# Risk Management Through Enterprise Diversification: A Farm-Level Analysis

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*Abstract*

Enterprise diversification is a self-insuring strategy used by farmers to protect against risk. This paper examines the impact of various farm, operator, and household characteristics on the level of on-farm diversification. Results provide evidence that larger farms are more specialized. Also, farmers who participate in off-farm income and farms located near urban areas are less likely to diversify. Additionally, results also show a significant positive relationship between diversification and farm/crop insurance and sole proprietorships. Finally, there is also evidence that farms that received government payments are more diversified than their counterparts.

***Keywords:*** Agricultural Resource Management Survey, farm diversification, off-farm income, farm size, location, soil productivity.

**Risk Management Through Enterprise Diversification: A Farm-Level Analysis**

After a wave of intense diversification in the 1960s and 70s, the 1980s and 90s have seen a migration or even a reversal of this trend. Nonetheless, as Montgomery (1994) points out, the diversified (multi-product) firm still is the rule rather than the exception. Analysis of the factors affecting firm (farm) diversification remains a busy field of research in strategic management and industrial organization (Briglauer, 2000). Additionally, farming is a risky business because it deals with uncertain factors such as weather and market conditions. This uncertainty can result in variable returns (farm income) to the decisions that farmers make in a particular year. Therefore, farm income variability is a problem that the farming household has to deal with. Enterprise diversification is one method of reducing income variability (Robison and Barry; Newbery and Stiglitz). There are two different aspects of diversification. One is that of planning under an assumption of perfect knowledge and the other is to minimize the variance of an outcome by attempting to put a floor under the income level or by preventing the occurrence of undesirable outcomes (Heady). Farmers and farm managers, faced by price and yield variability, may wish to select a combination of enterprises to reduce the variability of farm income.

Diversification is a frequently used risk management strategy that involves participating in more than one activity. It has the added advantage of mitigating price risk as well as fluctuations in outputs. In the U.S., corn and soybeans, and corn with beef or hogs are common combinations. In less developed economies, Walker and Jodha report multiple crops and inter-cropping are common, including agro-forestry. Diversification extending beyond the farm operating units is usually ignored (e.g. off-farm employment). Economically sized and diversified-enterprises may not be realized on the average farm. The management skills and capital required to establish and maintain such a business successfully may be beyond the ability of some farmers. It may be better for specialized farms to seek diversification off the farm. Off-farm diversification may come in the form of investments in public company stocks, government bonds, various forms of joint ventures related to agriculture (such as feeding in large cattle feedlots, or hog operations), or simply off-farm employment during slack seasons. Livestock investments should be large enough to take advantage of the economies of size but divisible into units that can be financed by the average farm business.

Despite the frequent observation that diversification plays an important role in agriculture, there are only a few empirical studies on the factors that contribute to farm diversification. The purpose of this paper is to examine factors that determined farm diversification in the U.S. in 1996 and 2000. This is particularly important, as it would allow for the testing of the notion that production flexibility prescribed under the FAIR Act will alter farmers' cropping mix (or production decisions). If this is the case then one would expect the impact of government payments in 1996, when FAIR was enacted, on diversification to differ from that of 2000. The analysis is conducted on a national level with the unique feature of a larger sample than previously reported, comprising farms of different economic sizes and in different regions of the United States.

**Literature Review**

A limited number of studies on diversification focus on the relationship between diversification and farm size. White and Irwin (1972), using aggregate U.S. Census data, compared diversification across farm size classes. The authors concluded that larger farms are more specialized. Pope and Prescott (1980), using 1,000 California crop farms and four different measures of diversification investigated the relationship between diversification and farm size and other socio-economic variables. The authors found a strong indication of a positive relationship between diversification and farm size. In analyzing data on 2,192 farms across three U.S. regions, Sun, Jinkins, and El-Osta (1995) distinguished between different "stages of diversification" which were found to influence the relationship between size and diversification. Although these studies differ substantially in the empirical approach and results reported, two common characteristics are to be mentioned. Firstly, they consider farm production diversification only and do not control for the impact of additional off-farm income. Secondly, the impact of commodity program participation is usually ignored. To the extent that participation in government commodity programs is viewed as a risk reducing mechanism (Goodwin; Calvin; and Just and Calvin), and because the 1996 Federal Agricultural Improvement Reform Act (FAIR) requires a reduction in payments[1], this study will examine the potential impact of payments on diversification. The need for examining such potential impact lies in the effect a change in commodity specialization or diversification might have on input usage and/or the environment.

**Theoretical Consideration**

The mean-variance (E-V) approach, which underlies this study, is a straightforward extension of utility theory. Under the assumptions of an E-V approach, an individual's preference ordering depends solely on the mean and variance of returns--an uncertain prospect can be represented fully by its mean and variance. The decision rule used by a farmer to choose the appropriate

[1] In practice payments have far exceeded the amounts called for in the 1996 Farm Act and the payments made were disbursed based on the ability ot earn payments under the 1996 Farm Act (e.g., emergency payments were some portion of AMTA.

enterprise mix from among virtually unlimited possibilities is to maximize the utility of income derived from the possible enterprise portfolios, where utility depends only on the mean and variance of returns. The assumption here is that the farmer's preference function can be described, approximately at least, in terms of the mean and the variance of returns. There are several reasons. One reason is that individuals maximize expected utility and either the underlying utility function is approximately quadratic in income or the distribution of returns involves only the mean and variance. Second, even if the expected utility maximization is not assumed, the mean-variance approach still can be considered a reasonable first approximation of behavior[2]. Markowitz asserted the existence of a utility function of income $U(E, V)$, where $dU/dE > 0$ and $dU/dV < 0$ hold. Our model is based on the assumption that $U(E, V)$ exists.

Given that $U(E, V)$ exists, the preference function will be linearized for ease of estimation in the following manner,

$$U(E,V) = E - bV. \qquad (1)$$

where the $b$ represents the subjective risk coefficient of the farm operator. Now the utility of returns to the farm operator is a direct function of the mean and variance of the returns. An extension of this model, so that the choice object is the maximization of utility of an enterprise portfolio is quite simple for a two-enterprise case. If the farm operator makes his enterprise decision between two enterprises, the equation for portfolio selection is to maximize

$$U(Z) = \lambda\mu_x + (1-\lambda)\mu_y - b\left[\lambda^2\sigma_x^2 + (1-\lambda)^2\sigma_y^2 + 2(\lambda - \lambda^2)\sigma_{xy}\right] \qquad (2)$$

where $Z$ represents the returns from a portfolio of two enterprises $x$ and $y$. The two enterprises are

[2] Several reasons for this approximation--people find it easier to compute (Borch, 1968) or distribution facing individuals exhibit little "skewness" (Borch, 1969) or "information costs" on higher-order moments are prohibitive

treated as stochastic variables, where $\lambda \geq 0$ is the fraction of total portfolio allocated to enterprise, *x*, and $1-\lambda$ is the fraction of total portfolio allocated to enterprise, *y*. In equation 2, $\mu_x = E(X)$ and $\mu_y = E(Y)$ represent the expected (mean) returns from enterprise *x* and expected (mean) returns from enterprise *y*, respectively. The variance of returns from enterprise *x* is $\sigma_x^2$ and the variance of returns from enterprise *y* is $\sigma_y^2$. Finally, the covariance of returns from enterprise *x* and *y* is $\sigma_{xy}$. Thus the expected value of returns per enterprise for a two-enterprise portfolio is:

$$E(Z) = \lambda\mu_x + (1-\lambda)\mu_y \tag{3}$$

and the variance of returns from the portfolio is

$$\sigma_z^2 = \lambda^2\sigma_x^2 + (1-\lambda)^2\sigma_y^2 + 2(\lambda-\lambda^2)\sigma_{xy} \tag{4}$$

where $E(Z)$ and $\sigma_z^2$ are simply the mean and variance of the combination of the two enterprises, respectively. For a portfolio consisting of two enterprises, the model will be of the form in equation 2. The farm operator is assumed to have maximized *U* and the decision is to choose $\lambda$ that would lead to this maximization. The first-order condition for the maximization of *U* is:

$$\frac{dU}{d\lambda} = \mu_x - \mu_y - b\left[2\lambda\sigma_x^2 - 2(1-\lambda)\sigma_y^2 + (2-4\lambda)\sigma_{xy}\right] = 0 \tag{5}$$

The model presented here could be generalized for more than two enterprises. Let us assume that returns from the *i-th* enterprise is $\widetilde{R}_i$, and the farm operator allocates a fraction of $\lambda_i$ of the portfolio to enterprise *i*, then the total income is:

$$\widetilde{I} = \sum_{i=1}^{n} \lambda_i \widetilde{R}_i \tag{6}$$

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(Gould, 1974).

which has the mean and variance:

$$\bar{I} = \sum \lambda_i \overline{R}_i$$

$$V^2 = \sum \lambda_i^2 Var(R_i) + 2\sum_{i \neq j} \lambda_i \lambda_j Cov(R_i, R_j) \tag{7}$$

As a farm operator varies his portfolio, that is, the farm plan, the income remains normally distributed, though its mean and standard deviation will depend on the choice of the fractions $\lambda_i$. Figure 1 plots the outcome of efficient portfolio choices (those which minimize $V$ for a given $\bar{I}$), and the indifference curves associated with the utility function (lines of constant expected utility). The goal of this analysis is to determine the effect of farm and operator characteristics, soil productivity, and distance to market on farm diversification. An empirical representation of equation 5 that relates diversification to several relevant explanatory variables is given by

$$Y_i = Z_i \beta + \psi_i \tag{8}$$

where $Y_i$ is the entropy index (measure of diversification); $Z_i$ is a vector of farm and operator characteristics, location, and soil productivity, and distance to market; $\beta$ is a vector of unknown parameters to be estimated; and $\psi_i$ is a residual term.

**Empirical Model and Estimation**

The empirical model in equation 8 can be expressed as:

$$L_i = log\left[\frac{Y_i}{1-Y_i}\right] = \alpha_0 + \alpha_1 X_{1,i} + \alpha_2 X_{2,i} + \ldots\ldots + \alpha_k X_{k,i} + \phi_i \tag{9}$$

where *log* is the natural logarithm operator, $X$ is an explanatory variable, and $\alpha$ is a coefficient to be estimated. Since the values of $Y_i$ are between 1 and 0 and in order to avoid violating the standard assumption about the error term (i.e., $\psi_i$ is required to have a non-truncated normal distribution) which is needed in least squares, a logistic transformation of $Y_i$ is carried out as depicted in $L_i$ (equation 9). El-Osta, Bernat, and Ahearn used a similar transformation of a Gini coefficient to investigate the role of off-farm income in income inequality (also *see* Fomby, Hill and Johnson; Slottje, Hayes, and Shackett; Greene).

The are several measures of diversification used in the literature (concentration ratio, Berry-index, Herfindhal index, Entropy index). The properties of these measures are discussed in more detail in Hackbart and Anderson as well as Gollop and Monahan. The entropy index was initially developed in information theory as a measure of the profitability distribution or entropy of random variables with a finite sample space, but its application has been expanded to other sciences. In this study enterprise diversification is measured using an entropy index[3] (Theil), which accounts for both the mix of commodities and the relative importance of each commodity to the farm business. The entropy index spans a continuous range from 0 to 1. The value of the index for a completely specialized farm producing one commodity is 0. A completely diversified farm with equal shares of each commodity has an entropy index of 1. Specifically, an entropy measure of farm diversification considers the number of enterprises a farm participates in and the relative importance of each enterprise to the farm. An operation with many enterprises, but with one predominant enterprise, would have a lower number on the diversification index. Higher

[3] $EINDX = \sum_{i=1}^{N} (\text{\% of production from entrprise i}) \frac{\ln\left(\frac{1}{\text{\% production from enterprise i}}\right)}{\ln(N)}$, where i refers to each of the N possible enterprises.

index numbers go to the operations that distribute their production more equally among several enterprises.

The model is estimated using Weighted Least Squares. Additionally, a multiplicative dummy variable approach will be used to test for statistical difference among regression coefficients over the two time periods.

**Test of Equivalency of Separate Coefficients Across Two Regressions**

Using the base model as an example, let the following represent the regression performed on pooled data (1996 and 2000):

$$L_i = \alpha_0 + \sum_{k=1}^{18} \alpha_k X_k + \delta_{19} D + \sum_{20}^{37} \delta_k D_k X_k + \xi \qquad (10)$$

where $D$ is a dummy variable that equals one if the year is 1996, and $D$ is zero otherwise. Since each of the dummy coefficients $\delta_{19}........\delta_{37}$, also known as differential slope coefficients, measures the difference in respective slopes across the two years (1996 and 2000), resulting *t*-tests from the regression performed on (9) provide useful information. For example, if the *t*-test that corresponds to $\delta_{20}$ indicates that $\delta_{20}$ is significantly different than zero, this is equivalent to the finding that the coefficients of the variable *OP_AGE* are based on two separate regressions--one for each year 1996 and 2000--are significantly different. If the resulting *t*-ratio is positively signed, this indicates that the *OP_AGE*'s coefficient in the year 2000 is significantly larger than its counterpart in the year 1996.

**Data**

Data for the analysis is pooled from the 1996 and 2000 Agricultural Resource Management Survey. ARMS is conducted annually by the Economic Research Service and the National

Agricultural Statistics Service. ARMS uses a multi-phase sampling design and allows each sampled farm to represent a number of farms that are similar, the number of which being the survey expansion factor. The survey collects data to measure the financial condition (farm income, expenses, assets and debts) and operating characteristics of farm businesses, the cost of producing agricultural commodities, and the well-being of farm operator households. In addition to collecting basic financial data, the ARMS is dedicated to the collection of special data on farm and farm operator households. In 1996 and 2000 the ARMS collected information on business contracts by farm operators, management decisions, sources of information, use of technology, management strategies, and off-farm employment.

Table 1 presents the definition and mean values of the explanatory variables and dependent variable (EINDX). In general, farms in year 2000 were slightly more diversified than farms in 1996. The average age of the farm operator in year 2000 was higher than the average age of the farm operator in 1996, however, the average level of education for farm operators was similar between the two samples. An average farm in the 2000 sample received twice as high a government payment compared to farms in 1996 (approximately $4,600 in 2000 and $2,400 in 1996). Further, the average value of agricultural products sold by an average farm fell from $82,300 in 1996 to $69,700. Finally, the data show that the number of full time farm operators decreased between the two years, from 30 percent in 1996 to 28 percent in 2000, correspondingly income from off-farm wages and salaried jobs increased by 29 percent, from $26,200 in 1996 to $33,700 in 2000.

**Results**

Weighted least squares estimates of factors affecting farm diversification as depicted in equation 9, for 1996 and 2000, are presented in Table 2. The adjusted $R^2$ of 0.19 and 0.22 for 1996 and 2000, respectively, indicates that the explanatory variables used in the weighted least squares explained 19 percent and 22 percent of the variation in farm diversification. These levels of explained variation are fairly typical when analyzes are based on cross-sectional data. In 1996, the estimated model in (9) reveals that nine variables are significantly correlated with farm diversification. The sixth column in Table 2 denote the t-test of the differences in parameters between 1996 and 2000 time periods. The test, using the multiplicative dummy variable approach (see Pindyck and Rubinfeld), is used to highlight any significant parameter differences across the two time-periods. Based on the values of the t-statistics, age of the operator, whether the farm has insurance, marketing and production contracts, and off-farm income variables exhibit statistical difference. Additionally, amount of government payments received, and whether the farm operator is full-time and the farm is located in the Northeast show statistical difference across the two periods.

Farm size measured by the value of agricultural product sold by the farm (FRM_SIZE) is significant and inversely related farm diversification (EINDX). This is in contrast with findings that diversification activities are concentrated on large farms (Pope and Prescott; Gasson; Ilbery; Shucksmith and Smith). Results suggest that larger farms may be more specialized. This is consistent with an economies of scale argument. That is, if there are large-scale economies in an enterprise then one might expect large farms to be more specialized. Our results support this hypothesis. Another possible explanation is that since farm size and wealth tend to be positively correlated, one can deduce that wealthier farms are less risk averse and less diversified--other things being equal. This is consistent with Pope and Prescott who find a negative and significant relationship between wealth and farm diversification.

The coefficient of age of the farm operator (OP_AGE) is negative and statistically significant at the 1 percent and 5 percent level for the 1996 and 2000 models, respectively. Results suggest that older farm operators are less likely to diversify. One possible explanation is that older farm operators have more wealth and wealthier farm operators are less risk averse and less diversified (Pope and Prescott). On the other hand, young and beginning farm operators are more risk averse and are in the wealth accumulation phase of their life cycle. But more plausibly, young farmers may start small and diversified and perhaps become more specialized as they expand their operation. The size of the farm household (HH_SIZE) is included because Bowler *et al*. are among the authors reporting that the need to create employment for family members is one of the important factors motivating farm diversification. Additionally, Damianos and Skuras note that the size of the farm household may be an indication that diversified farms are at an earlier stage in the life cycle. This is the stage when farmers tend to make the greatest change to the farm business (Potter and Gasson). Results from this study indicate that the size of the farm household and diversification are positively correlated in both models (1996 and 2000). Results are consistent with the findings of Damianos and Skuras; Bowler *et al*.; and McNally.

Government payments play an important role in production agriculture and the survival of farms. For example, in 2000 government payments played a major role in stabilizing gross and net income of U.S. farms. Three government programs, under the existing 1996 Farm Act, provided the bulk of these outlays: production flexibility contract payments (which replaced most commodity program payments), loan deficiency payments, and emergency supplemental appropriations enacted in October 2000. Federal direct payments to farmers totaled approximately $23 billion in 2000 with 22 percent of the amount in the form of production flexibility payments, 28 percent in deficiency payments, with the remainder primarily in the form of emergency assistance payments. To a great number of farms, federal government payments are used for debt reduction thereby improving their financial position. Yet to some farmers, government payments are used, as in the case of income from off-farm sources or in the case of cash received from the diminution of their capital stock, as means to guarantee their economic survival (see Harvey). The coefficient of government payments (GOV_PMT), AMTA and LDP, is positive and significant in both models (1996 and 2000). Results suggest that farms that received government payments are more likely to diversify. Receiving payments from government programs is often considered a primary risk-reducing mechanism (Kramer and Pope; Musser and Stamoulis). Goodwin and Schroeder note that government programs are intended to decrease agricultural producer risks. In addition, Robison and Barry point out that government programs emphasize the provision of risk-reducing opportunities for the farm. A further explanation could be that government payments provide necessary capital to start up new enterprises and diversify the farming operation.

The coefficient on off-farm income (OFF_WAGE), from wages and salaries, is negative and statistically significant only in the 2000 model. Because of low farm income and a better non-farm economy, many farm operators and their spouses worked off the farm. This is also apparent by the fact that the average number of farm operators working full time on the farm decreased in

2000. Additionally, Mishra and Goodwin found a positive relationship between the coefficient of variation for farm income and off-farm work. That is, the greater the variability of farm income, the higher the farm operators' off-farm labor participation rate. Off-farm income diversifies a farm operator's income portfolio and reduces the degree of farm diversification and possibly off-farm work is not compatible with the labor demands of farm diversification. This is consistent with the findings of Calvin; Just and Calvin; and Mishra and Sandretto. A negative and significant coefficient of OFF_WAGE supports the potential ability of farmers to self-insure. Results in Table 2 show that there is a positive and significant relationship between diversification and full-time farm operators (WRK_STAT). Results indicate that a full-time farmer is more likely to diversify compared with a part-time farm operator. A plausible explanation is that full-time farmers are committed to farming and want to diversify risk on the farm. Another explanation could be that full-time farm operators are involved in labor intensive farming[4], such as dairy, which leaves very little time to work off the farm.

Purchase of insurance, crop insurance or revenue insurance, is a private risk management strategies that farmers have used to reduce risk and uncertainty associated with farm income (Harwood *et al*.,). The coefficient of farm insurance (HAV_INSUR) is positive and statistically significant at the 1 percent level for both years, 1996 and 2000. Results indicate that farm operators who buy insurance would diversify their farms. This may be a case of a risk averse farm operator who is reducing risk in several ways. This result demonstrates the farm operator's ability to self-insure and that insurance and diversification are compliments. A positive and significant correlation is found to exit between farm diversification the legal form of business

[4] Farmers involved in highly seasonal production activities, such as cash grains, have more time to pursue non-

organization, particularly if the business is organized as a sole proprietorship (FRM_SOLE), when compared with others forms of business organization[5]. In the case of sole proprietorship the farm operator has much at stake in the form of capital financing (unlimited personal liability for the business's debts) and there is no risk sharing. On the other hand, corporations have members who have shares and risk is distributed among the shareholders. Second, sole proprietorships is a common form or business organization on small and medium farms. Therefore, it is not surprising for a sole proprietor to diversify the farm considering the fact that diversification is a private risk management strategy.

Aside from the farm, operator, and household characteristics, soil productivity and distance to the urban areas are also factors that may affect farm diversification. For example, if the soil is productive and can produce several crops, then the farm operator might be inclined to try new crops and other enterprises on the farm. The coefficient of mean productivity index (FRM_PROD) is positive and significant for both models at the 1 percent level. Previous work on farm diversification highlighted the importance of proximity to main roads and urban centers for development of other farm enterprises (Ilbery; Shucksmith *et al*.,; Edmond, Corcoran, and Crabtree). Such an access is assumed to provide the market stimulus for the development of farm enterprise. Results show a negative and significant correlation between farm diversification and proximity to urban area (FRM_URBAN) in both models. Operators and family members of farms located near urban areas are more likely to work off the farm and cannot meet the labor demand of a diversified farm. This is evident from negative and significant effect of off-farm work on diversification. Additionally, farms located near urban areas tend to specialize in niche

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agricultural activities--both on and off their farm.

products. Finally, geographic location of farms determines cropping pattern, rainfall, soil productivity. Four regional dummies to indicate location of the farm were defined and three were included in the regression. However, only the coefficient of Midwest was statistically significant in both models (1996 and 2000). Results indicate that compared to farms in the South (benchmark), Midwestern farms are more likely to diversify.

## Summary and Conclusions

The purpose of this paper is to identify farm, operator, and financial characteristics that are correlated with farm diversification in two time-periods (1996 and 2000). The present study uses national farm level data (1996 and 2000) with great diversity regarding farm size, location, commodities produced, and risk management strategies (such as crop insurance, participation in production and marketing contracts, and off-farm income). Evidence reported here suggests that diversification and farm size may be negatively correlated. Results suggest that economies of scale exist in production, which is consistent with economic theory. Further, older farm operators, farm households with off-farm income, and farm located near urban areas are less likely to diversify. On the other hand, the study also points out to a positive and significant correlation between farm diversification and family size, sole proprietorship, and having crop insurance or farm insurance and full time. Finally, there is also evidence that farms that received government payments are more diversified than their counterparts.

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[5] Other forms of business organization included family corporations. This acted as the benchmark.

## References


Berry, C.H. "Corporate Growth and Diversification". *Journal of Law and Economics,* 14 (1971): 371-383.

Briglauer, W. Motives fir Firm Diversification: A Survey on Theory and Empirical Evidence, WIFO, Working Papers, Vol. 26, 2000.

Borch, K. H. *The Economics of Uncertainty*. Princeton, N.J.: Princeton University Press, 1968.

Borch, K. H. "A Note of Uncertainty and Indifference Curves." *The Review of Economic Studies,* 36 (1969).

Bowler, I., G. Clark., A. Crockett., B. Ilbery., and A. Shaw. "The Development of Alternative Farm Enterprises: A Study of Family Labor Farms in Northern Pennines of England". *Journal of Rural Studies,* Vol. 12(3), 1996: pp. 285-295.

Calvin, L. *Participation in the U.S. Federal Crop Insurance Program*. U.S. Department of Agriculture, Economic Research Service , Washington DC, Tech. Bulletin # 1800, 1992.

Damianos, D., and D. Skuras. "Frm Business and the Development of Alternative Farm Enterprises: Aempircal Analysis in Greece". *Journal of Rural Studies,* Vol. 12(3), 1996: pp. 273-283.

Edmond, H., K. Corcoran., and B. Crabtree. "Modelling Location Access to Markets for Pluriactivity: A Study in the Grampian Region of Scotland". *Journal of Rural Studies,* Vol. 9(3), 1993: pp. 339-349.

El-Osta, H. S., G. A. Bernat., M. C. Ahearn. 1995. "Regional Differences in the Contribution of Off-Farm Work to Income Inequality". *Agricultural and Resource Economics Review,* 24(1): 1-14.

Fomby, T., R. C. Hill, and S. R. Johnson. *Advanced Econometrics Methods,* Springer-Verlag, New York, 1984.

Gasson, R. "Farm Diversification and Rural Development". *Journal of Agricultural Economics,* Vol. 39(2), 1988: pp. 175-182.

Gollpo, F.M. and J.L. Monahan. "A Generalized Index of Diversification: Trends in US Manufacturing". *The Review of Economics and Statistics,* Vol. 73(1991):318-330.

Goodwin, B. K. "An Empirical Analysis of the Demand for Multiple Peril Crop Insurance." *American Journal of Agricultural Economics,* 75(May, 1993):425-34.

Goodwin, B. K. and T. C. Schroeder. "Human Capital, Producer Education Programs, and the Adoption of Forward Pricing Methods," *American Journal of Agricultural Economics*, 76, 936, (1994).

Greene, W. *Econometric Analysis*, $4^{th}$ edition, NJ. Prentice-Hall Inc. Upper Saddle River, NJ, 2000.

Hackbart, Merlin M., and Donald A. Anderson. "On Measuring Economic Diversification': Reply". *Land Economics* 54 (1978):111-112.

Hadar, J., and W. Russell. "Diversification of Independent Prospects." *Journal of Economic Theory* 7 (1974):231-240.

Harwood, J. L., R. G. Heifner, K. H. Coble, J. E. Perry, and A. Somwaru. Managing Risk in Farming: Concepts, Research, and Analysis. Agr. Eco. Report 774, USDA-ERS, Commodity Economics Division, Washington D.C. 1999.

Heady, E. "Diversification in Resource Allocation and Minimization of Income Variability". *Journal of Farm Economics* 34 (1952):484-496.

Ilbery, B. "Farm Diversification as an Adjustment Strategy to the Urban Fringe of the West Midlands". *Journal of Rural Studies,* Vol. 7(3), 1991: pp. 207-218.
Just, R. E., and L. Calvin. "An Empirical Analysis of U.S. Participation in Crop Insurance." Unpublished Report to the Federal Crop Insurance Corporation, 1990.
Kramer, R. A., and R. D. Pope. "Participation in Farm Commodity Programs: A Stochastic Dominance Analysis." *American Journal of Agricultural Economics,* 66(Feb. 1981) :119-128.
Markowitz, H. *Portfolio Selection-Efficient Diversification of Investments*. NY, John Wiley &Sons, 1959.
McNally, S. "Farm Diversification in England and Wales-What Can We Learn from Farm Business Survey?" *Journal of Rural Studies,* Vol. 17(3), 2001: pp. 247-257.
Mishra, Ashok K. and Carmen L. Sandretto "Stability of Farm Income and the Role of Nonfarm Income in U.S. Agriculture." *Review of Agricultural Economics,* Vol 24(1) 2002: pp. 208-221.
Mishra, Ashok K. and B. K. Goodwin. "Farm Income Variability and the Supply of Off-farm Labor." *American Journal of Agricultural Economics*, 79, August, 1997: 880-887.
Montgomery, C.A. "Corporate Diversification", *Journal of Economic Perspectives*, 8 (1994). pp. 163-178.
Musser, W. N. and G. Stamoulis. "Evaluating the Food and Agricultural Act of 1977 with Firm Quadratic Programming," *American Journal of Agricultural Economics*, 63, 447, (1981).
Newbery, D.M.G. and J.E. Stiglitz. *The Theory of Commodity Price Stabilization*, Oxford Univ. Press, Oxford, U.K. 1985.
Pindyck, R. S., and D. L. Rubinfeld. *Econometric Models and Economic Forecasts*, Third Edition McGraw-Hill , New York, 1991.
Pope, R.D. and R. Prescott. "Diversification in Relation to Farm Size and Other Socioeconomic Characteristics," *American Journal of Agricultural Economics*, Vol. 62 (1980):554-559.
Potter, C., and R. Gasson. Farmer Participation in Voluntary Land Diversion Schemes: Some Prediction from a Survey". *Journal of Rural Studies,* Vol. 4(3), 1988: pp. 365-375.
Robison, L. J. and P. J. Barry. *The Competitive Firm's Response to Risk*. Macmillan Publishing Co., New York, 1987.
Samuelson, P. "A General Proof that Diversification Pays". *Journal of Finance. Quant. Anal*. 2 (1967):1-13.
Schucksmith, M. and R. Smith. "Farm Household Strategies and Pluriactivityin Upland Scotland". *Journal of Agricultural Economics,* Vol.42(3), 1991: pp. 340-353.
Schucksmith, M., J. Bryden, C. Rosenthall, C. Short., and M. Winter. "Pluriactivity, Farm Structure, and Rural Change". *Journal of Agricultural Economics,* Vol.40(3), 1989: pp. 345-360.
Slottje, D. J., K. J. Hayes, and J. Shackett. (1992). "Labour Force Participation, Race and Human Capital: Influence on Earnings Distributions Across States". *Review of Income and Wealth,* 38(1):27-37.
Sun, T.Y., J.E. Jinkins, and H.E. El-Osta. Multinomial Logit Analysis of Farm Diversification for Midwestern Farms. Paper Presented at the AAEA annual meetings, Indianapolis, IN, 1995.
Theil, Henri. *Principles of Econometrics*. New York: John Wiley & Sons, 1971.
Walker, T.S. and N.S. Jodha. "How Small Farm Households Adapt to Risk". In Hazell, P., Pomareda, C., and Valdes, A. (eds). *Crop Insurance for Agricultural Development, Issues and Experience.* pp 17-34. Johns Hopkins Univ. Press, Baltimore, MD (1986).

White, T., and G. Irwin. “Farm Size and Specialization”. *Size, Structure and Future of Farms*, eds. G. Ball and E.O. Heady. Ames: Iowa State University Press, 1972.

## Figure 1: Mean-variance portfolio choice

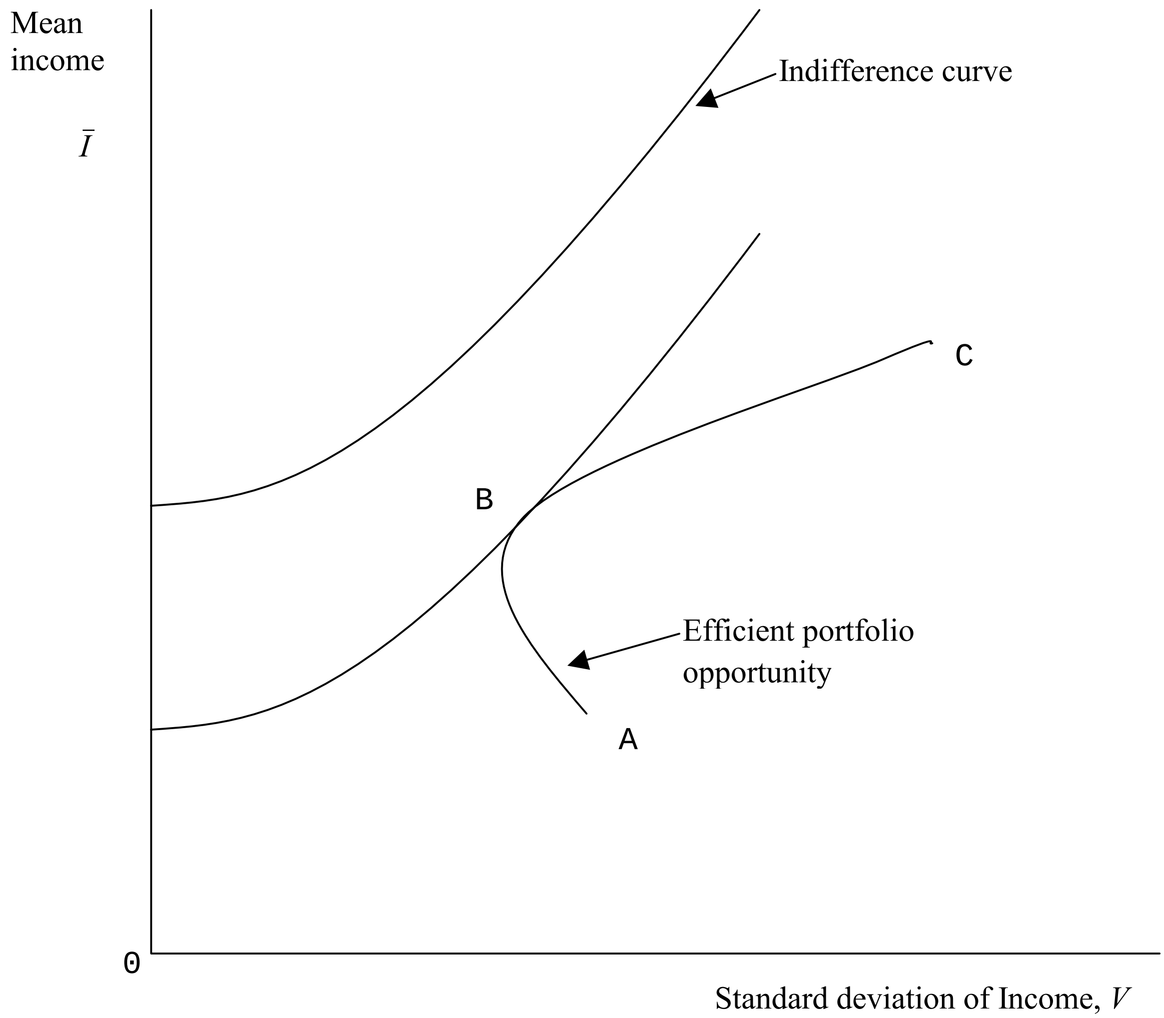

**Table 1: Definition and Means of Variables Used in Weighted Least Squares**

| Variables | Definition | Means 1996 | Means 2000 |
|---|---|---|---|
| OP_AGE | Age of farm operator | 52.68 | 55.25 |
| OP_EDUC | Educational level of farm operator | 12.63 | 12.55 |
| HH_SIZE | Size of the farm household | 3.00 | 2.71 |
| OP_GEND | Gender of the farm operator, =1 if male and 0 otherwise | 0.92 | 0.88 |
| HAV_INSUR | =1 if the farm has a crop insurance or business, 0 otherwise | 0.81 | 0.79 |
| HAV_CONTR | =1 if the farm has a production or a marketing contract, 0 otherwise | 0.12 | 0.10 |
| GOV_PMT | Total AMTA and LDP payments received by the farm *($10,000)* | 0.24 | 0.46 |
| FRM_SIZE | Value of agricultural production sold by the farm *($10,000)* | 8.23 | 6.97 |
| OFF_WAGE | Off-farm income (income from wages and salaries) *($10,000)* | 2.62 | 3.37 |
| HH_NETW | Farm household networth *($10,000)* | 40.74 | 51.42 |
| WRK_STAT | =1 if the farm operator works full time on the farm, 0 otherwise (working 2000 hours or more on the farm) | 0.30 | 0.28 |
| FRM_SOLE | =1 if the farm is organized as sole proprietorship, 0 otherwise | 0.87 | 0.92 |
| FRM_PART | =1 if the farm is organized as partnership, 0 otherwise | 0.06 | 0.05 |
| F_NEAST | =1 if the farm is located in the Northeast region of the U.S., 0 otherwise | 0.06 | 0.07 |
| F_MWEST | =1 if the farm is located in the Midwest region of the U.S., 0 otherwise | 0.09 | 0.10 |
| F_WEST | =1 if the farm is located in the Western region of the U.S., 0 otherwise | 0.19 | 0.20 |
| FRM_PROD | Mean productivity index of the farm | 73.76 | 72.98 |
| FRM_URBAN | Urbanization index, based on the proximity of farm from urban area | 1.84 | 1.82 |
| EINDX | Dependent variable, measure of diversification(*Entropy index*) | 0.15 | 0.17 |
| *Sample Size* | | 6548 | 9863 |

**Table 2: Weighted Least Squares Estimate for Factors Affecting Farm Diversification, 1996 and 2000.**

| Variables | Diversification (*EINDX*) | | | | |
|---|---|---|---|---|---|
| | Parameter estimates | | Parameter estimates | | $H_o$: $\beta_{1996} = \beta_{2000}$ t-statistics [2] |
| | $\beta_{1996}$ | t-statistics [1] | $\beta_{2000}$ | t-statistics | |
| *Intercept* | -9.946 [c] | 5.12 | -9.449 [c] | 4.15 | |
| OP_AGE | -0.010 [b] | 2.09 | -0.012 [b] | 1.93 | -2.13 [b] |
| OP_EDUC | 0.059 | 1.30 | 0.052 | 0.53 | 0.54 |
| HH_SIZE | 0.110 [c] | 2.73 | 0.146 [c] | 3.18 | 0.84 |
| OP_GEND | 0.292 | 1.23 | -0.128 | 0.69 | -0.27 |
| HAV_INSUR | 0.414 [b] | 2.13 | 0.669 [c] | 3.05 | 3.62 [c] |
| HAV_CONTR | 1.913 | 1.13 | 0.659 | 0.35 | -2.20 [b] |
| GOV_PMT | 0.350 [a] | 1.66 | 0.312 [c] | 3.17 | -2.51 [b] |
| FRM_SIZE | -0.002 [c] | 3.74 | -0.002 [b] | 2.26 | 0.39 |
| OFF_WAGE | -0.013 | 1.35 | -0.022 [b] | 2.23 | -2.44 [b] |
| HH_NETW | -0.000 | 0.12 | -0.000 | 0.65 | 0.76 |
| WRK_STAT | 1.931 [c] | 3.87 | 1.961 [c] | 3.61 | 3.34 [c] |
| FRM_SOLE | 0.424 [b] | 2.36 | 0.354 [b] | 2.09 | 0.90 |
| FRM_PART | -0.201 | 0.98 | -0.114 | 0.04 | 0.71 |
| F_NEAST | 1.442 | 1.58 | 1.131 | 1.21 | -1.98 [b] |
| F_MWEST | 1.705 [b] | 1.96 | 1.597 [b] | 2.01 | -1.31 |
| F_WEST | 1.796 | 1.34 | 1.438 | 1.12 | 0.93 |
| FRM_PROD | 0.037 [c] | 4.57 | 0.040 [c] | 4.47 | -0.95 |
| FRM_URBAN | -0.092 [b] | 1.99 | -0.080 [a] | 1.86 | 0.61 |
| $R^2$(*Adjusted*) | 0.19 | | 0.22 | | |

[a, b, c] Denote two-tailed statistical significance at 0.10, 0.05, and 0.01 levels, respectively.

[1] Reported t-statistics are absolute values.

[2] Each t-statistics in this column tests the hypothesis that a specific estimated parameter in the farm diversification model of 1996 is equal to the corresponding parameter in the 2000 farm diversification model. A negative superscripted t-statistics indicates that the corresponding $\beta_{2000}$ is statistically smaller than its $\beta_{1996}$ counterpart. A positive superscripted t-statistics indicates the opposite (i.e., $\beta_{2000} > \beta_{1996}$).