BUSINESS RISK IN RELATIONSHIP WITH FARM SIZE AND OTHER FARM CHARACTERISTICS

by

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CHAPTER I

Introduction

In the last thirteen years Great Plains farmers have experienced some of the best years in modern agriculture and also some of the worst since the "Great Depression". In 1973 the Russian grain deal and a world shortage of food increased the export demand for U.S. agricultural commodities which in turn increased the prices of those commodities and the incomes of farmers. The increase in prices spurred farmers around the world to increase production, "planting fence row to fence row", thus producing more than enough to handle the increased demand. The United States was in an excess capacity position in the late seventies which caused surpluses which led to reduced commodity prices and farm income. The reduction of commodity prices coupled with high real interest rates in the eighties has caused severe stress on farm businesses. Even with this instability in the agricultural economy, Great Plains farmers are continuing to operate and trying to survive.

All those who have worked closely with farmers know that uncertainties and risks are great. They stem from many sources, natural and otherwise, such as weather, disease, and variations in market prices.[1] Risk and uncertainty are terms that are frequently used interchangeably, however they have different implications when it comes to resource use according to Heady. Heady defines risk as referring to variability of outcomes which are measurable in an empirical or quantitative manner. Uncertainty is always present when knowledge of the future is less than perfect in the sense that the parameters of the probability distribution cannot be determined.

Uncertainty is of a "subjective" nature according to Heady.[2]

Farmers would benefit from knowing the main contributors to risk and uncertainty in their operations. With this type of information they may be able to develop a plan of action to reduce risk. Business firms encounter two kinds of risk, business and financial. Business risk refers to the variation in net income resulting from the type of business in which the firm is engaged. Financial risk refers to the relatively greater losses that occur under unfavorable business conditions when financial leverage is high.[3]

Diversification is one of the methods proposed to reduce variability by using a combination of enterprises to stabilize income. Hoping when one enterprise produces a low income another will have a high one. Enterprises whose returns are negatively correlated or have negative covariances are the most beneficial in reducing risk.

Agricultural programs also stabilize income. Programs during the study period were designed to reduce risk or reduce loses. Disaster payments in programs reduced risk associated with yield variability by paying producers when crops were destroyed by natural disasters. Loan programs and deficiency programs reduce price risk by holding a floor under prices or paying the difference in a payment between loan rate or market price and target price.

Farmers today are concerned about the relationship between the size of farm, risk and economic efficiency. They are interested in whether a larger farm is more economically efficient and if it is worth the risk to increase size of their farm. With present situation of farm foreclosures and government farm programs, farmers are interested in knowing whether adding available resources to increase size is in their best interest.

Researchers have worked with models to incorporate risk into decision making in the past. They have used simulated farm models and state or USDA regional data to study risk, however little work has been done with actual farm data to study farm income variability and characteristics of farms which are related to income variability.

The approach taken in this study is to analyze farm data to estimate relationships between characteristics of the farms and variability of farm income. This study may help provide Great Plains farmers with a better understanding of the sources of risk and relationships between risk and size of operation.

The objectives of this study are as follows:

1. To measure variability of net farm income, gross farm income, and farm expenses.
2. To examine the relationship between size of farm and the variability of net farm income, gross farm income, and farm expenses.
3. To estimate the relationship between variability of net farm income, gross farm income, and farm expenses and other farm characteristics such as diversification, government program payments, age of operator, enterprises of farm, machinery investment per acre, financial obligation, and location.

Justification for the Study

Variability of farm income and farm expenses in relation to farm characteristics is of major concern to Great Plains farmers. However, little research has been done with farm data to examine these relationships.

In this study farm data is analyzed to estimate the relationship between size of farm and other farm characteristics, and variability of net farm income, gross farm income and farm expenses. A purpose of this study is to estimate the relationship between size of farm and variability of farm income and expenses, to give farmers an idea of how size affects business risk.

Diversification has long been thought to reduce variability of income on the farm. Diversification will be discussed and the relationship to income variability will be estimated from farm data.

A final justification of the study will be to consider the relationships between other farm characteristics such as government program payments, age of operator, enterprises of farm, location, machinery investment per acre, and financial obligation of farm to variability of farm income and expenses. This may provide information so that farmers and researchers are better able to understand how these farm characteristics affect business risk.

Organization of Thesis

This thesis contains five chapters. The first chapter includes a justification of the study, three primary objectives of the study are stated at the outset of the chapter, and a description of the farm data set is included. The description of the farm data set gives a well rounded description of the types and sizes of farms in the study. The average, minimum, and maximum values of many farm characteristics are used to help better acquaint the reader with the type of information used in the study. Chapter two includes a review of the literature related to the study. References are made to previous studies and schools of thought dealing with such subjects as risk and uncertainty, business and financial risk, measures of size, and diversification.

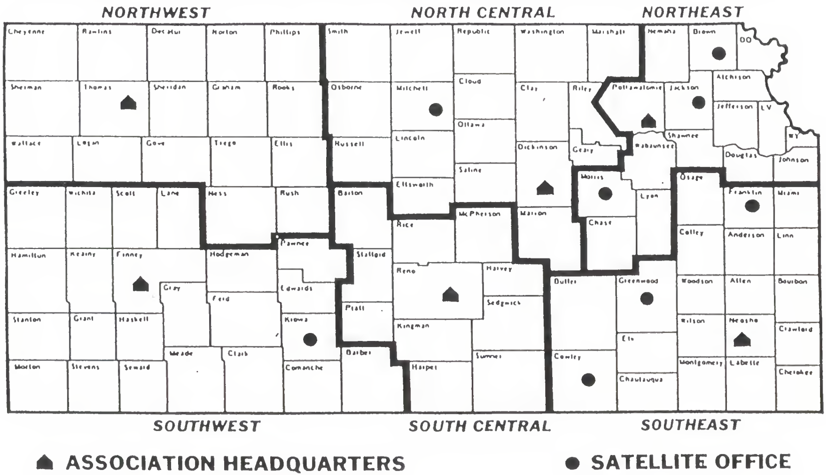
The third chapter is the theoretical framework for the study. A statistical investigation of risk/size relationships are made. Chapter four is the main body of the study. The chapter includes descriptions of the methods used, description of the variables used and results of the models used to investigate the objectives previously outlined. Chapter five of the study states the implications and limitations of the study. Conclusions and suggestions for further research are also included in this chapter.

Description of Farm Data

The data used in this study is from the Kansas Farm Management Association Program. The program consists of six separate associations (Figure 1). The associations have several types of farms such as cattle, wheat, swine, dairy, corn, sorghum, and mixtures

FIGURE 1.

KANSAS FARM MANAGEMENT ASSOCIATIONS

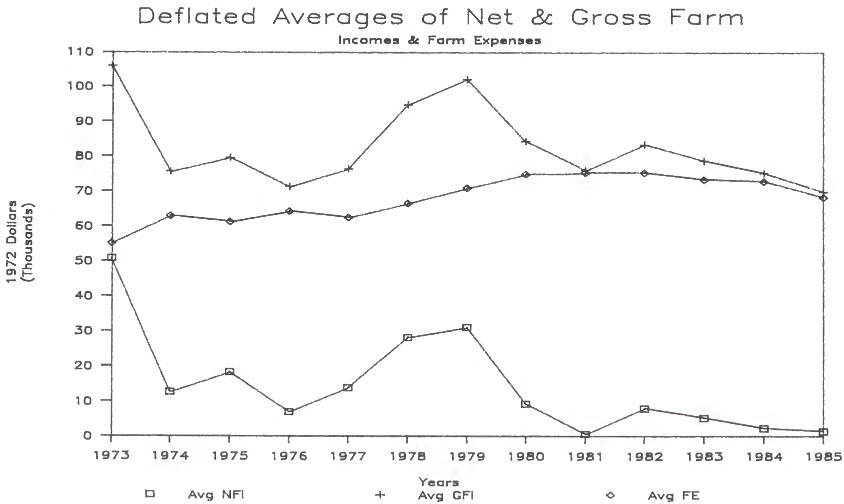


of each, thus providing information on a broad range of Kansas farms. However, it should be noted that farms used in the study are not a random sample of Kansas farms. Farms in the farm management associations in Kansas tend to be commercial operations with progressive managers, so the results may not apply to non commercial farms.

A total of 687 farms over a thirteen year period, 1973 through 1985, will be used in the study. One hundred and five variables for each year and farm are used in the analysis . Some variables used in the analysis were generated using the farm data and price series information. The variables used in the analysis provide a description of the farms in the study. Variables were deflated to 1972 dollars, using a GNP implicit deflator. Several income and expense measures provide information on the volume of business on the farm. Figure two shows the average gross and net farm incomes and farm expenses for all the farms by year. Table one has some descriptive statistics of characteristics of the farms in the data set. Average gross farm income over all the farms for the period was $82,660 ranging from $8,476 to $695,625. Average net farm income was $14,589 ranging from $-42,346 to $86,029. Average farm expenses for the period was $68,071 ranging from $8,266 to $698,064. Government payments per farm averaged $3,115 and ranged from $0.00 to $16,629.

Size of the farm can be measured by the capital managed. Average capital managed per farm varied some in that the average was $503,458 and ranged from a minimum of $96,125 to a maximum of $2,505,129. Interest payments average is $7,976 and ranges from $0.00 to $83,209.

FIGURE 2.



Deflated Averages of Net & Gross Farm
Incomes & Farm Expenses
1972 Dollars (Thousands)
110
100
90
80
70
60
50
40
30
20
10
0
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
Years
Avg NFI
Avg GFI
Avg FE

Depreciation on buildings, machinery, and equipment average is $9,780 with a minimum of $788 and a maximum of $73,856. The average machinery investment per acre is $32 ranging from $4 to $139.

Size of the farm can also be measured by the acres in the operation. The total acres operated average is 1448 acres with a minimum of 160 acres and a maximum of 7,542 acres. Owned acres operated average is 614 acres ranging from 0.0 to 5,672 acres. Rented acres operated average is 838 acres ranging from 0.0 to 7,925 acres. The average for total crop acres is 884 acres with a minimum of 13 acres to a maximum of 7,300 acres. The farms irrigated crop acres average is 105 acres with a minimum of 0.0 and a maximum of 2,655 acres. Dryland crop acres average is 778 acres ranging from 0.0 to 7,166 acres. The average for pasture land per farm is 527 acres, ranging from 0 to 8,638 acres.

The enterprise sizes, also help describe the farm in the study. The average wheat acreage per farm is 324 acres ranging from 0.0 to 2,369 acres. The average corn acreage is only 65 acres with a minimum of 0.0 and a maximum of 1,518 acres. The grain sorghum average acreage is 138 acres ranging from 0 to 1,416 acres. The soybean average acreage is 69 acres ranging from 0 to 720 acres. Alfalfa hay acreage average is 25 acres with a minimum of 0 and a maximum of 261 acres. The average beef cow herd is 38 ranging from 0.0 to 479 cows. The average dairy herd is 7 cows ranging from 0.0 to 333 cows. The average number of swine litters farrowed is 17 ranging from 0.0 to 975. The average number of feeder cattle handled per farm is 153 ranging from 0.0 to 3,869. The average number of feeder pigs handled

Table 1. Descriptive Statistics of the Variables Used to Describe the Farm Data Set After Use of GNP Deflator.

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Net farm income	14,589	13,450	-42,346	86,029
Gross farm income	82,660	63,041	8,476	695,625
Farm expenses	68,071	58,464	8,266	698,064
Government Payments	3,116	2,595	0.0	16,629
Capital managed	503,458	281,995	96,125	2,505,129
Interest payments	7,976	9,382	0.0	83,209
Depreciation	9,870	6,618	788	73,856
Machinery investment per acre	32.00	17.00	4.00	139.00
Acres operated	1,448	1,029	160	7,542
Owned acres operated	614	588	0.0	5,672
Rented acres operated	838	835	0.0	7,925
Total crop acres	884	730	13	7,300
Irrigated acres	105	292	0.0	2,655
Dryland crop acres	778	655	0.0	7,166
Pasture land	527	771	0.0	8,638
Wheat acres	324	332	0.0	2,369
Corn acres	65	143	0.0	1,518
Milo acres	138	133	0.0	1,416
Soybean acres	69	114	0.0	720
Alfalfa hay acres	25	37	0.0	261
Beef cows	38	58	0.0	479
Dairy cows	7	26	0.0	333
Number of hog litters	17	59	0.0	975
Number of feeder cattle handled	153	311	0.0	3,869
Number of feeder pigs handled	142	424	0.0	20,545
Number of operators	1.14	0.0	0.2	4.3
Number of men	1.75	1	0.5	6.78
Average age of operator	50	9	28.4	73.76

per farm is 142 ranging from 0.0 to 20,545.

The number of operators (unhired labor) for the farms range from .2 to 4.3 men and the average is 1.14 operators. The number of men (both hired and unhired labor) involved in the operations range from one half to 6.78 men and average one and three quarters. The average age of the operators over the study period is 50 years of age with a minimum of 28.4 years to a maximum of 73.76 years of age. The average age of the operator is the average of all the operators average ages over the study period.

Notes

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), pp. 440-443.

3. Warren F. Lee, Michael D. Boehlje, Aaron G. Nelson, and William G. Murray, Agricultural Finance Seventh Edition, Iowa State University Press, Ames, Iowa, 1980, p. 226.

Chapter II

Literature Review

This chapter discusses the literature that is relevant to the study. The first section of the chapter looks at the aspects of risk and uncertainty, types of risk, measures of size and the relationship of diversification to risk and uncertainty.

Risk and Uncertainty

The terms risk and uncertainty are often used interchangeably. Farmers are prone 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.[1] Risk refers to variability of outcomes which are measurable in an empirical or quantitative manner. The outcome for each particular item need not be predictable. It is only necessary that the probability of outcome 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 the knowledge of the future is less than perfect. Uncertainty is subjective in nature. Uncertainty refers to anticipations of the future and is peculiar to the mind of each individual producer. Uncertainty is subjective in the sense that the entrepreneur 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 perfect knowledge of significant future events. Significant events are all occurrences which, if foreseen perfectly, would have influenced a particular decision.[2]

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 prices from historical information. Uncertainty arises from weather, insects, diseases, unpredictable market forces, and other miscellaneous forces with unknown probabilities of occurrence.[3]

A definite difference exists between the terms risk and uncertainty, according to Kliebenstein and Scott. In the early theoretical work 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. Much of the work involving assessment of risky alternatives has involved an hypothesized distribution of outcomes and a hypothesis of how outcomes of different activities are related.[4]

Risk can be defined as variability of income. 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.[5]

Types of Risk

Two types of risks, business and financial risk, are encountered by farms and businesses. Business risk refers to the variations in net income resulting from the type of business in which the firm is engaged. Financial risk refers to the relatively greater losses that occur under unfavorable business conditions when financial leverage is high. The interaction between business and financial risk is described as the principle of increasing risk. Increased leverage tends to magnify potential gains as well as potential losses; and as leverage increases, the spread between them increases.[6] The so-called "principle of increasing risk" suggests that as a firm expands by use of borrowed capital the chance of loss of its own capital increases.[7]

Business risk is defined to be the risk inherent in the firm, independent of the way it is financed (Van Horne, pp. 207-8). Business risk generally is measured by the variability of net operating income or net cash flows. A high coefficient of variation of net cash flows, for example, would indicate high business risk. Business risk may be evaluated at a point in time based on the probability distribution of net cash flows.[8]

There are two major external sources of business risk in the agricultural firm. One is the market which produces price variability for both outputs and inputs and uncertain availability and quality of the latter. The other source is the biophysical environment which produces yield or production variability. These elements combine to form the bulk of business risk on the farm. The level of business risk also is influenced by internal factors such as investment decisions and management skills.[9] This study deals primarily with business risk.

Measures of Size

A perfect measure of size is impossible to attain. What is actually done is to choose that measurement of size for each industry which is workable and at the same time comes nearest to meeting the requirements of an ideal measure.[10] Measures of farm size vary from acres of land, amount of labor used, livestock units, value of farm product sales, level of farm income, total family income, net worth of operation, capital managed, value of farm products produced, and economic class.

Most frequently, farm size is spoken of in terms of acres, the land input. But this measure is not sufficient, except perhaps in a few areas of single crop farming. The land measurement is inadequate as a measure of farm size because it considers only one resource, land. For this reason acreage does not serve as a satisfactory measure of size.[11]

Commonly used size measures can be categorized as physical and financial measures of input and output. LaDue believes that present values of net income flows over a relevant time horizon, or a total wealth measure represents the most desirable measure of size. The real advantage of an income measure of size is its all inclusive nature. A desirable measure of size should reflect both intensive and extensive growth. Extensive growth involves changes that increase the quantity of resources used, while intensive growth includes those changes in firm organization and operation that increase productivity or efficiency.[12]

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 quantity of resources used depends on the nature of cost advantages or disadvantages (i.e., returns to scale) of farms of different size.[13]

Both input and output measures can be used for the measure of size. A key resource or input like labor leads us to talk in terms of one or two man farms. Where crops are dominant, 160 or 400 acre farms may be most descriptive. Output measures, like gross farm sales, provide a way of describing multiple enterprise businesses and making comparisons across type 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.[14] Volume or value of output gives, aside from fluctuations due to extremely favorable or unfavorable weather, a pretty good single measure of size. Where farms produce several products, output must be measured in terms of dollar sales, in order to convert them to a common denominator.[15]

Thus, with cross section of farm types in the data set gross farm income is used as the measure of farm size.

Diversification

Risk and uncertainty are products of imperfect knowledge.

Decisions must be made continually without adequate information or knowledge. However, diversification can serve as a precaution that one can use in adjusting to an uncertain or risky situation.[16] 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 an uncertainty precaution where the immediate objective is not so much one of profit maximization but, one of stability of income. The hope of the farmer is that if the return from one product is low, the return from another will be high when the "eggs are not all in one basket".[17]

Carter and Heady believe that diversification can be accomplished in two ways, 1) by adding sufficient resources to include the new enterprise or enterprises without reducing the size of the present enterprises, or 2) by redistributing fixed resources among more enterprises.[18,19] Diversification by adding resources, usually increases total income and total income variance, since net income correlations between crops ordinarily are zero or positive. Diversification by redistribution of fixed resources, reduces risk by dividing fixed resources (land) by a greater number of enterprises. Carter believes opportunities to reduce total income variability are greater with the redistribution of fixed resources rather than the resource expansion method.[20]

Diversification may be employed as a method of handling two aspects of income variability. First, the operator may consider the variability of income over his entire operating career. In this case the number of years involved becomes a population of production periods from which he may wish to minimize the variability of income. Second, the operator may think in the terms of possible large profits or possible large losses in a single year.[21]

Diversification considerations can include attempts to either put a floor under income, or level off the variations in income. To put a floor under income, the manager selects a stable enterprise to give some profit every year. He then selects the prospectively high return enterprise even though it does involve considerable risks. For leveling off the high and low spots and getting a more even income between years the farmer should not emphasis a stable, year-in and year-out enterprise as much as a search for contrasting enterprises. The goal is to get offsetting enterprises. The enterprise prices and yields should have as little positive correlation, or association as possible.[22]

According to Stovall in order for the addition of a farm enterprise to decrease the total income variance, income from the additional enterprise must be negatively correlated with the returns from one or more of the other enterprises. Other things being equal, the larger the number of enterprises which have incomes that are negatively correlated with the income from the added enterprise, the more total variance will decrease. This implies that the covariance between the returns from a new enterprise and all other enterprises is probably more important with respect to total income variance than the variance of the new enterprise. Thus, the addition of a seemingly risky enterprise may actually reduce the total income risk if its covariances are negative and large.[23]

Two kinds of limits exist in lowering income variability through diversification. First, adding more and more enterprises has less effect in reducing variability. Second, when two enterprises alone are used for diversification, adding more of the second enterprise may first reduce variability but, a point may be reached where still more of the second enterprise may begin to increase income variability.[24]

Diversification is a more effective means of lessening income variability for price fluctuations growing out of individual commodity cycles, annual variations in yields of individual crops, and very short-term changes in supply or demand. It is not very effective in reducing variations in income for major changes in overall farm sector prices.[25]

Diversification to meet risks usually means that income never falls as low in bad years and never as high in good years. The choice to use diversification must be that of the individual, depending on his financial position, his family responsibilities, and his general ability to shoulder the risks. If he has a good credit position, he may choose the high return, variable alternatives and carry cash reserves forward from good to poor years; or he may use credit during bad years and repay it in the lush years. If his debt load is at a maximum and debt payments are due each year, he may select the more stable alternatives even though it gives somewhat less income.[26]

Notes

1. E. Heady, Economics of Agricultural Production and Resource Use, (New York: Prentice-Hall, Inc., 1952), pp. 440-43.

2. Ibid.

3. 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.

4. John T. Scott Jr., and James B. Kliebenstein, "Assessment of Risk When Contract Crops Are Included Among Other Crop Alternatives," Department of Agricultural Economics, Agricultural Experiment Station (University of Illinois at Urbana-Champaign, April, 1975), p.3.

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

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

16. E. Heady, Economics of Agricultural Production And Resource Use, (New York: Prentice-Hall, Inc., 1952), p. 510.

17. Ibid.

18. H.O. Carter, and G.W. Dean, "Income, Price, and Yield Variability for Principal California Crops and Cropping Systems," Hilgardia, California Agricultural Experiment Station, Vol. 30, No. 6, October 1960, pp. 188-89.

19. E. Heady, Economics of Agricultural Production And Resource Use, (New York: Prentice-Hall, Inc., 1952), pp. 510-11.

20. H.O. Carter and G.W. Dean, "Income, Price, and Yield Variability for Principal California Crops and Cropping Systems," Hilgardia, California Agricultural Experiment Station, Vol. 30, No. 6, October, 1960, pp. 189-90.

21. E. Heady, Economics of Agricultural Production And Resource Use, (New York: Prentice-Hall, Inc., 1952), p. 511.

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

23. John G. Stovall, "Income Variation and Selection of Enterprises," Journal of Farm Economics, 48(1966): 1577.

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

25. Ibid.

26. Ibid., p. 531.

CHAPTER III

Statistical And Theoretical Framework

This chapter develops the statistical and theoretical framework for the study. The first section of the chapter contains an introduction of relationships to be examined. The rest of the chapter is devoted to the statistical and theoretical framework for the variability of gross farm income, farm expenses, net farm income, and the covariance of gross farm income and farm expenses.[1]

Economies of size related to costs and returns has long been a significant framework for analyzing efficiency of different farm sizes. While this framework has been used extensively, little attention has been paid to risk/size relationships. These relationships may be important even though they have not been addressed extensively.

Many economists are suggesting that farms will increase in size as consolidation occurs due to the exit of many highly leveraged farms in the current financial environment. Risk/size relationships could either hamper, be neutral, or encourage the increase in size. Thus risk/size relationships as well as the traditional economies of size concepts are of considerable importance in understanding the forces shaping the future structure of production agriculture.

Diversification has generally been viewed as a method of reducing variability of income according to Heady and Jensen. Pope and Prescott recognize this benefit, but also recognize that economics of size exist. They have suggested that there is a trade-off between the diversification benefits of reducing risk and the economics of size benefits due to specialization. If there are substantial economics of size in an enterprise, then one gives up a substantial expected return to reduce the variability of return by diversifying.[2]

Robinson and Barry suggest that specialization in some cases may reduce variability of incomes. They argue that learning can occur or quality control may increase due to specialization. They suggest this phenomena may be called increasing returns to scale in risk.[3]

These issues revolve around changing the enterprise mix for a given total resource base. The issue addressed in this paper is the possibility that increased size reduces business risk in a relative sense.

Risk has been split into two types: business risk which refers to variation in income, and financial risk which refers to the risk associated with increased leverage. Business risk refers to variation in net earnings due to yield, price and cost variability.[4] There is considerable emphasis currently on financial risk due to the debt crisis, but as agriculture moves out of this period, business risk will increase in relative importance.

This chapter of the study focuses on business risk and the relationships between business risk and size. As the size of a farm increases the variability of income will increase due to the increase in volume. However, does the relative variability increase, decrease, or stay the same as the size of the farm increases. A statistical framework is developed to explore risk/size relationships. Size will be removed mathematically from the equations so that the relative variability of net income, gross income, and farm expenses can be examined. Since NET = GROSS - EXPENSES,

$$V(NET) = V(GROSS) + V(EXPENSES) - 2C(GROSS, EXPENSES),$$

where V is variance and C is covariance. We will begin by analyzing the variability of gross, then expenses, then the covariance of gross and expenses. Then we will put these together to investigate the variability of net incomes.

Variability of Gross Income

First, let us look at the variance of gross, where gross is the sum of the revenue generated by n enterprises. In this case,

$$GROSS = \sum_{i=1}^{n} P_i S_i T Z_i \text{ where}$$

P_i = price of product

S_i = share of T devoted to enterprise i

T = total size

Z_i = production per unit of enterprise i

In this case,

$$V(GROSS) = V(P_1S_1TZ_1) + V(P_2S_2TZ_2) + \ldots + V(P_nS_nTZ_n)$$

$$+ 2[\text{Covariances of } \binom{n}{2} \text{ pairs of } P_iS_iTZ_i]$$

Now, assuming S_i is constant for a farm, i.e., the enterprise combination is fixed and the size T is fixed for a farm then

$$V(P_iS_iTZ_i) = S_i^2T^2V(P_iZ_i),$$

and

$$C(P_iS_iTZ_i, P_jS_jTZ_j) = S_iS_j T^2 C(P_iZ_i, P_jZ_j)$$

So

$$V(GROSS) = \sum_i S_i^2 T^2 V(P_i Z_i) + \sum_i \sum_j S_i S_j T^2 C(P_i Z_i, P_j Z_j)$$

$$\text{or, } V(GROSS) = T^2[\sum_i S_i^2 V(P_i Z_i) + \sum_i \sum_j S_i S_j \; C(P_i Z_i, P_j Z_j)]$$

$$\text{for } i \neq j.$$

Dividing both sides of the equation by T^2 gives

$$\frac{V(GROSS)}{T^2} = \sum_i S_i^2 \; V(P_i Z_i) + \sum_{ij}\sum S_i S_j \; C(P_i Z_i, P_j Z_j)$$
$$\text{for } i \neq j.$$

If gross is used as a measure of size then taking the square root of the left side of the equation results in the coefficient of variation of gross income.

While much of the impact of size has been eliminated from the right side of the above equation we can still argue that the variance of gross returns for enterprise i, $V(P_i Z_i)$ are functions of size. If we assume that price (P_i) and yield (Z_i) are bivariate normally distributed, then using Bohrnstedt and Goldberger, the variance of a product is

$$V(P_i Z_i) = E^2(P_i)V(Z_i) + E^2(Z_i)V(P_i) + 2E(P)E(Z_i)C(P_i, Z_i) + V(P_i)\; V(Z_i) + C^2(P_i, Z_i)$$

In particular, it can be argued that $V(Z_i)$ is a function of size, and that the variance of yield per acre will decrease as acres increase. To illustrate with an example, let

Y_1 = yield/acre on the first acre and

Y_2 = yield/acre on the second acre.

Then $V(Y_i)$ = variance of yield on acre i. Also, let $V(Y_1) = V(Y_2)$

since they are similar but not identical acres. Now, let us look at the variance per acre for two acres.

$$V\left(\frac{Y_1+Y_2}{2}\right) = \frac{1}{4}\left[V(Y_1) + V(Y_2) + 2C(Y_1,Y_2)\right]$$

Now, $V(Y_1) = V(Y_2)$ since the acres are similar. However, $C(Y_1,Y_2) < V(Y_1)$ since $C(Y_1,Y_2) = E[(Y_1 - \bar{Y}_1)(Y_2 - \bar{Y}_2)]$ and it is not likely that both Y_1 and Y_2 will be affected exactly the same way by localized weather patterns and other phenomena since while similar, they are not identical acres. So,

$$V\left(\frac{Y_1+Y_2}{2}\right) = \frac{1}{4}[2V(Y_1) + 2C(Y_1,Y_2)] < \frac{1}{4}[4V(Y_1)] =$$

$V(Y_1)$, which suggests that variance per acre decreases as the number of acres increases.

The same argument holds as a farm spreads out over more acres. The variance of yield per acre will likely decline as acres increase because of localized phenomena that affect some areas more than others. This result is a form of diversification, even though it is the same enterprise. We will call this type of diversification, natural diversification. The benefits of natural diversification due to differences in soil types, localized weather patterns, different planting dates and rotation schedules as well as different varieties should not be overlooked. One would expect that there would be diminishing returns to this type of diversification. However, as farm size grows, acreage is spread over a broader area and the likelihood of localized weather affecting one area and not the other grows. In addition, as a farm grows, the difference in planting dates, and other management practices may grow (given the same machinery size). One would also expect natural diversification benefits in livestock enterprises. In this case, the additional livestock units may have substantially different characteristics which could react differently to environmental conditions and diseases. The magnitude of benefits and the range of farm size that receives these benefits is an empirical question.

Variability of Expenses

Now, let us look at the variance of expenses. We can use the same analysis which we used for gross if we define

$$\text{EXPENSES} = \sum_{i=i}^{n} \sum_{j=i}^{m} P_j \, S_i T X_{ij} \text{ where}$$

P_j = price of input j

S_i = share of T devoted to enterprise i

T = total size

X_{ij} = quantity of input j used on enterprise i.

Now the above equation can be rearranged as

$$\text{EXPENSES} = \sum_{i=i}^{n} S_i T \sum_{j=i}^{m} P_j X_{ij}$$

Now, $\sum_{j=1}^{m} P_j X_{ij}$ = cost of m inputs per unit of enterprise i.

So, let $\sum_{j=1}^{m} P_j X_{ij} = C_i$.

C_i = total cost per unit of enterprise i.

Now, using the same logic used for analyzing the variance of gross,

$$V(\text{EXPENSES}) = V(S_1TC_1) + V(S_2TC_2) + \ldots + V(S_nTC_n) +$$

$$2[\text{Covariances of } \binom{n}{2} \text{ pairs of } S_iTC_i]$$

Now, when S_i is constant for a farm and size T is fixed for a farm then,

$$\frac{V(\text{EXPENSES})}{T^2} = \Sigma S_i^2 \; V(C_i) + \sum_{ij}\Sigma S_iS_j \; C(C_i,C_j) \quad \text{for } i \neq j.$$

Now, let us examine again whether $V(C_i)$ and $C(C_i,C_j)$ may be functions of size. Since $C_i = \sum_{j=1}^{m} P_jX_{ij}$, the question of relationship to size revolves around the likelihood that $V(X_{ij})$ may decrease as size increases. We can again argue that it decreases as size increases using the same argument that we used for $V(Z_i)$. That is, since we have similar, but not identical units, it is reasonable that the variance of input use per acre will decrease as acres increases. Thus one would hypothesize that the ratio between variance of expenses and gross farm income squared (i.e. $\frac{V(\text{EXPENSES})}{T^2}$) would decrease as size increases.

Covariance of Gross and Expenses

The final piece of the puzzle is the covariance of gross and expenses. Now, using previous definitions

$$\text{GROSS} = T \sum_{i=1}^{n} S_iP_iZ_i \text{ and}$$

$$\text{EXPENSES} = T \sum_{j=1}^{n} S_jC_j.$$

So, the covariance will be

$$C(\text{GROSS, EXPENSES}) = T^2 C\left(\sum_{i=1}^{n} S_i P_i Z_i, \sum_{j=1}^{n} S_j C_j \right).$$

This can be rewritten as

$$C(\text{GROSS, EXPENSES}) = T^2 \sum_{i=1}^{n} \sum_{j=1}^{n} C(S_i P_i Z_i, S_j C_j)$$

Now, the covariance of one of the pairs is

$$C(S_i P_i Z_i, S_j C_j) = S_i S_j C(P_i Z_i, C_j)$$

So,

$$\frac{C(\text{GROSS, EXPENSES})}{T^2} = \sum_{i=1}^{n} \sum_{j=1}^{n} S_i S_j C(P_i Z_i, C_j).$$

The issue now is whether $C(P_i Z_i, C_j)$ is related to size in any way. This is the covariance per unit of production. One can argue from a logical standpoint that gross and expenses are positively correlated since higher costs should result in higher gross. The question is, does this positive relationship increase or decrease as size of farm increases.

An argument for the hypothesis that the relationship between gross and expenses decreases as farm size increases is that the proportion of gross income used for family or personal consumption is larger for a small farm than a large farm. Therefore, when a small farm has a high gross income due to high yields per unit or high product prices, the operator may purchase large or high cost inputs that are needed such as new equipment. This type of action will increase expenses. Using this argument, one would expect the covariance per unit of production between gross and expenses to be larger for small farms than for large farms.

On the other hand, one can argue that the covariance per unit increases as size increases. From a tax standpoint, larger farms with higher incomes have been in higher marginal tax brackets. Thus the incentive is greater for larger farms to increase expenses when gross income is high to reduce the tax liability. This behavior will result in a larger positive covariance for large farmer than for small farms.

Variance of Net

Finally, we can put all the pieces together since

$$V(NET) = V(GROSS) + V(EXPENSES) - 2C(GROSS, EXPENSES).$$

First, dividing each component by T^2 gives

$$\frac{V(NET)}{T^2} = \frac{V(GROSS)}{T^2} + \frac{V(EXPENSES)}{T^2} - \frac{2C(GROSS, EXPENSES)}{T^2}.$$

Now, we have argued that $\frac{V(GROSS)}{T^2}$ decreases as size increases, $\frac{V(EXPENSES)}{T2}$ decreases as size increases, and $\frac{2C(GROSS, EXPENSES)}{T^2}$ can either increase or decrease as size increases. The relative sizes of these relationships could result in $\frac{V(NET)}{T^2}$ decreasing as size increases. If this is the case then risk economies of size exist.

Notes

1. The theoretical framework is from an unpublished paper by Bryan W. Schurle and Michael S. Tholstrup, titled "A Statistical and Empirical Investigation of Business Risk in Agricultural Production."

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

3. Lindon J. Robinson, and Peter J. Barry, The Competitive Firm's Response to Risk, Macmillan Publishing Company, New York, 1987, p. 68.

4. Warren F. Lee, Michael D. Boehlje, Aaron G. Nelson, and William G. Murray, Agricultural Finance Seventh Edition, Iowa State University Press, Ames, Iowa, 1980, p. 21.

CHAPTER IV

Methodology And Results Of The Analysis

This chapter describes how risk, size, and diversification will be measured in the analysis. A description of data used in the analysis is provided. Reasons for looking at specific relationships are explained, and the procedures for investigating the relationships will be described. Finally the estimated relationships among the variables will be evaluated.

As stated in the theoretical chapter, Net = Gross - Expenses, therefore the V(Net) = V(Gross) + V(Expenses) - 2C(Gross,Expenses) where V is variance and C is covariance. Each piece of the equation above will be investigated to determine what characteristics of a farm affect variability of net income.

Thirteen years of farm data from 687 farms will be used in the analysis. Inflation was present during the study period, so variables affected by inflation have been deflated. The variables are adjusted to 1972 dollars using an implicit price deflator for gross national product. The GNP deflator is chosen over the consumer price index for the following reasons. The consumer price index is overly biased in the areas of mortgage interest rates, energy costs, and food costs. Therefore, the GNP deflator is 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. The gross national product equation measures the general price level of domestically produced goods and services since imports are not included in the bundle of goods. After deflating the means and variances are calculated over the thirteen year period for each farm.

The equations developed in the theoretical chapter are used as a basis for the models used in the analysis. The dependent variables will be the ratio of the variance of gross farm income to gross farm income squared (RVG/T_s), the ratio of the variance of farm expenses to gross farm income squared (RVE/T_s), the ratio of the covariance of gross farm income and farm expenses to gross farm income squared ($RCGE/T_s$), and finally the ratio of the variance of net farm income to gross farm income squared (RVN/T_s).

During the study period many farmers increased their debt load or leverage position because of inflation. Since this study primarily examines business risk the interest payments paid have been added to net farm income to remove financial risk and leverage impacts. To keep the models consistent, interest payments have been removed from farm expenses.

Gross farm income has been chosen as the measure of size of farm for the study. Gross farm income is chosen because of the cross section of the farms used in the study. Gross farm income is the best variable to be used as a common denominator between all the different farm types in the data set.

The independent variables for the models have been determined by the equations in the theoretical framework and from a list of nine characteristics of a farm that may be related to variability of income or expenses. The list of farm characteristics that may affect variability consists of farm size, diversification of farm, location of farm, farm enterprises, experience of operator, financial obligation of the farm, timeliness of operations, government payments, and irrigation of crops. Variables have been chosen to represent these characteristics. Table 2 shows the descriptive statistics of the variables in the study.

As stated earlier, gross farm income is the measure of size used in the analysis. It will be used as an independent variable to investigate whether all of the size impacts have been removed from the variance of incomes expenses and covariance of gross and expenses after they have been divided by gross farm income squared.

Fifteen enterprise variables have been constructed. For the crop enterprises, crop production on the farm including landlords share for each enterprise is multiplied by the average price each year received by Kansas farmers to calculate gross sales for each crop. Gross sales are used for the production estimates for the livestock enterprises. Total sales is calculated by using the sum of all the enterprise sales. The means of each enterprise sales and total sales is calculated for the thirteen year period for each farm. The enterprise shares are computed by dividing the mean of each enterprise sales by the mean of total sales. The shares represent the proportion of the business in one enterprise but, should be independent of size of the total farm. The enterprises will be raised beef production, raised swine production, purchased beef production, purchased swine production, dairy production, other livestock production, irrigated wheat production, irrigated corn production, irrigated grain sorghum production, irrigated soybean production, dryland wheat production, dryland corn production, dryland grain sorghum production, dryland soybean production, and alfalfa hay production. The enterprise shares are then squared to comply with the equations in the theoretical framework.

In the theoretical framework, S_iS_j for $i \neq j$ is the product of the share of sales generated by enterprise i and the share generated by enterprise j. In this analysis the summation of all the S_iS_j, $i \neq j$ will be used as the independent variable, SS. Ideally each combination of enterprises would have used as a independent variable. However this would have made 105 variables for enterprise combinations alone, which would have been too many independent variables. Here is an example of how the summation works for a farm with three enterprises with each enterprise producing of 1/3 of the sales. The summation is equal to $(S_1*S_2 + S_1*S_3 + S_2*S_3)$, which is equal to $(1/9 + 1/9 + 1/9) = 3/9 = 1/3$. The summation is equal to zero if the farm is totally specialized and its maximum value is 0.5 for an infinite number of enterprises with equal sales.

Several other variables will be used to represent characteristics of the farm or farm operator. The age of the primary operator will be used as the variable to explain experience of the operator. Interest payments paid divided by gross farm income will be used as the

Table 2. Descriptive Statistics of Dependent and Independent Variables Used in the Analysis After Use of GNP Deflator.

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
V(Net + Int.)	725,289,926	1,514,244,822	6,923,411	1.8×10^{10}
V(Gross)	1,054,049,556	2,269,021,995	13,523,703	3.3×10^{10}
V(Exp. - Int.)	412,974,816	1,226,722,133	1,166,576	2.0×10^{10}
C(Gross,Exp)	370,867,222	1,131,394,249	-1,416,170,222	1,262,035,172
Net + Int.	22,565	14,963	-4,157	106,990
Gross	82,661	63,041	8,476	695,625
Expenses - Int.	60,095	51,612	8,214	614,855
RVG/T_s	0.13388	0.12883	0.01027	1.39904
RVE/T_s	0.03514	0.04847	0.00145	0.51977
$RCGE/T_s$	0.03499	0.06215	-0.08283	0.81929
RVN/T_s	0.09904	0.09296	0.00411	1.10634
SS	0.30859	0.08982	0.0	0.44359
Govt/Gross	0.0418	0.0268	0.0	0.1653
Int/Gross	0.0946	0.0742	0.0	0.4761
Age of operator	50	9	28.4	73.76
Mach. invest. per acre	32.00	17	4.00	139.40
Enterprises Squared:				
Raised beef	0.0393	0.1000	0.0	0.9681
Purchased beef	0.0905	0.1805	0.0	0.9855
Raised swine	0.0257	0.0885	0.0	0.8497
Purchase swine	0.0038	0.0202	0.0	0.2238
Dairy	0.0097	0.0581	0.0	1.0000
Other lvstk.	0.0015	0.0164	0.0	0.3728
Irrigated wheat	0.0025	0.0123	0.0	0.1554
Irrigated corn	0.0181	0.0724	0.0	0.6661
Irrigated grain sorghum	0.0041	0.0252	0.0	0.4861
Irrigated soy-beans	0.0007	0.0047	0.0	0.0832
Alfalfa hay	0.0065	0.0207	0.0	0.2714
Dryland wheat	0.1110	0.1828	0.0	0.9275
Dryland corn	0.0109	0.0410	0.0	0.3803
Dryland grain sorghum	0.0220	0.0369	0.0	0.2475
Dryland soy-beans	0.0198	0.0522	0.0	0.4971

variable representing the affect of debt on variability of income and expenses. Government payments received by the farm divided by gross farm income will be the variable to show the relationship of government programs to the variability of income and expenses. Both the financial obligation variable and the government payment variable are divided by gross farm income to remove size impacts. Crop machinery investment per acre will be the variable to represent timeliness of operation, on the assumption that the more investment in machinery and equipment the greater the likelihood of timely cropping operations.

The irrigated crop enterprises will be used to show the relationship irrigation has to variability of income and expenses. Originally a ratio showing the proportion of irrigated acres to acres operated was going to be used. However, it was decided there is a probability of a relationship between the ratio of irrigated acres to operated acres and the irrigated crop enterprises, which may lead to multicollinearity problems.

Variability of Gross Farm Income

The variability of gross farm income will be examined by using the ratio of the variance of gross farm income to gross farm income squared, developed in the theoretical framework. Gross farm income is defined as total receipts from farming enterprises, government payments, and miscellaneous income computed on the accrual basis. The model contains the independent variables discussed in the previous section. Table 2 shows the descriptive statistics of the dependent and independent variables used in the analysis. Table 3 shows the regression coefficients for the model. The model has an adjusted R^2 of .1837. Therefore, 18.37 percent of the variability in the ratio of the variance of gross farm income to gross farm income squared is explained by the independent variables.

Average gross farm income is a significant variable in the model. Gross farm income is used in the model to test the hypotheses that there are still size impacts on the variance of gross farm income after it has been divided by gross farm income squared. Gross farm income is significant at the .0001 level with a coefficient of -0.000000445. The results support the hypotheses that gross farm income has an impact on the relative variability of gross farm income. Since the coefficient is negative, the results support the argument for natural diversification, that as production units are increased the relative variability of production will decrease. These results suggest that risk economies of size do exist.

A stated goal of government farm programs is to increase farm income and reduce its variability. The variable representing government programs, government payments per farm as a proportion of gross farm income is significant at the .0081 level with a coefficient of -0.7434. This indicates that if government payments increase as a proportion of gross farm income the relative variability of gross farm income will decrease. This implies government payments have a stabilizing impact on gross farm income.

The financial obligation variable, interest payments as a proportion of gross farm income is significant at the .0025 level with a coefficient of 0.2040. The results suggest that as the financial obligation of a farm increases the relative variability of gross farm income increases. A potential explanation of the relationship is that a farm with higher financial obligations are less flexible or unable to take advantage of opportunities presented them. In the case of the variability of gross farm income, the inability to market products at the opportune time and/or to purchase inputs to increase production or correct production problems may lead to the increased variability of gross farm income.

The age of the primary operator is significant at the .0001 level with a coefficient of 0.00263. This suggests that the relative variability of gross farm income increases as the age of the operator increases. The original hypotheses was that there was an inverse relationship between the operators experience and variability of income. Several explanations for the positive relationship can be posited. It is possible that the operators experience is overshadowed by their inability or unwillingness to extend their labor efforts. Secondly, the older operator may be less flexible in adjusting to unusual circumstances. Thirdly, older operators may not keep pace with technological advances. Finally, as the operator gets older it can be assumed that if his wealth position increases, he may not be as risk averse.

Machinery investment per acre is significant at the .0287 level with a coefficient of -0.00072. This implies that there is an inverse relationship between machinery investment per acre and the relative variability of gross farm income. An explanation of the results is

Table 3. Regression Coefficients and T Values for the Equation Which Was Estimated to Investigate the Relationship Between the Ratio of the Variance of Gross Farm Income to Gross Farm Income Squared and Other Farm Characteristics.

Independent Variables	Equation Coefficients	T Value
Gross Farm Income	-0.00000044*	-5.366
SS	0.9039*	2.640
Government Payments	-0.7434*	-2.655
Interest Payments	0.2040*	3.038
Age of Operator	0.0026*	4.735
Machinery Investment per Acre	-0.0007*	-2.192
Enterprises Squared:		
Raised Beef	0.6238*	3.477
Purchased Beef	0.6181*	3.561
Raised Swine	0.4935*	2.786
Purchased Swine	0.9429*	3.279
Dairy	0.4733*	2.490
Other Livestock	0.5448	1.655
Irrigated Wheat	-0.0078	-0.016
Irrigated Corn	0.4978*	2.711
Irrigated Grain Sorghum	0.5360*	2.023
Irrigated Soybeans	-0.1919	-0.191
Alfalfa Hay	0.2705	0.915
Dryland Wheat	0.6306*	3.307
Dryland Corn	0.4303	1.954
Dryland Grain Sorghum	0.4409*	2.230
Dryland Soybeans	0.5312*	2.760
Locations:		
North Central	0.0336	1.881
South Central	0.0338	1.893
Southwest	0.0839*	4.267
Northeast	0.0278	1.934
Northwest	0.0436	1.833
Intercept	-0.4484*	-2.594
Adjusted R^2	0.1837	

* The variable is significant at the .05 level.

that as machinery investment per acre increases the farmer is better able to complete his cropping operations during the proper time frame.

The enterprise variable coefficients can be interpreted as the variance of gross returns per unit of the enterprise (i.e. $V(P_iZ_i)$). The unit of an enterprise is one dollar of sales of the enterprise. Thus, the coefficients are the variances of gross returns per dollar of total sales of the enterprises. With this type of interpretation a comparison can be made between enterprises. For example the variance of gross returns per dollar of sales of raised swine is .4935 compared to .9429 for purchased swine. Both coefficients are significantly (.05) different than zero. Of the fifteen enterprise variables, ten of their coefficients, variances of gross returns per unit of the enterprise, are significant at the .05 level or better.

The summation of enterprise combinations, SS, is significant at the .0085 level with a coefficient of 0.9039. The summation regression coefficient can be interpreted as a proxy for an aggregate covariance between gross sales of all the enterprises. For diversification to reduce variability of income when adding a new enterprise the covariance between enterprises must be negative, zero or positive and small.

Here is an example of how the enterprise shares, variances of gross returns per unit of the enterprise, and the summation of enterprise combinations and the proxy of covariances of gross returns between enterprises reduce variability. First, assume that a farm has a fixed amount of resources, with two enterprises, raised beef (RB) and dryland wheat (DW) with each enterprise contributing fifty percent of the business. Assume also that the operator wishes to start a dryland grain sorghum enterprise by redistributing resources. The operator wants the new enterprise mix to consist of raised beef forty percent, dryland wheat forty percent and grain sorghum twenty percent of the business. To examine the change in variability the net change must be examined using the equation from the theoretical framework and the coefficients estimated in the model.

Original Enterprise Mix	New Enterprise Mix	Net Change
$S_{RB} = .5$	$S_{RB} = .4$	-0.1
$S_{DW} = .5$	$S_{DW} = .4$	-0.1
$S_{GS} = 0$	$S_{GS} = .2$	+0.2
$S^2_{RB} = .25$	$S^2_{RB} = .16$	-0.09
$S^2_{DW} = .25$	$S^2_{DW} = .16$	-0.09
$S^2_{GS} = 0$	$S^2_{GS} = .04$	+0.04
$\sum_i \sum_j S_i S_j = .25$	$\sum_i \sum_j S_i S_j = .32$	+0.07

Therefore, the change in variability is equal to the $\Delta RB^2 V(P_{RB}Z_{RB}) + \Delta DW^2 V(P_{DW}Z_{DW}) + \Delta GS^2 V(P_{GS}Z_{GS}) + \Delta \Sigma\Sigma S_i S_j C(P_i Z_i, P_j Z_j)$. So, $-.09(.6237) + (-.09)(.6306) + .04(.4409) + .07(.9039) = -0.03198$ is the reduction in relative variability of gross farm income contributed by the change in enterprise mix.

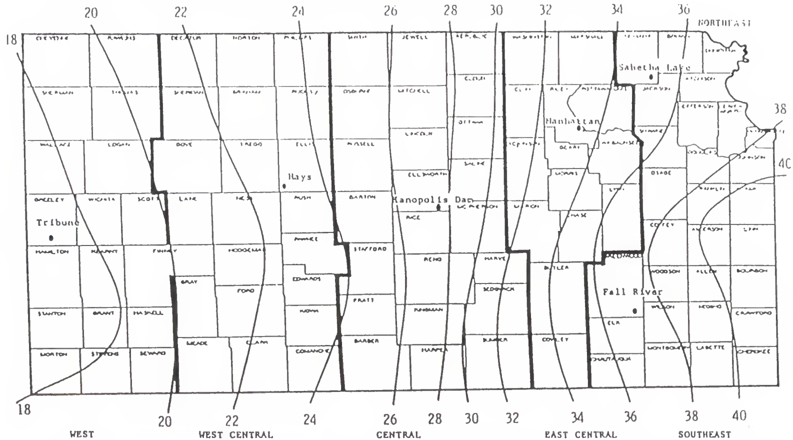
The location dummy variables representing location of the Kansas Farm Management Associations are not all significant at the .05 level. The coefficients of the location dummy variables can be interpreted as the deviation from the Southeast association. The southwest association coefficient is significantly different from the southeast with significance level of .0001 and a coefficient of .0839. The results suggest that the deviations from the southeast association increase as location moves from east to west. This relationship can be explained by weather. As shown in Figure 3, rainfall decreases from east to west in the state of Kansas. Yield variability is affected by the weather and rainfall, so farms in western Kansas should deviate more from the southeastern association than central or northeastern associations.

Variability of Farm Expenses

The variance of expenses is another piece of the puzzle in determining what farm characteristics affect variability of net farm income. Farm expenses is defined as cash operating expenses plus depreciation on equipment, machinery and buildings. However in this study interest payments have been removed from cash operating expenses and added to net farm income to remove financial risk and leverage impacts. The ratio of the variance of farm expense to gross farm income squared (RVE/T_s) is the dependent variable in the model. The independent variables are the same as those used in the model to examine the relative variability of gross farm income to size and other farm characteristics.

Table 4 shows the regression coefficients for the model. The model has an adjusted R^2 of .1363. Thus, 13.63 percent of the variability in the ratio of the variance of farm expenses to gross farm income squared is explained by the independent variables in the

FIGURE 3. Normal Annual Precipitation Isopleths (1941-70) for Kansas.



Source: <u>Field Workdays In Kansas</u>, Agricultural Experiment Station, Kansas State University, February, 1976.

model.

Only two independent variables are significant at the .05 level or better. Average gross farm income is significant at the .0246 level with a coefficient of -0.0000000723. The results suggest that as size of the farm increases the relative variability of farm expenses decreases. A possible explanation of this relationship is that large farm expenses may be less variable than small farms. Large farms may have an equipment replacement or service schedule resulting in smoother patterns of expense. Small farm repair costs and replacement costs will fluctuate because equipment on small may not need large repairs or replacement as often as on large farms. However, when the repairs become necessary it is a relatively large expense resulting in a lumpy pattern of expenses.

The financial obligation variable, interest payments as a proportion of gross farm income, is significant at the .0193 level with a coefficient of 0.0609. The results indicate that as the financial obligation of the farm increase the relative variability of farm expenses increases. A possible explanation of this relationship is that as the financial obligation of the farm increases the operator is no longer able to take advantage of opportunities that present themselves. The operator may no longer have enough credit or cash to purchase inputs at the opportune time which may result in a more uneven distribution of expenses.

None of the enterprise variables are significant. However, a discussion of what the coefficients represent is in order. The enterprise variable coefficients represent the variance of costs per

Table 4. Regression Coefficients and T Values for the Equation Which Was Estimated to Investigate the Relationship Between the Ratio of the Variance of Farm Expenses Minus Interest Payments to Gross Farm Income Squared and Other Farm Characteristics.

Independent Variables	Equation Coefficient	T Value
Gross Farm Income	-0.0000000723*	-2.252
SS	-0.0555	-0.419
Government Payments	-0.0283	-0.261
Interest Payments	0.0609*	2.345
Age of Operator	0.0001	0.682
Machinery Investment per Acre	-0.0001	-1.081
Enterprises Squared:		
Raised Beef	-0.0428	-0.617
Purchased Beef	0.0661	0.983
Raised Swine	0.0112	0.163
Purchased Swine	0.1724	1.549
Dairy	0.0190	0.258
Other Livestock	-0.0063	-0.050
Irrigated Wheat	-0.03153	-0.175
Irrigated Corn	0.0129	0.181
Irrigated Grain Sorghum	-0.0780	-0.761
Irrigated Soybeans	-0.1641	-0.421
Alfalfa Hay	-0.0320	-0.279
Dryland Wheat	-0.0520	-0.705
Dryland Corn	-0.0358	-0.420
Dryland Grain Sorghum	-0.0667	-0.871
Dryland Soybeans	-0.0339	-0.455
Locations:		
North Central	-0.0047	-0.679
South Central	0.0069	1.003
Southwest	0.0086	1.133
Northeast	0.0014	0.255
Northwest	-0.0041	-0.446
Intercept	0.0518	0.774
Adjusted R^2	0.1363	

* The variable is significant at the .05 level.

unit of the enterprise. In this case the unit of the enterprise is a dollar of sales. Therefore, the coefficients are the variances of costs per dollar of sales of the enterprise.

The summation of the enterprise shares multiplied in pairs, $\sum_i \sum_j S_i S_j$, the SS variable is not significant. The coefficient of the SS variable is a proxy for an aggregate covariance between enterprise costs.

Covariance of Gross Farm Income And Farm Expenses

The covariance of gross farm income and farm expenses is another piece of the puzzle in determining the relationship of variability of net farm income and farm characteristics. The covariance of gross farm income and farm expenses is defined as how gross farm income and farm expenses vary together. For consistency in the analysis, interest payments have been removed from farm expenses and added to net farm income.

The dependent variable in the model is the ratio between the covariance of gross farm income and farm expenses and gross farm income squared. The independent variables are the same as those used in the earlier models discussed in the analysis.

The model has an adjusted R^2 of .1192. Thus, 11.92 percent of the variability in the covariance of gross farm income and farm expenses is explained by the independent variables. Table 5 shows the regression coefficients.

Two of the independent variables are significant at the .05 level

Table 5. Regression Coefficients and T Values for the Equation Which Was Estimated to Investigate the Relationship Between the Ratio of the Covariance of Gross Farm Income and Farm Expenses Minus Interest Payments to Gross Farm Income Squared and Other Farm Characteristics.

Independent Variables	Equation Coefficients	T Value
Gross Farm Income	-0.00000013*	-3.155
SS	0.1113	0.649
Government Payments	-0.1524	-1.086
Interest Payments	0.0580	1.725
Age of Operator	0.0005	1.731
Machinery Investment per Acre	-0.0003	-1.654
Enterprises Squared:		
Raised Beef	0.0324	0.361
Purchased Beef	0.1676	1.927
Raised Swine	0.1143	1.287
Purchased Swine	0.3808*	2.642
Dairy	0.1298	1.363
Other Livestock	0.1243	0.753
Irrigated Wheat	-0.0140	-0.060
Irrigated Corn	0.1012	1.099
Irrigated Grain Sorghum	-0.0001	-0.010
Irrigated Soybeans	-0.2015	-0.399
Alfalfa Hay	0.0575	0.388
Dryland Wheat	0.0447	0.467
Dryland Corn	0.0352	0.318
Dryland Grain Sorghum	-0.0130	-0.131
Dryland Soybeans	0.0566	0.586
Locations:		
North Central	0.0025	0.284
South Central	0.0159	1.779
Southwest	0.0130	1.322
Northeast	0.0055	0.765
Northwest	-0.0006	-0.048
Intercept	-0.0401	-0.463
Adjusted R^2	0.1192	

* The variable is significant at the .05 level.

or better. Average gross farm income is significant at the .0017 level with a coefficient of -0.000000131. The results suggest that the ratio of the covariance of gross farm income and farm expenses to gross farm income squared decreases as gross farm income increases. A possible explanation for this inverse relationship is that the proportion of gross income used for family or personal consumption is larger for a small farm than a large farm. Therefore, when a small farm has a high gross income due to high yields per unit or high product prices, the operator may purchase large or high cost inputs that are needed such as new equipment.

The enterprise variables coefficients can be interpreted as the covariance of gross returns and expenses for the enterprise. With this type of interpretation an examination of whether there is a positive or negative relationship between gross returns and expenses for the enterprise can be done. The purchased swine enterprise is significant at the .0084 level with a coefficient of 0.3808. The results suggest that a purchased swine enterprise has a positive relationship between gross returns and expenses. None of the other enterprise variables are significant at the .05 level.

Variability of Net Farm Income

The variability of net farm income and its relationship to size and other farm characteristics is the main piece of the puzzle. Net farm income is defined as gross farm income minus cash operating expenses minus depreciation. Net farm income represents a return to unpaid operator labor, management and net worth. In this study interest payments paid have been added back into net farm income to remove financial risk and leverage impacts. The dependent variable in the model is the ratio of the variance of net farm income to gross farm income squared. The independent variables will be the same as those used in the earlier models.

The model has an adjusted R2 of .2312. Thus, 23.12 percent of the variability in the ratio of the variance of net farm income to gross farm income squared is explained by the independent variables. Table 6 shows the regression coefficients in the model.

Average gross farm income is significant at the .0001 level with a coefficient of -0.000000255. Gross farm income is used as an independent variable to determine whether size of farm still has an impact on the relative variability of net farm income. The results indicate that as size of farm increases the relative variability of net farm income decreases. This suggests that risk economies of size exist in production agriculture.

The financial obligation variable, interest payments as a proportion of gross is significant at the .0016 level with a coefficient of 0.1488. The results suggest that as the financial obligation of the farm increases the relative variability of net farm income increases. A possible explanation of this relationship is that as the financial obligation of a farm increases the operator cannot take advantage of opportunities. The operator may not be able to sell his products or buy inputs during the most opportune time. The operator may not have total management control over his operation.

Government payments as a proportion of gross farm income is

Table 6. Regression Coefficients and T Values for the Equation Which Was Estimated to Investigate the Relationship Between the Ratio of the Variance of Net Farm Income Plus Interest Payments to Gross Farm Income Squared and Other Farm Characteristics.

Independent Variables	Equation Coefficients	T Value
Gross Farm Income	-0.000000255*	-4.391
SS	0.6258*	2.610
Government Payments	-0.4670*	-2.381
Interest Payments	0.1488*	3.165
Age of Operator	0.0018*	4.661
Machinery Investment per Acre	-0.0003	-1.360
Enterprises Squared:		
Raised Beef	0.5161*	4.109
Purchased Beef	0.3490*	2.871
Raised Swine	0.2761*	2.226
Purchased Swine	0.3537	1.756
Dairy	0.2327	1.748
Other Livestock	0.2899	1.258
Irrigated Wheat	-0.0112	-0.034
Irrigated Corn	0.3084*	2.398
Irrigated Grain Sorghum	0.4608*	2.483
Irrigated Soybeans	-0.0468	-0.066
Alfalfa Hay	0.1235	0.597
Dryland Wheat	0.4892*	3.663
Dryland Corn	0.3242*	2.102
Dryland Grain Sorghum	0.400273*	2.891
Dryland Soybeans	0.3842*	2.851
Locations:		
North Central	0.0239	1.904
South Central	0.0089	0.711
Southwest	0.0665*	4.826
Northeast	0.0182	1.807
Northwest	0.0407*	2.440
Intercept	-0.3164*	-2.613
Adjusted R^2	0.2312	

* The variable is significant at the .05 level.

significant at the .0175 level with a coefficient of -0.4669. The results indicate that as government payments increase as a proportion of gross farm income the relative variability of net farm income decreases. This implies that government payments have a stabilizing impact on business risk in production agriculture.

The age of the primary operator is significant at the .0001 level with a coefficient of 0.00181. The results suggest that as the operator gets older the relative variability of net farm income increases. The original hypothesis was for the operators age to measure experience of the operator and that there would be an inverse relationship between age of operator and income variability. Several explanations can be made for the positive relationship between age of the operator and relative variability of net farm income. It is possible that the operators experience is overshadowed by their inability or unwillingness to extend their labor efforts. Secondly, the older operator may be less flexible in adjusting to unusual circumstances. Thirdly, older operators may not keep pace with technological advances. Finally, as the operator gets older it can be assumed that if his wealth position increases he may not be as risk averse. Thus, he does little to decrease income variability.

Machinery investment per acre has a negative coefficient which is not significant. This may suggest an inverse relationship between machinery investment per acre and the relative variability of net farm income. A possible explanation is that as machinery investment per acre increases the operator may be better able to complete work in a timely manner.

The enterprise variables coefficients can be interpreted as the variance of net returns per unit of the enterprise (i.e. $V(P_iZ_i-Ci)$). The unit of the enterprise is a dollar of sales for the enterprise. Thus, the coefficient is the variance of net returns per dollar of sales of the enterprise. With this type of interpretation a comparison can be made between enterprises. For example the variance of net returns per dollar of sales of dryland wheat is .489 compared to .40 for dryland grain sorghum. Both coefficients are significantly different than zero. Of the fifteen enterprise variables, nine of there coefficients, variances of net returns per dollar of sales of the enterprise, are significant at the .05 level or better.

The summation of enterprise combinations, SS, is significant at the .0093 level with a coefficient of 0.6258. The summation regression coefficient can be interpreted as a proxy for an aggregate covariance between net returns of all the enterprises. For diversification to reduce variability of income the covariance between enterprises must be negative, zero or positive and small.

Here is an example of how the enterprise shares, variances of net returns per unit of the enterprise, and the summation of enterprise combinations and the proxy of covariances of net returns between enterprises reduce variability. Assuming that a farm has a fixed amount of resources, with two enterprises, raised beef (RB) and dryland wheat (DW) with each enterprise contributing fifty percent of the business. Assume the operator wishes to start a dryland grain sorghum enterprise by redistributing resources. The operator wants the new enterprise mix to consist of raised beef forty percent, dryland wheat forty percent and grain sorghum twenty percent of the business. To examine the change in variability the net change must be examined using the equation from the theoretical framework and the coefficients estimated in the model.

Original Enterprise Mix	New Enterprise Mix	Net Change
$S_{RB} = .5$	$S_{RB} = .4$	-0.1
$S_{DW} = .5$	$S_{DW} = .4$	-0.1
$S_{GS} = 0$	$S_{GS} = .2$	+0.2
$S^2_{RB} = .25$	$S^2_{RB} = .16$	-0.09
$S^2_{DW} = .25$	$S^2_{DW} = .16$	-0.09
$S^2_{GS} = 0$	$S^2_{GS} = .04$	+0.04
$\sum_i \sum_j S_i S_j = .25$	$\sum_i \sum_j S_i S_j = .32$	+0.07

Therefore, the change in variability is equal to the $\Delta RB^2 V(Net_{RB}) + \Delta DW^2 V(Net_{DW}) + \Delta GS^2 V(Net_{GS}) + \Delta\Sigma\Sigma S_i S_j C(Net_i, Net_j)$. So, $-.09(.5161) + (-.09)(.4892) + .04(.4003) + .07(.6258) = -0.03066$ is the reduction in relative variability of net farm income contributed by the change in enterprise mix.

The location dummy variables representing location of the Kansas Farm Management Associations are not all significant at the .05 level. The coefficients of the location dummy variables can be interpreted as the deviation from the Southeast association. The southwest and northwest associations coefficients are significantly different from the southeast with significance level of .0001 and .0150 and coefficients of .0839 and .0407. The results suggest that the deviations from the southeast association increase as location moves from east to west. This relationship can be explained by weather. As shown in Figure 3, rainfall decreases from east to west in the state of Kansas. Yield variability is affected by the weather and rainfall, so farms in western Kansas should deviate more from the southeastern association than central or northeastern associations.

CHAPTER V

Implications

The study supports the concept of risk economies of size for business risk in production agriculture. The results of the analysis suggest that the ratios of the variance of gross farm income, variance of farm expenses and the covariance of gross farm income and farm expenses to size squared decrease as size of farm increases. The end result is that the ratio of the variance of net farm income to size squared decreases as size increases. This suggests that relative variability decreases as size increases. This relationship can be called economies of size for business risk.

A reason this occurs in production agriculture, but does not occur in finance is that additional production units in agriculture are similar, not identical. Thus, localized natural phenomena affect each production unit in a similar, but not identical manner. Therefore, "natural diversification" results due to the numerous small differences between one unit of an enterprise and another unit of the same enterprise.

The implications of this particular portion of the study are significant. First, it suggests that the concentration of resources into the hands of fewer, larger producers is encouraged not only by economies of size, but by business risk economies. Second, there needs to be major considerations given to the types of risk research conducted in agricultural economics and reconsideration of the types of models used. Because of the fundamental difference between production agriculture and finance, we should no longer borrow techniques without question from finance. Portfolio models in particular contain the implicit assumption that the variance of income per unit is constant as more units of an enterprise are used. While this relationship does hold true in finance, it does not hold true in production agriculture. The relationship suggest that risk model results in agriculture have been biased toward diversification among enterprises. Specialization in one enterprise has its own "natural diversification" which has not been recognized in the risk models to date.

The results of the study suggest that the financial obligation of a farm has a positive relationship to the ratios of the variance of gross farm income, variance of farm expenses, and variance of net farm income to size squared. The relationship suggests that as a farm increases its financial obligation, through borrowing for either firm growth or increased production efficiency, the relative variability of income and expenses increases. This suggests an important positive relationship between financial risk and business risk. This positive relationship implies that more attention should be focused on financial risk. Since economies of size and business risk economies of size exist, farmers are deterred from growth by financial risk. Also, since an increase in financial risk tends to increase business risk, financial risk should be a major focal point of future research.

The results of the study imply that government payments have had a stabilizing impact on business risk in production agriculture. Government programs have been a positive force in reduction of business risk during the study period. However, with the present situation, of high budget deficits and major overhauls in the farm programs, it is questionable whether government programs will continue to have the same affect on business risk. The study suggests that government programs decrease business risk. However, others argue that government programs in fact increase total risk because government programs indirectly encourage farms to increase in size to receive more government payments thus increasing financial risk. Government programs also reduce business risk which encourages growth in farm size. Financial risk is increased if borrowed capital is used for the expansion of farm size.

The study also suggests that as the age of the operator increases the relative variability of gross farm income and net farm income increases. The implications of these results are significant, with the present situation in agriculture where the average age of farmers is increasing due to the reduction in the amount of younger farmers from foreclosure or insufficient capital to start. As farmers become older they experience more business risk according to the study. This relationship may be due to the risk preference of the operators, who maybe wealthier as they grow older, or it maybe due to the inability or unwillingness of the operator to extend his labor efforts or keep up with technological advances.

The results of the study suggest that the location of a farm does have an effect on the relative variability of income. The results suggest that the relative variability of gross farm income and net farm income increase as the location of the farm moves from east to west. Weather is probably the major factor in this relationship.

A possible inverse relationship between machinery investment per acre and the relative variability of gross farm income and net farm income has been estimated. The results suggest that the relative variability of gross and net farm income decreases as machinery investment increases. A high investment in machinery per acre implies that the operator either has new or large equipment, thus he is able to complete his cropping operation during the correct time frame.

The results of the study suggest that several of the enterprise variables are significantly related to relative variability of gross farm income, farm expenses, and net farm income. The interpretation of the enterprise variables coefficients has strong implications. The coefficients can be interpreted as the variance of gross returns per unit of the enterprise, variance of costs per unit of the enterprise, the covariance of gross returns and cost per unit of the enterprise, and the variance of net returns per unit of the enterprise. With this type of interpretation a comparison can be made between different enterprises, to determine which has a greater affect on relative variability of income.

The results of the study suggests that the summation of SiS_j's for i=j is significantly related to relative variability of gross and net farm income. The interpretation of the coefficients for the summation variable are a proxy for an aggregate covariance between enterprises for gross and net returns. The results suggest that the aggregate covariance between enterprises is positive thus, suggests that incomes of enterprise are positively correlated.

Limitations

Several key assumptions are made in deriving the theoretical framework. First, it is assumed that the sizes of the farms are constant over the study period. However, the sizes of the farms are not constant over the study period, because actual farm data has been used.

Second, it is assumed that the enterprise mix per farm is constant over the study period. However, the enterprise mix of the farms is not constant over the study period. The enterprise mix of a farm may change from year to year due to many factors such as government programs, weather conditions, and product prices.

The data set is a representative sample of Kansas farms. The farm data from the 687 Kansas Farm Management Association farms is not a random sample. Farms in the farm management associations in Kansas tend to be commercial operations with progressive managers, so the results may not apply to non commercial farms.

Another possible limitation of the study is the economic environment in which the study period takes place. An attempt has been made to remove the affects of financial risk on business risk. However, the management decisions made by the operator due to either his financial obligation or to the economic environment cannot be measured or removed.

Finally, because of the composition of the dependent variable for the relative variability of gross farm income, there is some potential for heteroscedasticity of the residuals. The estimated coefficients are unbiased and efficient, but the significance of the t-tests may be unreliable.

Conclusions

The results of this study suggest that several farm characteristics are related to business risk. Some of these farm characteristics are under the control of the operator and can be used to reduce business risk. However, caution should be used in the application of the results.

Further research needs to be done in the area of risk encountered by production agriculture. The magnitude of business risk economies in production agriculture needs to be examined. The relationship between financial and business risk and their relationship to size is another area concern.

Further work needs to be done in the area of "natural diversification" and its affects on income variability. Further research needs to be done on relationship between enterprises and whether diversification in production agriculture today is for income enhancement or risk reduction.

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BUSINESS RISK IN RELATIONSHIP
WITH FARM SIZE AND OTHER
FARM CHARACTERISTICS

by

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ABSTRACT

The purpose of this study was to investigate business risk in production agriculture. Business risk is the variations in income resulting from the type of business in which the firm is engaged. The objectives of the study were to statistically and empirically investigate the relationship between business risk and size of farm, and the relationship between the variability of net and gross income, and farm expenses and other farm characteristics such as financial obligation, location, government payments, age of operator, machinery investment per acre, diversification, and enterprises of the farm.

A statistical framework was developed to examine the relationship between business risk and size of farm. Since Net = Gross - Expenses, V(Net) = V(Gross) + V(Expenses) - 2C(Gross, Expenses), where V is variance and C is covariance. Each piece of the equation was analyzed and then put together to investigate the variability of net income. From the statistical framework ratios of the variances of gross, net and expenses, and covariance of gross and expenses to size of farm squared were developed as the dependent variables for the empirical analysis.

Farm data from 687 Kansas Farm Management Association farms were used to estimate the relationships. Each farm had 13 years of data, so variances and means were calculated over the 13 years period from 1973-85 for each farm after financial variables were deflated using the implicit gross nation product deflator. Four models were developed using the ratios discussed above with gross as the measure of size. The independent variables were gross farm income, government payments and interest payments as proportions of gross, age of

operator, machinery investment per acre, enterprise shares squared, and the summation of the enterprise shares in pairs.

A significant inverse relationship was found between the ratios and size of farm. The relationship suggests that business risk economies of size exist in production agriculture.

A positive relationship was found between relative income variability and financial obligation and age of the operator. Government payments as a proportion of gross and machinery investment per acre had inverse relationship to relative income variability. Also, the location of the farm had an affect on the relative variability of income.