The Impact of Diversification on Farm Risk

by

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Abstract

Using farm data, this study estimates the relationship between income and variability of income. The affect of diversification and other farm characteristics on income variability is also investigated. Gross farm income, acres per operator, taxable nonfarm income, and machinery investment per acre were significantly related to variability of net income.

The Impact of Diversification on Farm Risk

Relationships have been suggested between diversification and risk (Heady, Carter, and Dean) but they have not been estimated from farm level data. The generally accepted relationship is that diversification reduces risk. However, other factors may also have an influence on this relationship. The ability of the manager to handle additional enterprises with no decrease in management allocated to already existing enterprises can influence the success of diversification in reducing risk. Addition of new enterprises to an operation might reduce management input to existing enterprises. So, if management ability is limited, then diversifying may produce more risk in existing enterprises and, thus, negate the benefits of diversification.

Several other factors may influence the relationship between diversification and risk. Heady (p. 516) suggests that diversification is subject to diminishing returns. Concentrating marketing efforts on fewer commodities may benefit income or reduce risks, depending on individual farmers' preferences. Many agricultural commodity price levels correlate positively, which also reduces the potential benefits of diversification. The impact of diversification on risk at the farm level needs to be estimated to determine if the traditionally accepted relationship exists.

Objectives

This study has two objectives. The first is to estimate, with farm data, the relationship between income and variability of income. The second is to estimate the relationships between variability of

income and diversification and the impact other farm characteristics have on income variability.

Procedure

Data for this study were obtained from 128 Kansas Farm Management Association farms in an 18-county, north-central Kansas area from 1973 through 1979. The data for each farm consist of 72 variables per year, including financial information, measures of size, and other information that helps describe the farm. The GNP deflator was used to adjust the data for inflation in general price levels from 1973 through 1979. The GNP deflator is a broad measure of domestic inflation constructed from price changes for the major components of gross national product.

We used two formulas to measure diversification. D_1 was suggested by Pope and Prescott; D_2 was developed as an alternative measure of risk. The Herfindahl index, 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.

The second measure of diversification was

$D_2 = N - \frac{N}{2} \left\{ |P_1 - 1/N| + |P_2 - 1/N| + \ldots + |P_N - 1/N| \right\}$. Where N = the maximum number of enterprises and P_i = proportion of the business in enterprise i. This formula modifies a summation of linear differences from the perfectly diversified operation as a proxy for diversification on the farm. As this measurement approaches 1, it indicates specialization, while values approaching N indicate the operation is highly diversified.

There are many choices for P_i. We used several different data elements in our search for an appropriate variable. For some results

not reported we used share of the total acres in each crop as P_i in each diversification formula. However, it was difficult to include livestock enterprises in this diversification measurement. We also used share of the total accrual gross income from each livestock enterprise, cash crops, and grain crops 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 reported here was a combination of the above measures. We approximated the proportion of the business in wheat, grain sorghum, and corn by multiplying grain accrual income by share of acres in each crop. We used these three approximations along with the gross accrual income for beef, dairy, sheep, swine, poultry, other livestock, and soybeans as estimates of the proportion of the business in each of the 10 enterprises. We used these estimates as the P_1's in each formula, and N = 10 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. D_2 ranged from 1.68 to 5.39 and it had a standard deviation of .74.

The important enterprises varied from farm to farm. However, in general, the most important enterprises in terms of gross incomes were beef, wheat, swine, and milo. Corn and soybeans were of lesser importance while dairy, sheep, poultry, and other livestock were relatively insignificant.

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. So the relationship indicated in Figure 1 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.

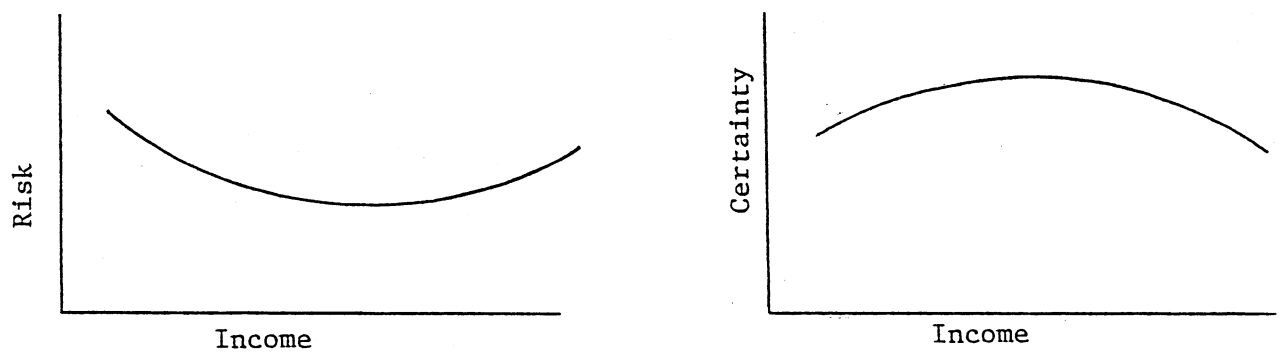

Figure 1. Hypothetical relationships between income and risk and income and certainty.

To investigate these relationships we first estimated the relationship between variability of income and level of income. Each farmer provided one observation giving us 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

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

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 2.

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. It does not suggest that unique situations do not exist where rearrangement of resources or adding

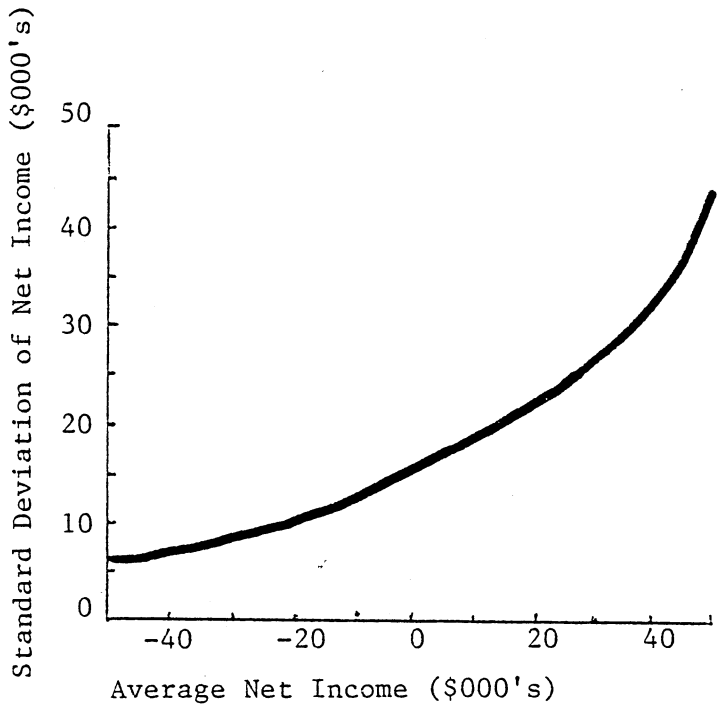

Figure 2. Empirically estimated relationship between net income and standard deviation of net income.

resources might allow an individual farmer to modify his income or variability of income. Both diversification and size of operation varied among the farms used to estimate this equation.

Relationship of Variability to Diversification

Diversification often has been suggested as a strategy to help reduce the risk associated with agricultural production. Few (if any) studies, however, have attempted to determine if more diversified farms actually have less income variability and theory suggesting relationships between other farm characteristics and variability of income is scarce. While looking for relationships between income variability and other farm characteristics, we studied many hypotheses, revised some, and rejected some. Many size-related variables provided multicollinearity that lead to

inconsistent results, until we chose gross farm income 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 1.

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. The positive relationship between acres per operator and variability of income may indicate that management can get spread too thinly so variability increases as one operator increases the acres he manages. The positive relationship between taxable nonfarm income and variability of income suggests that farm operators may pursue more risky courses of action or spend less management on their farm operations when they have higher nonfarm income. The negative relationship between machinery investment per acre and variability of income suggests that farms with more, newer, and/or larger equipment perform their operations more timely, which may reduce income variability.

The other four variables in the equations were not significantly related to income variability. It was hypothesized that crop production cost per acre might be positively related to income variability because higher crop production costs could result in high net incomes in good years but low net incomes in drought years. That hypothesis was rejected.

Operator's age was included because management decisions might change over time. The coefficients were negative, indicating somewhat lower income variability for older operators, but the coefficients

Table 1. 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 (16.32)	.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

were not significant ($P<0.05$).

Average county rainfall was included in the model specification because previous work (Pachta and Schurle) had shown wheat yield variability to be significantly related to average rainfall. Average rainfall reflects geographical location in Kansas because precipitation declines from east to west. The negative coefficients indicate higher rainfall is slightly associated with less income variability, but not significantly so.

The last variables included in the models were measures of diversification. 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 Heady (p. 516) suggests that diversification is subject to diminishing returns much like many inputs are in production functions. 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.

Summary and Conclusion

Data from 128 farms in Kansas were used to investigate the relationship between income and variability of income. The equations estimated suggest that income and variability of income are positively related for positive income levels. In addition, variability of income increases at an increasing rate as income increases, which suggests an important trade-off between farm income and variability of income.

The relationship between diversification and variability of income also was investigated. While diversification often is suggested as a method to reduce risk, data from Kansas farms indicate that diversification is not significantly related to variability of net farm income.

While diversification arguments are statistically justifiable, several other factors may offset the advantages of diversification. Price levels are often positively correlated which causes enterprise returns to be positively correlated which can reduce the benefits of diversification. Farmers' limited management capabilities may cause existing enterprise returns to increase in variability as more enterprises are added thus offsetting some of the potential variability reducing benefits of diversification. And finally, farmers in this sample may be diversified to the point where additional diversification has only minor impacts on income variability because diversification is subject to diminishing returns.

Several other variables were significantly related to income variability. Size as measured by gross farm income, acres per operator, nonfarm income, and machinery investment per acre were all significantly related to income variability. On the other hand, several

variables were not significantly related to income variability. Crop production cost per acre, operator's age, rainfall, and diversification were not significantly related to income variability.

Several additional points should be made concerning this study. The data used are not a random sample of farmers in Kansas. Farms in farm management associations in Kansas are generally commercial operations with progressive managers, so the results may not apply to farmers in general. We did not attempt to incorporate any proxy for management ability differences among farms. The measure of diversification also needs to be scrutinized carefully. Other measures may more accurately reflect "diversification," but to date few workers have attempted to quantify diversification of a farm operation. More research work is needed to justify an appropriate method of measuring diversification.

References

Carter, H. O., and G. W. Dean. "Income, Price and Yield Variability for Principal California Crops and Cropping Systems." Hilgardia 30(1960): 175-218.

Heady, E. "Diversification in Resource Allocation and Minimization of Income Variability." J. Farm Econ. 34(1952): 482-96.

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

Pachta, Jim and Bryan Schurle. "A Study of Farm Wheat-Yield Variability." Department of Economics Report, Kansas State University. Contribution number 80-326-D, 1980.

Pope, Rulon D., and Richard Prescott. "Diversification in Relation to Farm Size and Other Socioeconomic Characteristics." Amer. J. Agr. Econ. 62(1980): 554-559.