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Diversification in Relation to Farm Size
and Other Socioeconomic Characteristics

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Introduction

Interest by agricultural economists in farm diversification is evident in published research. Since the early work of Markowitz and Heady, attention has focused mainly on mean-variance portfolio approaches (S.R. Johnson, Stovall, Carter and Dean, Greve, et al.). These studies generally focus on the normative issue of optimal diversification under uncertainty. In the present paper a positive examination of diversification using detailed micro data is undertaken.

There are several fundamental reasons why diversification may be of interest. First, the relationship between diversification and farm size is an indicator of trade-offs between risk reduction and possible economies of size in a particular activity. That is, if there are substantial economies of scale in a particular activity, one clearly gives up a large expected return in order to insure against risk through diversification. Secondly, there is policy interest in promoting diversified small farms. In a recent paper prepared for the Congress (Public Policy and the Changing Structure of American Agriculture) several policy tools were proposed to "discourage the expansion of family-size farms into larger-than-family-size farms". Two such proposals which are particularly relevant here are:

1. "Commodity program benefits could be targeted to small, diversified farms. This could be accomplished by gearing program payments to farm size or existing ownership patterns, and by requiring two or three enterprises per farm for program eligibility."

2. "Public research and information could be aimed exclusively at small and part-time farmers. Diversified farming, labor-intensive production practices, organic farming, and direct marketing would be key research topics." The implication appears to be that a negative correlation exists between size and diversification.

Finally, the relationship between diversification and the form of ownership, wealth and other variables of interest has policy significance as well. For example, it is of interest to determine whether corporations are more specialized due to the risk-spreading nature of the corporate form of ownership.

Among the most prominent and recent studies of diversification and size is that by White and Irwin. Using aggregate U.S. Census data and comparing diversification across farm classes, they conclude that "Census data have suggested some connection between size and specialization in the past." Generally, the data suggested that larger farms are more specialized, but the data are not conclusive for all farm types and classes. Furthermore, the measure of diversification used was "Sales of Primary Product as a Percent of Total Sales by Farm Class."^{1/} Given the level of aggregation and the rough measure of diversification used, it would seem beneficial to further study diversification at the micro level.

The purpose of this paper is to examine the relationship between farm size and other socioeconomic variables and diversification in a large cross section of California farms. Contrary to earlier research findings, it is found that using any of four measures of diversification considered, there is a strong indication of a positive relationship between diversification and size. Further, some evidence suggests that the form of ownership and

diversification exhibit a "significant" relationship. It is also determined that there is a "significant" negative relationship between diversification and measures of financial "well-being". Finally and somewhat unexpectedly, farmer experience or age exhibits a positive effect on diversification (*ceteris paribus*). That is, younger or less experienced farmers are less diversified.

Theoretical Considerations

Certainty theory gives little explicit insight as to predicted diversification patterns unless three facts are known: (1) the nature of the production possibility curve, (2) the nature of constraints on firm choice, and (3) the prices of inputs and outputs. However, it is well known that increasing returns to scale may promote specialization by reducing the concavity of the transformation surface--or making it convex (White and Irwin).

When uncertainty is introduced, the model becomes more complex and diversification is usually promoted if the decision maker is risk averse and the covariance of enterprise returns is zero or negative. For later reference, we shall briefly state the results of several theorems assuming stochastic linear technology and risk aversion.

The basic theorem is that if returns in two activities are independently and identically distributed, then diversification is optimal with equal proportions in each activity (Samuelson). Hadar and Russell have generalized Samuelson's results for a number of cases. The result of interest here is that diversification (not necessarily equal proportions) is optimal when returns have equal means but covariances are negative.

These results suggest that diversification is likely to be optimal for a risk averter. However, large positive covariances, large disparities in mean returns (e.g., scale economies) or resource constraints may provide incentives for specialization. For example, assuming independence of returns, it can be shown that under risk aversion, optimal production levels of crop activities are found by weighing marginal increases in expected profits against marginal increases in risk (variance). Further, as farm size increases, all activity levels increase if there are sufficient increases in the marginal expected return with respect to the marginal increases in variance. (Therefore, if diversification were measured by the number of active enterprises, diversification would increase with size.) These results emphasize the potentially crucial nature of the trade-off between scale economies and benefits from diversification.

Aside from farm size, a number of potentially interesting variables may affect diversification choices. These include net worth, experience of the farm operator, form of ownership (e.g., family farm, corporation) and dummy variables which delineate the activity choice set (primarily variables that indicate geographical location and the extent of irrigation). Net worth, experience, and organizational form may be rationalized to affect diversification in a risk-preference framework as well as alternative models of behavior. For example, learning by doing may lead to incentives for specialization or, greater experience may change risk preferences. Also, one might expect wealthier farmers to be less risk averse, if the concept of decreasing risk aversion is applied in a cross-sectional sense, and perhaps less diversified (Markowitz).

Scalar Measures of Diversification

Since the primary purpose of this study is to conduct an inductive inquiry concerning diversification and the above socioeconomic variables in a cross section of crop farms, it is now necessary to become more precise regarding measures of diversification. Due to data limitations, it is necessary to restrict the indices to include only on farm agricultural production activities.^{2/} Two measures typically used are: the number of crops grown and the maximum over crop proportions of sales of a particular crop (see White and Irwin). For the cross-sectional analysis, it is argued that both net income and crop acreages are potentially interesting variables over which to define diversification. The disparity between these two approaches can be illustrated with two examples. If a farm grew ten acres of strawberries and 1,000 acres of wheat, with each activity yielding \$50,000 net income, then clearly, for many uses, acreage proportions may be a deficient measure of diversification. Similarly, suppose a farm grew 505 acres of wheat and 505 acres of tomatoes; yet, due to random forces, income on tomatoes was \$5,000 and income on wheat production was \$100,000. In such case, income proportions may be a poor measure of diversification (see also Gardner and Pope).

A great deal of research on diversification has been directed towards single-valued measures. However, when a vector of information is collapsed into a scalar, problems can arise (see, for instance, Scherer, pp. 67-69). Clearly, the propriety of a diversification measure depends on the nature of the problem studied. A central question posed here is "Are larger farms more specialized than smaller farms and is there a systematic relationship

between diversification and other farm characteristics." The approach taken is to utilize a wide variety of diversification measures in order to ascertain if the answer to this question is robust to the diversification measure used. Hence, four measures of diversification are considered: each has desirable properties and is defined over net income and acreage proportions and has been used in empirical analyses of diversification. A priori one cannot expect the various measures to yield identical results.

Define A_i as the crop acreage in activity i , and $\sum A_i$ as total farm acreage cropped and let $p_i = A_i / \sum_{i=1}^N A_i$ denote proportions. Then the following measures are considered (White and Irwin, Berry, Hackbart and Anderson).

1. $M_1 = \max_i p_i$ (Index of Maximum Proportion)
2. $M_2 = \sum_{i=1}^N I(p_i)$ where I denotes a zero-one indicator. (Number of Enterprises)
3. $M_3 = \sum_{i=1}^N p_i^2$ (Herfindahl Index)
4. $M_4 = \sum_{i=1}^N p_i \log \frac{1}{p_i}$ (Entropy Index).

When M_1 through M_4 are defined for net income, p_i is the proportion of income from crop i . All measures except M_2 can be computed such that they are bounded by zero and one. For increasing diversification, M_1 is generally decreasing, M_2 is increasing, M_3 is decreasing, and M_4 is increasing. This statement is apparent for M_1 and M_2 . For M_3 and M_4 (see Berry, Hackbart and Anderson, or Theil).

We shall briefly comment on some of the properties of the measures M_3 and M_4 . The Herfindahl index takes a value of 1 when there is complete specialization and approaches 0 as N gets large. That is, if diversification is "perfect" such that

$$A_i = \frac{1}{N} A \text{ and } N \rightarrow \infty, \text{ the } \sum_{i=1}^N p_i^2 = \frac{1}{N} \rightarrow 0.$$

M_4 is the entropy measure popularized in economics by Theil. It possesses several desirable properties (see Hackbart and Anderson). For our purposes, it is important to note that M_4 approaches its maximum when $p_i = \frac{1}{N}$, or when diversification is "perfect". Recalling Samuelson's theorem, the entropy index is maximized when optimal diversification is undertaken by a risk averter when returns are independent and have equal means. It approaches zero when a farm is specialized.

The Empirical Model

On the basis of theory, one can derive few (if any) firm hypotheses regarding diversification, scale, constraints, organizational form, and other relevant factors. The essential point is that the theory does suggest that these could be important elements in diversification decisions. As limited by our sample, we shall investigate the following relationship:

$$M_{jt} = a_0^j + a_1^j Z_t + a_2^j D_t + a_3^j S_t + a_4^j W_t + a_5^j E_t + \epsilon_t \quad \begin{matrix} t = 1 \dots T \\ j = 1 \dots 4, \end{matrix}$$

$$\epsilon_t \sim N(0, \sigma^2), E(\epsilon_t \epsilon_{t'}) = 0 \text{ for } t \neq t',$$

where M_{jt} is the j^{th} diversification measure on the t^{th} farm, Z_t is a

vector representing organizational forms (dummy variables for partnership, family corporation, and corporation; family farms are represented by the constant term). D_t is a vector of locational dummies; S_t (farm size) is acres cropped; W_t (wealth) is net worth per acres cropped;^{3/} and E_t (experience) is the year the farmer started farming.

The sample consists of data obtained from financial institutions on over 1,000 crop farms in the San Joaquin Valley in California. Most of these farms are not monocultures, and the potential to grow a number of crops is great.^{4/} This area seems well suited for the study. We note that we know of few other large micro samples that would allow one to investigate the above relationships (it is particularly difficult to obtain net worth figures).

The Empirical Results

The regression results via ordinary least squares for the four measures computed on crop acreages are given in Table 1.^{5/} At once it is clear that various null hypotheses on the coefficients may be sensitive to the measure of diversification used. However, all of the results suggest that farm size has a positive effect on diversification. This is in contrast to the meager and/or inconclusive evidence computed from the U.S. census by White and Irwin. These results shed some light on the nature of the trade-offs between scale economies and risk reduction mentioned above. That is, if there are large-scale economies in an enterprise, then one might expect larger farms to be more specialized. Clearly our results refute this hypothesis.

The net worth variable shows a significant negative effect on diversification (i.e., wealthier farms are more specialized, ceteris paribus) for all diversification measures in Table 1. These results would be consistent with a decreasing (in wealth) type risk aversion in a cross-sectional sense. That is, wealthier farms are less risk averse and less diversified--other things equal.

Another surprising result concerns the experience variable. Table 1 indicates that younger or less experienced farmers are more specialized. One might speculate that younger farmers are less risk averse. But, more plausibly, young farmers may start small and specialized and perhaps become more diversified as they expand their operation. This may be indicative of capital shortages for young farmers. Also, it may be difficult for less experienced farmers to manage diverse activities.

Concluding the discussion of results from Table 1, "significance" levels vary with the measure of diversification for the organizational dummies. Further, the signs among the different measures are not consistent. However, the evidence suggests that corporate farms are more specialized than other farms.^{6/}

Table 2 presents results for measures M_1 , M_3 , and M_4 when these measures are defined over net revenue (M_2 remains unchanged). Net revenue is defined as sales less variable costs. Here it is noted that all "significance" levels are low for variables representing organizational form. This is in contrast to evidence presented in Table 1. However, again there is strong evidence that larger farms are more diversified than smaller farms (ceteris paribus). Again, the results indicate that more experienced

farmers are more diversified than those with less experience, and wealthier farmers are more specialized (*ceteris paribus*). Therefore, on the basis of this sample, evidence suggests that the results stated above are fairly robust with respect to the diversification measure used.

Summary and Conclusions

Using alternative measures of diversification, a sample of California farms revealed evidence that larger farms are more diversified. Wealthier and less experienced farmers are more specialized. Finally, there is also evidence that corporations are more specialized than farms with other organizational forms.

Evidence reported here suggests that diversification and size (or growth) may be positively linked. Hence, there may not be sufficient economies of scale in a particular commodity to warrant specialization. In general, the results here are consistent with risk theories. That is, the firm diversifies to spread risk and wealthier farmers have fewer incentives to spread risk. However, as with all cross-section studies, questionable causation and the myriad of forces at work lead one to be cautious when interpreting results. The essential point is that these results may be cause for reservation for those supporting policies which are tied to diversified farms which are presumed to be relatively small. Raup and others have suggested that larger farms may be in relatively poorer risk posture than smaller farms. However, the results reported here may not support his hypothesis. They indicate that positive economic analysis of diversification needs further research in order to delineate more fully the economics of activity choice.

Table 1
Regression Results on Diversification Measures
Defined on Crop Acreages^{1/}

Independent variable (t-ratios)	Dependent variable			
	M ₁	M ₂	M ₃	M ₄
Constant	.670 (20.21)	2.09 (8.26)	.4 (13.1)	.61 (8.4)
Z ₁ = partnership	-.027 (-1.56)	3.56 (2.62)	-.0061 (-.41)	.082 (2.09)
Z ₂ = family corporation	-.048 (-1.44)	.818 (3.19)	-.043 (-1.57)	.166 (2.22)
Z ₃ = corporation	.030 (.84)	-.125 (-.45)	.034 (1.17)	-.046 (-.57)
D ₁ ^{2/}	.049 (2.17)	-.295 (-1.7)	.064 (3.15)	-.096 (-1.9)
D ₂ ^{3/}	.019 (.50)	.0826 (.28)	-.01 (-.29)	.0042 (.05)
D ₃ ^{4/}	-.060 (-2.78)	.68 (4.10)	-.021 (-1.09)	.18 (3.72)
D ₄ ^{5/}	-.141 (-7.96)	1.32 (9.79)	-.018 (-1.05)	.362 (9.2)
S = farm size in acres cropped	-.000033 (-5.94)	.00051 (11.93)	-.000012 (-2.74)	.0001 (8.50)
W = net worth/acres cropped	.000031 (7.65)	-.002 (-6.54)	.000018 (4.09)	-.00007 (-7.36)
E = experience	.002 (4.92)	-.0087 (-2.71)	.00065 (1.77)	-.0039 (-4.2)
R ²	.20	.30	.12	.25

^{1/} Refer to section IV for the relationship between the index value and diversification. Summarizing that discussion, M₁ and M₃ decreasing, M₂ and M₄ increasing implies increased diversification.

^{2/} Indicates farm is located in Fresno County, California.

^{3/} Indicates farm is located in Madera County, California.

^{4/} Indicates farm is located in Kern, Merced, San Joaquin or Tulare County, California.

^{5/} Indicates whether or not farm is irrigated, D₄ = 1, if irrigated.

Table 2
Regression Results Based on Diversification Measures
Defined on Farm Net Revenue^{1/}

Independent variable (t-ratios)	Dependent variable		
	M ₁	M ₃	M ₄
Constant	.77 (21.1)	.70 (16.5)	.478 (6.05)
Z ₁ = partnership	-.0046 (-.25)	-.0088 (-.40)	.028 (.70)
Z ₂ = family corporation	.026 (.64)	.016 (.33)	-.013 (-.14)
Z ₃ = corporation	.01 (.26)	.0081 (.16)	-.033 (-.37)
D ₁	.014 (.59)	.012 (.44)	-.042 (-.83)
D ₂	.038 (.94)	.047 (.97)	-.124 (-1.39)
D ₃	-.072 (-3.13)	-.095 (-3.53)	-.183 (3.67)
D ₄	-.011 (-6.40)	-.14 (-6.99)	.291 (7.39)
S = farm size /acres cropped	-.000054 (-7.19)	-.000071 (-7.96)	.00014 (8.95)
W = net worth/acres cropped	.000028 (1.40)	.000042 (1.75)	-.000085 (-1.90)
E = experience	.0017 (4.00)	.0021 (4.18)	-.0034 (-3.69)
R ²	.15	.18	.20

^{1/} See Table 1 for details.

Footnotes

1/ Primary product includes broad crop classifications, e.g., cash-grain, cotton, vegetable, fruit and nut, poultry, dairy, livestock and other field crops.

2/ It would be interesting to include nonfarm activities as well and define diversification over all income generating activities. However, the data at our disposal did not allow such an analysis. It is hoped that this omission does not substantively diminish our findings.

3/ Assets are measured at current market value. Net worth is then calculated as assets minus liabilities. These calculations include all assets (including nonfarm) and all liabilities for each entrepreneur.

4/ Though there is some opportunity for complementary land use cropping patterns, it is almost always the case that farms have a choice between crop patterns of varying degrees of complementarity. Not only do complementary cropping patterns (e.g., spring and fall vegetables) affect risk but they also reduce cash flow problems. Thus, increased liquid reserves may serve to reduce diversification.

5/ Since most of the diversification measures are bounded by zero and one, one may be suspicious of the assumption of normality. Further, one may wish an estimator which ensures that predicted values of M_j are in the interval (0, 1). A popular transformation to alleviate these problems is the logit transformation (Theil) where the dependent variable becomes $\ln[M_j/(1 - M_j)]$. However, such transformations are used for M_j in the open positive unit interval. Here, $M_j = 1$ is not only possible, but occurs over 100 times in the data. Hence, ordinary least-squares

estimators will be presented.

6/ The rankings in terms of diversification are

$$M_1: Z_3 < Z_2 > Z_1;$$

$$M_2: Z_3 < Z_2 < Z_1;$$

$$M_3: Z_3 < Z_2 > Z_1;$$

$$M_4: Z_3 < Z_1 < Z_2$$

where the Z's represent the sum of the estimated constant plus the dummy coefficient.

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