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CATASTROPHIC RISKS MANAGEMENT AT FARM: THE USE OF DIVERSIFICATION, PRECAUTIONARY SAVINGS AND AGRICULTURAL CREDIT

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Agricultural producers have a number of options in managing agricultural risks and many of them utilize these risk management strategies simultaneously. However, most of the previous studies ignore the potential correlation among the risk management adoption decisions and farmers' behavior of simultaneous adoption of the risk management tools. Therefore, the present study is designed to examine farmers' decisions of adopting risk management tools (diversification, precautionary savings and credit) and investigate the impacts of various factors on farmers' risk management decisions. The study is carried out in four districts of Khyber Pakhtunkhwa province in Pakistan. Multivariate model is used to assess the impacts of independent variables on farmers' decisions of adopting Diversification, Precautionary Savings and Credit to manage farm risk keeping in view the potential for simultaneous adoptions of these risk management tools. The results suggest that the decisions of adopting risk management tools are correlated and the adoption of one risk management tool induce farmers to adopt other risk management tool(s) at the same time. Furthermore, the risk management tools adoption decisions are influenced by variety of factors including farm and farm household characteristics, farmers' perceptions of catastrophic risk sources, their attitude towards risk and their access to information and credit sources.
Keywords: Risk management, Risk perceptions, risk attitude, multivariate Probit

INTRODUCTION

Weather is an important production factor in agriculture. However, this production factor can hardly be controlled. Agricultural production is riddled with risks and uncertainties that can adversely affect production levels and leads to sizeable losses (Drollette 2009). The uncertainty concerning outcomes that involve some adversity or loss that negatively affects individual well-being is normally associated with the idea of risk (OECD 2009). Previous literature finds a more useful distinction between uncertainty as imperfect knowledge and risk as exposure to uncertain unfavorable economic consequences (Hardaker *et al*., 2004). In economics, the study of risk focuses on the way individuals take decisions when their environment, and therefore the outcome of their decisions, is uncertain. However, in agricultural sector, theoretical and empirical works analyze farmers' input choices in relation to their impact on the expected output and to its variability (Just and Pope, 1978, 1979). Production uncertainty in crop enterprises is caused by variations in weather (drought, excess moisture, hail, freeze and flooding) and by disease, crop insects, and other biological pests (Miller *et al*., 2004; Schaffnit-Chatterjee, 2010). Extreme natural hazards like flood, drought, cyclone and storm surges, hails storm, etc. farmers have little to do against such natural calamities and they are mostly uncertain.

The concern about risk in agriculture should be left not only to farmers but also to the whole society, as the risk averse nature of farmers may result in misallocation of resources that reduce overall welfare. Even if the farmer is risk neutral, the presence of risk could have an impact on production decisions due to its impact on expected marginal productivity when randomness occurs inside the production or costs functions (Just, 1975). Managing risks and uncertainties in agriculture sector is crucial as it affects other sectors of the economy (Kammar and Bhagat, 2009). Since production is the main source of revenue for agricultural producers, it is important for farmers to recognize and manage production risk (Drollette, 2009).

The use of several risk management tools, rather than just a single tool, to manage risks is a common practice among the farming community (Velandia *et al*., 2009). However, most of the studies of factors affecting the adoption of agricultural risk management tools usually do not analyze the simultaneous utilization of multiple risk management tools. That is, most previous studies only analyze factors influencing the adoption of a single risk management tool rather than analyzing these factors while recognizing the possibility of simultaneous adoption and the potential correlation of the adoption decisions. Examples of studies that analyze adoption of a single risk management tool are: Shapiro and Brorsen (1988) and Makus *et al*. (1990) for hedging with futures and options; Goodwin and Schroeder (1994) and Davis *et al*. (2005) for forward contracting/pricing; and Sherrick *et al*. (2004) and Makki and Somwaru (2001) for crop insurance. The present study is, therefore, designed to analyze factors affecting farmers' decisions of adopting diversification, precautionary savings and agricultural credit as risk management. The findings of the study will be of great importance for government line agencies, extension educators and other researchers in a number of ways. Policy makers can use the findings to identify which type of farmers will use government supported risk coping tools (i.e. Crop Loan Insurance Scheme) in the presence of traditional risk management strategies. The traditional strategies most prevalent in the study area are Diversification, Precautionary Savings, Agricultural Credit, Forward Contracting (mostly for fruits and vegetables) etc. Among them, Diversification, Precautionary Savings and Agricultural Credit have been selected as these were the most adopted strategies in the study area. The present study will also help to understand how farmers' perception and attitude towards risk can affect their risk management decisions.

MATERIALS AND METHODS

***Sampling and data collection*:** The required sample households for data collection were selected using multistage sampling technique. In the first stage, Khyber Pakhtunkhwa (KP) province was purposively selected for the study. In the second stage, four districts in KP province viz Peshawar, Charsadda, Swat and Shangla were selected purposively. The main reason behind the selection of these four districts is that two districts, Peshawar and Charsadda, are located in Peshawar valley and the farmers have relatively higher access to input output market, extension and other publicly provided services, credit, information etc. While Swat and Shangla are relatively less developed districts and the farmers have limited access to markets, information, agricultural extension services and other government provided services and are less adoptive of modern technologies (Ahmad *et al.*, 2007; Shahbaz *et al.*, 2010). In the third stage, 8 villages in the selected districts are randomly selected for data collection. In the fourth stage, a total of 330 respondents are randomly selected using the below equation as suggested by Yamane (1967).

$$n = N/(1+Ne^2) \qquad (1)$$

Where,
n = Sample size in each Village
N = Total number of farming households in a village
e = Precision which is set at 15% (0.15)

***Multivariate Probit model*:** A multivariate probit model considering the possibility of contemporaneous correlation in the decisions to adopt diversification, precautionary savings and credit as risk management strategies can be specified as follows:

$$Y_{ij} = x'_{ij}\beta_j + \varepsilon_{ij} \qquad (2)$$

Where Y_{ij} (j =1,...,m) represent the risk management alternatives (in our case m = 3) faced by the i^{th} producer (i =1,..., n), is a 1×k vector of observed variables that affect the risk management adoption decision, is a k ×1 vector of unknown parameters (to be estimated), and is the unobserved error term. In this specification, each Y_j is a binary variable and, thus, equation (2) is actually a system of m equations (m = 3 in this case) to be estimated:

$$\left.\begin{aligned} Y_1^* &= \alpha_1 + X\beta_1 + \varepsilon_1 \\ Y_2^* &= \alpha_2 + X\beta_2 + \varepsilon_2 \\ Y_3^* &= \alpha_3 + X\beta_3 + \varepsilon_3 \end{aligned}\right\} \qquad (3)$$

Where, and 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, estimation of unknown parameters of the model would be simple. However, as noted above, there is possibility of 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 (MN) distributed (Ashford and Sowden 1970). Hence, in the Multivariate Probit approach the error terms (across j=1,...,m alternatives) are assumed to have MN distributions with mean vector equal to zero. With the assumption of multivariate normality, the unknown parameters in equation 2 can be estimated using simulated maximum likelihood (SML) that uses the Geweke-Hajivassiliour-Keane (GHK) simulator to evaluate the multivariate normal distribution.

***Farmers' risk perceptions*:** Assessing risk provides an insight how likely something is to go wrong (likelihood) and what the related impact will be (Wang and Roush 2000). Ranking the risks based on product of likelihood (P) and consequence (c) gives a risk factor (RF) (Cooper *et al*. 2005). In the present study catastrophic risks are categorized into i) risk of floods ii) risk of heavy rains iii) risk of pest and diseases and iv) risk of drought. Farmers were asked to score the incidence and severity of each source of risk, on a likert scale, from 1 (very low) to 5 (very high) to express how significant they consider each source of risk in terms of its potential impact on their farm enterprise. These scores are combined in a risk matrix (Rosenburg *et al*. 1999 and Cooper *et al*. 2005) and are categorized as low if it is between 2 and 5 and high if it is from 6 to 10. The risk matrix is given as;

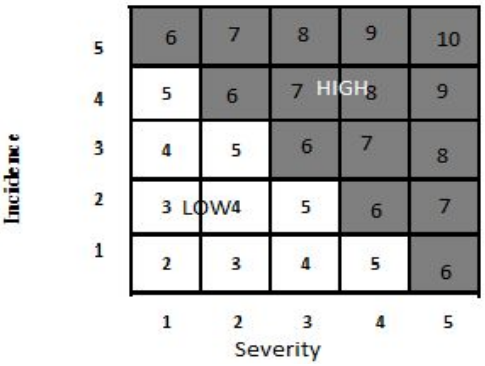

Figure 1. Risk matrix

***Eliciting farmers' risk attitude*:** The method most commonly used to elicit utility from an economic agent is the Equally Likely Certainty Equivalent (ELCE) model (Hardarker *et al*., 1997) where certainty equivalents (CE) are derived for a sequence of risky outcomes and matches them with utility values (Binici *et al*., 2003). For instance, the respondent was asked to specify the monetary value of a sure outcome that makes him indifferent between the two risky outcomes of PKR (Total Annual Household Income, say PKR 50,000) and PKR 0 with equal probability. Suppose the response was PKR 26,000, the respondent was again asked to specify the monetary value of a sure outcome that makes him indifferent between the two risky outcomes of PKR 26,000 and Rs. 0 with equal probability suppose the response was PKR 12,000. This process continues till sufficient data points are obtained. For the other half of the income distribution, the farmer was asked to specify the monetary value of a sure outcome that makes him indifferent between PKR 26,000 and PKR 50,000 each with 0.5 probabilities. In this way, several CE equivalent points were obtained and matched with their respective utility values. Utility value attached with the lower outcome (PKR 0) is 0 and with the higher outcome (PKR 50,000) is 1. The farmer response of PKR 26,000 is his CE for uncertain payouts of PKR 50,000 and PKR 0 with equal probabilities (0.5 each) and utility value for this CE is calculated as;

U(26,000)=0.5u(0)+0.5u(50,000)=0.5(0)+0.5(1)=0.50 (4)

Similarly utility values for all the CE points are calculated and are presented in Table 1 (for this example).

After deriving several certainty equivalents and match them with utility values, a cubic utility function is used to estimate the utility of each individual respondents. The cubic utility function can be written as;

$$u(w) = \alpha_1 + \alpha_2 w + \alpha_3 w^2 + \alpha_4 w^3 \quad (5)$$

Cubic utility function is consistent with risk aversion, risk preferring and risk indifferent attitudes (Binici *et al*., 2003). Utility is generally measured on an ordinal scale; however, the shape of the utility function on an ordinal scale can be transformed into a quantitative measure of risk aversion called absolute risk aversion (Pratt, 1964; Arrow, 1964). The absolute risk aversion is mathematically defined as

$$r_a(W) = -\frac{U'(W)}{U''(W)} \quad (6)$$

r_a (W) is coefficient of absolute risk aversion, U' and U" are first and second order derivatives of wealth (W) respectively. Following Olarinde *et al*. (2007) income is substituted for wealth. The coefficient of absolute risk aversion is positive if individual is risk averse, negative if individual prefers risk and zero if individual is indifferent to risk. The risk attitude of the farmers is included in the analysis as 1, if individual reflect risk averse nature and 0, otherwise.

***Access to information and credit sources*:** A composite index is used to measure the access of sampled households to information sources. The farmers were asked to report the number of contacts they made with each information source in one month period. The values for each information source are first transformed using the following equation.

$$\text{Transformed Value (TV)} = \frac{\text{Xi} - \text{Min}}{\text{Max} - \text{Min}} \quad (7)$$

The composite index for each sampled household is calculated by taking the sum of TV's for all sources of information. The composite index is calculated for formal and informal information sources separately.

Credit access of the sampled households is measured using credit access ratio (Amjad and Hasnu, 2007).

$$AC_i = \frac{c_i/C}{li/L} \quad (8)$$

Table 1. Example of elicitation of certainty equivalents and computation of utility values.

Step	Elicited CE	Utility Calculation
	Scale	U(0) = 0 and U(50,000) = 1
1	(26,000; 1.0) ~ (0, 50,000; 0.5, 0.5)	U(26,000) = 0.5u(0) + 0.5u(50,000) = 0.5
2	(12,000; 1.0) ~ (0, 26,000; 0.5, 0.5)	U(12,000) = 0.5u(0) + 0.5u(26,000) = 0.25
3	(5,000; 1.0) ~ (0, 12,000; 0.5, 0.5)	U(5,000) = 0.5u(0) + 0.5u(12,000) = 0.125
4	(2,000; 1.0) ~ (0, 5,000; 0.5, 0.5)	U(2,000) = 0.5u(0) + 0.5u(5,000) = 0.0625
5	(36,000; 1.0) ~ (50,000, 26,000; 0.5, 0.5)	U(36,000) = 0.5u(50,000) + (0.5u(26,000) = 0.75
6	(42,000; 1.0) ~ (50,000, 36,000; 0.5, 0.5)	U(42,000) = 0.5u(50,000) + (0.5u(36,000) = 0.875
7	(45,000; 1.0) ~ (50,000, 42,000; 0.5, 0.5)	U(45,000) = 0.5u(50,000) + (0.5u(42,000) = 0.937

Authors calculations

Where: AC_i = Access to credit of i^{th} household, c_i = Amount of credit received by the i^{th} household, C = Total amount of credit received by all sampled households in the study area, l_i = land holding belonging to i^{th} household, L = Total landholding belonging to all sampled households in the study area

The analysis based on the above formula has two advantages; firstly, it represents relative access of farmer to credit as compared to the whole sampled households in the study area. Secondly, it gives credit access per unit of land for each farming household. The credit access ratio is calculated for both formal and informal credit sources separately.

Regional variation**:** To capture the effect of regional variations on farmers' risk management decisions, a regional dummy is also incorporated in the analysis. The research site is divided into two regions based on farmers' access to main markets and publically provided services. Region 1 consist of Peshawar and Charsadda districts where the farmers have relatively higher access to main markets and other publically provided services while Swat and Shangla districts are listed under region 2 as the farmers in these districts have relatively lower access to main markets and publically provided services including agricultural extension services and credit facilities.

RESULTS AND DISCUSSION

Descriptive statistics of the variables used in the analysis are presented in Table 2. Diversification as a risk management tool is adopted by 55 percent of the farmers while precautionary savings and credit are adopted by 44 percent and 46 percent, respectively.

Farmers consider risk of flood, risk of heavy rains and risk of pest and diseases to be the major production risk sources that may lead to potential losses in yields of crops. Only 26 percent of the respondents considered risk of drought as a high production risk source that may alter their farm earnings. All districts in the province, except Karak, have easy access to the water of a river passing nearby or flowing through for irrigation (Khan, 2012). This may be the reason why farmers in the area consider drought as lower production risk to their farm enterprise. Majority of the

Table 2. Descriptive statistics of the variables.

Variables	Mean	SD	Maximum	Minimum
Dependent Variables				
Diversification	0.55	0.50	1	0
Precautionary Savings	0.44	0.50	1	0
Credit	0.46	0.50	1	0
Farm and Farm Household Characteristics				
Age (Years)	48.24	13.16	80	19
Education (Schooling Years)	3.88	5.28	16	0
Farming Experience (Years)	28.32	14.99	65	3
Monthly Off-Farm Income (PKR)	25434.55	1500.36	116000	6500
Farm Size (Hectare)	2.38	2.30	16	0.20
Proportion of own Land	0.41	0.44	1	0
High Risk Perceptions				
Risk of Flood	0.70	0.46	1	0
Risk of Heavy Rains	0.70	0.46	1	0
Risk of Pest and Diseases	0.74	0.44	1	0
Risk of Drought	0.26	0.44	1	0
Risk Attitude				
Risk Aversion	0.79	0.40	1	0
Access to Information				
Formal Sources	0.27	0.40	2.5	0
Informal Sources	0.67	0.40	2.5	0
Access to Credit				
Formal Sources	0.84	3.78	42.54	0
Informal Sources	1.27	2.43	17.61	0
Regional Dummies				
Region 1	0.50	0.50	1	0
Region 2	0.50	0.50	1	0

Derived from Survey Data, 2012-13

Table 3. Correlation coefficients of risk management adoption decisions.

Risk Management Decisions	Correlation Coefficients
Diversification and Precautionary Savings	0.299***
Diversification and Credit	0.357***
Precautionary Savings and Credit	0.242***

*** indicates significant at 1 % probability level

farmers (79 percent) in the area are reported here to be risk averse in nature and will avoid risk when facing a risky situation. Agricultural producers have higher access to informal information and credit sources compared to formal/institutional sources.

***Correlation coefficients*:** Correlation coefficients for the three risk management adoption decision are calculated and are presented in table 3. The coefficients are the pairwise correlation between the error terms in the system of equations in the multivariate probit model. The correlation coefficients in our case are positive and highly significant which implies that the decision to adopt one particular risk management strategy may make it more likely that another strategy(ies) will also be adopted.

***Parameter estimates of the Multivariate Probit model*:** The Likelihood Ratio test of ρ_{kj} (positive) justify the estimation of the multivariate probit and the hypothesis H_0 of conjoint nullity of ρ_{kj} can be rejected (p-value = 0.0018). The Wald chi2 test (240.61) also allows us to reject the H_0 hypothesis of conjoint nullity of variable coefficients included in the estimation. The parameter estimates of the multivariate probit model, allowing for the simultaneous adoption of the three risk management tools are presented in Table 4.

***Factors effecting adoption of diversification*:** Factors significantly affecting adoption of diversification as risk management tool are age, education, farming experience, monthly off-farm income, proportion of own land, farmers' risk perception of drought, risk averse nature of farmers, formal sources of information sources and informal credit sources. Our result for age is in accordance with Rehima *et al*. (2013) and Deressa *et al*. (2010) who also found a positive impact of age on adoption of diversification however, the result is in contrast with Mesfin *et al*. (2011) and Ashfaq *et al*. (2008) who found a negative relationship of age with adoption of diversification. More educated farmers are likely to adopt diversification as they have more ability to assess the merit of diversification as a strategy to cope with the negative shocks resulting from unfavorable weather conditions. Our result for education is in line with Tavernier and Onyango (2008), Kouame (2010) and Ashfaq *et al*. (2008) who observed a positive relationship of education and the adoption decisions of enterprise diversification as risk management strategy. However, Mesfin *et al*. (2011) and Rehima *et al*. (2013) found the higher education levels discourages farmers to adopt diversification to cope with farm incomes variability.

As indicated by the results, more experienced farmers tend to avoid the use of diversification. One possible explanation for this may be the fact that more experienced farmers generally stick to the use of time old traditional tools and practices in farming and are less adoptive of the modern tools and advance techniques including diversified agricultural operations and/or income sources diversification. Therefore, the coefficient reflects a negative relationship of farming experience and adoption of diversification to manage farm risks. Mesfin *et al*. (2011) also observed a negative impact of farming experience on farmers' decisions of adopting diversification to manage farm risk. However, Ashfaq *et al*. (2008) reported a positive impact of farming experience on farmers' decisions of adopting diversification. Farmers with higher off-farm income tend to use enterprise diversification to offset any negative shock to their agricultural enterprise with earnings from other enterprise(s). Higher off-farm incomes attract and motivate farmers to diversify their income sources and smooth their consumption. This translates into a positive and significant relationship of off-farm income and the adoption of diversification for farm risk management. Our result is in line with Rehima *et al*. (2013) and Deressa *et al*. (2010) who also reported a positive relation of non-farm income with the use of diversification. However, Ashfaq *et al*. (2008) found a negative relation of off-farm income with adoption of diversification to manage farm risks. Ullah and Shivakoti (2014) found that higher off-farm monthly income significantly encourages off-farm diversification while it strongly discourages on-farm diversification. Results revealed that larger proportion of own land discourages the use of diversification to manage farm risk. Larger proportion of owned land is related to greater wealth, greater stability of land control, and a larger asset base. Higher proportion of owned land signals a larger capacity for bearing risk and a lesser need for risk management instruments (Velandia *et al*., 2009).

Risk perception of farmers regarding drought significantly influence their decisions to adopt diversification to offset negative shocks to their farm enterprise arising from adverse weather conditions. Droughts may lead to significant yield losses of the major crops resulting in a decline of net returns from crop production. In order to continue earnings their livelihoods, farmers have to diversify their income sources. The risk averse nature of the farmers also force them to adopt diversification to minimize risk at farm. Kouame (2010) also found a significant positive affect of high risk aversion with the adoption decisions of diversification. The

Table 4. Parameter estimates from multivariate probit model for diversification, precautionary savings and credit

Independent Variables	Diversification	Precautionary Savings	Credit
Farm household characteristics			
Age	.0323***	-.0144	.0259**
	(.0118)	(.0114)	(.0109)
Education	.0719***	-.0276	-.0151
	(.0189)	(.0180)	(.0193)
Farming Experience	-.0362***	.0037	-.0184*
	(.0111)	(.0106)	(.0102)
Off-farm Income	.00003***	.00003***	-.000002
	(.0000)	(.0000)	(.0000)
Farm Characteristics			
Proportion of Own Land	-.4401**	-.3037*	-.3092
	(.1972)	(.1842)	(.1959)
Farm Size	.0254	.0031	.1038**
	(.0469)	(.0402)	(.0464)
Perception of risk source			
Flood	.0880	.5479***	.0645
	(.1836)	(.1810)	(.1939)
Heavy Rains	.0342	.4506**	.6015***
	(.1839)	(.1791)	(.1959)
Pests and Diseases	.1996	.5343***	.0237
	(.1930)	(.1971)	(.2126)
Drought	.6738***	.5966***	1.0508***
	(.2094)	(.1903)	(.2080)
Risk attitude			
Risk Aversion	.7495***	.5831***	.3299
	(.2250)	(.2148)	(.2302)
Access to information			
Formal Sources	.8335***	.3953	1.5085***
	(.2853)	(.2531)	(.3010)
Informal sources	.0145	.1998	.0689
	(.2475)	(.2286)	(.2553)
Access to credit			
Formal Sources	.0651	.0281	.0178
	(.0407)	(.0229)	(.0234)
Informal Sources	.1024**	-.0436	.2574***
	(.0455)	(.0360)	(.0592)
Location			
Region 1	.0963	.0853	.2394
	(.2183)	(.2053)	(.2212)
Log Likelihood Value	-481.8339		
Wald Test Chi2(48)	240.61***		
LR Test of ρ_{kj}	14.972***		
Total Number of Observations	330		

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

formal sources of information expand farmers' knowledge on climate variability and consequently encourage the use of risk management tools to suppress the risk at farm. Previous studies also found a positive effect of access to market information (for example Mesfin *et al*., 2011; Rehima *et al*., 2013) and access to extension services (Rehima *et al*., 2013; Deressa *et al*., 2010) on farmers' decisions to adopt diversification. Access to informal credit sources also enable the farmers to use diversification to cope with the negative shocks of weather. Compared to formal credit sources, the informal credit sources are readily and widely available to farmers and used to diversify their income sources by investing the borrowed money elsewhere to smooth their incomes in hard times. The regional dummy indicates that the use of diversification to manage farm risk is more practiced in region 1 compared to region 2.

***Factors effecting adoption of precautionary savings*:** Significant variables in the precautionary savings equation are monthly off farm income of the household, proportion of own land, farmers' perception of all catastrophic risk sources and the risk averse nature of the farmers. Higher monthly off farm income motivates farmers to adopt precautionary savings by investing their income in some liquid and/or semi-liquid assets which can be sold out whenever required. Most of the farmers in the study area rear animals which can be sold to cope with any negative shocks to agriculture enterprise due to natural disasters. Our result for off-farm income is in line with Mishra (2009) who found a positive impact of non-farm income with precautionary savings behavior of farmers. Deressa *et al*. (2010) also found a positive impact of non-farm income on farmers' strategy of selling livestock to cope climate risks. Similarly, farmers' risk perceptions and risk attitude also induce them to invest in some liquid assets that can be used as a buffer stock to stabilize their incomes when their farm incomes are altered by a negative shock. Farmers' attitude towards risk is also an important factor that shapes their decision to adopt precautionary savings as a tool to overcome any negative shock to their farm incomes due to adverse weather conditions.

Farming experience, farm size, access to information sources and access to credit sources are factors which have a positive but insignificant effect on farmers' decisions of adopting precautionary savings as risk management tool. The results suggest that a more experienced farmer will tend to adopt precautionary savings strategy as compared to a less experienced farmer. Large farm size provide large asset base to the farmers and encourage farmers to accumulate liquid assets to cope with fluctuations in their farm incomes resulting from adverse weather conditions. Farmers' access to credit and information sources encourages the use of precautionary savings to manage farm risk and play its role in farmers' risk management decisions, however, their effects are insignificant in our case. Regional dummy indicates that the use of precautionary savings is more common in region 1 compared to region 2.

***Factors effecting adoption of credit*:** Factors significantly effecting the adoption of agricultural credit to manage farm risk are age, farming experience, farm size, farmers' risk perceptions of heavy rains and drought, access to formal information sources and access to informal credit sources. Older and more experienced farmers are more likely to use credit to deal with climate risks at farm compared to their younger and less experienced counterpart. Larger farms may require more capital to rehabilitate its potential after a negative shock strike the farm; therefore, the use of credit as ex-post risk management tool is higher for larger farms compared to small farms. Farmers' perception of risk sources also necessitates their demand for the use of credit to overcome the negative shocks of adverse weather conditions and hence induce the farmers to adopt credit for farm risk management. Access to formal sources of information enlarges the probability to adopt agricultural credit as a risk management tool by farmers. Mainly due to lack of awareness, complicated procedure and interest factors, farmers in the study area are usually reluctant in obtaining institutional credit. Therefore, proper and effective information can expand farmers' knowledge on obtaining credit from formal sources and its use as a risk management tool. Access to credit has a crucial impact on farmers' decisions of managing farm risks. As the results indicate access to both formal and informal credits positively influence farmers' decisions of utilizing agricultural credit to manage farm risk.

The influence of farmers' perception regarding risk of flood and pest and diseases, risk averse nature of the farmers, access to informal information sources and access to formal credit sources is positive but insignificant. These factors also facilitate farmers' decision of adopting credit as a risk management tool. Deressa *et al*. (2010) also found a positive impact of age, farm size, farmers' access to credit, extension services and farmer-to-farmers information sharing on their decisions to adopt various risk coping strategies including borrowing from relatives. The influence of off-farm income was significant in diversification and precautionary savings equations however, its effect is negative in credit equation. One reason can be the adequate financial reserves of the producers that can guide their farm enterprise in hard times and therefore reducing the possibility/incentives of obtaining credit. Higher access to information and credit sources of farmers in region 1 translates into higher adoption of credit compared to region 2.

***Conclusion*:** The main conclusion drawn from the study is that the decisions of adopting risk management tools are indeed correlated and the adoption of one risk management tool induces farmers to adopt other risk management tool(s) at the same time. Furthermore, the risk management tools adoption decisions are influenced by variety of factors including farm and farm household characteristics, farmers' perceptions of production risk sources, their attitude towards risk and their access to information and credit sources. In the analysis of risk management choices, using multivariate approach provides richer interpretations, better inferences, and more information that may further improve understanding of the risk management decisions of farmers. Though the study is limited to only KP province of Pakistan, the findings can be generalized to all developing countries context particularly countries where formal/state owned risk management tools, such as crop insurance, is either absent or inefficient . The results obtained from multivariate probit model will help policy maker to anticipate which type of farmers will adopt government supported risk management tools in the presence of traditional risk management tools. Based on the information from the multivariate probit approach the agricultural extension educators can also improve their programs to guide the farmers in a better way and target farmers who need risk management information the most.

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