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EXPOSURE TO RISK AND RISK MANAGEMENT IN SMALLHOLDER AGRICULTURE

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Abstract

Using a moment based approach, introduced by ANTLE for producers' risk behavior elicitation, we develop an empirical model to evaluate the implication of risk preferences on farm portfolio decisions. With a comprehensive household level panel data of rounds of 2004 and 2009, we estimate risk aversion behavior of farm households in uncertain climate and market imperfections. To solve the problem of endogeneity, the risk parameter is instrumented in a two stage maximum likelihood estimation technique, and used as a determinant of the level of farm level diversification. We find that farmers with higher level of relative risk premium will more likely opt for diversified farms. The engagement of farm households to off and non-farm income generating activities could likely reduce the on-farm diversification level. On-farm diversification and engagement in off-farm and non-farm activities can be considered as substitutable risk mitigation strategies

1 Introduction

There is a growing interest to explore farmers' risk preferences and their implications in decision making (KIM and CHAVAS, 2003, CHAVAS et al., 2010, DERCON and CHRISTIAENSEN, 2011, DE BRAUWA and EOZENOU, 2014), as risk preferences might influence adoption and disadoption of technologies (KIM and CHAVAS, 2003, KOUNDOURI et al., 2006, DERCON and CHRISTIAENSEN, 2011, LIU and HUANG, 2013, WOSSEN et al., 2015) and shape adaptation and mitigation mechanisms (GROOM et al., 2008, LYBBERT and MCPEAK, 2012, MINTEWAB and SARR, 2012, MCINTOSHA et al., 2013). Farmers not only consider the income they generate but also are concerned with the risk associated to it (KIM and CHAVAS, 2003, CHAVAS and DI FALCO, 2012). The role of risk is particularly crucial when it comes to the developing world, where both the individual and public readiness and market mechanisms to mitigate the pervasive effects of occurrence of risk are either lacking or underdeveloped (DI FALCO and CHAVAS, 2009, CHAVAS and DI FALCO, 2012, NIELSEN et al., 2013, KASSIE et al., 2014).

Smallholder farmers in sub-Saharan Africa frequently face climate change related challenges (IPCC, 2007). Ethiopia has experienced a couple major famines in recent decades with disastrous consequences (DERCON, 2004, DI FALCO and CHAVAS, 2009, ALEM et al., 2010). Adding up with the effects of climate change, occurrence of pests and shocks related to price volatility also cause difficulties in smallholder agriculture (YESUF and BLUFFSTONE, 2009, MINTEWAB and SARR, 2012). In countries like Ethiopia where the market and other institutional mechanisms to adapt after shock are underdeveloped, farmers could opt for ex-ante production risk management strategies (DI FALCO and CHAVAS, 2009, MINTEWAB and SARR, 2012) and informal risk mitigation schemes (DI FALCO and BULTE, 2013). Farmers facing frequent shocks could consider sub-optimal land rental deals as distress response (TEGEGNE and HOLDEN, 2011) or cost reducing production choices (ALEM et al., 2010). Farmers' decisions might sometimes seem sub-optimal; nonetheless, their choices could be justified when risk comes in to consideration (YESUF and BLUFFSTONE, 2009).

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On-farm diversification is one of the frequently noted risk mitigation strategies in development economics literatures (HARDAKER et al., 2004). However, empirical evidences analyzing the causal relationships between risk preferences and farmers adaptation response are scarce (DI FALCO and CHAVAS, 2009, MINTEWAB and SARR, 2012, LIVINGSTON and MISHRA, 2013) and the existing evidences share significant shortcomings (ALEM et al., 2010, FINGER and SAUER, 2014). The existing literatures limited to specific decision aspects and didn't consider shifts in the overall farm plan (FINGER and SAUER, 2014). They also often overlook the intertwining relationship between physical, economic and social elements (DI FALCO and BULTE, 2013, FINGER and SAUER, 2014). This paper will contribute to the existing empirical literature and policy on economic development by extending the analysis of risk aversion behavior using profit moments with ex-ante risk management strategies. For this purpose, we implement a framework that integrates farmers' risk aversion behavior with risk mitigation strategies.

2 Theoretical Framework

Following a number of theoretical developments (ANTLE, 1983, ANTLE, 1987) and empirical works (GROOM et al., 2008, DI FALCO and CHAVAS, 2009, ZUO et al., 2014), we develop an empirical model to explore the role of risk aversion behavior of the decision maker on the choice of the farm portfolio. Starting with a simple farm expected utility maximization model, the farm allocation decision can be represented as:

$$EU(\pi) = \mathrm{D}(L, X) \tag{1}$$

Where D is the level of on-farm diversification of the household given a certain amount of land (L) and the vector of other inputs (X). A risk averse individual is willing to pay a certain amount of implicit cost farmers are willing to pay to eliminate risk – called risk premium (ARROW, 1965, PRATT, 1964). Developing on equation (1), the expected value of the profit function with the consideration of cost of private risk bearing could be specified as:

$$EU(\pi) = U[E(\pi) - RP] \tag{2}$$

Where the right hand side of the equation is the certainty equivalent of profit (Pratt, 1964), and RP is the risk premium. From this equation, it is possible to see that certainty equivalent is a function of the mean value of profit and the level of risk premium. This can be also considered as the willingness to pay of the household for insurance for a secured level of income (PRATT, 1964, KIM and CHAVAS, 2003). As it can be seen from equation (2), maximizing the expected utility is similar to maximizing the certainty equivalent of the farm (KIM and CHAVAS, 2003, CHAVAS, 2004, FINGER and SAUER, 2014). We follow a moment based approach by ANTLE (ANTLE, 1987), to develop an empirical model in a smallholder farm context. With the principal assumption that farmers' behavior is consistent with expected utility theory, a farm expected utility maximization model can be developed. Hence, the expected utility of a risk averse farmer's profit π can be estimated as:

$$\max_X U(\pi) = \max_X \int U[pf(X, \varepsilon) - w'X]dg(\varepsilon) \tag{3}$$

Where $U(.)$ is the von Newmann-Morgenstern utility function, P is vector of prices of the agricultural commodities in the farm portfolio, $f(.)$ is a continuous production function, X is the vector of input variables, w is the respective cost of inputs and $g(.)$ is the distribution of the higher moments. From this model, one can see that output, price and input cost and the transformation functions are random. This is quite common in smallholder agriculture, where the institutional capacity to stabilize such shocks is not well developed, and can be captured by the error term (ε) and its distribution $g(.)$. Maximizing the profit function with respect to any input in equation (3) is then equivalent to maximizing the moments of the profit distribu-

tion (ANTLE, 1987, GROOM et al., 2008, DI FALCO and CHAVAS, 2009). With this principle, the optimization problem is reduced to:

$$EU = U[\mu_1(\dots), \mu_2(\dots), \dots, \mu_m(\dots)] = U[\mu^m] \tag{4}$$

The income distribution of each farmer can be specified by the mean ($\mu_1(\dots)$), variance ($\mu_2(\dots)$), skewness ($\mu_3(\dots)$) and other higher level moments of the function. We follow the moment based approach introduced by ANTLE (ANTLE, 1983, ANTLE, 1987) to estimate the risk attitudes of farmers based on the population distribution. This is based on the assumption that a population with a specific choice on the input mix is equivalent to a farmer with N choices of inputs. The FOC of equation (4) can give us:

$$\sum_{i=1}^{m}\left(\frac{\partial U[\mu^m]}{\partial \mu_i}\frac{\partial \mu_i}{\partial x_k}\right) = 0 \tag{5}$$

With some mathematics and rearrangement of terms and with TAYLOR expansion (TAYLOR, 1984), the FOC can be approximated to[2]:

$$\frac{\partial \mu_1(X)}{\partial X_k} = \theta_{1k} + \theta_{2k}\frac{\partial \mu_2(X)}{\partial X_k} + \theta_{3k}\frac{\partial \mu_3(X)}{\partial X_k} + \cdots\ \theta_{mk}\frac{\partial \mu_m(X)}{\partial X_k} + u_k \tag{6}$$

Where $\theta_{jk} = \frac{-1}{j!}\left(\frac{\partial F(X)/\partial \mu_2(X)}{\partial F(X)/\partial \mu_1(X)}\right)$, θ_{jk} represents the jth average population risk related to the input, K=1,2….K the inputs used in agricultural production and m is the unknown parameters for each input. It is important here to note that this mathematics is in line with the theory stating that the mean profit distribution is a function of all the higher level moments of profit distribution. Nonetheless, empirical works agree to restrict to the second and third level moments (GROOM et al., 2008). Using the definition by PRATT (PRATT, 1964) and KIMBALL (KIMBALL, 1990), parameters in equation (6), θ_{2k} and θ_{3k}, can be translated to the Arrow-Pratt absolute risk aversion (AP) and downside risk aversion (DS) respectively.

$$AP = -\frac{\partial F(X)/\partial \mu_2(X)}{\partial F(X)/\partial \mu_1(X)} = 2\theta_2 \tag{7}$$

$$DS = \frac{\partial F(X)/\partial \mu_3(X)}{\partial F(X)/\partial \mu_1(X)} = -6\theta_3 \tag{8}$$

A positive AP (*AP>0*) indicates risk averse decision maker. This in other words mean the farmer is willing to pay a positive amount of money to reduce the variability of the profit. If DS is positive (*DS>0*), the average farmer is averse to low income levels. The farmer is willing to implement strategies that can avoid low levels of returns (e.g. crop failure with climate variability) (MENEZES et al., 1908, DI FALCO and CHAVAS, 2009, FINGER and SAUER, 2014). AP and DS can then be used to estimate the risk premium (RP) - the positive amount of money that farmers are willing to pay to get rid of risk.

[2] The detail mathematics can be seen from Vollenweider et al (2011)

$$RP = \frac{1}{2}\mu_{2k}AP - \frac{1}{6}\mu_{3k}DS \quad (9)$$

Where μ_2 and μ_3 are the second and third order moments of the profit distribution. The risk premium is estimated per input level k and per observation, and this further used to estimate the relative risk premium of the household. It is important to note that there is no a priory assumption on the risk premium per household, and it is possible that this estimate could vary over time. The relative risk premium is then calculated as the ratio of the risk premium to the income level of the household.

$$RRP = \left(\frac{1}{2}\mu_{2k}AP - \frac{1}{6}\mu_{3k}DS\right) \Big/ Y \quad (10)$$

The relative risk premium (RRP) is used as a proxy for indicator of the risk aversion of individual farmers (FRANKLIN et al., 2006, VOLLENWEIDER et al., 2011). Controlling for other demographic, socio-economic, physical, locational and institutional variables, this estimate is used to analyze the implication of the risk attitude of farmers on their decision making related to farm portfolio.

3 Data and Econometrics

We use the Ethiopian Rural Household Survey panel data collected by the International Food Policy Research Institute (IFPRI) in collaboration with the Center for the Study of African Economies (University of Oxford) and Economics department of Addis Ababa University. It is a rich panel dataset from smallholder farmers in 4 major regions in Ethiopia. The dataset consists of information related to household demographics and socio-economic characteristics, agricultural activities, production, consumption, marketing and many more. We use the recent rounds of the dataset (2004 and 2009) for the analysis. We reject some observations with missing information with respect to the most important variables for the analysis. This dataset lacks rainfall measures in absolute terms; nonetheless, a subjective judgement of households on the adequacy of rainfall on the onset and entire growing season is available. We use these two variables, measured with scales on the level of rain, for our estimation. Summary statistics of the sample for the year 2004 and 2009 are presented in table 1.

Table 1: Descriptive statistics

Variable	Mean	Std. Deviation
Gross margin per hectare	19840.01	40244.89
Seed per hectare	1047.31	3252.25
Family labor per hectare	101.53	258.89
Other inputs per hectare	261.31	607.58
Age	51.52	14.86
Education	1.56	2.69
Landholding	1.97	1.87
Number of plots	5.47	3.186
Slope index of agricultural land	1.307	0.548
Soil fertility index	1.618	0.742
Off/non-farm income	399.14	1152.99
Concentration (Ogive) index	2.34	1.13

The analysis has two major steps. The first one is estimation of risk parameters using the three moments of profit distribution - the mean, variance and skewness. In the second stage, we use the risk parameter estimates along with other control variables to estimate the on-farm diversification models.

3.1 Estimation of moments

Starting from a simple household model, as ANTLE (ANTLE, 1987) employed, the gross margin from the production activities can be represented by:

$$y_{it} = f(X_{it}; \beta) + u_{it} \tag{11}$$

Where y_{it} represents the aggregated gross margin per hectare from farm production using vector of farm inputs, X. Seed cost, family labor and other intermediate inputs[3] are used aggregated per hectare of land (GROOM et al., 2008, FINGER and SAUER, 2014). Following previous empirical works, for example (GROOM et al., 2008, VOLLENWEIDER et al., 2011), all the variables are rescaled with their standard deviations. The results of the overall procedure are influenced by the choice of the functional form (ANTLE, 1983, KUMBHAKAR and TVETERAS, 2003, VOLLENWEIDER et al., 2011). We employ a quadratic specification, which is commonly used in empirical papers (ANTLE, 1983, GROOM et al., 2008, VOLLENWEIDER et al., 2011, ZUO et al., 2014).

The basic premises in the moment based approach is to capture the risk attitude of the household in the residual of the estimation (u_{it}), which is assumed to have a zero mean and variance (δ^2). The residuals of equation (11) then used to estimate the second (variance) and third (skewness) order moments of profit distribution. The square and cube of the residuals are regressed with the same explanatory variables included in the first moment estimation.

$$\hat{u}_{it^2} = g(X_{it}; \alpha) + \breve{u}_{it} \tag{12}$$

$$\hat{u}_{it^3} = h(X_{it}; \gamma) + \tilde{u}_{it} \tag{13}$$

We use fixed effect model for the estimation of the first, second and third order moments of profit distribution. These estimated coefficients ($\widehat{\beta}$, $\hat{\alpha}$, and $\hat{\gamma}$) will then be used to compute the marginal contribution of each input are computed. By recalling equation (6), we finally regress the derivatives of variance and skewness functions over of the derivative of the expected profit function with a 3SLS method. We use the region dummy, livestock holding and access to credit as instruments in the estimation procedure. Consequently, we compute the Arrow-Pratt (AP) absolute risk aversion and downside (DS) risk aversion estimates.

3.2 On-farm diversification and participation in off-farm activities

Following on previous empirical endogenous technology adoption models under risk (KIM and CHAVAS, 2003, MINTEWAB and SARR, 2012, FINGER and SAUER, 2014, ZUO et al., 2014), we develop a model for the on-farm diversification decision of the farm household given a wide variety of constraints.

$$E(D_{it}) = f\left(\alpha X_{it} + \beta R_{it} + \delta L_{it} + \gamma O_{it} + \tau R_{i(t-1)} + \sigma Y_{i(t-1)} + \rho D_{i(t-1)}\right)$$
(13)

Diversification of a household at a given time is expressed as a function of household specific demographic and socio-economic variables (X_{it}), the predicted value of risk aversion indicator from the first stage (R_{it}), land quality, fragmentation and location related factors (L_{it}) and other institutional and organization related factors (O_{it}). We also include the lagged estimate of risk aversion behavior, income of the household and diversification index as explanatory variables in the diversification function. In the literature of diversification, variety of approaches have been employed to measure the diversification level of farm households (BENIN et al., 2003, MINTEWAB and SARR, 2012, FINGER and SAUER, 2014). MINTWAB and SARR (2012) and FINGER and SAUER (2014) for instance, used count index - the number of crops or

[3] Intermediate inputs include fertilizer, pesticides and hired labor

activities that the farmer engaged in - as a measure of diversity index. We use Ogive index to measure the level of diversification in the household farm portfolio as this approach captures intensity of diversification in contrast to count index. (ALI et al., 1991) used it to measure the export diversification level of the country and (COELLI and FLEMING, 2004) for measuring on farm diversification.

$$Ogive = \sum_{n=1}^{N} \frac{\left(x_n - \left(1/N\right)\right)^2}{1/N} \tag{14}$$

Where N is the total production activities and X_n is the share of the total land allocated for the production activities (cereal crops, pulse crops, horticultural crops, tree and grass production). This index measures the deviation of the overall farm plan from equal allocation of the farmland among these different production activities. A value approaches to zero indicates perfect diversification of production activities by the household (on cereal, pulse crops, horticulture crops, tree and plantations and livestock production). A value approaches to four indicates specialization in one of the farm production activities. Diversification index is censored from both directions (ranges from zero for perfectly diversified farms to four for farms engaged in only one activity), and the Tobit model could be applied for equation (13). Land fragmentation in smallholder agriculture might influence the farm diversification level in the household. Count index (BENIN et al., 2003) and Simpson index (BLAREL et al., 1992, SAUER et al., 2012) are the two commonly used approaches for the measurement of land fragmentation. We use Simpson Index (SI) which gives an advantage over the count index, by capturing the evenness of land fragmentation in the household.

$$SI = 1 - \sum_{1}^{i} \frac{A_i^2}{A^2} \tag{15}$$

A_i is the total area of the ith plot and A is the total landholding of the farm household. SI is censored between 0 and 1 where 0 indicates the household produces all the farm outputs on one plot of land while 1 indicates higher level of land fragmentation.

One of the econometric challenges in the estimation of this diversification model is the problem of endogeneity. One could expect simultaneity between the profit moments and farm management decisions (in this case, diversification) (ZUO et al., 2014). In order to control for the potential endogeneity problem, we use a two stage least squares estimation technique (NEWEY, 1987). The predicted value of the risk parameter, which is assumed exogenous, will be used as an explanatory variable in the diversification model.

4 Result and Discussions

4.1 Estimation of risk parameters

We estimate the profit function with the quadratic specification, which is more flexible and commonly employed in empirical literatures (GROOM et al., 2008, VOLLENWEIDER et al., 2011, FAUDI and ERDLENBRUCH, 2012, KIM et al., 2014). We also check the Feasible Generalized Least Squares (FGLS) estimation and the result is similar to the one estimated with the fixed effect procedure. The Hauseman specification test (WOOLDRIDGE, 2010) rejected the null hypothesis of no systematic difference between random and fixed effect models. Accordingly, we use the fixed effects estimator for the profit moments estimation.

Table 2: Fixed effect estimates of first, second and third moments

Variables	Gross margin		$\hat{u}_{it^2}$		$\hat{u}_{it^3}$	
	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err
Seed	-0.391***	0.070	-1.330***	0.389	-8.163***	2.979
Family labor	0.158***	0.054	0.739***	0.301	5.783**	2.299
Other inputs	0.264***	0.064	0.864***	0.351	6.045**	2.689
Seedsq.	0.053***	0.010	0.173***	0.057	0.944**	0.440
laborsq	-0.021***	0.004	-0.061***	0.023	-0.557***	0.177
Otherinpsq.	-0.007	0.006	-0.066*	0.037	-0.614**	0.287
Seed*labor	0.029***	0.008	-0.031	0.045	-0.121	0.345
Seed*other	-0.051***	0.012	-0.064	0.069	-0.233	0.535
Labor*other	0.245***	0.007	0.074*	0.041	0.764**	0.312
Year dummy	0.297***	0.045	1.169***	0.251	7.398***	1.921
Const.	0.178***	0.028	0.355**	0.157	1.011	1.199
Hauseman test (Chi2)	147.66 ***		133.02***		101.90***	
N of households =2724	* if p < 0.10, ** if p < 0.05, *** if p < 0.01					

We save the marginal effects of each input for each individual observation from the above estimation and use them to estimate the first order condition. We estimate the first order condition using three stage least squares (3SLS) procedure. We also checked the results of the Seemingly Unrelated Regression approach for the first order condition for consistency reasons and the result remains the same. The Wald test of parameters equality was employed for the three estimations and rejected the null hypothesis of parameters equality between inputs. Except for the family labor, farmers show risk aversion behavior with respect to the other two inputs used in the production process. They exhibit risk averse behavior in terms of both absolute risk aversion (variability of returns) and downside risk aversion (e.g. risks related to crop failure, bad harvest or price fall). The negative values in the AD and DS in labor indicates that farmers seem risk loving with respect to family labor. Given the low level of opportunity cost they experience in family labor, farmers would likely choose to employ the available labor though remained risky. We have found an average sample relative risk premium of 18.27%[4], with the overall picture in line with previous studies. The rough estimate for the willingness to pay of farmers in order to avoid risk is 3864 *Birr*. GROOM et al. (2008) in Cyprus have found the RRP ranging from 6% to 20% with respect to different inputs. They indicated that the RRP is different among producers of different types of crops.

Table 3: Risk parameters

Inputs	Seed		Family labor		Other inputs	
	Coeff.	Std. err	Coeff.	Std. err	Coeff.	Std. err
Constant	0.008	0.005	0.125***	0.002	-0.023***	0.002
θ_2	0.685***	0.024	-1.263***	0.016	0.849***	0.008
θ_3	-0.063***	0.004	0.167***	0.002	-0.074***	0.000
AP	1.37		-2.52		1.69	
DS	0.38		-1.00		0.44	
RRP	25.7%		12.2%		16.9%	
Chi2 test of parameters equality	23533.49		24740.17		12493.40	
	p> x^2=0.0000		p> x^2=0.0000		p> x^2=0.0000	

N of households= 2688 * p < 0.10, ** p < 0.05, *** p < 0.01

Estimation: 3SLS with region dummy, access to credit and livestock ownership in TLU as instruments

[4] When calculating the sample relative risk premium, the observations with negative RRP has been neglected since they are not in line with the assumptions of risk aversion and risk neutrality (for further information, see Groom et al, 2008).

4.2 Role of risk behavior on farm portfolio

The overall model adequacy of the two-step Tobit model with endogenous regressors is good. The Wald test rejects the null hypothesis of no endogeneity in the estimation using predicted value of risk aversion behavior. Hence, our use of the two stage least squares estimation technique for this empirical estimation is justified. The results of the model are illustrated in the table below, and afterwards, we will turn to explain the results of the on-farm diversification function.

Table 4: Estimation results for concentration index

Variables	Coeff.	Std. err	T
Age	-0.001	0.003	-0.33
Education level	-0.032*	0.017	-1.79
Landholding	0.006	0.029	0.22
Number of plots	0.001	0.018	0.06
Slope index of agricultural land	0.119	0.083	1.43
Soil fertility index	-0.057	0.066	-0.86
Off/non-farm income	0.005*	0.003	1.67
Access to credit	-0.206**	0.095	-2.16
Concentration index lagged (t-1)	0.260***	0.039	6.63
Relative Risk Premium (RRP)	-0.799**	0.398	-2.01
Relative Risk Premium lagged (t-1)	-0.014	0.024	-0.58
Regional dummy_Amhara	0.434**	0.204	2.13
- Oromiya	1.166***	0.244	4.77
- South	-0.311*	0.182	-1.70
Constant	1.806***	0.328	5.50
Number of observations	949		
Model: Two-step Tobit model with endogenous regressors[5]			
Model adequacy: Log likelih.=-2765.06 Wald-chi2 (14)=173.9 prob>chi2=0.0000			
Wald test of exogeneity chi2 = 5.12 Prob > chi2 = 0.0237			

The diversification level of farms is different across different regions of the country. We could find variations in the physical, agro-ecological and biodiversity, socio-economic and institutional conditions across different regions in Ethiopia (BENIN et al., 2003, DERCON, 2004). The education level of the household is positively associated with the diversification level of farm households. This is in line with the previous empirical finding by MINTWAB and SARR (2012). BENIN et al. (2003) on the other hand indicated that the education level of the household head only influences the number of crop varieties that the household grows. The level of education of the household head might also improve the possibility of being hired, especially when it comes to skilled employment. This on the one hand reduce the dependency of the household on the farm and can be seen as a risk mitigation mechanism. On the other hand, these additional demand for labor for non-farm employment might discourage the interest of further on-farm diversification. In a way or the other, it is apparent that farmers' level of education corresponds with human capital and educated farm households might easily adjust their farm as compared to the illiterate counterparts.

As the level of land fragmentation rises, the level of on-farm diversification increases. Suitability of those plots[6] for different production activities is among the crucial criterion farmers usually employ in land allocation decisions. Our result is in line with previous empirical works in Ethiopia and abroad (BENIN et al., 2003, DI FALCO et al., 2010). (DI FALCO et al., 2010) found out that land fragmentation contributes to diversity, while reducing the profitability of farms. This could be due to the increased cost of routine farm management, supervision

[5] We use livestock ownership, frequency of extension contact and income of the previous period as instruments

[6] As we include fertility and slope index of the plots in the estimation procedure, it is vital to note that the influence from land fragmentation is not related to these variables.

or transportation with the level of fragmentation. On the other hand, such costs can be offset by the gain from temporal allocation of labor and other production inputs. Access to credit influences the level of on-farm diversification of the household. As investment after severe shocks might be challenging for smallholder farmers, credit has special relevance in risk management. Credit improves resilience and can be used as a buffer against shocks. For instance, there are empirical findings on the role of credit for the purchase of fertilizer (MCINTOSHA et al., 2013), insurance policy (HILL et al., 2013) or for consumption. The informal credit service from social networks is frequently viewed as an option for consumption smoothing in case of unforeseen event (DERCON and KRISHNAN, 2000). BARRETT et al. (2001) underlined the multi-directional influence of credit markets on the level of diversification. Lack of access to credit, for instance, might help farmers to diversify their production activities, so as to improve their liquidity condition. Despite pervasive experiences of production shocks and adverse conditions, missing credit markets may also hinder farmers from moving towards diversification. In smallholder agriculture, the thin and less developed credit market coupled with other market imperfections including the product market, impede flexibility in farm management.

The level of diversification of the farm households is positively related to their past experience in diversification. FINGER and SAUER (2014) have got similar findings in their work using a UK farm level panel dataset. This is partly due to the irreversibility (or costly reversibility) of some investments at least in a short run or the time lag that some adjustments require (SONG et al., 2011). It is more complicated, for example, to change land with perennial crops and trees (like eucalyptus or chat) to other arable land use systems. As SONG et al. (2011) underscore, farmers seem reluctant to change the existing production pattern; since they otherwise, have to deal with higher level of uncertainties. MINTWAB and SARR (2012) also found out that past rainfall trends play an important role on the level of crop diversification. Such experience based judgements are particularly crucial in a developing country and smallholder context, where institutional mechanisms are inefficient in supporting the sector.

We verified the research hypothesis, and relative risk premium is positively associated with on-farm diversification. The lagged relative risk premium has got the expected sign, though statistically insignificant. Given the long lag between the two time frames of the panel dataset, the result could be fairly acceptable. This result is in line with both the theory in applied economics and empirical works. MINTWAB and SARR (2012) have found similar result using the application of experimental risk elicitation technique for risk aversion. FINGER and SAUER (2014) have got an evidence on the association of lagged flood occurrence and the level of diversification. BARRETT et al. (2001) stress the role of diversification as an ex-ante risk management tool in smallholder agriculture. Risk aversion behavior of farmers is shaped by their experience (for example, rainfall scenario, pest infestation, market conditions etc.), expectations and projections of weather and price developments and subjective judgements. It is vital to note that on-farm diversification is one of the ex-ante production risk mitigation mechanisms in smallholder agriculture. Off-farm and non-farm income is negatively associated with the on-farm diversification level of the household. This is in line with previous empirical findings on the trade-off between on-farm diversification and off-farm income (WOLDEHANA et al., 2000, SERRA et al., 2005, FINGER and SAUER, 2014). FINGER and SAUER (2014) for example, argue that farmers might choose either to diversify their farm or look for off-farm investment options as a response to occurrence of extreme events. Farmers might use the income from off-farm activities to invest in a more specialized farm with higher expected profit. The liquidity condition of the farm improves with the engagement of the household in off-farm activities, which otherwise might be limiting in the farm decision making process (BARRETT et al., 2001). Farms may stay specialized though risky, as far as the off-farm activities provide adequate buffer against extreme events. Farmers might also consider off-farm income, for instance from wage employment, as post shock adaptation mechanisms. The choice of risk

mitigation mechanism is determined by comparative contribution of on-farm diversification or engagement in off-farm activities to risk reduction.

5 Conclusion and Policy Implications

We use the panel data of households in Ethiopia to develop an empirical model to analyze the implication of farmers risk behavior on their farm decision making. This work adds up to the existing literature with the application of a more extensive in terms of exploiting the household, farm and regional level information and robust approach in its econometric specification. We try to capture on-farm diversification decision of the households using a more recent and robust risk elicitation econometric approaches from profit moments. In addition, we make use of panel data which allows us to capture both the within and between variation in the estimation of risk premium.

We estimate the relative risk premium (18.27%) which is in line with most of the previous findings. The sample average willingness to pay for risk aversion is estimates around 3864 *Birr*. This can be translated as a rough estimate of farmer's willingness to pay for risk (such as income variability, crop failure, price fall, forward contracts and future markets etc.). There are some initiations from the government and some organizations towards index based insurance schemes in the country. There is also an interest to initiate future markets integrated with the commodity exchange in Ethiopia. This finding could helpful to develop strategies and policies to implement such insurance schemes and integrate smallholder farmers to the future markets in the country.

Household head's education level, and access to credit influence the level of on-farm diversification. Risk behavior is positively associated to on-farm diversification and farmers with a higher level of relative risk premium are more likely to opt for diversification of farms. The engagement of farm households to off and non-farm income generating activities could reduce the incentive to diversify in the farm level. The income generated could improve the liquidity condition of the farm and such farms might choose specialized commercial orientation. These could be due to the fact that households with extra income from off and non-farm activities use this income as a safety net and go for concentrated farms. Hence, from the risk perspective, there two can be considered as substitutable risk mitigation strategies. It is important to note that, agricultural risk management goes beyond farm level resource allocation, and rural development policies and strategies will benefit from integration of farm and non-farm contexts. Analysis of the interrelation between different ex-ante and ex-post risk mitigation and adaptation mechanisms might be interesting for future research.

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