time a new piece of information becomes available.

6. The formulation of the expectation model should allow for changes, to take advantage of experience from past periods.

7. Without being naive, the expectation model should be simple enough to facilitate its application by the clientele.

The Models

There exist several expectation schemes ranging from the most naive to the most complicated models. In this paragraph, some of the methods will be reviewed, from which a selection will be made for the empirical part of this study. The goal, here, is to provide an adequate procedure which generates expectations similar to the mechanism used by producers to generate the expected component of the time series. Such procedure should not suffer theoretical deficiencies which would bring both the scientist or the common user to show a lack of interest for it.

The Overall Mean. It is one of the naive processes. Although simple, it violates most of the theoretical criteria. The prediction for any one period is computed as the average value of all the observations in the series. Symbolically:

$$x_t = \frac{x_1 + x_2 + \cdots + x_{t-1}}{n}$$

$\hat{x}_t$ = prediction for x in period t-1

n = number of periods.

Linear Time Trend and First Differences. This method has been used by Jones and Smith. A regression line (OLS) is obtained, and that line estimates the time trend. The first differences were considered as random components of the series. This method implicitly assumes a linear trend. The regression line is defined as follows:

$$\hat{x}_t = a + bt$$

The first differences are given by $\hat{x}_t$ (prediction) less x_t (current observation).

Variate Difference Method and Polynomial Time Trend. This procedure developed by Tintner has been used by Carter and Dean, Yaha and Adams, and Walker, et al. The method assumes that time series are made of two terms: a mathematical expectation and a random element. Using the variate difference method allows the researcher to disaggregate the data series. One key advantage of this trend removal scheme is that it does not require prior information about the mathematical form of the systematic component of the series. Tintner states that one can reduce the trend in the series by finite differencing. The level of differencing should correspond to the degree of the polynomial function which generates the systematic part. Practically, the variate difference method works as shown below.

Original data	Order of Differencing 1	2	3
56			
59	3		
64	5	2	
49	15	20	-22
82	33	48	68

Tintner proposes a criteria which allows the user to determine when the trend component has been significantly removed (see Tintner). Besides that criteria, Tintner also suggests that one can calculate the variance of the successive differences; the trend is removed when a conservative result is obtained (Tintner, Walker, et al.).

Although the variate difference method is explicit, it suffers the weakness of violating Young's criteria 3 and 4. It also reduces the number of data points available, especially when a high degree of differencing is needed.

Exponentially Weighted Moving Average Procedure (EWMA). It is identical to the simple moving average model; but it offers the advantage of overcoming some of the limitations of the simple moving average procedure referred to above. Its mathematical form, as presented by McGuigan and Moyer, is:

$$\hat{x}_{t+1} = \hat{X}_t(1-w) + wx_t$$

which can also be written as:

$$\hat{x}_{t+1} = w(x_t - \hat{x}_t) + \hat{x}_t \tag{3-1}$$

with:

$\hat{x}_{t+1}$ = forecast in year t for x_{t+1}

x_t = current value of x

$\hat{x}_t$ = forecast value in year t-1 for x_t

w = weight.

Expression (3-1) implies that the forecast of the year ahead is the current year's prediction adjusted with a weighted value of the deviation from the current year's forecast. This expectation model offers the user the possibility of choice for the parameter w. The higher the value of w, the heavier the weight of current information, and vice versa. The selection of the parameter w renders the EWMA model particularly attractive, for it permits the decision maker to use subjective judgement.

Continuously Adjusted Weighted Moving Average (CAWMA). This model has been used by Calvin. It satisfies most of the theoretical criteria. Its predictive equation is:

$$\hat{x}_t = \hat{\beta}_{1t}x_{t-1} + \hat{\beta}_{2t}x_{t-2} + \hat{\beta}_{3t}x_{t-3}$$

with:

$\hat{x}_t$ = prediction for time period t

x_{t-i} = observation for period t-i, i = 1,2,3

$\hat{\beta}_{it}$ = moving average coefficient i for the t^{th} period predictive equation.

The determination of the $\hat{\beta}_{it}$'s is a constrained problem which minimizes the quantity:

$$\sum_{t=0}^{n_0-1} (\alpha^t e_t)$$

in which α = the weight,

$$e_t = x_t - \hat{\beta}_1 x_{t-1} - \hat{\beta}_2 x_{t-2} - \hat{\beta}_3 x_{t-3}$$

The minimization problem is subject to:

(1) $\sum_{i=1}^{3} \hat{\beta}_i = 1$

(2) $0 \leq \hat{\beta}_i \leq 1$ for all $\hat{\beta}_i$, and

(3) $\hat{\beta}_1 \geq \hat{\beta}_2 \geq \hat{\beta}_3$

Statement (3) clearly indicates that more recent information carries more weight.

ARIMA Model. The Autoregressive Integrated Moving Average process was used by Ibrahim and William to comment Klein's measure of price uncertainty. The ARIMA procedure draws its flexibility from a pool of some of the methods that we have already reviewed, and which includes regression, time series differencing, and moving averages. The model is based on an adaptive expectation scheme which incorporates only lagged observations as independent variables. The general form of the ARIMA model is:

$$\hat{x}_{t+1} = \sum_{j=0}^{\infty} a_j x_{t-j}$$

with:

$\hat{x}_{t+1}$ = forecast for x for period t+1

x_{t-j} = observed value of x for all periods t-j

$j = 0,1,2,\ldots, \infty$

a_j = coefficient for period t-j.

As such, the ARIMA procedure satisfies criteria 5 and 6, but fails to meet Young's criteria 3 and 4.

Klein's Moving Regression. Answering Ibrahim and William's critics of his precedent article, Klein pointed out the major weakness of the ARIMA model used by Ibrahim and William. He argued that the use of data unavailable until the end of the growing period was a major deficiency, and proposed an autoregressive prediction scheme as a proxy for actual prediction practice. He also emphasized the fact that more recent information should carry more weight. The one step into the future forecast as defined by Klein was:

$$\widehat{(\dot{P}/P)}_{t+1} = \hat{a}_1 + \hat{\rho}_1 \ (\dot{P}/P)_t$$

with:

$\hat{a}_1$ = intercept

$\hat{\rho}_1$ = coefficient (arbitrary)

$\widehat{(\dot{P}/P)}$ = forecast for $(\dot{P}/P)$

Conclusion

The methods reviewed were all used by Calvin, with the exception of the exponentially weighted moving average model (EWMA).

As Calvin wrote, the variate difference method appeared not to perform well for "zig zag" time series, while the autoregressive models lead to unrealistic prices and risk indices. The CAWMA and moving average scheme were recognized by Calvin as the methods yielding more interesting results than the other procedures. The author observed that the simple moving average and the CAWMA yielded identical predictions 36 percent of the time, for the most risky crops, and 24 percent of the time for the least risky ones.

In this work, the EWMA, CAWMA, and moving average procedures were selected and their efficiency tested using price series. The results showed that all three models had a good performance, but the EWMA offered better results than the other two models.

Price and Yield Adjustment Procedures

Introduction

The crops considered in this study are essentially grown in the same period throughout the Willamette Valley; as a result, the marketing of the produce occurs at the same time in the area. Produce marketing conditions are also similar, from one farm to another one across the valley. Based on these facts, there is reason to believe that the district weighted average[9/] price is appropriate in deriving proxies for risk (variability) measures for Willamette Valley farms. On the contrary, crop yields vary among farms within the Valley. Explicitly, soils and microclimate differences at the farm level are sources of divergence for the yields from different farms. Also, farmers' management practices, their financial situation, and ability to receive and adopt information are some other aspects that contribute to the observed yield diversity among farms. Thus, unlike the weighted average prices, the yield averages are not as useful for risk studies. Averaging the yields smooths out their variability which, in fact, is the focus of interest (Carter and Dean, Nelson[10/]). An alternative way to assess yield stochasticity may be to collect some microdata from individual farms; but using such data is not without any problem, mainly because each farmer's subjective feelings will affect the time and attention he devotes to each enterprise. Moreover, the collection of the microdata from an adequate statistical farm sample has considerable time and cost requirements. If time and cost do not limit normative research

9/ The weighted average price is defined as the ratio of the sum of production values from individual counties (in the Valley) over the total production of the Valley.

10/ Discussion with Dr. Nelson.

activity, then the ideal alternative for deriving yield figures is that which combines both aggregate and microdata.

Respective of the lack of similarity between price and yield characteristics, as exposed earlier, the generation of the data for each variable follows a different path.

Price Adjustment Procedure

The actual prices are collected from the Extension Service files. For each commodity, the Extension Service provides the yearly weighted average price for the Willamette Valley. These weighted average price series did reflect the influence of inflation over the years; therefore, it was necessary to inflate them by the index of prices paid by farmers. This process generated the inflated price series. The later figures were detrended furthermore, using the exponentially weighted moving average (EWMA) model. Symbolically, the model reads:

$$\hat{x}_{t+1} = w(x_t + \hat{x}_t) + \hat{x}_t \quad (3\text{-}2)$$

This formula is the same as equation (3-1), and the variables are as specified previously. It was programmed on the HP-41C for computational ease (see Appendix D-1). The input values of the program are the forecast and current values $\hat{x}_t$ and x_t, respectively. For the first year, the overall mean is used as the forecast value $\hat{x}_t$. The program outputs two values which are the expected price, and the deviation of the current price from the expected level. The deviation is referred to as the "random element" of the current observation. The random price series are built around the 1980 predicted price by adding the "random elements" to it. The actual, inflated, predicted and random price series are listed in Appendix A-1.

Yield Adjustment Procedure

Two categories of yield data are available for the derivation of random yields. The first category was drawn from the Extension Service files. The data in this group are weighted average yields for the Willamette Valley, in the sense that they are obtained by dividing the total production (which is the sum of production from individual counties in the Valley) by the total number of acres harvested in the Valley. The second category of data contains yield records collected from the files of AGRIPAC Corporation (Salem), and data received from individual farmers to whom a questionnaire was mailed.

The removal of the trend component from the series was approached with a method different from that of the price series trend removal case; the essential reason being that technological change affects yields and prices differently. Some other reasons which add to the main one are the limited number of observations for individual farms, and the gaps in the yield series. It is expected that building a yield index and treating the individual observations with it will satisfactorily detrend them, and isolate purely random yields.

The formation of the yield index involves two stages. In the first stage, a regression line is fitted for each yield series pertaining to a particular farm; the same operation is performed for the Willamette Valley weighted average yields. The second stage concerns the calculation of the index itself. The index is a yearly figure defined for the individual farms only, by using their yearly yield prediction and the Willamette Valley 1980 mean. Empirically, the index formula reads:

$$IND_{fi} = \frac{P_{fi}}{WM}$$

with:

IND = Index

P = Prediction

WM = 1980 Willamette Valley Mean

and where f and i indicate the farm and the year, for which the index is being computed, respectively.

Following the calculation of the index, the equation for the trend adjusted yields is written as:

$$TAY_{fi} = \frac{AY_{fi}}{IND_{fi}}$$

with:

TAY = Trend Adjusted Yield

AY = Actual yield

IND, f, and i are as defined previously.

Table (3-1) exhibits an illustration of the methodology described above. The crop chosen for the purpose of this illustration is annual ryegrass. The second column in Table 3-1 shows the actual ryegrass yields which are individual farm yields, collected from the sources already mentioned. The third column presents the predicted yields generated by the regression line fitted to the actual yields for the particular farm on which the crop was grown. Column 4 displays the index calculated as the ratio of each item in column 3 over the Willamette Valley 1980 mean (1618.61 pounds). Column 4 bears the trend adjusted yields; they are computed as the ratio of the items in column 2 (actual yields) over the corresponding elements in column 4 (indices). This illustration addressed the "how" of the adjustment procedure. Needless to say, it is equally important to point out the rationale of two important steps in the adjustment process, namely, the choice of a base year (1980) and the choice of the Willamette Valley 1980 mean (1618.61 pounds).

The choice of a base year (1980) for the calculation of the yield index is aimed at reducing the period trend effect exhibited by curve 1 in Figure 3-1(a). The use of the Willamette Valley 1980 mean has for purpose to remove the differences among the farms the data of which are being used in this study. As a result of these two adjustments, curve (1) in Figure 3-1(a) becomes curve (1) in Figure 3-1(b).

The trend adjusted yields as shown on curve 1 (Figure 3-1(b)) depart randomly from their mean (1618.61 pounds), which is the

TABLE 3-1. Annual Ryegrass Yields

Year	Actual Yield	Prediction	Index	Adjusted Yield
75	2000	2046.07	1.26	1582.17
76	2100	2096.65	1.30	1621.21
77	2200	2131.39	1.32	1670.72
78	2300	2150.28	1.33	1731.32
79	1950	2153.32	1.33	1465.79
80	2083.31	2140.52	1.32	1575.28
81	2196.21	2111.88	1.30	1683.78

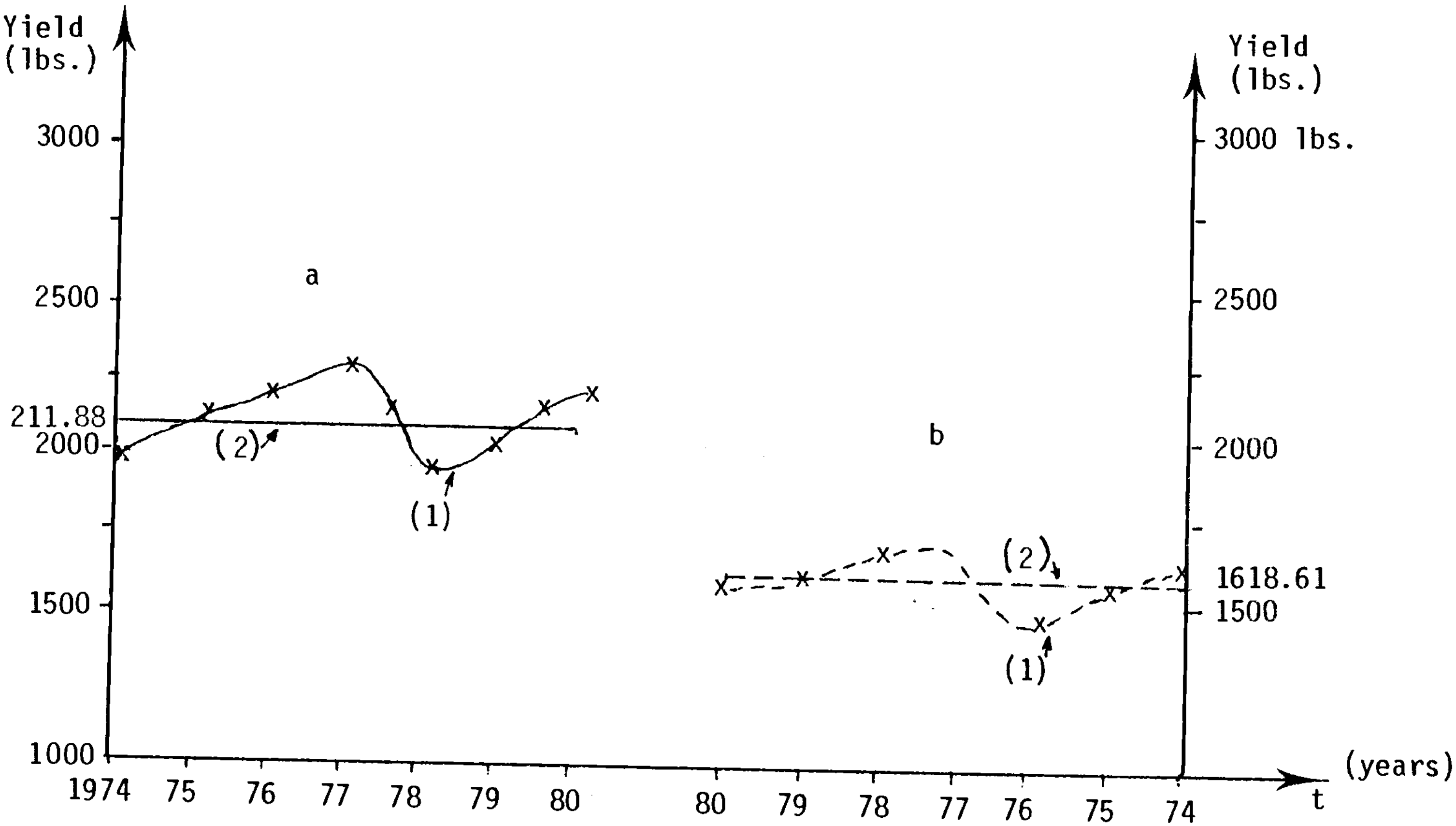

Figure 3-1 Illustration of the Yield Adjustment Procedure.

—x—x—x—x— actual yields

———————— 1980 mean yield for the annual ryegrass farm

- - - - - - - - 1980 Willamette Valley mean

— x — x — x — Adjusted yields

Willamette Valley 1980 mean. These yield series are the random series to serve in the derivation of the probability distribution. They are listed in Appendix A-3.

Conclusion

Different approaches were used to adjust actual prices and yields. In the case of the price series, the EWMA model provided a consistent basis to detrend all price series. As for the yield series, the use of the index was found to be an adequate technique in dealing with the type of yield information available.

The next step following this adjustment process deals with the construction of the price and yield histograms, and the selection of theoretical distributions which more closely describe the observed distributions.

Probability Distributions

Introduction

It is known that flipping a fair coin will give either a "head" or a "tail" with a probability of one half and one half, the appearance frequency limit of each side of the coin for an infinite number of trials. However, how many times the coin will show "head" or "tail" on a specific number of tosses remains unknown. In the business world, a bank or a shop manager cannot have a sure knowledge of the number of customers who visit the facility in a typical day. The situation of the farm manager is no different than the cases of the bank or shop manager. In the following, we present the probabilistic approach as a method to answer the felt need.

The farm manager is interested in product and factor prices, and crop yields. Before growing a specific crop, he inquires about whether yields and market prices will allow him to achieve his goals. Like the outcome of rolling a fair die, the price at which the produce from his farm will sell when harvested cannot be known *a priori* with certainty. One method used to provide some information in such a situation is the probabilistic approach. Practically, since the occurrence of an event is unpredictable as would be in a certainty case, a probability is assigned to it. That allows the interested farmer to reduce his ignorance about what the chances to obtain a given price (or yield) level are.

Assigning a probability to each event requires an awareness of the "law" that governs the manifestation of the events. Usually, objective and/or subjective information is gathered, and it serves to build a histogram showing the frequency distribution of events. But a question arises, which is: does such a histogram bring a full information on the "real" distribution of the relevant variable? In other terms, how close is the observed distribution to the "real" one? To answer this question, it is common practice to refer to theory to try to explain the observed phenomena; that is, a certain type of theoretical distribution is considered. The parameter estimates of that distribution are computed, then compared to those of the observed distribution. A match between the two groups of statistics is accepted as a sound ground to state that the theory (which the theoretical distribution is based on) supports the observed facts. Logically, that theory reflects the "law" that generates the facts. Some statistical tests, including the x^2 test of goodness of fit, are available to compare the fitted and theoretical distributions in case the parameter comparisons are not convincing enough.

Theorical Distributions

Previous results of price and yield analysis indicate that the distributions of these two variables exhibit some skewness.[11/] Therefore, it is appropriate for the purpose of this study, to consider a theoretical distribution which would allow for skewness. The beta and the triangular functions are commonly used distributions which possess that characteristic. This explains why the two distributions were referred to for this analysis.

The Beta Distribution. The general form of the beta distribution function as presented by Johnson and Kotz, reads:

$$f_x(x) = \frac{1}{B(p,q)} x^{p-1} (1-x)^{q-1} \quad 0 \leq x \leq 1 \qquad (3\text{-}3)$$

where

$$B(p,q) = \frac{G(p)\ G(q)}{G(p+q)}$$

11/ Skewness relates to the departure from symmetry for frequency curves. A longer tail to the right indices a positive skewness, and a longer tail to the left indicates a negative skewness.

with

$G(z)$ = Value of the gamma function for z

z = Argument

and p,q parameters

The beta distribution is referred to as the Pearson type I function. Two parameters (p and q) are required to derive the value of $f_X(x)$.

The estimates of p and q can be calculated by making use of the moment approach. In that case, four elements are required which are: the lowest and highest possible observations (A and B), then the first and second moments (μ and σ^2) (see Johnson and Kotz, page 44). The mean price (or mean yield) is a concept with which farmers are familiar; but it is not certain that they have enough understanding about the concept of variance. In practical situations, it may be easy to collect subjective estimates for mean price and yield, but that may not be true for the variance. As a result, the computation of the parameters involve some difficulty. The PERT assumptions have been very useful in coping with that difficulty. In fact, two equations provide estimators of the mode and mean. These equations read:

$$M_o = p/(p+q) \tag{3-4}$$

$$\overline{X} = (p+1)/(p+q+2) \tag{3-5}$$

The variance is assumed to be equal to:

$$s^2 = 1/36\ (B-A)^2 \tag{3-6}$$

When A and B are known, equations (3-5) and (3-6) can be solved simultaneously to get estimates of p and q (see Appendix B).

Once p and q are obtained, they are fed into equation (3-3) to give the value of the density function for x. Figure 3-2(a) illustrates a typical beta density function.

For simulation purposes, it is preferable to derive the value of $f_x(x)$ for a given interval, like x_1 to x_2 on Figure 3-2(a), rather than a point estimate of $f_x(x)$ for x_1. That is achieved by adopting the Cumulative Density Function (CDF). The CDF is generated by the integral of expression (3-3), which is called the incomplete beta function ratio $I_x(p,q)$ or the incomplete beta function. Mathematically, $I_x(p,q)$ is defined as:

$$I_x(p,q) = \frac{B_x(p,q)}{B(p,q)}$$

where

$$B_x(p,q) = \int_0^t x^{p-1}\,(1-x)^{q-1} \qquad 0 \leq x \leq 1$$

and B(p,q) as previously specified.

When p and q are equal, the CDF has a smoothly increasing slope. It is a sign that the graph of the density function $f_x(x)$ is bell-shaped. The steeper the slope of the CDF, the more important the skewness of the distribution.

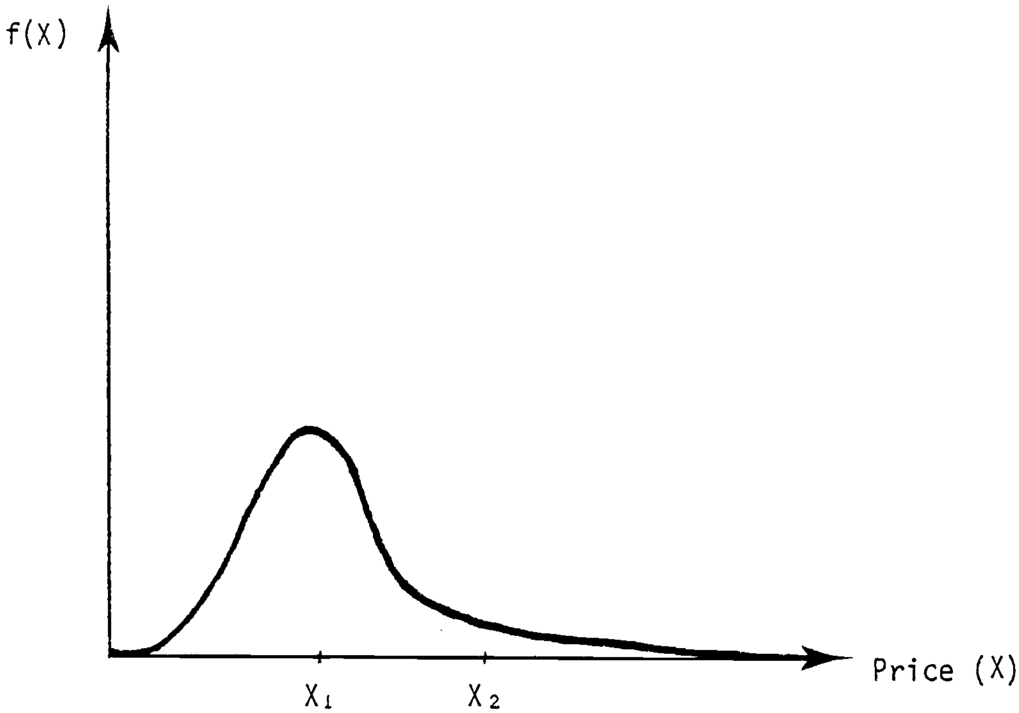

Figure 3-2.a A Beta density function.

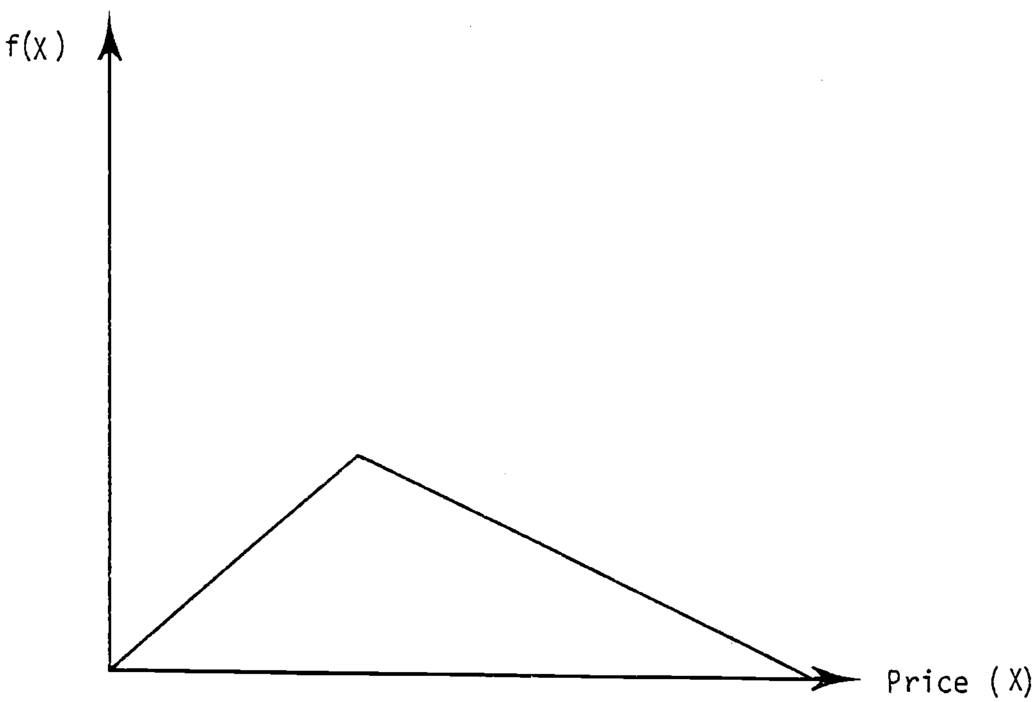

Figure 3-2.b A triangular density function.

The calculation of $I_x(p,q)$ complicates the use of the beta distribution. Fortunately, some $I_x(p,q)$ tables have been published, along with approximation formulae for unlisted values (Pearson).

The Triangular Distribution. The triangular function was presented in Chapter II; consequently, it will not be reviewed in this section. Unlike the beta distribution function, it does not necessitate any parameter to generate the value of the density function; when the modal, lowest and highest possible points are known, the value of the triangular density function can be easily evaluated (see Figure 3-2(b)). The simplicity associated with its use gives an edge to the triangular function over the beta function.

Price Distributions

An histogram was built for each crop price series. To achieve that purpose, the range of the random price series was divided in a certain number of intervals. It was observed that the number of intervals significantly influences the shape of the frequency curve. Therefore, there was a need for consistency in the determination of the number of intervals. A formula proposed by Benjamin and Cornell was used to define the number of intervals. This formula, which is also referred to for the yield distribution, reads:

$$n = 3.3 \log_{10} N$$

where

n = number of intervals

N = number of observations.

The graphs shown in Appendix A-2 represent the frequency distributions of the prices for the crops involved in this study.[12/] Table 3-2 provides a summary of the information displayed by the graphs. For all crops but strawberries, the mean price tends to be greater than the modal price; that is, the price distributions associated with most crops are positively skewed.

Yield Distributions

The construction of the yield frequency distributions was based on the trend adjusted yields (random yields). The graphs in Appendix A-4 are the histograms pertaining to the relevant crops.[12/] Table 3-3 contains the values of the the mean and modal yields, the lowest and highest possible yields. As shown in Table 3-3, the mean yields tend to be slightly lower than the modal yields, except for the sweet corn yield distribution.

Conclusion

In this summary, two points will be addressed, which are the comparison of the price and yield frequency curves, and the appropriateness of the theoretical distributions selected.

12/ No probability distributions were derived for annual ryegrass and peppermint prices and yields, due to the lack of sufficient data series.

TABLE 3-2. Price Probability Distributions.

Crop \ Price ($/unit)	Lowest	Highest	Mode	Mean
Snap beans	118.12	309.68	163.73	170.64
Sweet corn	62.35	140.46	81.88	82.70
Wheat	2.18	9.35	3.98	4.35
Strawberries	604.20	897.40	757.80	742.80

TABLE 3-3. Yield Probability Distributions.

Crop \ Yield	Lowest	Highest	Mode	Mean
Snap beans (t)	2.53	6.53	4.96	4.94
Sweet corn (t)	5.34	11.88	8.59	8.60
Wheat (bu.)	41.96	96.46	72.23	71.69
Strawberries (t)	1.37	6.93	4.17	4.08

The price frequency curves appeared positvely skewed; whereas, those related to the yield series exhibited a light negative skewness. These results are consistent with previous findings. Given these observations, one may inquire about the differences in the shapes of the two groups of distributions. In the following, an attempt is made to answer the inquiry.

In years of large production, the price level tends to fall as more produce is poured on the market,[13/] and as the supplied quantity tends to exceed the demand from buyers. In years of low production, however, prices tend to rise, as less produce reaches the consumer; that is, as the quantity supplied falls short of the demand from consumers. It should be mentioned that the use of modern technology, fertilizers, and chemicals contributes to keep crop yields at above average levels. Low crop yields, in the meantime, occur as a result of unfavorable natural factors (drought, pests, ...) strong enough to overcome human intervention on the field. Since the so-named disastrous events do not manifest very often, the crop yields modal observation will tend to lie above the average yield level, thus generating a negatively skewed distribution for that variable. On the opposite side, as low prices are provoked by a large production, prices will tend to lie below the mean price, thus to exhibit a positive skewness.

[13/] The 1981 large production of avocados by California growers and the following price fall illustrate this point.

In the light of this information, it would still be difficult to establish that crop prices and yields show a negative trade-off. The argument for the latter statement is that though below the average level, crop prices may experience an increase, parallel to a rise in yields, which may reflect a variation in production cost.

The price histograms appeared positively skewed as expected. Thus, choosing a distribution which allows for skewness seems to be a sound decision. However, in light of the weakness of the difference between the mean and modal yields, one could argue that the normal distribution should be selected as the theoretical distribution which more appropriately describes the yield series. Although such an argument would be adequate, it is clear that no mistake is made in adopting the beta and the triangular functions. In fact, the beta density function is very flexible; it can be bell-shaped if the mean and modal points are the same, and skewed whenever the two points are apart. The traingular density function takes the form of an equilateral trangle when the mean and modal points are identical. The triangular function can also be used to represent very skewed cases. Obviously, there is a need to investigate whether or not the choice of the beta and triangular distributions are appropriate. To satisfy that need parameter comparison is selected, instead of the χ^2 test of goodness of fit for which the length of the data series (especially the price series) does not provide enough degrees of freedom.

The parameter comparison preformed in this case concerns the mode and the mean of the crop price and yield series. The formula hereafter computes the would-be mean and mode values, were the crop prices beta or traingular distributed.

$$E(X) = \frac{A + 4Mo + B}{6} \tag{3-7}$$

$$E(X) = \frac{A + Mo + B}{3} \tag{3-8}$$

$$Mo = \frac{6\ E(X) - A - B}{4} \tag{3-9}$$

$$Mo = 3E(X) - A - B \tag{3-10}$$

where A = Lowest possible value of X

B = Highest possible value of X

$E(X)$ = Mean value of X

Mo = Most likely value of X

X = Relevant variable (price or yield)

Formulate (3-7) and (3-8) are the empirical expressions of the first moments of the beta and triangular distributions respectively, whereas (3-9) and (3-10) represent the most likely values of X related to the beta and triangular functions, respectively. The statistics calculated for Mo using expressions (3-9) and (3-10) are matched with the ones read on the histograms. The aim is to realize the magnitude of the difference between the computed statistics and their corresponding observed values.

The values in Tables (3-4) and (3-5) indicate the beta function estimates better the price and yield distribution modes, than does the triangular function. Meanwhile, it should be pointed out that the computed modes are fairly close to their corresponding observed values, except in the case of skewed distributions; for those cases, the triangular function is less reliable than it is for close to normal distributions (as is the case for the crop yield distributions).

Despite the departure of the computed modes from their observed values, the author believes that the beta and triangular functions are well indicated for this analysis. In fact, unlike the normal distribution function, they can be fitted to both normal and skewed price and yield distributions. Moreover, their inverse functions are available for use in this analysis.

TABLE 3-4. Computed Modes Inherent to the Beta and Triangular Distributions, and Corresponding Observed Price Distribution Modes.

Crop \ Item	Mean	Calculated Mode: Triangular	Calculated Mode: Beta	Observed Mode
Snap beans	170.64	84.12	149.01	163.73
Sweet corn	82.70	45.29	73.34	81.88
Wheat	4.35	1.52	3.64	3.98
Strawberries	742.80	726.80	738.80	757.80

TABLE 3-5. Computed Modes Inherent to the Beta and Triangular Distributions, and Corresponding Observed Yields Distribution Modes.

Crop \ Item	Mean	Calculated Mode: Triangular	Calculated Mode: Beta	Observed Mode
Snap beans	4.94	5.76	5.15	4.96
Sweet corn	8.60	8.58	8.60	8.59
Wheat	71.69	76.65	72.93	72.23
Strawberries	4.08	3.94	4.05	4.17

CHAPTER IV

DERIVATION OF THE RELATIONSHIP BETWEEN PRICES, BETWEEN YIELDS, AND BETWEEN PRICES AND YIELDS

Introduction

The purpose of this analysis is to learn more about the trade-off between crop prices, between crop yields, and the relationship between crop prices and yields. The interest of this analysis stems from the fact that the decision maker may want to get some knowledge about which price (or yield) level to expect for say, snap beans, given the expectation for snap beans yields, or the expectation for the price and yield of another crop grown on the farm. To provide the desired information, three studies will be performed which concern: a) the interaction between yields; b) the interaction between prices; and c) the interaction between prices and yields.

Relationship Between Yields

Theoretical Model

The maximum number of observations collected for each of the 28 farms amounts to thirteen. To make more use of the information in hand, a panel data set (cross section of time series) was constructed. Following that, a base crop, snap beans, was selected. The yield of the base crop was designated as the independent variable; and the yield of each of the remaining crops as the dependent variable. A quadratic trend line was established, based on the relevant variables. Its general form reads:

Table 4-1. Crop Identification Scheme

Crop Name	Designation
Annual Ryegrass	AR
Peppermint for Oil	PO
Snap Beans	SB
Strawberries	ST
Sweet Corn	SC
Wheat	WH

$$Y_t = a + b * SB_t + c * SB_t^2 + u \qquad (4\text{-}1)$$

where Y = Dependent variable

a = Constant term

b = Coefficient

c = Coefficient

SB = Snap beans yield

t = Prediction year

u = Disturbance term

Empirical Results

Each crop in the study was designated by the first two letters of its name, or by the first letters, if the crop has a composite name. The designation scheme so established appears in Table 4-1.

The empirical equations derived are presented in Table 4-2. These equations are expressed in terms of the coefficients a, b, c which were specified in the theoretical model (4-1). The table also displays the coefficient of multiple determination R^2, and the Durbin Watson statistic; as indicated, the R^2 values remained very low for most of the empirical equations (below .15), except for the equation concerning peppermint and snap beans yields. The significance of the R^2 was tested using the t statistic. The computed value for each model can be read in Table 4-2, along with the conclusion of the test. Similarily, the presence of autocorrelation was tested using the Durbin Watson statistic; the conclusion of this test is also listed in Table 4-2.

Table 4-2. Empirical Equations Corresponding to the Interaction Between Crop Yields

Independent Variable: Snap Beans Yield

Dependent Variables &	Coefficient	Value	t Statistic	Significance (two-tailed; x = .05)
	a	10.80		
SC	b	-.97		
	c	.10		
	R^2	.007	.7463	Ho 14/
	D.W.	2.13		C_1 15/
	n	81		
	$Y_t = 10.80 - .97\ SB_t + .10\ SB_t^2$			
	a	7.33		
ST	b	-1.14		
	c	.09		
	R^2	.13	1.8539	Ho
	D.W.	1.98		C_1
	n	25		
	$Y_t = 7.33 - 1.14\ SB_t + .09\ SB_t^2$			
	a	71.15		
WH	b	2.66		
	c	-.52		
	R^2	.02	.5890	Ho
	D.W.	3.10		C_1
	n	19		
	$Y_t = 71.15 + 2.66\ SB_t - .52\ SB_t^2$			

Table 4-2. (Continued)

Independent Variable: Snap Beans Yield

Dependent Variables	& Coefficient	Value	t Statistic	Significance (two-tailed; x = .05)
	a	245.80		
PO	b	-80.00		
	c	8.11		
	R^2	.50	2.4495	Ho
	D.W.	2.35		C_1
	n	8		
	$Y_t = 245.80 - 80\ SB_t + 8.11\ SB_t^2 + u$			
	a	1.83		
AR	b	-.41		
	c	.04		
	R^2	.05	.4588	Ho
	D.W.	2.26		C_1
	n	6		
	$Y_t = 1.83 - .41\ SB_t + .04\ SB_t^2$			

14/ Indicates that there was not sufficient evidence to reject the null hypothesis that there is no interaction between the relevant variables.

15/ Indicates absence of serial correlation.

Relationship Between Prices

Theoretical Model

The adjusted prices served in this analysis. Like in the case of yields equations, a base crop was selected which was, again, snap beans. The established quadratic trend line takes snap beans price as the independent variable, and the price of each of the remaining crops as the dependent variable. The general form of the quadratic equation derived reads:

$$P_t = a + b * SB_t + c * SB_t^{\,2} + u \qquad (4\text{-}2)$$

where P = Price of selected crop

a = Constant term

b = Coefficient

c = Coefficient

SB = Snap beans price

t = Prediction year

u = Disturbance term

Empirical Results

Table 4-3 exhibits the models derived for the price interaction study. As shown on this table, the R^2 value for the equation involving sweet corn and snap beans prices is the highest (.7107), followed by that of the equation concerning peppermint and snap beans prices. The significance of the R^2 coefficients was tested using the t statistic. The computed t value for each case can be read in Table 403, along with the conclusion of the test. Similarly, the Durbin-

Table 4-3. Empirical Equations Corresponding to the Interactions Between Crop Prices

Independent Variable: Snap Beans Price

Dependent Variable & Coefficient		Parameter Value	t Statistic	Significance (two-tailed test; x = .05)
	a	164.96		
SC	b	-1.02		
	c	.003		
	R^2	.7107	6.8320	Ha 16/
	D.W.	1.2099		u 17/
	n	21		

$$P_t = 164.96 - 1.02\ SB_t + .003\ SB_t^2$$

Dependent Variable & Coefficient		Parameter Value	t Statistic	Significance (two-tailed test; x = .05)
	a	34.65		
ST	b	.013		
	c	.00001		
	R^2	.0259	.7108	Ho
	D.W.	2.0202		C_1
	n	21		

$$P_t = 34.65 + .013\ SB_t + .00001\ SB_t^2$$

Dependent Variable & Coefficient		Parameter Value	t Statistic	Significance (two-tailed test; x = .05)
	a	3.44		
WH	b	.0024		
	c	.00002		
	R^2	.0690	1.1867	Ho
	D.W.	1.4008		C_1
	n	21		

$$P_t = 3.44 + .0024\ SB_t + .00002\ SB_t^2$$

16/ Indicates that the null hypothesis that there is no interaction between the relevant variables was rejected.

Table 4-3. (Continued)

Independent Variable: Snap Beans Price

Dependent Variable & Coefficient		Parameter Value	t Statistic	Significance (two-tailed test; x = .05)
	a	40.37		
PO	b	-.29		
	c	.0008		
	R^2	.5398	4.7209	Ha
	D.W.	.753		C_2 18/
	n	21		
	$P_t = 40.37 - .29\ SB_t + .0008\ SB_t^2$			
	a	33.87		
AR	b	-.22		
	c	.0006		
	R^2	.1648	1.9362	Ho
	D.W.	1.3360		C_1
	n	21		

17/ Unconclusive test.

18/ Indicates presence of autocorrelation.

Watson statistic was used to detect the presence of autocorrelation; the conclusion of this latter test is also listed in Table 4-3.

Relationship Between Prices and Yields

Theoretical Model

Twenty-one observation points are available for the crop price time series, against a maximum of 13 yield observation points. for the farms with the longest records. Pracitcally, the result of this analysis will be more meaningful if the same type of data (time series or cross section) is used for all variables being considered. Based on this argument, regressing price time series over cross section yields was discarded, to consider price and yield time series only. A few farms were selected which offered maximum length for the yield time series. The equation derived for each farm is a quadratic trend line of price (dependent variable) regressed over yield (independent variable). The theoretical form of the equation reads:

$$P_t = a + b * Y_t + c * Y_t^2 + u \qquad (4\text{-}3)$$

where P = Crop price

a = Constant term

b = Coefficient

c = Coefficient

Y = Crop Yield

t = Prediction year

u = Disturbance term

This analysis involves prices and yields pertaining to the same crop.

Empirical Results

Three trend lines related to different farms were derived for each crop, with the exception of wheat, for which no more than two farms offer some yield data. The equations derived are presented in Table 4-4 in the same format as for the previous analysis.

Table 4-4 indicate that the relationship between crop prices and crop yields is very low. For the equation involving most crops, the R^2 kept the same value on almost every farm. The exception came from the wheat equations, for which the R^2 reached a significant level in one case (Farm 27), and remained insignificant in the other one (Farm 28). The computed t and Durbin-Watson statistics and the conclusion of the tests performed are listed in Table 4-4.

Conclusion

The analyses performed show some evidence of very low interrelation between a) the yields, b) the prices, and c) between the prices and yields of the relevant crops. Also the coefficient in most equations obtained were not found to be significant; statistically, they approached zero. However, the reader should be aware that the "state of the art" in the point of view of the specialist in econometrics and the "state of the art" as viewed by the farm manager differ to a great extent. Where the former individual finds some reason to overlook the relationship between two variables, the latter may not. The farm decision maker considers as important even a very weak relationship between decision variables.[19/]

19/ Discussion with Dr. Nelson.

Table 4-4. Empirical Equations Corresponding to the Interaction Between Crop Prices and Crop Yields

Independent Variable: Crop Yield

Crop	Farm Unit	Coef-ficients	Parameter Value	t Statistic	Significance (two-tailed test. x = .05)
	Farm 01	a	-364.54		
		b	105.18		
		c	-6.09		
		R^2	.075	.8048	Ho
		D.W.	1.563		C_1
		n	10		

$$P_t = -364.54 + 105.18\ Y_t - 6.09\ Y_t^2$$

Crop	Farm Unit	Coef-ficients	Parameter Value	t Statistic	Significance (two-tailed test. x = .05)
SC	Farm 02	a	-19.03		
		b	26.47		
		c	-1.62		
		R^2	.046	.7283	Ho
		D.W.	1.62		C_1
		n	13		

$$P_t = -19.03 + 26.47\ Y_t - 1.62\ Y_t^2$$

Crop	Farm Unit	Coef-ficients	Parameter Value	t Statistic	Significance (two-tailed test. x = .05)
	Farm 05	a	-89.14		
		b	41.53		
		c	-2.42		
		R^2	.054	.7909	Ho
		D.W.	1.693		C_1
		n	13		

$$P_t = -89.14 + 41.53\ Y_t - 2.42\ Y_t^2$$

Table 4-4. (continued)

Independent Variable: Crop Yield

Crop	Farm Unit	Coef-ficients	Parameter Value	t Statistic	Significance (two-tailed test x = .05)
	Farm 01	a	-2646.20		
		b	1103.29		
		c	-105.91		
		R^2	.2629	1.5801	Ho
		D.W.	1.5755		C_1
		n	9		

$$P_t = -2646.20 + 1103.29\ Y_t - 105.91\ Y_t^{\ 2}$$

Crop	Farm Unit	Coef-ficients	Parameter Value	t Statistic	Significance (two-tailed test x = .05)
SB	Farm 05	a	72.59		
		b	34.68		
		c	-3.09		
		R^2	.0293	.5762	Ho
		D.W.	2.5969		C_1
		n	13		

$$P_t = 72.59 + 34.68\ Y_t - 3.09\ Y_t^{\ 2}$$

Crop	Farm Unit	Coef-ficients	Parameter Value	t Statistic	Significance (two-tailed test x = .05)
	Farm 27	a	-986.45		
		b	467.69		
		c	-46.67		
		R^2	.2096	1.5449	Ho
		D.W.	2.62		C_1
		n	11		

$$P_t = -986.45 + 467.69\ Y_t - 46.67\ Y_t^{\ 2}$$

Table 4-4. (continued)

Independent Variable: Crop Yield

Crop	Farm Unit	Coef-ficients	Parameter Value	t Statistic	Significance (two-tailed test x = .05)
	Farm 27	a	7.27		
		b	-.83		
		c	.04		
		R^2	.4561	2.7472	Ha
		D.W.	.7000		u
		n	11		
		$P_t = 7.27 - .83\ Y_t + .04\ Y_t^2$			
WH	Farm 28	a	1.16		
		b	1.23		
		c	-.09		
		R^2	.2941	1.5811	Ho
		D.W.	1.0497		u
		n			
		$P_t = 1.16 + 1.23\ Y_t - .09\ Y_t^2$			

The ultimate goal of this study is to serve as a tool in the farm decision process; thus, it is important that, just like the farm manager, the author provides, in the decision model, for the trade-off between the different variables of interest. To fulfill that goal, the probability distributions of the residuals generated by models (4-1) and (4-2) were elicited (Table 4-5 (a and b)). When the yield (or price) of the base crop is known, the price (or yield) of each crop in the mix can be calculated using models (4-1) or (4-2) (these two models contain a disturbance term u).[20/] Methodologically, prior to the calculation of the yields (or prices) of the remaining crops, some random values of residuals must be generated using the inverse of either the beta or triangular function, the same which served for the random price generation for the base crop. The results of the simulation runs, which will figure in the next section, are based on the information developed here.

20/ The interaction between crop prices and yields is not considered. The crop production originating from each farm represents a small portion of the total supply for that commodity, and as a result, has almost no impact on the commodity price. It follows that the consideration of the price-yield interaction is not justified.

Table 4-5.a Probability Distribution of Residuals from regression of crop yields over snap beans yields.

Residuals / Crops	Lowest	Highest	Mean	Mode	N
SC	-2.44	3.03	0	.30	81
ST	-1.26	1.07	0	.10	25
WH	-31.5	23.2	0	3.67	19
PO	-4.06	3.83	0	-.11	8
AR	-.067	-.066	0	-.03	6

Table 4-5.b Probability Distribution of Residuals from regression of crop prices over snap beans prices.

Residuals / Crops	Lowest	Highest	Mean	Mode
SC	-16.30	12.50	0	-1.90
ST	-6.17	8.20	0	-3.78
WH	-1.78	5.24	0	.17
PO	-6.41	3.94	0	1.72
AR	-5.26	12	0	-.95

CHAPTER V

FARM SIMULATION

Simulation Technique

The Procedure

The simulation technique has been presented as one of the widely used methods to study risk in investment analysis. At this point, it seems important to refine the reader's understanding about such terms as system and model, and about the steps which are implicated when we refer to simulation. According to Gordon, a system is "an aggregation or assemblage of objects joined in some regular interaction or interdependence." For a model, he writes that " . . . a model is not only a substitute for a system, it is also a simplification of the system. Different models of the same system will be produced by different analysts . . , or by the same analyst as his understanding of the system changes." (p. 5.)

Anderson (1974 (a)) defines simulation as "a numerical manipulation of a symbolic model of a system over time." He identifies several distinct stages which intervene in the simulation process; these stages are defined in the following lines.

Stage 0: State simulation goals and plans.

Stage 1: System analysis: determine its major components and features, and discover the relationship between those components.

Stage 2: Synthesis: summarize the results into a coherent and logical structure to help make final decision.

Stage 2.1: Stochastic specification: specify the stochastic variables and how they are generated.

Stage 2.2: Model implementation: select a computer and a programming language.

Stage 3: Checking the model.

Stage 3.1: Verification: inquire about the adequacy of the model. Does it measure up to intentions?

Stage 3.2: Validation: investigate the performance of the model as a way to "mimic" the system.

Stage 4: Model analysis: this stage includes three steps dealing with the behavior of the model.

Stage 4.1: Sensitivity analysis: Assess how the model output changes as a result of a change in the values of key variables.

Stage 4.2: Model experimentation: run the model for some specific variable values which are of some interest.

Stage 4.3: Interpretation: interpret the result.

Among the stages listed above, stochastic specification can be viewed as the most critical of all; therefore, it will be more widely presented in the following lines.

In stochastic programming, the generation of random variates occupies an essential place. The random variates fed into the model, for each run of the simulation model, can be read from published random number tables or derived by making use of congruence relationship (see Gordon). Practically, the congruence method yields numbers lying between 0 and 1; following their generation, they give random values of the pertinent variable, via the inverse of the cumulative function of the specified probability distribution. To summarize, the random variate generation and the specification of the probability distribution constitute the basis of the simulation procedure. If the probability distribution is not properly specified, the usefulness of the simulation output will be null. In this thesis, since the interest goes to stochastic simulation, the inverses of the beta and triangular CDFs are required to generate the random prices and yields. The random numbers to feed into the CDFs are provided by a pseudo random number generator.

In fact, when a standardized beta distributed variable x is fed into the beta CDF, the result is $I_x(P,q)$.[21/] The reverse operation via the inverse of the beta CDF yields back the value of x.

Given that, since the aim is to obtain beta distributed random prices and yields, random values of $I_x(P,q)$ are generated and used to calculate values of x. Following the calculation of x, a random value for the variable of interest can be computed by applying the following formula:

$$Y = x\,(B-A) + A$$

where Y = Random value of variable Y

B = Highest possible of variable Y

A = Lowest possible of variable Y

x = Beta distributed random variate (0 to 1)

21/ Both x and $I_x(P,q)$ lie between 0 and 1.

A computer algorithm[22/] exists which evaluates the value of the inverse of the beta CDF for any number between 0 and 1 (inclusive). It has been "translated" and programmed on the Apple II computer. A listing of this program, named MDBETI (version for Apple II) is joined to this work as part of the proposed model which we describe in the next section.

As written in chapter II, given a random number u, the triangular CDF can be solved to obtain a random value of the relevant variable. The computer program to use and generate triangular distributed prices and yields is also included in the proposed model.

The Model

The system to "mimic" is that which provides a measure of a farm operation solvency. The model BETATRI proposed to represent that system, is made of three components, which are: 1) an algorithm which generates beta distributed prices and yields (MDBETI), 2) a model which generates triangular distributed prices and yields, 3) a model which calculates the ending cash balance, and the probability of that cash balance being below specified levels. The first two components have been exposed in earlier paragraphs, and as a result need no presentation here. Thus, the interest goes to the third component, which contains the cash balance formula. The cash balance equation reads:

$$EB = BS + TG + OCR + CS - DXP - INR - PP - CE - LVW - TTX$$

22/ The algorithm can be found in the IMSL library under the name MDBETI.

with EB = Ending balance

BS = Beginning balance

TG = Gross income

OCR = Other Cash Income

CS = Capital sales

DXP = Cash expenses (includes variable and fixed costs)

INR = Interest payment (includes interest on loan and on operating capital)

PP = Principal Payment

CE = Capital expenses

LVW = Living withdrawals

TTX = Tax payment (includes self-employment and income taxes)

The last two elements of BETATRI have originally been developed by the Extension Service.[23/] For this analysis they were merged with the first element (MDBETI) into a single model (BETATRI). A listing of BETATRI is joined to this work in Appendix D-2.

Cost Data

The total production cost of a commodity embodies two broad categories of expenses: a) the fixed costs which are made of implicit costs (gains foregone for producing the commodity), plus all expenditures that don't vary as the level of output increases; and b) the variable costs which involve those expenses related to the output level. Practically, to increase the output level, more inputs are needed. Given this definition of total production cost, the issue to discuss next is the stochasticity of the quantity so defined.

23/ See Financial Risk Evaluator. Programmable Calculator Series

It is widely admitted that crop prices and yields are stochastic. They vary from one growing season to another. Likewise, total production costs may vary as a result of: a) new technology that can increase machinery prices (fixed costs); b) an oil price increase capable of raising fertilizers and fuel prices (variable costs); and c) new labor contracts which may put an upward pressure on wages (variable costs), etc. At the time when crop price and yield variability is getting a meticulous attention, one may inquire about what share of efforts is devoted to cost studies. Essentially, the need concerns cost records from past years; their availability can offer the decision maker the possibility of deriving a variation pattern. These records can also serve as a basis for the decision maker's subjective judgements about the quantity. The difficulty in getting reliable cost figures stems from the fact that they necessitate consistent bookkeeping. The recent developments in computer technology brings some hope for a solution to the cost data problem; for computers provide a data storage and retrieval alternative different from the traditional techniques. Bristol in his work mentioned that 20 percent of the farmers he surveyed kept cost records with local firms offering computerized services. As the problem stands, farmers will always have the most important task to perform, that of reporting production layouts.

In empirical studies, many authors including Carter and Dean, and Pope, elected to consider total production cost as a fixed quantity. A similar attitude is adopted here, as we lack the necessary data.

HP-41CV. Oregon State University by Extension Service, July 1981.

The cost figures available for this study were compiled by Extension economists and agents. While the 1981 enterprise data existed for some crops, they were lacking for some others. In the latter case, the index of prices paid by farmers proved very useful in coming up with some cost estimates at the 1981 level. The table in appendix C-1 shows the percent increase in the price index from a reference period to July 1981. The table exhibits the aggregate change which relates to the index of price of all items, and the variation per item category. To obtain the 1981 enterprise cost, its value in the reference period[24/] is simply added to the product of its multiplication by the percent change; symbolically, that is written as:

$$C_{j1981} = C_{jr}(1+dj)$$

where C_{j1981} = Cost of item j in 1981

C_{jr} = Cost of item j in reference period r

dj = Change in price index for item j

However, the operating capital interest was set to 16.5 percent, a rate closer to those currently charged by banks. This rate was used in computing the 1981 charges.

The total production cost, expressed in 1981 terms, is the sum of expenses for all individual (input) items intervening in the production process; that is:

$$C = \sum_{j=1}^{n} c_{j1981}$$

24/ i.e., year for which cost record is published.

where C is the total production cost, and n the number of input items.

The adjusted figures inherent to the relevant crops are presented in Appendix C-2; the depreciation, interest, fixed and variable cost data listed in Table 5-1 were drawn from the tables in that appendix.

Case Farm Description

The goal of the farm simulation performed in this study is to assess how the farmer's risk varies as the cropping strategy changes. In fact, a total of five strategies were defined which appear in Table 5-2; they relate to the distribution of the farm land among the relevant crops.

The farm operation in this case represents a typical Willamette Valley farm, in the sense that the price and yield distributions, and the cost defined for the area serve as inputs in the analysis. The total acreage is assumed to be 400 acres, as indicated in Table 5-2. The farmers pay $75,000 annually on outstanding debt. His living expenses, and withdrawals amount to $20,000, and the capital expenses during each operating year also add up to $20,000.

The simulation model was run for 300 years[26/] to come up with estimates of the lowest, highest, and average ending balances, as well as the risk measures for different cash balance levels.

26/ This is equivalent to writing that, for each crop, 300 price and yield combinations were randomly generated. The number of combinations can be estimated by use of sampling methods, but that was done in this analysis.

Table 5-1. Interest, Depreciation, Variable and Fixed Costs Paid Per Acre.

Crop	Item	Amount($)
Snap Bean	Interest	10.20
	Harvest Cost (/t)25/	43.78
	Fixed Cash Cost	400.60
	Depreciation	27.60
Sweet Corn	Interest	12.50
	Harvest Cost (/t)25/	11.83
	Fixed Cash Cost	396.60
	Depreciation	30.68
Wheat	Interest	8.95
	Harvest Cost (/bu)25/	.35
	Fixed Cash Cost	94.05
	Depreciation	12.60
Strawberries	Interest	29.89
	Harvest Cost (/t)25/	329.21
	Fixed Cash Cost	130.52
	Depreciation	39.03

25/ Harvest cost stands for the variable cash cost.

Table 5-2. Cropping Strategies Based on 400 Acres.

Crop Strategy	Snap Beans	Sweet Corn	Wheat	Strawberries
1	120	120	100	60
2	150	150	100	0
3	200	0	200	0
4	0	200	200	0
5	0	0	400	0

Results and Interpretations

Results

We know that the output of the simulation model includes such values as, the ending cash balances (lowest, highest, and average), and also the probabilities of getting the cash balance below some prespecified values. These values were selected all negative to illustrate the definition of risk as "the chance of adverse outcomes." The financial leverage of a farm operation, varies from one farm to another. It is obvious that each farmer has his own cash requirements to meet; but unfortunately, it is not realistic to derive a risk index for each case. The various (negative) cash values for which the risk indices are calculated are expected to be meaningful to most farmers whose enterprises are similar to the case farm being studied.

Table 5-3 exhibits the outputs of the simulation model for the 300 runs performed. For each strategy two groups of estimates are listed: one group which is derived by using the beta distribution as the random prices and yields generator (beta option), and another group which is obtained by using the triangular distribution in lieu of the beta distribution in BETATRI (triangular option). The logical step following the calculation of these estimates is to establish their usefulness for the farm manager. Clearly, there is a need to point out the information provided by the output of the simulation model, since this information is what is needed by decision makers as a basis for selecting the choice of their cropping system.

Table 5-3. Farm Simulation Output.

Strategy	Items	Estimated Values: Beta Option	Estimated Values: Triangular Option
1	Beginning Cash Balance	5,000	5,000
	Ending Balance - Lowest	-117,462	-117,462
	- Highest	283,697	283,697
	- Average	33,389	50,543
	Probability Neg. Balance (%)	12	6
	Prob. of Bal. Below $-10,000	4	2
	Prob. of Bal. Below $-30,000	0	0
	Prob. of Bal. Below $-60,000	0	0
	Prob. of Bal. Below $-100,000	0	0
2	Beginning Cash Balance	5,000	5,000
	Ending Balance - Lowest	-128,437	-128,437
	- Highest	191,695	191,695
	- Average	1,148	11,129
	Probability Neg. Balance (%)	55	38
	Prob. of Bal. Below $-10,000	36	25
	Prob. of Bal. Below $-30,000	9	7
	Prob. of Bal. Below $-60,000	0	0
	Prob. of Bal. Below $-100,000	0	0
3	Beginning Cash Balance	5,000	5,000
	Ending Balance - Lowest	-134,684	-134,684
	- Highest	176,758	176,758
	- Average	-5,039	11,674
	Probability Neg. Balance (%)	57	36
	Prob. of Bal. Below $-10,000	43	25
	Prob. of Bal. Below $-30,000	18	10
	Prob. of Bal. Below $-60,000	4	1
	Prob. of Bal. Below $-100,000	0	0

Table 5-3. (Continued)

Strategy	Item	Estimated Values: Beta Option	Estimated Values: Triangular Option
4	Beginning Cash Balance	5,000	5,000
	Ending Balance - Lowest	-112,727	-112,727
	- Highest	141,450	141,450
	- Average	-15,927	-8,173
	Probability Neg. Balance (%)	84	65
	Prob. of Bal. Below $-10,000	57	42
	Prob. of Bal. Below $-30,000	20	15
	Prob. of Bal. Below $-60,000	3	2
	Prob. of Bal. Below $-100,000	0	0
5	Beginning Cash Balance	5,000	5,000
	Ending Balance - Lowest	-114,242	-114,242
	- Highest	93,923	93,923
	- Average	-30,010	-17,359
	Probability Neg. Balance (%)	89	73
	Prob. of Bal. Below $-10,000	79	59
	Prob. of Bal. Below $-30,000	46	31
	Prob. of Bal. Below $-60,000	12	7
	Prob. of Bal. Below $-100,000	0	0

Interpretation

The examination of the figures in Table 5-3 indicates that the order of dominance of one strategy over another is different, depending on whether the beta or triangular distribution was used to generate the random prices and yields during the 300 runs.

When the cash balances and risk indices are estimated by running BETATRI with the beta option, it appears that each strategy dominates the next one, starting with strategy 1. The dominance relation is based on the magnitude of the average cash balance as well as on the importance of the risk indices. It can be explained by looking at the results of strategies 1 and 2. We can write that strategy 1 dominates strategy 2, for alternative 1 provides an average cash balance equal to $33,389 against $-1,148 for alternative 2; strategy 1 also yields a 12 percent chance of getting a negative cash balance, as opposed to 55 percent for strategy 2. As shown on Table 5-3, the risk measures for getting the cash balance below the specified levels ($-10,000, $-30,000, $-60,000, $-100,000) are lower for strategy 1 (4 percent, 0 percent, 0 percent, and 0 percent respectively) than for strategy 2 (36 percent, 9 percent, 0 percent, and 0 percent respectively).

As I wrote earlier, system 1 dominates any other system considered in the analysis; at the opposite, system 5 is dominated by any other strategy. This means that the crop mix involving all four crops (snap beans, sweet corn, wheat, and strawberries) represents the least risky and more profitable of all five cropping systems; whereas the crop mix containing wheat alone stands as the least profitable and riskiest of all.

The fact that alternative 3 dominates alternative 4 implies that sweet corn is a riskier crop than snap beans; but the dominance of the second strategy over the third and fourth ones demonstrates that the riskiness of snap beans and sweet corn can be reduced. To reach such a goal, there is a need to include snap beans, sweet corn, and wheat in a single cropping system (strategy 2). This finding is in relation with current practice in the Willamette Valley where some farmers who run snap beans and sweet corn enterprises also run a wheat enterprise. In fact, growing wheat in association with snap beans and sweet corn offers an agronomic advantage, in the sense that it serves as a rotation crop.

Let's now consider the results derived by running BETATRI with the triangular option. In this case strategy 1 dominates any other strategy, the opposite being true for strategy 5. It is also apparent that strategy 3 dominates strategy 4. These two observations are consistent with the previous results obtained with the beta distribution as the random prices and yields generator. As a result, all conclusions drawn then are valid in this case too.

Unexpectedly, there exists no dominance relationship between the second and third strategies, since alternative 2 offers a lower average cash balance, and lower risk elements than does alternative 3. In more explicit terms the average cash balance of alternative 2 is $540 lower than that pertaining to alternative 3; and alternative 2 provides lower risk indices (7 percent and 0 percent) for a cash balance below $-30,000 and $-60,000 respectively, than strategy 3 for which the calculated respective risk indices are

10 percent and 1 percent. It should be mentioned that alternative 2 yields a 38 percent chance of getting a negative cash balance against 36 percent for alternative 3. Based on these facts we can argue that the selection of a strategy among alternatives 2 and 3 depends on the farmer's perception of risk, and on how solvent he is. It is the author's belief that a revenue shortfall of $545 is not given much consideration by most farmers;[27/] so that ultimately, strategy 2, which offers less risk of a high cash deficit, than strategy 3, will remain the more desirable choice for a decision maker who has to choose between alternatives 2 and 3.

To summarize, strategy 1 emerges as the best alternative the decision maker can select, whereas strategy 5 turns out to be the worst he can adopt. Data is needed to study Willamette Valley farmers' attitude with respect to these two strategies. Due to a lack of data, such a study, although interesting, could not be carried out in this thesis.

One striking point which emerges from Table 5-3 is that the cash balance figures assessed by using beta distributed prices and yields are much lower than those computed by using triangular distributed prices and yields. The reverse is true for the risk indices. Genera-ly, farmers and especially those who do not have much contact

27/ In this particular case, since wheat is a rotation crop, growing it in association with snap beans and sweet corn (strategy 2) will more than compensate the $545 forgone by not adopting strategy 3.

with new techniques,[28/] are suspicious about new methods which reach them through extension agents. Therefore, consistency is a condition necessary to establish the credibility of the extension agents, thus to maintain the link between researchers and farmers. This concern leads us to investigate about which of the beta or the triangular distributious provides the more useful information about prices and yields; that is, which distribution allows us to more precisely simulate the case farm. To carry out this investigation, the estimated values of the first and second moments of the simulated prices and yields are compared to their observed values.

For prices, the figures in Table 5-4(a), indicate that in 50 percent of the cases, the beta option provides estimates of the first moment relatively closer, than those provided by the triangular option, to the observed values. That percentage becomes null when the estimates of the second moment is considered. For yields, the figures in Table 5-4(b) indicate that the beta option provides better estimates than the triangular option in 13 percent of the cases. When the second moment is considered, that percentage increases to 87 percent.

Unlike the comparison of the modal values performed in Chapter III, the beta probability distribution function does not consistently provide better estimates than the triangular probability distribution

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28/ This is a reference to third world peasants for whom the introduction of a new technique needs a longer time than would be required.

Table 5-4. a Mean and Standard Deviation for Crop Prices.

Crop	Item	Observed	Estimated	
			Beta Option	Triangular Option
SB	Mean	170.64	167.16	197.08
	S. Dev.	40.60	35.95	42.20
SC	Mean	82.70	80.20	83.77
	S. Dev.	15.24	7.72	12.41
WH	Mean	4.35	4.12	5.03
	S. Dev.	1.46	1.00	1.15
ST	Mean	742.80	652.20	721.42
	S. Dev.	86.07	48.83	63.56

Table 5-4. b Mean and Standard Deviation for Crop Yields.

Crop	Item	Observed	Estimated	
			Beta Option	Triangular Option
SB	Mean	4.93	4.90	4.66
	S. Dev.	.64	.78	.85
SC	Mean	8.60	8.97	8.83
	S. Dev.	1.25	1.21	1.31
WH	Mean	71.72	76.03	71.54
	S. Dev.	12.85	10.26	11.28
ST	Mean	4.08	4.37	4.30
	S. Dev.	.98	1.00	1.08

function. Hence, none of the beta or triangular functions can be singled out as the more appropriate to use for extension activities.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary of Research

Selecting a cropping strategy is a task which farmers have to perform every year. Different techniques have been developed to cope with the difficulty involved in the decision process, but they do one appear to have satisfied the felt needs. Some of the obstacles restricting the use of the existing techniques by the farmers are: a) the difficulty of understanding the concepts on which the techniques are built, and b) the availability of these techniques.

When the decision models were simple enough and made readily available, they failed to address some specific aspects of the decision problem. One of the problems facing decision makers is to know how the risk element associated with selected crops varies as the crop combination changes.

In this study, four crops were chosen among all crops grown in the Willamette Valley. The beta and triangular probability distribusions were fitted to the adjusted crop prices and yields. Following that, an analysis was performed to assess the relationship among crop prices, among crop yields, and also the relationship between crop prices and yields. The information developed was input into the proposed model.

The proposed model (BETATRI) offers the possibility to use the beta probability distribution to generate the random prices and yields (beta option), or the triangular probability distribution to reach that same goal (triangular option).

A hypothetical farm with a total cropping land of 400 acres was chosen to be simulated. BETATRI was run 300 times for each of the five cropping strategies defined. The output of the model indicated that strategy 1, which involves all four crops, was the least risky and the most profitable of all strategies; at the opposite, alternative 5, which concerns only wheat, was found to be the riskiest and the least profitable of all alternatives. The output also indicated that there was a real risk reducing benefit in growing wheat in association with snap beans and sweet corn, as opposed to growing snap beans alone in association with wheat, or growing sweet corn alone in association with wheat.

The performance of the beta and triangular probability distributions was investigated, but it could not be established that the beta distribution was a better alternative than the triangular distribution, or vice-versa.

Application of the Model

The BETATRI model requires three main groups of inputs which include the following:

1) The price and yield probability distributions: the need of these distributions evolves as the random prices and yields, used to compute the gross income, are drawn from these distributions. This relates to the base crop (snap beans) only. For the remaining crops, only the distributions of of the regression residuals are required, since

the prices and yields of each of these crops are determined as a function of the prevailing price and yield of the base crop, plus a random term which is randomly drawn from the corresponding residual distribution.

2) The regression coefficients: they relate to the regression line, which defines the price (or yield) of an individual crop as a function of the price (or yield) of the base crop.

3) The production costs: the cost figures intervene in the calculation of the taxable income.

Other input items include living expenses, and withdrawals, loan repayment, capital expenses, and finally the tax rate schedule.

The BETATRI model was programmed on the Apple II computer. The time needed to run BETATRI 100 times with a cropping system involving four crops depends on whether the beta option or triangular option is selected. When BETATRI is run with the beta option, the running time approaches four hours. The importance of this running time is explained by the length of the algorithm which generates the beta distributed prices and yields. With the triangular option, only 15 minutes are needed for the 100 runs.

Despite the lengthy time required to run BETATRI with the beta option, the model can still be useful for extension education. Practically, assuming that the choice of the beta option prevails, and that one has a cropping system comprising several crops, the simulation loop can be started at night so that the results are available the next morning. Else, it can be started in the morning, and results will be obtained later in the day.[29/] It is obvious that the more important the number of relevant crops and the number of runs are, the longer the simulation process lasts.

Limitations of the Model

The variable cash cost is computed by dividing the harvest cost by the average yield. As calculated, the variable cash cost could be lower if a higher yield than the average yield was used; it could also be higher if a lower yield than the average yield was considered. The flaw which characterizes the variable cash cost brings an error in the cash flow estimation, since the yields generated by the simulation are not necessarily equal to the average yield; else, the simulation process itself would not have any role to play.

All the cost variables which comprise the input of the model are considered as non stochastic. But, to what extent are we sure that the adjusted cost figures will turn out to be at the expected levels? Oil price (to use only this item) which influences production cost has experienced some unforeseen hikes in the past, and such price hikes can occur again. Thus, there is a need to take into account the unexpected situations. That can be done by attaching probability values to the cost elements.

29/ It is a good practice to measure the time it takes to perform one run and derive the duration time of the total number of runs desired.

Implications for Future Research

The algorithm used to generate the beta distributed prices and yields is long, and it imposes a lengthy running time to the simulation model when the beta option is selected. Beta distributed variables can be generated using the Gamma and Erland distributions. Using these distributions to develop a new approach would improve the practicality of BETATRI. Explicitly, the memory space required to program the model would be reduced, thus making it possible to program BETATRI on a hand held computer such as the HP-41C. Also, the running time of the BETATRI (beta option) on the Apple II computer would decrease considerably.

More work is required to collect longer individual farm price and yield series for the purpose of more adequately deriving the respective probability distributions. Longer price and yield series would make it interesting to perform a test of goodness of fit and determine which of the beta or triangular probability distribution functions is more appropriate for simulation purpose.

Finally, more research is needed to assess the variability of the cost variable and incorporate it in the determination of the taxable income.

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APPENDIX A-1

ACTUAL AND TREND ADJUSTED PRICES

Table A-1. Snap Beans Prices

Year	Actual Price*	Inflated Price	Expected Price	Deviation	Adjusted Price
			- - - $/ton - - -		
1959	124.31	401.84	--	--	--
1960	125.00	394.89	343.11	51.79	238.83
1961	116.00	366.45	369.00	- 2.55	184.49
1962	119.00	367.58	367.73	- .15	187.03
1963	114.98	355.16	367.66	-12.50	174.55
1964	117.31	362.36	361.41	.95	187.99
1965	108.83	321.86	361.89	-40.03	147.02
1966	111.66	316.75	341.88	-25.13	161.92
1967	112.45	318.99	329.32	-10.33	176.72
1968	107.82	293.84	324.16	-30.32	156.73
1969	109.25	286.52	309.00	-22.48	164.56
1970	103.35	261.19	297.76	-36.57	150.47
1971	103.00	246.84	279.48	-32.64	154.41
1972	111.00	248.85	263.16	-14.31	172.73
1973	107.84	211.12	256.01	-44.89	142.16
1974	207.57	356.20	233.57	122.64	309.68
1975	148.31	231.63	294.89	-63.26	123.37
1976	132.68	194.13	263.26	-69.13	118.12
1977	151.13	210.07	228.70	-18.63	168.52
1978	141.15	181.67	219.39	-37.72	149.38
1979	153.60	173.58	200.53	-26.95	160.12
1980	154.54	154.54	187.06	-32.52	154.54
Mean	126.40	284.37	289.51	-16.42	170.64
SDev.	24.76	76.96	63.52	40.60	40.60
Var.	612.93	5,922.42	4,034.57	1,648.24	1,648.24

Table A-2. Sweet Corn (Processed Prices)

Year	Actual Price*	Inflated Price	Expected Price	Deviation	Adjusted Price
			- - - $/ton - - -		
1959	27.21	87.96	--	--	--
1960	23.91	75.53	82.37	- 6.84	76.65
1961	23.90	75.50	80.66	- 5.16	78.33
1962	25.70	79.38	79.37	0.01	83.50
1963	26.40	81.55	79.37	2.18	85.67
1964	25.54	78.89	79.92	- 1.03	82.46
1965	24.58	72.69	79.66	- 6.97	76.52
1966	25.19	71.46	77.92	- 6.46	77.03
1967	29.41	83.43	76.30	7.13	90.62
1968	30.04	81.87	78.09	3.78	87.27
1969	29.35	76.97	79.03	- 2.06	81.43
1970	27.97	70.69	78.52	- 7.83	75.66
1971	28.90	69.26	76.56	- 7.30	76.19
1972	29.90	67.03	74.73	- 7.70	75.79
1973	40.12	78.54	72.81	5.73	89.22
1974	76.46	131.21	74.24	56.97	140.46
1975	62.85	98.16	88.48	9.68	93.17
1976	59.14	86.53	90.90	- 4.37	79.12
1977	66.70	92.71	89.81	2.90	86.39
1978	59.77	76.93	90.53	-13.60	69.89
1979	64.20	72.55	87.13	-14.58	68.91
1980	62.35	62.35	83.49	-21.14	62.35
Mean	39.53	80.51	80.82	- .79	82.70
SDev.	18.35	14.07	5.37	15.24	15.24
Var.	325.42	198.00	28.83	232.18	232.18

Table A-3. Wheat Prices

Year	Actual Price*	Inflated Price	Expected Price	Deviation	Adjusted Price
			- - - $/bu. - - -		
1959	1.84	5.95	--	--	--
1960	1.84	5.81	5.39	.42	4.89
1961	1.89	5.97	5.58	.39	4.86
1962	1.97	6.09	5.75	.34	4.81
1963	1.90	5.87	5.91	- .04	4.43
1964	1.33	4.11	5.89	- 1.78	2.69
1965	1.40	4.14	5.09	- .95	3.52
1966	1.61	4.57	4.66	- .09	4.38
1967	1.45	4.11	4.62	- .51	3.96
1968	1.13	3.08	4.39	- 1.31	3.16
1969	1.34	3.51	3.80	- .29	4.18
1970	1.50	3.79	3.67	.12	4.59
1971	1.45	3.48	3.72	- .24	4.23
1972	2.06	4.62	3.61	1.01	5.48
1973	4.57	8.95	4.07	4.88	9.35
1974	4.50	7.72	6.26	1.46	5.93
1975	3.69	5.76	6.92	- 1.16	3.31
1976	2.81	4.11	6.40	- 2.29	2.18
1977	2.78	3.86	5.37	- 1.51	2.96
1978	3.42	4.40	4.69	- .29	4.18
1979	3.85	4.35	4.56	- .21	4.26
1980	4.10	4.10	4.47	- .37	4.10
Mean	2.38	4.93	4.96	- .12	4.35
SDev.	1.13	1.45	.96	1.46	1.46
Var.	1.27	2.09	.92	2.12	2.12

Table A-4. Strawberry Prices

Year	Actual Price*	Inflated Price	Expected Price	Deviation	Adjusted Price
			- - - ¢/lb. - - -		
1959	13.52	43.70	--	--	--
1960	14.36	43.36	42.42	2.94	40.79
1961	12.73	40.22	43.74	- 3.52	34.33
1962	13.37	41.30	42.16	- .86	36.99
1963	12.61	38.95	41.77	- 2.82	35.03
1964	14.25	44.02	40.50	3.52	41.37
1965	16.00	47.32	42.08	5.24	43.09
1966	17.48	49.59	44.44	5.15	43.00
1967	14.16	40.17	46.76	- 6.59	31.26
1968	16.72	45.57	43.79	1.78	39.63
1969	17.20	45.11	44.59	.52	38.37
1970	15.82	39.98	44.83	- 4.85	33.00
1971	14.98	35.90	42.65	- 6.75	31.10
1972	17.73	39.75	39.61	.14	37.99
1973	23.85	46.69	39.67	7.02	44.87
1974	25.57	43.88	42.83	1.05	38.90
1975	22.83	35.66	43.30	- 7.64	30.21
1976	28.53	41.74	39.86	1.88	39.73
1977	28.38	39.45	40.71	- 1.26	36.59
1978	26.84	34.54	40.14	- 5.60	32.25
1979	33.75	38.14	37.62	.52	38.37
1980	33.00	33.00	37.85	- 4.85	33.00
Mean	19.71	41.27	41.68	- .71	37.14
SDev.	6.83	4.32	2.67	4.30	4.30
Var.	46.72	18.67	7.14	18.52	18.52

* Source: Bureau of Economic Information, Department of Agricultural and Resource Economics, Oregon State University.

APPENDIX A-2

ADJUSTED PRICE HISTOGRAMS

Crop: Snap Beans

Scale: $31.927

Mean: $170.64

Mode: $163.73

n: 21 (Number of Observations)

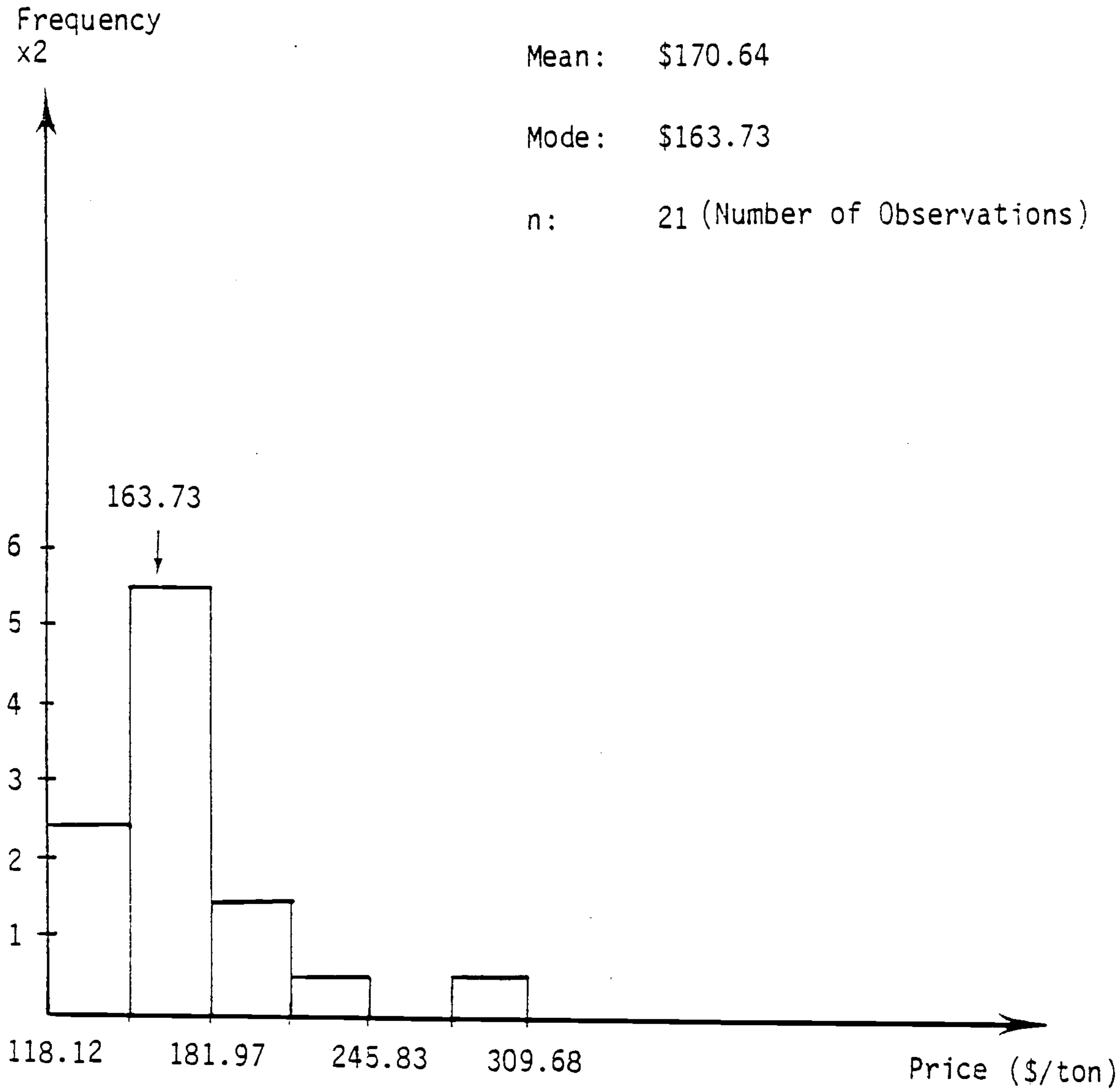

Figure A-1 Trend Adjusted Price Distribution for Snap Beans.

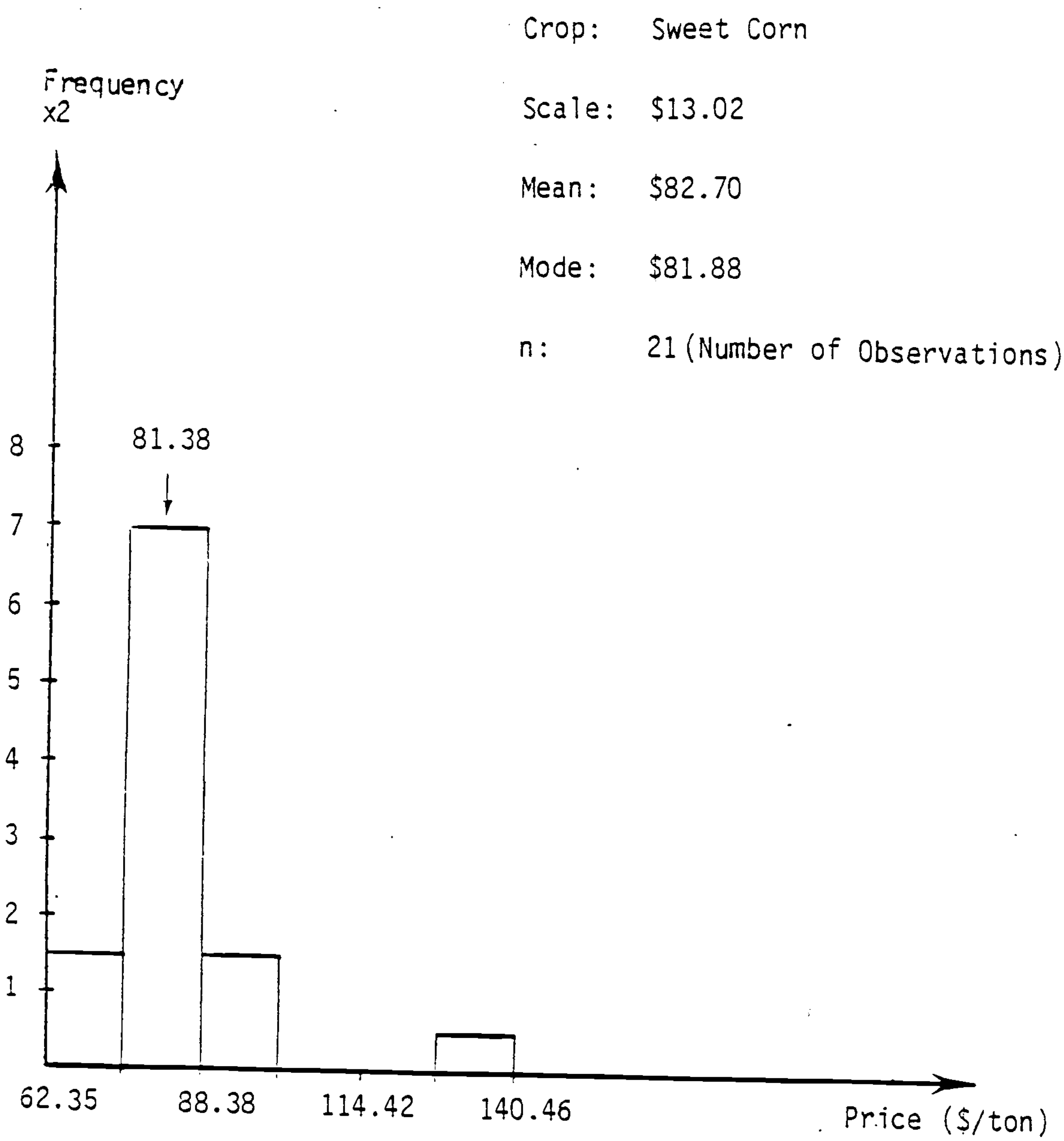

Figure A-2. Trend Adjusted Price Distribution for Sweet Corn.

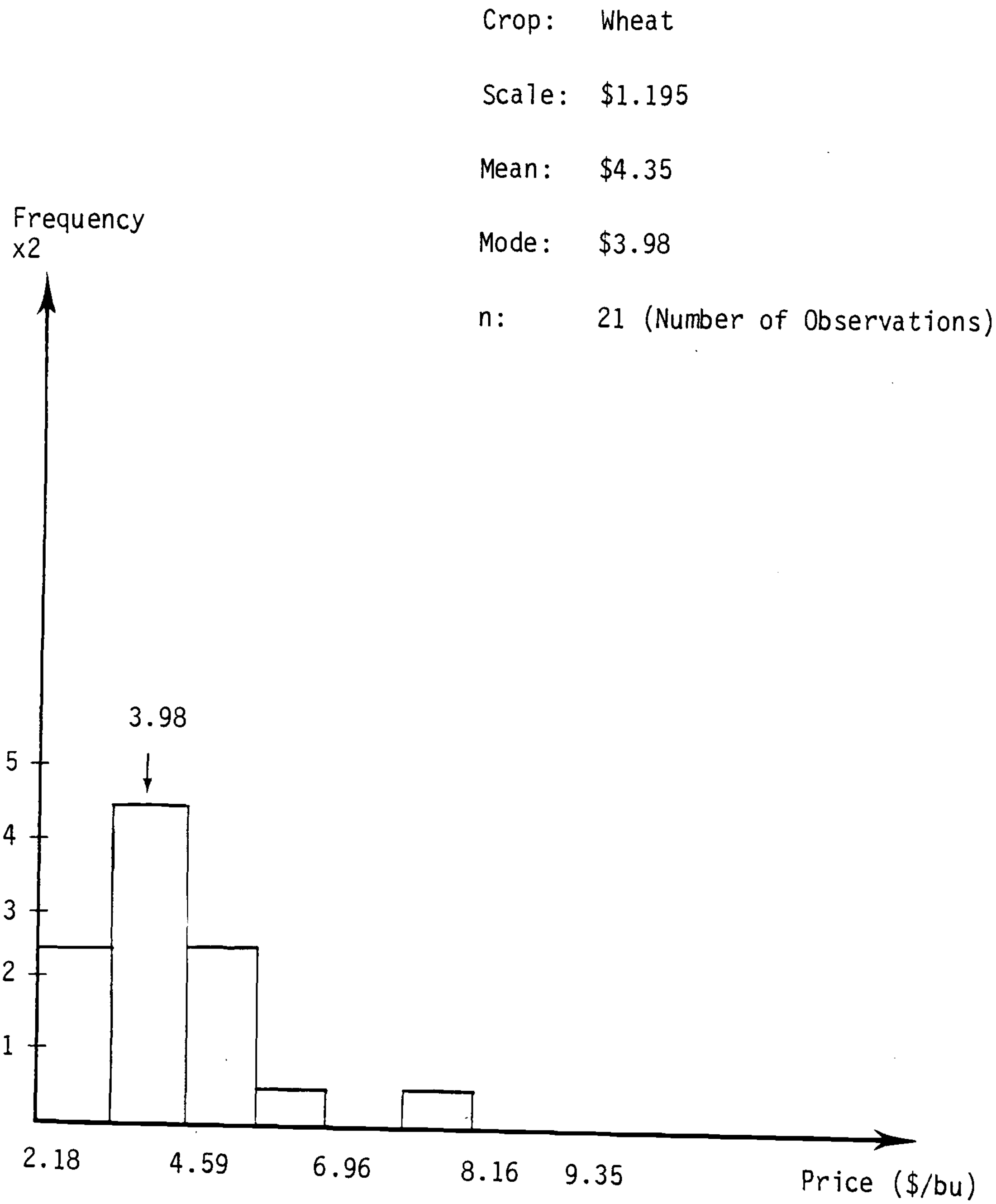

Figure A-3. Trend Adjusted Price Distribution for Wheat.

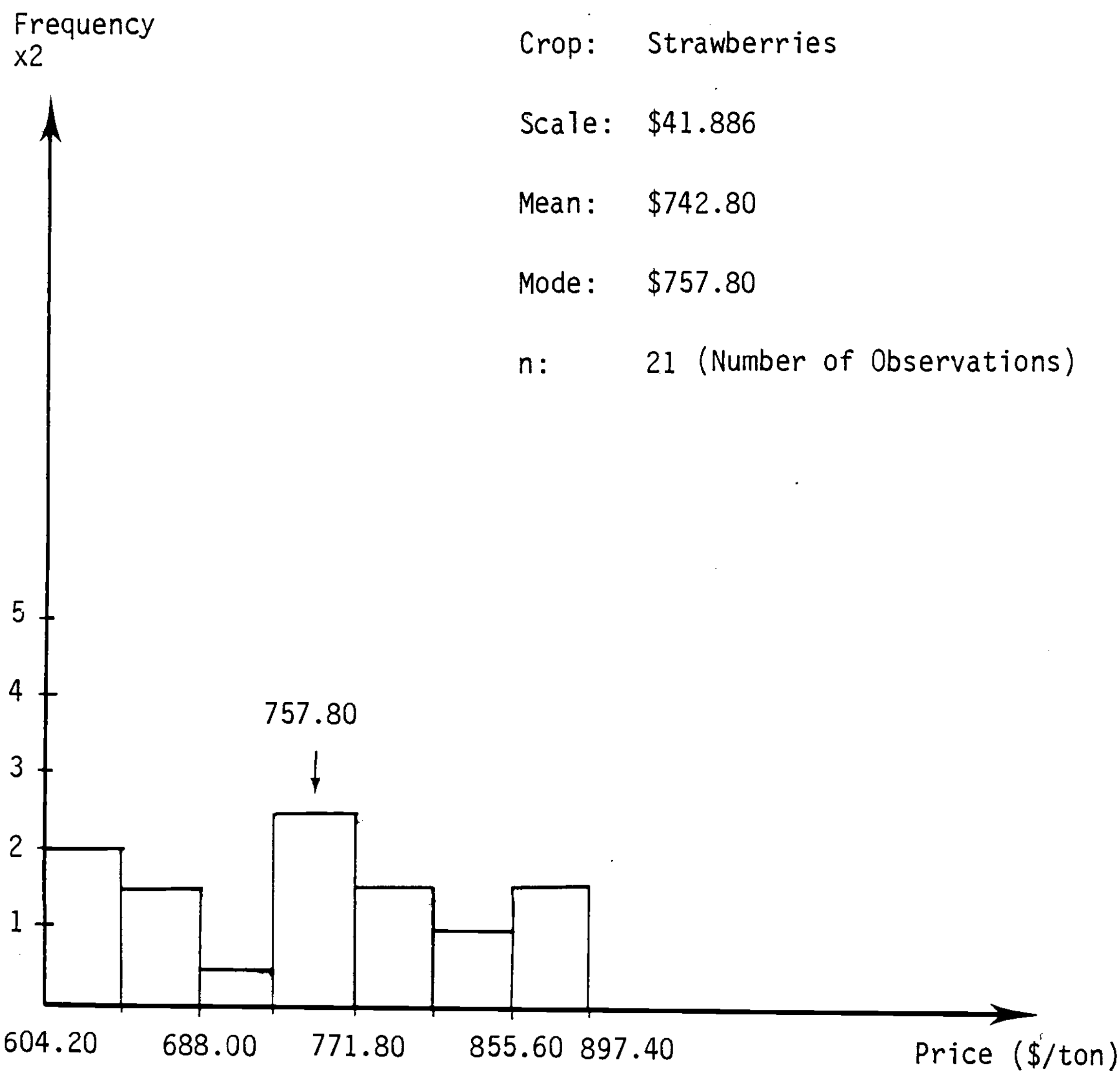

Figure A-4. Trend Adjusted Price Distribution for Strawberries.

APPENDIX A-3

ACTUAL AND TREND ADJUSTED YIELDS (TAY)

SNAP BEANS

Farm 01 (9)

Year	Actual	Index	TAY
71	3.49	.77	4.55
72	4.50	.80	5.65
73	4.97	.82	6.02
74	4.16	.85	4.88
75	3.60	.88	4.08
76	3.96	.91	4.34
77	4.32	.94	4.59
78	4.37	.97	4.51
79	6.12	1.00	6.13

Farm 02 (8)

Year	Actual	Index	TAY
72	5.05	.97	5.22
73	4.61	.91	5.06
74	3.48	.88	3.97
75	4.40	.86	5.10
76	5.00	.87	5.74
77	4.45	.90	4.95
78	5.57	.95	4.82
79	4.99	1.02	4.91

Farm 04 (8)

Year	Actual	Index	TAY
72	3.24	.64	5.10
73	3.35	.72	4.62
74	4.39	.81	5.39
75	4.39	.90	4.86
76	5.42	.99	5.45
77	4.96	1.08	4.58
78	4.79	1.17	4.08
79	7.16	1.26	5.68

Farm 05 (13)

Year	Actual	Index	TAY
67	3.12	.50	6.25
68	2.08	.54	3.86
69	3.55	.58	6.13
70	1.57	.62	2.53
71	3.13	.66	4.74
72	4.45	.70	6.36
73	4.40	.74	5.94
74	3.90	.78	5.00
75	3.23	.82	3.93
76	4.27	.86	4.95
77	3.99	.90	4.42
78	5.10	.94	5.40
79	5.10	.98	5.18

Farm 07 (8)

Year	Actual	Index	TAY
72	3.88	.77	5.06
73	4.12	.77	5.32
74	3.38	.78	4.31
75	3.89	.79	4.91
76	4.26	.80	5.31
77	3.99	.81	4.92
78	4.04	.82	4.93
79	4.15	.83	5.01

Farm 08 (11)

Year	Actual	Index	TAY
69	2.91	.70	4.16
70	4.08	.73	5.57
71	4.11	.76	5.42
72	3.35	.79	4.26
73	4.10	.81	5.06
74	4.45	.84	5.29
75	4.41	.87	5.09
76	5.32	.90	5.94
77	4.19	.92	4.55
78	3.99	.95	4.20
79	5.05	.98	5.17

Farm 09 (9)

Year	Actual	Index	TAY
71	5.39	1.13	4.78
72	5.45	1.03	5.27
73	4.76	.96	4.95
74	4.47	.91	4.89
75	4.78	.89	5.40
76	3.73	.88	4.24
77	4.72	.89	5.28
78	4.52	.93	4.85
79	5.02	.99	5.06

Farm 11 (8)

Year	Actual	Index	TAY
72	4.24	.98	4.33
73	4.27	.82	5.21
74	3.87	.79	4.89
75	3.11	.70	4.00
76	4.82	.77	6.25
77	3.74	.78	4.77
78	3.74	.81	4.62
79	4.32	.85	5.10

SNAP BEANS (Continued)

Farm 27 (11)

Year	Actual	Index	TAY
70	2.96	.66	4.46
71	4.00	.72	5.54
72	3.87	.77	5.00
73	3.55	.81	4.36
74	3.96	.85	4.66
75	3.68	.87	4.21
76	5.61	.89	6.31
77	4.34	.90	4.85
78	3.62	.89	4.05
79	3.74	.88	4.24
80	4.51	.86	5.22

Farm 28 (8)

Year	Actual	Index	TAY
73	3.82	.72	5.29
74	3.95	.86	4.61
75	4.11	.95	4.35
76	5.17	.99	5.22
77	5.85	.99	5.92
78	4.14	.94	4.41
79	3.55	.85	4.19
80	3.80	.71	5.37

Farm 29 (9)

Year	Actual	Index	TAY
72	4.67	.93	5.00
73	4.21	.81	5.17
74	3.34	.74	4.54
75	4.07	.70	5.85
76	2.66	.69	3.83
77	3.40	.73	4.64
78	4.00	.81	4.93
79	6.06	.93	6.53
80	4.52	1.08	4.17

Farm 30 (9)

Year	Actual	Index	TAY
72	3.60	.77	4.70
73	3.80	.77	4.92
74	4.10	.78	5.22
75	3.39	.80	4.24
76	4.44	.82	5.42
77	3.75	.84	4.46
78	4.00	.87	4.60
79	4.35	.90	4.84
80	4.50	.94	4.81

SWEET CORN

Farm 01 (10)

Year	Actual	Index	TAY
70	8.18	.85	9.61
71	6.17	.87	7.12
72	7.31	.88	8.30
73	7.59	.90	8.47
74	7.55	.91	8.28
75	8.47	.93	9.13
76	9.65	.94	10.23
77	7.73	.96	8.07
78	8.47	.97	8.70
79	7.79	.99	7.87
80	--	--	--

Farm 02 (13)

Year	Actual	Index	TAY
67	8.13	.79	10.26
68	5.53	.80	6.88
69	8.43	.82	10.32
70	7.79	.83	9.40
71	4.49	.84	5.34
72	7.68	.85	9.01
73	7.14	.86	8.27
74	7.92	.88	9.05
75	7.32	.89	8.24
76	7.53	.90	8.37
77	6.84	.91	7.50
78	9.20	.92	9.97
79	8.37	.93	8.95

Farm 03 (13)

Year	Actual	Index	TAY
67	7.13	.93	7.68
68	7.94	.90	8.84
69	9.00	.87	10.31
70	7.46	.85	8.77
71	5.92	.83	7.09
72	7.23	.82	8.81
73	6.51	.81	8.01
74	7.26	.81	8.99
75	7.45	.81	9.22
76	7.39	.81	9.11
77	6.03	.82	7.36
78	6.48	.83	7.79
79	8.12	.85	9.56

Farm 04 (13)

Year	Actual	Index	TAY
67	4.60	.71	6.49
68	7.32	.72	10.13
69	7.97	.74	10.82
70	8.45	.75	11.24
71	4.51	.77	5.89
72	5.73	.78	7.35
73	6.79	.79	8.55
74	6.12	.81	7.58
75	7.16	.82	8.70
76	6.90	.84	8.25
77	6.62	.85	7.78
78	7.60	.86	8.79
79	8.79	.88	10.00

Farm 05 (13)

Year	Actual	Index	TAY
67	8.59	1.17	7.36
68	9.74	1.12	8.71
69	11.90	1.08	11.06
70	9.39	1.04	9.03
71	7.01	1.01	6.95
72	7.97	.98	8.11
73	8.19	.96	8.51
74	8.58	.95	9.04
75	8.37	.94	8.90
76	8.52	.94	9.08
77	6.65	.94	7.06
78	9.46	.95	9.96
79	9.36	.97	9.72

Farm 06 (12)

Year	Actual	Index	TAY
67	5.72	.81	7.03
68	6.83	.82	8.35
69	9.59	.82	11.69
70	8.49	.82	10.32
71	5.35	.82	6.50
72	6.84	.82	8.31
73	5.56	.82	6.78
74	--	--	--
75	7.20	.81	8.88
76	7.04	.81	8.74
77	6.91	.80	8.67
78	8.20	.79	10.39
79	8.20	.78	7.32

SWEET CORN (Continued)

Farm 07 (13)

Year	Actual	Index	TAY
67	7.59	.77	9.84
68	5.34	.79	6.76
69	7.52	.81	9.30
70	7.68	.83	9.29
71	6.32	.84	7.48
72	6.40	.86	7.42
73	7.54	.88	8.56
74	7.54	.90	8.38
75	8.26	.92	9.01
76	10.81	.94	11.55
77	7.44	.95	7.80
78	8.48	.97	8.72
79	7.36	.99	7.43

Farm 11 (6)

Year	Actual	Index	TAY
74	6.78	.76	8.95
75	7.42	.81	9.16
76	6.32	.86	7.33
77	8.80	.92	9.61
78	6.38	.97	6.59
79	10.08	1.02	9.87

Farm 27 (4)

Year	Actual	Index	TAY
70	7.07	.80	8.87
71	4.21	.57	7.36
72	4.44	.44	10.19
73	3.11	.39	7.99

Farm 28 (8)

Year	Actual	Index	TAY
73	7.00	.86	8.09
74	7.48	.89	8.39
75	8.88	.92	9.66
76	9.00	.95	9.51
77	7.50	.97	7.70
78	8.10	1.00	8.08
79	7.88	1.03	7.66
80	10.10	1.06	9.55

Farm 29 (13)

Year	Actual	Index	TAY
67	5.80	.92	6.33
68	7.26	.85	8.56
69	8.97	.79	11.33
70	8.86	.75	11.88
71	5.85	.71	8.24
72	4.26	.69	6.22
73	5.51	.67	8.21
74	5.31	.67	7.94
75	6.16	.68	9.11
76	5.86	.69	8.44
77	4.38	.72	6.05
78	7.16	.76	9.38
79	7.94	.81	9.76

Farm 30 (10)

Year	Actual	Index	TAY
72	5.80	.79	7.30
73	7.80	.81	9.57
74	7.40	.84	8.86
75	7.60	.86	8.88
76	7.30	.88	8.33
77	8.00	.90	8.93
78	8.00	.92	8.72
79	7.54	.94	8.05
80	8.25	.96	8.61
81	8.37	.98	8.56

WHEAT

Farm 27 (11)

Year	Actual	Index	TAY
70	84.90	1.19	71.49
71	96.70	1.31	73.67
72	90.80	1.41	64.36
73	119.20	1.48	80.42
74	101.60	1.53	66.55
75	121.60	1.54	78.73
76	107.10	1.54	69.75
77	130.00	1.05	86.68
78	60.30	1.44	41.96
79	112.00	1.35	83.10
80	92.50	1.23	75.11

Farm 28 (8)

Year	Actual	Index	TAY
73	88.33	1.31	67.28
74	79.33	1.01	78.83
75	67.33	.80	84.10
76	42.00	.70	60.37
77	48.00	.69	69.42
78	39.00	.79	49.49
79	97.00	.99	96.46
80	83.33	1.28	64.94

STRAWBERRIES

Farm 01 (5)

Year	Actual	Index	TAY
70	4.07	1.03	3.96
71	4.31	1.03	4.20
72	--	--	--
73	3.93	.95	4.14
74	3.28	.87	3.76
75	3.27	.77	4.24

Farm 05 (9)

Year	Actual	Index	TAY
67	5.82	1.35	4.30
68	4.52	1.27	3.55
69	4.15	1.21	3.44
70	6.25	1.15	5.44
71	5.14	1.11	4.64
72	3.21	1.08	2.98
73	3.45	1.06	4.95
74	5.23	1.06	4.95
75	4.19	1.07	3.93

Farm 11 (7)

Year	Actual	Index	TAY
67	2.91	.54	5.36
68	2.35	.84	2.80
69	3.80	1.03	3.68
70	4.92	1.12	4.37
71	5.68	1.11	5.11
72	3.21	1.00	3.21
73	3.23	.78	4.12

Farm 16 (10)

Year	Actual	Index	TAY
70	3.49	.92	3.79
71	4.23	.99	4.28
72	4.84	1.04	4.65
73	4.36	1.08	4.04
74	2.78	1.11	2.52
75	5.46	1.11	4.90
76	5.07	1.11	4.57
77	3.98	1.09	3.65
78	4.41	1.06	4.18
79	4.01	1.01	3.98

Farm 20 (9)

Year	Actual	Index	TAY
67	4.83	1.25	3.86
68	5.44	1.19	4.58
69	4.30	1.13	3.79
70	3.86	1.10	3.52
71	4.69	1.07	4.38
72	4.57	1.06	4.33
73	5.03	1.05	4.78
74	2.73	1.07	2.56
75	5.09	1.09	4.68

Farm 21 (11)

Year	Actual	Index	TAY
67	4.37	1.27	3.43
68	6.29	1.20	5.24
69	6.00	1.14	5.28
70	1.80	1.08	1.66
71	--	--	--
72	--	--	--
73	4.97	.97	5.11
74	2.55	.95	2.68
75	3.34	.94	3.55
76	5.52	.94	5.89
77	4.24	.94	4.49
78	3.50	.96	3.65
79	3.56	.98	3.63

Farm 22 (8)

Year	Actual	Index	TAY
72	5.24	1.19	4.40
73	3.84	1.01	3.79
74	3.53	.88	4.00
75	1.97	.80	2.47
76	4.64	.75	6.15
77	1.82	.76	2.40
78	5.11	.81	6.32
79	2.69	.90	2.98

STRAWBERRIES (Continued)

Farm 24 (12)

Year	Actual	Index	TAY
67	5.91	1.49	3.97
68	6.51	1.32	4.94
69	3.66	1.17	3.14
70	4.77	1.04	4.60
71	3.71	.93	4.01
72	2.38	.83	2.85
73	2.17	.76	2.84
74	3.59	.71	5.04
75	2.84	.69	4.14
76	--	--	--
77	3.46	.69	5.03
78	4.99	.72	6.93
79	1.06	.77	1.37

Farm 25 (7)

Year	Actual	Index	TAY
67	2.91	.54	5.36
68	2.35	.84	2.80
69	3.80	1.03	3.68
70	4.92	1.12	4.37
71	5.68	1.11	5.11
72	3.21	1.00	3.21
73	3.23	.78	4.12

Farm 27 (11)

Year	Actual	Index	TAY
70	6.44	1.55	4.16
71	5.61	1.44	3.89
72	4.42	1.34	3.30
73	5.83	1.25	4.68
74	5.37	1.16	4.62
75	5.37	1.08	4.96
76	3.52	1.01	3.48
77	2.61	.95	2.76
78	3.83	.89	4.30
79	3.13	.84	3.73
80	3.74	.80	4.69

APPENDIX A-4

ADJUSTED YIELD HISTOGRAMS

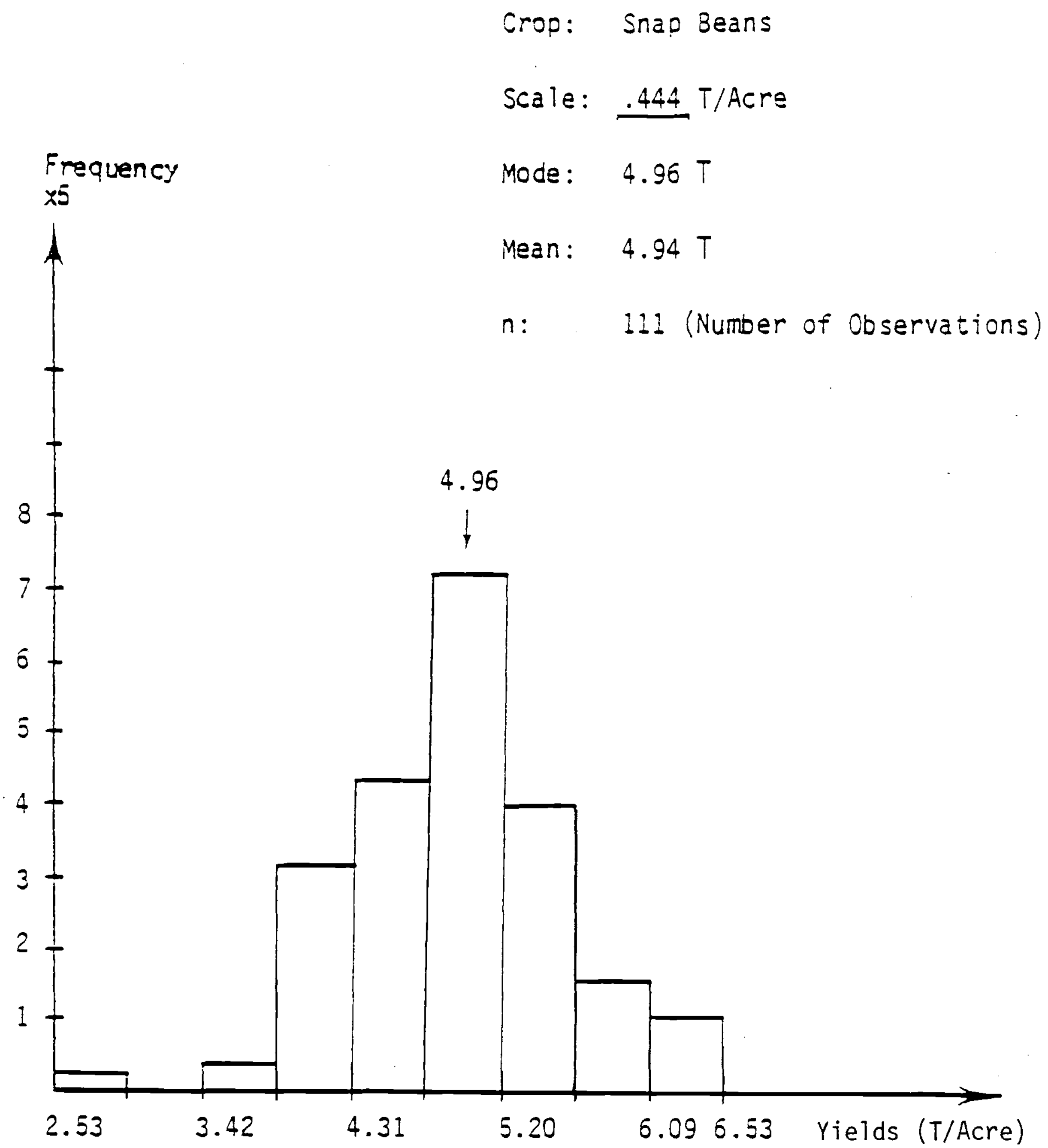

Figure A-5. Trend Adjusted Yield Distribution for Snap Beans.

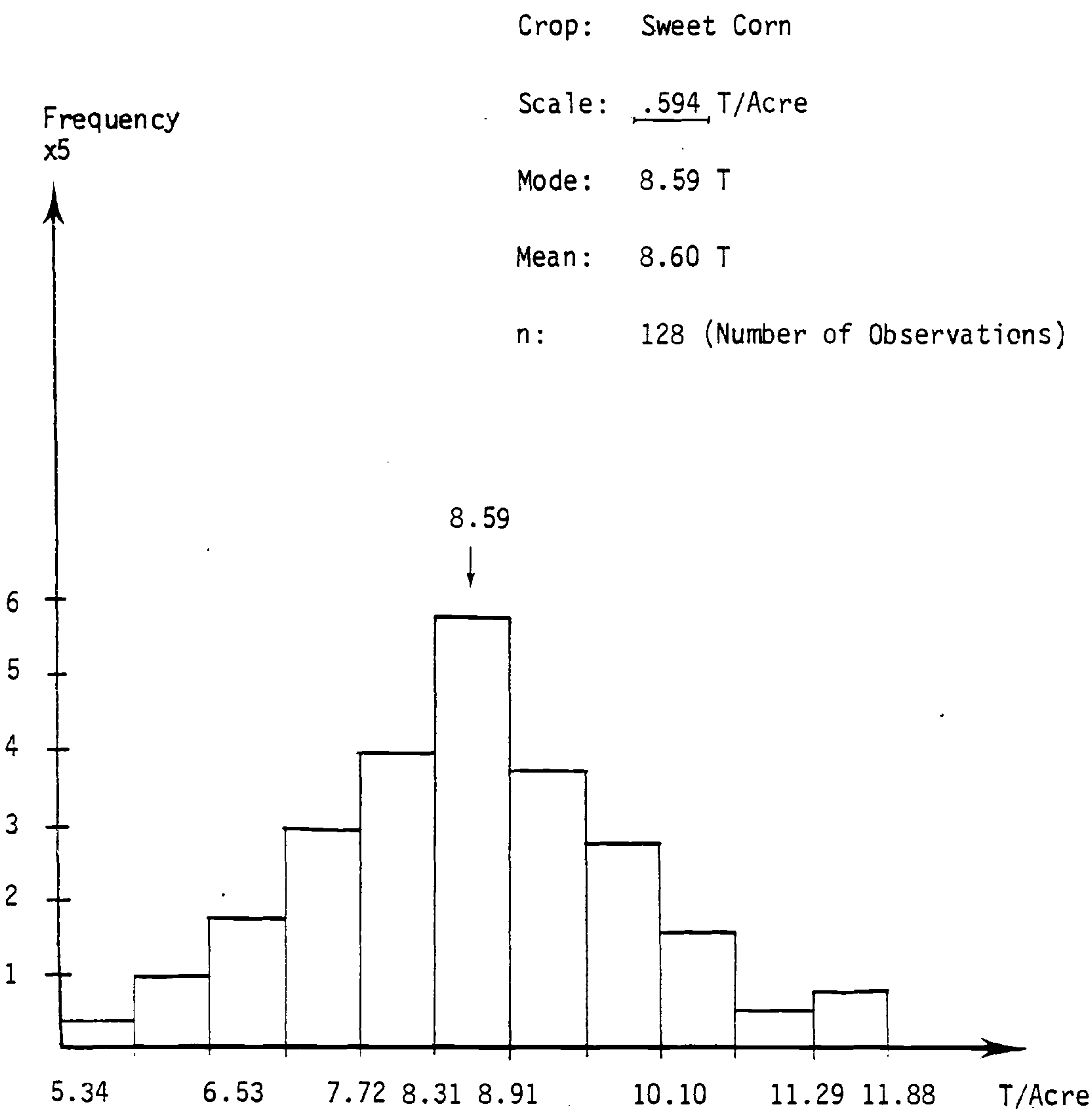

Figure A-6. Trend Adjusted Yields Distribution for Sweet Corn.

Crop: Wheat

Scale: 10.90 bu/Acre

Mode: 72.23 bu

Mean: 71.69 bu

n: 19 (Number of Observations)

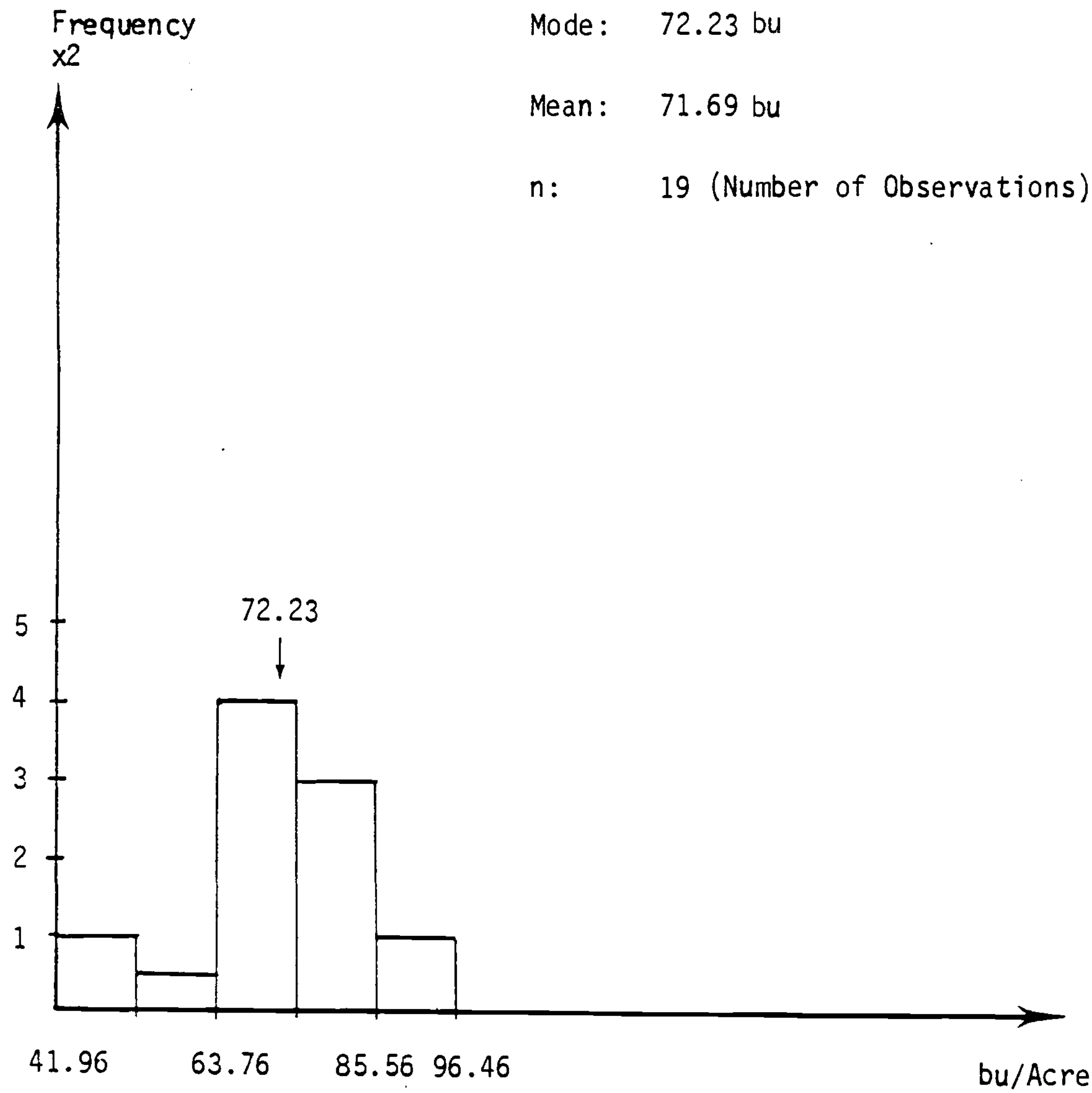

Figure A-7. Trend Adjusted Yields Distribution for Wheat.

Crop: Strawberries

Scale: .618 T/Acre

Mode: 4.17 T

Mean: 4.08 T

n: 89 (Number of Observations)

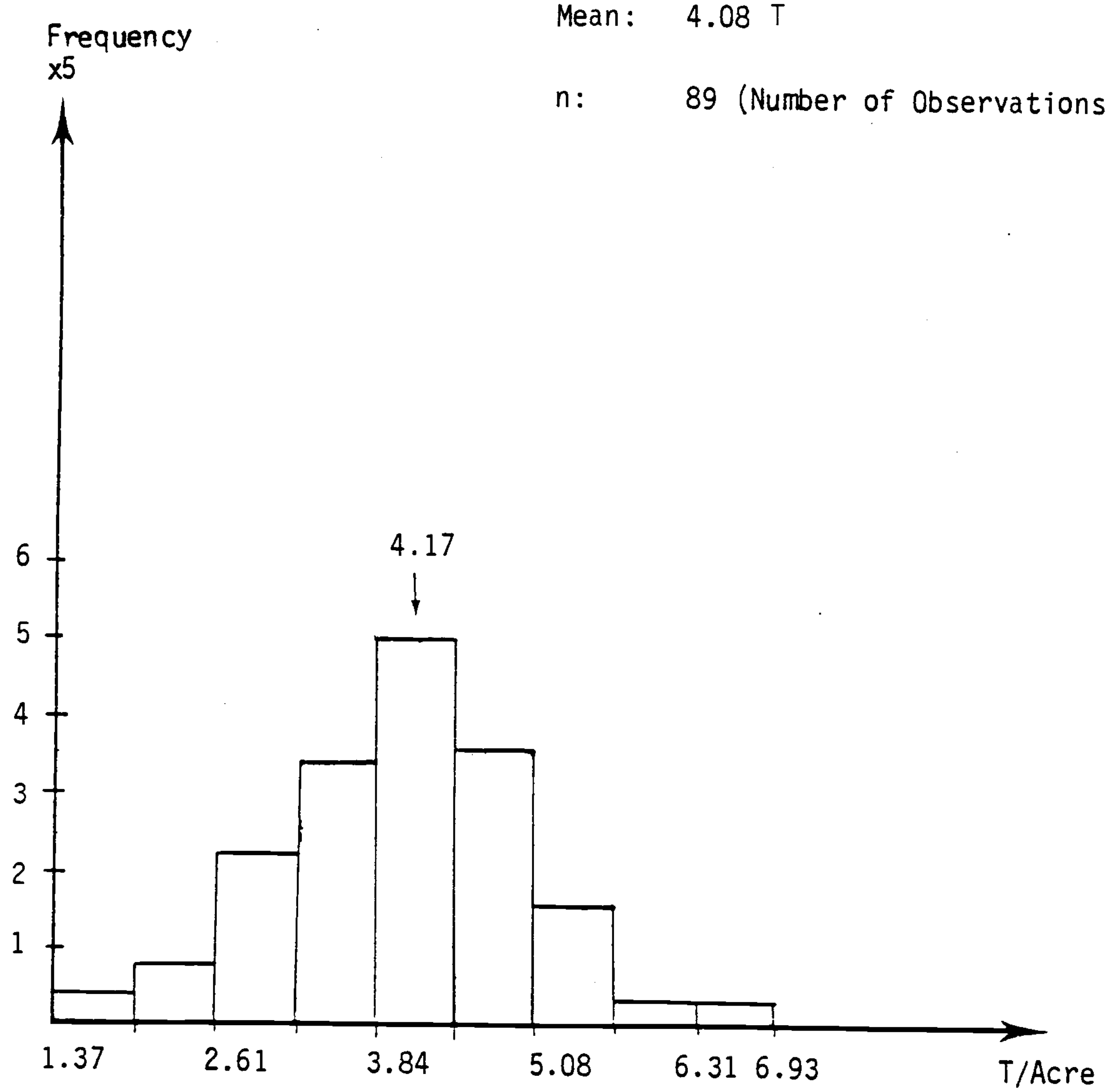

Figure A-8. Trend Adjusted Yields Distribution for Strawberries.

APPENDIX B

METHOD TO COMPUTE THE PARAMETERS (p,q) OF THE BETA PROBABILITY DISTRIBUTION

The approach selected to compute the parameters p and q of the beta probability distribution is based on the mean and the variance of the relevant variables. The respective equations of the mean and variance are:

$$\mu = a + (b-a)\ ((p+1)/(p+q+2)) \qquad \text{(B-1)}$$

and

$$\sigma^2 = \frac{(b-a)^2\ (p+1)\ (q+1)}{(p+q+3)\ (p+q+2)^2} \qquad \text{(B-2)}$$

where

a = lowest possible point

b = highest possible point.

Expression (B-1) and (B-2) allow us to write:

$$(\mu-a)/(b-a) = (p+1)/(p+q+2) \qquad \text{(B-3)}$$

and $\sigma^2/(b-a)^2 = ((p+1)(q+1))/((p+q+3)(p+q+2)^2)$ (B-4)

Expression (B-4) is equivalent to:

$$\sigma^2/(b-a)^2 = ((p+1)/(p+q+2))\ (1-((p+1)/(p+q+2)))\ (1/(p+q+3)) \qquad \text{(B-5)}$$

From expression (B-5) we can calculate the value of p+q+2, which is equal to:

$$p+q+2 = (\sigma^2/(b-a)^2)^{-1}\ ((p+1)/(p+q+2))\ (1-((p+1)/(p+q+2))) - 1 \qquad \text{(B-6)}$$

since $(\mu-a)/(b-a) = (p+1)/(p+q+2)$, expression B-6 can be written as:

$$p+q+2 = (\sigma^2/(b-a)^2)^{-1} (\mu-a)/(b-a)) (1-((\mu-a)/(b-a))) - 1 \quad \text{(B-7)}$$

From expression (B-3) we know that $p+1 = (p+q+2)(\mu-a)/(b-a)$. Based on this information, expression (B-7) can be multiplied by $(\mu-a)/(b-a)$ to yield p+1. Symbolically,

$$(p+1) = (\sigma^2/(b-a)^2)^{-1} ((\mu-a)/(b-a))^2 (1-((\mu-a)/b-a)) - ((\mu-a)/(b-a)) \quad \text{(B-8)}$$

Expression (B-8) implies that:

$$p = (\sigma^2/(b-a)^2)^{-1} ((\mu-a)/(b-a))^2 (1-((\mu-a)/(b-a))) - ((\mu-a)/(b-a)) - 1 \quad \text{(B-9)}$$

If the relevant variable is beta distributed, then the variance σ^2 can be estimated by $1/36\ (b-a)^2$,* so that equation (B-9) becomes:

$$p = 36((\mu-a)/b-a))^2 ((b-\mu)/(b-a) - ((\mu-a)/(b-a)) - 1 \quad \text{(B-10)}$$

From expression (B-3), we know that

$$p+q+2 = (p+1)(b-a)(\mu-a)^{-1} \quad \text{(B-11)}$$

Given a value of p, q can be derived by setting

$$q = (p+1)(b-a)(\mu-a)^{-1} - p - 2$$

* This estimate of the variance is given the PERT assumptions.

APPENDIX C-1

VARIATION OF PRICES PAID BY U.S. FARMERS

Table C-1. Change in Prices Paid by U.S. Farmers to July 81

From

	1979 (Annual)	1980 (Annual)	1980 January	1980 April	1980 July	1980 October	1981 January	1981 April
Prices paid for commodities and services, interest, taxes and wage rates	.221	.085	.131	.108	.086	.059	.021	.004
Selected Items								
1) Feed	.243	.104	.196	.210	.141	.007	-.042	-.027
2) Feeder livestock	-.137	-.101	-.142	-.075	-.065	-.126	-.079	-.071
3) Seed	.310	.212	.271	.201	.201	.185	.185	.000
4) Fertilizer	.362	.095	.199	.089	.071	.080	.077	.016
5) Agri. Chemicals	.178	.002	.167	.116	.087	-.036	-.036	.032
6) Fuels and Energy	.564	.135	.181	.125	.112	.125	.066	-.014
7) Farm and motor supplies	.285	.100	.157	.125	.083	.055	.038	.019
8) Autos and trucks	.241	.176	.209	.203	.189	.182	.089	.057
9) Tractors and S.P. machine	.274	.138	.219	.161	.131	.092	.092	.058
10) Other machinery	.256	.120	.199	.146	.100	.081	.081	.040
11) Buildings and fencing	.131	.049	.069	.067	.055	.029	.021	.008
12) Services and cash rent	.247	.101	.101	.101	.101	.171	.000	.000
13) Wages	.058	.067	.076	.076	.057	.059	.040	.000

Source: Agricultural Prices, Crop Reporting Board, ESCS, USDA

APPENDIX C-2

TABLES OF PRODUCTION COSTS

Table C.2 Production costs for Snap Beans

Based on:

1. 100 ac. beans on 300 ac. farm
2. 4 ton graded yield per acre
3. 125 h.p. tractor @ $17.95/hr.
4. 80 h.p. tractor @ $10.80/hr.
5. Hired labor @ $5.30/hour. 1/
6. Irrigation labor @ $3.85/hr. 1/

INPUTS PER ACRE

	Labor			Other		Total
	Hrs.	Value	Machinery	Item	Value	cost
Cultural Practices						
Subsoil 2/	.3	1.60	6.65			8.25
Disc	.2	1.05	6.30			7.35
Plow	.33	1.75	9.45			11.20
Disc	.2	1.05	6.30			7.35
Broadcast fertilizer 3/	.25	1.35	5.10	Fert.	23.25	29.70
Disc with preplant herbicide 3/	.2	1.05	6.30	Herb.	21.00	28.35
Disc	.2	1.05	6.30			7.35
Field cultivator and roller (2X)	.4	2.10	10.35			12.45
Planting (2 men) 3/	1.6	7.30	16.05	Seed	85.80	
				Fert.	40.00	
				Insect.	10.25	
				Herb.	9.70	169.10
Cultivate (1.5 X) 4/	.5	2.65	6.30			8.95
Irrigate (4X) *	8	30.80	43.10	Elec.	20.25	94.15
Insecticide 3/				Custom	11.15	11.15
Fungicide 3/				Custom	15.00	15.00
Lime 5/				Custom	25.00	25.00
Harvest Costs						
Picking ($41/ton graded yield)				Custom	164.00	164.00
Hauling ($8.50/ton gross yield)				Custom	51.00	51.00
Rotary chop	.15	.80	3.20			4.00
Other Charges						
Land charge 6/					135.00	135.00
Operating capital interest (16.5%.					10.20	10.20
General overhead 7/					34.25	34.25
Management charge 8/					55.75	55.75
CASH COSTS		52.55	56.40		520.85	629.80
NON-CASH COSTS		0	69.00		190.75	259.75
TOTAL COSTS		52.55	125.40		711.60	889.55
Cost per ton @ 3.5 ton graded yield						246.50
Cost per ton @ 4 ton graded yield						222.40
Cost per ton @ 5 ton graded yield						188.65

1/ Includes SAIF, Social Security, etc.

2/ Subsoiling computed on every other year, ½ charge on sheet.

3/ See your Extension Agent or fieldman for recommended materials and rates.

4/ Approximately half of growers cultivate 2 times and half cultivate 1 time.

5/ Lime at 2.5 tons generally applied every 4th year, 1/3 of cost charged annually.

6/ Land charge is based on rental value but is considered a non-cash cost.

7/ Approximately 9% of cash costs excluding harvest costs.

8/ Approximately 9% of cash costs.

* Generally hired labor

These data were obtained and computed by John Burt, Polk County Extension Agent in cooperation with growers in the Mid-Willamette Valley.

Department of Agricultural Economics, May 1981.

Table C.3 Production costs for Sweet Corn.

Based on:

1. 100 ac. corn on 300 ac. farm
2. 8 ton yield per acre
3. 125 h.p. tractor @ $17.95/hr.
4. 80 h.p. tractor @ $10.30/hr.
5. Hired labor @ $5.30/hr. 1/
6. Irrigation labor @ $3.85/hr. 1/

INPUTS PER ACRE

	Labor			Other		Total
	Hrs.	Value	Machinery	Item	Value	cost
		($)	($)		($)	($)
Cultural Practices 2/						
Lime 3/				Custom	22.00	22.00
Subsoil	.33	1.60	6.65			8.25
Plow	.33	1.75	9.45			11.20
Disc (2x)	.30	1.60	9.40			11.00
Disc preplant herbicide	.20	1.05	6.35	Herb.	32.60 4/	40.00
Cultimulch (2x)	.33	1.75	8.05			9.80
Broadcast fertilizer	.25	1.35	5.10	Fert.	51.50	57.95
Planting	.50	2.65	12.15	Fert.	53.65	
				Seed	15.30	83.75
Cultivate	.33	1.75	5.35			7.10
Irrigate (4.5x)	9.00	34.65	48.50	Elec.	24.30	107.45
Mid-season fert.	.25	1.35	5.05	Fert.	8.25	14.65
Insecticide				Insect.	17.35 4/	17.35
opping				Custom	5.30	5.30
Harvest Costs						
Custom pick				Custom	51.00	51.00
Custom haul				Custom	50.70	50.70
Post Harvest Costs						
Disc stalks (2x)	.50	2.65	15.70			18.35
Harrow	.05	.25	.70			.95
Seed cover crop	.25	1.35	5.40	Seed	10.70	17.45
Other Charges						
Truck	1.00	5.30	1.65			6.95
Land charge 5/					135.00	135.00
Operating capital interest (16.5%)					12.50	12.50
General overhead 6/					33.80	33.80
Management 7/					45.95	45.95
CASH COSTS		59.05	62.80		388.95	510.80
NON-CASH COSTS		0	76.70		180.95	257.65
TOTAL COST		59.05	139.50		569.90	768.45
Cost per ton @ 10 ton yield						79.40
Cost per ton @ 8 ton yield						96.05
Cost per ton @ 7 ton yield						107.95
Cost per ton @ 5 ton yield						123.85

1/ Includes SAIF, Social Security, etc.

2/ See your Extension Agent or fieldman for recommended materials and rates.

3/ One to two tons of lime general applied every 4th year, lime cost amortized over 3 years at 11%.

4/ Includes custom rate for application.

5/ Land charge is based on rental value but is considered a non-cash cost.

6/ Approximately 9% of cash costs excluding harvest costs.

7/ Approximately 9% of cash costs.

These data were obtained and computed by John Burt, Polk County Extension Agent in cooperation with growers in the Willamette Valley.

Department of Agricultural and Resource Economics, May 1981.

Table C.4 Production costs for Wheat.

Based on:

1. 100 Ac. on 500 Ac. farm
2. 75 bushel yield per acre
3. 90 h.p. tractor @ $11.60/hr.
4. 120 h.p. tractor @ $14.60/hr.
5. Hired labor @ $5.15/hr. 1/
6. Operators labor @ $6.85/hr.

	Labor		Machinery	Other		Total cost
	Hrs.	Value ($)	($)	Item	Value ($)	($)
Cultural Operations 2/						
Plow	.33	2.25	7.45			9.70
Cultimulch (1.5X)	.15	1.05	3.45			4.50
Drill & harrow 3/	.25	1.70	6.15	Seed	9.80	
				Fert.	14.85	32.50
Herbicide (fall) 4/				Custom	9.15	9.15
Herbicide (winter) 4/				Custom	13.50	13.50
Insect & rodent control					.55	.55
Fertilizer (spring) 5/				Custom	40.00	40.00
Herbicide (spring)					4.80	4.80
Lime 6/					8.15	8.15
Harvest						
Combining	.7	4.80	35.75			40.55
Hauling	.7	3.60	4.50			8.10
Other Charges						
Land charge 7/					80.00	80.00
Operating capital interest (16.5%)					8.95	8.95
General overhead 8/					12.50	12.50
Management charge 9/					13.65	13.65
Cash Cost		3.60	25.80		122.25	151.65
Non-Cash Cost		9.80	31.50		93.65	134.95
Total Cost		13.40	57.30		215.90	286.60
Cost per bu. @ 55 bu. yield						5.10
Cost per bu. @ 75 bu. yield						3.80
Cost per bu. @ 95 bu. yield						3.10

1/ Includes SAIF and other payroll expenses.
2/ Consult your extension agent for specific recommendations on cultural practices.
3/ Add 14.00 for carbon planting.
4/ One spray for ryegrass control and winter spray for wild oat control.
5/ Add 16.00 when using high chloride fertilizer.
6/ Cost amortized over 8 year life.
7/ Land charge is based on rental but is considered a non-cash cost.
8/ Approximately 9% of cash costs.
9/ Approximately 9% of cash costs.

These data were obtained and computed by John Burt, Polk County Extension Agent, in cooperation with Mid-Willamette Valley Producers.

Department of Agricultural and Resource Economics, May 1981.

Table C.5 Production costs for Strawberries.

Based on:

1. 20 ac. on a 200 ac. farm
2. 3 bearing yrs., 4 ton/ac. average
3. Operator's labor, \$8/hr.1/
4. Hired labor, \$5/hr. 1/
5. Tractors:
   90-100 HP \$12/hr.
   50 HP \$ 6/hr.
   25 HP \$ 3/hr.

INPUTS PER ACRE

PRODUCING YEARS	Labor Hrs.	Labor Value (\$)	Machinery (\$)	Other Item	Other Value (\$)	TOTAL Cost (\$)
Pre-Harvest Cultural Operations						
Cultivate (3x)	3.0	25.39	15.18			40.57
Hoeing	8.0	42.32				42.32
Insecticide & fungicide spray or dust (3x)	1.0	8.46	11.39	Mtl.	47.12	66.97
Irrigation (2x, 2" ea.)	2.0	10.58	25.30	Elec.	4.36	40.24
Harvest Costs						
Picking & supervision labor (14c/1b)		1184.96				1184.96
Hauling (1c/1b.)		42.32	50.60			92.92
Bookkeeping, recruiting, etc.		84.64		Supplies	10.99	95.63
Post-harvest Operations						
Irrigation (2x, x" ea.)	2.0	10.58	25.30	Elec.	4.36	40.24
Clip tops	.33	2.80	5.82			8.62
Weevil control (banded)	.2	1.69	2.28	Mtl.	21.20	25.17
Cultivate & runner control (2x)	2.0	16.93	12.65			29.58
Subsoil	.5	4.23	8.54			12.77
Herbicide	.2	1.69	2.28	Mtl.	7.07	11.04
Side dress fertilizer2/				Fert.	64.01	64.01
Other Charges						
Land charges, including taxes					187.05	187.05
Operating capital interest (11%)					29.89	29.89
General overhead					21.67	21.67
Cash Costs		1248.40	63.77		221.75	1533.92
Non-Cash Costs		188.19	95.57		196.44	480.20
TOTAL ANNUAL PRODUCTION COSTS		1436.59	159.34		418.19	2014.12
Amortized establishment cost (back page)	14				586.08	

Cost/lb. @ 6 ton yield	23.6c	Cost/lb. @ 3 ton yield	32.1c
Cost/lb. @ 5 ton yield	25.3c	Harvest cost/lb @ 4 ton yield	\$335.79/ton
Cost/lb. @ 4 ton yield	27.8c		

1/ Includes Social Security, Workman's Compensation, and other labor expenses.

2/ Generally done but not required in all cases.

3/ Applied during another operation and includes soil insecticide.

These data were obtained and compiled by County Agent Arden Sheets and Extension Economist Stanley Miles in cooperation with Washington County growers.

Department of Agricultural and Resource Economics, February 1979.

APPENDIX D-1

THIS PROGRAM CALLED "EXPONT" IS THEORETICAL BASED ON THE EXPONENTIAL WEIGHTED MOVING AVERAGE MODEL. IT WAS USED TO DETREND THE INFLATED PRICE SERIES.

```
01◆LBL "EXPONT"
02 0.00
03 STO 16
04 0.00
05 STO 09
06 0.00
07 STO 08
08 0.00
09 STO 15
10 0.0000
11 STO 12
12 "W=?"
13 PROMPT
14 STO 01
15 "Y=?"
16 PROMPT
17 STO 02
18 "F=?"
19 PROMPT
20 STO 03
21 -
22 STO 06

23◆LBL 01
24 RCL 06
25 RCL 01
26 *
27 RCL 03
28 +
29 STO 03
30 ADV
31 SF 12
32 "WP="
33 ARCL X
34 AVIEW
35 PSE
36 PSE
37 CF 12
38 "CP=?"
39 PROMPT
40 X=0?
41 GTO 10
42 STO 05
43 RCL 05
44 RCL 03
45 -
46 STO 06
47 SF 12
48 "DEV="
49 ARCL X
50 AVIEW
51 PSE
52 PSE
53 X↑2
54 FIX 2
55 STO 12
56 CF 12
57 RCL 06
58 ST+ 15
59 1
60 ST+ 16
61 RCL 06
62 ENTER↑
63 0
64 X<>Y
65 X>Y?
66 GTO 06
67 RCL 12
68 ST+ 08
69 GTO 01

70◆LBL 06
71 RCL 12
72 ST+ 09
73 GTO 01

74◆LBL 10
75 ADV
76 SF 12
77 "SUMMATIONS"
78 ADV
79 AVIEW
80 CF 12
81 RCL 01
82 "W="
83 ARCL X
84 AVIEW
85 RCL 08
86 "SSND="
87 ARCL X
88 AVIEW
89 RCL 09
90 RCL 08
91 +
92 "TSSD="
93 ARCL X
94 AVIEW
95 PSE
96 PSE
97 PSE
98 RCL 16
99 /
100 SF 12
101 "V3="
102 ARCL X
103 AVIEW
104 CF 12
105 RCL 15
106 "TDEV="
107 ARCL X
108 AVIEW
109 PSE
110 PSE
111 PSE
112 RCL 16
113 /
114 SF 12
115 "MEANDV="
116 ARCL X
117 AVIEW
118 PSE
119 PSE
120 PSE
121 CF 12
122 RCL 16
123 "Mb OF DEV="
124 ARCL X
125 AVIEW
126 OFF
127 END
```

APPENDIX D-2

THIS PROGRAM CALLED "BETATRI" REPRESENTS THE PROPOSED MODEL USED TO SIMULATE THE CASE FARM

```
30  HOME : INVERSE : FOR I = 1 TO
     5: HTAB 07: PRINT "BBBBEEEET
     TTTAAAATTTTRRRRIIII": NEXT I
50  NORMAL
70  VTAB 6: PRINT "THIS PROGRAM U
     SES THE BETA OR TRIANGULAR"
90  VTAB 9: HTAB 2: PRINT "PROBAB
     ILITY DISTRIBUTION TO GENERA
     TE"
110  VTAB 12: HTAB 2: PRINT "RAND
     OM VALUES  FOR PRICES AND YI
     ELDS"
130  VTAB 15: PRINT "WHICH SERVE
     TO SIMULATE  NET FARM INCOME
     "
150  VTAB 18: HTAB 4: PRINT "OVER
      A SPECIFIED PERIOD OF TIME"
170  VTAB 20: HTAB 5: PRINT "( HI
     T <RETURN> TO CONTINUE )";
190  GET D$
210  IF  ASC (D$) <  > 13 GOTO 16
     150
230  HOME : VTAB 13: HTAB 8: PRINT
     "INPUT THE NUMBER OF CROPS";
     : INPUT NC
250  HOME : VTAB 11: HTAB 17: PRINT
     "WAIT!"
270  VTAB 14: HTAB 08: PRINT "I W
     ILL TAKE A FEW SECONDS"
290  VTAB 16: HTAB 13: PRINT "TO
     GET READY!"
310 W9 = 2 * NC
330 PN(1) = 118.12
350 PM(1) = 163.73
370 PX(1) = 309.68
390 PA(1) = 170.64
410 AP(2) = 164.96
430 BP(2) =  - 1.023
450 CP(2) = .0030
470 PN(2) =  - 16.30
490 PM(2) =  - 1.90
510 PX(2) = 12.50
530 PA(2) = 0
550 AP(3) = 3.440
570 BP(3) = .0024
590 CP(3) = .00002
610 PN(3) =  - 1.780
630 PM(3) =  - .33
650 PX(3) = 3.24
670 PA(3) = 0
690 AP(4) = 692.92
710 BP(4) = .2560
730 CP(4) = .00020
750 PN(4) =  - 123.00
770 PM(4) =  - 83.14
790 PX(4) = 164.00
810 PA(4) = 0
830 YN(1) = 2.53
850 YM(1) = 4.96
870 YX(1) = 6.53
890 YA(1) = 4.94
910 AY(2) = 10.804
930 BY(2) =  - 0.970
950 CY(2) = 0.102
970 YN(2) =  - 3.01
990 YM(2) = .30
1010 YX(2) = 3.03
1030 YA(2) = 0
1050 AY(3) = 71.151
1070 BY(3) = 2.665
1090 CY(3) =  - .516
1110 YN(3) =  - 31.50
1130 YM(3) = 3.67
1150 YX(3) = 23.00
1170 YA(3) = 0
1190 AY(4) = 7.334
1210 BY(4) =  - 1.137
1230 CY(4) = .0934
1250 YN(4) =  - 2.72
1270 YM(4) = .10
1290 YX(4) = 2.53
1310 YA(4) = 0
1330 NY(1) = 60.0
1350 PCNT(1) = 0
1370 IPYT(1) = 0
1390 ISUR(1) = 0
1410 NY(2) = 0
1430 PCNT(2) = 0
1450 IPYT(2) = 0
1470 ISUR(2) = 0
1490 NY(3) = 0
1510 PCNT(3) = 0
1530 IPYT(3) = 0
1550 ISUR(3) = 0
1570 NY(4) = 0
1590 PCNT(4) = 0
1610 IPYT(4) = 0
1630 ISUR(4) = 0
1650 CN(1) = 0
1670 PW(1) = 0
1690 DF(1) = 0
1710 CN(2) = 0
1730 PW(2) = 0
1750 DF(2) = 0
1770 CN(3) = 0
1790 PW(3) = 0
1810 DF(3) = 0
1830 CN(4) = 0
1850 PW(4) = 0
1870 DF(4) = 0
1890 OCR = 0
1910 CS = 0
1930 BS = 5000
1950 PP = 14000
1970 CE = 20000
1990 LVW = 20000
2010 NDEP = 4
2030 STX = 0
2050 FS = 2
2070 K1 =  - 10000
2090 K2 =  - 30000
2110 K3 =  - 60000
2130 K4 =  - 100000
2150 NRN = 1
2170 RN = 0.23456
2190  REM >>INITIALIZE VARIABLES
2210 R = 0
2230 TEB = 0.
2250 HBAL =  - 1000000
2270 LBAL = 1000000
2290 TNG = 0
2310 KO = 0
2330 KA = 0
2350 KB = 0
```

```
2370 KC = 0
2390 ARC = 0
2410 AN = 0
2430 DEPR = 0
2450 INR = 0
2470 FCE = 0
2490 AGI = 0
2510 AXP = 0
2530 AIT = 0
2550  FOR I = 1 TO NC
2570 LP( I ) =  + 1000
2590 LY( I ) =  + 1000
2610 HP( I ) =  - 1000
2630 HY( I ) =  - 1000
2650 VP( I ) = 0.0
2670 VY( I ) = 0.0
2690  NEXT I
2710 ZP( I ) = 0:ZY( I ) = 0:SP( I ) =
     0:SY( I ) = 0
2730  REM  >>TAX RATE SCHEDULES
      FOR 1982 AND 1983
2750  DIM DEPR( 5 ),INR( 5 ),FCE( 5 ),V
     CE( 5 )
2770  DIM TAX( 14,12 )
2790  RESTORE
2810  READ EFPS,IMAX,S1,SM
2830  READ AL,EFS,ES
2850  READ BIG1,ENPS,P8,XF
2870  READ PO( 0 ),PO( 1 ),PO( 2 ),PO( 3
     ),PO( 4 ),PO( 5 ),PO( 6 ),PO( 7 )
2890  READ PB( 0 ),PB( 1 ),PB( 2 ),PB( 3
     ),PB( 4 ),PB( 5 ),PB( 6 ),PB( 7 )
2910  READ RK( 0 ),RK( 1 ),RK( 2 ),RK( 3
     ),RK( 4 ),RK( 5 ),RK( 6 ),RK( 7 )
2930  READ PK( 0 ),PK( 1 ),PK( 2 ),PK( 3
     ),PK( 4 ),PK( 5 ),PK( 6 ),PK( 7 )
2950  READ QA( 0 ),QA( 1 ),QA( 2 ),QA( 3
     ),QA( 4 ),QA( 5 ),QA( 6 )
2970  READ QB( 0 ),QB( 1 ),QB( 2 ),QB( 3
     ),QB( 4 ),QB( 5 ),QB( 6 )
2990  READ QC( 0 ),QC( 1 ),QC( 2 ),QC( 3
     ),QC( 4 ),QC( 5 ),QC( 6 )
3010  DIM LO( 9 ),HI( 9 ),MO( 9 ),ME( 9 )

3030  DATA         1.0E-8,02.0,1.5E
     -03,-675.81850104594
3050  DATA  -674.65743224725,1.0E
     -13,1.7E-38
3070  DATA  1.723E36,1.6414E19,3.
     14159265535898,3.777E19
3090  DATA  2.4317524352442E2,-2.
     6172185838561E2,-9.222613728
     8015E2
3110  DATA  -5.1763834980232E2,-7
     .7410640713329E1
3130  DATA  -2.2088439972161,4.12
     08431858477,8.5689820628313E
     1
3150  DATA  5.2689832559l4E3,1.95
     53605540630E4,1.204317380987
     1E4
3170  DATA  -2.0648294205325E4,-1
     .5086302287667E4,-1.51383183
     41150E3
3190  DATA  5.1550576176408,3.775
     1067979721E2
3210  DATA  -1.9718301158609E7,-8
     .7316754382383E7,1.119385354
     2998E8
3230  DATA  4.8180771027736E8,-2.
     4483217690328E8,-2.407986980
     1733E8
3250  DATA  -1.0377016517329E4,-9
     .8271022814204E5
3270  DATA  9.1893853320467E-1,8.
     3333333333267E-2,-2.77777765
     05151E-3,7.9358449768E-4,-5.
     82399983E-4
3290  DATA  0.0,0.0,0.0
3310  DATA  3.7783724848239E2,9.5
     132359767970E2,8.46075536202
     07E2,2.6230834702694E2
3330  DATA  2.4435196625063E1,4.0
     977929210926E-1,4.5646771875
     859E1
3350  DATA  3.0399030414394E3,2.2
     029562144156E4,5.71202553960
     25E4,5.2622863838411E4
3370  DATA  1.4402090371700E4,6.9
     8327414057355E2,1.28909318901
     29E2
3390  DATA  -3.1140628473406E5,-1
     .0485775830499E7,-1.11925411
     62633E8,-4.0443597282914 3E8
3410  DATA  -4.3537071480437E8,-7
     .9026111141876E7,-2.01527519
     55004E3
3430  FOR I = 1 TO 14: FOR J = 1 TO
     12
3450  READ TAX( I,J ): NEXT J: NEXT
     I
3470  DATA       2300,.12,.11 ,3400
     ,.12,.11 ,1700,.12,.11 ,2300
     ,.12,.11
3490  DATA        3400,.14,.13 ,550
     0,.14,.13 ,2750,.14,.13 ,440
     0,.14,.13
3510  DATA        4400,.16,.15 ,760
     0,.16,.15 ,3800,.16,.15 ,650
     0,.16,.15
3530  DATA       6500,.17,.15 ,1190
     0,.19,.17 ,5950,.19,.17 ,870
     0,.20,.18
3550  DATA       8500,.19,.17,1600
     0,.22,.19,8000,.22,.19,11800
     , .22,.19
3570  DATA      10800,.22,.19,20200
     ,.25,.23,10100,.25,.23,15000
     ,.23,.21
3590  DATA      12900,.23,.21,24600
     ,.29,.26,12300,.29,.26,18200
     ,.28,.25
3610  DATA      15000,.27,.24,29900
     ,.33,.30,14950,.33,.30,23500
     ,.32,.29
3630  DATA      18200,.31,.28,35200
     ,.39,.35,17600,.39,.35,28800
     ,.38,.34
3650  DATA      23500,.35,.32,45800
     ,.44,.40,22900,.44,.40,34100
     ,.41,.37
3670  DATA      28800,.40,.36,60000
     ,.49,.44,30000,.49,.44,44700
     ,.49,.44
```

```
3690 DATA 34100,.44,.40,85600,.50,.48,42800,.50,.48,60600,.50,.48
3710 DATA 41500,.50,.45,109400,.50,.5,54700,.5,.50,81800,.50,.5
3730 DATA 55300,.50,.5,162400,.5,.5,81200,.50,.5,108300,.5,.5
3750 J = FS * 3 - 2
3770 HOME : VTAB 4: HTAB 8: PRINT "YOU NEED TO INPUT THE ACREAGE "
3790 VTAB 7: HTAB 4: PRINT "ALLOCATED TO EACH CROP BEGINNING WITH"
3810 VTAB 10: HTAB 8: PRINT "CROP 1, THEN CROP 2, 3, AND 4."
3830 VTAB 13: HTAB 9: PRINT "HIT <RETURN> AFTER YOU TYPE"
3850 VTAB 16: HTAB 10: PRINT "THE ACREAGE FOR EACH CROP..."
3870 VTAB 18: HTAB 06: PRINT "NOW, HIT <RETURN> TO CONTINUE...";
3890 GET X$
3910 IF ASC (X$) < > 13 GOTO 16150
3930 HOME : VTAB 8: HTAB 10: PRINT "INPUT THE ACREAGE"
3950 VTAB 9: HTAB 7: PRINT "FOR THE CROPS IN THE MIX"
3970 VTAB 10: HTAB 1: PRINT "(INPUT ACREAGE BEGINING WITH CROP 1)"
3990 FOR I = 1 TO NC: INPUT AC(I): NEXT I
4010 HOME : VTAB 12: HTAB 8: PRINT "DO YOU WANT TO CHANGE"
4030 VTAB 14: HTAB 06: PRINT "THE ACREAGE ALLOCATION?(Y/N)";: INPUT B$
4050 IF B$ < > "Y" AND B$ < > "YES" GOTO 4110
4070 GOTO 3930
4090 GOTO
4110 TU = 185.26 * AC(4):TV = 534.31 * AC(4)
4130 J = FS * 3 - 2
4150 REM >>THIS ENDS TAX INPUT
4170 REM INPUT VALUES FOR INTEREST, FIXED COST, AND DEPRECIATION
4190 FOR I = 1 TO 4: READ INR(I): NEXT I
4210 DATA 10.20,12.50,8.95,29.89
4230 FOR I = 1 TO 4: READ VCE(I): NEXT I
4250 DATA 43.78,11.83,.35,329.21
4270 FOR I = 1 TO 4: READ FCE(I): NEXT I
4290 DATA 400.60,396.60,94.05,130.52
4310 FOR I = 1 TO 4: READ DEPR(I): NEXT I
4330 DATA 27.60,30.68,12.60,39.03
4350 FOR I = 1 TO NC:DEPR = DEPR + DEPR(I) * AC(I): NEXT I
4370 FOR I = 1 TO NC:FCE = FCE + FCE(I) * AC(I): NEXT I
4390 FOR I = 1 TO NC:INR = INR + INR(I) * AC(I): NEXT I:INR = INR + 61000
4410 IF NC = 4 THEN INR = INR + TU
4430 IF NC = 4 THEN PP = PP + TV
4450 FOR I = 1 TO 4
4470 READ FV(I),FW(I),GV(I),GW(I)
4490 NEXT I
4510 DATA 309.68,118.12,6.53,2.53
4530 DATA 140.46,62.35,11.88,5.34
4550 DATA 9.35,2.18,96.46,41.96
4570 DATA 897.40,604.20,6.93,1.37
4590 HOME
4610 VTAB 8: HTAB 3: PRINT "DO YOU WANT TO USE THE TRIANGULAR"
4630 VTAB 9: HTAB 2: PRINT "OR THE BETA PROBABILITY DISTRIBUTION "
4650 VTAB 10: HTAB 2: PRINT "(TYPE 1 FOR BETA ,2 FOR TRIANGULAR)";: INPUT KW
4670 HOME : INVERSE : VTAB 5: HTAB 6: PRINT "THIS IS AN OPPORTUNITY"
4690 VTAB 6: HTAB 6: PRINT "TO RECONSIDER YOUR CHOICE": NORMAL
4710 VTAB 8: HTAB 3: PRINT "DO YOU WANT TO USE THE TRIANGULAR"
4730 VTAB 9: HTAB 2: PRINT "OR THE BETA PROBABILITY DISTRIBUTION "
4750 VTAB 10: HTAB 2: PRINT "(TYPE 1 FOR BETA ,2 FOR TRIANGULAR)";: INPUT KW: IF KW = 1 GOTO 5150
4770 REM USING TRIANGULAR DISTRIBUTION
4790 FOR I = 1 TO NC
4810 PZ(I) = ((PM(I) - PN(I)) ↑ 2) / ((PX(I) - PN(I)) * (PM(I) - PN(I)))
4830 PY(I) = ((YM(I) - YN(I)) ↑ 2) / ((YX(I) - YN(I)) * (YM(I) - YN(I)))
4850 NEXT I
4870 RN = RND ( - RN)
4890 HOME
4910 REM >>START SIMULATION LOOP
4930 R = R + 1
4950 FOR I = 1 TO NC
```

```
4970 RN =  RND (RN)
4990  IF PZ(I) > RN THEN P(I) = P
     N(I) + (RN * (PX(I) - PN(I))
      * (PM(I) - PN(I))) ↑ 0.5
5010  IF PZ(I) <  = RN THEN P(I) =
     PX(I) - ((1 - RN) * (PX(I) -
     PN(I)) * (PX(I) - PM(I))) ↑
     0.5
5030 RN =  RND (RN)
5050  IF PY(I) > RN THEN Y(I) = Y
     N(I) + (RN * (YX(I) - YN(I))
      * (YM(I) - YN(I))) ↑ 0.5
5070  IF PY(I) <  = RN THEN Y(I) =
     YX(I) - ((1 - RN) * (YX(I) -
     YN(I)) * (YX(I) - YM(I))) ↑
     0.5
5090  NEXT I
5110  GOTO 5530
5130  REM   USING BETA DISTRIBUTI
     ON
5150 P =  RND ( - RN)
5170 I = 0:J = 0
5190 I = I + 1:J = J + 1
5210 LO(I) = PN(J):HI(I) = PX(J):
     MO(I) = PM(J):ME(I) = PA(J)
5230 I = I + 1
5250 LO(I) = YN(J):HI(I) = YX(J):
     MO(I) = YM(J):ME(I) = YA(J)
5270  IF J < NC GOTO 5190
5290 J = FS * 3 - 2
5310  FOR I = 1 TO W9
5330 ME(I) = (LO(I) + HI(I) + (4 *
     MO(I))) / 6
5350 MU(I) = (ME(I) - LO(I)) / (H
     I(I) - LO(I)):NU(I) = (HI(I)
      - ME(I)) / (HI(I) - LO(I))
5370  NEXT I
5390  FOR I = 1 TO W9
5410 A(I) = MU(I) * MU(I) * NU(I)
      * 36 - MU(I) - 1:B(I) = ((A
     (I) + 1) * (HI(I) - LO(I))) /
     (ME(I) - LO(I)) - A(I) - 2
5430  NEXT I
5450  HOME
5470  REM >>START SIMULATION LOOP

5490  GOSUB 9030
5510 R = R + 1
5530  FOR I = 1 TO NC
5550  IF R > 3 GOTO 5770
5570  IF R > 1 GOTO 5650
5590 P(I) = PM(I)
5610 Y(I) = YM(I)
5630  GOTO 5770
5650  IF R > 2 GOTO 5730
5670 P(I) = PN(I)
5690 Y(I) = YN(I)
5710  GOTO 5770
5730 P(I) = PX(I)
5750 Y(I) = YX(I)
5770  IF I = 1 GOTO 6310
5790 FK(I) = AP(I) + BP(I) * P(1)
      + CP(I) * P(1) ↑ 2
5810 FM(I) = AY(I) + BY(I) * Y(1)
      + CY(I) * Y(1) ↑ 2
5830  IF I > 2 GOTO 5990
5850  IF FK(I) < FW(I) - PN(I) GOTO
     5910
5870  IF FK(I) > FV(I) - PX(I) THEN
     FK(I) = FV(I) - PX(I)
5890  GOTO 5930
5910 FK(I) = FW(I) - PN(I)
5930  IF FM(I) < GW(I) - YN(I) GOTO
     13150
5950  IF FM(I) > GV(I) - YX(I) THEN
     FM(I) = GV(I) - YX(I)
5970  GOTO 6290
5990  IF I > 3 GOTO 6110
6010  IF FM(I) < GW(I) - YN(I) GOTO
     6070
6030  IF FM(I) > GV(I) - YX(I) THEN
     FM(I) = GV(I) - YX(I)
6050  GOTO 6290
6070 FM(I) = GW(I) - YN(I)
6090  GOTO 6290
6110  REM << I=4
6130  IF FK(I) < FW(I) - PN(I) GOTO
     6190
6150  IF FK(I) > FV(I) - PX(I) THEN
     FK(I) = FV(I) - PX(I)
6170  GOTO 6210
6190 FK(I) = FW(I) - PN(I)

6210  IF FM(I) < GW(I) - YN(I) GOTO
     6270
6230  IF FM(I) > GV(I) - YX(I) THEN
     FM(I) = GV(I) - YX(I)
6250  GOTO 6290
6270 FM(I) = GW(I) - YN(I)
6290 P(I) = FK(I) + P(I):Y(I) = F
     M(I) + Y(I)
6310  NEXT I
6330 CR = 0.0
6350 CO = 0.0
6370 GI = 0.0
6390 DXP = FCE
6410  FOR I = 1 TO NC
6430 PT = Y(I) * AC(I)
6450 CT = CN(I)
6470  IF CN(I) > PT THEN CT = PT
6490  REM >> CALC MARKET SALES
6510 CR = CR + P(I) * (PT - CT)
6530  REM >> CALC CONTRACT SALES
6550 CO = CO + PW(I) * CT
6570  IF CN(I) > PT THEN CO = CO +
     (PW(I) - P(I) - DF(I)) * (CN
     (I) - PT)
6590 IY = PCNT(I) * NY(I) / 100.
6610  REM >> CALC INSUR PYMTS
6630  IF Y(I) < IY THEN GI = GI +
     IPYT(I) * (IY - Y(I)) * AC(I
     )
6650  REM  >> CALC TAX DEDUCTABLE
     EXPENSES
6670 DXP = DXP + VCE(I) * Y(I) +
     ISUR(I) * AC(I)
6690  NEXT I
6710  REM  >> CALC GROSS INCOME
6730 TG = CR + CO + GI
6750  REM  >> CALC TAXABLE INCOME

6770 TIN = TG + OCR - DXP - INR -
     NDEP * 1000 - DEPR
6790  REM  >> CALC OF INCOME TAX
6810 TX = 0
6830  FOR L = 1 TO 14
```

```
6850  IF TIN < TAX(L,J) THEN 6990

6870 TB = TIN
6890  IF L = 14 THEN 6970
6910  IF TIN > TAX(L + 1,J) THEN
      TB = TAX(L + 1,J)
6930  REM   >> IN NEXT STATEMENT
       I=1 FOR 82 TAXES--CHANGE TO
      I=2 FOR 83 TAXES
6950 I = 1
6970 TX = TX + TAX(L,J + I) * (TB
       - TAX(L,J))
6990  NEXT L
7010  REM >>CALC SELF EMP. TAX
7030 TIN = TIN + NDEP * 1000.
7050  IF I = 1 THEN BAL = 32400
7070  IF I = 2 THEN BAL = 35000
7090  IF TIN > BAL THEN TIN = BAL

7110  IF TIN < 1600 THEN TIN = 16
      00
7130 SET = .0935 * TIN
7150 TTX = TX + SET
7170  REM >>IF STX > 0 STATE INCO
      ME TAX WOULD BE CALCULATED A
      ND ADDED HERE
7190  REM >>THIS ENDS TAX CALC
7210  REM  >> CALC ENDING BALANCE

7230 EB = BS + TG + OCR + CS - DX
      P - INR - PP - CE - LVW - TT
      X
7250  REM  >> CALC STATISTICS
7270 KG = KG + EB
7290 KE = KG / R
7310  IF EB < LBAL THEN LBAL = EB

7330  IF EB > HBAL THEN HBAL = EB

7350  IF EB < 0 THEN TNG = TNG +
      1
7370  IF EB < K1 THEN KO = KO + 1

7390  REM >>THIS MAY FIX IT
7410  IF EB > K2 THEN 7490
7430 KA = KA + 1
7450  IF EB < K3 THEN KB = KB + 1

7470  IF EB < K4 THEN KC = KC + 1

7490 PG = TNG / R
7510 KS = KO / R
7530 KT = KA / R
7550 KU = KB / R
7570 KV = KC / R
7590  IF EB > LBAL THEN  GOTO 771
      0
7610 LRC = CR
7630 LCN = CO
7650 LGI = GI
7670 LDXP = DXP
7690 LTX = TTX
7710  IF EB < HBAL THEN  GOTO 733
      0
7730 HRC = CR
7750 HCN = CO
7770 HGI = GI
7790 HDXP = DXP
7810 HTX = TTX
7830 ARC = ARC + (CR - ARC) / R
7850 AN = AN + (CO - AN) / R
7870 AGI = AGI + (GI - AGI) / R
7890 AXP = AXP + (DXP - AXP) / R
7910 AIT = AIT + (TTX - AIT) / R
7930  REM >>CALC P AND Y STATISTI
      CS
7950  FOR I = 1 TO NC
7970  IF P(I) < LP(I) THEN LP(I) =
      P(I)
7990  IF P(I) > HP(I) THEN HP(I) =
      P(I)
8010  IF Y(I) < LY(I) THEN LY(I) =
      Y(I)
8030  IF Y(I) > HY(I) THEN HY(I) =
      Y(I)
8050 VP(I) = VP(I) + (P(I) - VP(I
      )) / R
8070 VY(I) = VY(I) + (Y(I) - VY(I
      )) / R
8090 ZP(I) = ZP(I) + P(I):ZY(I) =
      ZY(I) + Y(I):SP(I) = SP(I) +
      P(I) * P(I):SY(I) = SY(I) +
      Y(I) * Y(I)
8110  REM >>LATER CALC S.D. HERE
8130  NEXT I
8150  HOME
8170  HTAB 4: PRINT "FINANCIAL RI
      SK EVALUATION REPORT"
8190  PRINT : PRINT
8210  HTAB 19: PRINT "TOTAL RUNS"
      ;:VAR = NRN: GOSUB 8750
8230  HTAB 19: PRINT "COMPLETED";
      :VAR = R: GOSUB 8750
8250  PRINT : PRINT
8270  PRINT "BEGINNING CASH BALAN
      CE";:VAR = BS: GOSUB 8750
8290  PRINT
8310  PRINT "ENDING BALANCE - LOW
      EST";:VAR = LBAL: GOSUB 8750

8330  HTAB 15: PRINT "- HIGHEST";
      :VAR = HBAL: GOSUB 8750
8350  HTAB 15: PRINT "- AVERAGE";
      :VAR = KE: GOSUB 8750
8370  PRINT : PRINT
8390  PRINT "PROBABILITY NEG. BAL
      ANCE (%)";:VAR = PG * 100: GOSUB
      8750
8410  PRINT
8430. PRINT "PROB. OF BAL. BELOW
      $-10,000";:VAR = KS * 100: GOSUB
      8750
8450  PRINT "PROB. OF BAL. BELOW
      $-30,000";:VAR = KT * 100: GOSUB
      8750
8470  PRINT "PROB. OF BAL. BELOW
      $-60,000";:VAR = KU * 100: GOSUB
      8750
8490  PRINT "PROB. OF BAL. BELOW
      $-100,000";:VAR = KV * 100: GOSUB
      8750
8510  IF R < NRN AND NW = 1 GOTO
      5490
8530  IF R < NRN AND NW = 2 GOTO
      4930
```

```
8550  REM  >>END SIMULATION LOOP
8570  PR# 0
8590  PRINT : PRINT
8610  PRINT "NUMBER OF RUNS TO AD
     D";: INPUT ADD
8630  IF ADD = 0 THEN  GOSUB 8830
8650  IF ADD =  - 99 THEN  GOSUB
     15570
8670  IF ADD < 0 THEN  GOSUB 8970
8690 NRN = NRN + ADD
8710  IF KW = 1 GOTO 5490
8730  GOTO 4930
8750  REM  >> OUTPUT
8770  HTAB (37 -  LEN ( STR$ ( INT
     (VAR))))
8790  PRINT  STR$ ( INT (VAR))
8810  RETURN
8830  REM >>TERMINATE
8850  HOME
8870  VTAB 10
8890  FOR K = 1 TO 4
8910  HTAB 17: PRINT "GOODBYE"
8930  NEXT
8950  END
8970  REM >>PRINT REPORT
8990  PR# 1
9010  GOTO 8150
9030  REM  GENERATION OF BETA DIS
     TRIBUTED RANDOM VARIABLE VAL
     UES
9050  FOR W1 = 1 TO W9
9070 P =  RND (P)
9090 A = A(W1):B = B(W1)
9110  GOTO 9410
9130  REM  THIS A DIFFERENT APPRO
     ACH FOR PARAMETER DERIVATION
9150  FOR W1 = 1 TO W9
9170 P =  RND (P)
9190  IF W1 = 1 GOTO 11470
9210 B = ((LO(W1) + HI(W1)) - 2 *
     ME(W1)) * (HI(W1) - MO(W1)) /
     ((ME(W1) - MO(W1)) * (HI(W1)
     - LO(W1)))
9230 A = (MO(W1) - LO(W1)) * B /
     (HI(W1) - MO(W1))
9250  IF A < 0.0 AND B < 0.0 GOTO
     9310
9270  IF A > 0.0 AND B > 0.0 GOTO
     9410
9290  GOTO 15350
9310 A = A * ( - 1.0)
9330 B = B * ( - 1.0)
9350 W8 = A
9370 A = B
9390 B = W8
9410  IF (A > B) THEN XL = B
9430  IF (A <  = B) THEN XL = A
9450  IF (XL <  = 0.0) GOTO 11670
9470  IF (XL <  = 1.0) GOTO 10110
9490  IF (A > B) THEN XR = A
9510  IF (A <  = B) THEN XR = B
9530  IF (10.0 * XL <  = XR) GOTO
     10110
9550 IC = 0.0
9570 XL = 0.0
9590 XR = 1.0
9610 FL =  - P
9630 FR = 1.0 - P
9650  IF (FL * FR > 0.0) GOTO 116
     30
9670 Z0 = 0
9690  REM  BISSECTION METHOD
9710  INVERSE : FLASH
9730  HOME : VTAB (12): HTAB (8):
     PRINT "COMPUTATION OF "
9750  VTAB 13: HTAB 8: PRINT "BET
     A DISTRIBUTED"
9770  VTAB (14): HTAB (8): PRINT
     "PRICES AND YIELDS"
9790 X = (XL + XR) * .5
9810  GOSUB 11710
9830  IF (IER <  > 0.0) GOTO 1011
     0
9850 F0 = P9 - P
9870  IF (F0 * FL > 0.0) GOTO 995
     0
9890 XR = X
9910 FR = F0
9930  GOTO 9990
9950 XL = X
9970 FL = F0
9990 XM = XR - XL
10010  IF (XM <  = SG) AND ( ABS
     (F0) <  = EPPS) GOTO 15350
10030 IC = IC + 1.0
10050 Z0 = Z0 + 1
10070  IF (IC <  = IMAX) GOTO 973
     0
10090  REM  ERROR RETURNED FROM M
     DBETA:USE NEWTON METHOD FOR
     SKEWED CASES
10110  IF (P <  = 0.0) OR (P >  =
     1.0) GOTO 11630
10130  IF (P > .5) GOTO 10230
10150 AA = A
10170 BB = B
10190 Q0 =  LOG (P)
10210  GOTO 10290
10230 Q0 =  LOG (1.0 - P)
10250 AA = B
10270 BB = A
10290 B9 = AA + BB
10310 XT = AA / B9
10330  REM  CALCULATE THE GAMMA T
     ERMS
10350 X2 = B9
10370  GOSUB 13510
10390 M = GAMA
10410 X2 = AA
10430  GOSUB 13510
10450 N = GAMA
10470 X2 = BB
10490  GOSUB 13510
10510 AOK = GAMA
10530  REM  RETURN TO MAIN FLOW
10550 DTEMP = M - N - AOK
```

```
10570 DTEMP = DTEMP - B9 *  LOG (
      B9) + (AA - .5) *  LOG (AA) +
      (BB - .5) *  LOG (BB)
10590 DTEMP = DTEMP + .5 *  LOG (
      BB / AA) + AA *  LOG (1.0 +
      BB / AA) + BB *  LOG (1.0 +
      AA / BB)
10610  REM  LOOP BEGINS
10630  INVERSE : FLASH
10650  FOR D = 1 TO 50
10670  HOME : VTAB (12): HTAB (8)
      : PRINT "COMPUTATION OF "
10690  VTAB 13: HTAB 8: PRINT "BE
      TA DISTRIBUTED"
10710  VTAB (14): HTAB (8): PRINT
      "PRICES AND YIELDS"
10730 TM =  LOG (15.0 + B9)
10750  REM  FIND MAX(XT*B9-AA,0.0
      )
10770 K = XT * B9 - AA
10790  IF (K > 0.0) THEN L = K
10810 L = 0.0
10830  REM  RETURN TO MAIN FLOW
10850 F = .7 * TM * TM + L
10870 TM = AA + F + F
10890 FA =  INT (F) + 1.0
10910 C = 1.0 - B9 * XT / TM
10930 ZI = 2.0 / ( SQR (C * C - 4
      .0 * F * (F - BB) * XT / (TM
      * TM)))
10950 FA = FA - 1.0
10970  IF (FA < .5) GOTO 11090
10990 TM = AA + FA + FA
11010 ZI = (TM - 2.0) * (TM - 1.0
      - FA * (FA - BB) * XT * ZI /
      TM)
11030 TM = AA + FA - 1.0
11050 ZI = 1.0 / (1.0 - TM * (TM +
      BB) * XT / ZI)
11070  GOTO 10950
11090 ZZ = ZI
11110 TM =  LOG (XT)
11130  IF (TM <  = SM) GOTO 11390
11150 QX = DTEMP + AA * TM + BB *
      LOG (1.0 - XT) +  LOG (ZZ)
11170 XC = (Q0 - QX) * (1.0 - XT)
      * ZZ / AA
11190  IF (XC >  - .99) THEN V =
      XC
11210  IF (XC <  =  - .99) THEN V
      =  - .99
11230 TM = .5 / XT - .5
11250  IF (V > TM) THEN VI = TM
11270  IF (V <  = TM) THEN VI = V
11290 XT = XT * (1.0 + VI)
11310  IF ( ABS (VI) < S1) GOTO 1
      1410
11330  NEXT D
11350 IER = 131
11370  GOTO 15330
11390 XT = 0.0
11410  IF (P > .5) GOTO 11530
11430 X = XT
11450 W7(W1) = X * (HI(W1) - LO(W
      1)) + LO(W1)
11470  NEXT W1
11490  NORMAL
11510  GOTO 15350
11530 X = 1.0 - XT
11550 W7(W1) = X * (HI(W1) - LO(W
      1)) + LO(W1)
11570  NEXT W1
11590  NORMAL
11610  GOTO 15350
11630 IER = 129
11650  GOTO 15330
11670 IER = 130
11690  GOTO 15330
11710 Y = X
11730  IF (X <  = 1.0) AND (X >  =
      0.0) GOTO 11790
11750 IER = 129
11770  GOTO 13430
11790  IF (A > 0.0) AND (B > 0.0)
      GOTO 11850
11810 IER = 130
11830  GOTO 13430
11850 IER = 0.0
11870 AA = A
11890 BB = B
11910  IF (X > 0.5) GOTO 11970
11930 IT = 0.0
11950  GOTO 12070
11970 IT = 1.0
11990 TEMP = AA
12010 AA = BB
12030 BB = TEMP
12050 Y = 1.0 - Y
12070  IF (X <  > 0.0) AND (X <  >
      1.0) GOTO 12130
12090 P9 = 0.0
12110  GOTO 13370
12130 TEMP =  INT (BB)
12150 PS = BB - TEMP
12170  IF (BB = TEMP) THEN PS = 1
      .0
12190 DA = AA
12210 DB = BB
12230 PX = DA *  LOG (Y)
12250 D4 =  LOG (DA)
12270  REM  CALCULATE GAMA TERMS
12290 X2 = DA + DB
12310  GOSUB 13510
12330 PQ = GAMA
12350 X2 = DA
12370  GOSUB 13510
12390 P1 = GAMA
12410 X2 = DB
12430  GOSUB 13510
12450 CZ = GAMA
12470 X2 = PS + DA
12490  GOSUB 13510
12510 A0 = GAMA
12530 X2 = PS
12550  GOSUB 13510
12570 XB = PX + A0 - GAMA - D4 -
      P1
12590  REM  SCALING
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12610 IB = XB / AL
12630 XIT = 0.0
12650  REM  FIRST TERM OF DECREAS
     ING SERIES WILL UNDERFLOW
12670  IF (IB > 0.0) GOTO 12870
12690 XIT =  EXP (XB)
12710 CC = XIT * DA
12730  REM  COMPUTE CNT
12750 WH = 0.0
12770 WH = WH + 1.0
12790 CC = CC * (WH - PS) * Y / W
     H
12810 XB = CC / (DA + WH)
12830 XIT = XIT + XB
12850  IF (XB / EPS > XIT) GOTO 1
     2770
12870 T9 = 0.0
12890  IF (DB <  = 1.0) GOTO 1335
     0
12910 XB = PX + DB *  LOG (1.0 -
     Y) + PQ - P1 -  LOG (DB) - C
     Z
12930  REM  SCALING
12950 TEMP = XB / AL
12970 TEMP =  INT (TEMP)
12990  IF (TEMP < 0.0) THEN TEMP =
     0.0
13010 CZ = 1.0 / (1.0 - Y)
13030 PS = TEMP
13050 CC =  EXP (XB - PS * AL)
13070 PS = DB
13090 WH = DB
13110 WH = WH - 1.0
13130  IF (WH < 0.0) GOTO 13350
13150 PX = (PS * CZ) / (DA + WH)
13170  IF (PX > 1.0) GOTO 13210
13190  IF (CC / EPS <  = T9) OR (
     CC <  = ES / PX) GOTO 13350
13210 CC = CC * PX
13230  IF (CC <  = 1.0) GOTO 1329
     0
13250 TEMP = TEMP - 1.0
13270 CC = CC * ES
13290 PS = WH
13310  IF (TEMP = 0.0) THEN T9 =
     T9 + CC
13330  GOTO 13110
13350 P9 = T9 + XIT
13370  IF (IT <  > 0.0) THEN P9 =
     1.0 - P9
13390  RETURN
13410  GOTO 13470
13430 K$ = "ERROR MESSAGE 1"
13450  PRINT K$
13470  RETURN
13490  REM  ALGAMA BEGINS
13510 M$ = "FALSE"
13530 T = X2
13550  IF ( ABS (T) < BIG1) GOTO
     13630
13570 IER = 129
13590 GAMA = XF
13610  GOTO 15270
13630  IF (T > 0.0) GOTO 13990
13650  IF (T < 0.0) GOTO 13710
13670 GAMA = XF
13690  GOTO 15270
13710 M$ = "TRUE"
13730 T =  - T
13750 RO =  INT (T)
13770 S1 = 1.0
13790  DEF  FN MOD(W) =  INT ((W /
     2.0 -  INT (W / 2.0)) * 2.0 +
     0.5) *  SGN (W / 2.0)
13810  IF (MOD(RO) = 0.0) THEN S1
     =  - 1.0
13830 RO = T - RO
13850  IF (RO <  > 0.0) GOTO 1391
     0
13870 GAMA = XF
13890  GOTO 15270
13910 RO = P8 /  SIN (RO * P8) *
     S1
13930 T = T + 1.0
13950 RO =  LOG ( ABS (RO))
13970  REM  EVALUATE APPROXIMATIO
     N FOR LN(GAMA)
13990  IF (T > 12.0) GOTO 14990
14010  IF (T > 4.0) GOTO 14770
14030  IF (T >  = 1.5) GOTO 14510
14050  IF (T >  = 0.0) GOTO 14230
14070  REM  0.0<T<0.5
14090 B2 =  -  LOG (T)
14110 A2 = T
14130 T = T + 1.0
14150  IF (A2 > EKPS) GOTO 14290
14170 GAMA = B2
14190  GOTO 15310
14210  REM  0.5<=T<1.5
14230 TP = T - 0.5
14250 B2 = 0.0
14270 A2 = TP - 0.5
14290 TP = PO(6) * T + PO(7)
14310 DN = T + QA(6)
14330  FOR JO = 0 TO 6
14350 TP = TP * T + PO(JO)
14370 DN = DN * T + QA(JO)
14390  NEXT JO
14410 Y2 = (TP / DN) * A2 + B2
14430  IF (M = 2) THEN Y2 = RO -
     Y2
14450 GAMA = Y2
14470  GOTO 15310
14490  REM  1.5<=T<=4.0
14510 B2 = T - 1.0
14530 A2 = B2 - 1.0
14550 TP = PB(6) * T + PB(7)
14570 DN = T + QB(6)
14590  FOR H = 0 TO 6
14610 TP = TP * T + PB(H)
14630 DN = DN * T + QB(H)
14650  NEXT H
14670 Y2 = (TP / DN) * A2
14690  IF (M = 2) THEN Y2 = RO -
     Y2
14710 GAMA = Y2
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14730  GOTO 15310
14750  REM  4.0<T<12.0
14770 TP = RK(6) * T + RK(7)
14790 DN = T + QC(6)
14810  FOR JH = 0 TO 6
14830 TP = TP * T + RK(JH)
14850 DN = DN * T + QC(JH)
14870  NEXT JH
14890 Y2 = TP / DN
14910  IF (M = 2) THEN Y2 = RO -
       Y2
14930 GAMA = Y2
14950  GOTO 15310
14970  REM  12.0<X2<BIG1
14990 TP =  LOG (T)
15010 TP = (T - 1.5) * (TP - 1.0)
       + TP
15030  IF (T < 20) GOTO 15090
15050 TP = TP - .575
15070  GOTO 15110
15090 TP = TP - .578
15110 T = 1.0 / T
15130  IF (T < EKPS) GOTO 15190
15150 B2 = T * T
15170 TP = (((PK(5) * B2 + PK(4) *
       B2 + PK(3) * B2 + PK(2) * T +
       PK1 + TP
15190 Y2 = TP
15210  IF (M = 2) THEN Y2 = RO -
       Y2
15230 GAMA = Y2
15250  GOTO 15310
15270 L$ = "ERROR MESSAGE 2"
15290  PRINT L$
15310  RETURN
15330  PRINT "ERROR MESSAGE"
15350  REM  COMPUTATION OVER
15370  VTAB 13
15390 P(1) = W7(1)
15410 Y(1) = W7(2)
15430 P(2) = W7(3)
15450 Y(2) = W7(4)
15470 P(3) = W7(5)
15490 Y(3) = W7(6)
15510 P(4) = W7(7)
15530 Y(4) = W7(8)
15550  RETURN
15570  REM >>>PRICES AND YIELDS
15590  PR# 1
15610  HOME
15630  HTAB 10: PRINT "PRICE AND
      YIELD REPORT"
15650  HTAB 14: PRINT "(TIMES 100
      )"
15670  PRINT
15690  PRINT "CROP";: HTAB 11: PRINT
      "LOW  HIGH  MODE  MEAN  S.DE
      V"
15710  FOR I = 1 TO 4
15730  PRINT
15750 PD(I) = ((SP(I) - (ZP(I) *
      ZP(I) / R)) / (R - 1)) ↑ .5
15770 YD(I) = ((SY(I) - (ZY(I) *
      ZY(I) / R)) / (R - 1)) ↑ .5
15790  IF I > 1 THEN PO(I) = AP(I
      ) + BP(I) * PM(1) + CP(I) *
      PM(1) ↑ 2 + PM(I)
15810  IF I > 1 THEN YO(I) = AY(I
      ) + BY(I) * YM(1) + CY(I) *
      YM(1) ↑ 2 + YM(I)
15830  HTAB 1: PRINT I;: HTAB 3: PRINT
      "PRICE"
15850  HTAB 9:VAR = LP(I) * 100: GOSUB
      8750;
15870  HTAB 15:VAR = HP(I) * 100:
      GOSUB 8750;
15890  HTAB 21:VAR = PO(I) * 100:
      GOSUB 8750;
15910  HTAB 27:VAR = VP(I) * 100:
      GOSUB 8750;
15930  HTAB 33:VAR = PD(I) * 100:
      GOSUB 8750
15950  PRINT
15970  HTAB 3: PRINT "YIELD";
15990  HTAB 9:VAR = LY(I) * 100: GOSUB
      8750;
16010  HTAB 15:VAR = HY(I) * 100:
      GOSUB 8750;
16030  HTAB 21:VAR = YO(I) * 100:
      GOSUB 8750;
16050  HTAB 27:VAR = VY(I) * 100:
      GOSUB 8750;
16070  HTAB 33:VAR = YD(I) * 100:
      GOSUB 8750
16090  NEXT I
16110  PR# 0
16130  GOTO 8590
16150  HOME : HTAB 8: VTAB 12: PRINT
      "SIMULATION LOOP NOT EXECUTE
      D "
16170  HTAB 08: VTAB 14: PRINT "-
      ---------GOODBYE-----------"
```