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Interlinked diversification strategies: Evidence from farm business households¹

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Abstract

We analyze the factors influencing farmer's diversification decisions while taking into account the simultaneous decision making. Using a national data on farm-level in the US and a multivariate analysis, our study suggests that agricultural, structural, environmental, and income diversification strategies are interlinked.

I. Introduction

Agricultural sector in the United States has experienced a significant structural changes. Large farms have increased while small farms are declining over time. By the nature of agricultural production, farm business households face greater production risk. Additionally, small to medium sized agricultural business households in the US face greater challenges for continuation and survival through conventional commodity production methods. These farm business households contribute significantly in the national and local economies—a U.S. Department of Agriculture (USDA) report suggests that farm households engaged in such non-commodity entrepreneurial activities contributed almost 40 percent of the total value of U.S. agricultural production (Vogel, 2012). The decline in the ability to generate sufficient income from commodity production has caused many farmers to embrace diversification of their agricultural bases and to undertake structural adjustments on the farm. With an advent of new farm bill and the revised structure of conservation and government programs, US agriculture is on the move and farmers have to adjust their farming behavior.

Additionally, farms have limited land, capital, managerial ability, and limited skilled labor. These farms are subject to greater challenges in agricultural business. Small and medium sized farms are often unable to adopt improved technology, new managerial practices, intensive cultivation, and thereby a viable option is to use more profitable enterprise

combinations on the farm. In that, enterprise diversification is an important tool for risk management in farm households (Mishra et al., 2004).

Adoption of alternative farm business activities and diversification strategies has been the subject in some of the previous studies (Abdulai and Crolerees, 2001; Bagi and Reeder, 2012; Joo et al., 2013; Vogel, 2012; Mishra et al. 2004). These studies mainly report an overview and importance, and identify factors influencing adoption or participation decisions in various activities both on and off the farm. A drawback in these previous studies is that they consider each diversification strategy as independent choices by farm households and fail to account for diversification decisions simultaneously. Taking into account the potential complementarity between different diversification activities can improve our understanding—perhaps interaction between strategies is likely in the farmer’s decision-making process. To the current challenging agricultural context, diversification could be an attractive farm adjustment strategy (Barbieri and Mahoney, 2009).

Therefore, the objective of this study is to analyze the factors influencing farmer’s diversification decisions while taking into account the simultaneous decision making. We mainly classify *diversification activities* into 4 major categories—namely, agricultural diversifications, structural diversifications, environmental diversifications, and income diversifications. This paper contributes to the literature by providing a quantitative analysis of farm household decisions taking into account the potential jointness of the strategies (activities). Using a nation-wide survey in the US and a multivariate probit analysis, our study suggests that farm diversification strategies are interlinked—particularly, agricultural with structural diversification strategies and environmental with income diversification strategies. Remaining section of the paper is organized as follows. Section II presents literature review,

section III describes about methodology, section IV explains about data, section V presents results and section VI provides concluding remarks.

II. Literature Review

Diversification in the farm business has been discussed in two broad perspectives in the literature. First, diversification is linked with multifunctionality of agriculture and rural development, particularly in European studies connecting with sustainability and conservation activities. Recall that European Union's agricultural policy has agri-environmental support schemes that encourage on- and off- farm activities to increase farm household's income and to allow farmers to tackle with tough market environment (Van Der Plog and Roep, 2003; Meraner et al., 2015). Multifunctionality of agriculture has also been viewed as generating externalities that enhance social welfare. In this context, diversification generates social value, a part of rural development strategy, while providing supplementary income for farm households (Wilson, 2007; Van Huylenbroeck et al., 2007).

Second, diversification is viewed as risk management tool for farm households (Mishra et. al. 2004; Aguglia et al. 2009). Engaging in many alternative business activities, on- and off-farm enterprises, diversification reduces variability in income for farm business households. Diversified farming system helps farmers to maximize their utility through risk management, complementarity/ supplementary relationships between enterprises in production process, tackle with input and output constraints (Mishra et al., 2004), as well as provides non-pecuniary benefits from ecosystem services (Bowman and Zilberman, 2013).

Farm diversification system is supported by the Common Agricultural Policy (CAP) reform in the Europe. Bartolini et al. (2014) studied factors influencing on-farm diversification in the context of new policy reforms. Using data from Italy and count data models, Bartolini et al.

(2014) found a significant effect of agricultural and farm payment policies on on-farm diversification decision and intensity of diversification. In another study, also in Europe, Meraner et al. (2015) analyzed the determinants of farm diversification strategies in the Netherlands. Considering six different diversification activities and a multinomial logit model, their study suggested that socio-demographic, economic, and geophysical farm characteristics influence the diversification decision. Similarly, Dries et al. (2012) studied Italian farm systems to analyze decision making process in farm diversification. Using a multivariate probit model, Dries et al. (2012) found that the farm diversification decisions about agricultural, structural, environmental, and income diversification strategies were interlinked.

While researchers in European countries have studied farm diversification for some time, the literature is limited in the US context. Farm diversification among American farms is an interesting area of research because farms, particularly small to medium, are increasingly involved in alternative on- and off- farm activities. Adoption of farm diversification activities such as on-farm processing, direct sales, agritourism, participation in conservation programs are getting greater attention from researchers, extension agents, and policy models. For example, Soh (2014) in Voice of America reports that farms are diversifying their farms to attract tourist; agricultural tourism generated over \$700 million in 2012—a 24 percent increase over five years. Soh (2014) writes, “...many American families head to the farm, whether they go to pick the fruits, take a hay ride, or wander through a corn maze, they are part of a fast growing sector of the U.S. economy—agricultural tourism or agritourism, in short.”

There are a few studies examining the adoption of alternative activities among American farms. For example, Joo et al. (2013) analyzed the impact of agritourism on financial performance of American farms and found its significant impact on farm household income, and

return on farm assets among small farm business households. Recently, Khanal and Mishra (2014) considered agritourism and off-farm work as a survival strategy for small farm business households. Using national level survey data of American farms, they found a significant effect of the agritourism and off-farm work participation on farm household income. Mishra et al. (2004) suggested enterprise diversification as a self-insuring strategy used by American farmers to protect against risk. The major limitation in these studies is that they chose one diversification strategy and then separately analyze while ignoring possibility of interlinkage between decisions. This study analyzes agricultural, structural, environmental, and income diversification strategies among US farm business households. This study overcomes the limitation of previous studies by simultaneously analyzing the diversification strategies while accounting for interlinkages between these diversification strategies.

Factors affecting farm diversification decisions

Previous studies have suggested a number of factors influencing farm household's decision to diversify activities. Broadly, the variables related to farm location, farm and farmer characteristics are reported to have a significant effect on agricultural, structural, environmental, and income diversification strategies. Dries et al. (2012) classified community and location related factors (such as region, county or district, population density in the area, social capital etc.) as 'external factors' while farm size, farm labor, age, farm type etc. as 'internal' factors influencing diversification decisions. Bartolini et al. (2014) used similar factors to analyze determinants of the on-farm diversification. Meraner et al. (2015) considered on-farm sale, on-farm processing, agritourism, and nature conservation as farm diversification strategies and included age, family size, farm size, farm type, and geographical characteristics as the factors influencing such strategies. Mishra and Khanal (2013) found that the financial condition of the

farm significantly influenced farm household's participation in agri-environmental and conservation programs. Finally, Mishra et al. (2004) found that off-farm work hours, farm location, financial condition (debt-to-asset ratio), government payments, farm size, family size, and farm operator characteristics significantly influenced enterprise diversification on the US farms.

III. Methodology

We estimate the likelihood of observing a certain activity associated with a set of factors such as farm and farmer characteristics, location and other related characteristics.

One of the most important assumptions in these types of models is about the assumption of alternative strategies. For example, Mishra et al. (2004) used enterprise diversification index (ranges from 0 to 1) as a dependent variable and computed factors affecting such enterprise diversification on the farm using weighted least squares methods, with an assumption of logistically distributed error term. Meraner et al. (2015) used multinomial logit model to assess the determinants of diversification. However, standard logit and multinomial logit are suitable when the alternatives are proportionally substitutes to each other because their models require independence of irrelevant alternatives (IIA) assumption, which is often too restrictive and erroneous (Train 2009). If the IIA assumption is violated, logit models may fail to provide appropriate inferences.

Various diversification strategies are associated with decisions regarding the allocation of resources to different activities. In that, decisions are correlated, for example: a) spending time in one diversification activity may lower the time left for another strategy; b) earnings from off-farm employment can be used to invest or finance on-farm diversification activities; and c) participation in agri-environmental programs may complement farmers to do organic farming

etc. (Dries et al., 2012). Therefore, we used an appropriate multivariate probit model to study the joint-decision making between different diversification strategies. The diversification strategies in this study include: 1) agricultural diversification, 2) structural diversification, 3) environmental diversification, and 4) income diversification. Using multivariate probit model allows us to account for simultaneous decision making while accounting for potential substitutability and complementarity between various diversification strategies. Equation 1 represent latent utility framework to represent the strategic decision.

$$Y_i^* = X_i\beta + \varepsilon_i \quad (1)$$

where Y_i^* denotes latent variables of net payoffs (or net gains) in j^{th} different diversification strategy for farm business household i . X_i represents a set of explanatory variables that are exogenously determined. These include the variables such as farm and farmer characteristics and location of the farms; ε_i represent the error term. We considered four types of diversification strategies namely, agricultural, structural, environmental, and income diversifications.

Description about these strategies are presented in Table 1. Representing equation for each alternative diversification strategies for $j=1, \dots, 4$ can be shown as:

$$Y_{i1}^* = X_i\beta_1 + \varepsilon_{i1} \text{ for } j=1 \text{ (agricultural diversification)} \quad (2)$$

$$Y_{i2}^* = X_i\beta_2 + \varepsilon_{i2} \text{ for } j=2 \text{ (structural diversification)} \quad (3)$$

$$Y_{i3}^* = X_i\beta_3 + \varepsilon_{i3} \text{ for } j=3 \text{ (environmental diversification)} \quad (4)$$

$$Y_{i4}^* = X_i\beta_4 + \varepsilon_{i4} \text{ for } j=4 \text{ (income diversification)} \quad (5)$$

Let Z_i represents a vector of observed binary outcome for farm business household i , Z_{i1}, \dots, Z_{i4} defined by latent variables presented in equations such that $Z_{ij} = 1$ if $Y_{ij}^* > 0$, 0 otherwise; $j=1, \dots, 4$. Multivariate probit assumes that the error terms ($\varepsilon_{i1}, \varepsilon_{i2}, \varepsilon_{i3}, \varepsilon_{i4}$) may be correlated.

Therefore, instead of independently estimating each equation, all four equations are considered

as multivariate limited dependent variable model and estimated using simulated maximum likelihood approach. Multivariate probit model assumes that error terms follow a multivariate normal distribution with mean zero ($E[\varepsilon_1] = E[\varepsilon_2] = E[\varepsilon_3] = E[\varepsilon_4] = 0$) and variance-covariance matrix ρ .

$$cov[\varepsilon] = \rho = \begin{bmatrix} 1 & \cdots & \rho_{14} \\ \vdots & \ddots & \vdots \\ \rho_{41} & \cdots & 1 \end{bmatrix} \quad (6)$$

The variance-covariance matrix has diagonal elements all 1 (while off-diagonal elements are correlations between respective diversification strategies to be estimated).

IV. Data and descriptive statistics

We used a national level survey of farm households, 2012 Agricultural Resource Management Survey (ARMS) collected by Economic Research Services (ERS) of the United States Department of Agriculture (USDA). We classified diversification strategy into four broader diversification strategies, namely, agricultural, structural, environmental, and income diversifications. As shown in figure 1, 94% of the farms are at least engaged in one of the diversification activities analyzed in this study. Our sample consists of 13, 852 farm business households. Figure 2 and table 1 suggest some interesting description about the adoption of diversification strategies. Figure 2 shows the adoption and non-adoption of different diversification strategies among all farm business households while table 1 shows the share of each activity on diversification. Figure 2 suggests that farms are adopting one or more diversification strategies, income diversification strategy is adopted by the most of the farms—around 92%, which is around 91.6% share on total number of diversified farms (table 1).

Agricultural diversification, which includes activities such as organic farming, is adopted by 2% of the farms (figure 2); about 2% of all diversified farms (table 1). Around 18% of the farms

are structural diversified (such as agritourism, on-farm processing and direct-to-consumer sales); have around 18.6% of all diversified farms. Finally, 20% of all farms have undertaken environmental diversification activities (such as participation in conservation programs and/or environmental incentive programs) (figure 2). Environmental diversification is adopted by around 22% of all diversified farms (table 1). These four types of diversification strategies are also classified in previous studies (Dries et al., 2012; Meraner et al., 2015).

Figure 3 presents diversification strategies by farm size. Small to medium sized farms are (those generating less than \$500,000 in gross cash farm income) comprising of 57% of the total farms in our sample. Large farms (those generating greater or equal to \$500,000 in gross cash farm income), on the other hand, consists 43% of the total farms in our sample. Proportional share of small to medium sized farms is relatively higher than larger farms for income diversification strategies while being relatively lower for structural and environmental diversifications. This indicates that higher proportion of small to medium sized farms undertake income diversification strategies compared to other diversification strategies.

Table 3 shows summary statistics of the independent variables used in the study. We include four main types of independent variables in the analysis: a) variables representing location and county characteristics, b) operator, spouse, and household characteristics, c) farm characteristics, and d) farm types. Mean, standard deviations, and definition of variables are presented in table 3. Table 3 suggest that 21% of the farms in our sample are located in farming dependent counties while 30% of the farms are located in metro counties. Summary statistics show that average age of farm operators is 57 years, and the average schooling of the operator and the spouse is 13 years and 14 years, respectively. Households consists of 3 members on average and 4% of the households have female operators. Main farm types are cash grain farms (around 39%), livestock

farms (around 35%), high value crop farms (around 12%), cotton farms (around 2%), and other field crop farms (around 11%).

V. Results and discussion

Results from multivariate probit analysis are presented in table 3. Multivariate probit is estimated using simulated maximum likelihood method with 150 draws (replications)¹. The results presented in table 3 show the impact of explanatory variables on the likelihood of choosing a diversification strategy, while allowing for possible correlation among strategies. A significant likelihood ratio test result (with p value 0.000) indicates that we reject the null hypothesis of no correlation between diversification strategies indicating that a multivariate probit model is the appropriate compared to separate probit equations. Additionally, table 3 presents correlation between strategies as indicated by different ρ_{ij} , indicating if strategies are substitutes (negative correlations) or complements (positive correlations).

Factors affecting diversification decisions

Farm location

In our analysis the role of farm location is linked to several socio-geographical economic sectors of the county where the farm is located. We used county categories defined by the Economic Research Services (ERS) of USDA, which includes: farming dependent, non-farming dependent, mining dependent, manufacturing dependent, government dependent and service dependent. Additionally, counties are classified as *metro counties* based on whether it is located in metropolitan region or not. Results suggest that location is a significant factor determining the diversification strategies. For example, farms located in farming dependent counties are less

¹Cappellari and Jenkins (2003) showed that higher the number of draws (R) in simulated maximum likelihood, more accurate would be coefficients and correlation matrix in multivariate probit model. For sample sizes of the order of several thousands, setting R at least equal to an integer approximately equal to the square root of the sample size can be considered as a general thumb rule (Cappellari and Jenkins, 2003).

likely to adopt structural diversification compared to other non-farm dependent counties.

Dependence classification is based on economic contribution of the sector (or economic dependence) in the county². Since more specialized large farms usually have higher total income than small to medium diversified farms, farms in farming dependent counties may be dominated by specialized farms and structurally less diversified. Similarly, results suggest that farms located in the mining depend counties are less likely to adopt income diversifications. Farms located in Metro counties are less likely to adopt environmental diversification activities, (*i.e.*, they less likely participate to conservation or environmental incentive programs).

Farmer and household characteristics

Our results suggest that the likelihood of choosing structural and environmental diversification activities increases with the age of the operator, up to certain level, suggesting that relatively older operators are more likely to adopt structural and environmental diversification activities. However, relatively younger operators are more likely to choose income diversification activities. This is plausible because younger farmers are more likely to be more educated and more likely to find off-farm jobs easily than older operators. On the other hand, older operators are relatively more experienced in farming, some are retired from off-farm jobs and also enjoy farming for recreational purposes and thus are more likely to be engaged on the farm (McNally, 2001; Ollenburg and Buckley, 2007).

Education of the operator (years of schooling) is positive and significant across all diversification strategies, suggesting that educated operators are more likely diversify their farms. This finding is consistent with Mishra et al. (2004). However, education attainment of

²Farming dependent counties are non-metropolitan counties classified as follows: counties where farm earnings account for an annual average of at least 15 percent or more of total county earnings or farm occupations accounting for 15 percent or more of all occupations of employed county residents during 1998-2000 (For detail, see: <http://www.ers.usda.gov/data-products/county-typology-codes/documentation.aspx>).

spouse is positive and significantly associated with only structural diversification. Larger family size, indicator of family labors available, increases the likelihood of participation in agricultural and structural diversification strategies. This result supports the findings from some previous studies who found that households with larger families are more likely to be engaged in agritourism and care-farming activities (Benjmin and Kimhi, 2006; Nilsson 2002). Operators with farming as main occupation are more likely to participate in environmental diversification strategy while less likely to participate in income diversification strategy. This is plausible because operators with farming as occupation are expected to devote more time in farming and less or no hours for off-farm work. Another interesting result is the coefficient of gender (operator being female)—Female operators are more likely to participate in structural and environmental diversification strategies.

Farm characteristics

Farms with higher acreage are less likely to participate in agricultural and income diversification strategies while more likely to participate in structural and environmental diversifications. Similarly, Likelihood of participating in agricultural diversification and structural diversification decreases with farming efficiency (measured as the ratio of value of production to variable costs). This finding supports the findings from the limited literature about agritourism in the US. Bagi and Reeder (2012) found that farmers with higher land acreage are more likely to make costly long-term investments related to agritourism enterprises and other farm related investments on the farm. Particularly, authors note that land not suitable for crop production, is more likely to be used in agritourism enterprises (Bagi and Reeder, 2012). Additionally, findings about negative relationship between efficiency and diversification suggests that more efficient farms are expected to have higher value of output per total variable

costs, which is usually a feature of specialized farms. Farms receiving government payments are more likely to undertake agricultural and structural diversifications than farms not receiving government payments.

Our result also suggests that financial condition of the farm also plays an important role in choosing environmental and income diversification strategies. As indicated by debt-to-asset ratio, farms with higher solvency problems (higher debt-to-asset ratio) are less likely to participate in environmental diversification activities. This result supports the findings from Khanal and Mishra (2013) who found that farm's debt-to-asset ratio is negatively associated with the decision to participate in agri-environmental programs in the US. Coefficient of operator on-farm hours suggests that farm operators devoting more hours on the farm are more likely to participate in agricultural and structural diversification strategies while less likely to participate in environmental diversification strategy. Spouse's on farm hours, on the other hand, suggests that the likelihood of structural and environmental diversification increases as spouse devotes more on the farm.

Our result suggests that high value crop farms, livestock farms, and other field crop farms are more likely to adopt agricultural diversification strategy. This finding is plausible because there has been an increasing demand for organic fruits, vegetables, milk, and meat. In that, one would expect that high value fruit and vegetable farms, and livestock and dairy farms are more likely to produce organic products as compared to cash grain farms. This also supports the findings from Uematsu and Mishra (2012) who found that high value crop farms are more likely to participate in organic certifications. Additionally, our finding in environmental diversification strategy (last column, table 3) shows that high value crops and other field crop farms are more likely to participate in environmental diversification strategy while cotton farms are less likely to

participate in environmental diversification strategy. This finding is plausible because, compared to cash grain farms which tend to be large and very large farms that specialize in cash grains (Ali, 2002) and intensified cotton farms (Foreman 2012), high value crops and field crops are less intensive and are more likely to enroll some part of the land in conservation and participate in environmental programs.

Correlation between strategies

We found a significant correlation between diversification strategies. Our results suggest a positive correlation between agricultural and structural diversification strategy, a positive correlation between agricultural and environmental diversification strategies, a positive correlation between structural and income diversification strategies, and a positive correlation between environmental and income diversification strategies.

Significantly positive correlation between agricultural and structural diversification decisions indicates that these strategies complement to each other. This is plausible because many synergies are possible between agricultural and structural diversifications. For example, the decision regarding agricultural diversification, organic production for instance, is likely linked with decision regarding market connection to organic produce, which is supported by activities such as direct-to-consumer sales, on-farm processing, and agritourism—activities that support short supply chains at local level. These results are consistent with previous studies (Mansury and Hara 2007; Dries et al. 2012). Additionally, result suggests that significantly positive correlation exists between environmental and income diversification strategies suggesting a complementarity effect among these strategies. This finding is contradictory to Dries et al. (2012) who found a negative correlation between these strategies in Italian farms. Dries et al. (2012) have explained a negative correlation because of the constrained and scarcer labor—when

more labor hours is supplied to off-farm works, less time is available to undertake conservation related on-farm activities. In our study, however, the positive correlation can be explained in a counter way. Recall that environmental diversification is defined as the participation in government conservation programs or environment incentives programs. Since such government programs in the US are dominated by conservation reserve payments (CRP) that requires enrollment of the certain acres of agricultural land for conservation (for example, remain uncultivated, fallow, or zero-tilled) to get CRP payments. One would think that when labor is constrained, farms would maximize their household income by enrolling in such conservation programs to get government program payments and enjoy more off-farm income by allocating more hours for off-farm works. In that, a positive correlation fairly explains the choice decision between strategies.

VI. Conclusions

This paper analyzes the decision about farm diversification strategies among American farms. We considered simultaneous decision making between strategies that allows for possible interlinkages between farmers' diversification strategies. Our results suggests for a presence of interlinkage between diversification strategies. We found a significant complementarity and synergy between agricultural diversification and structural diversification and income diversification and environmental diversification.

In general, we view farm diversification as farmers' response towards various demographic and socio-economic conditions that tend to reduce the capacity in specialization or high production. In that view, diversification is a risk management tool for farm households and a mechanism to stabilize the household income. We find that the factors such as location, farm and

farmer characteristics, farm types, and financial condition of the farms are major determinants in strategic decisions about farm diversification.

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Table 1: Diversification in American farms, 2012

Diversification Strategies	Share of farms
1. Agricultural Diversification	0.020
<i>Organic farming</i>	0.020
2. Structural diversification	0.186
<i>Agritourism</i>	0.022
<i>Direct-to-consumer sales</i>	0.037
<i>On-farm processing</i>	0.131
3. Environmental diversification	0.218
<i>Participation in conservation programs (CRP, CREP and/or WRP)</i>	0.147
<i>Participation in environmental incentives programs and contracts (EQIP, CSP, and/or CStP)</i>	0.071
4. Income diversification	0.916

Source: Author's own computation based on ARMS data, 2012

Note: Share does not add to 1 because farms are adopting multiple strategies.

Table 2: Variable definition and summary statistics of the variables used in the study

Variable definition	Mean	Standard Deviation
<i>Location and county characteristics</i>		
Farming dependent (=1 if the farm located county is classified as farming dependent county, 0 else)	0.209	0.407
Mining dependent (=1 if the farm located county is classified as mining dependent county, 0 else)	0.014	0.118
Manufacturing (=1 if the farm located county is classified as manufacturing dependent county, 0 else)	0.155	0.362
Govt. dependent (=1 if the farm located county is classified as government dependent county, 0 else)	0.041	0.197
Service dependent (=1 if the farm located county is classified as services dependent county, 0 else)	0.096	0.294
Metro (=1 if farm located county is classified as metro county, 0 else)	0.302	0.459
<i>Operator, spouse, and household characteristics</i>		
Age (Age of the operator)	57.541	11.755
Age squared (Age of the farm operator, squared)	3449.121	1363.542
Education (years of schooling of the farm operator)	13.418	1.770
Spouse's education (years of schooling of the spouse)	14.190	2.310
Household size (Size of the farm household, in number)	2.675	1.310
Female (=1 if operator is female, 0 if not)	0.038	0.191
Farming occupation (=1 if farming is the main occupation of the operator, 0 if not)	0.948	0.221
<i>Farm characteristics</i>		
Log of acres (log of the total acres of the farm)	6.167	1.693
Farming Efficiency (farming efficiency= total value of production / total variable costs in the farm)	6.309	270.494
Gov. pay (=1 if the farm household received government payments in 2012, else 0)	0.629	0.483
Debt to asset (Debt to asset ratio)	0.115	0.451
Farm hr. Operator (Total annual hours of operator worked on the farm)	2464.763	1102.646
Farm hr. Spouse (Total annual hours of spouse worked on the farm)	458.092	846.514
<i>Farm types</i>		
High value crops (=1 if farm is high value crop producing farm, 0 else)	0.123	0.328
Livestock (=1 if farm is classified as livestock farm, 0 else)	0.359	0.479
Cotton (=1 if farm is classified as cotton farm, 0 else)	0.019	0.137
Cash Grain crop (=1 if farm is cash grains producing farm, 0 else)	0.390	0.487
Other field crop (=1 if farm is classified field crops producing farm, 0 else)	0.109	0.312

Source: Author's own computation based on ARMS data, 2012

Table 3: Factors influencing diversification: multivariate probit model using simulated maximum likelihood approach

Variables	Agricultural diversification			Structural diversification			Environmental diversification			Income diversification		
	Coeff	t-score ^a	Marginal effect ^b	Coeff	t-score ^a	Marginal effect ^b	Coeff	t-score ^a	Marginal effect ^b	Coeff	t-score ^a	Marginal effect ^b
Constant	-3.46	-5.81*		-2.57	-9.31*		-8.95	-0.08		2.29	6.93*	
Location and county characteristics (Base: Non-farm dependent county)												
Farming dependent	-4.38	-0.24	-0.001	-0.14	-3.47*	0.001	0.09	2.11*	0.004	-0.07	-1.38	-0.008
Mining dependent	-4.37	-0.00	-0.023	0.12	1.15	0.023	-0.14	-1.09	0.009	-0.32	-2.68*	-0.024
Manufacturing	-0.02	-0.24	-0.001	0.03	0.72	0.004	-0.04	-0.86	0.001	-0.08	-1.46	-0.008
Govt. dependent	-0.15	-0.87	-0.024	0.02	0.26	0.004	-0.05	-0.62	0.000	0.13	1.44	0.036
Service dependent	0.08	0.77	-0.000	0.06	1.32	0.005	-0.02	-0.32	-0.005	0.10	0.16	0.004
Metro	0.03	0.33	-0.000	-0.01	-0.30	0.003	-0.20	-4.59*	-0.001	-0.04	-0.80	-0.003
Operator, spouse, and household characteristics												
Age	-0.00	-0.06	-0.000	0.02	2.27*	0.002	0.03	3.38*	0.001	-0.02	-2.10*	-0.004
Age squared	-0.00	-0.07	-0.000	-0.00	-2.31*	-0.000	-0.00	-3.19*	-0.000	0.00	4.01*	0.000
Education	0.04	2.13*	0.000	0.04	4.76*	0.001	0.07	7.50*	-0.001	0.06	6.70*	0.010
Spouse's education	0.01	0.70	0.000	0.02	2.58*	0.001	-0.00	-0.15	0.002	-0.41	-5.72*	-0.007
Household size	0.08	3.88*	0.002	0.04	3.30*	0.001	0.00	0.29	0.001	-0.01	-0.72	-0.001
Female	0.01	0.09	-0.021	0.17	2.52*	-0.005	0.21	2.07*	0.011	0.01	0.10	0.016
Farming occupation	0.22	1.29	0.013	0.09	1.35	0.225	0.14	1.76*	0.022	-0.61	-5.43*	-0.301
Farm characteristics												
Log of acres	-0.05	-2.22*	0.000	0.05	4.75*	0.003	0.16	11.56*	0.006	-0.07	-6.14*	-0.008
Farming Efficiency	-0.02	-2.35*	-0.000	-0.01	-3.30*	-0.000	0.00	0.35	0.000	0.00	0.78	0.000
Gov. pay	0.13	1.65*	-0.001	0.13	3.63*	-0.006	5.81	0.05	0.305	-0.05	-1.24	-0.255
Debt to asset	0.03	0.72	0.000	-0.01	-0.14	0.002	-1.51	-1.94*	0.001	-0.10	-3.38*	-0.010
Farm hr. Operator	0.00	2.25*	0.000	0.00	2.97*	0.000	-0.00	-7.30*	0.000	-----	-----	-----
Farm hr. Spouse	0.00	0.30	0.000	0.00	2.55*	0.000	0.00	3.97*	0.000	-----	-----	-----

Variables	Agricultural diversification			Structural diversification			Environmental diversification			Income diversification		
	Coeff	<i>t</i> -score ^a	Marginal effect ^b	Coeff	<i>t</i> -score ^a	Marginal effect ^b	Coeff	<i>t</i> -score ^a	Marginal effect ^b	Coeff	<i>t</i> -score ^a	Marginal effect ^b
<i>Farm types (Base: Cash grain farms)</i>												
High value crops	0.96	8.98*	0.000	-0.10	-1.90*	0.011	0.16	1.76*	0.010	-0.33	-5.07*	-0.031
Livestock	0.40	4.68*	0.000	-0.38	-11.59*	-0.006	-0.02	-0.70	0.003	-0.06	-1.50	-0.007
Cotton	-4.00	0.00	-0.016	-0.72	-6.60*	-0.003	-0.32	-3.51*	0.009	-0.27	-2.80*	-0.015
Other field crop	0.63	6.37*	-0.011	-0.30	-6.56*	-0.004	0.09	1.83*	0.001	-0.01	-0.16	0.011

Correlation between farm diversification strategies

Agri. & structural	0.161	4.32*	Stru. & env.	0.024	1.24
Agri. & environ.	0.089	1.84*	Stru. & income	0.045	1.96*
Agri. & income	-0.01	-0.13	Env. & income	0.091	3.63*

Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{32} = \rho_{42} = \rho_{43} = 0$: $\chi^2(6) = 39.151$, $p > \chi^2 = 0.0000^*$

Log likelihood = -16755.06; Wald $\chi^2(90) = 1464.43$; $p > \chi^2 = 0.0000^*$; N = 13,852

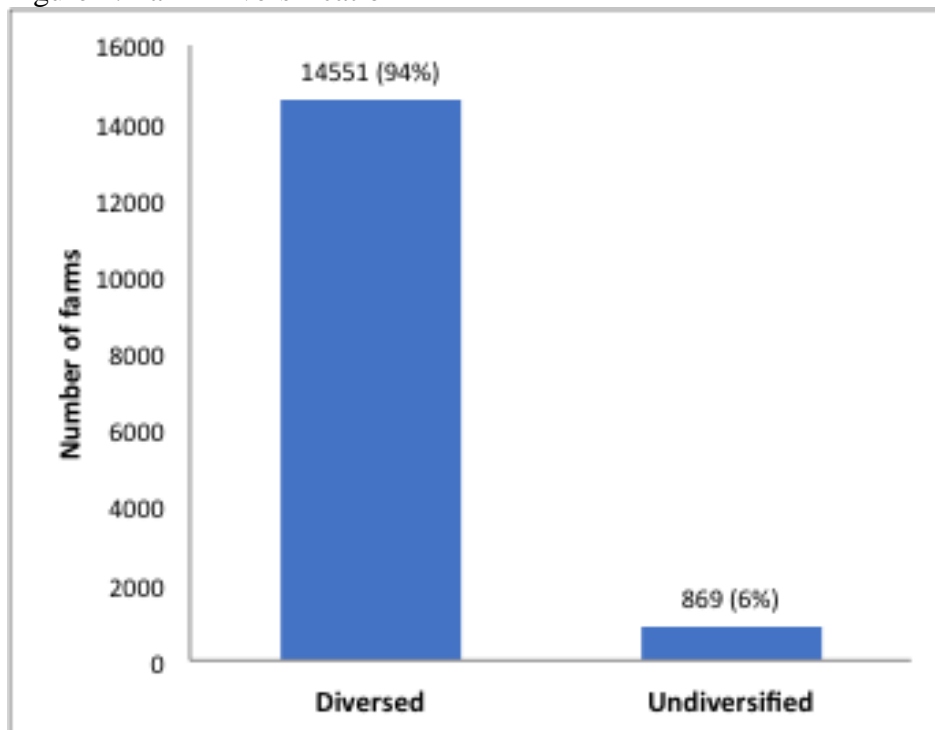
SML number of draws (R) = 150

^a*t*-scores are asymptotic *t*-values,

*indicates statistical significance at 10% or higher (includes 5%, or 1%)

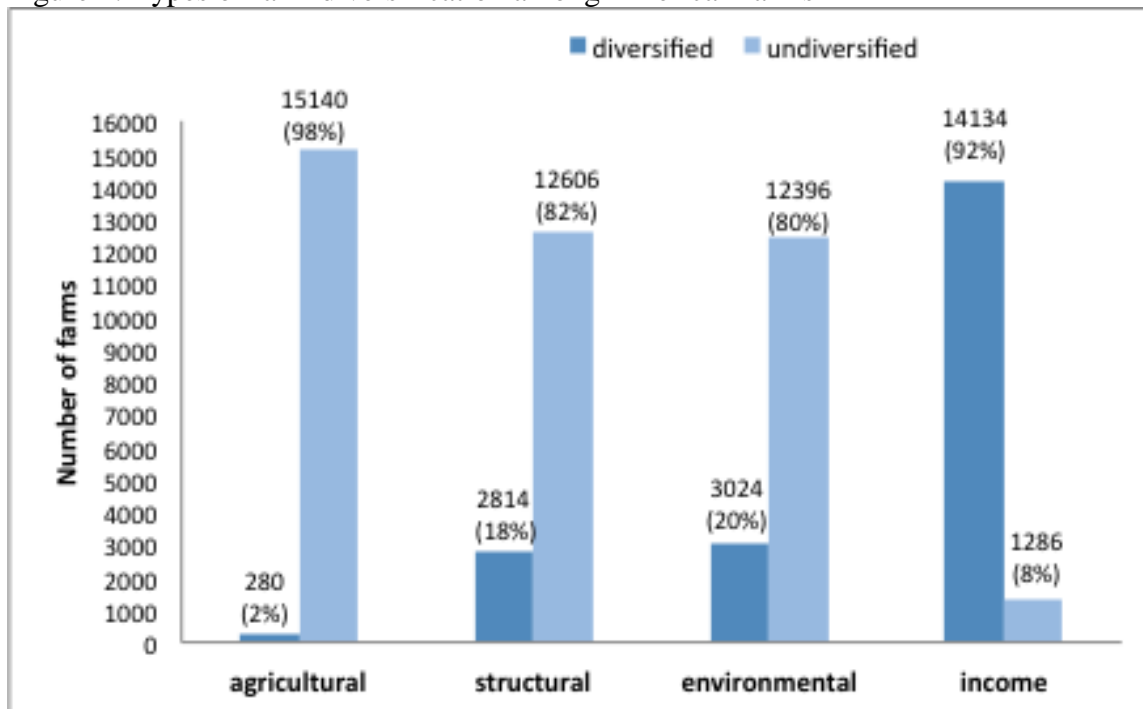
^bmarginal effects are predicted average marginal effects; decision to remain undiversified is used as a base strategy; though coefficients account for the assumption of correlated decisions, marginal effects are computed based on independent alternatives for computational easiness

Figure 1: Farm Diversification



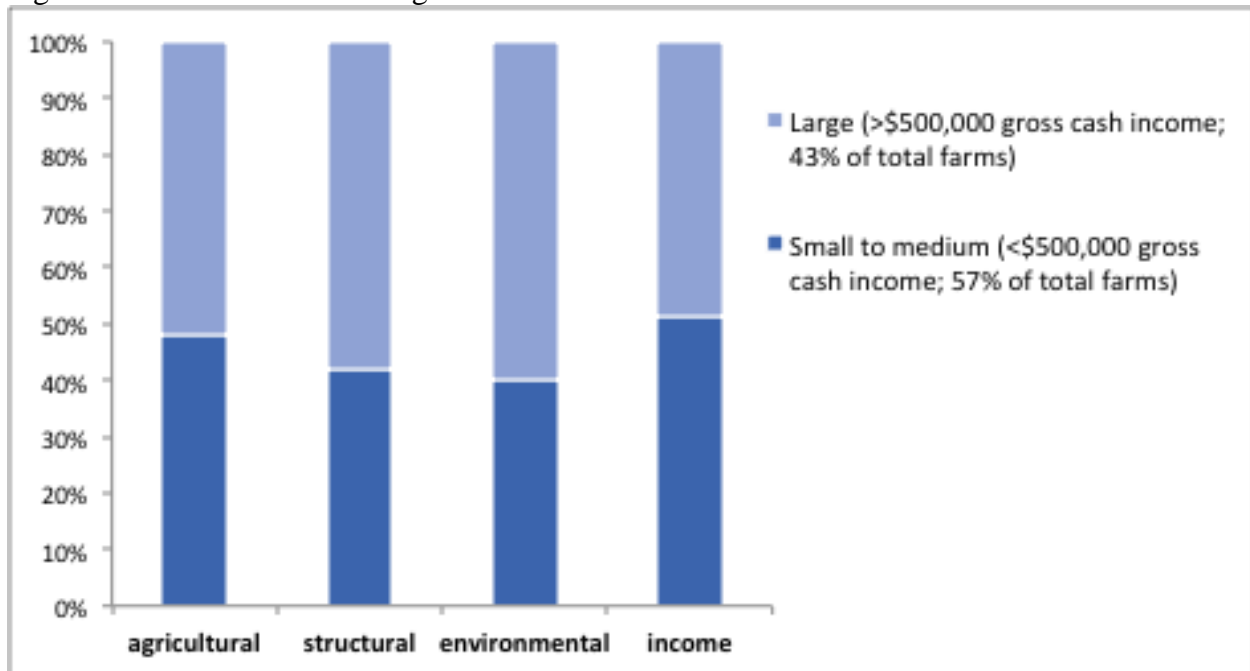
Source: Author's own computation based on ARMS data, 2012

Figure 2: Types of farm diversification among American farms



Source: Author's own computation based on ARMS data, 2012

Figure 3: Share of small and large farms in diversification



Source: Author's own computation based on ARMS data, 2012