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What Determines the Uptake of Multiple Tools to Mitigate Agricultural Risks among Hybrid Maize Growers in Pakistan? Findings from Field-Level Data

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Abstract: Arable farming is an intrinsically risky enterprise. Therefore, managing risks and uncertainties in agriculture is very important as it affects all sectors of the economy of a developing country like Pakistan. To do so, a whole suite of options is available to the farming community to safeguard against any type of risk. However, farmers' behavior of the concurrent adoption of multiple risk management tools is largely ignored in previous studies and has formed the rationale for this research. Thus, the current study is intended to investigate farmers' decisions of adopting risk management strategies (contract farming, off-farm income diversification, and farm credit use) and to examine the impacts of a variety of factors on farmers' risk management decisions. The present study is carried out in four districts of Punjab province, Pakistan with a focus on hybrid maize growers. A multivariate probit model is used to evaluate the impacts of independent variables on growers' choices of adopting contract farming, off-farm income diversification, and farm credit use to manage farm risks keeping in view the potential for the concurrent adoption of these risk management strategies. Results show that 78% of farmers are risk-averse and hence ready to manage risks. The top risk faced by farmers is price risk followed by biological, climatic, and financial risks. Contract farming is the most popular strategy (61% farmers) followed by off-farm income diversification (49% farmers), and the use of farm credit (42% farmers). The findings also reveal that the decisions of adopting risk management strategies are interlinked while the adoption of one risk management tool complements farmers' decision to adopt other risk management strategies. In addition, the risk management strategies' adoption choices are affected by the number of factors including socioeconomic characteristics, farmers' risk perceptions about risk sources, and their attitude towards risk. The study recommends the provision of timely information (climatic, extension) along with easy access to farm credit and the streamlining of contractual arrangements.

Keywords: risk perceptions; risk attitude; concurrent adoption; multivariate probit

1. Introduction

Risk in agricultural production is pervasive and multifaceted, particularly in arable farming [1]. Farmers confront a variety of yield risks, input availability risk, output price volatility, and deep-seated changes in production technology in their farming operations. These risks affect the stability in farm productivity and profitability from season to season and from one year to another [2,3]. The risk sources and level of their severity can fluctuate

according to the agricultural operation, supporting government policies, climatic conditions, geographic location, and farm types. In developing countries, where risk is a major concern, there is a lack of information to forecast things such as agricultural input prices, output prices, and climate conditions, which might impact farm output and resultantly farmers' livings in the current period as well casting implications on their future wellbeing [4,5]. Integrating and considering the effects of risk at the farm level can potentially benefit the policy makers who make appropriate strategies that can help farmers survive the number of risks they confront.

Risk sources in agriculture are categorized into business risk and financial risk [1,6]. Business-related risks can be categorized further into (1) production or output risk, (2) marketing or price risk, (3) legal, policy or institutional risk, (4) individual or human risk, and (5) technology-related risk. In addition, financial risk occurs when farmers borrow to support farming operations, as they often face variability in the interest rate on borrowed funds, but inadequacy and interruption of cash flow results in farmers' inability to retire debt timely amidst changes in credit terms and conditions. With such a wide array of risk provisions, farmers find themselves striving and struggling to manage them either individually or through communal organization, using single technique or a multiple risk-mitigating options [3,5] depending upon the circumstances and farmers' asset-base.

Risk management is described as an intricate process, which includes several steps and integrated efforts. Primarily, the nature of the risk must be determined in order to be in a position to fight risk. This is a necessary condition as it allows the farmer to plan a set of coping measures if they are not in a position to plan or execute a risk-mitigation strategy. The next step is to consider the occurrence of risk followed by judgement on risk outcomes such as the intensity, severity, and scope leading to the assessment of anticipated losses [1,3]. Such a management drive in the agriculture sector is further complicated by the primary nature of economic activities while having great bearing on the sustainability of rural livelihoods and food security. To evaluate farmers' options to control/mitigate risk, an evaluation of their behavior towards risk becomes a top priority [6].

To address risks, a collective risk-mitigating approach dealing in production, marketing, and financial risks has greater chances of success. Production responses reduce the risks by controlling the production change. Marketing responses may try to shift the price risks to other people and organizations/establishments while the financial responses, for example insurance, transfers risks to other parties, and focuses on the availability of those sources with which firm can bear the adverse conditions [1]. Such an integrated approach has further trickle-down impacts in reducing risk by boosting the farm's capacity to tolerate risk and not become affected by the probability of unfavorable conditions. The range of risks faced by agriculture is not limited to regions and crops, however, non-traditional crops trying to make in-roads to the existing agricultural systems face greater challenges. Hybrid maize is one such example in the context of Pakistan's agriculture.

Maize is the third most important cereal crop in Pakistan after wheat and rice. The majority of maize output is obtained as hybrid maize which has offered significant yield increases to farmers over the past few years. The share of maize in the country's GDP is 0.6% whereas the share in agricultural value added is 3.4% during the 2020–2021 cropping season [7]. Area under the maize cultivation area expanded from 1251 thousand hectares in 2017–2018 to 1418 thousand hectares in 2020–2021, thus registering a 13.3% increase in the overall area. Similarly, maize production witnessed a 43.4% increase between 2017–2018 to 2020–2021 (from 5902 thousand tons to 8465 thousand tons, respectively) [7]. According to an estimate, two provinces of the country, namely Punjab and Khyber Pakhtunkhwa, account for up to 98% of the country's total maize production [8]. However, the significant gains in maize production seem not to have translated into increased incomes for farmers in Pakistan. The maize farmers, too, continue to face a variety of risks including production risks, market risks, financial risks, and environmental risk. The production risk appears when farmers have to face significant fluctuations in the expected output due to climatic shocks such as droughts, floods, or extreme temperatures. Nevertheless, financial and

marketing risks do also complement production risk through constrained use of inputs or farmers' inability to realize good commodity price who are financially indebted to liabilities of cash, inputs, and machinery from wealthy landlords or commission agents [2,3].

The nature of risks faced by farmers in Pakistan has seldom varied although one form has dominated the other in terms of intensity overtime. In the past decade, the country has faced drought, flooding, outbreak of diseases in crop and animal, and unstable inputs and outputs prices. This situation has led to weakened farmers' status amidst an uncertain market situation. Although public institutions have played their role partly through subsidized loaning and price support for dealing with different type of risks, however, they could not shield them against such disasters completely. The private sector, on the other hand, is still in evolving stage but has shown a greater capacity to manipulate the situation for their personal gains at the cost of forgone farmers' incomes. The insurance system related to agriculture is still infantile, which could provide a useful alternative to recover from daily sufferings. In this respect, the crop loan insurance scheme (CLIS) was introduced in 2008, however, a majority of the farmers are not aware of this scheme and still rely on conventional methods related to risks management [9]. CLIS is a federal government project wherein farmers can ensure their crop(s) against potential risk through extending short-term loans that are subject to the payment of insurance premium upfront. However, there is a guaranteed indemnity if some natural calamity occurs. As this scheme failed to gain popularity, there is a dire need to educate farmers about different risks and remedial strategies. Managing risks and uncertainties in the agriculture sector is crucial as it affects other sectors of the economy as well [10]. Since production is the main source of revenue for agricultural producers, it is imperative for growers to identify and manage output risk [11].

Applying many risk-management tools rather than just a single one to manage risk is a common practice among farm growers worldwide [12]. However, most of the literature on influencing the adoption of risk management strategies usually do not examine the concurrent use of multiple risk management strategies. That is, most of the previous literature only explores factors influencing the adoption of a single risk management tool rather than analyzing the factors that influence the uptake of simultaneous adoption and the potential correlation of adoption choices. Examples of studies that have investigated the adoption of a single risk management strategy are [13] for hedging with options and futures, [14] for forward pricing/contracting, and [15,16] for agricultural insurance.

The current study is, therefore, designed to analyze factors affecting farmers' decisions of adopting traditional measures viz. contract farming, income diversification, and agricultural credit as risk management at the same time. The choice of these three strategies stems from field knowledge, expert discussions, and an exploratory survey of the studied region. The study also tries to understand how farmers perceive risks and how attitudes toward these risks can affect risk management decisions. The findings of this study provide insights for extension workers, government line agencies, and others researchers in numerous ways. Policy makers can use the findings to identify which types of farmers will use government-supported risk coping strategies, i.e., Crop Loan Insurance Scheme (CLIS) in the presence of traditional risk management tools. The traditional risk management strategies most prevalent in the research are contract farming, off-farm income diversification, precautionary saving, agricultural credit, etc.

2. Materials and Methods

2.1. Sampling Procedure and Study Area

For this study, primary data were collected from 400 hybrid maize farmers from the Punjab province of Pakistan. The province and study area are representative of the country in the case of hybrid maize production. Almost 100% of hybrid maize production takes place within the selected province whereas the contribution of studied districts is more than 50% of the country's total hybrid maize area [7]. A multistage random sampling technique was used for sample selection. In the first stage, the Punjab province was selected

as the main study area. In the second stage, four hybrid maize growing districts were selected randomly. Next, from each district, 2 cities and from each city, 2 union councils were selected at random. In the next stage, a random selection of villages from the selected union councils followed by face-to-face interviews of randomly selected hybrid maize growers were accomplished. Figure 1 shows the sampling framework of the study. The type of information elicited from the respondents constituted on, among others, farmers' socioeconomic status, sources of risk, their attitude toward risk, their choices of risk management tools, and income sources.
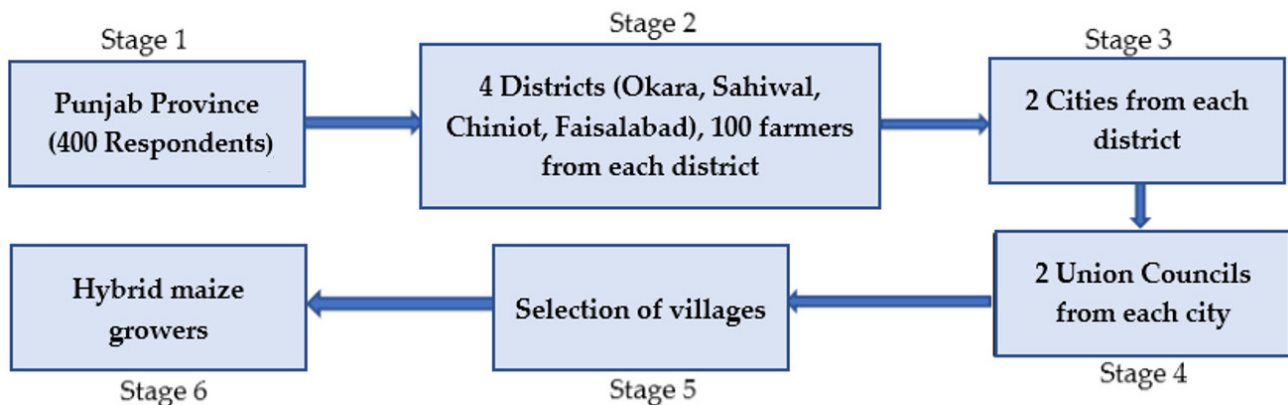
Figure 1. The sampling and data collection framework of the study.

To estimate the sample size, following the formula [17] represented by Equation 1 was applied. The total number of farmers in the Punjab province is 5,249,800 according to the 2016–2017 census of agriculture (see: http://www.agripunjab.gov.pk/overview). Assuming 50% of this population (i.e., 2,624,900) is engaged in maize production, the required sample size to be truly representative of the study area is 384. Therefore 400 farmers were selected in order avoid any missing values, outliers, and/or under-representation:

$$n = N \times \frac{\frac{Z^2 \times p \times (1-p)}{e^2}}{\left[N - 1 + \frac{Z^2 \times p \times (1-p)}{e^2}\right]}. \tag{1}$$

Here, n = sample size; N = Population size; Z = Critical value (95% confidence level = 1.96); e = Margin of error (5% = 0.05); and p = Sample proportion (0.5).

After calculating the total sample size, 100 hybrid maize farmers were interviewed at random irrespective of the district size due to the unavailability of authentic information on the number of maize/hybrid maize growers.

The geographical location of the study area is shown in Figure 2. The selection of the Punjab province as the study area was motivated from its dominant share in being overall the most-populous within the country, having 59% of the total geographical area under cultivation (out of 20.63 million hectares), contributing around 53% to the overall agricultural GDP, providing 74% of the entire cereal output of the country, and most importantly, having around an 81% share in the total hybrid maize crop [8,18,19].
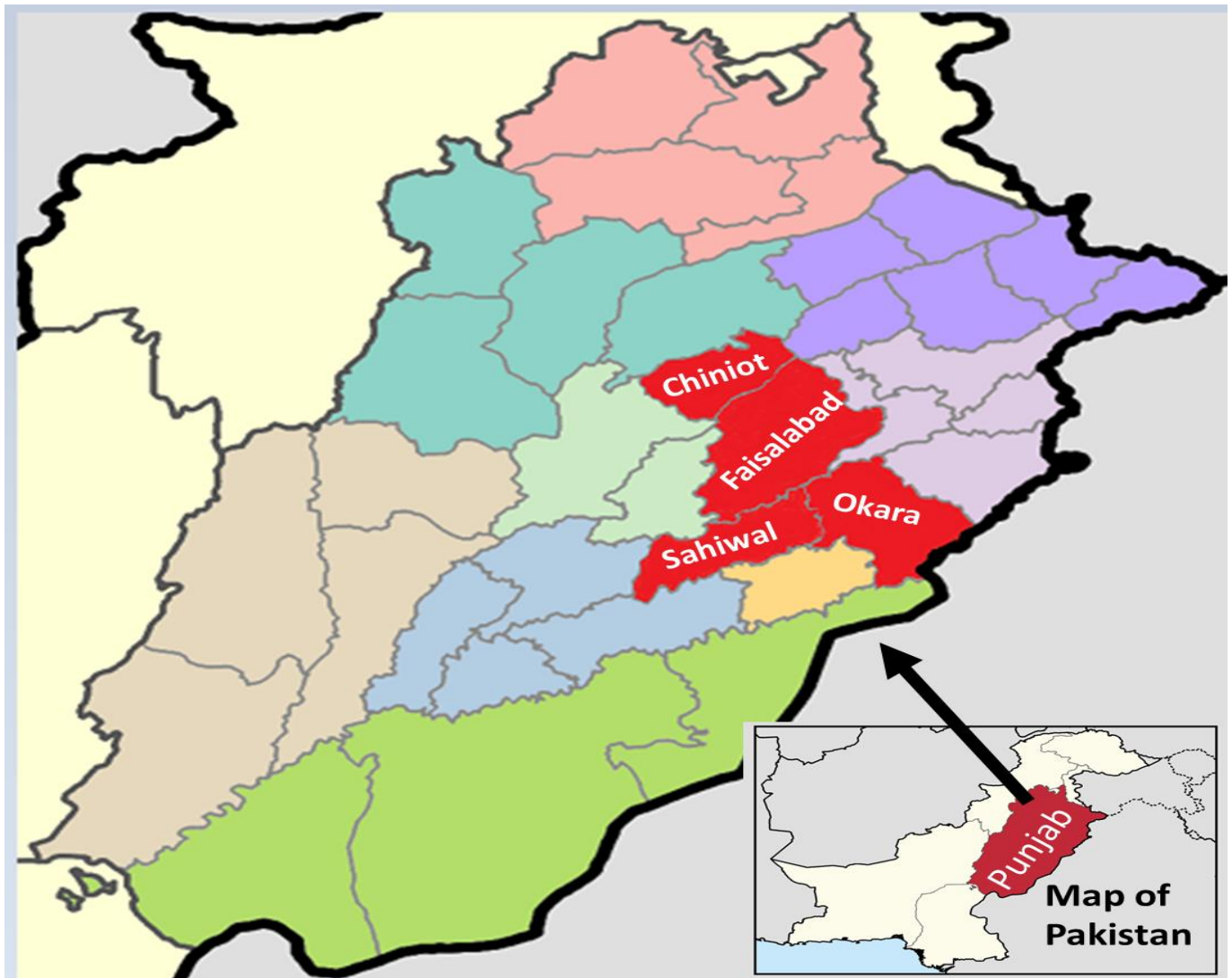
Figure 2. Study area map.

2.2. Multivariate Probit Model

A multivariate probit model (MVP) considering the possibility of contemporaneous correlation in the choices to adopt contract farming, off-farm income diversification, and agricultural credit as risk management strategies can be stated as follows:

$$Y_{ij} = \acute{x}_{ij}\beta_j + \varepsilon_{ij} \tag{2}$$

where Y_{ij} (j = 1 ... , m) characterizes the risk management alternatives (in our case m = 3) faced by the ith producer (i = 1 ... , n), x_{ij} is a 1 × k vector of observed variables that influence the adoption decision of risk management tools, β_j is a k × 1 vector of unknow parameters (to be estimated), and ε_{ij} is the unobserved error term. In this description, each Y_{ij} is a binary variable and, thus, Equation (1) is actually a system of m equations (m = 3 in this case) to be estimated:

$$Y_1^* = \alpha_1 + X\beta_1 + \varepsilon_1 \tag{3}$$

$$Y_2^* = \alpha_2 + X\beta_2 + \varepsilon_2 \tag{4}$$

$$Y_3^* = \alpha_3 + X\beta_3 + \varepsilon_3 \tag{5}$$

Whereas Y_1, Y_2, and Y_3 are three latent variables underlying each of the risk management adoption decision, such that Y_j = 1 if > 0; 0 otherwise. If the vector of random errors

ε_{ij} were independently and identically distributed, an estimation of unknown parameters of the model would become simple. However, as noted above, there is possibility of a simultaneous utilization of risk management strategies and thus it is likely that these decisions are correlated. The elements of ε_{ij} likely will experience stochastic dependence which can be considered by assuming that ε_{ij} is multivariate normally distributed [20].

Hence, in the multivariate probit approach, the error terms (across $j = 1 \ldots$, m alternatives) are assumed to have multivariate normal distributions with a mean vector equal to zero. With the assumption of multivariate normality, the unknown parameters in Equation (2) can be estimated using a simulated maximum likelihood (SML) technique that uses the Geweke–Hajivassiliou–Keane (GHK) simulator to evaluate the multivariate normal distribution [21–23]. The SML method is generally free from simulation bias for a given number of simulations. This method involves a likelihood function and the estimated parameters achieves efficiency when the number of simulations increases quickly [24].

2.3. Farmers' Risk Perceptions

Measuring risk provides an insight into how likely something may get wrong (likelihood) and the subsequent outcome [25]. In the present study, risks are categorized into four types: (i) Price risk, (ii) climate risk, (iii) biological risk, and (iv) financial risk. The severity and incidence of every risk source were scored on a Likert scale, from very low (1) to very high (5), by the growers in order of importance for their possible impact on their crop. Ranking the risks based on the product of consequences or severity (c) and likelihood or incidence (p) gives a risk factor (RF) [26]. These scores are combined in a risk matrix [26] and are classified as low if RF is between 2 and 5 and high if RF is from 6 to 10.

2.4. Risk Attitude

For assessing the behavior of farmers toward risks, the equally likely certainty equivalent (ELCE) model was applied. The certainty equivalents (CE) were obtained for an order of risky results and were matched with utility values [27]. For example, the farmers were asked to find the monetary worth of certain output that made them indifferent in a choice amongst two risky outcomes as a total PKR 1 (total yearly family income, about 80,000 PKR) and 0 PKR with same probability (in this example the utility related with 80,000 PKR is 1 and with 0 PKR is 0). Suppose that the reply is 41,000 PKR, this is the certainty equivalent (CE) of the agriculturalists for the income level of 80,000 PKR and 0 PKR with equivalent chances. The farmer was once more enquired to state the monetary values of a certain outcome that made him uninterested among the two risky outcomes of 41,000 PKR and 0 PKR with equal probability. This process continued until appropriate data points were found. The parallel process is approved for the other portion of income distribution to get the CE and matched them with utility values. The farmer's response of 41,000 PKR is the CE for indeterminate payouts of 80,000 PKR and 0 PKR with matching probabilities (each 0.5) and utility values for this CE are considered as:

$$U(41,000) = 0.5u(0) + 0.5u(80,000) = 0.5(0) + 0.5(1) = 0.5. \tag{6}$$

After finding quite a few certainty equivalents and corresponding them with utility values, a cubic utility function was applied for an assessment of the utility of each farm household. The equation of cubic utility function is:

$$U(w) = \alpha_1 + \alpha_2 w + \alpha_3 w^2 + \alpha_4 w^3. \tag{7}$$

This risk aversion is associated with cubic utility function, risk indifferent attitudes and risk perceptions [28,29]. The absolute risk aversion is arithmetically written as:

$$r_a(W) = -\frac{U'(W)}{U''(W)}. \tag{8}$$

Hence, U' and U'' are 1st and 2nd order derivatives of wealth (W), respectively and $r_a(W)$ is the parameter of absolute risk aversion. Subsequently, income is replaced with wealth [30]. The farmer is risk averse if the absolute risk aversion coefficient is positive, if the farmer is a risk lover, then it is negative, and zero if the farmer is neutral to risk. The farmers' risk behavior is captured within the analysis as 1 and 0 if the farmer reflects a risk averse attitude.

3. Results and Discussions

This section presents the findings of the study based on the descriptive and multivariate probit analysis along with discussion of the important findings in light of the policy and research.

3.1. Socioeconomic Profile of the Respondents

Table 1 presents the socioeconomic characteristics of the respondents in the study area. It is clear that contract farming was the dominant strategy for adaptation to risk at 61%, followed by off-farm income diversification by 49% while resorting to agricultural credit was 42% of the study area. Regarding demographic aspects, the average age was around 45 years with around 7 years of farming experience. The average size of farm holdings was about 43 acres out of which 75% is devoted to maize farming. About 73% of farmers have access to the extension services. Out of surveyed farmers, 78% are risk averse showing a higher number of respondents being aware and ready to mitigate the incidence of such unwanted events. Price risk was the top most reported risk source (79% farmers) followed by biological risk (72%), climate risk (69%), and financial risk reported by 61% of farmers. These finding clearly depict the nature of risks sources faced by the farmers and the percentage of farmers who are ready to take control/adaptation measures against confronting risks.

Table 1. Descriptive statistics of the study variables.

Variables	Mean	SD
Dependent Variables		
Risk Management Tools		
Contract Farming	0.61	0.49
Off-farm Income Diversification	0.49	0.50
Availing Agriculture Credit	0.42	0.49
Explanatory Variables		
Socioeconomic Characteristics		
Farmer's Age (years)	44.77	9.93
Household head's Education (schooling years)	6.89	4.02
Household head's Farming Experience (years)	22.58	9.09
Farm Size (acres)	43.04	41.21
Proportion of Maize Area (area under maize/total farm area in acres)	0.75	0.16
Distance from Output Market (Km)	15.83	8.78
Extension contact (1 = yes, 0 = otherwise)	0.73	0.45
Regional Dummies		
Okara	0.25	0.43
Sahiwal	0.25	0.43
Chiniot	0.25	0.43
Risk Attitude		
Risk Aversion	0.78	0.42
Perception of Risks (1 = Yes, 0 = Otherwise)		
Price Risk	0.79	0.41
Biological Risk	0.72	0.45
Climate Risk	0.69	0.46
Financial Risk	0.61	0.49

3.2. Correlation among Risk Management Strategies

Table 2 presents the correlation matrix among multiple risk adaptation strategies. The pairwise correlation coefficients between the error terms of one risk management strategy with the other ones in the multivariate probit model for all risk management tools were significant and positive. This finding also justifies the use of multivariate probit model instead of the individual probit model [9,12].

Table 2. Correlation coefficients of risk management adoption decisions.

Risk Management Tool	Correlation Coefficient
Contract Farming and Agricultural Credit	0.5103 ***
Contract Farming and Off-farm Income	0.5010 ***
Off-farm Income and Agricultural Credit	0.4056 ***

Note: *** shows highly significant correlation coefficient at 0.01 level of significance.

3.3. Parameter Estimates of the Multivariate Probit

The significant values of the likelihood ratio test (LR) and the Wald chi-square test provide basis for the rejection of the null hypothesis on conjoint nullity. The parameter estimates of the multivariate probit model, allowing for the concurrent adoption of the three risk management tools are presented in Table 3.

Table 3. Parameter estimates from multivariate Probit model for contract farming, off-farm income, and agricultural credit.

Independent Variables	Contract Farming	Off-Farm Income Diversification	Agricultural Credit
Farmer's Age	0.0309 *** (0.0140)	0.0337 ** (0.0149)	0.0123 (0.0143)
Household Head's Education	0.0202 (0.0182)	0.0505 *** (0.0181)	0.0140 (0.0181)
Farm Experience	0.0031 (0.0164)	−0.0352 ** (0.0166)	0.0199 (0.0160)
Farm Size	0.4208 (0.4595)	0.7324 ** (0.4491)	−0.5186 (0.4444)
Proportion of Maize Land	0.4208 (0.4595)	0.7324 * (0.4491)	−0.5186 (0.4444)
Distance Output Market	0.0157 ** (0.0082)	0.0010 (0.0079)	0.0010 (0.0079)
Access to Extension Information	−0.0174 (0.1581)	−0.1642 (0.1565)	0.3115 ** (0.1588)
Okara	0.5414 *** (0.2015)	−0.1315 (0.1926)	0.6143 *** (0.1918)
Sahiwal	0.4854 ** (0.2088)	−0.6653 *** (0.2063)	0.0586 (0.2043)
Chiniot	0.3901 ** (0.1935)	0.1118 (0.1922)	0.4669 *** (0.1948)
Risk Aversion	0.4207 *** (0.1709)	0.3807 ** (0.1643)	0.0439 (0.1638)
Price Risk	0.4958 *** (0.1623)	0.1484 (0.1659)	0.1363 (0.1662)

Table 3. *Cont.*

Independent Variables	Contract Farming	Off-Farm Income Diversification	Agricultural Credit
Climate Risk	0.1488 *** (0.0544)	0.1613 ** (0.0504)	0.1016 ** (0.0444)
Biological Risk	0.2982 ** (0.1380)	0.2678 *** (0.1345)	−0.0208 (0.1324)
Financial Risk	0.1508 (0.1420)	−0.0755 (0.1392)	0.0883 (0.1380)
Log Likelihood Value		−735.079	
Wald Test Chi2(45)		137.42 ***	
LR Test of ρkj		11.44 ***	
Total Observations		400	

Figures in parenthesis are standard errors. ***, ** and * represent statistical significance at 1%, 5%, and 10% levels, respectively.

3.4. Factors Effecting the Adoption of Contract Farming, Off-Farm Income, and Credit

As given in Table 3, the significant variables in the contract farming equation are the age of the household head, distance from farm to output market, regional dummies (Okara, Sahiwal, and Chiniot), the risk averse nature of the farmers, and farmers' perception of three catastrophic risk sources (price, climatic, and biological). All these variables have a positive association with the uptake of contract farming. With the increasing age of the farmer, there is more probability of increase in the risk aversion attitude of a farm household and, therefore, old age farmers may select a less risky option by indulging into contract arrangements [31]. Likewise, [32] has shown the encouraging impact of farmers' age on the adoption of contract farming as a risk management tool by growers [32]. Variables on the farming experience, farm size, and proportion of maize area to total farm exhibit a statistically non-significant impact on the adoption of contract farming. This implies that the greater proportion of maize land discourages the adoption of contract farming as a risk management tool. Nevertheless, this is justified as a higher proportion of maize land may be related to better stability of land control, a greater asset-base, more flexibility in terms of crop-area adjustment, a larger capacity for bearing risk, and a lesser need for risk management tools [12]. Similarly, the farmers located away from the main market may adopt contract farming more readily as compared to the farmers who are located near the output market. This finding is intuitively revealing and justified as the farmer would desist larger transportation distance for the disposal of farm produce given the nature of infrastructure and transport facilities. Conversely, in the case of those located near the market who can easily handle transportation issues with lesser effort while—at the same time—having better access to a timely market and price information [9,31,32]. The results indicate that different (the selected districts to be precise) hybrid maize growing areas show a positive linkage with the adoption of contract farming as was the role of farmers' attitude towards risk. Farmers' attitude towards risk is an important factor that shapes their decision to practice contract farming as a strategy to overcome any negative shock(s) to their farm incomes due to different adverse conditions. In addition, perceived biological (disease, pest attack, etc.), price-related and climatic risks show a positive impact on the adoption of contract farming that can be justified on many grounds, the major one being the inability of a farmer to face or control them by any means except through entering into contractual arrangements [9]. As farmers cannot negate or defer such risks, the better choice is to opt contract farming for ensuring a reasonable income before the onset of such untoward happenings [31].

Education, farming experience, farm size, perception of financial risk source, and access to extension sources are factors which have positive coefficients except for access to extension information although all of them show a non-significant impact on the adoption

of a contract farming risk management tool. Our findings are in agreement with [9]. Regional dummy indicates that the choice of contract farming is common in three regions.

Factors significantly affecting the adoption of off-farm income diversification as a risk management strategy include farmers' age, household head's education, farming experience, farm size, proportion of maize area, regional dummy (Sahiwal), risk averse nature of farmers, and farmers' perception of climate and biological risks. Our findings for farmers' age is in line with [32] who also found an encouraging impact of age on the use of off-farm diversification of income, however, this result is in divergence with [33,34] who observed a discouraging impact of age with the choice of off-farm income diversification. Farmers who have more education are possibly better placed to adopt off-farm diversification of income as they may have more capability to evaluate the merits as well as openings/opportunities of diversification off the farm as a strategy to cope with the adverse shocks resulting from any adverse conditions. The finding for education is supported by [33,35] who found a significantly positive relationship of education with the adoption decisions of off-farm diversification. Although, [34] reported that a higher levels of farmer education discourages farmers to practice off-farm income diversification to cope with farm incomes variability.

As shown by the findings, more experienced farmers tend to avoid the practice of off-farm income diversification. One possible exposition to this effect comes from the fact that more experienced farmers would generally stick to the adoption of time-old traditional tools and/or develop a higher level of skills related to farming while at the same time becoming more attached to farm production, thus finding it difficult to switch to some other activity away from a farm. Therefore, the coefficient reflects a statistically negative relationship of farming experience with the adoption of off-farm diversification to manage the risk. As noted by [34] too, farming experience has a negative impact on the farmers' decision to diversify off the farm. However, [33] reported a positive impact of farming experience on farmers' decisions of adopting diversification. The findings of this study also disclose that a greater proportion of maize land in the total farm size has a negative effect on the adoption of off-farm income diversification as a risk management tool. Since a larger proportion of maize land is linked with greater wealth, greater stability of income and land control, a larger capacity to bearing risk, but also limited time availability to look for and/or undertake off-farm engagements [12].

Farmers' perception about sources of risk regarding climate and biological risks significantly influences their choice to adopt off-farm diversification drive to offset adverse shocks to their farm earnings arising from any adverse conditions. Perception of climate and biological risk may lead to potential yield losses of the main crops resulting in a decline of net return from agricultural production. Farmers would, therefore, strive to diversify their income sources, in order to continue earning their livelihoods. The risk averse nature of growers also motivate them to practice a diversification option off the farm to minimize risk at farm. An earlier study by [35] also documented a significant encouraging impact of high-risk aversion with the adoption of off-farm diversification of income as a risk management strategy.

Determinants significantly affecting the practice of availing agricultural credit to manage risk include access to extension information, regional dummies (Okara and Chiniot), and farmers' perception of climate risk. These findings imply that the probability of farmers' consideration to avail farm credit increases with increased access to extension information, belong to Okara and Chiniot districts and perception on climate risk. Other risk sources along with other variables show non-significant impact on the uptake of agricultural credit for safeguarding against the risk. Access to sources of information enhance farmers' understanding about potential risks, enabling them to opt farm credit use as a risk management strategy [36]. In the study region, availing farm credit is generally a tough venture but once farmers get a clue—through easy access to further information—about its beneficial aspects along with the windows providing farm credit, they would readily like to avail as a means of protection against potential risks. Lack of information about credit sources and conditions to avail it make farmers reluctant to opt this strategy. Thus, a potential

policy intervention to advocate is to expedite appropriate and effective information sharing, which can expand farmers' knowledge on obtaining credit from formal sources and its use as a risk management strategy. The influence of farmers' perception regarding price risk, biological risk and financial risk, farmers risk averse nature, household age, household education, and distance from the main market is positive but insignificant. However, [9,32] show a weaker to a medium level of impact on the uptake of farm credit as risk mitigating options via farmer's age and education, farm size, and farm-to-market distance.

4. Conclusions

Among the many challenges maize farmers face is variability in farm production, mainly due to adverse climate, fluctuation in price, biological diseases, and financial risk. In view of these multiple risks, farmers adopt several risks management strategies often simultaneously. However, the literature on factors affecting the adoption of two or more risk management tools has not analyzed the issue in this context. Using a multivariate probit approach, our analysis suggests that decisions of adopting risk management tools are indeed correlated and decisions to adopt one risk management tool positively influences the decision to adopt the other tools at the same time. Given the correlation of risk management adoption decisions, it appears more appropriate to investigate factors that affect risk management decisions in a multivariate context rather than estimating each adoption equation individually.

Furthermore, the risk management tools adoption choices are affected by a number of factors, including socioeconomic characteristics, farmers' risk perceptions about various risk sources, and their attitude towards risk. Among the farm and farm household characteristics, age, farming experience, education, and proportion of maize land play imperative roles in farmers' decisions related to different risk management tools. As expected, a higher risk perception relating to sources of risk encouraged farmers to adopt a relevant risk management tool. The concurrent adoption of numerous risk management tools pointed not only to the complex nature of farming production but also to farmers' complicated decision-making process. Though the study is limited to only the Punjab province of Pakistan, the results can be generalized to all developing countries, particularly countries where formal/state-owned risk management tools, such as crop insurance, are either absent or ineffective. The provision of alternative risk management options to farmers through market mechanisms, including the Crop Loan Insurance Scheme, easy access to further, environmental (such as early warning), and price-related information are key interventions that can effectively shape the adaptation drive towards various forms of risks, including climate change. To facilitate adaptation drive, easy access to information related to environment, market, and extension are imperative along with providing a one-stop provision for farm credit with minimum documentary requirements.

The findings of the study report a significant role of climate change in enticing farmers to incorporate multiple tools to avoid risky outcomes in the wake of other policy and market-related risks. This finding provides a greater impetus to shift focus of policy makers and professionals for contemplating the role of integration among institutions entrusted with the mandate to safeguard farmers in the larger interest of safeguarding livelihood, food provision, and rural development. Although other types of risks were also forcing farmers to adopt a singular or concurrent options to confront their onslaught, however, climate change prominently pushed them to opt off-farm diversification, contract farming, and availing farm credit. This implies that farmers must have unconstrained access to easy farm credit, as well as protected or streamlined contractual arrangements with no chances of manipulation, providing them the opportunities to work away from a farm. One option to this end is equipping farmers with skills and information (ICTs) wherein they can be timely informed about any ensuing risky event. With the majority of farmers being risk-averse, one must focus on the initiation of an on-farm diversification drive at least to secure the livelihoods of farm families while at the same time ensuring uninterrupted supplies of food items.

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