Determinants of Farm Household Income Diversification in the United States: Evidence from Farm-Level Data

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Abstract

This study examines the determinants of income diversification of farm households in the United States. Farm households allocate their time between farm and off-farm activities to help stabilized household income (consumption). What characterizes those households who engage in off-farm activities? Is there any pattern over time? Using 1999, 2003 and 2007 farm-level data from the USDA's Agricultural Resource Management Survey (ARMS), this study estimates intensity of off-farm income (or income diversification). The results show that older operators, full owners, and small farms have higher intensity of off-farm income in total household income. In contrast, dairy farms, vertically coordinated farms and farms located in the Southern and Pacific regions have lower intensity of off-farm income. In other words, household incomes of these farms are less likely to be diversified.

Keywords: Tobit, income diversification, vertical integration, tenure, farm households
JEL Codes: D1, J2, Q12

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1. Introduction

Farming deals with uncertain factors such as weather and market conditions. These uncertainties can result in variable returns (farm income) to the decisions farmers make in a particular year. 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, 1987; Newbery and Stiglitz, 1987).

Another method to reduce household income variability is to work off the farm (Mishra and Goodwin, 1997). Recent changes in the agricultural sector have focused increased attention on the role of farm household income diversification (Mishra and Goodwin, 1998; Mishra and Holthausen, 2002; Mishra et al., 2002). The received doctrine based on the standard farm household is that household members jointly choose their consumption, and the allocation of their total time endowment: leisure, off-farm work, and farm work, to maximize the present value of household wealth or consumption (Blank 2008; Blank, Erickson et al. 2008; Mishra et al. 2002).

Figure 1 reveals that since 1988—since the inception of Agricultural Resource Management Survey (ARMS), which is the sole survey that measures income of farm households[1]—average total[2] farm household income has risen consistently and exceed

[1] The current definition of a family farm (used for the 2005 and forward estimates) is based on the Agricultural Resource Management Survey and is one in which the majority of the business is owned by individuals related by blood, marriage, or adoption. Immediately prior to the implementation of the current definition, farm operator households consist of all members of the households of the primary operators of farms organized as individual operations, partnerships, and family corporations. Household members include all persons dependent on the household for financial support, whether they live in the household or not. (Students away at school, for example, are counted as household members if they are dependents.)

[2] The total income of farm operator households includes income from both farm and nonfarm sources. Consistent with the Census Bureau's definition of self-employment income, farm income to the household

average nonfarm household income since 1995. In recent years, average farm household income has been much higher than the average nonfarm household income (figure 1). Finally, over the last two decades (1988-2008, the share of off-farm income in total farm household income has been about 88 percent, on average, through time.

Consistent with the finding of Mishra and Sandretto (2002) figure 1 also reveals that farm household income is variable. For example, during 2001-2005 when the farm economy was booming, the share total farm household income accounted for by net farm income increased from 8 percent to 17 percent.

As evident from figure 1and in the literature (Mishra et. al. 2002; Mishra and Goodwin, 1997) farm households now receive the majority of their income from off-farm sources. In other words, farm households engage in off-farm employment to increase the level and reduce variability in total household income—variability in total income is perceived to be generated from the net farm income.

In the context of this paper, income diversification is risk minimization. Robison and Barry (1987) argue that if the profits from different activities are negatively correlated with each other, it is possible to reduce the variability of total income. Using level of income, farm size, and risk attitudes, Mishra, El-Osta and Sandretto (2004) and McNamara and Weiss (2005) studied farm diversification and off-farm income diversification. The goal of this study is to identify demographic and economic factors affecting farm household income diversification. Particular attention is given to the role of farm household asset portfolio, farm operator liquidity, attitudes toward risk, and vertical integration in income diversification. The analysis is conducted on a national

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is defined as the net cash farm income less depreciation (adjusted for the share received by the primary operator household in the case of multiple-household farms).

farm-level basis with the unique feature of a larger sample, comprising farms of different economic sizes, and in different regions of the United States. Finally, gaining a good understating of the determinants of income diversification of farm households is essential for the design of new approaches to rural development.

2. Empirical Model

A standard household model for the determinants of income diversification has the following features. The household maximizes utility subject to several constraints; (a) an income constraint; (b) production technologies for on-farm and nonfarm self-employment; (c) exogenous effective prices for tradables; (d) and an equilibrium condition for family labor. Specifically, let us assume that farm families have labor (F_O) and land (A) as production inputs; labor can either be provided by the household or hired. The farm household is involved in farming, characterized by constant returns to scale production function $Y = Y(A, F_O)$. Finally, in addition to leisure, farm households can allocate time to farming activity and/or off-farm activities $T = L + F_O + O$, where L represents hours of leisure, F_0 represents hours worked on-farm, and O represents hours worked off-farm. Let us assume that each household maximizes a time separable utility function of the form:

$$U_t = E_t \sum_{\alpha=t}^{T} \gamma^{\alpha-t} u(C_\alpha) \qquad (1)$$

where E_t is the expectation operator given information set at age t; γ is the subjective discount factor; C represents household consumption; and T is the number of periods. In maximizing equation 1 each household faces an inter-temporal budget constraint, an endowment constraint (time and land), and a non-negative constraint. The first order

conditions for labor allocation obtained from solving the maximization problem can be used to illustrate how households allocate resources across different (farm and off-farm) activities. If the marginal utility from farming is greater than the marginal utility derived from off-farm activities (or off-farm employment) then the household would tend to specialize in faming.

Now let us assume that the marginal returns to off-farm employment is denoted by $W_{tn} f(O_{tn} | M_n)$, where W_{tn} represents the wage rate, M_n represents an entry constraint—such as investment capital or human capital skills, and O_{tn} denotes labor allocation to off-farm work. The relationship between expected marginal utilities can be expressed as:

$$E\left[U'(C_t) P_{tf} \frac{\partial Y}{\partial F_{Otn}}\right] > E\left[U'(C_t) W_{tn} \frac{\partial f}{\partial O_{tn}}\right], \text{ with } F_{Otn} > 0 \text{ and } O_{tn} = 0 \qquad (2)$$

where $U'(C_t)$ represents marginal utility of consumption; F_{Otn} and O_{tn} represent labor allocation to farming and off-farm work, respectively; and P_{tf} represent farm output prices. Equation 2 implies that the farm household does not need to undertake off-farm work since the marginal utility of allocating labor hours to farming exceeds marginal utility in off-farm work. However, income instability in farming may force the household to invest in a diverse range of activities, such as off-arm work, rather than specialize in a single farming activity. Such measures might reduce expected income, but also reduce the variance of their household income. Mishra and Goodwin (1997) and Mishra and Holthausen (2002) point out that off-farm work is normally considered less risky than farming. The authors also argue that a risk-averse farm household would be more likely to engage in off-farm work than a less risk-averse farm household. IF the household choose to allocate their labor to off-farm work, besides farming, the first-order optimal

conditions for labor allocation will equalize the marginal utility of allocating labor to farming and off-farm activities. Specifically:

$$E\left[U'(C_t)P_{tf}\frac{\partial Y}{\partial F_{Otn}}\right]=E\left[U'(C_t)W_{tn}\frac{\partial f}{\partial O_{tn}}\right],\ \text{with } F_{Otn}>0 \text{ and } O_{tn}>0 \qquad (3)$$

Equation 3 shows that the farm household will allocate labor to farming as well as the off-arm activities. In other words, first order conditions of these types of model give a system of factor supply and demand functions, which in turn permit the determination of the labor allocation between farm and off-farm sectors. The reduced form equations for the model have the following form:

$$S_i = f\left(X_i; R, G, FT, VI\right) \qquad (4)$$

where S_i is the share of total income derived from off-farm income of the ith household; X_i is a vector of farm operator characteristics (such as age of the operator) and farm characteristics (farm assets, land value, working capital, use of farm debt, index of farm diversification); R is the regional location of the farm; *G* is a dummy variable indicating if the farm receives government payments; *FT* is farming type; and *VI* is a measure of risk (degree of vertical integration).

The presence of zeros in the dependent variable is indicative of censoring of an underlying variable and calls for Tobit estimates. A censored regression model has been very popular and well-known as a standard Tobit model in economics since it was first introduced by Tobin (1958)The structural equation in the Tobit model (Greene, 2003) is:

$$y_i^* = X_i\beta + \varepsilon_i \qquad (5)$$

where $\varepsilon_i \sim N\left(0,\sigma^2\right)$. y_i^* is a latent variable that is observed. The Tobit model can be generalized to account for censoring both from below and/or above. The likelihood function for the Tobit model is given by:

$$L = \prod_i^N \left[\frac{1}{\sigma}\phi\left(\frac{y_i - X_i\beta}{\sigma}\right)\right]^{d_i}\left[1-\Phi\left(\frac{X_i\beta}{\sigma}\right)\right]^{1-d_i} \tag{6}$$

The log-likelihood function for the Tobit model is:

$$\ln L = \sum_{i=1}^N \left\{ d_i\left(-\ln\sigma + \ln\phi\left(\frac{y_i - X_i\beta}{\sigma}\right)\right) + \left(1-d_i\right)\ln\left(1-\Phi\left(\frac{X_i\beta}{\sigma}\right)\right)\right\} \tag{7}$$

The overall log-likelihood is made up of two parts (equation 7). The first part in equation 7 corresponds to the classical regression for the uncensored observations, while the second part corresponds to the relevant probability that an observation is censored.

3. Data

The data used in this analysis are from the 1999, 2003, and 2007 Agricultural Resource Management Survey (ARMS). To check the robustness of our model and data we use three different years of ARMS data. The ARMS survey includes sample farm households that, when used with the sample weights, are representative of the U.S. farm operator household population.

The ARMS is USDA's primary vehicle for collecting and disseminating data on a wide range of issues about resource use and costs and farm financial conditions. Generally, it is used to gather information about the relationships between agricultural production, resources, and the environment. It also provides the data for the estimation of production costs and returns of agricultural commodities and in the measurement of net-farm income of farm businesses. Yet, another aspect of the contribution made by

ARMS is the information it provides on the characteristics and financial conditions of farm households, including information on management strategies and off-farm income.

The target population of the survey is operators associated with farm businesses representing agricultural production in the 48 contiguous states. A farm is defined as an establishment that sold or normally would have sold at least $1,000 of agricultural products during the year. Farms can be organized as sole proprietorships, partnerships, family corporations, non-family corporations, or cooperatives. Data have been collected for up to 3 operators per farm since 2002. However, more data are collected about the primary operator - - the senior farm operator who makes the majority of the day-to-day management decisions. For the purpose of this study, operator households organized as nonfamily corporations or cooperatives and farms run by hired managers were excluded.

Attempts to quantify income diversification (our dependent variable) focus on estimating the share of nonfarm income in total household income (e.g., Block and Webb 2001; Lanjouw, Quizon, and Sparrow 2001). The assumption in those studies is that a higher share of nonfarm income amounts to higher diversification and less vulnerability to weather-related shocks, the main risk factor where agriculture is the main livelihood. Consistent with previous literature we use share of total household income from off-farm income (income through wages and salaries from off-farm jobs) as a measure of income diversification.

In this study enterprise diversification is measured using an entropy index[3]

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

(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 scale. Higher index numbers go to operations that distribute their production more equally among several enterprises.

Incorporating the survey weights, and following the jackknifing procedure described in Kott, ensures that regression results are suitable for inference to the population in each of the regions analyzed. The USDA/NASS version of the delete-a-group jackknife divides the sample for each year into 15 nearly equal and mutually exclusive parts. Fifteen estimates of the statistic, called ‘‘replicates,’’ are created. One of the 15 parts is eliminated in turn for each replicate estimate with replacement. The replicate and the full sample estimates are placed into the following basic jackknife formula:

$$\text{Standard Error } (\beta) = \left\{ \left\{ \frac{14}{15} \sum_{k=1}^{15} \left(\beta_k - \beta^2 \right) \right\} \right\}^{1/2} \tag{8}$$

where β is the full sample vector of coefficients from the SAS@ program results using the replicated data for the ‘‘base’’ run and β_k is one of the 15 vectors of regression coefficients for each of the jackknife samples. The t-statistics for each coefficient are simply computed by dividing the ‘‘base’’ run vector of coefficients by the vector of standard errors of the coefficients (Dubman, 2000).

4. Results and Discussion

Table 1 presents estimates for factors affecting income diversification of farm households in the U.S. The null hypothesis that the correlation is statistically equal to zero is rejected, since the likelihood ratio test is higher than the conventional significance level in all three models (1999, 2003, and 2007). The pseudo-R^2 is low for all three models, but this is typical for cross-sectional data. Based on the number of significant variables and pseudo-R^2 the 1999 model performs better than the other two. This may be consistent with the fact that during the mid-90s the economy was expanding rapidly. As a result, demand for non-farm labor was increasing. Mishra et al. (2002) report that in 1999 more farm operators and spouses reported working off the farm and farm households increased their off-farm investments.

The age of the operator is a significant factor affecting income diversification in the 2003 and 2007 models. This is consistent with the life-cycle hypothesis, where young operators are likely to work more off the farm. This is consistent with finding in the off-farm labor supply literature (El-Osta et al., 2004; Goodwin and Mishra, 2004; Ahearn et al. 2006; Hallberg et al., 1991). Results in table 1 show that full owners of the farm are likely to diversify their income. This variable is significant in the 1999 and 2007 models. A plausible explanation is that full owners are more likely to work off the farm. There may be a farm-size effect acting here. Full owners are more likely to run small farms, and operators of small farms are more likely to work off-farm. Farm size is reflected in our "hobby farm" measure. We will explore the "farm-size effect" more fully in subsequent analysis.

We use working capital (total current assets) as a variable in assessing the impact of credit constraint on income diversification. Results in all three models (1999, 2003, and 2007) show a negative relationship with income diversification. The results indicate that an increase in working capital decreases the share of household income coming from off-farm sources—that is, income diversification decreases. This may be consistent with the fact that higher working capital may signal greater commitment to farming. Thereby, operators are likely to concentrate their labor and efforts into farming.

Dairy farms are less likely to diversify their household income. The coefficient on dairy farm is negative and statistically significant at the 1 percent level of significance in all three years. A possible explanation is that dairy farms are labor intensive enterprises and hence operators and spouses are less likely to work off the farm. Further, the income stream of dairy farm households is more stable and continuous compared to cash grain and other types of farms.

In this study we included hobby farms (those defined as limited resource, retirement, or residential/lifestyle farms by USDA) as an independent variable. Results in table 1 show that in all cases (1999, 2003, and 2007) the coefficient is positive and significant at the 1 percent level of significance. Results confirm the notion that farms defined as hobby farms have a higher share of off-farm income it total household income. This is consistent with the fact that operators and spouses of hobby farms are more likely to work off the farm (Mishra et al., 2002).

We use an index of vertical integration (value of agricultural output sold through marketing and production contract to value of agricultural output) to assess the impact of contracting on income diversification. Results in table 1 indicate that as the index of

vertical integration increases the share of off-farm income in total household income decreases. A plausible explanation is that by contracting, farm households are able to reduce farming risk—stabilize farm income and hence have less need for off-farm income. Further, it is also noted that large farms are more likely to adopt production and marketing contracts.

Results pertaining to the impact of regional location of the farm on income diversification show that in 1999 farms located in the South, Corn Belt, Mountain, and Pacific regions were less likely to diversify their income, compared to farms located in the Northeast, the base region. However in 2003, only two regions, namely, Southern and Pacific regions have lower intensity of off-farm income, compared to farms located in the Northeast region. By 2007, no regions were significant. This finding is not surprising as farm located in the Northeast region are likely to be small farms and located near major metro areas and employment centers (such as New York, Boston, Philadelphia, and Washington DC). However, the importance of regional impact on off-farm income diversification is disappearing—regional dummies are not significant in 2003 and 2007 models, because farms across the regions are more likely to diversify into off-farm income, hence regional differences are less important.

Another variable depicting location influence is *county population density*, which based on its positive and significant coefficient, shows that as population density increases, as proxy for urbanization, farm households intensity of off-farm income increases—or in other words, farm households are likely to earn more income off the farm. This is consistent with the fact that an increase in population density signals an

increase in labor demand and hence increased opportunities for off-farm work by farm operators and spouses.

5. Conclusions

This study uses farm-level data from the USDA's ARMS survey to examine the factors affecting income diversification of U.S. farm households. The importance of this question is reflected in Secretary Thomas J. Vilsack's testimony (April 21, 2010) before the House Committee on Agriculture:

"In the past 40 years, the United States lost more than 1 million farmers and ranchers. During that period, income from farming operations, as a percentage of total farm household income, plunged to half of the previous level. Today, only 11 percent of family farm income comes from farming."

Given that only 11 percent of family farm income comes from farming, our analysis identifies the characteristics that affect farm households' choices regarding off-farm work vary over space and time. We focus on the roles of farm household asset portfolio diversification, farm operator liquidity, attitudes toward risk, and vertical integration of production, and farm household income diversification.

We examine the characteristics of those households engaging in off-farm work by year, by region, and by farm type, conditioning on a variety of variables that economic theory suggests affect these choices. Specifically, we use a standard farm household model and farm-level data from the USDA's ARMS surveys to estimate a censored Tobit regression model for 1999, 2003, and 2007. The censored Tobit model reveals the factors that affect the intensity of off-farm income (or income diversification) of farm households. The results show that older operators, full owners, and small farms have higher intensity of off-farm income in total household income. However, dairy farms,

vertically coordinated farms and farms located in the Southern and Pacific regions have lower intensity of off-farm income and thus these farms are less likely to be diversified.

These results are directly related to recent structural changes in production agriculture. As a result of efforts by NASS to improve its Census and ARMS samples, the sample now better reflects the underlying distribution of farms and the recent structural changes affecting the sector. We now have a larger share of farms with sales less than $10,000. These farms are small, full-owners, and get their income from off-farm. This, plus the natural aging of the existing farmers in 1999, helps explain what is driving the income diversification of farm households.

Therefore, these results suggest that the abilities of farm business and farm households to help manage weather, climate, and market risks associated with production agriculture through farm household income diversification vary over space and time, and by the specific demographic and economic factors associated with those farm households.

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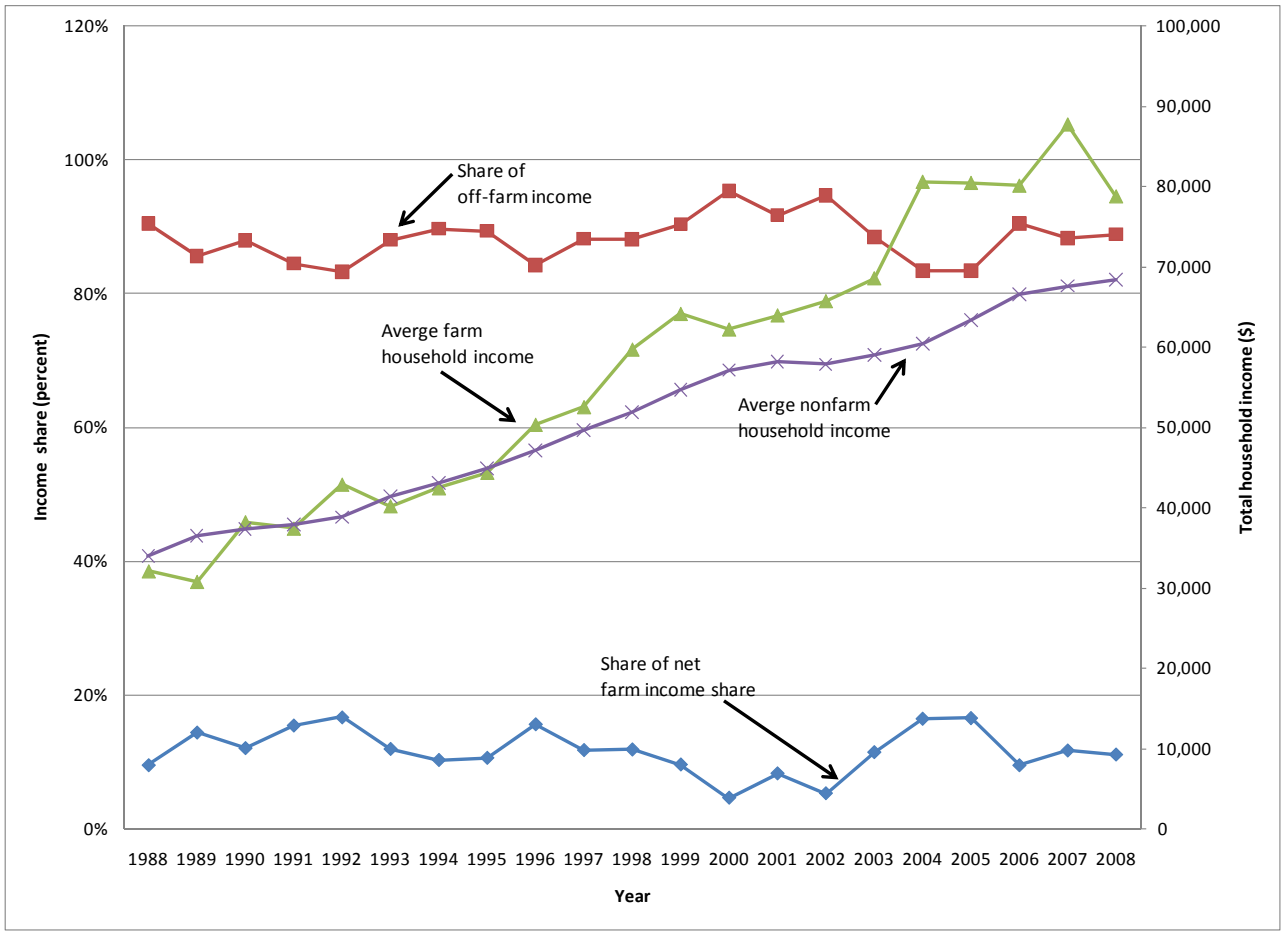
Figure 1: Comparison of average farm and U.S. household income (1988-2008).



Source: **Authors used data from "Farm Household Economics and Well-Being: Historic Data on Farm Operator Household Income" http://www.ers.usda.gov/Briefing/WellBeing/Gallery/historic.htm Accessed on May 2, 2010.**

Table 1: Parameter estimates of factors affecting income diversification among U.S. farm households, selected years, 1999, 2003, and 2007

Dependent variable=ln(share of off-farm income/total household income)

Variable	1999 Parameter estimate	2003 Parameter estimates	2007 Parameter estimates
Intercept	3.884 **	-4.587***	0.064
	(1.508)	(1.606)	(0.359)
Age of the operator	-0.002	0.548***	0.009**
	(0.017)	(0.018)	(0.003)
Full owner	2.610***	1.27	0.501**
(dummy variable, =1 if the operator is full-owner of the farm; 0 otherwise)	(0.865)	(0.998)	(0.211)
Part-owner	1.064	1.008	0.363*
(dummy variable, =1 if the operator is part-owner of the farm; 0 otherwise)	(0.854)	(1.001)	(0.216)
Share of farm net worth to	0.018	0.030	-0.002
total net worth	(0.107)	(0.039)	(0.029)
Working capital (total current farm assets)	-6.28e-06***	-5.85e-06***	-8.61e-06***
	(1.48e-06)	(1.33e-06)	(1.75e-06)
Dairy farm	-4.643***	-2.655**	-1.262***
(dummy variable, =1 if farm is classified as dairy farm; 0 otherwise)	(1.112)	(1.26)	(0.300)
Hobby farm[1]	1.278**	2.404***	0.473***
(dummy variable, =1 if farm is classified as a hobby farm; 0 otherwise)	(0.526)	(0.555)	(0.147)
Index of vertical integration	-3.974***	-2.111***	-0.435**
	(1.007)	(0.747)	(0.166)
Farm enterprise diversification index	-4.904**	1.706	-0.659
	(2.205)	(2.05)	(0.456)
Share of crop insurance expenses	0.394	0.175	-0.060
to total variable cost	(0.848)	(0.525)	(0.126)
Government payment	0.817	-0.122	-0.153
(dummy variable; =1 if the farm receives government payments; 0 otherwise)	(0.547)	(0.574)	(0.123)
Farming region, South	-4.990***	-1.605*	-0.267
	(0.947)	(0.859)	(0.221)
Farming region, Corn belt	-3.706***	-0.787	-0.067
	(0.913)	(0.947)	(0.211)
Farming region, Mountain	-4.776***	-1.432	-0.120
	(1.116)	(1.160)	(0.253)
Farming region, Pacific	-0.981***	-0.463*	-0.083
	(0.261)	(0.278)	(0.063)
County population density	0.004***	0.001	0.001
	(0.000)	(0.001)	(0.001)
Pseudo R^2	0.07	0.05	0.03
LR χ^2 test	132.48***	109.88***	134.56***
Sample Size	8,420	15,252	14,232

[1] Includes farms classified as limited resource, retirement, and residential/lifestyle farms.

Notes: *** Significance at the 1% level (t=2.977). ** Significance at the 5% level (t=2.145). and * Significance at the 10% level (t=1.761) . All t-statistics evaluated with 15 degrees of freedom given the 15 replicates employed in the jackknifing procedure.