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Economic Sustainability and Multiple Risk Management Strategies: Examining Interlinked Decisions of Small American Farms

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Abstract: Economic viability of small farms and farming businesses depends on multiple factors. These farms have limited production and financial resources to maintain their operation. Therefore, to sustain farming, adopting appropriate risk management strategies is a pivotal decision for small farmers. We surveyed Tennessee's small farms and utilized multivariate probit models to study factors influencing the adoption of various risk management strategies. Our findings suggest that the decisions related to the adoption of risk management strategies are significantly interlinked. Along with factors representing the operator's age, education, and farm operator's income and land holdings, we also found that the government incentives (payments), smartphones, and farmers' continuation plan significantly influence the strategic decisions of adopting risk management strategies.

Keywords: risk management; small farms; sustainability challenges; correlated decisions; small farm business; Tennessee

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1. Introduction

Agriculture encounters several risks and uncertainties. Due to its inherent link with natural and environmental conditions beyond control, sometimes farmers are exposed to harsh conditions hindering regular plans and even total failure of the farm operation [1]. Even though various risk management apparatuses, including farmers' and government's (policies) strategies are available, the agricultural risk has not been addressed fully [2,3]. Specifically, small farms are challenged continuously by the overall risk of sustaining farm operation as a viable farm business. In the U.S., small family farms, farms generating annual gross cash farm income less than USD 350,000, account for around 88% of the total number of farms. These small family farms contribute approximately 21.5% of the U.S.'s overall yearly agricultural sales [4]. Small farms play a crucial role in sustaining rural areas' economies [5].

Generally, the operating profit margin (OPM) of small farms is less than 10%. An OPM below 10% is considered a red (a high risk) zone of financial risk [6]. Thus, risk management plays a critical role in the survival of small farms. Government policies are said to have a higher emphasis on crop or livestock insurance-based strategies than addressing the multiple dimensions of risk management [7], which may not be well suited for small farms. Koesling et al. [8] suggest the importance of institutional risks like agricultural policies on the farm's production. Garrido and Zilberman [9] argue that premium subsidies have a significant degree of influence on the likelihood of purchasing Insurance. Finger and Lehmann [10], on the other hand, in Switzerland, found a negative effect of the government's income support program on the insurance purchasing decision. In a similar context, Székely and Pálinkás [11] compared farmers' risk management between U.S. and Europe and found that American farmers take agricultural policies more seriously than their European counterparts. Additionally, the authors found that in both U.S. and E.U.,

farmers consider government programs and diversification strategies as vital means for risk management.

Moreover, variability in weather, and infestation of diseases and insect-pests provide substantial challenges leading to an unexpected production that adversely affect regular operation [12]. Total elimination of the risk in farming operation is almost impossible, even with the best effort, but the effects can be curtailed using different risk management tools [5]. It is crucial to approach multiple facets of risk through strategies on multiple dimensions. In addition to crop or livestock insurance, crop and enterprise diversifications, adoption of alternative farm enterprises (AFE), participation in government support programs, and income support through off-farm work are some examples of risk management strategies (RMS). Diversification on crops, livestock, and enterprises allows allocating available resources to multiple ventures [13]. By adopting such strategies, farmers are likely to generate overall higher revenue or additional income support for farm operations [14]. Adoption of AFE include the development of business ventures on farm such as Agritourism. Agritourism provides supplemental income to the farm operations. Agritourism is also claimed to have its contribution on regional economic development and sustainable environment, such as it helps to create many job opportunities by stimulating local food and lodging enterprises, small businesses, cultural values, and associated industries [15] and helps to conserve area's environmental aspects and ecological values. In that, agritourism is a promising tool of sustainable rural and regional development [16], promoting cultural values, protecting the environment, job creation, and stimulating local businesses and economies [17].

Small farms lack the resources to invest in expensive technologies and practices. They seek ways to maximize overall income and minimize risk, and for that, enterprise diversification is a promising strategy to sustain their farming and manage associated risks [18]. Similarly, Huirne et al. [13] discussed that simultaneously utilizing multiple risk mitigating tools is more effective than giving sole emphasis to one. One of the critical dimensions of RMS is income stabilization through diversified income sources [19]. In the U.S., around one in three farms adopt these income diversification techniques [20]. Aguglia et al. [21] suggested that farm household revenue is continuously shifting from food and fiber production to non-traditional activities in the European farms. In some cases, the change is so considerable that agricultural income is no longer the primary source of household income. Khanal and Mishra [22] argue that diversification increases the portfolio of income generation and synergistically complements each other.

RMS like insurance significantly impacts production decisions by incentivizing the producer to opt for riskier and high-income generating activities [23]. Similarly, Velandia et al. [24] suggest that farmers choose risk management alternatives and are likely to adopt multiple tools simultaneously. The use of only one RMS might not be sufficient. Therefore, Martin [25] suggests to adopt multiple RMS.

Farmers' RMS have been discussed in previous studies as risk management tools for farmers. Such tools include enterprise diversification on the farm [26] and development of farm enterprise and income diversification through off-farm incomes etc. [18,22]. Adopting enterprises that are alternative to regular crop or livestock production, such as income from farm based tourism, processing component within a farm, and high-valued organic produce, have also been studied as possible risk mitigation and income diversification methods for agricultural farms [14,27]. Moreover, many studies have examined insurance purchase decisions as risk mitigation approaches [10,28,29]. Nevertheless, limited studies have assessed the decisions of adopting multiple strategies simultaneously.

Some papers have recently emphasized the critical aspect of examining decisions on simultaneous adoption of multiple risk mitigating and diversification strategies [3,22,24] instead of analyzing strategies independently in separate equations. These recent studies considered multiple management tools or strategies using simultaneous decision-making framework accounting for a possible correlation of these decisions. However, there have been limited studies on the adoption of multiple RMS especially considering small farms in

the developed economy like in the U.S. None of the previous studies have closely examined the factors influencing the decisions regarding AFE as a part of the multiple strategic risk management decision of small farms. Additionally, some factors like government payments, use of a smartphone, and operator's continuation plan on selecting RMS have received attention only in few previous studies, yet these factors have potential importance in risk management. To address these limitations in the literature, we have estimated the risk management decision model of small farmers using primary data from Tennessee.

This paper examines various risk mitigating approaches among small farmers of Tennessee, where small farms are the predominant farm types accounting for approximately 95% of the number of farms in the State. Specifically, we assessed the decision regarding four RMS: crop and livestock diversification, adoption of AFE, off-farm work, and crop or enterprise insurance. We looked at their interlinkages and factors influencing small farmers' decision to adopt these multiple RMS, accounting for the simultaneous decision-making process.

2. Material and Method

2.1. Conceptual Model

Theoretically, farmer's decision to adopt any RMS stems from her aim to maximize revenue from available alternatives (like Insurance, enterprise, and income diversification) and their combinations [24,30–32]. We assume that a farmer is a risk-averse agent and tries to manage risk using various RMS. The adoption of RMS impacts each farmer's net revenue distribution (NRD). Moreover, a farmer estimates the NRD in adopting each RMS according to its associated costs. The adoption of RMS incurs some costs, mainly in two forms. First, in the form of reduced net revenue due to capital allocation on less profitable but safer activities to curtail variation in net revenue [33]. Second, to purchase Insurance premiums for different enterprises. Our study assumes that a risk-averse farm operator tends to choose multiple RMS and safer income-generating activities rather than, if subjected to, high risk-high return ventures with greater variability. Accordingly, a farmer calculates her return distribution relying upon certainty equivalent (i.e., risk-free return or guaranteed return) of each RMS. Using the return distribution associated with each RMS, which is likely to be influenced by each farmer's risk attitude and risk environment, the farmer estimates each strategy's reservation cost. The reservation cost refers to the sum that makes an operator indifferent in adopting a particular agricultural RMS. Upon comparing the reservation cost of an agricultural RMS with its real cost of adoption, the farmer adopts the strategy if the reservation cost is higher than its real cost of adoption. This implies that the farmer chooses only those strategies with equivalent certainty return large enough to make reservation costs higher than the real cost of the adoption.

The mathematical representation of the concept is briefly shown below. Following Sherrick et al. [32] and Velandia et al. [24], consider a farm operator deciding whether to adopt any (could be few, or all) agricultural RMS, k, available to him or her $(k = 1, \ldots, n)$. The operator assesses each of the RMS about the returns distribution to a set of assets M used in production, which have a stochastic rate of return, r_M, with mean $\overline{\nabla}_M$, and variance σ_M^2, signifying overall business risks. On the other hand, financial risk is assumed to be captured through debt and returns on equity. Applying accounting equation, $Assets\ (M) = Debt(d) + Equity\ (e)$, expected rate of return to equity $(\overline{\nabla}_e)$ and variance of the return to equity (σ_e^2) in terms of the fixed cost of debt C_d and return on assets r_M, can be represented as shown in Equations (1) and (2):

$$\overline{\nabla}_e = \overline{\nabla}_M\left(\frac{M}{e}\right) - C_d\left(\frac{d}{e}\right) \tag{1}$$

$$\sigma_e^2 = \left(\frac{M}{e}\right)^2 \sigma_M^2 \tag{2}$$

Under known sufficient condition, maximized expected utility of end-of-period wealth, represented in terms of certainty equivalent can be expressed as $\mathcal{W}_{CE} = \overline{\mathcal{W}} - \beta\sigma^2_{\mathcal{W}}$, where $\mathcal{W}_{CE}$ is the operator's certainty equivalent of end-of-period wealth $(\mathcal{W})$ with mean $\overline{\mathcal{W}}$ and variance $\sigma^2_{\mathcal{W}}$, and β, a parameter of risk preferences. Linking this $\mathcal{W}_{CE}$ correspondence on maximizing certainty equivalent rate of return on equity (∇_{CE}) would be:

$$\nabla_{CE} = \overline{\nabla}_e \ - \beta\sigma^2_e \tag{3}$$

By substituting the expression of $\overline{\nabla}_e$ and σ^2_e from Equation (1), Equation (3) can be re-expressed as:

$$\nabla_{CE} = \overline{\nabla}_M\left(\frac{M}{e}\right) - \mathcal{C}_{\mathcal{D}}\left(\frac{d}{e}\right)\beta\left(\frac{M}{e}\right)^2\sigma^2_M \tag{4}$$

The impacts of utilizing agricultural RMS, assumingly, can be realized in the form of changes in means and variance of return distribution and the incurred cost $(\mathcal{C})$ (for example, cost of purchasing insurance premium). The cost $(\mathcal{C})$ incurred in adopting any strategy would decrease in the rate of return to equity by $\frac{\mathcal{C}}{e}$. Therefore, the certainty equivalent rate of return to equity under each agricultural RMS k available to the farmer can be expressed as:

$$\nabla_{CE,\,k} = \ \overline{\nabla}_{M,k}\left(\frac{M}{e}\right) - \mathcal{C}_{\mathcal{D}}\left(\frac{d}{e}\right) - \ \left(\frac{\mathcal{C}_k}{e}\right) - \beta\left(\frac{M}{e}\right)^2\sigma^2_{M,k} \tag{5}$$

In the adoption of each RMS, the highest expense a farmer likes to make (i.e., the reservation cost $\mathcal{C}^*_k$) for the adoption is implicitly a level of expected utility where the farmer is indifferent in utility before and after the adoption of strategy k. Therefore, the reservation cost can be estimated, as shown in Equation (7), using Equations (4) and (5) as follows shown below (Velandia et al., 2009).

$$\begin{aligned}\left[\overline{\nabla}_M\left(\tfrac{M}{e}\right) \quad -\mathcal{C}_{\mathcal{D}}\left(\tfrac{d}{e}\right) - \ \beta\left(\tfrac{M}{e}\right)^2\sigma^2_M\right] \\ = \left[\overline{\nabla}_{M,k}\left(\tfrac{M}{e}\right) - \mathcal{C}_{\mathcal{D}}\left(\tfrac{d}{e}\right) - \ \left(\tfrac{\mathcal{C}_k}{e}\right) - \ \beta\left(\tfrac{M}{e}\right)^2\sigma^2_{M,k}\right]\end{aligned} \tag{6}$$

Solving Equation (7), we get the expression for $\mathcal{C}^*_k$ as:

$$\mathcal{C}^*_k = M(\overline{\nabla}_{M,k} - \overline{\nabla}_M) - \beta M\left(\frac{M}{e}\right)(\sigma^2_{M,k} - \sigma^2_M) \tag{7}$$

A farmer considers the difference between reservation premium $\mathcal{C}^*_k$ and real cost $\mathcal{C}^{real}_k$ of the particular RMS and decides to adopt a particular strategy if the difference $\hat{\mathcal{C}}^{\mathcal{D}}$ is greater than zero. $\hat{\mathcal{C}}^{\mathcal{D}}$ is unobservable, but the Choice $\mathcal{Y}_k$, the adoption or non-adoption decision, is observable such that:

$$\mathcal{Y}_k = \begin{cases} 1 \, if \, \hat{\mathcal{C}}^{\mathcal{D}} > 0 \\ 0 \, if \, \hat{\mathcal{C}}^{\mathcal{D}} \leq 0 \end{cases} \tag{8}$$

where $\mathcal{Y}_k = 1$ if the farmer adopts the RMS k and $\mathcal{Y}_k = 0$, otherwise.

Equation (8) allows us to perform empirical estimations of the factors affecting RMS's simultaneous adoption. Equation (7) approximates farmer's reservation cost of k, specifically by using asset size (M), risk attitudes (β), leverage $\left(\frac{M}{e}\right)$, and variables that influence the mean and variance of return distribution with RMS k. We further assume that farmers' attitude towards risk can be proxied with a set of demographic, socio-economic and institutional characteristics. Based on previous studies, we used variables like age and education of the operator and farm size [34], operator's gender, household income [35], market and

information access [36], and farm characteristics including main crops grown and farm incomes [37] to approximate the decision choice $\mathcal{Y}_k$.

This framework clearly suggests that the adoption decision depends on the variables influencing return distribution before adoption and variables that determine the degree to which return distribution changes after adopting RMS k. The framework can also work under the simultaneous adoption of multiple RMS utilizing its effect on mean $(\overline{\nabla}_{M,k} - \overline{\nabla}_M)$, and variance $(\sigma^2_{M,k} - \sigma^2_M)$. This implies that the effect of one risk management, say $k = 1$, on mean and variance of return distribution, is conditional on whether the farmer uses other RMS (i.e., $k = 2 \ldots n$) and vice-versa, suggesting for the use of appropriate empirical tools that account for simultaneous decision analysis.

Consistent with the theoretical concept, we empirically examined factors influencing multiple RMS. Following generic form can be represented for our empirical equation for each strategy: $Y = f(X, \beta)$, where Y represents the operator's decision to choose an RMS, as a function of X. The X is a set representing independent variables, and β represents parameter estimates that define the relationship between each independent variable with the decision to adopt each RMS strategy. The following section shows how we fit individual equations denoting each RMS in an econometric estimation framework.

2.2. Econometric Specification

Empirically, the decision analysis of alternatives choices is based on the assumption about the relations between alternatives in the decision-making process. In that, two popular models representing a distinct class of assumptions about alternatives include multivariate probit regression and multinomial logit regression. The basic assumption underlying the multinomial logit is 'independence of irrelevant alternatives', commonly called as IIA. According to IIA, while choosing an alternative from a set of choices, the decision to choose a particular alternative is independent of the other alternatives. The violation of this assumption could lead to a misleading statistical analysis [38]. Besides, many studies have questioned its relevancy in various cases [39]. On the other hand, the multivariate probit model allows for the decisions regarding alternatives to be correlated, representing simultaneous decision making rather than complete independence of these alternatives on decision making [40]. This study utilizes a multivariate probit model (MPM) to examine multiple RMS determinants whose decisions are closely associated. The MPM can ensure the association (complementing and competing) effect of one strategy to another when they are simultaneously adopted [41,42].

Following Khanal et al. [42] the multivariate model can be represented in a generic term as $Y^*_{ij} = x'_{ij}\beta_i + \epsilon_{ij}$. Where Y^*_{ij}, $(j = 1, \ldots, m)$ represents the latent variable of net revenue for different risk management alternatives by the ith producer $(i = 1, \ldots, n)$, x'_{ij} denotes a set of predictor variables determined exogenously, and ϵ_{ij} captures the error term. In our study, we considered four RMS ($m = 4$). For each RMS $(j = 1, \ldots, 4)$, representative equations can be expressed, as shown in Equations (10)–(13).

$$Y_{i1} = x'_i\beta_1 + \epsilon_{i1} \ (crop/livestok\ diverisficatin) \tag{9}$$

$$Y_{i2} = x'_i\beta_2 + \epsilon_{i2} \ (Alternative\ farm\ enterprise\ diversification) \tag{10}$$

$$Y_{i3} = x'_i\beta_1 + \epsilon_{i3} \ (off\text{-}farm\ work) \tag{11}$$

$$Y_{i4} = x'_i\beta_4 + \epsilon_{i4} \ (Insurance) \tag{12}$$

$Y_{i1}, \ldots, Y_{i4}$ represent observed binary outcomes for producer i such that $Y_{ij} = 1$ if $Y^*_{ij} > 0$, 0 otherwise, for each $j = 1, \ldots, 4$. In multivariate probit, we assume correlation among error terms (ϵ_{i1}, ϵ_{i2}, ϵ_{i3}, ϵ_{i4}). The multivariate probit model is fitted using a simulated maximum likelihood approach. The multivariate probit model assumes that

the error terms follow a multivariate normal distribution with $E[\varepsilon] = 0$ and variance-covariance matrix p as shown in Equation (13).

$$cov(\varepsilon) = p = \begin{bmatrix} 1 & \cdots & p_{14} \\ \vdots & \ddots & \vdots \\ p_{41} & \cdots & 1 \end{bmatrix} \quad (13)$$

The matrix has diagonal elements 1 (error term variance) while off-diagonal represent correlations between respective diversification strategies.

2.3. Sampling Procedure and Data Collection

In this study, we collected data by sending a survey with a structured questionnaire via electronic mail. We sent multiple reminders at regular intervals to increase the number of responses. After three weeks of the initial survey, we sent the first reminder; second and third reminders were sent each in a two-week interval after the first.

We used farmer contacts and email addresses maintained on Pick Tennessee Products in collaboration with the Tennessee Department of Agriculture. The Pick Tennessee Products maintains a list of farmers running various agricultural enterprises—grains, specialty crops, livestock, organic production (certified), eco-friendly farms, and farm-based tourism. Likewise, the entity includes farm information from all counties of three divisions of Tennessee: East, Middle, and West Tennessee. To define our sample, we divided Tennessee into various strata to include farms from the maximum possible counties and farm enterprises. The survey was sent to a total of 720 farm households: 250 to East TN, 250 to Middle TN, and 220 to West TN. Considering our response rate of 14% (a total of 104 responses) satisfactory, we proceeded for analysis. We had pretested our questionnaire before heading for the main survey to make possible improvements to the questionnaire. The pretested groups were selected, avoiding the targeted household of 750. Since our study is specifically on the small farms, we used only 100 observations in our analyses, removing four responses who indicated their annual gross farm income higher than USD 350,000. The questionnaire includes a number of questions under three broad sections: agricultural production activities, farm financial information, and farm household information.

3. Result and Discussion

3.1. Descriptive and Summary Statistics

Figure 1 shows that around 84% of the sampled farms adopted at least one RMS. We have considered four specific RMS in this study: crop or livestock diversification (CLD), adoption of AFE, participation in work off the farm, and participation (purchase) of crop/livestock or overall enterprise insurance. In our study, crop/livestock diversification is a dummy variable which has value "1" if the farm has more than two crop or livestock enterprises, each of them contributing at least 5 percent or more share on the total agricultural commodity production, else the variable has the value of "0". Similarly, adoption of AFE is a dummy variable which has value "1" if the farm has adopted alternative agricultural enterprises, such as agritourism, recreational or educational activities hosted on the farm, or on-farm processing facility to generate supplemental income, else the variable has the value of "0". Off-farm work is a dummy variable with value "1" if the farm operator involves any off-farm work/job for income, else 0. Finally, Insurance is a dummy variable having the value "1" if the farm has crop/livestock or overall enterprise insurance, else 0. The figure shows that insurance participation is higher in non-diversified farms than diversified farms indicating that specialized operations are more likely to buy Insurance. Regarding the adoption of individual RMS level, Table 1 presents the breakdown. The highest number of sampled farms adopted crop and livestock diversification, followed by the adoption of an AFE, pursuing job off the farm strategy, and the adoption of crop or livestock or enterprise insurance, respectively (Table 1).

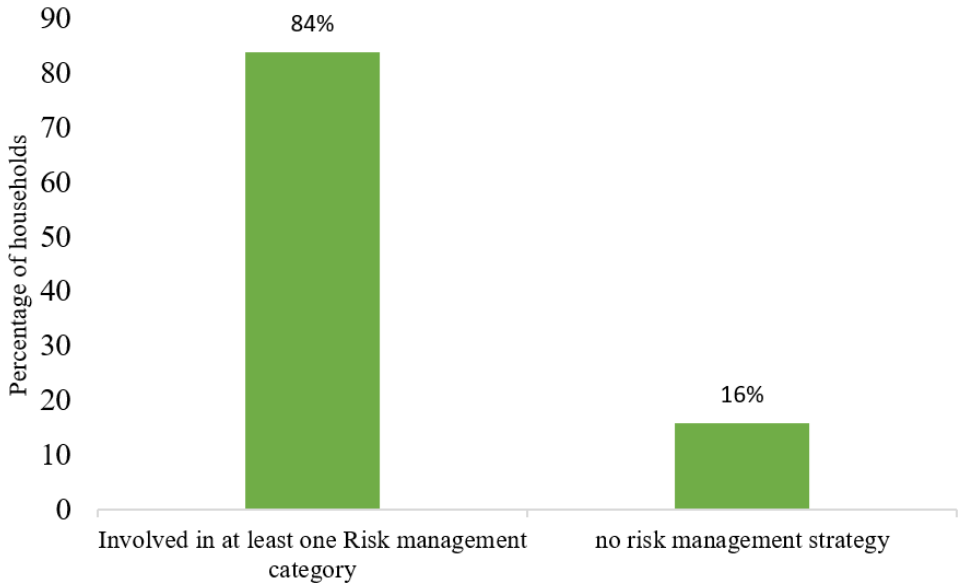


Figure 1. Farms involved in at least one risk management strategies: crop/livestock diversification, Alternative farm enterprises, off-farm work, or Insurance, Tennessee, 2017 (Source: Primary survey).

Table 1. Percentage of sample farm with different risk management strategies, Tennessee, 2017.

Risk Management Strategies	Percentage of Total Farms
Diversification	65%
Alternative Farm enterprises (AFE)	61%
off-farm work	35%
Insurance	32%

(Source: Primary survey).

Table 2 shows the definition and summary statistics of the explanatory variables used in our models. Recall that analysis of this paper is based on farmers with annual gross farm income under USD 350,000—typically referred to as small family farms. Table 2 shows that our sampled farmers averaged around 53 years of age and 14 years of formal education. The average annual household income averaged around USD 55,930. Similarly, the sampled farms held, on average, 71.58 acres of land. Around 84% of farmers had a smartphone with access to the Internet, 85% of sample farms planned to continue farming for the next 5 to 10 years, and 18% of these farms received some sort of government payments. Finally, 67% of the sampled farms involved their family members in different farm activities and derived around 27% of their total household income from agricultural income.

Table 2. Variable definition and summary statistics, Tennessee, 2017.

Variables Definitions	Mean	Std. Dev.
Age (age of the principal farm operator)	53.29	10.38
Education (years of schooling of principal farm operator)	14.06	2.79
Log of income (log of the total household income)	5.56	9.08
Income (total household income)	55,930.25	47,098.40
Log of acres (log of the total acres of the farm)	2.52	2.76
Acres (total farm acreage in acres)	71.58	129.78
Smartphone (=1 if the principal operator uses a smartphone with internet access)	0.84	0.37
Continuation plan (=1 if the principal operator expects to farm for the next 5 or 10 years)	0.85	0.36
Family involvement (=1 if family members other than principle operator also involve on-farm activities)	0.67	0.47
Share of Agriculture (percentage of agriculture on total household income)	26.93	32.87
Government payment (=1 if farm household received any type of government plan)	0.18	0.39
Number of Observations		100

(Source: Primary survey).

3.2. Results from Multivariate Regression

Table 3 presents the estimates from multivariate probit analysis examining the explanatory variable's relationship on the likelihood of adopting each RMS. A significant likelihood ratio test result (with *p*-value 0.000) rejects the null hypothesis of no correlation between four RMS under study. This indicates that a multivariate probit model choice accounting for correlated decisions is an appropriate method instead of independent probit. This also suggests that we would have biased parameters if we had neglected the possible association between simultaneous decisions.

Table 3. Factors affecting adoption of risk management decisions estimated using the multivariate probit.

Independent Variables	Crop/Livestock Diversification		Adoption of Alternative Farm Enterprises (AFE)		Off-Farm Work		Crop/Livestock Insurance	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Age	−0.0399 ** (0.0174)	−0.0114 (0.0051)	−0.0359 ** (0.0165)	−0.0137 (0.0044)	−0.0111 (0.0169)	−0.0032 (0.0051)	−0.0131 (0.0163)	−0.0022 (0.0048)
education	0.1131 ** (0.0498)	0.0332 (0.0152)	−0.0056 (0.0524)	−0.0032 (0.017)	0.0303 (0.0548)	0.0119 (0.0169)	−0.087 * (0.0509)	−0.0171 (0.0151)
Log of income	−0.0005 (0.0166)	0.0003 (0.0056)	0.0329 * (0.0172)	0.006 (0.0051)	0.0018 (0.0188)	0.0007 (0.0057)	−0.0172 (0.0174)	−0.0009 (0.0052)
Log of acres	0.1804 ** (0.0772)	0.0494 (0.0221)	−0.0949 (0.0661)	−0.0241 (0.0185)	0.00009 (0.0647)	0.0005 (0.0196)	0.2224 * (0.0842)	0.0542 (0.0238)
smartphone	−0.4603 (0.4444)	−0.1167 (0.137)	0.8505 * (0.3905)	0.2524 (0.1153)	0.6439 (0.4645)	0.2035 (0.1392)	−0.04 (0.4363)	−0.0346 (0.1226)
Continuation plan	−0.1295 (0.4527)	0.0077 (0.1428)	−0.3022 (0.4452)	−0.0904 (0.1267)	0.8592 * (0.5076)	0.2834 (0.1475)	−0.1981 (0.458)	−0.0258 (0.1349)
Family involvement	−0.0826 (0.3241)	−0.0325 (0.1428)	0.2186 (0.3117)	0.0457 (0.0936)	0.017 (0.3185)	0.0053 (0.0984)	−0.491 (0.3216)	−0.1762 (0.0884)
Share of Agriculture	0.0081 * (0.0046)	0.0022 (0.0014)	0.0069 (0.0047)	0.0019 (0.0014)	−0.0194 ** (0.0059)	−0.0058 (0.0015)	0.0023 (0.0045)	0.0005 (0.0014)
Government pay	−0.9925 ** (0.4389)	−0.2605 (0.127)	−0.2951 (0.3977)	−0.11 (0.00014)	0.7806 * (0.4508)	0.2323 (0.1309)	0.8053 ** (0.3784)	0.2215 (0.1111)
Constant	0.1362 (1.5171)		1.6992 (1.482)		−1.2312 (1.6288)		1.164 (1.5276)	
Joint decisionparameters	AFE and Diversification (rho 21)		0.4765 ** (0.1377)		off-farm work and diversification (rho31)		0.039 (0.180)	
	Insurance and Diversification (rho41)		−0.3679 ** (0.1862)		off-farm work and AFE (rho32)		0.061 (0.176)	
	Insurance and AFE (rho42)		0.3779 ** (0.1734)		Insurance and off-farm work (rho43)		−0.301 * (0.184)	
Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: chi2(6) = 19.2248, Prob > chi2 = 0.0038								
Wald-Chi-square statistics of overall fit: 86.01 (Prob > chi2, 0.0000)							N = 100	
Log-likelihood: −203.05851								

Note: Parameter estimates are based on a multivariate probit model fitted using the simulated maximum likelihood method. Figures in parenthesis are standard errors. * represents the level of significance at 10%, ** represents the significance level at 5% or higher level.

3.3. Interlinkage between Risk Management Decisions

The correlations and interlinkages between RMS are shown in Table 3 (bottom). Our results suggest that crop or livestock diversification (CLD) and AFE have a significant positive relationship (rho21, Table 3). We can expect the supportiveness between these

two decisions because diversified farms comprising a mixture of grains, specialty crops, livestock, and ecologically suited practices make a farm more attractive and educational—a typical attribute that would benefit AFE like Agritourism. The diversified crops and livestock also complement the decision to adopt another AFE, like establishing a farm processing component. Mastronardi et al. [43] also argued that Agritourism enhances biodiversity, an ecological and environmental conservation attribute. Moreover, the model results suggest a significant positive association between adopting AFE and Insurance purchase (rho 42, Table 3). Remember that AFE includes lucrative activities like farm tourism and the processing component of the farm. To establish and boost farm-based tourism, farmers need to invest in the farm's recreational and aesthetic aspect and some level of initial investment. Therefore, considering the possible risk of losing capital investment of AFE, farmers tend to purchase Insurance. As mentioned above, these findings suggest that policies promoting one strategy may contribute to the other's adoption.

However, our findings show that the adoption of crop/livestock diversification and Insurance purchase decisions have a significant negative relationship (rho 41, Table 3), suggesting that decisions to adopt these strategies are competitive. It may stem from financial reasons: farmers may face financial constraints to adopt both tools simultaneously; thus, financially obligated to pick one over the other. Unlike specialized farmers who typically concentrate on few crop/livestock and are highly concerned about the performance and loss of specialized product, a farmer producing multiple commodities probably gives less emphasis to Insurance, given limited access to capital. To accurately examine which one is true, one may need to investigate these, ideally by tracking these farms and analyzing panel data models. This could be an interesting further study. Likewise, a competitive relationship between Insurance and off-farm work suggests a trade-off on time allocations between on-farm activities for agricultural operations and off-farm work hours. In our sample, perhaps an off-farm work participant less likely purchases farm-related Insurance because farming is not the main occupation. In contrast, farmers that bought Insurance premiums likely to focus on on-farm agricultural activities, therefore less likely to allocate time and focus for off-farm jobs. Further research may be needed to explore the underlying details behind the competitiveness of the strategies. This could help develop an appropriate strategic instrument like subsidy on Insurance, rewards-based payments, or other educational programs. The positive effect of education on crop-livestock diversification suggests that educational workshops and training programs could enhance the adoption. A positive relationship between income and AFE indicates that the government's financial support could be a promising strategy to accelerate the strategy's adoption rate. The effectiveness of different means of government support such as loan support, paychecks, or any other forms is beyond this paper's scope but could be interesting further research.

3.4. Factors Influencing Risk Management Decisions

The parameter estimates in Table 3 reflect that the primary operator's age significantly affects the RMS decision. This implies that old aged operators are less likely to adopt CLD and AFE than relatively younger operators. Meraner and Finger [3] and potter and Lobley [44] also argue that younger operators usually have an excess workforce but lack sufficient capital assets, thus seeking RMS within their farm rather than purchasing outside sources. Our result suggests that the operator's years of schooling and decision to adopt CLD are significantly and positively related. A significant notably high marginal effect of 0.0332 on the education coefficient (Table 3) suggests that with every one-year increase in schooling, the likelihood of choosing CLD increases by 3.32%. This could be because education enhances farmers' ability to seek innovations and updates. The finding regarding education is consistent with Mishra et al. [18]. Moreover, Knight et al. [45] suggest that education is related to adopting innovative ideas and technologies. However, we found a significant negative effect of education on the insurance purchase decision. This finding, somewhat counterintuitive, shows that the likelihood of buying insurance decreases by 1.19% with every one-year increase in schooling.

The estimates in Table 3 suggest a significant positive effect of farmland holdings on CLD adoption. This may sound counterintuitive as one expects that specialized operations typically have large acreage, and those farms tend to diversify less [46]. However, this finding is consistently similar with the results of Bartolini et al. [26], who found that the lack of sufficient land hinders the diversification process—inadequate space to establish many enterprises. Likewise, in Table 3, we see that higher land holding contributes to the Insurance buying decision. Our finding could also indicate that farms with larger landholding probably have comparatively larger capital financing and perhaps subjected to the risk of losing significant wealth if they do not buy Insurance. Therefore, they are more likely to buy insurance.

The model results suggest that an increase in the share of agricultural income enhances the likelihood of adopting the CLD strategies by 0.21%—the value of the marginal effect is 0.0021. Similarly, this finding matches with the study of Khanal et al. [42]—farmers having farming as their primary profession tend to diversify their farm more than farmers pursuing another profession as the primary source of income. We found an expected, a negative, effect of on-farm income and the farmer's decision to work outside the farm. The estimate, marginal effect (0.0056), suggests that the probability of an operator pursuing jobs outside the farm decreases by 0.56%. with a 1% increase in on-farm income.

Our findings also suggest that government supports in the form of payments hampers the adoption of CLD strategies by 26.05%, as reflected by the marginal effect (0.2605). This could be because some specific payments on some focused crops or commodities make farmers specialized. However, such payments increased the chance of pursuing a job outside the farm—a finding consistent with Khanal and Mishra [14]. A likely reason behind this phenomenon is that such payments eliminate farmers' fear of losing income from farming as they can compensate for such losses. Therefore, farmers may dedicate hours for off-farm work while enroll and maintain some threshold-level acreage under farming (for example, acreage or enrollment requirements under conservation and environmental program to qualify for it). However, it needs further research to understand the underlying phenomenon fully. To ensure better safety nets, it would be better if small farms adopt multiple strategies. However, the model results suggest that government payment supports the insurance purchase decision while undermines diversification. Therefore, to promote both Insurance and diversification, our results likely suggest formulating independent support programs that do not compromise one another.

As shown in Table 3, smartphones having Internet service promotes the AFE diversification and increases the adoption rate by 25% (as indicated by a marginal effect); this parameter estimate is incongruous with the results of Bartolini et al. [26]. The smartphone plus internet service fills in the farmers with the latest news and knowledge on marketing and farming techniques available globally and helps communicate with the agriculture sector stakeholder. This suggests that enabling farmers for easy access to information and communication helps to manage risk. McElwee and Bosworth [47] inferred that the operators having smartphones plus the Internet have a better chance of establishing networking and obtaining valuable information related to innovative ideas and farming technologies.

Finally, our model estimates in Table 3 show that total income and the decision to adopt AFE are significantly and positively related. The result is somewhat expected because that high income would support the financing required to establish a processing component and agriculture-based tourism within a farm. Our findings suggest that principal operator with a plan to stay in farming for the next 5 to 10 years have a 28.34% higher likelihood of pursuing an off-farm work. There could have two explanations. First, the operators working outside their farm might be farming for recreational purposes like part-time jobs (on a part-time basis), including retirees doing part-time off-farm work or part-time farming who plan to continue farming on a limited scale. The other reasonable aspect could be that small farms continuously struggle to survive and seek alternative income-generating sources to broaden their income portfolio to sustain farming. Small-scale farms are continually fighting for their subsistence and are relentlessly bearing the pressure [48].

4. Summary and Conclusions

Production agriculture is a complex and delicate business because its success depends upon many biotic and abiotic factors of environment, financial and marketing aspects, and various governmental policies. Mostly farms with an inadequate amount of capital and technical resources, typically small farms, are more susceptible to any undesirable changes in these elements. For this study, we surveyed the small farms of Tennessee and studied the effect of various factors on the decision to adopt RMS: crop or livestock diversification, AFEs, working off the farm, and insurance. While choosing the statistical model, we considered for the possible association between the decisions to adopt these strategies. We allowed the effect of such correlation to impact our parameter estimates in the simultaneous decision framework. Our results suggest that the results would have been biased had we not accounted for these simultaneous decision process—justifying the appropriateness of our estimation method.

Although many studies have examined risk-related decisions in agriculture, very few have accounted for decision analysis of multiple risk management tools that are adopted simultaneously among small farms in a developed economy like U.S. Furthermore, our study includes the factors like government payments, use of a smartphone, and operator's continuation plan on the simultaneous adoption of risk-mitigating tools. Very few previous studies have given attention to these factors despite their potential importance in risk management.

Our significant parameter estimates suggest that RMS decisions are associated, which indicates that this aspect needs special attention while formulating policies. For example, the relationship between Insurance and crop or livestock diversification is competitive; a policy supporting one strategy may undermine the other. Therefore, it may require separate policies that promote both of these strategies without compromising one another. The significant results like education, smartphone use, operator's continuation plan, total farm income, and government payments could help extension workers, educators, government, and related stakeholders design their programs and policies more precisely. For instance, farmers having smartphones plus Internet tend to adopt AFEs more than those without access. This suggests that enabling farmers for easy access to information and communication could help mitigate their risk. Our findings on small farmers' risk management behavior could play a vital role in their risk management, survival, and sustainable development.

Our study has provided an insight into the adoption of RMS and simultaneous decision process in four strategies. Future studies can examine risk management of small and large farms including few additional important strategies like liquidity management (to reduce financial risk), contracts (to reduce market risk and price of the outputs and inputs), hedging (to reduce price risk), and spreading sales of agriculture produce (to manage surplus produce in peak season and get a better price in the off-season). On empirical analysis, our study is limited by a single year data of farmers of Tennessee. Future studies can use a more extensive nationwide multiyear or panel data to further enhance the understanding of risk management behavior more accurately.

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