THE RELATIONSHIP OF DIVERSIFICATION TO RISK AND EFFICIENCY

by

SHELDON RAY ZENGER

B. S., Kansas State University, 1980

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Economics
Agricultural Economics

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

Approved by:

Major Professor

ACKNOWLEDGMENTS

I would first like to thank my major professor, Dr. Bryan Schurle, for his continuous help, guidance and encouragement throughout my graduate program. Thanks goes to Dr. Orlan Buller and Dr. Don Pretzer for their support and guidance as members of my graduate committee. Thanks also goes to every member of the faculty and staff for making my graduate program a very memorable experience.

Appreciation is extended to Sandy Field for typing from my hand writing and Tammy Arnold for typing the final draft in such a short period of time.

Finally, a very special thanks goes to my parents, Drs. Weldon and Sharon Zenger, my brother, Sheahon and sister, Shannon for their faithful encouragement and prayers throughout my education and my entire life.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The Great Plains farmers are very aware of the problems, difficulties and tribulations that not only society but mother nature herself thrusts at them almost continuously. Despite the variabilities of income and the uncertainties of weather patterns the Great Plains farmers continue to operate and survive.

All those who have worked closely with farmers know that uncertainties and risks in farming are great. They stem from many sources - natural and otherwise, such as weather, disease, and variations in market prices.[1]

Farmers would benefit from new ideas, methods and procedures which would help to reduce their risks and uncertainties. Another major consideration is the efficiency with which they operate. Management strategies which would increase efficiency of operation would also be beneficial.

Researchers have done a great deal of modeling with attempts to incorporate risk into their decision making. One precaution which has been suggested to help farmers reduce their risk and uncertainty is diversification. Diversification might be defined as the selection of multiple products as a risk precaution where the immediate objective is not so much one of profit maximization but one of stability of income. If the return from one product is low the return from another might be high when the eggs are not all in one basket. However, one of the costs of diversification might be reduction in efficiency depending on the management and use of resources in the operation.

The approach taken in this study is to investigate and analyze farm data to discover management strategies and find procedures which might help the Great Plains farmer to reduce risk and uncertainty and increase or at least evaluate the efficiency of his operation.

The objectives of the research in this study are the following:

1. To measure diversification.
2. To estimate the relationship between diversification and variability of income.
3. To estimate the relationship between other farm characteristics and variability of income.
4. To estimate the relationship between diversification and efficiency.
5. To estimate the relationship between other farm characteristics and efficiency.

Justification for the Study

Diversification has long been thought to contribute to the reduction of risk and uncertainty and a better utilization of labor resources on the farm, nevertheless, it has also been accused of not allowing full attainment of economies of size. However, these relationships have not been estimated from farm data to discover whether they hold empirically.

In this study farm data is analyzed to estimate the relationship of diversification and other farm characteristics to risk and efficiency at the farm level. Specifically this study hopes to investigate and discover some practical and implemental methods for Great Plains farmers to not only estimate their diversification and efficiency positions in relation to other farmers, but then to suggest some possible management strategies to help combat the risk and uncertainties and maybe help deal with the efficiency levels they find themselves facing.

A final justification of the study will be to consider the question of best farm size in terms of economies of size and risk. Full benefits of economies of size may or may not be achieved at the optimal farm size for risk, but as Heady states "The continuance of small farms suggests the hypothesis that the economic dynamics of risk and uncertainty may be the final determinant of farm size in agriculture."[3]

Organization of Thesis

This thesis contains four chapters. The first chapter includes a justification for the study. Five primary objectives are stated explicitly at the outset of the chapter and a description of the farm data used is also offered. The description of farm data is somewhat detailed, expressing the average, minimum and maximum values of many of the variables used, to help better aquaint the reader with the type of information being used in the study. Chapter two includes a review of the literature related to this study. References are made to previous studies dealing with such topics as diversification, risk, efficiency, economies of size, variability of income, and the relationships of many of these with each other. The third chapter is the main body of the study and includes descriptions of methods used to estimate various relationships, the difficulties encountered in the search for relationships and results of models used to explore the objectives previously outlined. The fourth chapter of this investigation states many of the implications derived both directly and indirectly from the significant relationships found in the study. Conclusions and suggestions for further future research are also included in this chapter.

Description of Farm Data

The data used in this study is from Farm Management Association #1, one of six regions making up the Kansas Farm Management Association program (Figure 1). Association #1 includes 18 counties in the North Central part of Kansas. This association is the first association in Kansas and has several different types of farms such as cattle, wheat, hog, sorghum and mixtures of each, thus giving a broad view of Kansas farms.

A total of 128 farms over a seven year period, 1973 through 1979, were used in the study. Seventy-two different variables for each year and each farm were observed and includes such things as crop acres, gross and net income, capital managed and age of operators.

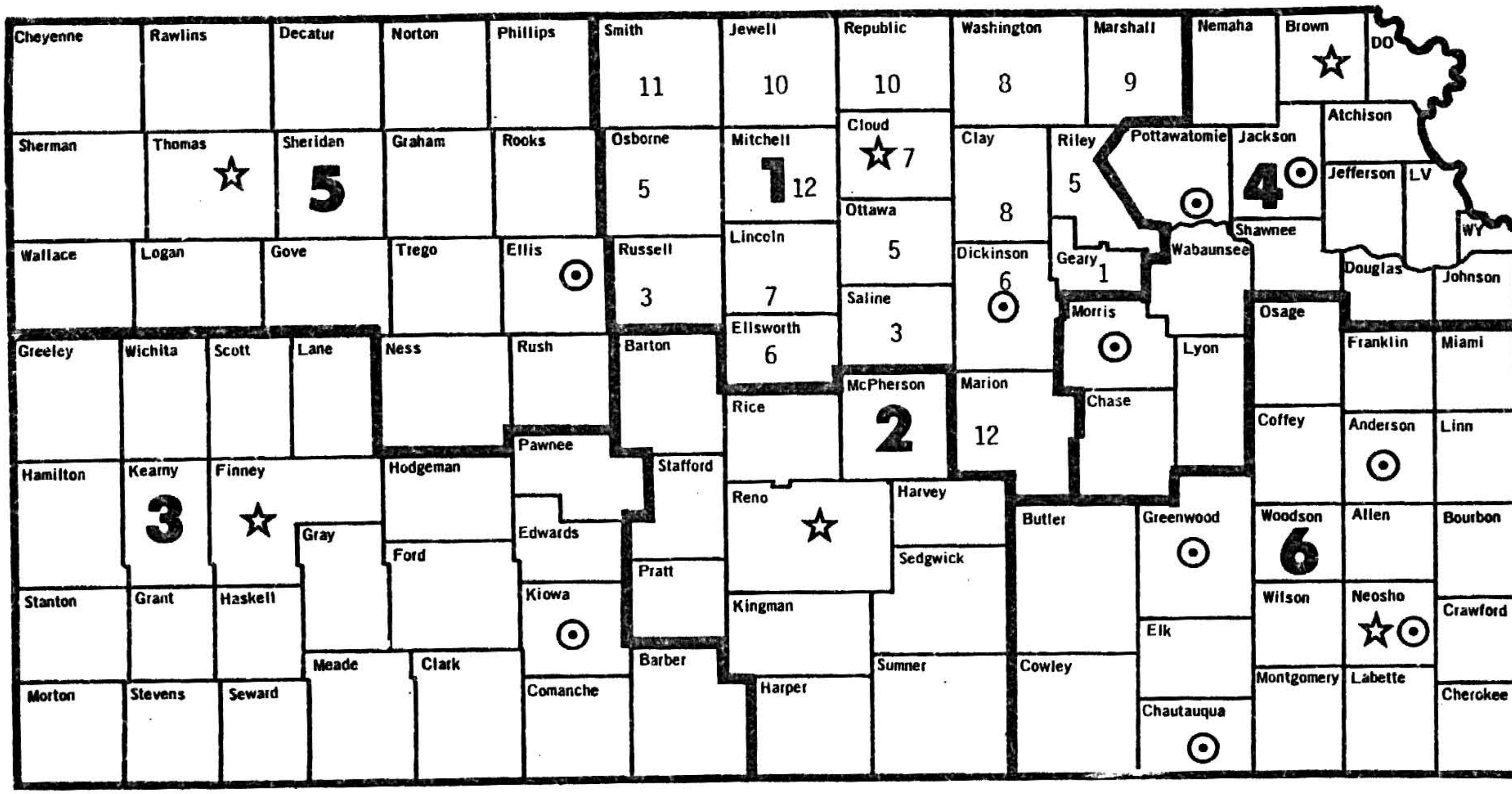
However, it should be noted that the farms used were not just a random sample in Kansas. Farms in farm management associations in Kansas tend to be commercial operations with progressive managers, so the results may not apply to non commercial farms.

A more extensive discussion of variables included in the analysis of the 128 farms will give a better understanding and description of the type of farms used in this study. Average gross farm income for the period was 90,094 and ranged from a minimum of 23,128 to a maximum of 412,647, while average net farm income was 20,539 and ranged from -23,777 to 93,687. Taxable non-farm income ranged from 0 to 18,182 dollars and averaged 2,212 dollars for the 128 farms.

Capital managed per farm also varied greatly, from 116,962 to

Figure 1.

KSU Farm Management Associations



☆ **Association Headquarters**

⊙ **Satellite Office**

Numbers in Association #1 Represent the Number of Farms Participating in Each County.

1,804,022, while averaging 438,132 dollars. The ratio of current and intermediate assets to current and intermediate loans averaged 3.2 and ranged from 0 to 20.4.

The average size of crop acres farmed was 726 and ranged from 74 to 3,243. The major crops are wheat, corn and grain sorghum. The average number of wheat acres was 306 while ranging from 0 to 1,682. Corn acres ranged from 0 to 158 and averaged only 8 acres per farm. Grain sorghum acres averaged 176 and ranged from 0 to 639. Crop production costs averaged 29,781 and ranged from 4,859 to 127,286 dollars. Crop production costs per acre averaged 44 and ranged from 20 to 95 dollars per crop acre.

The number of operators (unhired labor) for these operations ranged from one half to three and averaged almost one and one quarter. The number of men (both hired and unhired labor) involved in these operations ranged from one to nine and one half and averaged one and three quarters. The average age of farmers in this data was 46 while ranging from 25 years of age to 67 years.

Capital managed per man averaged 260,364 and ranged from 80,646 to 591,501 dollars. Crop acres per man averaged 434 while ranging from 74 to 1,407. The total number of acres owned and operated ranged from 0 to 4,991 and averaged 517. Acres owned and operated per operator averaged 459 and ranged from 0 to 1,858. Total machinery investment averaged 23,177 per farm while ranging from 2,291 to 100,501 dollars. Investment in machinery per acre ranged from 10 to 176 dollars and averaged 34.

To take account of location of the farms a rain variable was also included in the analysis. County rainfall data from the 63rd Kansas

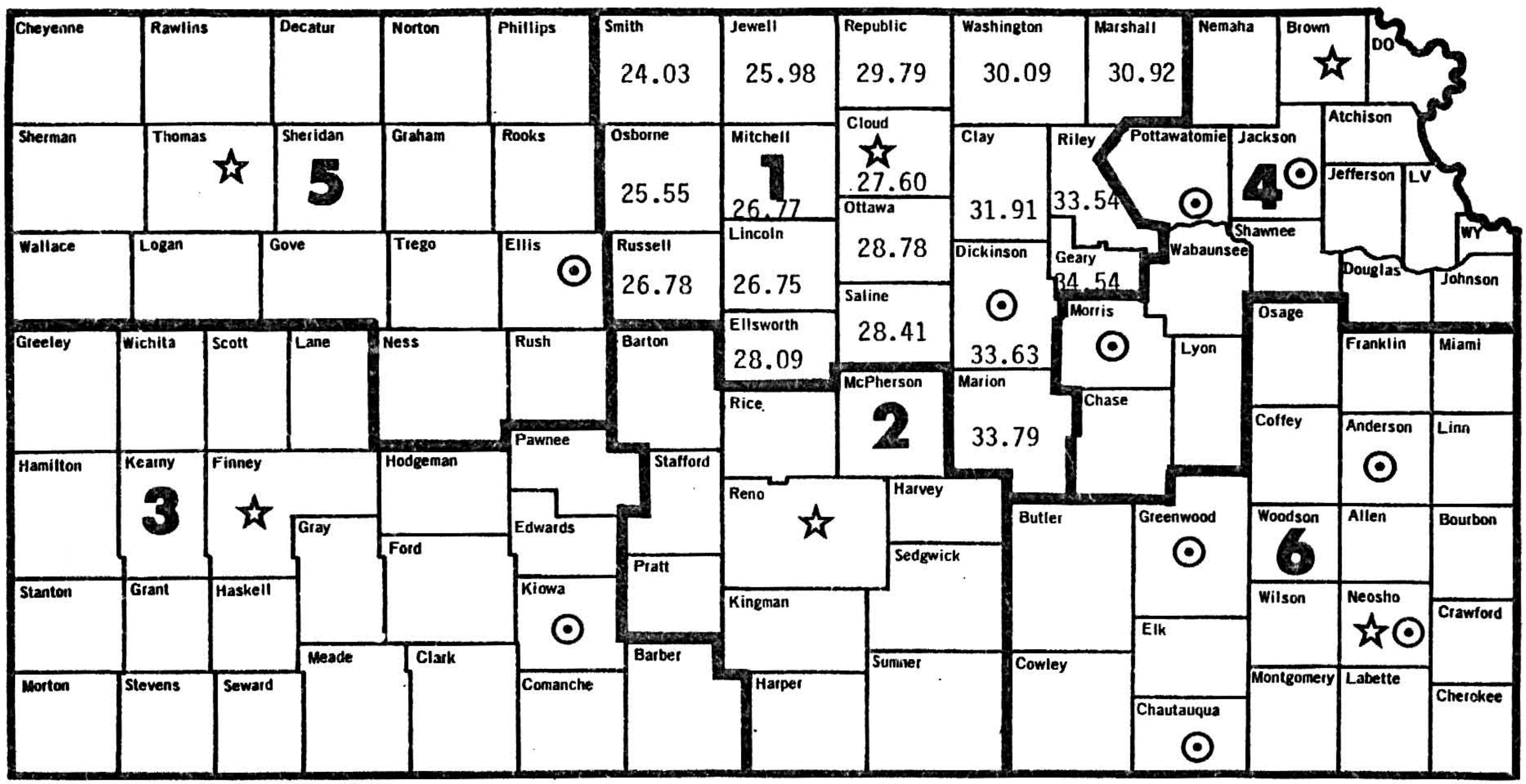
Agricultural Report was used to approximate the rainfall for each farm (Figure 2). The average annual rainfall ranged from 24 to 35 and averaged 29 inches for the 128 farm sample.

The types of farms and farmers vary greatly in the data collected for use in this study; however, this has hopefully contributed to the overall applicability of this study to the more generalized rather than the situations of specific occurrence for the farmers of the Great Plains.

Figure 2.

Kansas Precipitation --- 1941-70 Average By County.

KSU Farm Management Associations



☆ **Association Headquarters**

⊙ **Satellite Office**

Source: Crop and Livestock Reporting Service, Sixty Third Annual Report and Farm Facts (Kansas State Board of Agriculture, U.S. Department of Agriculture, 1979), p. 118.

CHAPTER II

LITERATURE REVIEW

This chapter discusses the literature that is relevant to this study. The first portion deals with several aspects of risk and diversification such as diversification's relationship to risk, methods of diversification used to reduce risk, selection and relationship of income to risk, and types of diversification used to reduce income variability. The last portion of this chapter deals with efficiency, size, measures of these concepts and also includes diversification considerations. Such topics as diversification's relationship to efficiency, measuring efficiency in farming, measures of size, and the relationship of economies of size to diversification and efficiency are reviewed.

Diversification's Relationship to Risk

The terms risk and uncertainty are sometimes used to refer to different aspects of the problem. Farmers tend to classify all outcomes which lead to losses as risks. However, a useful distinction between risk and uncertainty does exist according to Heady. The differentiation between risk and uncertainty is useful because it has implications for how resources should be or are used.[4] Risk and empirical prediction refers to variability of outcomes which are measurable in an empirical or quantitative manner. The outcome of each action need not be predictable, all that is necessary is that the probability of certain outcomes or loss can be established for a large number of cases or observations. Uncertainty and subjective prediction in contrast to pure risk is when the probability of an outcome cannot be established in an empirical or quantitative sense. Uncertainty is always present when knowledge of the future is less than perfect. The "subjective" nature of uncertainty refers to anticipations of the future and is peculiar to the mind of each individual producer. It is subjective because the enterpreneur must formulate an "image of the future" in his mind but has no quantitative manner by which these predictions can be verified. Uncertainty can be used in a very broad sense to include all circumstances in which decisions must be made without knowledge of significant future events. Significant events are all occurrences which if foreseen perfectly would have influenced a particular decision.[5]

Risk and uncertainty are always present in farm decision making. Risk has a probability distribution that permits an expected outcome to be estimated. Examples of this relationship would be estimations of price on the basis of historical information. Uncertainty arises from weather, insects, diseases, unpredictable market forces, and other miscellaneous forces with unknown probabilities of occurrence.[6]

According to Kliebenstein and Scott, a definite difference exists between the terms risk and uncertainty. Early in the theory about unknown outcomes, risk was defined as the chance of loss when this chance, had some probability associated with it. Whereas, uncertainty was when the probability of the outcome of an event was unknown. Most of the theoretic work involving the assessment of risky alternatives has involved a hypothesized distribution of the outcomes and hypothesized relationships among different activities.[7]

This study will be dealing primarily with risk defined as variability of income. Risk and uncertainty will be used interchangeably throughout the paper and will mean the same thing unless otherwise specified.

If an individual is a risk averter, he is more likely to choose a production plan with a low variance in income than would someone who likes risky ventures. The individual who has a preference for risk has the chance for higher income but also accepts the chance for greater losses.[8]

A common precaution taken to meet risk and uncertainty is diversification, the producing of several enterprises. Diversification can be carried on purely to meet risk and to prevent putting all the eggs in one basket.[9] Direct results of research are consistent with the theory of decision making under uncertainty. Enterprise diversification is an effective risk management strategy. But this strategy, as well as other risk management tools, generally involves an income sacrifice.[10]

Methods of Diversification Used to Reduce Risk

Uncertainty is a situation in which there is imperfect knowledge and many times decisions have to be made based on this lack of adequate knowledge or information. However, diversification can serve as a precaution that one can use in adjusting to an uncertain or risky situation. Heady suggests that any economic unit which employs resources and makes decisions about the future can use diversification for adjusting to risk and uncertainty.

Diversification, selection of multiple products, can be employed as a risk precaution where the immediate objective is not so much one of profit maximization but one of stability of income. If the return from one product is low the return from another will be high when the eggs are not all in one basket, diversification is mainly a method of preventing large losses.[11]

Heady and Carter believe that diversification might be accomplished through an increase in sufficient resources to include the new enterprise or enterprises without reducing the size of present enterprises or by redistributing fixed resources among more enterprises. Adding resources to accomplish diversification usually increases total income variance and total net income. While using redistribution of fixed resources causes a reduction of risk by dividing a fixed quantity of land among a greater number of enterprises. Redistribution may have more widespread application since most farmers have limited capital. Carter believes opportunities to reduce total income variability are greater with the redistribution of fixed resources rather than the adding resources method.

Addition of more plants and a greater volume of output contributes to risk along with change and the imperfect knowledge of future prices and yields. As the uncertainty increases, the number of decisions which must be made by management also increases. The greater the number of decisions, the less perfect they become because the supporting knowledge upon which each is based becomes less perfect. Diminishing returns for management, poorer decisions increase as management encompasses more, come about because of imperfect decisions and the corresponding misdirection of resources relative to price and production outcomes. The greater the amount of change and uncertainty the greater are the possible errors in prediction and choice. The smaller the change and uncertainty, the greater is the opportunity for expansion in farm size.[12] So, increasing farm size is less taxing on management if uncertainties are fewer and changes are small.

On a small farm the farmer is typically a general manager concerned first with production, then marketing and finance. The wide range of management responsibilities limits his capacity to continually absorb and process new information. Larger producing firms have tended to specialize and decentralize the management functions, allowing the firm to embrace a wider range of managerial services than is typically found in smaller farm proprietorships.[13]

If a manager should choose diversification to meet risk, like all other precautions to lessen the impact of unknown outcomes, it comes at a cost. The cost is the income sacrificed over a period of years by organizing the farm to lessen the variability of income between years. Diversification to meet risks usually means that income never falls as low in bad years and never gets as high in good years as it could. Diversification considerations can include attempts to either (1) put a floor under income, or (2) level off the variations in income. To put a floor under income, a stable enterprise would be selected to give some profit every year, then a prospectively high return enterprise would be selected, even though it would involve considerable risks. For leveling off the high and low spots and getting a more even income between years the farmer should emphasize contrasting or offsetting enterprises. If enterprises are to reduce income variation, they must possess certain characteristics. Their prices and yields should not have positive correlations but should be negatively correlated. An excellent example of this would be combining a livestock enterprise with a cash crop enterprise.[14]

Types of Diversification Used to Reduce Income Variability

Carter proposes that net income variability results from the interaction to yield, price and cost. Diversification is believed not to be very effective in reducing variations in income for major changes in farm prices. It is more effective as a means of combating yield variability.[15] Heady suggests that if prices, yields, and incomes have positive correlation coefficients the combinations of products need not reduce variability. However, if the correlation coefficients are negative, the different enterprises would serve optimally as an uncertainty or risk precaution. Two negatively correlated enterprises help guarantee some income in a single year. While the chance of low income is lessened, the chance of high income also is lessened under diversification.

Diversification may be employed as a method of handling two aspects of income variability. First, the operator may think in terms of the variability of income over his entire operating career, in this case the number of years involved become a population of production periods for which he may wish to minimize income variability. Second, the operator may think in terms of possible large profits or possible large losses in a single year, in this case he may choose to treat the single year as a sample and organize his resources to minimize the chance of a large loss. These two considerations are similar but not identical and they need not lead to the same course of action. One type of diversification may allow low variability of income over the farmer's career, but may also allow infrequent large losses, according to Heady.

A plan can be adopted which involves large variations from year to year but allows a greater income over time, the surplus or lush years can be carried forward to lean years. Or a course of action can be adopted which results both in smaller variations between years and a lower income over all years. The optimum choice is unique to each individual.[16]

The extent to which diversification is practiced as a means of reducing income variability is unknown. However, it is of importance to beginning operators and established farmers in a weak financial position and for some operators in all areas where weather gives rise to gains from diversification, such as the Great Plains.[17]

Diversification cannot be extended indefinitely and have equal effects in reducing the variability of income. Two kinds of limits exist in lowering income variability through diversification: (1) adding more and more enterprises has less effect in reducing variability, and (2) when two enterprises alone are used for diversification, adding more of the second may first reduce variability but a point may be reached where still more of the second enterprise may begin to increase income variability.

The extent to which more and more enterprises reduces the variability of income depends on the variability of each enterprise. Diminishing returns is also encountered in diversification as a method of adding stability to income. By adding some of the second enterprise while reducing the amount of the first, the variability for the farm as a whole can often be reduced, the variations for the two enterprises offset each other. Eventually a combination of the two which gives the very lowest variation can be reached, addition of more of the enterprise at this time will cause an increase in income variability. This increase comes about as the effects of the second enterprise are mainly expressed and there is too little of the first enterprise to offset the year to year savings in income of the second enterprise.

The operator is faced with making a choice between the level of income and the stability or "sureness" of income. Only he can make the choice depending on his ability to shoulder risks, his capital position, family responsibilities, and like or dislike for taking chances.[18]

Selection and Relationship of Income to Risk

Resource managers such as farmers must make choices between increasing income and reducing variability of income (or for the probability of loss). They may select sacrifices in incomes for producing patterns which minimize the probability of loss or bankruptcy. Heady, believes that each farmer's choice will be unique and depend on his (1) risk preference, (2) capital, (3) equity, and (4) family responsibilities.

Variations in net income serve as barometers of the degree of uncertainty or risk involved in production.[19] As income increases so does risk, as measured by the estimated standard error of expected income (variability of income).[20] If the dispersion of expected prices for a commodity is zero, the producer is certain about his estimate of prices or yields, but if the dispersion of expected outcomes is very great the degree of uncertainty is very great.[21]

Uncertainty or risk helps explain the coexistence of farms of many sizes. Variability of income is probably more important than scale relationships in explaining the varied pattern of farm sizes. It may offset entirely the large farm's cost advantage of a few dollars per acre.[22]

Uncertainty or risk is not "theoretical and impractical". Major decisions of individual persons and nations fall into this category.[23] Four major types of uncertainty or risk are as follows: (1) price uncertainty, (2) technical or yield uncertainty refers to variation in the production coefficients for a given technique, (3) technological uncertainty, and (4) sociological and legal framework.[24]

Heady looks at "certainty" as a "product" which can be produced by different uses of resources. If certainty increases as income increases, then over a range money income and certainty are complimentary products. A rearrangement of resources to produce more income also results in "production of more certainty" (reduction in variability). Beyond this point, greater certainty can come only at the expense of income. In a competitive relationship, a shift of resources to bring about greater income is always accompanied by an increase in income variance.

Given an uncertainty setting, the optimum plan for any individual depends on his psychological makeup, his capital position, and the ends to be maximized.[25] Guesses are better if the person making them studies, learns and tries to predict the future. However, his predictions always involve uncertainty which refers to outcomes which cannot be predicted perfectly.[26]

The need for management grows out of change and inability to predict the future with certainty.[27] Six important kinds of change or risk give rise to imperfect knowledge and hence in possible mistaken plans for the future. One is price change, price change more than anything else provides the major uncertainty, although all types of uncertainty are extremely important in planning. The second type of risk is yield or production uncertainty. The third type of uncertainty is that surrounding new techniques or methods of production. The fourth type of important uncertainty involves government policy and the decision of legislators. The fifth uncertainty involves the actions of other people with whom we do business. The sixth risk surrounding any individual or family, whether engaged in business for themselves or otherwise occupied is the uncertainty of sickness, injury or death.[28]

Precautionary measures to meet risk can take one or all of three related but distinct forms: (1) measures to reduce the variability or dispersion of income, (2) measures to prevent profit from falling below some minimum level such as zero, and (3) measures to increase the farmer's ability to withstand unfavorable economic outcomes. The first and second measures are attempts to ward off income variability and uncertainty, the third is more nearly a way to meet uncertainty as it is encountered.[29]

Johnson believes that the diversification strategy chosen depends greatly on: (1) criterion function of the farmer, (2) feasible combinations of enterprises, and (3) the particular farm situation.

Diversification's Relationship to Efficiency

A very important facet of diversification is the effect of diversity on efficiency in resource use. Diversification may reduce the economies of size which could be achieved in a large specialized operation. If a farmer becomes very specialized according to Pope and Prescott, one would expect that he would achieve economies of size, or enjoy the benefits of using every piece of equipment and resource to its fullest potential. This is contrasted with the farmer who is more diversified. This entrepreneur would likely benefit from the reduction of variance of income, but at the expense of not taking advantage of such things as specialization of labor and other efficiencies which result from larger sized operations.

"Efficiency in resource use" refers primarily to the advantages obtained due to economies of size. Gardner and Pope state that economies of size may be either of a technological or a pecuniary nature. Those of a technological nature involve reductions of the technological coefficients of production while those of a pecuniary nature result from the reductions in the prices paid for the factors as a result of increases in the amounts purchased according to Viner.

Risk and uncertainty cause two types of inefficiency. First, precautions which are taken to meet uncertainty almost always necessitate a sacrifice that either results in a less-than-maximum product from given resources or does not allow a minimum cost for a given output. Second, both the individual farmer and the consuming society sacrifice when production is geared to inaccurate expectations. Uncertainty particularly discourages long time capital investment and places a premium on the use of labor.[30] When precautions are used to avoid risk, such as diversification, results will sometimes be inefficient. Heady suggests that combinations which result in little or no sacrifice in income, raise the minimum income received in any one year and lessen variance are the most efficient diversification systems. However, a cost of diversification may be the possible sacrifice of gains from increasing returns to scale or size.[31] This indicates that a highly diversified operation may be less efficient.

Measuring Efficiency in Farming

Production efficiency has been measured several different ways. A partial productivity index considers a single factor of production and ignores all other inputs and thus is inadequate as an overall measure of efficiency. Index numbers have been constructed to include all inputs. This method of measuring production efficiency suffers from the problem of choosing base years and deciding weights. Cost synthesis approaches are used, but this method estimates a theoretical function that is optimistic as compared to the best results observed in practice.[32]

Some measures of economic efficiency are simply productive efficiency or the private, pecuniary unit cost of production. These measures are quite different from the concept of Pareto Optimality, which is the only theoretical definition of economic efficiency. The definition of economic efficiency may sometimes correspond to the overall efficiency of the firm. For Farrell, production efficiency is the joint occurrence of technical efficiency and price efficiency.

Technical efficiency is achieved when the minimum quantities of factors (X_1 and X_2) are used (in fixed proportions) to produce a given level of output (Y). Price efficiency is achieved when the ratio of factor prices is equal to the ratio of factor use. Economic efficiency (Pareto Optimality) in consumption, in production and in general are clearly defined. Economic efficiency in consumption is defined by the equation of marginal rates of commodity substitution (MRCS) between consumers. Economic efficiency in production is defined by the equation of marginal rates of technical substitutions (MRTS) between producers and between factors of production. Economic efficiency in general is defined by the point at which the marginal rate of commodity substitution (MRCS) for all consumers equals the marginal rate of technical substitution (MRTS) between factors for all producers.[33]

Efficiency still remains a relative concept, judgements about the efficiency of an observed situation can be made only by comparing the observed situation with some defined efficiency norm.[34] When resources are given and limited, maximum efficiency is attained only as it becomes impossible to reshuffle resources without decreasing the total value of the product.[35] However, a meaningful efficiency concept, has yet to be defined for a world characterized by uncertainty, imperfect knowledge, and costly information.[36]

In this study it was decided that efficiency would be defined as average net income over average gross income. Major reasons for this decision was the availability of the necessary data as well as the common belief that a farmer maintaining more of his gross income as net income must surely be an efficient operator.

Measures of Size

A perfect measure of size is impossible to attain. What is usually done is to choose those measures of size for each industry which are workable and at the same time come nearest to meeting the requirements of an ideal measure.[37] Measures of farm size vary from acres of land, units of livestock, value of farm products sold, days worked off-farm, level of farm income, level of total family income, economic classes, sales or total output to annual cash receipts in current dollars.[38,39] However, complications are associated with many of these measures of size. Farm area is not necessarily a good measure of size, as feedlots involve limited amounts of land but produce large amounts of beef.[40] Farm size measured by acres is not sufficient because it considers only the land resource.[41]

LaDue believes there is a need for a size measure that can evaluate the net out firm changes that imply an improvement in the owner-operator income position and those that imply deterioration. Wealth and profit units are measures that might meet this criteria. Profit units have the advantage that the necessary firm data are easier to obtain, some standardization of individual firm data is achieved and the net income concept is maintained. The wealth measure incorporates projected net income and net worth through discounting, and requires complete business and financial data.[42] Present value of net income flows over the revelant time horizon represents the most desireable measure of size. The real advantage of an income measure of size is its all-inclusive nature.[43]

Farm size is related to income in two ways: (1) the amount of income is dependent on the size of the farm and hence the amount of capital. (2) The amount of income relative to the quantity of resources used depends on the nature of cost advantages or disadvantages (returns to scale) to farms of different size.[44]

The size of farms can be described with both input and output measures. Key input measures like labor leads to the description of farms as one- or two-man farms. Where crops are dominant, 160 or 640 acre farms may be most descriptive. Output measures, like gross farm sales or income, provide a way of describing multiple enterprise businesses and making comparisons across types of farms and with other nonfarm businesses. Value of farm sales is widely used as the basis for classifying farms in the census and most other national statistical series.[45] Volume or value of outputs give a reasonable single measure of size except for fluctuations due to extremely favorable or unfavorable weather. Where farms produce several products, output must be measured in terms of dollar sales, in order to convert them to a common denominator.[46]

Therefore, gross farm income was used as the measure of size in this study as it appeared to be the most justifiable measure of size.

Diversification and Economies of Size

The impacts of diversification on risk reduction and economies of size is a major issue. One should keep in mind that signs among different measures were not consistent. Pope and Prescott found that alternative measures of diversification reveal evidence that larger farms are more diversified, wealthier and less experienced farmers are more specialized, and corporations are more specialized than farms with other organizational forms. However, White and Irwin in a study using U.S. census data, concluded that smaller farms are more diversified when sales of a primary product as a percent of total sales by farm class is used as the measure of diversification. This finding would suggest a possible tradeoff between risk reduction and economies of size, but is in opposition to Pope and Prescotts discovery. Pope and Prescott also found that smaller farms generally have a larger proportion of their income from non-farm sources, especially true of farms having less than 40,000 dollars worth of sales.

In the study by Pope and Prescott diversification measures are limited to farm production activities and do not include farm income from nonfarm sources or other farm sources such as custom hire. Diversification in production was examined using both measurements on net income and acreage. When using any of four measures of diversification there was a strong indication of the following:

- a positive relationship between diversification and size.
- form of ownership and diversification exhibit a significant relationship.
- significant negative relationship between diversification and measures of financial well-being.
- farmer experience or age exhibits a positive effect on diversification - younger, less experienced are less diversified.

One might think that large scale economies or resource constraints may provide incentives for specialization. However, in light of tradeoffs between scale economies and risk reduction, Pope and Prescott's results that farm size exhibits a positive relationship to diversification refute the hypothesis that if there are large scale economies in an enterprise, then one might expect larger farms to be more specialized.

The net worth variable showed a significant negative relationship to diversification. This indicates that wealthier farms are less diversified--other things equal. Diversification and size (or growth) may be positively linked, therefore there may not be sufficient economies of scale in a particular commodity to warrant specialization. Pope and Prescott believe that generally results have been consistent with risk theories. While Heady suggests that the nature of returns to scale will have some effect on the quantity by which variance will be changed as two enterprises are combined.

Causes of increased size are 1) pecuniary and technical economies of scale, and 2) government policies (price supports and taxes). Government policies tend to reduce risk by truncating the lower tail of the probability distribution of returns, according to Gardner and Pope. At the lowest level of farm size (acres) innovation becomes impossible because risks of failure threaten family subsistence. As we ascend the size-of-farm scale the opportunities for experimentation increases and the price of failure declines.[47]

This lead to estimating the relationship between diversification and farm size in this study.

Efficiency and Economies of Size

Conventional wisdom has held that technological advancements over time have created efficiencies that could more effectively be captured by larger farms. The investment cost of machinery per acre or per unit of output is supposedly smaller for larger farms due to economies of size. The cumulative impact is seen as the consolidation of farms and the reduction in unit costs of production.[48] Smaller farmers may be able to survive, but they may require more resources to do so, hence, there could be an efficiency cost. Large farms generally have lower production costs.[49] The desirable size of farm for the efficient use of any one resource is one which permits reasonably full utilization of the resource. From the standpoint of labor and machine efficiency, the desirable size of farm permits full utilization of labor and field equipment during critical periods of the growing season, without interfering with timely performance of any of the work.

In the early to middle fifties Heady stated "The optimum size will differ between farms depending on the stock of labor and management possessed in the household of each and it need not result in the most efficient use of a nation's resources. It is doubtful that cost economies are great enough in most segments of American agriculture to endanger the units typically operated by farm families." "Continuance of the so-called family farm as the main structure of agriculture suggest that if size economies exist, they soon give way to diseconomies."

After studying various farm types, Raup found that efficiency in resource use was to be largely irrelevant as an argument for increasing farm size above a two man scale of operation. Larger farms might increase total profits but would not result in lower average costs. Raup suggests that above a two man operation studies show no significant economies or diseconomies of size. Heady indicates that cost economies in machines, buildings, and labor together show that as farm size is increased by increasing some resources in proportion to others, costs per acre decline and returns per acre increase on small units up to those which can be handled by two men.[50]

Cost economies or diseconomies are the phenomena which cause unit costs to decrease or increase respectively as size of the plant and output are expanded. Cost economies or diseconomies may be either internal or external to the individual producing unit, or may also be monetary (pecuniary or market) in nature or of a physical (technological) nature.

Previous studies show that most of the economies are attained at relatively small sizes and capturing the relatively small remaining economies involves much further growth beyond the size where most economies can be attained. There may be technical size economies in the input supply and marketing functions rather than in the production of products.[51] This indicates that the LRAC curve for farms declines rapidly as farm size increases, up to a point and then becomes relatively flat over a wide range in size. Most of the primary farms have reached, or are significantly larger than the size needed to attain most cost economies.

Heady believes three things ordinarily lead to lower costs as the size of the farm is increased: 1. Fixed costs can be spread over more units of output as volume increases and more variable resources are used in proportion to resources which are fixed. 2. Specialization of work and supervision can lead to more product in proportion to resources where size is increased by expanding all resources by the same relative amount. 3. Lower prices for the things which the farmer purchases and higher prices for the things he sells may be obtained if output is expanded far enough. The greatest cost advantage for larger farms and single enterprises arises as the proportions of resources are changed and total fixed costs are spread over a greater output.[52] Economies of size, whereby large farms reduce their costs by spreading fixed machinery and labor costs over more land and output is evident. Pecuniary economies of size, especially in volume discounts for purchased inputs, are thought to be significant for large farms. However, the cost advantages associated with purchased inputs do not contribute in any substantial way to the overall advantages of large farms.[53]

Hall and LeVeen indicate that the long-run average cost curve is L-shaped. That is, production costs decline rapidly with initial increases in size and then decline slowly, if at all. Little evidence is found of increasing costs for very large farms, most of the benefits of technology are achieved by modestly sized firms.[54] While cost advantages may exist for the medium-large farm, there are not so many further advantages that very large-scale units are likely to predominate in agriculture.[55] Although the economies to scale, or cost advantages, for larger enterprises are not great enough to crowd all small enterprises out of business, the advantages are great enough that many general farms are now beginning to specialize.[56]

According to Hall and LeVeen sales per acre tend to be higher for larger farms than smaller ones. Three reasons for this phenomenon:

1. Large farms probably have greater access to high-quality resources.
2. Large farms may produce more per acre because they are better managed.
3. Large farms may be able to sell more of their output because of greater market access and the availability of premium prices for large volume producers.[57]

Heady found with no fixed resource, some cost advantages or scale economies do exist over small ranges chiefly because of standardization of methods under large-scale production simplifies the task of supervision and increases the productivity of labor. Opportunities for standardization of methods on the farm are much more limited than in most industries. Little is actually known about cost changes or scale economies for farms as units when all resources are increased in roughly the same proportions.[58] A relationship can exist between farm size and economic efficiency either because there are economies of scale in the physical production function of the farm or because relative prices are such that cost savings result from increasing size. Efficiency associated with physical economies of scale can be characterized as technical efficiency, while efficiency associated with adjusting factor use and output mix to relative prices can be characterized as allocative or price efficiency. Overall economic efficiency is a function of both price and technical efficiency, and a firm is only completely efficient economically if it minimizes cost per unit of output.

Researchers indicate there are several approaches to the empirical analysis of the relationship between farm size and efficiency. A common approach is to estimate the parameters of production and cost functions using statistical techniques. There are methodological problems, however, with the estimation of production and cost functions.[59] Studies suggest that after per unit costs reach a low point on the long-run average cost curve, they continue at this level over quite a wide range of production capacities. Over this range, marginal cost must equal average cost per unit. Diseconomies do not set in and the long run average cost curve appears to be essentially flat. It has been easier to identify what makes this cost curve fall than to discover evidence or demonstrate economic logic that shows LR costs rising after some point.[60] Evidence shows that the long-run average cost curve is relatively flat after initially declining rapidly. Sources of declining production costs have a significant technical basis for economies of size, other factors such as management, resource quality, and the overall institutional structure are even more important.[61]

Johnson and Hvinden believe increased management time requirements as farm size increases could be a critical determinant of economies of farm size.[62] Management as much as anything else is the limiting factor in increasing farm size and decreasing cost per acre for many small units. Some persons do not have the decision-making and supervisory ability which are needed for larger and more complex units. There are long-run economies of size in the use of total management time. This is expected since many management activities, such as marketing, record keeping, and planning must be performed irregardless of farm size. Long-run diseconomies of farm size are attributed to problems of coordination. It has been suggested that problems in coordination are particularly difficult in farming because of the lack of uniformity among resources, spatial dispersion of operation, and the unpredictable behavior of resources, environment and the market.[63]

Many ideas have been suggested in this chapter. Diversification is practiced in several ways to reduce risk and uncertainty and have beneficial effects on efficiency. Some attempts have been made to measure efficiency and size of operations and to discover their relationships to diversification. Economies of size have been evaluated in their roles affecting diversification and efficiency. The next chapter continues to investigate and analyze several of these major ideas through the methods and procedures that this study was originally developed to research.

CHAPTER III

METHODOLOGY AND RESULTS OF STUDY

This chapter describes how risk, efficiency, income, size and diversification was measured. Sources and descriptions of data used in the analysis are provided. Reasons for looking at specific relationships are explained and the procedures for investigating the relationships are described. Finally the estimated relationships among variables are evaluated.

Relationship Between Income and Variance of Income

Heady has suggested that "certainty" may be a "product" that can be produced by different uses of resources, or diversification. If income increases as variance decreases, then over a range, income and certainty are complimentary. Then rearranging resources to produce more income also "produces more certainty" (reduction in risk). An example might be two enterprises such as wheat and hogs which might produce more income and more certainty than one enterprise.

But beyond a point, greater stability or certainty can come only at the expense of income. If a competitive relationship exists, then a shift of resources that increases income always will be accompanied by an increase in income variance (a decrease in certainty our second product). So the relationship indicated in Figure 3 is suggested with income represented on the horizontal axes and certainty and risk on the verticle axes. At low income, income and certainty are complimentary products, both increasing over a given range. At high income levels the relationship becomes competitive, indicating that a greater degree of certainty can be obtained only by reducing income.

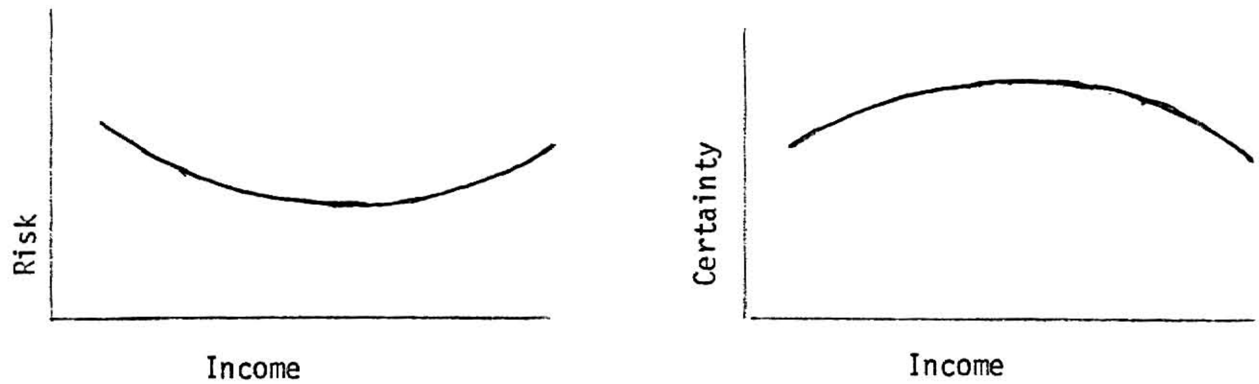


Figure 3. Hypothetical Relationships Between Income and Risk and Income and Certainty.

The relationship between variability of income and the level of income was estimated to investigate the possibility of complimentary and competitive relationships between risk and income. Each farmer provided one observation giving a total of 128 observations. The average net income (AVNET) over the seven years for each farm was used as a measure of income for each farm. Net income is calculated using accrual accounting procedures rather than cash accounting procedures. The standard deviation of net income (STDNET) for each farm over the seven years was then used as a measure of variability. A nonlinear relationship was estimated to investigate Heady's hypothesis that complementary and competitive relationships might exist between "certainty" and income level.

The estimated equation was

$$\underset{}{\text{STDNET}} = \underset{(6.55)}{15{,}568} + \underset{(2.15)}{.35}\ \text{AVNET} + \underset{(1.72)}{.0000035}\ \text{AVNET}^2$$

The R^2 for this equation was .41. T values, recorded under the coefficients, are significant at the 10% level if greater than 1.64. This equation suggests that the general relationship is curvilinear and that variability increases at an increasing rate as income increases. This estimated equation is shown in Figure 4.

The estimated equation indicates that any complementarity between "certainty" and income level may be only at negative income levels. At positive income levels, a competitive relationship exists, so increases in income are generally accompanied by increases in variability of income. In addition, variability increases at an increasing rate as income increases.

This estimated equation indicates a general relationship that exists between income and variability of income.

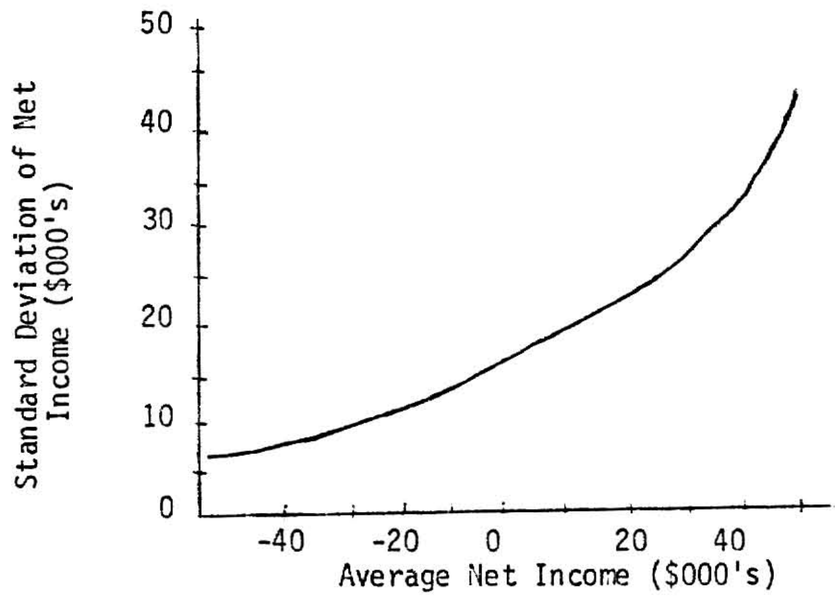


Figure 4. Empirically Estimated Relationship Between Net Income and Standard Deviation of Net Income.

However, an individual farmer might be able to modify his income or variability of income by rearranging resources or adding resources to his farm. Both diversification and size of operation varied among the farms used to estimate this equation.

Measures of Diversification

Several formulas to measure diversification were tried. Four such formulas were suggested by Pope and Prescott and one was developed as an alternative measure of diversification.

The index of maximum proportion expressed as $\max_i P_i$ and the number of enterprises diversification measure expressed as $\sum_{i=1}^{N} I\ (P_i)$ where I = a function that allows counting of the number of enterprises and P_i = proportion of the business in an enterprise, were both eliminated very early in the study because they did not measure satisfactorily the type of diversification which was being analyzed in this study. Each measure was taken individually and evaluated. When each of these were tested, it was found that some farms intuitively more diversified would not be indicated as such by the measurement so the measurement was eliminated from the study.

However, the Herfindahl index: $\sum_{i=1}^{N} P_i^2$ and the entropy index: $\sum_{i=1}^{N} P_i \log \frac{1}{P_i}$ were believed to be quite satisfactory in their measurements of diversification as was the developed alternate measure: $N - \frac{N}{2} \{ |P_1 - \frac{1}{N}| + |P_2 - \frac{1}{N}| + \ldots + |P_N - \frac{1}{N}| \}$.

After initial attempts to use the entropy index it was also dropped because of the difficulty encountered when negative P_i's were confronted.

This left the Herfindahl index, which will be referred to as D_1 in the study and the alternative measure which will be indicated as D_2.

D_1 is represented as $\sum_{i=1}^{N} P_i^2$ where P_i = proportion of the business in an enterprise. A value approaching 1 with this measurement indicates specialization, while smaller values reflect diversification.

$$D_2 = N - \frac{N}{2}\{|P_1 - \frac{1}{N}| + |P_2 - \frac{1}{N}| + \ldots + |P_N - \frac{1}{N}|\}$$

where N = the maximum number of enterprises and P_i = proportion of the business in enterprise i. As this measurement approaches 1, it indicates specialization, while values approaching N indicate the operation is highly diversified. These two measurements of diversification were kept as they seemed to indicate, at an intuitive level, when one farm was more diversified than another.

Several different data elements were used in the search for an appropriate variable as there are many choices for P_i. Total acres in each crop were used as P_i in each diversification formula; however, it was difficult to include livestock enterprises in this type of measurement. Share of the total accrual gross income from each livestock enterprise, cash crops and grain crops were also used in the formulas to estimate diversification. Cash crops include primarily soybeans while grain crops include wheat, grain sorghum, and corn. This measurement was deficient because it did not accurately reflect crop diversification.

The measurement of diversification finally used was a combination of the above measures. Accrual gross wheat income, accrual gross grain sorghum income, and accrual gross corn income were approximated by multiplying grain accrual income by share of acres in each crop. Estimates of the gross accrual income for 10 enterprises including beef, dairy, sheep, swine, poultry, other livestock, wheat, grain sorghum, corn, and soybeans were available. The share of total gross accrual income from each enterprise was used as the P_i's in each formula, and N = 10 was used in the second measure of diversification.

The diversification measures varied from farm to farm. The mean D_1 value for the 128 farms was .43. This value ranged from .23 to .87 and it had a standard deviation of .15. The mean D_2 value was 3.37 and ranged from 1.68 to 5.39 with a standard deviation of .74.

The important enterprises varied from farm to farm and were determined by taking each enterprise and dividing it by the total accrual income for the operation. After each enterprise share of the total operation for each farm was determined an average or mean for each enterprise on all 128 farms were found. On the average, in terms of gross accrual income, beef was the most important with 32% of the share, wheat was second with 25% of the share, swine was third with 22% of the share and grain sorghum was fourth with 15% of the share. On average, the rest of the enterprises were relatively insignificant on the 128 farms studied.

The Relationship of Income Variability to Diversification

Many attempts were made to discover relationships between diversification and the riskiness of the total operation. The Statistical Analysis System computer package and several regression models were used for much of this analysis. Some of the attempts and revisions made to improve upon results are discussed. Then the final ideas, trials and results of estimating the relationship of diversification to income variability are discussed more fully.

Diversification was measured by two different formulas:

$$D_1 = \sum_{i=1}^{N} P_i^2 \text{ and } D_2 = N - \frac{N}{2} \{|P_1 - \frac{1}{N}| + |P_2 - \frac{1}{N}| + \ldots + |P_N - \frac{1}{N}|\} .$$

The first regressions incorporated measures of diversification among crops. More specifically, diversification among wheat, sorghum, corn and soybeans was evaluated by letting P_i = the share of total crop acres devoted to each specific crop or $\frac{\text{acres of crop i}}{\text{total crop acres}}$.

Two different data sets were used in these regressions, information for seven years for each of the 128 farms and the means for the seven year period 1973 through 1979 for each individual farm. The primary purpose for using the means of the seven year periods was to remove the impact of fluctuations from year to year on each farm, thus providing a better measure of the usual farm organization.

This analysis produced low R^2 values and no significant variables, thus indicating wheat, sorghum, corn and soybean acres were not related to net income over gross income.

By using the standard deviation of net or gross incomes as the dependent variable a measure of income variability had been developed to analyze. Once again using the means of the seven year data for each of the 128 farms, the measures of diversification and the four basic crops, simple regression equations were estimated and nothing significant was found.

However, when using this same data and a multiple rather than a simple regression more significant relationships became apparent.

Still dealing strictly with crop acres the dependent variable was changed to the standard deviation of net income divided by the average of net income (coefficient of variation of net income) and the standard deviation of gross income divided by the average of gross income (coefficient of variation of gross income). After only a few regressions it became very clear that something was throwing the expected values off. Examining plots of the data revealed several extreme values for the coefficients of variation. These extreme values occurred because several farms had net incomes slightly above or below zero. The resulting coefficient in these cases is an extremely large positive or negative number.

Therefore, the dependent variables standard deviation of gross and net income divided by their respective averages were abandoned and the reciprocals were tried, but nothing was found. The dependent variables standard deviation of net and standard deviation of gross incomes were once again returned to as they had showed the most promise up to this point.

At this point the measure of diversification used in the regressions was changed from one which measured only crop diversification to one which measured diversification between livestock and crops. The livestock categories included beef, dairy, sheep, swine, poultry and other livestock. While crop categories included grain (consisting of wheat, milo, and corn), cash crops (consisting primarily of soybeans), and government payments which are primarily if not completely tied to crops rather than livestock. In the measures of diversification P_i = the share of total gross accrual income from each enterprise or $\frac{\text{gross accrual income for enterprise i}}{\text{total gross accrual income}}$ and N = 10 or the total number of enterprises.

Relationships between this new measure of diversification and the dependent variables standard deviation of gross income and standard deviation of net income were explored. Simple regressions involving only the dependent variables and one measure of diversification turned up no significant relationships.

Up to this point all of the regression models were estimated with all of the independent variables included in the equation at one time.

At this point a forward stepwise procedure for selecting the most influential independent variable was used. This procedure adds variables by selecting the one which is most related to the dependent variable at each step. This forward stepwise procedure continues until all of the independent variables, up to a 0.5000 level of significance, are included in the model.

Regressions were run using the forward stepwise procedure, the dependent variable standard deviation of net income, the two measures of diversification and their respective squares as independent variables. Average net income and the means over the seven years for crop acres, capital managed, and crop production costs were added to the list of independent variables. Results from this analysis were very promising, and R^2 value of .67 and a respectable number of significant variables were found.

Encouraged by the results of this livestock and crop accrual income basic regression model, more independent variables were added. Once again the set of independent variables was expanded to include the means for the seven years of the following variables = number of operators (referring to unhired labor), number of men (referring to unhired labor and hired labor), operator's age, taxable nonfarm income (teaching wages, rent from housing complexes, etc.), crop acres, total machinery investment, current and intermediate assets divided by current and intermediate loans, and crop production costs divided by crop acres.

The relationship between average gross income and both the standard deviation of net income and the average net income were also explored. Several additional independent variables were also explored including average net income squared and average gross income squared as well as average net income divided by average gross income. In addition, a variable to represent location and rainfall was included in the models. Rainfall and location are related because rainfall decreases as one moves west in Kansas. A new variable was created by assigning each farm the average amount of rainfall for the county in which it was located. Data on rainfall by county from 1941-1970 came from the <u>63rd Kansas Agricultural Report</u> as shown in Figure 2. The counties were broken down according to the designated 18 counties in the #1 Kansas Management Association area as illustrated in Figure 1. Many significant relationships were found and high R^2 values (up to .86) resulted.

However, not all of the significant variables could be supported by arguement and there were some negative relationships that could not be explained. Correlations between variables were suspected which could cause multcollinearity problems in the models. Correlations were found between some important variables as indicated in Table 1.

Gross farm income (eventually to become the measure of size in this study) showed strong positive linear correlations with net farm income, standard deviation of gross income and standard deviation of net income at high significant levels. D_1 and D_2 have only very slight correlations with the gross farm income variable and considerably lower significant values.

Net farm income also exhibited reasonably strong positive linear correlations with standard deviation of gross income and standard deviation of net income with relatively high significance levels. D_1 and D_2 showed only very slight correlations (positive and negative respectively) with net

Table 1. Correlation Coefficients of Some Important Variables

	Gross farm income	Net farm income	Standard deviation of gross income	Standard deviation of net income	D_1	D_2
Gross farm income	1.00 0.00	.74 .01	.85 .01	.85 .01	.18 .04	-.14 .11
Net farm income	.74 .01	1.00 0.00	.67 .01	.63 .01	.11 .24	-.07 .47
Standard deviation of gross income	.85 .01	.67 .01	1.00 0.00	.84 .01	.13 .14	-.10 .27
Standard deviation of net income	.85 .01	.63 .01	.84 .01	1.00 0.00	.13 .15	-.07 .43
D_1	.18 .04	.11 .24	.13 .14	.13 .15	1.00 0.00	-.96 .01
D_2	-.14 .11	-.07 .47	-.10 .27	-.07 .43	-.96 .01	1.00 0.00

farm income and had a relatively low level of significance.

Standard deviation of gross income showed a highly significant positive linear correlation with standard deviation of net income and low significance levels of non correlations with D_1 and D_2. Standard deviation of net income also exhibited poor correlations with D_1 and D_2 at relatively low significance levels.

Finally D_1 showed a very strong negative linear relationship with D_2 at a very high significance level. The Pearson product - moment correlations were used in this particular analysis.

The problem of correlation between size related variables was then considered. Variables which appeared to be related to size were adjusted to remove the relationship. Four new variables were created in this way. Total machinery investment was divided by total crop acres, total acres operated was divided by number of operators (unhired labor), capital managed was divided by number of men (unhired and hired labor) and total crop acres was also divided by number of men.

Other regression models were estimated using the forward stepwise regression analysis measuring diversification as the shares of gross income from both livestock and crop income. The standard deviation of net income measuring the variability of net income was the dependent variable. Independent variables were as follows: the two measures of diversification as indicated by D_1 and D_2, the means of the seven year data period of average gross income, acres operated and owned (crop and grass) divided by number of operators (unhired labor), crop production costs divided by total number of crop acres, taxable nonfarm income (teaching wages, rent from housing complexes, etc.), total machinery investment divided by total number of crop acres. A few more variables were capital managed divided by number of men (unhired and hired labor), operator's age, current and intermediate assets divided by current and intermediate loans, total crop acres divided by number of men (hired and unhired labor), average net income, average rainfall for the county where the farm is located and finally the measure of livestock sector importance to crop sector. This measure was broken into two parts, the livestock sector defined as $\frac{\text{total livestock gross accrual income}}{\text{total gross accrual income}}$ and the crop sector defined as $\frac{\text{total crop gross accrual income}}{\text{total gross accrual income}}$. The equation showed an R^2 value of .81, indicating that as much as eighty-one percent of the variability in net income was explained by the independent variables. Four independent variables were significant (at .05 level) showing that they are related to variability of net income.

Average gross income was a significant variable in the regression. This variable is a measure of the size of operation of each individual farm. Average gross income had a significance level of 0.0001 and a coefficient of 0.1949. The coefficient value indicates that the larger the average gross income or size of the operation the greater the variability of net income or risk. This seems logical since larger fluctuations in income would be expected for larger farms.

Acres operated (owned in this case) divided by number of operators (unpaid labor) had a significance level of 0.0002 and a coefficient of 10.0296. The coefficient implies that the more acres being operated per operator the greater the risk or variability of income. This seems logical since the more acres an operator tries to manage the more information he must obtain and an increase in the number of decisions he must make allows a greater chance of an error being made.

Taxable nonfarm income entered the regression analysis. This includes all other sources of income not having a connection with the farm operation, such as teaching wages, rent from housing complexes, and national guard compensation. Coefficient value was 0.9866 while the significance level was 0.0001. The coefficient in this case implies that the more taxable nonfarm income received the greater the deviation or variability of net income. This appears to be valid as when an individual has an alternate source of income he is less likely to feel insecure and dependent on that one form of income from his primary occupation. He might also have less time to contribute to the one primary source of income if he is trying to manage many different sources of income.

The final important variable in this regression model was total machinery investment divided by total crop acres, a measure of amount of dollar investment in machinery per acre being farmed. The significance level was 0.0022 and the coefficient value was -109.3815. This suggests that the more machinery on a farm or the newer the machinery on a farm the less variability of net income. This again seems logical because with more machinery available the farmer could accomplish his operations in a timely manner with the appropriate type of equipment. Newer machinery might perform more efficiently with fewer breakdowns and repairs.

In this particular analysis neither of the two measures of diversification (D_1 of D_2), entered the model as significant. This indicates that as far as the livestock and crop sectors of production are concerned, diversification of these enterprises was not related to variability of net income.

Other variables were still included if it was felt that they could adequately be argued to have an effect on variability of net income. These variables were operator's age, crop production costs divided by crop acres, amount of rain received for location of county and the two measures of diversification, D_1 and D_2.

After more evaluation it was determined that the variable grain accrual income needed to be broken down into its components, wheat, corn, and grain sorghum. This was accomplished through taking each share of wheat, corn, and grain sorghum of the total acres and multiplying this amount by the grain accrual income to obtain the dollar amount of each share on an income accrual basis. The same type of calculations were done for all of the other variables to change them into a percentage share of the total accrual income instead of independent accrual income variables as they were previously. This changed the measure of diversification to include the percentage share of all ten variables for which we had estimates, each share was divided by the total of all the other shares such as beef share = $\frac{\text{beef gross accrual income}}{\text{total gross accrual income}} = P_i$. While this seemed to be a better measure of diversification the results from regression models still showed no relationship between this measure of diversification and variability of income.

In order to determine the range of the measures of diversification a Proc Means was run on D_1 and D_2. $\sum_{i=1}^{N} P_i^2$ or D_1 was found to have a mean of .44 with a standard deviation of .15 while the minimum value was .23 and the maximum value was .88.

$N - \frac{N}{2} \{|P_1 - \frac{1}{N}| + |P_2 - \frac{1}{N}| + \ldots + |P_N - \frac{1}{N}|\}$ or D_2 was found to have a mean value of 3.35 with a standard deviation of .74 while the minimum was 1.63 and ranged to a maximum of 5.32.

Ranges were also determined for the variables beef, dairy, sheep, swine, poultry, other livestock, wheat, corn, milo and soybeans through the same methods as was used for discovering diversification ranges for D_1 and D_2.

After much discussion it was decided that certain variables should be adjusted for the changes in prices occurring over the years 1973 through 1979. Variables such as gross income, net income, capital managed and taxable nonfarm income would change greatly on the same farm because of the prices received in 1978 compared to prices received in 1979 even if everything else were to remain the same. Several variables were chosen to be deflated by the GNP deflator. They were as follows: gross income, net income, government payments, capital managed, crop production costs, taxable nonfarm income, machinery investment, and the gross accrual incomes of beef, dairy, sheep, swine, poultry, other livestock, wheat, milo, corn and soybeans.

The GNP deflator was chosen over the consumer price index for various reasons. The consumer price index was felt to be overly biased in the areas of mortgage interest rates, energy costs, and food. Therefore, the GNP deflator was chosen as it is defined as a broad measure of domestic inflation constructed from price changes for the major components of GNP, consumption, investment, government expenditures, and net exports. The deflators for each of the major components are constructed as a weighted average of prices for various subcomponents, using variable weights to reflect current spending patterns. The GNP deflator reflects a variable rather than a fixed bundle of goods. Since imports are netted out of the GNP equation the GNP deflator measures the general price level of domestically produced goods and services.

Once the necessary variables were deflated by the GNP deflator for each year 1973 through 1979, general linear model (GLM) regressions were run on the models including the independent variables average gross income, acres per operator, taxable non-farm income, machinery investment per acre, crop production cost per acre, operator's age, average rainfall for county in which farm is located and the two measures of diversification D_1 and D_2.

The results were as follows: crop production costs per acre, operator's age, average rainfall for county in which farm is located and each measure of diversification, D_1 and D_2, were found not to be statistically significant. While average gross income, acres per operator, taxable non-farm income and machinery investment per acre were found to be statistically significant. The estimated coefficients indicate that the greater the average gross income the greater the variability of income. Greater the acres per operator and the amount of taxable nonfarm income the greater the risk encountered. The larger the machinery investment per acre the less likely the farmer is to encounter variability in his income. The R^2 in this model was .78.

This model was run through a procedure in which the means, standard deviations, minimums and maximums were established for the diversification measures of D_1 and D_2. D_1 had a mean value of .43 with a standard deviation of .15, while the minimum value was .23 and the maximum value .87. D_2 showed a mean value of 3.37 with a standard deviation of .74, while the minimum value was 1.68 and the maximum value was 5.39. All values changed only very slightly from those yielded previous to use of the GNP deflator as indicated in Table 2.

Table 2. Descriptive Statistics of Variables Used in the Analysis

Variables	After Use of GNP Deflator Mean	Standard Deviation	Minimum Value	Maximum Value
D_1	.43	.15	.23	.87
D_2	3.37	.74	1.68	5.39
Percentage Share of Beef	.32	.23	-.04	.93
Percentage Share of Wheat	.25	.16	.00	.62
Percentage Share of Swine	.22	.28	-.0003	.93
Percentage Share of Sorghum	.15	.10	.00	.47
Gross Farm Income	90,094.09	68,081.24	23,128.20	412,646.53
Net Farm Income	20,539.20	17,952.13	-23,776.63	93,687.13
Acres per Operator	458.71	379.47	.00	1,858.29
Taxable nonfarm Income	2,212.34	3,006.17	.00	18,181.86
Machinery Investment per acre	34.29	20.11	9.58	176.21
Crop Production Cost per acre	43.85	12.99	20.03	95.46
Operator's age	45.95	8.50	25.00	67.00
Average rainfall for county in which farm is located	29.01	3.08	24.03	34.54
Beef Accrual gross income	26,623.89	32,358.26	-279.17	192,034.94
Swine Accrual gross income	22,437.85	49,271.05	-16.35	360,739.06
Government payments gross accrual income	2,295.05	1,549.30	127.65	11,639.47
Capital managed	438,132.00	251,570.69	116,961.75	1804,022.15
Number of operators (unhired labor)	1.16	.41	.57	3.00
Number of men (hired and unhired labor)	1.77	1.06	1.00	9.43
Wheat acres	305.54	258.74	.00	1,681.86
Sorghum acres	176.40	124.76	.00	638.86
Crop acres	725.63	459.14	74.29	3,243.43

This completes the discussion of the attempts and revisions that were made in trying to explore and estimate the relationship of diversification to variability of incomes.

Relationships Between Variability of Income and Other Farm Characteristics

Many relationships among income variability, diversification and other farm characteristics were hypothesized. Many of these relationships were then revised or rejected. Multicollinearity was apparent among size related variables which lead to inconsistent results until gross farm income was chosen as the single variable reflecting size. Other variables were then modified as ratios (such as acres per man) to remove the impact of size. Estimated coefficients for two equations are given in Table 3.

The variables gross farm income, acres per operator, taxable nonfarm income, and machinery-investment per acre were significantly related to variability of income.

Gross farm income, as a measure of size, was positively related to variability of income, suggesting that income variability is higher for larger farms. This seems reasonable since a farm with 100,000 dollars annual income would be expected to have a greater income variability (fluctuation of 10,000 to 20,000 dollars) than a farm with only a 10,000 dollar annual income which might only fluctuate 1,000 to 2,000 dollars. This could occur even though both farms have competent managers and are operating at the same level of efficiency.

Acres per operator also had a positive relationship to income variability which may be indicative of the possibility of management being spread too thinly so variability increases as one operator increases the number of acres or enterprises he attempts to manage in an operation.

Table 3. Regression Coefficients and T Values for 2 Equations Which Were Estimated to Investigate the Relationship Between Standard Deviation of Net Income and Other Farm Characteristics.

Independent variables	Equation using D_1	Equation using D_2
Gross farm income	.20 (16.37)	.20 (16.57)
Acres per operator	8.37 (3.78)	8.43 (3.85)
Taxable nonfarm income	.71 (2.55)	.70 (2.51)
Machinery investment per acre	-111.09 (-2.23)	-107.78 (-2.15)
Crop production cost per acre	-34.36 (-.42)	-39.40 (-.49)
Operator's age	-146.61 (-1.55)	-152.11 (-1.60)
Average rainfall for county in which farm is located	-289.18 (-1.11)	-267.05 (-1.02)
Measure of diversification	-86.13 (-.02)	-571.16 (-.54)
Intercept	22,105.64 (2.55)	23,793.53 (2.61)
R^2	.78	.78

The positive relationship between nonfarm income and variability of income suggests that farm operators may pursue more risky courses of action or spend less management time on their farm operations when they have nonfarm income. The tendency for incomes to vary more when nonfarm income is greater is again reasonable. Farmers might have a greater feeling of security with an alternate form of income and therefore, purposely not give their farming operation the full attention required. Or, they may not be able to give the attention necessary if the alternative occupation in which they are involved robs them of time which should be devoted to the farm operation. Nonfarm income is an important source of income to many farmers. Gardner and Pope state that income from nonfarm sources does exceed that from farm sources at the present time.

Machinery investment per acre and variability of income had a negative relationship suggesting that farms with more, newer, and/or larger equipment perform their operations more timely, which may reduce income variability. However, it is useful to know that large, expensive, or newer machinery may be contributing benefits, such as reduction in income variability.

The other four variables in the equations were not significantly related to income variability. The variables were crop production cost per acre, operator's age, average county rainfall and the measures of diversification.

The hypothesis that crop production cost per acre might be positively related to income variability was rejected. It was believed that higher crop production costs might result in high net incomes in good years but low net incomes in poor crop years.

Operator's age was included because it was thought that older operators might have different management goals and different operations than younger operators. Pope and Prescott also thought that younger or less experienced farmers would tend to be more specialized or they might be more speculative and less risk averse. They also might start small and specialized and become more diversified as the operation expands. This could be caused by the capital shortages faced by young farmers or the difficulty of less experienced farmers to manage diverse activities. All of these factors would suggest that income variability would be greater for younger operators. The coefficients were negative, indicating somewhat higher income variability for younger operators, but the coefficients were not statistically significant.

Previous work done by Pachta and Schurle had shown wheat yield variability to be significantly related to average rainfall, therefore average county rainfall was included in the model. Average county rainfall reflects geographical location in Kansas because precipitation declines from east to west. Negative coefficients in the model for average county rainfall indicated that the higher rainfall is slightly associated with less income variability, but the relationship was not statistically significant.

The possibility of the livestock sector contributing more to the standard deviation of net income than the crop sector was suggested. This possibility was immediately checked out by adding another independent variable to the regression analysis, no significant relationship showed up. Neither the livestock nor the crop sector was any more important than the other in effecting the standard deviation of net income or variability of net income.

Measures of diversification were variables included in the model. The coefficient for D_1 had a sign that indicated more diversified operations had higher variability of income, while the coefficient for D_2 had a sign indicating more diversified operations had lower variability of income. However, neither D_1 nor D_2 approached statistical significance. The equations reported here estimated linear relationships between diversification and variability of income. Other equations were estimated to investigate curvilinear relationships which could capture diminishing returns to diversification. However, no significant relationships were found.

This result may not be that surprising since diversification is subject to diminishing returns much like many inputs are in production functions.[64] The switch from one to two enterprises may provide the greatest variability reduction. Further diversification may be beneficial, but as each enterprise is added, the variability reduction becomes smaller. The average D_2 value indicates that farms had slightly more than 3 enterprises if each produced an equal share of the gross income. There were no farms that were specialized in only one crop. This suggests that farms may be diversified to the point where additional diversification has only minor impacts on income variability. Heady suggested previously that managerial limitations may give rise to some increase in variance as enterprises are added. The entrepreneur may make less efficient decisions as he spreads his expertise thinner over more obtaining added information and in making more decisions for an increased number of crop or livestock enterprises. The evidence Pope and Prescott came up with suggest the possibility of multicollinearity between diversification and size, i.e. gross farm income. In order to explore this possibility further, two more regression equations were estimated with all the variables in the previous equation except for gross farm income.

In the previously estimated equations average gross income had entered the regression as statistically significant. However, dropping this variable changed some of the other estimated relationships (Table 4).

Acres per operator and taxable-non-farm income still remained statistically significant. Operator's age also became statistically significant with a negative coefficient indicating the greater the age of the operator the less variability involved in the operation. All other variables were not statistically significant with the exception of D_1. This measurement entered the regression with a positive coefficient indicating the more specialized an operation the greater the variability of income.

Additional relationships were then investigated. First, it was found that D_1 was related significantly to average gross income having a T-value of 3.36 and a coefficient of 130827.48. Since the D_1 measure of diversification becomes larger with specialization this analysis indicated the more specialized farms tend to be larger in terms of average gross income.

The D_2 measure of diversification was not quite significant, T-value of -1.94 when regressed on average gross income. However, with the addition of D_2^2 to the regression both D_2 and D_2^2 became significant with T-values of -2.33 and 2.07 respectively and an R^2 value of .06. The coefficients were -128,840.70 and 16,763.29 respectively indicating once again that the more specialized farms tend to be larger. This

Table 4. Regression Coefficients and T Values for 2 Equations Investigating the Relationship Between Standard Deviation of Net Income and Other Farm Characteristics When Gross Farm Income Variable Was Dropped.

Independent variables	Equation using D_1	Equation using D_2
Acres per operator	13.44 (3.43)	12.57 (3.19)
Taxable nonfarm income	1.62 (3.29)	1.66 (3.34)
Machinery investment per acre	-120.54 (-1.35)	-114.64 (-1.26)
Crop production cost per acre	77.84 (.53)	148.31 (1.04)
Operator's age	-426.53 (-2.55)	-430.45 (-2.55)
Average rainfall for county in which farm is located	-887.67 (-1.92)	-851.09 (-1.81)
Measure of diversification	21,653.40 (2.20)	-2,973.61 (-1.56)
Intercept	52,219.88 (3.44)	67,735.22 (4.29)
R^2	.28	.27

regression suggested a curvilinear relationship between average gross income and the D_2 measure of diversification.

Regressions were also run on D_1 and D_2 as dependent variables and average gross income and average gross income squared as independent variables, but no statistically significant relationships were found.

Next, D_1 and D_2 were both run on variability of net income. In both cases D_1 and D_2 were significantly related to variability of income. D_1 had a T-value of 2.17 and a coefficient of 22218.15 and D_2 had a T-value of -2.09 and a coefficient of -4323.40. D_1 indicated the more specialization the more risk encountered in terms of variability of net income, while D_2 also showed the more specialization involved in an enterprise the greater the variability of income encountered. However, the R^2 was only .03 and .04 indicating that many other variables must also play a role in risk.

Relationships Between Efficiency and Other Farm Characteristics

Relationships between efficiency and other variables were then explored. The independent variables were: two measures of diversification, D_1 and D_2, average gross income, acres operated and owned over number of operators, crop production costs over crop acres, taxable non-farm income, machinery investment over crop acres, operator's age and rain. Efficiency was defined as average net income over average gross income.

Only machinery investment per acre and operator's age were statistically significant. Other variables were then investigated, the importance of different enterprises was investigated by including the percentage of gross income coming from each enterprise as an independent variable. Enterprises included beef share, swine share, wheat share, milo share a financial ratio, current and intermediate assets over loans was added to the model also.

Analysis of a regression model indicated the share variables were not contributing anything of statistical significance. The model was run again with only the asset to loan ratio variable included in the original model. Results were that only machinery investment per acre and the asset to loan ratio were statistically significant. Machinery investment per acre had a negative coefficient indicating the more machinery in an operation the less efficient it would be. Current and intermediate assets over loans showed a positive coefficient indicating the fewer debts or loans one acquires the more efficient the operation tends to be. No other variables were found to be statistically significant, not even the diversification measures, D_1 and D_2. This indicated that at least in this model and set of regressions, diversification did not appear to have a statistically significant impact on efficiency.

Because average gross income had been very important in the regressions on variability of net income, another run was made after dropping the average gross variable. The results remained almost identical to those attained when the average gross variable was included in the model.

When using D_1 as the measure of diversification the R^2 value remained the same at .38. The T-value and coefficients of the only two statistically significant variables, machinery investment and asset to loan ratio, also remained the same. Machinery investment had a T-value of -3.74 and a coefficient of -.0026. Asset to loan ratio showed a T-value of 3.85 and a coefficient of .0117.

Using the D_2 measurement of diversification the R^2 value also remained the same at .39. The T-values and coefficients of machinery investment and asset to loan ration, the only two significant variables once again, retained the same value as they had before the measure of size was eliminated from the model. Asset to loan ratio yielded a T-value of 3.86 and a coefficient of .0116, while machinery investment exhibited a T-value of -3.58 and a coefficient of -.0025. These are further illustrated in Table 5. The D_2 measurement of diversification was close to statistical significance with a T-value of -1.80 and a coefficient of -.0258 indicating the more diversification in an operation the less efficient it would tend to be.

This finding suggests that the variable average gross income, the measure of size used in this study, may play a much greater role in explaining the variability of net income or risk in an operation than it does in contributing to efficiency in an operation.

Finally, D_1 and D_2 were run on the measure of efficiency used in this study, which was defined as average net income over average gross income. D_1 was not statistically significant, but D_2 was very close with a T-value of -1.89. D_2^2 was added to D_2 in the regression of efficiency and both showed statistical significance. D_2 had a T-value of 2.90 and a coefficient of 0.33, while D_2^2 had a T-value of -3.22 and a coefficient of -.05, the R^2 value was .10. This relationship indicates a positive relationship between diversification and efficiency. This correlation between D_2, D_2^2 and efficiency might not be too surprising if one recalls the previous relationship found between D_2, D_2^2 and average gross income since average gross income is a part of the definition of efficiency in this study.

Table 5. Regression Coefficients and T Values for 2 Equations Which Were Estimated to Investigate the Relationship Between Efficiency and Other Farm Characteristics.

Independent variables	Equation using D_1	Equation using D_2
Acres per operator	-.000003 (-.10)	-.000045 (-.15)
Taxable nonfarm income	-.000016 (.42)	-.000019 (-.51)
Machinery investment per acre	-.0026 (-3.74)	-.0025 (-3.58)
Crop production cost per acre	-.0015 (-1.36)	-.0015 (-1.38)
Operator's age	.0023 (1.80)	.0022 (1.72)
Average rainfall for county in which farm is located	-.0041 (-1.15)	-.0032 (-.91)
Current and intermediate asset to loan ratio	.0017 (3.85)	.0016 (3.86)
Measure of diversification	.0672 (.89)	-.0258 (-1.80)
Intercept	.3393 (2.90)	.4325 (3.63)
R^2	.38	.39

Alternative Measures of Efficiency and Results

Alternative measures of efficiency of an operation were also used. Both rate of return on capital managed and rate of return on net worth were considered. These two variables along with their standard deviations were run in four stepwise regression procedures as dependent variables to find the independent variables which are related to them.

Results indicated that none of the independent variables were related to rate of return on net worth or variability of rate of return on net worth. However, rate of return on capital managed and variability or rate of return on capital managed were both investigated further. The variable rate of return on capital managed as a dependent variable was run with the following independent variables: operator's age, machinery investment per acre, asset over loan ratio, operated acres over number of operators, crop production costs over crop acres and average gross income. The first GLM regression was run without the inclusion of average gross income as an independent variable, this yielded no independent variables of statistical significance. When average gross income was added as an independent variable to the GLM regression the asset to loan ratio came close to being statistically significant and the average gross income was statistically significant (4.39 T-value) with an R^2 value of .16. The coefficient was .0000144 indicating that the larger the operation the greater the rate of return on the capital managed.

Next, a GLM regression was run with the standard deviation of rate of return on capital managed as the dependent variable. The independent variables were: D_1 (a measure of diversification), average rain received in county where farm is located, capital managed over number of men, operator's age, taxable non-farm income, operated acres over number of operators, machinery investment over crop acres and average gross income. The first GLM regression excluded average gross income as an independent variable. The R^2 value was .29 and 5 variables were statistically significant. With the inclusion of average gross income as an independent variable in the GLM regression the R^2 was raised to .31 while the coefficients remained basically the same. Four instead of five independent variables were statistically significant, but three others were very close to statistical significance as well.

The results of the model shown in Table 6 indicate several variables were significantly related to the standard deviation of rate of return on capital managed. D_1 had a positive coefficient indicating that more specialized operations had greater variability of rate of return on capital managed. Rain had a negative coefficient showing that farms with greater rainfall had lower variability of rate of return on capital managed. Capital managed per number of men had a negative coefficient showing that as capital managed per number of men increases the variability of rate of return on capital managed is actually slightly decreased. Finally operator's age had a negative coefficient indicating the older the operator the less variability of rate of return on capital managed.

The three variables that were close to statistical significance were taxable-non-farm income, operated acres per number of operators and average gross income (a measure of size). Only machinery investment per acre was not close to being statistically significant in this GLM regression.

To better understand the variables, rate of return on capital managed and standard deviation of rate of return on capital managed in this study, the mean of the data used for rate of return on capital managed in per-

Table 6. Regression Coefficients and T Values for the Equation Which Was Estimated to Investigate the Relationship Between Standard Deviation of Rate of Return on Capital Managed and Other Farm Characteristics.

Independent variables	Estimated equation
Acres per operator	.0014 (1.95)
Taxable nonfarm income	-.0001 (-1.75)
Machinery investment per acre	-.0161 (-1.42)
Operator's age	-.0677 (-2.51)
Capital managed per man	-.00001 (-3.96)
Average rainfall for county in which farm is located	-.2317 (-3.17)
Gross farm income	.000006 (1.79)
D_1 measure of diversification	5.0966 (3.26)
Intercept	16.1592 (5.70)
R^2	.31

centage terms was 2.73. The standard deviation was 2.57 with a minimum value of -4.34 and a maximum value of 10.58. The mean of the data used for the standard deviation of rate of return on capital managed in percentage terms was 6.16 with a standard deviation of 2.78 and a range of 1.57 to 19.26.

CHAPTER IV

IMPLICATIONS AND CONCLUSIONS

Implications

This analysis of relationships among variables suggest many implications. First, it was found that income is related to variability of income. This suggests that as an entrepreneur weighs the alternatives of whether or not he should try to increase his income he must also analyze whether he is willing to accept and withstand financially the accompanying increase in variability of income.

The curvilinear relationship between income and variability of income suggests that variability increases at an increasing rate as income increases. Thus at extremely high levels of income (beyond most of these farmers) variability of income may become a major concern. The positive relationship between income and variability of income should be well understood and evaluated by any individual contemplating a major decision.

Multicollinearity problems exist because diversification and gross farm income are correlated. These variables are so highly correlated that it is difficult to separate their respective effects on variability of income. Gross farm income, the variable measuring size, was eventually dropped in the investigation of variability of income since the inclusion of gross farm income in the regression equation influenced the estimated relationships of other variables to risk.

Several other farm characteristics are also related to variability of income. Acres per operator and taxable nonfarm income both had positive relationships to risk and were significant before dropping gross farm income as well as after dropping gross farm income as an independent variable. As the number of acres per operator increases the variability of net income also increases. This may primarily be due to the possibility of spreading management too thinly over too many acres leading to untimely operations or decisions. Whenever taxable nonfarm income is present there tends to be an increase in variability of net income. This relationship may be attributed to the pursuance of more risky adventures triggered from a feeling of security or the lack of time and effort spent in the management of the operation.

The age of the operator had a negative relationship to the variability of income, so that as the operator's age increased, the risk associated with his operation decreased. Management decisions may change over time with experience or the problem of capital shortages faced by young enterpreneurs may be reflected in this relationship. Operator's age had a negative relationship before and after gross income was dropped; however, the relationship was insignificant previous to gross incomes removal. Once gross income was dropped, the negative relationship to income variability became significant.

Average rain per county exhibited negative relationships to risk, but were insignificant until gross income was dropped. When gross income was removed average rain per county became close to significant and still retained a negative relationship. The negative relationship would indicate that as rainfall increased variability of income would decrease. This finding is substantiated by previous work done by Pachta and Schurle as they showed that wheat yield variability was significantly related to average rainfall.

The significance of the diversification measures, D_1 and D_2, depended on whether gross farm income was included as an independent variable. After dropping gross income the D_1 measure of diversification came into the equation significantly with a positive relationship indicating that the more specialized an operation is the more variability of income it encoucountered. Diversification measure D_2 was insignificant before dropping gross income, but after removing gross income D_2 came close to being significant with a negative relationship. This would indicate that as diversification increased variability of income decreased.

Other variable relationships to variability of income were also investigated, but were found to be insignificant. It was hypothesized that crop production cost per acre might be positively related to income variability. The reasoning was that higher crop production costs could result in high net incomes in good weather years, but low net incomes in drought years, thus resulting in high income variability. Before dropping gross income crop production costs per acre were found to have a negative relationship to risk but were insignificant. After gross farm income was dropped crop production cost per acre was found to have a positive but insignificant relationship to risk.

Machinery investment per acre was significant and had a negative relationship to risk. However, after dropping gross income, the relationship between machinery investment per acre and variability of income became insignificant.

Other important implications might be suggested from the investigation of efficiency which was measured as average net income over average gross income. Machinery investment per acre exhibited a significant negative relationship to efficiency. This suggests that one might try to make the wisest purchases of machinery possible to keep this investment to a minimum and, thus be operating as efficiently as possible in this manner. Another strategy to enchance efficiency is to keep the debts and loans acquired to a minimum as the current and intermediate asset to loan ratio exhibited a positive relationship to efficiency. Other things might be sacrificed in this attempt to attain efficiency, but those tradeoffs must be evaluated.

Variability of rate of return on capital managed relationships also suggest important implications. As the average amount of rain for location of farm increased, the variability of rate of return on capital managed decreased. This would indicate that the farmer who can locate his operation in an area of greater rather than lesser amounts of rainfall might have somewhat of an advantage and could possibly afford to invest more in a location which received more rainfall.

When capital managed per number of men increased, the variability of rate of return for capital managed actually showed a slight decrease. The implication here might be that as an individual manages more and more capital he is either able to take advantage of economies of scale, such as lower costs for his supplies or greater prices for his products, or he may have better capabilities and skills in the management of capital.

A decrease was also found in the variability of rate of return on capital managed whenever the operator's age increased. This suggests that older operators may be better managers of capital or they may pursue less risky options in their operations.

The D_1 measure of diversification showed that as specialization increases in an operation so does the variability of rate of return on capital. This implies that one could diversify an operation in order to decrease the amount of variability of rate of return on capital.

Finally, some worthwhile implications can be realized from the relationships of diversification to size, risk and efficiency. Size was defined as average gross income in the study. The D_1 measure of diversification indicated that the more specialized farms tend to be larger in terms of average gross income. The D_2 measure of diversification combined with its squared value also showed that the larger farms (in terms of average gross income) tended to be more specialized operations. An implication from this analysis is that the larger farms in this data tended to be more specialized and less diversified.

Risk was defined as variability of net income in this study and both measures of diversification (D_1 and D_2) were found to be statistically significant. This suggests that with greater specialization comes more risk or greater variability in average net income. Alternately stated the more diversification in an operation the less risk in the form of variability of average net income encountered. However, this estimated relationship had a very low R^2 value indicating that diversification may play a part in reducing risk, but many other variables are involved also. This would imply that any entepreneur wishing to reduce risk or variability of net income should diversify his operation to some extent.

Average net income over average gross income (one measure of efficiency used in this study) is related to average cost per dollar of gross income produced. This is conceptually related to average costs which are smaller for large farms when economies of size exist. Previous studies of economies of size in agriculture indicate that average costs dropped drastically at first, but then flattened out indicating that very few additional reductions of average cost were obtained once the initial economies of size had been achieved. Results of this research indicate little relationship between average net over average gross and gross income, the measure of size. This finding agrees with previous studies on economies of size.

When the two measures of diversification were analyzed with efficiency, defined as average net income over average gross income, D_1 was found not statistically significant while a regression with both D_2 and D_2^2 showed statistical significance. This indicated that the more diversified an operation the more efficient it tends to be. The implication here would be that at least some form of a curvilinear relationship exists between D_2 and efficiency. Therefore, it might be a worthwhile consideration for a manager trying to be as efficient as possible to investigate diversification as a method to increase efficiency.

Conclusion

The results of this study suggest that some variables are related to risk and efficiency. Some of these variables are under the control of the operator who can use them to reduce risk and improve efficiency of his operation. Many significant relationships and general implications were discovered throughout the study and could be applied to entrepreneurs in general.

Several cautions are in order in the interpretation of these results. The farmers in the sample are probably not the average type of farm manager. Most were very progressive in their business endeavors and managed commercial operations. Also many of the measures in this study should be further analyzed. This includes the two measures of diversification, the measure of size (average gross income), the measure of risk (variability of net income), and perhaps most controversial, the measure of efficiency (average net income over average gross income). Multi-collinearity as well as overlooked correlations are also possibilities. Whether the correct variables in the data were used or whether different procedures should be used to investigate and evaluate the findings should be considered. In addition, every manager could be further analyzed and categorized as risk takers, risk neutral or risk averters. The relationship of personal risk preferences to risk could then be analyzed. This would improve the analysis attempted in this study.

Additional research should be done in this area. Much more research is needed in the investigation and determination of acceptable and accurate measures of diversification, size, risk, and efficiency. More investigation is needed on diversification itself, specifically the degrees that such a management strategy should be used to reduce the risk encountered and improve the efficiency of an operation.

FOOTNOTES

[1] James B. Kliebenstein, and John T. Scott Jr., "Assessment of Risk When Contract Crops Are Included Among Other Crop Alternatives," Southern Journal of Agricultural Economics, p. 105, December, 1975.

[2] E. Heady, Economics of Agricultural Production and Resource Use (New York: Prentice-Hall, Inc., 1952), p. 510.

[3] B. F. Stanton, "Perspective on Farm Size, "American Journal of Agricultural Economics, 60:731, December, 1978.

[4] E. Heady, Economics of Agricultural Production and Resource Use (New York: Prentice-Hall, Inc., 1952), p. 440.

[5] Ibid.

[6] James B. Kliebenstein, and John T. Scott Jr., "Farm Production Decision-Making Using Quadratic Programming-An Empirical Application," Department of Agricultural Economics, Agricultural Experiment Station (University of Illinois at Urbana-Champaign, April, 1975), p. 3.

[7] John T. Scott Jr., and James B. Kliebenstein, "Assessment of Risk When Contract Crops Are Included Among Other Crop Alternatives," Department of Agricultural Economics Report, (University of Illinois at Urbana-Champaign, 1973), contribution number AE-4318.

[8] James B. Kliebenstein, and John T. Scott Jr., "Farm Production Decision-Making Using Quadratic Programming-An Empirical Application," Department of Agricultural Economics, Agricultural Experiment Station (University of Illinois at Urbana-Champaign, April, 1975), p. 3.

[9] Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 531.

[10] Thomas A. Miller, "Risk Management and Risk Preferences in Agriculture: Discussion," American Journal of Agricultural Economics, 61:1082, December, 1979.

[11] E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), p. 524.

[12] Ibid, pp. 536-537.

[13] Peter J. Barry, and Donald R. Fraser, "Risk Management in Primary Agricultural Production: Methods, Distribution, Rewards, and Structural Implications," American Journal of Agricultural Economics, 58:289, May, 1976.

14
Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 531.

15
Ibid., p. 533.

16
E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), p. 529.

17
Ibid., p. 521.

18
Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 534.

19
E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), p. 461.

20
James B. Kliebenstein, and John T. Scott Jr., "Assessment of Risk When Contract Crops Are Included Among Other Crop Alternatives," Southern Journal of Agricultural Economics, p. 108, December, 1975.

21
E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), p. 449.

22
Ibid., p. 547.

23
Ibid., p. 439.

24
Ibid., pp. 453-454.

25
Ibid., pp. 500-501.

26
Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 515.

27
E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), p. 465.

28
Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 516.

29
Ibid., p. 519.

30
E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), p. 530.

31
Ibid., p. 522.

32
Ahmed A. Araji, "The Affect of Vertical Integration on the Production Efficiency of Beef Cattle Operations," American Journal of Agricultural Economics, 58:101, February, 1976.

[33] Mahlon George Lang, "Economic Efficiency and Policy Comparisons," American Journal of Agricultural Economics, 62:772-773, November, 1980.

[34] E. C. Pasour, Jr., and J. Bruce Bullock, "Implications of Uncertainty for the Measurement of Efficiency," American Journal of Agricultural Economics, 57:335, May, 1975.

[35] E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), pp. 706-707.

[36] Pasour, op. cit., p. 338.

[37] B. F. Stanton, "Perspective on Farm Size," American Journal of Agricultural Economics, 60:728-729, December 1978.

[38] William Franklin Lagrone, "The Great Plains," Another Revolution in the U.S. Farming?, U. S. Department of Agriculture (Washington, D.C.: U.S. Government Printing Office, 1979), p. 339.

[39] Bruce F. Hall, and E. Phillip LaVeen, "Farm Size and Economic Efficiency: The Case of California," American Journal of Agricultural Economics, 60:591, November, 1978.

[40] Lagrone, op. cit., p. 339.

[41] Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 451.

[42] Eddy L. LaDue, "Toward a More Meaningful Measure of Firm Growth," American Journal of Agricultural Economics, 59:215, February, 1977.

[43] LaDue, op. cit., pp. 210-211.

[44] Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), pp. 449-450.

[45] B. F. Stanton, "Perspective on Farm Size," American Journal of Agricultural Economics, 60:728-729, December, 1978.

[46] Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 452.

[47] Phillip M. Raup, "Some Questions of Value in Scale in American Agriculture," American Journal of Agricultural Economics, 60:305, December, 1969.

[48] J. B. Penn., "The Changing Farm Sector and Future Public Policy: An Economic Perspective," Agricultural Food Policy Review: Perspectives For the 1980's, Economics and Statistics Service, U.S. Department of Agriculture (Washington D.C., April, 1981), p. 50.

[49] Bruce T. Hall, and E. Phillip LaVeen, "Farm Size and Economic Efficiency: The Case of California," American Journal of Agricultural Economics, 60:589, November, 1978.

[50] Earl O. Heady and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 463.

[51] J. B. Penn., "The Changing Farm Sector and Future Public Policy: An Economic Perspective," Agricultural Food Policy Review: Perspectives For the 1980's, Economics and Statistics Service, U.S. Department of Agriculture (Washington D.C., April, 1981), p. 52.

[52] Earl O. Heady and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 454.

[53] Bruce T. Hall, and E. Phillips LeVeen, "Farm Size and Economics Efficiency: The Case of California," American Journal of Agricultural Economics, 60:594-596, November, 1978.

[54] Ibid., p. 591.

[55] Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), p. 452.

[56] Ibid., p. 471.

[57] Hall, op. cit. p. 596.

[58] Earl O. Heady, and Harald R. Jensen, Farm Management Economics (Prentice-Hall, Inc., New Jersey, 1954), pp. 473-474.

[59] Hall, op. cit., p. 590.

[60] B.F. Stanton, "Perspective on Farm Size," American Journal of Agricultural Economics, 60:729-730, December, 1978.

[61] Hall, op. cit., p. 599.

[62] Roger G. Johnson, and Steven C. Hvinden, "Labor and Management Components in Economics of Farm Size Studies," Western Journal of Agricultural Economics, 3:205, December, 1978.

[63] Ibid., pp. 208-209.

[64] E. Heady, Economics of Agricultural Production and Resource Use (Prentice-Hall, Inc., New York, 1952), p. 516.

BIBLIOGRAPHY

Araji, Ahmed A., "The Effect of Vertical Integration on the Production Efficiency of Beef Cattle Operations," American Journal of Agricultural Economics, 58:101-104, February, 1976.

Barry, Peter J., and Donald R. Fraser. "Risk Management in Primary Agricultural Production; Methods, Distribution, Rewards and Structural Implications," American Journal of Agricultural Economics, 58:286-95, May, 1976.

Carter, H.O., and G.W. Dean. "Income, Price and Yield Variability For Principal California Crops and Cropping Systems," Hilgardia, pp. 175-218. California Agricultural Experiment Station. University of California at Berkeley, October, 1960.

Crop and Livestock Reporting Service. Sixty Third Annual Report and Farm Facts. Kansas State Board of Agriculture. U.S. Department of Agriculture, 1979.

Gardner, B. Delworth, and Rulon D. Pope. "How is Scale and Structure Determined in Agriculture?," American Journal of Agricultural Economics, 60:295-302, May, 1978.

Hall, Bruce F., and E. Phillip LeVeen. "Farm Size and Economic Efficiency: The Case of California," American Journal of Agricultural Economics, 60:589-600, November, 1978.

Heady, Earl O., "Diversification in Resource Allocation and Minimization of Income Variability," Journal of Farm Economics, 34:482-96, November, 1952.

Heady, E., Economies of Agricultural Production and Resource Use. New York: Prentice-Hall, Inc., 1952.

Heady Earl O., and Harald R. Jensen. Farm Management Economics. New Jersey: Prentice-Hall, Inc., 1954.

Johnson, Roger G., and Steven C. Hvinden. "Labor and Management Components in Economies of Farm Size Studies," Western Journal of Agricultural Economics, 3:205-10, December, 1978.

Johnson, S.R., "A Re-examination of the Farm Diversification Problem," American Journal of Agricultural Economics, 49:610-21, August, 1967.

Kliebenstein, James B., and John F. Scott Jr., "Assessment of Risk When Contract Crops are Included Among Other Crop Alternatives," Southern Journal of Agricultural Economics, pp. 105-10, December, 1975.

Kliebenstein, James B., and John F. Scott Jr. "Farm Production Decision-Making Using Quadratic Programming-An Empirical Application," Department of Agricultural Economics. Agricultural Experiment Station. University of Illinois at Urbana-Champaign, April, 1975.

LaDue, Eddy L. "Toward a More Meaningful Measure of Firm Growth," American Journal of Agricultural Economics, 59:210-15, February, 1977.

Lagrome, William Franklin. "The Great Plains," Another Revolution in U.S. Farming?, pp. 335-61. U.S. Department of Agriculture. Washington D.C.: U.S. Government Printing Office, 1979.

Lang, Mahlon George. "Economic Efficiency and Policy Comparisons," American Journal of Agricultural Economics, 62:772-77, November, 1980.

Miller, Thomas A. "Risk Management and Risk Preferences in Agriculture: Discussion," American Journal of Agricultural Economics, 61:1081-82, December, 1979.

Pachta, Jim, and Bryan Schurle. "A Study of Farm Wheat-Yield Variability," Department of Agricultural Economics. Kansas Agricultural Experiment Station. Kansas State University at Manhattan. Contribution number 80-326-D, April, 1980.

Pasour Jr., E.C., and J. Bruce Bullock. "Implications of Uncertainty for the Measurement of Efficiency," American Journal of Agricultural Economics, 57:335-39, May, 1975.

Penn, J.B. "The Changing Farm Sector and Future Public Policy: An Economic Perspective," Agricultural Food Policy Review: Perspectives For the 1980's, pp. 27-58. Economics and Statistics Service. U.S. Department of Agriculture, Washington D.C., April, 1981.

Perrin, Richard, and Don Winkelmann. "Impediments to Technical Progress on Small versus Large Farms," American Journal of Agricultural Economics, 58:888-94, December, 1976.

Pope, Rulon D., and Richard Prescott. "Diversification in Relation to Farm Size and Other Socioeconomic Characteristics," American Journal of Agricultural Economics, 62:554-59, August, 1980.

Raup, Philip M. "Economies and Diseconomies of Large-Scale Agriculture," American Journal of Agricultural Economics, 51:1274-83, December, 1969.

Raup, Philip M. "Some Questions of Value in Scale in American Agriculture," American Journal of Agricultural Economics, 60:303-08, May, 1978.

Schertz, Lyle P. "A Dramatic Transformation," Another Revolution in U.S. Farming?, pp. 13-41. U.S. Department of Agriculture. Washington D.C.: U.S. Government Printing Office, 1979.

Schertz, Lyle P. "A Preview of the Future," Another Revolution in U.S. Farming?, pp. 76-82. U.S. Department of Agriculture. Washington D.C.: U.S. Government Printing Office, 1979.

Scott Jr., John F. and James B. Kliebenstein. "Assessment of Risk When Contract Crops are Included Among Other Crop Alternatives," Department of Agricultural Economics Report. University of Illinois at Urbana-Champaign. Contribution number AE-4318, 1973.

Stanton, B.F. "Perspective of Farm Size," American Journal of Agricultural Economics, 60:727-37, December, 1978.

Viner, Jacob. Cost Curves and Supply Curves, Readings in Price Theory, pp. 198-232. The American Economic Association. Illinois: Richard D. Irwin, Inc., 1952.

Zenger, Sheldon, and Bryan Schurle. "The Impact of Diversification on Farm Risk," Department of Agricultural Economics, Kansas Agricultural Experiment Station. Kansas State University at Manhattan. Contribution number 81-33-A, May, 1981.

THE RELATIONSHIP OF DIVERSIFICATION TO RISK AND EFFICIENCY

by

SHELDON RAY ZENGER

B. S., Kansas State University, 1980

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Economics
Agricultural Economics

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

ABSTRACT

The purpose of this study is to use farm data and empirical analysis to estimate relationships of diversification to risk and efficiency. Data came from Association #1 of the Kansas Farm Management Associations and included 128 farms. Seventy-two variables, such as acres owned and operated, average net income, machinery investment, taxable nonfarm income and operator's age were collected for each farm from 1973 to 1979. Regression analysis was used to investigate the relationships among the averages and standard deviations of these 72 variables. Various types of measures for diversification, risk, size and efficiency are used. Risk is measured as variability of average net income, efficiency as average net income over average gross income, and size as average gross income (other size related variables are turned into ratios to nullify the size affect such as capital managed per men or machinery investment per acre). Diversification is measured in two ways: $D_1 = \sum_{i=1}^{N} P_i 2$ and $D_2 = N - \frac{N}{2} \{ | P_1 - \frac{1}{N} | + | P_2 - \frac{1}{N} | + \ldots + | P_N - \frac{1}{N} | \}$ where N = the maximum number of enterprises and P_i = proportion of the business in enterprise i.

The relationship between income and variability of income is found to be complimentary only at negative income levels. A competitive relationship exists at positive income levels such that increases in income are generally accompanied by increases in variability of income and variability increases at an increasing rate as income increases.

Variability of net income is also found to be significant to such farm characteristics as acres per operator, taxable nonfarm income, operator's age and diversification.

Efficiency is found to be statistically significant to machinery investment per acre and current and intermediate asset to loan ratio.

Significant relationships are discovered between variability of rate of return on capital managed and four other farm characteristics, diversification, average amount of rainfall for farm, capital managed per number of men and operator's age.

Direct significant relationships are also found between diversification and average gross income, variability of average net income and efficiency. However, these findings have such low R^2 values that it would tend to suggest that even though diversification may be related to size, risk and efficiency, many other variables and characteristics must also be affecting them.