Risk and diversification in Arizona crop farm production

RISK AND DIVERSIFICATION IN ARIZONA
CROP FARM PRODUCTION

by

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ABSTRACT

This study estimates the degree of variability in prices, yields, and incomes associated with various crops and crop diversification systems in Arizona. Relationships among variabilities, returns above variable cost levels, equity levels, and farm sizes associated with various cropping systems are investigated.

The variate difference method of calculating variability is used to derive estimates of income variability for various crops and crop diversification systems based on state price, yield, and cost data over a series of years.

The results show that vegetable crops have high expected returns and high variability in returns in contrast to field crops with low expected returns and low variability in returns. However, in some specific diversification systems vegetable crops result in higher variability and lower returns than field crops.

Further, the results indicate that a farmer should consider his scale and equity level when deciding what to produce. Varying degrees of risk are inherent in different equity and scale levels. A farmer at either of the two scales of operation considered in this study, 320 or 800 acres, and with a low equity level can easily go bankrupt in one bad year.

CHAPTER I

INTRODUCTION

Farm size increases, technological change, a tight money supply, and government program changes are only a few of the factors increasing the complexity of the decision making process for Arizona farmers and agribusinessmen. Now, more than ever before, farmers, ranchers, and other businessmen need reliable and accurate statistics and an adequate procedure for analyzing alternative courses of action in order to make effective decisions.

This study is designed to augment the information base currently available for decision making in Arizona crop farm production by estimating the degree of variability in prices, yields, and income associated with various crops and crop diversification systems. Also investigated is the degree of risk inherent in alternative income levels, equity positions, and scales of operations. A formal statement of the objectives appears later in this chapter. However, first the magnitudes and interrelationships among the forces of change referred to above will be discussed in order to establish why knowledge of the relationships investigated in this study is essential for effective decision making.

Farm Size and Capital Requirements Increase

The scale of farms in Arizona has been increasing through the past decade. Table 1 shows that the number of farms with sales greater than $40,000 increased 87 per cent from 1960 to 1969. During the same period farms with sales under $10,000 decreased over 39 per cent.

As farm size increases, the amount of mechanical equipment and other inputs needed increases. "Mechanical power and machinery as farm inputs have increased by one-third and fertilizer and liming material inputs have tripled in the past two decades" (Menzie, 1970, p. 12). Over the same period the price of farm machinery increased 40 per cent, farm wage rates 71 per cent, and the value of farm real estate increased 115 per cent (Table 2).

Credit Squeeze

From personal interviews, it was found that many Arizona farmers are presently paying 8 and 9 per cent interest on new farm real estate loans and 8 per cent on new equipment loans. The average interest rates on farm mortgages from all lenders in the southern plains states (Arizona, New Mexico, Nevada, Utah, Colorado, Wyoming, Idaho, and Montana) has increased from 4.7 per cent in 1961 to 5.7 per cent by January 1, 1968 (U.S. Department of Agriculture, "Agricultural Statistics," 1969, p. 494).

Increasing interest rates have affected the amount of capital borrowed for farm investment. The exact extent

Table 1. Amount of Sales per Farm, by Sales Classes, 1960-1969

	Farms with sales--			
	$40,000 & Over	$20,000-$39,999	$10,000-$19,999	Under $10,000
Year	1,000	1,000	1,000	1,000
1960	113	227	497	3,125
1961	123	239	494	2,965
1962	135	254	493	2,803
1963	144	267	491	2,659
1964	146	268	482	2,546
1965	160	287	487	2,406
1966	184	320	502	2,233
1967	182	317	491	2,156
1968	193	331	494	2,036
1969	211	357	505	1,898

Source: U. S. Department of Agriculture, "1970 Handbook of Agricultural Charts" (1970, p. 4).

Table 2. Prices of Selected Farm Inputs, 1960-1970

Year	Farm Wage Rates	Farm Machinery	Fertilizer	Farm Real Estate
		(1950 = 100)		
1960	148	138	106	171
1961	151	141	107	172
1962	155	144	106	182
1963	159	146	106	189
1964	163	149	105	202
1965	171	154	106	214
1966	185	160	106	231
1967	199	167	106	246
1968	216	175	103	262
1969	238	184	99	275
1970[a]	253	193	101	286

[a]Preliminary.

Source: U. S. Department of Agriculture, "1970 Handbook of Agricultural Charts" (1970, p. 10).

of its dampening effects are unknown but it is known that despite the increase in interest rates Arizona farmers continue to borrow more money. The farm mortgage debt in Arizona from all sources was $118.6 million at the beginning of 1960 and increased to $269.7 million by January 1, 1968 (U.S. Department of Agriculture, "Agricultural Statistics," 1969, p. 498).

Government Payment Changes

Cotton has long been the single most important crop in Arizona. In the last decade, the average acreage of cotton harvested per year was 333.5 thousand acres. The closest crop to cotton in the same time period was milo with an average of 164 thousand acres harvested per year (Arizona Crop and Livestock Reporting Service, 1970, pp. 12, 19).

Cash receipts from marketings of crops in Arizona are presented in Table 3. Cotton accounted for 38.4 per cent of total cash receipts in 1966, 27.2 per cent in 1967, and 32.4 per cent in 1968. Note the importance of cotton in that cash receipts from cotton exceed all vegetable crop cash receipts in two of the three years.

However, government payments on cotton have been limited to $55,000 per farm. Furthermore, there are indications that cotton payments will be limited even further in the future. The exact impact this will have on cotton production is only speculation. The limitations will

Table 3. Cash Receipts from Marketings of Farm Products in Arizona, 1966, 1967, and 1968

Commodity Group	1966	1967	1968
		1,000 dollars	
Cotton Lint	89,802	67,981	82,150
Cottonseed	14,224	9,935	15,650
Feed Grains	26,117	31,843	31,379
Hay	22,119	24,799	19,830
Wheat	1,415	3,493	3,405
Sugar Beets	--	2,143	4,179
Vegetables	73,717	89,443	83,638
Citrus	19,697	23,352	38,511
Grapes	3,268	5,369	5,306
Other Miscellaneous Crops	20,307	27,723	17,488
Total, All Crops	270,666	286,081	301,536

Source: Arizona Crop and Livestock Reporting Service (1970, p. 7).

not affect all farmers but those who are affected may be seeking crops to replace part of the cotton in their diversification system. The farmer who does shift from cotton to another crop may be forced to increase his capital investment even further. As new types of machines are required, production costs may also increase demanding still more capital investment in the farm enterprise.

The Principle of Increasing Risk

Farmers face a number of problems when deciding how to adjust their operations in light of these developments. For example, if land is diverted from cotton production, lack of experience in producing alternative crops may limit the range of alternatives the farmer has open to him and/or make it very difficult for him to rationally evaluate the potential consequences of a given crop rotation or farm plan.

Arizona farmers, ranchers, and other businessmen do have at their disposal a number of publications to provide a more comprehensive, reliable decision making base (Wildermuth, Martin, and Rieck, 1969; Young et al., 1968; U.S. Department of Agriculture, "Agricultural Statistics," annual issues 1960-1970; Arizona Crop and Livestock Reporting Service, 1970). These publications incorporate data from a large number of farms. However, the data are in the form of averages and in discrete terms such as tons per acre, cost per unit, expected returns above growing and harvest costs, etc. "These references are of limited application when the mean is provided without some notion of the error or degree of risk which applies to a single year" (Heady, 1952, p. 445). An example vis a vis the "Principle of Increasing Risk" will serve to illustrate just how serious such a limited planning base can be.

The principle of increasing risk states that as a business is expanded through the use of borrowed capital, the chance of the owner losing his own capital (i.e., going out of business) increases. Consider the case of a farmer who with $100,000 of equity capital borrows $100,000 in order to increase the size of his business and/or invest in new equipment which will enable him to grow a high-value vegetable crop and thereby decrease his dependence on cotton production. Further assume that the farmer's decision to do this was based on the knowledge that on the average such a plan would allow him to realize a return of 50 per cent on invested capital. The farmer's position before and after the acquisition of the borrowed capital is summarized below:

Before (100% Equity)

Assets - liabilities = Net Worth
$100,000 - 0 = $100,000

After (50% Equity)

Assets - liabilities = Net Worth
$200,000 - $100,000 = $100,000

Now assume, as can frequently happen where experience is limited or the farm is highly specialized, that the farmer has a bad year during the first year of his reorganized operation. The effect of a 50 per cent decrease in asset value is clearly apparent below:

Before (100% equity) @ 50% decrease		
Assets - liabilities	=	Net Worth
$50,000 - 0	=	$50,000

After (50% equity) @ 50% decrease		
Assets - liabilities	=	Net Worth
$100,000 - $100,000	=	0

Objectives

Therefore, it is the purpose of this study to provide a comprehensive and reliable statistical basis for Arizona farmers to utilize in analyzing the potential consequences of actions that they are considering or may already be engaged in. More explicitly the objectives of this study are:

1. To derive estimates of returns above variable cost for Arizona crops and crop combinations.
2. To derive estimates of the variability in returns above variable cost for Arizona crops and crop combinations.
3. To estimate the expected income and degree of risk associated with alternative crops and crop combinations under various equity levels and scales of operation.

Procedure

In order to derive estimates of variability in crops and crop combinations, data from a series of years are required. The choice of a reliable data base is not easy and leads to an even more difficult decision in the selection of an appropriate method of analysis. The reasons for selecting the methods of analysis utilized in this thesis will be presented in Chapter II.

To reach the ultimate objective of investigating relationships among crop combinations, a series of steps must be taken. Gross income variability can be calculated utilizing the interaction of price and yield data. This in turn must be combined with budgets of variable cost of production for each crop to arrive at variability estimates of returns above variable cost for each crop. These first empirical steps will appear in Chapter III.

In Chapter IV, the effects of diversification will be investigated as the data from single crops are combined to form various crop diversification systems. Next the results of the diversification analysis can be combined with equity level and scale considerations. Simple examples will be used to demonstrate how farmers and loan officials can use the data generated in this study as a basis for evaluating the riskiness associated with a given farming situation. Finally, in Chapter V, a brief summary will be provided.

CHAPTER II

METHODS OF ANALYSIS

The purpose of this chapter is to present step-by-step the methods of analysis that will be utilized to reach the objectives as stated at the end of the first chapter. First consideration is given to the nature of the variability in Arizona crop farm production. Next, the procedures for deriving estimates of expected returns and relative and absolute variability for each crop are presented. Third, diversification principles showing how to combine the above estimates for individual crops to derive similar estimates for crop diversification systems are discussed. Finally, the procedure for combining the variability estimates with equity and scale considerations and thereby to investigate the riskiness of specific rotation schemes and farm resources configurations is discussed.

Variability in Crop Production

"Variability in crop production stems from the fact that yields, prices, and incomes are influenced by many variables in an unpredictable or 'random' manner" (Carter and Dean, 1960, p. 177). Each alternative course of action or crop combination (a crop combination is a selection of crops composing a rotation for any farmer) has a probability distribution due to these random effects, i.e., insects, diseases, and weather cause agricultural prices, yields, and subsequently incomes to vary on a year to year basis.

"From the standpoint of the individual farmer, what portions of the total variation in price, yield, and income is unpredictable or 'random' and what portion predictable?" (Carter and Dean, 1960, p. 177). If farmers recognize trends from cycles, inflation, and technological advance and utilize this knowledge in decision making, this becomes the predictable part of variability. Recognizing these long-run trends, "the farmer planning crop production for the year ahead is more likely to view the 'random' element as a deviation from the 'current level' (e.g., of prices or yields over the last five years) rather than as deviation from the long-run mean" (Carter and Dean, 1960, p. 177).

The definition of variability inherent in the discussion above is utilized in this study. While empirical variability estimates are not necessarily identical with the traditional concepts of "risk" and "uncertainty" (Knight, 1921), they are, if appropriately derived, objective measures of past variability in crop production. And, assuming that future variability of particular crops is closely related to past variability empirical variability estimates will provide a reasonable basis for assessing the "degree of risk" inherent in both short-run and long-run cropping decisions.

Sources of Data and Procedure

Having adopted the view of variability as outlined above, it is now appropriate to outline the exact nature of the data needed for the analysis.

Crops Selected and Sources of Data

The first step in this study is to select the crops to be analyzed. Fourteen crops were selected on the basis of acres harvested in 1969. All crops with 2000 or more acres harvested in 1969, except corn, are included in this study. Corn was eliminated because it is not profitable to produce and its acreage has been declining rapidly. Table 4 presents the crops selected and their corresponding 1969 harvested acreage. Also presented in Table 4 are the average prices and yields over the last five years.

Having specified the crops to be included in the analysis, the next step is the selection of an appropriate price and yield series. It would be ideal to have time series and cross section data from a random sample of individual farms. However, to interview the large number of farmers necessary for this study would have been very expensive and time consuming. Further, even if farmers did have records of prices and yields for the number of years desired, it is doubtful that costs of production would be available from the farmers. Therefore, state time series

Table 4. Acreage Harvested in 1969 and Mean Price and Yield for 1965-1969 of Selected Arizona Crops

Crop	Acres Harvested	Mean			
		Price		Yield	
	1,000 acres		Unit		Unit
Alfalfa	188.0	26.78	$/ton	5.3	ton/acre
Barley	144.0	2.46	$/cwt	34.1	cwt/acre
Cantaloupe	12.8	7.10	$/cwt	112.0	cwt/acre
Carrots	2.8	5.19	$/cwt	182.0	cwt/acre
Cotton	267.7	24.36	¢/lb	1085.4	lbs/acre
Fall Lettuce	13.1	6.12	$/cwt	169.0	cwt/acre
Spring Lettuce	20.0	6.30	$/cwt	186.0	cwt/acre
Milo	199.0	2.17	$/cwt	43.7	cwt/acre
Onions	2.0	3.92	$/cwt	381.0	cwt/acre
Potatoes	12.8	3.01	$/cwt	230.0	cwt/acre
Safflower	25.0	79.40	$/ton	1.2	ton/acre
Sugar Beets	30.8	11.54	$/ton	20.3	ton/acre
Watermelons	5.1	2.51	$/cwt	162.0	cwt/acre
Wheat	73.0	2.51	$/cwt	29.8	cwt/acre

Source: Arizona Crop and Livestock Reporting Service (1970).

data for prices and yields (from Arizona Crop and Livestock Reporting Service, 1970) of each crop will be used.

The use of state data may be justified because Arizona's crop production areas are rather homogeneous. In fact, many vegetable crops are grown in very localized areas with similar growing conditions. While it can be argued that state data does tend to average out individual variability and may understate absolute variability, state data should still result in unbiased estimates of the relative and absolute variabilities. Most important is the fact that the use of state time series data is the only basis for analysis that is feasible.

Given a price and yield series and thereby gross income estimates for each year (gross income = price x yield) it is necessary to derive variable production cost estimates and subtract them from the gross income estimates to yield a time series of returns above variable costs for each crop.

Data for compiling unit budgets for each year were not available, therefore, unit budgets were prepared in terms of 1970 input prices and adjusted for varying yields or harvest costs and inflation or increasing input prices.

The procedure for compiling preharvest operating costs was taken from Wildermuth et al. (1969) and Mack (1968). These two sources contain unit budgets which show the various production processes (plow, plant, etc.) and materials (seed, fertilizer, etc.) which are necessary to produce each crop. The operating costs associated with each production process and material item were taken from Wildermuth (1970) and totaled to arrive at the pre-harvest operating costs for each crop.

Yields do not affect harvest costs significantly for field crops so no annual adjustment was made in field crop harvest costs. Yields of vegetables do affect harvest cost so an adjustment was necessary in the yearly harvest cost for vegetable crops. This adjustment was made by calculating the harvest cost, based on each season's yield and the present per unit harvest cost rate. For example, the carrot yield series shows yields of 165 cwt. in 1968 and 180 cwt. in 1969. Per cwt. harvest rates are $1.62 and at this rate the difference in yield between the two years results in a harvest cost difference of $25 per acre.

A second adjustment in operating costs was necessary due to the effects of inflation on farm input prices. The U.S. farm input price index (U.S. Department of Agriculture, "Agricultural Statistics," 1970, p. 425) was used to adjust costs arising from machine repair, fuel, and labor. Other input prices (fertilizer and seed) did not change significantly over the 1960-1969 time period so they were not adjusted. For example, assume operating costs of $350 for a crop, $200 of which is harvest cost and $50 for fuel, labor, and repairs in 1970. The yield of the crop decreases one-fourth from 1970 to 1969 so harvest cost was adjusted downward to $150. Farm input prices in 1969 were only 95 per cent of 1970 prices so the $50 charge for fuel, labor, and repairs was deflated by 5 per cent to $47.50 for a total operating cost of $297.50. This process was duplicated for each year in the study.

Finally, additional adjustments were made for operating a pickup, paying fees, dues, and subscriptions, hiring additional labor, and borrowing operating capital. These additional costs are dealth with more extensively in Young et al. (1968, pp. 75-76).

The Variate Difference Method

Given the data base as just discussed there are several alternative empirical procedures that can be used to estimate the random variability inherent in this data. One method is to approximate the "current level" of the time series by a fitted trend line and then to assume that deviations from the trend represent the "random" component (Heady, 1952). Another method approximates the "current level" by a moving average, and then assumes that deviations from the moving average are the "random" element.

> There are arguments for and against each of these alternative procedures. The authors believe that the most reasonable of these is the trend removal method which is based on the assumption that the systematic component of the time series (i.e., general price level, technological trend, etc.) can be characterized by linear, polynomial, or other types of mathematical functions. The authors prefer a statistical method that does not require *a priori* specification of rigid functions.

> Because the variate difference method appears to meet this objection, it is the technique employed in this study (Carter and Dean, 1960, p. 177).

The first step of the variate difference method is to calculate the variance of the original series. This is done by summing the squares of the deviations from the arithmetic mean and dividing by N-1, the degrees of freedom.

Equation 1 shows the means of calculation of the variance of the 0th difference of original series:

$$Vo = \frac{\sum_{i=1}^{N} (W_i - \overline{W})^2}{(N-1)} \quad (1)$$

where Vo is variance of 0th difference, W_i the observations, $\overline{W}$ the mean, and (N-1) the degrees of freedom.

The next step is finite differencing. The series for the first finite difference is calculated by subtracting the first item from the second item of the original series, the result being the first item in the series of first differences. The second item is formed by subtracting item two from three of the original series, the third by subtracting item three from four, etc. The series of second difference is formed by subtracting the items of the first difference series in the same manner as above.

The sum of squares of deviations from the arithmetic mean is not considered the best basis for estimating variances of finite differences. Rather, the sum of squares of deviations from zero are used. This is done because the true mean is expected to be zero for any finite difference series.

To form the variance for each finite difference series, sum the squares of the finite differences and divide by the degrees of freedom and then by another constant. The sum of squares of the difference is symbolized by $S_2^{(k)}$, k = kth difference. Divide this by the degrees of freedom and the mean square results (Equation 2).

$$V_{(k)} = \frac{S_2^{(k)}}{(N-K)} = \text{mean square} \qquad (2)$$

Having found the mean squares, the best estimate of the random variance of the finite differences is yet to be calculated. The mean squares of each successive finite difference series increases rapidly. It has been found that the original variance is multiplied by a certain binomial coefficient (constant mentioned above) with each successive finite differencing. This coefficient is for the kth difference equal to the number of combinations of 2k things taken k at a time 2kCk (e.g., the coefficient for the second finite difference = $2(2)C_2 = 6$). The mean squares are then divided by this coefficient and the estimate of the true variance of the random element in a series is formed.

To be sure the differencing has been taken far enough the kth difference and all higher differences must be equal or nearly equal. The equality here is that

$K_o = K_{o+1} = K_{o+2}$, etc. Because this is essentially dealing in the realm of probability, a test for this equality was devised. It is required only that the difference between the variances of two successive series of finite differences be smaller than three times its standard error (Tintner, 1940).

The variate difference method explained above derives measures of absolute variability in the variance and square root of the variance, the standard deviation. The standard deviation is in the same terms (i.e., tons, bushels) as the observations. A measure of variability which is independent of the unit of measurement used is the variability coefficient.

$$\text{Variability coefficient} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100 \qquad (3)$$

The variability coefficient is a measure of relative variation and may be used to evaluate results from different experiments involving the same character since it is a ratio. It is defined as the sample standard deviation expressed as a percentage of the sample mean as shown in Equation 3 (Steel and Torrie, 1960, p. 20).

By examining Equation 3, the effect of using the last five years' mean is readily seen. If the last five years' mean is smaller than for the entire period, the relative variability would increase and if the last five years' mean is larger than the entire period mean, the relative variability is smaller.

Diversification and Variability

Utilizing procedures discussed to this point, estimates of the absolute and relative variability can be derived for each crop. Now these crops can be combined as "farmers diversify with the expectation that high risk from one crop will be offset by low risk from another crop" (Heady, 1952, p. 510).

Diversification can be accomplished using two different methods. First, the resource base may be increased. If a farmer has capital totaling $10,000 to produce A and B he may add $5,000 to produce C. Second, the resource base may be held constant and a part of it shifted to another product. A farmer with $10,000 capital producing A and B may shift $3,000 to produce C and produce A and B with the remaining $7,000. A discussion of these two methods follows. This discussion is taken from Carter and Dean (1960, pp. 189-190).

Diversification by Adding Resources

Suppose a crop farmer diversifies by adding to a fixed acreage of crop A an equal acreage of crop B. The income variance of the crop A is represented by σ_A^2, the income variance of crop B by σ_B^2. When enterprise B is added A the total variance (σ_T^2) becomes:

$$\sigma_T^2 = \sigma_A^2 + \sigma_B^2 + 2_T r_{AB} \sigma_A \sigma_B$$

where r_{AB} = correlation between the incomes of enterprises A and B, and σ_A and σ_B are the standard deviations for crops A and B, respectively. The assumptions made in calculating correlation coefficients are similar to those made in estimating variances for each crop, except that two time series are now being considered. Each time series consists of the unpredictable mathematical expectation and the random element. Only corresponding elements of both series are correlated (Tintner, 1940, pp. 117-129).

Since net income correlations between crops ordinarily are zero or positive, diversification by adding resources usually increases total income variance. However, total net income also is usually higher, hence relative variance (total income variance divided by mean income) may stay the same or decrease even with positive income correlations between crops.

The total variance equation for n enterpris s is written as:

$$\sigma_T^2 = \sum_{\substack{i \\ i=j}}^{n} \sigma_{ij}^2 + 2 \sum_{\substack{ij \\ i>j}}^{n} r_{ij} \sigma_i \sigma_j \quad i,j = 1,2 \ldots n$$

Diversification With Redistribution of Fixed Resources

The second method of diversification is to redistribute a fixed quantity of resources, say land, among additional enterprises. This method is most common for farmers operating with relatively fixed acreage, capital, and other resources. In this case, the goal is to reduce uncertainty by dividing a fixed quantity of land among a greater number of enterprises. The equation for the total income variance where one-half of the acres used in producing crop A and the remainder are diverted toccrop B becomes:

$$\sigma_T^{\ 2} = (1/2)^2\ \sigma_A^{\ 2} + (1/2)^2\ \sigma_B^{\ 2} + 2_{T_{AB}}\ (\sigma_A/2)\ (\sigma_B/2)$$

$$\sigma_T^{\ 2} = .25\sigma_A^{\ 2} + .25\sigma_B^{\ 2} + .50\ r_{AB}\ \sigma_A\ \sigma_B$$

In this case, if $.25\sigma_B^{\ 2} + .5\ r_{AB}\sigma_A\sigma_B > .75\ T_A^{\ 2}$ or, if the

ratio $\dfrac{T_B^{\ 2} + 2r_{AB}\sigma_A\sigma_B}{3\ T_A^{\ 2}} > 1,$

diversion of one-half the total acres into crop B results in an increase in total income variance; if the ratio equals unity, no change in income variance results; if the ratio is less than unity income variance is decreased. Thus, opportunities for reducing total income variance by this method of diversification are much greater than by the first method of increasing total resources. With the second method it is often possible to reduce total income variance even in the common case where incomes from crops A and B are positively correlated and the variance of the added crop (σ_B^2) is greater than the variance of the original crop (σ_A^2). Also, if the variance of crop B is less than the variance of crop A, total income variance is always reduced, regardless of the income correlation between crops. As noted later, however, the reduction in income variance may be achieved only at sacrifice in income level.

When the proportion of land resources distributed between two enterprises is unspecified, the variance equation becomes:

$$\sigma_T^2 = q^2 \sigma_A^2 + (1-q)^2 \sigma_B^2 + 2q(1-q)r_{AB}\sigma_A\sigma_B$$

where q = proportion of land resources devoted to A and 1-q = proportion of land resources devoted to B.

Similarly, the total variance for redistributing land resources among n enterprises becomes:

$$\sigma_T^2 = {}_{i=1}^{n} q^2 \sigma i^2 + 2 \sum_{\substack{i,j=1 \\ i > j}}^{n} q_1 q_j r_{ij} \sigma_i \sigma_j$$

where qi (i = 1, ... n) = proportion of land resources devoted to enterprise i and $\Sigma q_i = 1$.

The possible effects of diversification on absolute variability are indicated above. However, the farmer is interested in relative variability also. The net results of relative variability as measured by the variability coefficient is dependent on the degree of change in the absolute level of the standard deviation and expected returns for a crop or crop combination. If the standard deviation and expected returns vary in the same magnitude, the variability coefficient will not change. If they vary in opposite directions with the mean decreasing and the standard deviation increasing the variability coefficient will increase substantially. If they both vary in the opposite directions the variability coefficient will decrease. Various other degrees of change may occur depending on the relative changes of the expected returns and standard deviations.

Break-Even Returns

The Principle of Increasing Risk example, beginning on page 7 of Chapter I, pointed out that the potential impact of the variability inherent in a given crop or operations plan is affected by the scale of operation and the farmer's debt (equity) position. If equity levels are low, the farmer has a corresponding high cash fixed cost due to large loan installments. Insurance and taxes as well as loan installments must be paid annually. If these annual payments cannot be made the farmer must either refinance his loans, sell assets to pay cash fixed cost or file for bankruptcy.

The amount of risk due to the variability in returns from a crop combination that a farmer ultimately accepts depends on his own attitude towards gambling. "Established farmers or those with high risk preferences might concentrate on high risk crops. New farmers, farmers with limited capital or farmers who prefer not to gamble on high risk crops could choose crop combinations which minimize risk, thus avoiding the short-run possibility of bankruptcy" (Carter and Dean, 1960, p. 176). Certainly in the long run profits will be maximized by those who are willing and able to accept the risks.

However, if a farmer gets into a tenuous equity position, he may not be around to realize the long run gains. The procedure required to develop the means for making risk-income decisions on a rational basis involves the calculation of the Z statistic. The Z statistic is the number of standard deviations from the mean that are required to contain a given percentage of total possible outcomes. The Z relationship for determining a certain outcome follows:

$$Z = \frac{X - \mu}{\sigma}$$

where Z equals the value from the standard normal area table corresponding to a given probability level, μ equals the mean of a series, σ equals the standard deviation of a series, and X equals the expected outcome for a given probability level (Yamane, 1964, pp. 115-118). By combining means and standard deviations with the Z statistic, returns above variable costs for various probability or certainty levels can be calculated. For example, if returns are estimated to have a mean of $50 and standard deviation of $10 and a 90 per cent income certainty level is required, the corresponding Z value is 1.65 standard deviations. Solving for X, returns can be expected to be at least $33.50 nine times out of ten.

Next, the range of probable incomes for selected crop combinations can be combined with cash fixed cost to find short-run break even returns at the desired probability level. For example, assume an annual cash fixed cost of $60 per acre and a resource base that can produce the two following crop combinations in equal proportions.

	Returns above variable cost with 60	70	80	90 percent certainty
Alfalfa - fall lettuce	200	130	60	-10
Alfalfa - cotton	120	100	80	60

If a farmer in this position desires to take the added risk associated with higher expected returns, he will choose to produce alfalfa and fall lettuce. However, at the 80 per cent probability level, he will only be breaking even (cash fixed cost = return above variable cost) and at the 90 per cent probability level (one time out of ten) his return above variable cost will be a negative $10. He must also meet a cash fixed obligation of $60, so in total he would lose $70 per acre. On the other hand if he chose to produce alfalfa and cotton, his break even point would be at the 90 per cent probability level.

Utilizing all of the above methods of analysis, it is now possible to calculate the various measures which lead to the ultimate objective of estimating the degree of risk associated with various crops and crop combinations.

CHAPTER III

YIELD, PRICE, AND INCOME VARIABILITY OF SELECTED ARIZONA CROPS

This chapter contains empirical estimates of the random variability in yields, prices, gross incomes, and returns above variable cost for 14 major Arizona field crops. As explained in Chapter II, a variate difference analysis of state price, yield, and variable cost data is utilized to derive these variability estimates. First, consideration is given to the absolute and relative price and yield variabilities. Next, the price and yield data are combined to arrive at estimates of gross income variability. Finally, variability in returns above variable cost is presented.

Yield Variability of Arizona Crops

Yield variability is the deviation or error from the mean yield of a crop expressed in units of the crop harvested brought about by random or unpredictable sources. The yield variability data are presented in Table 5 with the crops being ranked on the basis of the yield variability coefficients. These coefficients are derived using the method described in Chapter II by combining the standard deviations

Table 5. Selected Crops: Ranking by Yield Variability Coefficients

Crop	1965-1969 Mean	Standard Deviation	Variability Coefficient	Unit
			(%)	
Barley	34.10	1.51	4	cwt/acre
Fall Lettuce	169.00	7.47	4	cwt/acre
Alfalfa	5.30	.25	5	ton/acre
Potatoes	230.00	12.48	5	cwt/acre
Watermelon	162.06	12.69	8	cwt/acre
Sugar Beets	20.30	1.62	8	ton/acre
Cotton	1,085.40	90.15	8	lbs/acre
Milo	43.70	3.93	9	cwt/acre
Spring Lettuce	186.00	16.87	9	cwt/acre
Safflower	1.20	.14	12	ton/acre
Wheat	29.80	4.34	15	cwt/acre
Onions	381.00	69.10	18	cwt/acre
Carrots	182.00	37.30	20	cwt/acre
Cantaloupe	112.00	25.20	22	cwt/acre

Source: Data compiled and calculated utilizing Arizona Crop and Livestock Reporting Service (1970).

calculated by the variate difference method with the last five years' means (VC = $\frac{\text{standard deviation}}{\text{65-69 mean}}$).

As would be expected, given the favorable weather conditions existing in Arizona and the availability of water for irrigation purposes, the yield variability of all crops is quite low. The ranking of the crops, contrary to beliefs, does not appear to have any pattern as vegetable and field crops are interspersed throughout the entire range of variability coefficients. Barley, a field crop, and fall lettuce, a vegetable crop, are the most stable with variability coefficients of 4. Potatoes and watermelons rank among the low relative variability group with 5 and 8 respectively. Then three field crops appear in the rankings followed by a vegetable and two field crops and three more vegetable crops. The most variable crop is cantaloupe, with a variability coefficient of 22.

Vegetable crop yields were expected to be relatively more variable than field crops because of special skills, soils, and climatic conditions required for their production. For example, melons are affected by the weather as high temperatures can cause sun spots and cooking. The fact that some of the vegetable crops have relatively stable yield variabilities may be explained by the fact that frequently vegetable crops are not harvested unless yields are high enough to cover harvesting costs. This would tend to stabilize yields as low yields are not recorded as the data used in this study is based on acres harvested.

Price Variability of Arizona Crops

Price variability is the deviation or error from the mean value of a crop unit as affected by variables such as random quality changes, the number of units produced in the state, and the number of units produced in other states.

The ranking of price variability coefficients for Arizona crops presented in Table 6 ranges from the most stable barley, 15 per cent, to the least stable fall lettuce, 27 per cent. In general, the most stable crops are those which have come under much direct government control (i.e., wheat, cotton, and sugar beets). As expected field crops which usually are not characterized by widely fluctuating prices have relatively low price variability coefficients. Also as expected, the vegetable crops which are normally considered specialty vegetable crops and produced to be sold in limited markets are characterized by high variability coefficients relative to field crops.

Gross Income Variability of Arizona Crops

Gross income variability is the deviation or error from the mean arising from the interaction of price and yield. Therefore, gross income variability is a function of both price and yield variability. If high prices are associated with high yields, the correlation of price and

Table 6. Selected Crops: Ranking by Price Variability Coefficients

Crop	1965-1969 Mean	Standard Deviation	Variability Coefficient	Unit
			(%)	
Barley	2.46	.13	5	$/cwt
Milo	2.17	.12	6	$/cwt
Alfalfa	26.78	2.54	10	$/ton
Sugar Beets	11.54	1.18	10	$/ton
Safflower	79.40	9.49	12	$/ton
Wheat	2.51	.42	17	$/cwt
Cotton	24.36	4.38	18	¢/lb
Carrots	5.19	.95	18	$/cwt
Cantaloupe	7.10	1.32	19	$/cwt
Watermelon	2.51	.52	21	$/cwt
Potatoes	3.01	.66	22	$/cwt
Onions	3.92	.91	23	$/cwt
Spring Lettuce	6.30	1.57	25	$/cwt
Fall Lettuce	6.12	1.66	27	$/cwt

Source: See Table 5.

yield is positive and gross income variability tends to be high. However, if prices and yields are negatively correlated or vary in opposite directions, gross income variability tends to be lower.

Table 7 presents gross income variability coefficients for Arizona crops ranging from the least variable barley to the most variable onions. The ranking by price variability and gross income variability (Tables 6 and 7) are similar. The field crops are at the least variable end of the range of variability and vegetables at the most variable end in both rankings. Because price and gross income variability rankings are similar, it would appear that price variability is more important than yield variability in determining gross income variability. The greater effect of price variability is especially noticeable in fall lettuce which ranks second in yield variability (Table 5), fifteenth in price variability (Table 6), and eleventh in gross income variability (Table 7).

Although it appears that price variability has a greater impact on gross income variability than yield variability, it can be shown that yield variability exerts influence through its impact on price. Arizona's yield variability may have only slightly noticeable effects on price and therefore price variability appears to be dominant in determining gross income variability. However, vegetables in Arizona are produced for limited markets and

Table 7. Selected Crops: Ranking by Gross Income Variability Coefficients

Crop	1965-1969 Mean	Standard Deviation	Variability Coefficient	Unit
			(%)	
Barley	83.63	4.70	7	$/acre
Alfalfa	142.93	15.37	11	$/acre
Milo	94.57	11.24	12	$/acre
Sugar Beets	234.81	29.88	13	$/acre
Wheat	74.19	10.10	14	$/acre
Cotton	263.48	50.29	19	$/acre
Potatoes	686.62	132.02	19	$/acre
Safflower	93.52	18.41	20	$/acre
Watermelon	413.90	106.66	26	$/acre
Fall Lettuce	1,034.90	279.10	27	$/acre
Spring Lettuce	1,189.60	354.12	30	$/acre
Carrots	944.00	288.00	31	$/acre
Cantaloupe	781.20	240.31	31	$/acre
Onions	1,531.26	560.40	37	$/acre

Source: See Table 5.

yields or production in other areas influence Arizona's price.

For example, Arizona spring lettuce production decreased from 1967 to 1968 and the price of lettuce dropped also. This unexpected price drop can be explained if California and New Mexico production for 1968 are acknowledged. New Mexico spring lettuce production icreased by 50 per cent from 1967 to 1968 and California which had nearl nearly half the total U.S. spring lettuce production in 1967 increased spring lettuce production by two-thirds, 67 per cent from 1967 to 1968 (U.S. Department of Agriculture, "Agricultural Statistics," 1969, Table 263, p. 179). This explains the decrease in Arizona prices even though Arizona production decreased and exemplifies the impact of yield, total production from all states, on gross income variability.

Carrot price and production provide another example of the same point made above. Arizona carrots are harvested in the spring following the California and Texas harvests of winter carrots. Arizona carrot production decreased by only 10 per cent from 1967 to 1968 but the Arizona carrot prices nearly doubled. However, the winter carrot harvest in Texas decreased from 3.5 million cwt. to 2.6 million cwt. during the same period and California production increased from 2 million cwt. to 2.7 million cwt. for a net decrease of .4 million cwt. This seems small but the total carrot production for that period was only 5.3 million cwt. and the

.4 million cwt. decrease created a substantial price rise. (Figures stated in the example were taken from United States Department of Agriculture, "Agricultural Statistics," 1969, Table 245, p. 170.)

Return Above Variable Cost Variability of Arizona Crops

Variability in returns above variable cost is the deviation from mean returns as determined by the interaction of price, yield, and variable cost. A farmer ultimately must consider cash fixed cost and total fixed cost as well as variable costs if he is to assess the riskiness of his farming situation. It is inappropriate to assign fixed costs on an individual crop basis as all crops grown on a farm must help meet fixed costs. As this section deals with single crop returns, only variable costs will be considered at this stage. The fixed cost considerations will be introduced subsequent to the development of alternative diversification systems which permits the consideration of fixed costs on a total farm basis.

In order to calculate returns above variable cost for each crop year, budgets were prepared using the procedure discussed in Chapter II.

Table 8 presents the average variable production costs derived for two farm sizes in Arizona. The larger farm size enjoys lower variable production costs for all crops. The lower production costs arose from the use of

Table 8. Per Acre Variable Costs of Producing Arizona Crops Based on 1970 Input Prices and 1960-1969 Yield Levels

	Farm Size	
Crop	320 Acres	800 Acres
Alfalfa (establishment)	60	58
Alfalfa	100	93
Barley	66	64
Cantaloupe	541	533
Carrots	446	440
Cotton	228	216
Fall Lettuce	645	639
Spring Lettuce	707	701
Milo	71	69
Onions	834	832
Potatoes	557	553
Safflower	87	84
Sugar Beets	203	198
Watermelon	307	302
Wheat	62	60

Source: Data compiled and calculated utilizing budgets from Wildermuth et al. (1969), Mack (1968), and Wildermuth (1970).

larger more efficient machinery and fewer custom charges, as the larger farm owned more machines than the smaller farm. The apparent pattern in differences of costs between the farm sizes arises because most of the gains of the larger farm were in land preparation practices which are similar in nearly all of the crops.

By subtracting variable costs from gross income, returns above variable cost are derived. The results of the analysis of the return above variable cost for each crop and farm size are presented in Table 9. Crops are ranked by relative variability as evidenced in the variability coefficients, column 3. As expected, field crops are the least variable and vegetable crops the most variable. The rank of variability coefficients does change from one size to another due to the economics of the larger farm size. Also, the larger farm size has a smaller range of variability coefficients brought about by its lower production costs. The lower production costs of the 800 acre farm allow higher mean returns than for the 320 acre farm. The standard deviations are nearly the same for both farm sizes, and, therefore, the variability coefficients for the larger farm are smaller.

Also, as expected, return above variable cost for crops with variable costs which are fairly stable from year to year (Appendix, Tables 19 and 20) have standard deviations similar to those for gross income (Tables 7 and 9). Crops

Table 9. Selected Crops: Variability of Returns Above Variable Cost for 320 and 800 Acre Arizona Crop Farms

Crop	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
	($)	($)	(%)	($)	($)	($)	($)
320 Acre Farm							
Cotton	197	34.2	17	189	180	169	154
Barley	20	3.8	19	19	18	17	15
Sugar Beets	92	27.9	30	85	78	69	56
Milo	26	9.5	37	23	21	18	14
Carrots	500	240.5	48	439	375	298	192
Alfalfa	27	14.7	54	24	20	15	9
Onions	697	464.3	67	581	456	307	103
Spring Lettuce	468	324.8	69	387	299	195	52
Wheat	14	10.1	72	11	9	6	1
Cantaloupe	250	184.0	74	204	154	95	14
Fall Lettuce	375	277.9	74	305	230	142	19
Watermelon	123	106.5	87	96	67	33	-13
Potatoes	155	138.2	89	121	83	39	-22
Safflower	17	18.6	108	13	9	2	-17
800 Acre Farm							
Cotton	210	34.0	16	201	192	181	166
Barley	21	3.8	18	20	19	18	16
Sugar Beets	97	27.9	29	90	82	73	61
Milo	27	9.3	34	25	22	19	15
Alfalfa	34	14.9	43	31	27	22	15
Carrots	506	240.4	47	445	380	304	198
Wheat	15	10.1	65	13	10	7	3

Table 9.--Continued

Onions	700	464.3	66	584	458	310	106
Spring Lettuce	473	324.1	68	392	304	200	58
Cantaloupe	258	184.0	71	212	162	103	22
Fall Lettuce	381	277.9	73	311	236	147	25
Watermelon	128	106.5	83	102	73	39	-8
Potatoes	159	138.2	87	124	87	43	-18
Safflower	19	19.2	97	14	9	2	-6

Source: Data calculated utilizing gross income and budget data derived in this study.

whose yields are highly variable and therefore have highly variable harvest costs do not have standard deviations similar to those for gross income. The standard deviations are unequal because if a constant is subtracted from gross income every year, the standard deviation remains the same. However, where yields are more variable, and therefore, harvest costs, a constant amount is not subtracted from gross income and hence, differing standard deviations result. Therefore, as a decision making tool, variability in return above variable cost is superior to variability in gross income. Consider the example of onions. The gross income standard deviation for onions is $560 (Table 7, col. 2) and the return above variable cost standard deviation for onions is $464 (Table 9, col. 2) for a difference of $96.

As well as relative and absolute variability estimates, a range of expected returns at various probability levels are calculated. This is done utilizing the normal curve table, standard deviation, and mean as components of the Z relationship discussed in Chapter II.

Table 9, columns 4, 5, 6, and 7 present the expected returns at varying probability levels for each crop.

Interpretation of return above variable cost at varying probability levels means that the estimated return above variable cost levels or greater should be realized 60, 70, 80, or 90 per cent of the time or alternatively returns should fall below the given levels only 40, 30, 20, or 10 per cent of the time. Consider cotton on a 320 acre farm. In column 4, return above variable cost of $189 or more should be realized 60 per cent of the time or alternatively a return lower than $189 should occur only 40 per cent of the time or four out of ten years.

The range of returns at the given probability levels is quite small for crops with low absolute variability (Table 9, column 2). The crops with low absolute variability are the field crops. The vegetable crops with higher absolute variability exhibit a wide range in expected returns depending on the desired probability level. For example, cantaloupe on a 320 acre farm has an expected return level of $204 or greater 60 per cent of the time. Expected return falls to $154 or greater at 70 per cent probability and way down to $14 at 90 per cent probability. A more stable field crop, cotton, on a 320 acre farm has expected returns ranging from $189 at 60 per cent probability to $154 at 90 per cent probability resulting in a range of $35 as compared to a $190 range in cantaloupe returns. This exemplifies further the greater amount of risk inherent in vegetable production.

Also, apparent in Table 9 is the advantage of larger scale production. For the returns of the different crops presented, expected returns at all probability levels on an 800 acre farm are greater than expected returns on a 320 acre farm. For example, at 60 per cent probability, the expected return from an acre of cotton on a 320 acre farm is $189 compared with an expected return of $201 on an 800 acre farm. At 70, 80, or 90 per cent probability, the expected returns from an acre of cotton on a 320 acre farm are $180, $169, and $154 respectively compared with $192, $181, and $166 on an 800 acre farm.

CHAPTER IV

DIVERSIFICATION AND SHORT-RUN BREAK-EVEN RETURNS

In the preceding chapter, relative and absolute variability estimates were presented for various single crops. As indicated in the methods of analysis in Chapter II, it is now time to combine the individual crop data in order to investigate the effects of diversification on the level and variability of returns above variable costs.

After variability estimates are derived for various diversification systems, it will be possible to take the final and most intersting step of this thesis. This step is to investigate *vis a vis* the Principle of Increasing Risk, the risk inherent in alternative equity levels and scales of operation. As in the last chapter the results will be keyed via the Z statistic to returns at alternative probability levels.

Effects of Diversification on Returns Above Variable Cost

Diversification is practiced by many farmers in an attempt to decrease the variability in their incomes. However, some diversification schemes have exactly the opposite effect (higher variability). In addition, diversification can lead to a reduction in expected returns above variable cost.

The expected returns and variability in returns associated with various crop diversification schemes are calculated using fixed asset diversification. As explained in Chapter II, fixed asset diversification reallocates a fixed resource base to adjust the proportions of crops in a diversification scheme.

An infinite number of crop combinations are possible using varying proportions of each of the 14 crops in this study. There are 3,558 combinations of 2, 3, 4, and 5 crop diversification schemes when equal proportions of each crop are used per acre (i.e., 2 crop combination: .5 acre cotton and .5 acre barley). It is apparent that all possible combinations cannot be presented in this thesis; therefore, only selected combinations are presented.

In Chapter I, the section entitled Government Program Changes pointed out the possible need for altering diversification systems to include less cotton. Farmers forced to produce less cotton will be seeking a crop to replace cotton in their rotation. Since the crop production experience of many farmers is limited to cotton, alfalfa, barley, and milo, and only selected diversions can be discussed, this section emphasizes diversion of cotton acreage to alternate crops.

Before getting to the diversification systems emphasizing cotton diversion, it should be noted that information on numerous other diversification schemes is contained in the Appendix. Only equal proportions of crops per acre (i.e., .5 acre cotton and .5 acre barley; .25 acre cotton, .25 acre barley, .25 acre milo, and .25 acre alfalfa) are considered in the 2, 3, 4, and 5 crop diversification systems selected. All possible two crop diversification systems are presented and only a few 3, 4, and 5 crop diversification systems are presented in the Appendix, Tables 21 through 28. The only comment about these results is that, in general, as more crops are added to the diversification systems, the range of relative variabilities decreases.

Now, attention focuses on the diversion of cotton acreage to alternative crops. Tables 10 through 17 present the effects of diverting cotton acreage to other crops. All the crop combinations include constant proportions of alfalfa and barley at .2 acre each and .6 acre at varying proportions of cotton and the alternate crops. The alternatives will be discussed in the context of decreasing proportions of cotton and increasing proportions of the alternate crop. Data are presented for both the 320 and 800 acre farms but absolute variability and expected returns for both sizes are similar. Therefore, discussion of results is in terms of 320 acre farms and of the crop replacing cotton and applied to 800 acre farms by simply replacing 320 with 800.

Sugar Beets, Milo

Diversion of cotton to sugar beets or milo (Tables 10 and 11), which are considered stable irrigated field crops, resulted in decreasing expected returns as more of either sugar beets or milo was produced. Absolute variability (standard deviation) decreases in both cases but relative variability (variability coefficient) increases. As relative variability depends on the interrelationsip of the changes in expected income and absolute variability changes (variability coefficient = $\frac{\text{standard deviation}}{\text{expected income}} \times 100$), it may increase even though both expected income and absolute variability decrease. In these two cases, expected income decreases proportionally more than the absolute variability. Thus, the net result is an increase in relative variability under diversion to both sugar beets and milo.

The range of expected returns at varying probability levels for both sugar beets and milo is quite low (columns 4, 5, and 6). Recall from Chapter III that returns at various probability levels refers to that return which can be expected a given per cent of the time.

For example, returns at 60 per cent probability refer to those returns which can be expected 60 per cent of the time or six times out of ten. Alternatively, four out of ten years' returns will be less than the given amount. The small range of expected returns at varying levels of probability further indicates the relative stability of

Table 10. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Sugar Beets

Acres Used For		320 Acre Farm							800 Acre Farm						
					Return Above Variable Cost Greater Than (% of Time)							Return Above Variable Cost Greater Than (% of Time)			
C[a]	SB[b]	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%
.60	0	128	21.0	16	123	117	110	101	137	21.0	15	132	126	119	110
.55	.05	123	20.3	17	117	112	105	97	131	30.3	16	126	121	114	105
.50	.10	117	19.6	17	112	107	101	92	126	19.6	16	121	115	109	100
.45	.15	112	19.0	17	107	102	96	88	120	19.0	16	115	110	104	96
.40	.20	107	18.4	17	102	97	91	83	114	18.5	16	110	105	99	90
.35	.25	101	18.0	18	97	92	86	78	109	18.0	17	104	99	94	86
.30	.30	96	17.6	18	92	87	81	74	103	17.7	17	99	94	88	80
.25	.35	91	17.3	19	87	82	76	69	97	17.4	18	93	88	83	75
.20	.40	86	17.1	20	81	81	71	64	92	17.1	19	87	83	77	70
.15	.45	80	17.0	21	76	72	66	59	79	16.6	21	75	71	65	58
.10	.50	75	17.0	23	71	66	61	53	80	17.1	21	76	72	66	59
.05	.55	70	17.1	25	66	61	55	48	75	17.2	23	71	66	60	53
0	.60	65	17.1	27	60	56	50	42	69	17.4	25	65	60	55	47

[a]C = Cotton
[b]SB = Sugar Beets
[c]μ = Mean Returns Above Variable Cost
[d]σ = Standard Deviation
[e]VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

Table 11. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Milo

Acres Used For		320 Acre Farm							800 Acre Farm						
					Return Above Variable Cost Greater Than (% of Time)							Return Above Variable Cost Greater Than (% of Time)			
C[a]	M[b]	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%
.60	0	128	21.0	17	123	117	110	101	137	21.0	15	132	126	119	110
.55	.05	119	19.6	16	114	109	103	94	128	19.6	15	123	118	111	103
.50	.10	111	18.1	16	106	101	95	87	119	18.2	15	114	109	103	95
.45	.15	102	16.8	16	98	93	88	81	110	16.8	15	105	101	95	88
.40	.20	93	15.4	17	90	85	81	74	100	15.4	15	97	92	87	81
.35	.25	85	14.1	17	81	78	73	67	91	14.1	16	88	84	79	73
.30	.30	76	12.8	17	73	70	66	60	82	12.9	16	79	75	71	66
.25	.35	68	11.6	17	65	62	58	53	73	11.7	16	70	67	63	58
.20	.40	59	10.5	18	57	54	50	46	64	10.6	17	61	58	55	50
.15	.45	51	9.6	19	48	46	43	38	55	9.6	18	52	50	47	42
.10	.50	42	8.8	21	49	37	34	31	46	8.8	19	43	41	38	34
.05	.55	33	8.3	25	31	29	26	23	37	8.3	23	34	32	30	26
0	.60	25	8.0	32	23	21	18	15	27	8.0	29	25	23	21	17

[a]C = Cotton
[b]M = Milo
[c]μ = Mean Returns Above Variable Cost
[d]σ = Standard Deviation
[e]VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

returns from sugar beets and milo. It also indicates that probability levels higher than 99 per cent are required before variable costs exceed gross income resulting in negative returns.

Potatoes, Watermelons

Diversion of cotton to what have been traditionally considered high risk vegetable crops shows varied results. The crops are groups according to changes in expected returns.

As acreage is diverted from cotton to potatoes or watermelons which are very unstable relative to the other single crops in this study (Table 9), the expected returns decrease only moderately but the absolute variabilities increase substantially (Tables 12 and 13). The relative changes in expected returns and absolute variability yield a net result of a greatly increased variability coefficient in both cases.

A farmer diverting acreage from cotton to potatoes or watermelons is accepting greater amounts of risk and also lower expected returns. Observe the range of expected returns at varying probability levels. An acre of potatoes, for example, at 60 per cent probability (six out of ten years), yields an expected income of $82. This figure decreases rapidly to a -$3 at 90 per cent probability (nine out of ten years returns from potatoes are expected to

Table 12. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Potatoes

Acres Used For		320 Acre Farm							800 Acre Farm						
					(% of Time) Return Above Variable Cost Greater Than							(% of Time) Return Above Variable Cost Greater Than			
C[a]	P[b]	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%
.60	0	128	21.0	17	122	117	110	101	137	21.0	15	132	126	119	110
.55	.05	126	22.4	18	120	114	107	97	134	22.4	17	129	123	116	106
.50	.10	124	25.5	21	117	110	102	91	132	25.5	19	124	119	110	99
.45	.15	122	29.7	24	114	106	97	94	129	29.6	23	122	114	104	91
.40	.20	119	34.6	30	111	101	90	75	127	34.6	27	118	109	98	83
.35	.25	117	39.9	34	107	97	84	66	124	39.9	32	114	103	91	73
.30	.30	115	45.6	40	104	91	77	57	122	45.6	38	110	98	83	63
.25	.35	113	51.5	46	100	86	70	47	119	51.5	43	106	92	76	53
.20	.40	111	57.5	52	97	81	63	37	117	57.5	49	102	87	68	43
.15	.45	109	63.6	58	93	76	55	27	114	63.6	56	98	81	61	33
.10	.50	107	69.8	65	89	71	48	17	112	69.8	63	94	75	53	22
.05	.55	105	76.0	73	86	65	41	7	109	76.0	70	90	70	45	12
0	.60	103	82.3	80	82	58	33	-3	107	82.3	77	86	64	37	1

[a]C = Cotton
[b]P = Potatoes
[c]μ = Mean Returns Above Variable Cost
[d]σ = Standard Deviation
[e]VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

Table 13. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Watermelons

Acres Used For		320 Acre Farm							800 Acre Farm						
					(% of Time) Return Above Variable Cost Greater Than							(% of Time) Return Above Variable Cost Greater Than			
C[a]	Wa[b]	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%
.60	0	127	21.0	17	123	117	110	101	137	21.0	15	132	126	119	110
.55	.05	124	22.0	18	119	113	106	96	133	22.0	17	127	121	114	105
.50	.10	120	24.0	20	114	108	100	90	129	24.0	19	123	116	109	98
.45	.15	117	26.8	23	110	103	94	82	125	26.8	22	118	111	102	90
.40	.20	113	30.2	27	105	97	88	74	121	30.2	25	113	105	95	82
.35	.25	109	34.0	31	101	92	81	66	117	34.0	29	108	99	88	73
.30	.30	105	38.0	36	96	86	74	57	112	38.0	34	103	93	80	64
.25	.35	102	42.3	42	91	80	66	48	108	42.3	39	98	86	73	54
.20	.40	98	46.7	48	86	74	59	38	104	46.7	45	93	80	65	45
.15	.45	94	51.2	54	82	68	51	29	100	51.3	51	87	74	57	35
.10	.50	91	55.8	62	77	62	44	19	96	55.8	58	82	67	49	25
.05	.55	87	60.4	70	72	55	36	10	92	60.4	66	77	61	41	15
0	.60	83	65.1	78	67	49	28	0	88	65.1	74	72	54	33	5

[a] C = Cotton
[b] Wa = Watermelon
[c] μ = Mean Returns Above Variable Cost
[d] σ = Standard Deviation
[e] VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

exceed -$3). Recal that returns exceed $42 nine years out of ten for .6 acre of sugar beets compared to -$3 for .6 acre of potatoes (milo and watermelons are similar). This comparison of potatoes and sugar beets shows the greater element of risk involved in producing potatoes or watermelons compared to sugar beets or milo. Also, remember that expected returns at the other end of the probability scale (one out of every ten years) are much greater for potatoes or watermelons than for sugar beets or milo. It is the high returns at the upper end of the probability scale that induce farmers to undertake the greater risk and produce potatoes or watermelons.

Cantaloupes

Table 14 yields results similar to potatoes and watermelons but of a smaller magnitude. The expected return actually increases by a small amount but the absolute variability increases substantially giving a net result of increased relative variability. The relative variability is not as great as for potatoes and watermelons because the small increase in expected return moderates the large increase in absolute variability but the range of expected returns at various probability levels follows the same pattern as potatoes and watermelons only slightly higher.

Table 14. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Cantaloupe

Acres Used For		320 Acre Farm							800 Acre Farm						
					Return Above Variable Cost Greater Than (% of Time)							Return Above Variable Cost Greater Than (% of Time)			
C[a]	Ca[b]	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%
.60	0	128	21.0	17	123	117	110	101	137	21.0	15	132	126	119	110
.55	.05	130	22.0	17	125	119	112	102	139	22.0	16	134	128	121	111
.50	.10	143	27.5	19	136	129	120	108	142	26.5	19	135	128	119	108
.45	.15	136	33.0	24	127	119	108	93	144	33.1	23	136	127	116	102
.40	.20	138	40.7	29	128	117	104	86	147	40.8	28	136	125	112	94
.35	.25	141	49.0	35	129	115	100	78	149	49.1	33	137	123	108	86
.30	.30	144	57.6	40	129	114	95	70	151	57.7	38	137	121	103	77
.25	.35	146	66.5	46	129	112	90	61	154	66.6	43	137	119	98	69
.20	.40	149	75.4	51	130	110	85	52	156	75.5	48	137	117	93	59
.15	.45	151	84.5	56	130	108	80	43	159	84.6	53	137	115	87	50
.10	.50	154	93.6	61	131	105	75	34	161	93.7	58	138	112	82	41
.05	.55	157	102.8	66	131	103	70	25	163	102.8	63	138	110	77	32
0	.60	159	112.0	70	131	101	65	16	166	112.0	68	138	107	72	22

[a]C = Cotton
[b]Ca = Cantaloupe
[c]μ = Mean Returns Above Variable Cost
[d]σ = Standard Deviation
[e]VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

Fall Lettuce, Onions, Carrots

Diversion of cotton acreage to fall lettuce, onions, and carrots increased expected returns substantially. For example, expected returns increased from $128 with .6 acre of cotton to $234 with .6 acre of fall lettuce (Table 15). Even greater increases occur with diversion to carrots and onions (Tables 16 and 17). Absolute variabilities also make large increases yielding relative variabilities which lie between sugar beets or milo and potatoes or watermelons.

In the case of fall lettuce, expected returns at various probability levels remain relatively high up through 80 per cent probability levels and decrease to as low as $20 with .6 acre fall lettuce and 90 per cent probability levels (one out of ten times) the return from fall lettuce will be lower than $20.

Onions and carrots both have pretty high expected returns at the probability levels given. For example, .6 acre of onions are expected to result in a $70 return nine years out of ten and .6 acre carrots $127 nine years out of ten. However, if the rate of decrease in expected income between probability levels is noticed, it is apparent that at 95 per cent probability the expected return from onions will be nearly zero and the expected return from carrots approximately $100. A very high probability level is needed to make expected return from carrots decrease to the level of expected return from sugar beets or milo which are

Table 15. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Fall Lettuce

Acres Used For		320 Acre Farm							800 Acre Farm						
					Return Above Variable Cost Greater Than (% of Time)							Return Above Variable Cost Greater Than (% of Time)			
C[a]	FL[b]	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%
.60	0	128	21.0	17	123	117	110	101	137	21.0	15	132	126	119	110
.55	.05	137	23.2	21	130	122	113	100	145	28.2	19	138	136	122	109
.50	.10	146	38.8	27	136	125	123	96	154	38.8	25	144	134	121	104
.45	.15	154	50.7	33	142	128	112	90	163	50.7	31	150	136	120	98
.40	.20	163	63.2	39	148	130	110	82	171	63.2	37	155	138	118	90
.35	.25	172	75.9	44	153	133	108	75	180	76.0	42	161	140	116	82
.30	.30	181	88.9	49	159	135	106	67	188	88.9	47	166	142	113	74
.25	.35	190	101.9	54	164	137	104	60	197	102.0	52	171	144	111	66
.20	.40	199	115.0	58	170	139	102	52	205	115.0	56	176	145	109	58
.15	.45	208	128.2	62	176	141	100	44	214	128.2	60	182	146	105	49
.10	.50	217	141.4	65	181	143	98	36	222	141.4	64	187	149	104	41
.05	.55	226	154.6	69	187	145	96	28	231	154.6	67	192	150	101	33
0	.60	234	167.8	72	192	147	93	20	239	167.9	70	197	152	98	25

[a]C = Cotton
[b]FL = Fall Lettuce
[c]μ = Mean Returns Above Variable Cost
[d]σ = Standard Deviation
[e]VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

Table 16. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Onions

Acres Used For		320 Acre Farm							800 Acre Farm						
					(% of Time) Return Above Variable Cost Greater Than							(% of Time) Return Above Variable Cost Greater Than			
C[a]	O[b]	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%	μ[c]	σ[d]	VC[e]	60%	70%	80%	90%
.60	0	127	21.0	17	123	117	110	101	137	21.0	15	132	126	119	110
.55	.05	153	33.1	22	145	136	125	110	161	33.2	21	153	144	136	119
.50	.10	178	53.0	30	165	150	133	110	186	53.2	29	173	158	141	118
.45	.15	203	74.8	37	184	164	140	107	210	74.9	36	192	171	148	115
.40	.20	228	97.2	43	204	177	146	103	235	97.2	41	211	184	153	110
.35	.25	253	119.8	47	223	191	152	100	259	119.9	45	230	197	159	106
.30	.30	278	142.5	51	242	204	158	95	284	142.6	50	248	210	164	101
.25	.35	303	165.4	55	262	217	164	91	309	165.4	54	267	222	160	97
.20	.40	328	188.2	57	281	230	170	87	333	188.3	57	289	235	175	93
.15	.45	353	211.2	60	300	243	175	83	358	211.2	59	305	248	180	87
.10	.50	378	234.1	62	319	256	181	78	382	234.2	61	324	260	185	82
.05	.55	403	257.1	64	339	269	187	74	407	257.1	63	342	273	191	77
0	.60	428	280.1	66	358	282	193	70	431	280.1	65	361	285	196	73

[a]C = Cotton
[b]O = Onions
[c]μ = Mean Returns Above Variable Cost
[d]σ = Standard Deviation
[e]VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

Table 17. Return Above Variable Cost Levels and Variabilities on 320 and 800 Acre Farms in Arizona with .2 Acre of Alfalfa, .2 Acre of Barley, and Variable Proportions of .6 Acre Allocated to Cotton and Carrots

Acres Used For		320 Acre Farm							800 Acre Farm						
					(% of Time)							(% of Time)			
					60%	70%	80%	90%				60%	70%	80%	90%
					Return Above Variable Cost Greater Than							Return Above Variable Cost Greater Than			
C[a]	Cr[b]	μ[c]	σ[d]	VC[e]					μ[c]	σ[d]	VC[e]				
.60	0	128	21.0	17	123	117	110	101	137	21.0	15	132	126	119	110
.55	.05	143	24.2	17	137	130	123	112	152	24.2	16	146	139	131	121
.50	.10	158	31.7	20	150	142	131	117	166	31.7	19	159	150	140	126
.45	.15	173	41.2	24	163	152	139	120	181	41.2	23	171	160	147	129
.40	.20	188	51.7	27	172	161	145	122	196	51.6	26	183	159	153	130
.35	.25	203	62.6	31	188	171	151	123	211	62.5	30	195	178	158	131
.30	.30	218	73.7	34	200	180	157	124	226	73.7	33	207	187	164	131
.25	.35	234	85.0	36	212	189	162	125	240	85.0	35	219	196	169	132
.20	.40	249	96.5	39	225	199	168	125	255	96.4	38	231	205	174	132
.15	.45	264	107.9	41	237	208	173	126	270	107.9	40	243	214	179	132
.10	.50	279	119.5	43	249	217	179	126	285	119.5	42	255	223	184	132
.05	.55	294	131.0	45	261	362	184	126	300	131.0	44	267	231	187	132
0	.60	309	142.6	46	274	235	189	127	314	142.6	45	279	240	195	132

[a]C = Cotton
[b]Cr = Carrots
[c]μ = Mean Returns Above Variable Costs
[d]σ = Standard Deviation
[e]VC = Variability Coefficient

Source: Data compiled and calculated using state price and yield series from Arizona Crop and Livestock Reporting Service (1970).

considered more stable. The expected return from carrots has large fluctuations from year-to-year but at high enough levels to insure a reasonable expected return at very high probability levels.

Sugar Beets-Cotton vs. Fall Lettuce-Cotton

As an example of how a farmer or agribusinessman may choose between alternatives with the information presented, consider sugar beets at .3 acre and cotton at .3 acre (Table 10). This diversification shows a range in expected returns of $18 from 60 to 90 per cent probability. Under the same acreage conditions cotton and fall lettuce (Table 15) exhibit a range of $92. However, with sugar beets the expected returns range from $92 to $74 while with fall lettuce the expected returns range from $159 to $67. This example shows that fall lettuce would be a more rational crop to include in a diversification than sugar beets as even at high probability levels (90 per cent) lettuce yields expected returns as high as sugar beets and at a lower probability level (60 per cent) expected returns from lettuce exceed sugar beet returns by over $60.

However, if a farmer adds more sugar beets or more lettuce to the diversification system (.6 acre of both), it is shown that at higher probability levels the expected returns from sugar beets are greater than expected returns from lettuce by $22 but at a lower probability level (60 per cent) lettuce exceeds sugar beets by $132. The attitude of the farmer on acceptance of risk will have an influence on the combination chosen. If one farmer wants only 60 per cent certainty of a given return level, he will probably plant lettuce. However, a second farmer who requires 90 per cent probability of a given return level will probably produce sugar beets. The second farmer is trading chances of receiving higher income for a more stable income and the first farmer is accepting more risk for a chance to receive a high income.

Short-Run Break-Even Returns

As discussed in Chapter II, short-run break-even return is the return level from a diversification system required to pay cash fixed costs. These cash fixed costs play an important role in determining the amount of risk inherent in a given rotation, equity level, and scale of operation. Not only cash fixed cost but all fixed costs must be paid in the long-run for the farm business to remain viable. However, in the short run, only variable and cash fixed cost are of major concern to the farmer. Cash fixed costs are fixed obligations which must be paid each year and consist mainly of taxes, insurance, and loan installments. If returns above variable cost are not high enough to pay these fixed costs, the farm business may be rendered insolvent.

In order to arrive at cash fixed cost estimates for any farm, fixed costs must be compiled. Since return data are completed for 320 and 800 acre farms, fixed costs are compiled for the same two sizes. Fixed costs are compiled assuming a typical machinery complement for each farm size (Jones, 1967; Mack, 1968). The fixed costs per farm are found in Appendix Tables 29 and 30.

Using the fixed costs from Tables 29 and 30, cash fixed costs (Table 18) can be derived. It should be noted that every farmer will have a unique cash fixed cost position, therefore, these particular figures in Table 18 cannot be used in general, but only by farmers in a similar fixed cost situation. Taxes and insurance in Table 18 were taken from Appendix Tables 29 and 30 and assumed constant at all equity levels. Equipment loan installments were calculated assuming a four-year term and an 8 per cent interest rate in the average value of investment. Real estate loan payments were amortized at 8 per cent for 25 years at $800 per acre. Each of these costs for varying equity levels assumes equal percentage of equity in all assets. For Example, 50 per cent equity means 50 per cent equity in equipment and 50 per cent equity in real estate. Depreciation is taken from Appendix Tables 29 and 30, and opportunity cost is figured at 8 per cent of the value of owner's equity.

Farmers should be interested in the short-run break-even return as defined by the equality between returns above

Table 18. Cash Fixed Costs Per Acre on Arizona Farms

Equity	Taxes, Insurance, and Miscellaneous		Real Estate and Equipment		Cash Fixed Cost = Col. 1 & 2 Total		Depreciation		Interest (Opportunity Cost)		Total Fixed Cost	
	(320)	(800)	(320)	(800)	(320)	(800)	(320)	(800)	(320)	(800)		
100%	15	13	0	0	15	13	49	31	76	69	140	113
90%	15	13	14	11	29	24	49	31	68	62	146	117
80%	15	13	28	23	43	36	49	31	61	55	153	122
70%	15	13	43	34	58	47	49	31	54	48	161	126
60%	15	13	57	45	72	58	49	31	46	41	167	130
50%	15	13	71	57	86	70	49	31	38	34	173	135
40%	15	13	85	68	100	81	49	31	31	28	180	140
30%	15	13	100	79	115	92	49	31	25	21	189	144
20%	15	13	114	91	129	104	49	31	15	14	193	149
10%	15	13	128	102	143	115	49	31	8	7	200	153

Source: Calculated and compiled from Jones (1967, pp. 8-17) and Wildermuth (1970).

variable cost and cash fixed costs. An agribusinessman extending credit to a farmer should also be concerned with the break-even point of various alternatives to estimate the potential repayment ability of the loan applicant. To demonstrate the use of these empirical data in the above context, various examples follow.

With the data presented thus far in this study, a farmer or businessman can take the following steps to evaluate various crops and crop combinations as to their potential to yield short-run break-even returns.

1. Pick farm size.
2. Pick equity level.
3. Locate cash fixed cost on Table 18 which corresponds to the chosen farm size and equity level.
4. Choose crop combination and locate table for the chosen combination in Chapter IV for the appropriate farm size.
5. Compare returns above variable cost data with cash fixed cost to find short-run break-even return above variable cost.

For example, assume a farm size of 320 acres and a 100 per cent equity level. From Table 18, cash fixed cost is $15 per acre. Compare this figure with various returns above variable cost in Table 10 (crop combination alfalfa-barley-cotton-sugar beets). It is apparent that a farmer in this equity position is in little danger of decreasing his equity by realizing return above variable cost that is less than cash fixed cost even at high probability levels. A farmer in this equity situation, no matter which crop combination chosen (Tables 10 through 17), would expect cash fixed cost to exceed returns only at very high probability levels. A farmer working 800 acres in the same equity position is in an even better position as cash fixed costs are $2 lower per acre and expected returns at all probability levels are larger than for the 320 acre farm.

Secondly, assume a farmer is operating 320 acres and owns 70 per cent of his assets. From Table 18, cash fixed cost per acre is $58. Again referring to Table 10, break-even returns are exceeded except with .6 acre sugar beets at 70 per cent probability, .55 and .6 acre sugar beets at 80 per cent probability, and .45 acre sugar beets and .15 acre cotton and increasing amounts of sugar beets at 90 per cent probability.

If the farmer working 320 acres and having 70 per cent equity considers other crop combinations, break-even returns occur with various amounts of cotton production. For example, with cotton-fall lettuce, break-even returns occur only at 90 per cent probability levels w th .2 acre cotton and .4 acre fall lettuce; with carrots on the other hand returns are above cash fixed cost even at high probability levels. Again, a farmer operating 800 acres is in a better position as his cash fixed costs are $11 per acr acre less and returns are higher than on the 320 acre farm.

A final example assumes a farmers operating 320 and 800 acres with 30 per cent equity. Cash fixed costs are $115 and $92 per acre respectively. On Table 10, returns above variable cost exceed cash fixed cost for the 320 acre farm only at .6 acre cotton with 70 per cent probability and .55 acre cotton and .05 acre sugar beets at 60 per cent probability. The 800 acre farmer can produce more sugar beets than the 320 acre farmer in this equity situation, again showing the advantage of the larger farm.

There are a large number of examples that could be given here. However, these examples suffice to show the relative positions of 320 acre and 800 acre farmers at varying equity levels. Farmers with low amounts of equity must be considerably more careful in choosing crops with high enough returns and stable enough returns to cover cash fixed cost. As shown by these examples, a poor year (90 per cent probability) will have little if any effect on a farmer with 100 per cent equity, but a farmer with only 30 per cent equity can wipe out a considerable amount of his equity in one bad year.

To show that a farmer can decrease his equity, consider the following example. A farmer with 320 acres decides to expand his operation to 800 acres using borrowed capital. The farmer has 100 per cent equity before expanding or $306,000 in net worth (Appendix, Table 29). After expanding, his assets are $688,000 (Appendix, Table 30). The amount of borrowed capital must therefore be $688,000 less $306,000, or $382,000. This results in an equity level of about 45 per cent. Assuming the real estate loan was amortized at 8 per cent for 25 years and the equipment loan was figured at 8 per cent for four years, Table 30 can be used to estimate cash fixed cost per acre. Cash fixed cost for 45 per cent equity on an 800 acre farm is approximately $15 per acre. Assume further that this farmer was a lettuce producer before the expansion and has decided to remain in lettuce production. At his former 100 per cent equity level cash fixed costs were low and profits for the short run high assuming the farmer had above average and average returns for the last five years (a possibly biased sample of years on which to base a decision to produce more lettuce). However, this year's crop is not very good and returns above variable cost are only $10 per acre. The farmer must pay cash fixed costs of $75 per acre and, therefore, must use up part of his equity to pay these obligations. At a loss of $65 per acre, the total loss in equity is $52,000. The farmer's position now is $688,000 assets minus $434,000 liabilities equals $254,000 equity or net worth. If depreciation is also subtracted, the farmer's equity position decreases another $24,800 for a net result of $229,200 equity.

If this same farmer had chosen to remain at 320 acres and 100 per cent equity, the loss in equity could have been only $5 per acre or $1,600 compared to a loss of $52,000 after expansion.

Position Before Expansion:

Assets - liabilities = net worth (equity)

$306,000 - 0 = $306,000

$306,000 - $1,600 = #304,400

$306,000 - ($1,600 + $15,680 Depr.) = $288,720

Position After Expansion:

Assets - liabilities = net worth (equity)

$688,000 - $382,000 = $306,000

$688,000 - $434,000 = $245,000

$688,000 - ($343,000 + $24,800 Depr.) = $229,200

Thus, exemplifying the Principle of Increasing Risk: as a farm or business is expanded through the use of borrowed capital, the probability of decreasing one's equity increases.

CHAPTER V

SUMMARY

The purpose of this the fifth and final chapter of this thesis is, as implied by the title, to summarize the major stages of the analysis. As will be apparent in the summary, the objectives of this thesis were directed at providing farmers and agribusinessmen with information to aid them in making their own decisions regarding risk income tradeoffs in Arizona crop farm production. Thus, the results are not conclusive in nature. The best crop combinations were not computed as such and, therefore, no specific recommendations as to which crop combinations to produce can be made.

The introductory chapter pointed out that as a result of farm size increases, technological advances, inflation, and government program changes Arizona farmers have been and are being forced to make adjustments involving increased capital requirements and uncertain outcomes. A simple example via the Principle of Increasing Risk was then introduced to show the potential consequences of not introducing variability concepts into a farm planning process involving such complexities as those introduced above. Thus, the general objective of the study was stated to be that of deriving objective measures of the variability and risk inherent in alternative Arizona crops and diversification schemes. With this goal in mind, Chapter II was utilized to present and explain the reasons for the data and methods of analysis employed in this study. As discussed, the lack of a better data base necessitated the use of state time series data on crop prices, yields, and production costs. Given the data base, the variate difference method was then selected as the best available means of deriving the appropriate variability estimates.

The estimates of the random variability in prices, yields, and income were derived for 14 individual crops and presented in Chapter III. These results indicated that in general both field and vegetable crops have low yield variability in Arizona. This was not found to be true for price variability. The government supported crops (e.g., wheat, cotton, and sugar beets) were shown to have low variability in prices while the majority of the vegetable crops were found to have very high price variabilities. The pattern of low price variability in field crops and high price variability in vegetable crops appeared again in the gross income variability estimates. The similar patterns observed for price and gross income variabilities indicate the dominance of price variability over yield variability in determining gross income variability.

The next step was the combination of gross income and variable production cost data to derive estimates of the variability in returns above variable cost. These results clearly established the superiority of variability in return above variable cost over variability in gross income for decision making purposes. This being founded on the fact that gross income variability and return above variable cost variability were similar for field crops but dissimilar for crops affected by varying harvest cost.

In Chapter IV, the variability data derived for individual crops were combined to estimate return levels and variabilities associated with various crop diversification systems. The diversification systems emphasized the reallocation of .6 acres of cotton to alternate crops with alfalfa and barley held constant at .2 acres each. As cotton acreage was diverted to sugar beets or milo, the relative variability was found to change very little but the expected returns were found to decrease substantially. In comparison, reallocation of cotton acreage to onions, carrots, cantaloupe, or fall lettuce resulted in higher expected returns but also much higher variability levels (risk). Therefore, it was concluded that farmers forced to divert cotton acreage to alternate crops must make a choice involving tradeoffs between increasing returns and an acceptable risk level. To emphasize the importance of making this tradeoff the expected returns at varying probability levels for the diversification systems presented were combined with equity and scale considerations.

All of the above diversification systems were analyzed for both a 320 and 800 acre farm. The larger farm scale was shown to have higher expected returns per acre and the same relative risk levels as the smaller farm scale. Further, the farmer who operates an 800 acre farm and has 100 per cent equity was shown to be in a better position than a farmer who operates 320 acres and has 100 per cent equity. However, the results also indicated that farmers with low equity levels could have a hard time paying cash fixed cost and breaking even in the short-run. Thus while the larger farm size is clearly superior from an earnings standpoint, the 320 acre farmer who attempts to realize the gain by borrowing expansion capital may end up in worse shape than he was before, namely bankruptcy.

APPENDIX

SUPPLEMENTARY TABLES

Table 19. Variable Production Costs on 320 Acre Arizona Crop Farms[a]

Crop	Year									
	69	68	67	66	65	64	63	62	61	60
Alfalfa[b]	120	117	115	114	112	110	110	109	108	108
Barley	66	64	64	63	62	62	62	61	61	61
Cantaloupe	547	578	427	561	543	594	692	457	642	557
Carrots	443	418	441	476	478	334	406	544	479	357
Corn	88	87	86	85	84	84	84	83	83	83
Cotton	227	231	217	221	223	218	220	221	215	212
Fall Lettuce	666	664	650	661	660	622	622	646	683	645
Spring Lettuce	709	695	756	668	779	666	779	753	714	714
Milo	71	69	68	68	66	66	66	65	65	65
Potatoes	533	532	551	530	509	539	554	538	538	538
Onions	825	725	814	804	1001	865	955	631	648	684
Safflower	87	85	84	83	82	82	82	81	80	80
Sugar Beets	201	208	192	197	198	198	200	197	191	195
Watermelon	293	306	308	308	275	289	306	292	292	292
Wheat	62	61	60	59	59	58	58	58	57	57

[a]Costs are deflated using the U. S. farm input price index and rounded to nearest whole dollar.

[b]Includes establishment cost.

Source: Data compiled and calculated utilizing Wildermuth et al. (1969), Jones (1967), Mack (1968), and Wildermuth (1970).

Table 20. Variable Production Costs on 800 Acre Arizona Crop Farms[a]

Crop	Year									
	69	68	67	66	65	64	63	62	61	60
Alfalfa[b]	113	110	108	107	105	104	104	103	102	101
Barley	64	63	62	62	61	61	61	60	60	60
Cantaloupe	539	571	419	553	535	586	684	449	634	549
Carrots	437	412	435	467	442	328	401	538	473	351
Corn	87	85	85	84	83	82	82	82	82	82
Cotton	215	219	205	208	210	206	206	208	202	199
Fall Lettuce	660	658	644	656	654	617	617	640	677	639
Spring Lettuce	702	689	750	661	773	659	772	747	708	708
Milo	69	68	67	66	65	64	64	64	64	63
Potatoes	529	528	548	527	506	535	550	535	534	534
Onions	823	722	811	802	998	863	953	628	646	682
Safflower	84	83	82	81	80	80	80	79	79	78
Sugar Beets	196	203	187	192	193	194	195	191	186	191
Watermelon	288	300	303	302	179	179	301	287	287	287
Wheat	61	59	59	58	57	57	57	56	56	56

[a]Costs are deflated using the U. S. farm input price index and rounded to nearest whole dollar.

[b]Includes establishment cost.

Source: See Table 19.

Table 21. Return Above Variable Cost Levels and Variabilities on 320 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Barley-Cotton	109	17.7	16	104	99	94	86
Alfalfa-Cotton	112	18.6	17	108	103	97	88
Cotton-Wheat	106	18.3	17	101	96	90	82
Cotton-Milo	111	19.5	18	107	101	95	87
Cotton-Sugar Beets	145	28.3	20	138	130	121	108
Cotton-Safflower	107	21.4	20	102	96	89	80
Sugar Beets-Wheat	53	13.2	25	50	46	42	36
Sugar Beets-Barley	56	14.3	26	53	48	44	38
Sugar Beets-Milo	59	15.3	26	55	51	46	39
Sugar Beets-Alfalfa	60	16.1	27	56	51	46	39
Barley-Milo	23	6.1	27	21	20	18	15
Sugar Beets-Safflower	55	17.2	31	50	46	40	33
Barley-Wheat	17	5.6	33	15	14	12	10
Milo-Wheat	20	7.1	36	18	16	14	11
Cotton-Carrots	348	125.4	36	317	283	243	188
Carrots-Spring Lettuce	484	176.5	37	440	392	336	258
Carrots-Fall Lettuce	437	170.7	37	397	353	301	230
Carrots-Potatoes	327	123.0	38	297	263	224	170
Alfalfa-Barley	24	8.9	38	21	19	16	12
Cotton-Watermelon	160	61.4	38	145	128	108	81
Alfalfa-Milo	26	10.2	39	24	21	18	13
Milo-Safflower	21	8.5	40	19	17	14	11
Sugar Beets-Carrots	296	122.3	41	265	232	193	139
Cotton-Cantaloupe	224	93.2	42	200	175	145	104

Table 21.--Continued Return Above Variable Cost Levels and Variabilities on 320 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Carrots-Cantaloupe	375	156.5	42	336	293	243	174
Carrots-Watermelon	311	134.1	43	278	241	199	140
Cotton-Potatoes	176	76.8	44	157	136	112	78
Carrots-Alfalfa	263	117.0	44	234	203	165	114
Alfalfa-Wheat	21	9.4	46	18	16	13	9
Carrots-Onions	599	273.4	46	530	456	369	249
Carrots-Milo	263	120.0	46	233	200	162	109
Carrots-Barley	260	119.4	46	230	198	159	107
Carrots-Wheat	257	120.9	47	229	194	155	102
Potatoes-Cantaloupe	203	96.8	48	178	152	121	79
Fall Lettuce-Onions	536	256.9	48	491	403	320	207
Carrots-Safflower	258	124.6	48	227	194	154	99
Cantaloupe-Spring Lettuce	359	174.7	49	315	268	112	35
Cotton-Spring Lettuce	333	169.0	50	290	245	191	116
Cotton-Fall Lettuce	286	146.3	51	250	210	162	99
Alfalfa-Safflower	22	11.4	51	19	16	13	8
Barley-Safflower	18	9.5	51	16	14	10	6
Cantaloupe-Fall Lettuce	312	161.0	52	272	229	177	107
Cotton-Onions	447	235.0	53	389	325	250	147
Potatoes-Watermelon	139	76.5	55	120	99	75	41
Sugar Beets-Watermelon	107	59.2	55	93	77	58	32
Sugar Beets-Cantaloupe	171	95.1	56	147	121	91	49
Onions-Watermelon	410	229.5	56	353	291	217	116
Fall Lettuce-Watermelon	249	140.0	56	214	176	131	70
Fall Lettuce-Spring Lettuce	422	238.8	57	362	297	220	116

Table 21.--Continued Return Above Variable Cost Levels and Variabilities on 320 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Spring Lettuce-Onions	583	340.5	58	498	406	297	147
Sugar Beets-Spring Lettuce	280	164.0	59	329	195	142	70
Spring Lettuce-Watermelon	295	173.5	59	252	205	150	73
Sugar Beets-Onions	395	232.8	59	336	274	199	97
Sugar Beets-Potatoes	124	73.0	59	105	86	62	30
Potatoes-Onions	426	253.3	59	363	295	214	102
Spring Lettuce-Potatoes	312	185.5	60	265	215	156	74
Sugar Beets-Fall Lettuce	233	141.7	61	198	160	114	52
Fall Lettuce-Potatoes	265	162.3	61	225	181	129	57
Cantaloupe-Onions	474	291.3	62	401	322	229	101
Milo-Onions	362	233.8	65	303	240	165	62
Alfalfa-Onions	362	235.1	65	304	240	165	61
Cantaloupe-Watermelon	186	121.2	65	156	123	85	31
Barley-Onions	359	233.0	65	300	237	163	60
Onions-Wheat	356	232.0	65	298	235	161	59
Onions-Safflower	357	234.5	66	299	235	160	57
Spring Lettuce-Milo	247	163.7	66	206	162	109	37
Spring Lettuce-Barley	244	163.9	67	203	159	106	34
Spring Lettuce-Alfalfa	248	166.9	67	206	161	108	35
Spring Lettuce-Wheat	241	162.5	67	200	157	105	33
Cantaloupe-Milo	138	94.0	68	114	89	59	17
Cantaloupe-Barley	135	92.3	69	112	87	57	17
Safflower-Wheat	16	10.7	69	13	10	7	2
Fall Lettuce-Safflower	196	135.2	69	162	126	83	23
Spring Lettuce-Safflower	243	167.2	69	201	156	102	29

Table 21.--Continued Return Above Variable Cost Levels and Variabilities on 320 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Cantaloupe-Wheat	132	91.1	69	109	85	55	15
Cantaloupe-Alfalfa	139	95.8	69	115	89	58	16
Cantaloupe-Safflower	134	89.4	70	111	87	58	19
Fall Lettuce-Alfalfa	201	140.9	70	166	128	83	21
Fall Lettuce-Barley	197	139.8	71	162	125	80	18
Fall Lettuce-Milo	200	141.9	71	165	127	81	19
Fall Lettuce-Wheat	194	141.0	73	159	121	76	14
Milo-Watermelon	74	54.6	74	61	46	28	4
Alfalfa-Potatoes	91	67.3	74	74	56	35	5
Alfalfa-Watermelon	75	56.1	75	61	46	28	3
Barley-Watermelon	71	53.6	75	58	43	26	3
Watermelon-Wheat	68	51.9	76	55	41	25	2
Milo-Potatoes	90	70.9	78	73	54	31	0
Safflower-Watermelon	70	55.2	79	56	41	24	-1
Safflower-Potatoes	86	68.3	79	69	51	29	-1
Barley-Potatoes	88	69.5	79	70	51	29	-1
Potatoes-Wheat	85	68.5	81	68	49	27	-3

Source: Calculated using gross income and variable production cost data derived in this study.

Table 22. Return Above Variable Cost Levels and Variabilities on 800 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Cotton-Barley	115	17.6	15	111	106	101	93
Cotton-Alfalfa	122	18.8	15	117	112	106	98
Cotton-Wheat	113	18.3	16	108	103	97	89
Cotton-Milo	118	19.4	16	114	108	102	93
Cotton-Sugar Beets	153	28.3	18	146	139	129	117
Cotton-Safflower	115	21.4	19	110	104	97	88
Sugar Beets-Wheat	56	13.2	24	53	45	28	5
Sugar Beets-Barley	59	14.3	24	55	52	48	41
Sugar Beets-Milo	62	15.3	25	58	54	49	42
Sugar Beets-Alfalfa	66	16.2	25	62	57	52	45
Barley-Milo	24	6.1	25	23	21	19	16
Sugar Beets-Safflower	58	17.2	30	54	49	44	36
Barley-Wheat	18	5.6	31	17	15	14	11
Alfalfa-Barley	28	9.1	33	80	77	74	70
Alfalfa-Milo	31	10.3	33	28	25	22	18
Milo-Wheat	21	7.2	34	20	18	15	12
Cotton-Carrots	358	125.3	35	326	293	252	197
Carrots-Spring Lettuce	489	176.3	36	445	397	341	264
Cotton-Watermelon	169	61.5	36	154	137	117	90
Carrots-Fall Lettuce	443	162.0	37	403	359	307	236
Carrots-Potatoes	332	123.0	37	302	268	229	175
Milo-Safflower	23	8.6	37	21	19	16	12
Alfalfa-Wheat	25	9.5	38	23	20	17	13
Cotton-Cantaloupe	234	93.4	40	210	185	155	114

Table 22.--Continued Return Above Variable Cost Levels and Variabilities on 800 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Carrots-Sugar Beets	301	122.3	41	270	238	198	145
Carrots-Cantaloupe	382	156.5	41	342	300	250	181
Cotton-Potatoes	184	76.7	42	165	144	120	86
Carrots-Watermelon	317	134.2	42	283	247	204	145
Alfalfa-Safflower	27	11.5	43	24	21	17	12
Alfalfa-Carrots	270	117.0	43	241	209	172	120
Carrots-Milo	266	120.1	45	236	204	165	113
Carrots-Onion	603	273.4	45	534	461	373	253
Carrots-Barley	263	119.4	45	233	201	163	110
Carrots-Wheat	260	120.9	46	230	198	159	106
Cantaloupe-Potatoes	208	96.8	47	184	158	127	84
Barley-Safflower	20	9.5	47	18	15	12	8
Carrots-Safflower	262	124.6	48	231	198	158	103
Fall Lettuce-Onion	540	257.0	48	476	407	324	211
Cantaloupe-Spring Lettuce	365	174.6	48	322	274	219	142
Cotton-Spring Lettuce	341	168.6	49	299	253	200	124
Cotton-Fall Lettuce	295	146.2	50	259	219	172	108
Cantaloupe-Fall Lettuce	319	161.0	50	279	236	184	113
Cotton-Onion	455	235.1	52	396	333	257	154
Sugar Beets-Watermelon	113	59.2	53	98	82	63	37
Potatoes-Watermelon	144	76.5	53	124	104	79	46
Sugar Beets-Cantaloupe	177	95.1	54	153	128	97	56
Fall Lettuce-Watermelon	254	140.0	55	219	182	137	75
Onion-Watermelon	414	229.5	55	357	295	221	120

Table 22.--Continued Return Above Variable Cost Levels and Variabilities on 800 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Fall Lettuce-Spring Lettuce	427	237.8	56	367	303	227	122
Sugar Beets-Potatoes	128	73.0	57	110	90	67	34
Sugar Beets-Spring Lettuce	285	163.7	58	244	200	147	75
Spring Lettuce-Watermelon	300	173.3	58	257	210	155	79
Spring Lettuce-Onion	586	340.5	58	501	409	300	150
Sugar Beets-Onion	398	232.3	58	340	277	203	100
Spring Lettuce-Potatoes	316	185.2	59	270	220	160	79
Potatoes-Onions	430	253.3	59	366	298	217	105
Sugar Beets-Fall Lettuce	239	141.8	59	203	165	120	57
Fall Lettuce-Potatoes	270	162.3	60	229	185	134	62
Cantaloupe-Onion	479	291.3	61	406	367	233	106
Safflower-Wheat	17	10.7	62	15	12	8	4
Cantaloupe-Watermelon	193	121.2	63	163	130	91	38
Milo-Onion	364	233.8	64	305	242	167	64
Alfalfa-Onion	367	235.2	64	308	245	170	66
Cantaloupe-Safflower	138	89.4	65	116	92	63	24
Barley-Onion	361	233.0	65	302	239	165	62
Wheat-Onion	358	232.0	65	300	237	163	61
Safflower-Onion	360	234.5	65	301	238	163	59
Spring Lettuce-Milo	250	163.4	65	209	165	113	41
Alfalfa-Spring Lettuce	254	166.2	66	212	164	114	41
Alfalfa-Cantaloupe	146	95.9	66	122	96	66	23
Cantaloupe-Milo	142	93.8	66	119	94	64	22
Cantaloupe-Barley	139	92.3	66	116	91	62	21
Spring Lettuce-Wheat	244	162.2	66	204	160	108	36

Table 22.--Continued Return Above Variable Cost Levels and Variabilities on 800 Acre Farms in Arizona With One Acre Allocated Equally Between Two Crops

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
Spring Lettuce-Barley	247	163.5	66	206	162	110	38
Cantaloupe-Wheat	137	91.1	67	114	89	60	20
Fall Lettuce-Safflower	200	135.2	68	166	130	86	27
Spring Lettuce-Safflower	246	166.9	68	204	159	106	32
Alfalfa-Fall Lettuce	208	141.0	68	172	134	89	27
Alfalfa-Watermelon	81	56.2	69	67	52	34	9
Alfalfa-Potatoes	97	67.3	70	80	62	40	10
Barley-Fall Lettuce	201	139.8	70	166	128	83	22
Fall Lettuce-Milo	204	141.8	70	168	130	85	22
Milo-Watermelon	78	54.5	70	64	49	32	8
Fall Lettuce-Wheat	198	141.1	71	163	125	79	17
Barley-Watermelon	75	53.6	72	61	47	30	6
Wheat-Watermelon	72	51.9	72	58	45	28	5
Safflower-Watermelon	74	55.2	75	60	45	27	3
Milo-Potatoes	93	70.9	76	75	56	33	2
Potatoes-Safflower	89	68.3	77	72	54	32	1
Potatoes-Barley	90	69.5	77	73	54	31	1
Potatoes-Wheat	87	68.5	79	70	52	30	-1

Source: See Table 21.

Table 23. Return Above Variable Cost Levels and Variabilities on 320 Acre Arizona Farms with One Acre Allocated Equally Among Three Crops for Selected Diversification Systems

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
A-C-B[a]	81	13.0	16	75	74	70	64
C-B-M	80	13.4	17	77	73	69	63
A-C-SB	104	19.4	19	100	94	88	80
C-SB-Wh	100	18.7	19	95	90	84	76
B-M-Sa	21	6.2	30	19	17	16	13
A-B-M	24	7.9	33	22	20	17	14
A-Ca-Cr	256	103.1	40	231	203	170	124
A-C-Ca	157	64.1	41	141	123	103	75
C-B-P	123	51.0	42	110	96	80	58
SL-Cr-O	549	235.3	43	491	427	352	248
A-Cr-Wh	178	77.7	44	159	138	113	79
Ca-SL-SB	267	117.0	44	238	206	169	118
C-SL-M	228	112.5	49	200	170	134	84
A-P-SB	91	47.1	52	79	66	51	30
FL-SB-P	205	109.4	53	178	148	113	65
A-Ca-SB	122	65.3	54	105	88	67	38
SL-O-P	436	237.4	55	376	312	236	132
A-FL-SL	287	160.1	56	247	204	153	82
SL-M-SB	193	109.1	56	166	137	102	54
A-SB-SL	194	110.8	57	166	136	101	52
A-Wa-Ca	132	82.6	63	111	89	63	26
A-Wa-B	56	37.4	67	47	37	25	8

[a]For Tables 23-28, symbols--crop A, Alfalfa; B, Barley; C, Cotton; Ca, Cantaloupes; Cr, Carrots; FL, Fall Lettuce; SL, Spring Lettuce; Wa, Watermelons; Wh, Wheat.

Source: See Table 21.

Table 24. Return Above Variable Cost Levels and Variabilities on 800 Acre Arizona Farms with One Acre Allocated Equally Among Three Crops for Selected Diversification Systems

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	(% of Time) 60%	70%	80%	90%
				Return Above Variable Cost Greater Than			
A-C-B	88	13.2	.15	84	81	76	71
C-B-M	85	13.4	.16	82	78	74	68
A-C-SB	113	19.5	.17	108	102	96	88
A-SB-Wh	48	10.5	.22	46	43	40	35
B-M-Sa	22	6.3	.28	21	19	17	14
A-B-M	27	7.9	.29	25	23	21	17
A-C-Ca	166	64.2	.39	150	132	112	83
A-Ca-Cr	263	103.2	.39	237	210	177	131
C-B-P	129	50.9	.40	116	102	86	63
A-Cr-Wh	183	77.7	.42	164	143	118	84
SL-Cr-O	554	235.3	.43	495	431	356	263
SL-Ca-SB	273	116.9	.43	244	212	175	123
C-SL-M	234	112.3	.48	206	176	140	90
A-SB-P	96	47.2	.49	84	71	56	35
A-SB-Ca	128	65.4	.51	112	94	56	45
FL-SB-P	210	109.4	.52	183	153	118	70
SL-O-P	439	237.5	.54	380	316	240	135
A-FL-SL	293	159.6	.55	253	210	159	89
SL-M-SB	197	108.9	.55	170	140	105	57
A-SL-SB	199	110.7	.56	172	142	106	58
A-Ca-Wa	139	82.7	.60	118	96	69	33
A-B-Wa	61	37.5	.62	51	41	29	13

Source: See Table 21.

Table 25. Return Above Variable Cost Levels and Variabilities on 320 Acre Arizona Farms with One Acre Allocated Equally Among Four Crops for Selected Diversification Systems

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
B-C-M-Wh	64	10.7	17	62	59	55	50
A-C-M-Wh	66	11.4	17	63	60	57	52
A-B-C-Sa	65	11.7	18	62	59	56	50
B-C-M-Sa	65	11.7	18	62	59	55	50
A-B-C-SB	84	15.1	18	80	76	71	65
C-Wh-Sa-SB	80	15.7	20	76	72	67	60
B-M-Sa-SB	39	8.9	23	36	34	31	27
A-C-P-Cr	220	63.6	29	204	187	166	138
A-B-M-Wh	22	6.7	31	20	18	16	13
A-Cr-FL-SB	248	82.3	33	228	206	179	143
A-C-P-Ca	157	52.1	33	144	130	114	91
Ca-SL-P-SB	241	94.8	39	218	192	162	120
A-SB-P-Ca	113	51.9	40	100	86	70	47
Cr-SL-O-Wa	447	178.5	40	402	354	297	219
FL-SL-P-Ca	312	128.2	41	280	245	204	148
A-Cr-P-O	345	142.4	41	309	271	225	163
M-Cr-P-O	344	143.0	42	309	270	224	161
Ca-Cr-O-Wa	392	165.9	42	351	306	253	180
C-Ca-M-Wa	149	63.5	43	133	116	96	68
Ca-B-P-Wa	137	59.1	43	122	106	87	61
B-C-P-SL	210	97.4	46	186	159	128	85
A-Ca-B-SL	191	90.9	48	169	144	115	75
A-C-O-SL	348	174.5	50	304	257	201	124
A-Ca-SB-Wa	123	64.7	53	107	89	69	40
A-P-O-SB	243	128.4	53	211	176	135	79

Source: See Table 21.

Table 26. Return Above Variable Cost Levels and Variabilities on 800 Acre Arizona Farms with One Acre Allocated Equally Among Four Crops for Selected Diversification Systems

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	60%	70%	80%	90%
				(% of Time) Return Above Variable Cost Greater Than			
C-B-M-Wh	68	10.8	15	66	63	59	55
A-C-M-Wh	72	11.5	16	69	66	62	57
A-C-B-Sa	71	11.8	17	68	65	61	56
A-C-B-SB	91	15.2	17	87	83	78	71
C-B-M-Sa	69	11.7	17	66	63	59	54
C-SB-Wh-Sa	85	15.7	18	81	77	72	65
SB-B-M-Sa	41	9.0	22	39	36	34	30
A-B-M-Wh	25	7.8	28	23	21	19	16
A-C-P-Cr	227	63.6	28	211	194	174	146
A-C-P-Ca	165	52.2	32	152	138	121	98
A-SB-Cr-FL	254	82.4	32	234	212	185	149
SB-Ca-P-SL	249	94.8	38	223	197	167	126
SL-Cr-O-Wa	452	178.6	40	407	359	302	223
SL-FL-Ca-P	318	127.8	40	286	251	210	154
A-Sa-Ca-P	118	47.8	41	106	93	77	56
A-Cr-O-P	350	142.5	41	314	276	230	167
C-M-Ca-Wa	156	63.4	41	140	123	102	75
M-O-P-Cr	348	143.0	41	312	274	228	165
O-Cr-Ca-Wa	398	165.9	42	356	312	259	185
B-P-Ca-Wa	142	59.1	42	127	111	92	66
B-P-C-SL	216	97.2	45	191	165	134	91
A-B-Ca-SL	196	90.9	46	174	149	120	80
A-C-O-SL	354	174.6	49	311	263	208	131
A-SB-Wa-Ca	129	64.7	50	113	96	75	46
A-SB-P-O	248	128.4	52	215	181	140	83
A-Ca-Sa-Wa	88	49.5	56	76	62	46	25

Source: See Table 21.

Table 27. Return Above Variable Cost Levels and Variabilities on 320 Acre Arizona Farms with One Acre Allocated Equally Among Five Crops for Selected Diversification Systems

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	Return Above Variable Cost Greater Than (% of Time) 60%	70%	80%	90%
A-C-M-Wh-SB	71	12.7	18	68	65	61	55
A-B-C-M-SB	72	13.0	18	69	66	61	56
A-B-M-Sa-SB	36	8.2	23	34	32	29	26
A-C-Ca-P-SB	144	44.0	31	133	121	107	88
A-B-C-P-SB	98	32.6	33	90	81	71	57
A-Cr-FL-SL-M	279	95.0	34	255	230	199	157
B-C-M-Ca-SB	117	49.3	34	107	96	83	65
B-C-P-Ca-SL	218	78.2	36	198	177	152	118
A-C-Ca-SL-SB	207	75.8	37	188	168	143	110
A-C-P-O-Cr	315	116.1	37	286	255	218	167
C-Ca-FL-SL-Wa	283	104.7	37	256	228	195	148
A-B-Ca-Cr-Wh	162	62.3	38	147	130	110	82
Ca-Cr-P-O-Wa	345	133.1	39	312	276	233	175
B-M-P-Ca-SB	109	42.1	39	98	87	73	55
A-P-O-Cr-SB	294	114.6	39	266	235	198	148
A-C-P-SB-Wa	129	50.5	39	117	103	87	65
M-P-O-Cr-SB	294	115.1	39	265	234	197	147
A-M-P-O-Cr	281	114.6	41	252	221	185	134
A-P-Ca-FL-SL	255	104.2	41	229	201	168	122
B-M-P-Ca-Wa	115	48.5	42	103	89	74	53
O-Ca-SL-FL-Wa	383	162.3	42	342	298	246	175
P-O-SL-SB-Ca	333	156.8	47	293	251	201	131
A-P-SB-FL-SL	224	106.0	47	197	168	134	88
A-B-M-P-O	185	103.3	56	159	121	98	53
A-B-Sa-Wa-Ca	87	49.7	57	75	62	46	24

Source: See Table 21.

Table 28. Return Above Variable Cost Levels and Variabilities on 800 Acre Arizona Farms with One Acre Allocated Equally Among Five Crops for Selected Diversification Systems

Crop Combination	Mean Net Income	Standard Deviation	Variability Coefficient	60%	70%	80%	90%
				(% of Time) Return Above Variable Cost Greater Than			
A-C-M-Wh-SB	77	12.8	17	74	70	66	60
A-C-M-B-SB	78	13.1	17	75	71	67	61
A-M-B-SB-Sa	40	8.4	21	38	35	33	29
A-C-SB-P-Ca	152	44.2	29	140	129	114	95
A-C-SB-P-B	104	32.6	31	96	87	77	62
A-M-Cr-SL-FL	284	94.8	33	260	235	204	163
C-M-B-SB-Ca	122	40.2	33	112	102	89	71
C-B-P-SL-Ca	224	78.2	35	205	183	158	124
A-C-SB-SL-Ca	214	75.8	35	195	175	151	117
C-SL-FL-Ca-Wa	290	104.4	36	264	236	202	156
A-C-P-O-Cr	322	116.2	36	293	261	224	173
B-M-P-SB-Ca	112	42.0	37	102	91	77	41
A-B-Wh-Ca-Cr	167	62.3	37	151	134	114	87
A-SB-P-Wa-Ca	135	50.6	37	123	109	93	70
P-O-Cr-Wa-Ca	350	133.1	38	317	281	238	180
A-SB-O-Cr-P	299	114.7	38	270	240	203	152
M-SB-P-O-Cr	298	115.1	39	269	238	201	150
A-P-SL-FL-Ca	261	104.0	40	235	207	174	128
A-M-P-O-Cr	285	114.6	40	257	226	119	138
B-M-P-Ca-Wa	119	48.4	41	107	93	78	57
SL-FL-Ca-Wa-O	388	162.2	42	347	303	252	180
A-SB-FL-SL-P	229	105.8	46	202	174	140	93
SB-SL-Ca-P-O	337	156.8	47	298	256	206	137
A-B-SB-O-SL	265	138.7	52	230	193	149	88
A-M-B-P-O	188	103.3	55	162	135	102	56

Source: See Table 21.

Table 29. Annual Fixed Cost for a Representative 320 Acre General Crop Farm in Arizona

Resource	Average Value of Investment	Costs Per Year: Depreciation	Costs Per Year: Interest	Costs Per Year: Taxes, Insurance, and Miscellaneous
	($)	($)	($)	($)
Automotive	6,300	840	504	345
Power Equipment	28,451	3,862	2,276	210
Land Preparation Equipment	11,186	1,332	895	85
Planting and Cultivating Equipment	7,728	1,163	618	56
Harvesting Equipment	24,585	4,023	1,967	192
Land and Buildings	224,000	4,074	17,920	3,636
Irrigation Equipment				
Miscellaneous Equipment	3,631	479	290	27
Other Miscellaneous Fixed Costs				300
Totals	305,881	15,773	24,470	4,851
Total Annual Fixed Cost				45,094

Source: Data calculated utilizing Jones (1967) and Wildermuth et al. (1969).

Table 30. Annual Fixed Costs for a Representative 800 Acre General Crop Farm in Arizona

		Costs Per Year		
Resource	Average Value of Investment	Depreciation	Interest	Taxes, Insurance, and Miscellaneous
	($)	($)	($)	($)
Automotive	8,100	1,080	648	420
Power Equipment	38,751	5,884	3,100	285
Land Preparation Equipment	17,904	1,571	1,432	135
Planting and Cultivating Equipment	8,806	1,053	704	63
Harvesting Equipment	48,895	8,001	3,912	362
Land, Buildings, and Irrigation Equipment	560,000	6,569	44,800	8,471
Miscellaneous Equipment	5,115	710	409	37
Other Miscellaneous Fixed Costs				550
Totals	687,571	24,868	55,005	10,323
Total Annual Fixed Costs				90,196

Source: See Table 29.

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