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# **On Smallholder Farmers' Exposure to Risk and Adaptation Mechanisms: Panel Data Evidence from Ethiopia**

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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 level diversification. For the purpose, we use a household level panel data of years 2004 and 2009 from Ethiopia. The estimation is done in two stages; the first one for the elicitation of risk aversion behavior of farm households and the second one, for the inclusion of the first estimate on the factors that determine the level of on-farm diversification. To control for endogeneity problem in the estimation of diversification equation, we use efficient two stage least squares technique. We find that farmers with higher level of relative risk premium will more likely opt for more on-farm diversification. The engagement of farm households to off and non-farm income generating activities could likely reduce the on-farm diversification level. These could be due to the fact that households with income from off and non-farm activities use this income as a safety net and go for specialized farms.

Keywords: Ethiopia, risk aversion, risk management, smallholder,

## **1. Introduction**

There is a growing interest to understand farmers' risk preferences and their implications (Kim and Chavas, 2003, Chavas et al., 2010, Sauer, 2011) . Risk preference might influence adoption of technologies, participation in different enterprises, choice of adaptation mechanisms and the overall societal wellbeing (Groom et al., 2008, Di Falco and Chavas, 2009, Mintewab and Sarr, 2012, Bozzola, 2014). Farmers not only consider the income they generate but also are concerned with the risk associated to it (Kim and Chavas, 2003) to it (Orea and Wall, 2012). The role of risk is particularly crucial when it comes to the developing world, where both the individual and public readiness to mitigate the pervasive effects of occurrence of risk are lacking and underdeveloped (Hailemariam and Köhlin, 2011, Mintewab and Sarr, 2012, Nielsen et al., 2013).

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).

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 inter-twining relationship between physical, economic and social elements (Di Falco and Bulte, 2013, Finger and Sauer, 2014). This paper will fill the gap by making use of household level panel data and recent approaches to elicit famers risk preferences and analyze the implication on farm decision making.

## 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 have developed an empirical model to explore the role of risk aversion behavior of the decision maker on the choice of the farm portfolio. The general premises of this paper is that smallholder farmers in general are risk averse and will decide their farm production plan in order to mitigate risk. The major sources of risk in smallholder farming are attributed to production (e.g. climate change and pests), institutional and market (demand and price shocks) (Hardaker et al., 2004, Di Falco and Chavas, 2009, Mintewab and Sarr, 2012).

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:

$$EU(\pi) = U[E(\pi) - RP] \quad (1)$$

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.

$$CE = E(\pi) - RP \quad (2)$$

The risk premium of the household measures the positive amount of money that he/she is willing to pay to secure a certain amount of income. 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).

The basic framework of the paper will be an optimization problem of the farm household, whether to diversify or specialize, given the physical, socio-economic and institutional constraints. A farm household will choose a certain level of input combinations and decide on the farm plan that maximizes the certainty equivalent from the production portfolio. The basic presumption is the land allocation decision of the household is influenced by the risk aversion behavior of the decision making agent. Hence in this paper, we first develop an empirical model to find the risk attitude of the household, and hence to analyze the implication of risk on farm decision making.

We have followed a moment based approach by Antle (Antle, 1987), to develop an empirical model in a smallholder farm context. Our aim is to formulate a model that represents the farm resource allocation decision making with respect to the available resources and risk as an inherent element in the farm plan. 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  $\pi$  can be estimated as:

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

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 the function of output price, the 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  $(\varepsilon)$  and its distribution  $g(.)$ .

Using the flexible estimation approach, which only requires limited information related to price, profit and input quantities, we can estimate the farmer's optimization problem. Maximizing the profit function with respect to any input in equation (3) is then equivalent to maximizing the moments of the profit distribution (Antle, 1987, Groom et al., 2008, Di Falco and Chavas, 2009). With this principle, the optimization problem is reduced to:

$$EU = U[\mu_1(...), \mu_2(...), \dots, \mu_m(...)] = U[\mu^m] \quad (4)$$

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:

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

With some mathematics and rearrangement of terms and with Taylor expansion (Taylor, 1984), the FOC can be approximated to<sup>1</sup>:

$$\frac{\partial \mu_1(X)}{\partial x_k} = \theta_{1k} + \theta_{2k} \frac{\partial \mu_2(X)}{\partial x_k} + \theta_{3k} \frac{\partial \mu_3(X)}{\partial x_k} + \dots \theta_{mk} \frac{\partial \mu_m(X)}{\partial x_k} + u_k \quad (6)$$

Where  $\theta_{jk} = \frac{-1}{j!} \left( \frac{\partial F(X)}{\partial F(X)} \frac{\partial \mu_j(X)}{\partial \mu_1(X)} \right)$ ,  $\theta_{jk}$  represents the jth average population risk related to the input,  $K=1,2,\dots,K$  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. This is due to the fact that other higher level moments can face collinearity with the already exploited moments and challenges related to interpretation of other higher level moments (Groom et al., 2008). Our analytical expression will then be analyzing the marginal contribution of each input to the expected profit as a function of the second and third order moments of the profit distribution.

Using the definition by Pratt (Pratt, 1964) and Kimball (Kimball, 1990), parameters in equation (6),  $\theta_{2k}$  and  $\theta_{3k}$ , can be translated to the Arrow-Pratt absolute risk aversion (AP) and downside risk aversion (DS) respectively.

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

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<sup>1</sup> The detail mathematics can be seen from Vollenweider et al (2011)

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

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.

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

Where  $\mu_2$  and  $\mu_3$  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 priori 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.

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

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 Empirical Model

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 collected from smallholder famers in 4 major regions in Ethiopia. The dataset is rich that consists information related to household demographic and socio-economic characteristics, agricultural activities, production, consumption, marketing and many more. We use the more

recent data from 2004 and 2009 rounds for the analysis. We reject some observations with missing information with respect to the most important variables for the analysis. The 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 is done with 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:

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

Where  $y_{it}$  represents the aggregated gross margin per hectare from farm production using vector of farm inputs,  $X$ . We have used three major inputs in smallholder agricultural

production. Seed cost, family labor and other intermediate inputs<sup>2</sup> are 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.

One crucial step in the estimation procedure is to decide the functional form for the profit function. 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 have employed a quadratic specification, which is commonly used in empirical papers (Antle, 1983, Groom et al., 2008, Vollenweider et al., 2011, Zuo et al., 2014). Hence, the input levels, their interaction terms and the square of the input levels are used as explanatory variables in this function.

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 ( $\delta^2$ ). 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 (inputs, input squares and the interaction terms) included in the first moment (mean) estimation. Fixed effect model was used for the estimation of the first, second and third order moments of profit distribution.

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

And

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

These estimated coefficients ( $\hat{\beta}$ ,  $\hat{\alpha}$ , 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. The region dummy, livestock holding and access to credit are assumed exogenous to the risk attitude, while are correlated with the input use of farmers. Hence, they can be used as instruments in the estimation procedure.

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<sup>2</sup> Intermediate inputs include fertilizer, pesticides and hired labor

Arrow-Pratt (AP) absolute risk aversion and downside (DS) risk aversion estimates can be computed from this estimation (equation 7 and 8). In the estimation procedure, we didn't employ a constraint to keep the relative risk premium to be positive. However, like Groom et al (Groom et al., 2008), those observations that are not following the assumption of risk neutrality and risk aversion are neglected when calculating the average relative risk premium for the population.

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

The second stage of the analysis estimates the implication of risk on smallholder farmer's on-farm diversification and participation of off-farm activities. The basic hypothesis is that farmers' decision to allocate their scarce resources is influenced by their risk perception and experience. This has got special importance in Ethiopia where both production and market related risks play a significant role (Dercon, 2004, Di Falco and Chavas, 2009, Mintewab and Sarr, 2012). Household level adaptation mechanisms are crucial in these countries where the institutional support mechanisms to mitigate risk are not well developed (Yesuf and Bluffstone, 2009, Hailemariam and Köhlin, 2011).

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 adoption of on-farm diversification. In the literature of diversification, variety of approaches have been employed to measure the diversification level of farm households (Mintewab and Sarr, 2012, Finger and Sauer, 2014). We use Ogive index to measure the level of diversification in the household farm portfolio. This approach was used to measure the export diversification level by Ali et al (Ali et al., 1991) and on farm diversification by Coelli and Fleming (Coelli and Fleming, 2004). The Ogive index is preferred from the count index since it considers intensity of diversification of the production activities.

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

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 deviation of the overall farm plan from equivalent allocation of land among production activities.

Diversification of a household (measured by the ogive index) at a given time is given as a function of household specific 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 ( $O_{it}$ ).

$$E(D_{it}) = f(\alpha X_{it} + \beta R_{it} + \delta L_{it} + \gamma O_{it}) \quad (15)$$

Land fragmentation might influence the diversification level in the household. Simpson Index (SI) (Blarel et al., 1992) is one of the extensively used approaches to measure farm fragmentation.

$$SI = 1 - \sum_1^i \frac{A_i^2}{A^2} \quad (16)$$

$A_i$  is the total area of the  $i^{\text{th}}$  plot and  $A$  is the total landholding of the farm household. SI is censored between 0 and 1 where 0 indicates the land of household is concentrated in cone area while 1 indicates higher level of fragmentation.

The diversification index is censored from both directions (ranges from 0 for perfectly diversified farms to 4 for farms engaged in only one activity), and the Tobit model could be applied for equation (14). A value approaches to zero indicates diversification of production activities by the household while a value approaches to 4 indicates concentration of the production activities.

The most important question to answer here is whether such a specification is robust to endogeneity problem (Greene, 2002, Wooldridge, 2010). Such a problem might happen due to the possibility of presence of unobservable factors that might influence farm portfolio decisions (Kim et al., 2014). There could also be potential endogeneity bias due to the simultaneity between the profit moments used for estimation of risk attitude and the diversification index (Zuo et al., 2014). The existence of such a problem could lead to inconsistent parameter estimates, and any inference based on those parameters could be misleading (Greene, 2002, Wooldridge, 2010).

In such a case, use of robust econometric procedures (for example, instrumental variable technique) is recommended (Greene, 2002, Koundouri et al., 2006, Kim et al., 2014). In order to control for endogeneity problem, we use two stage least squares estimation technique (Newey, 1987). This approach utilizes the estimated value of an endogenous variable as an

instrumental variable in two stage procedure (Greene, 2002, Wooldridge, 2010). In the first stage, we regress the risk parameter with some explanatory variables<sup>3</sup> which we assume to influence the risk behavior of farm households. The estimated value of the risk parameter, which is assumed exogenous, then will be used as explanatory variable in the diversification model.

After the consideration of the instrumental variable, the two stage least square estimation looks like:

$$\left. \begin{aligned} E(D_{it}) &= f(\alpha X_{it} + \beta \widehat{R}_{it} + \delta L_{it} + \gamma O_{it} + \tau R_{i(t-1)} + \sigma Y_{i(t-1)} + \rho D_{i(t-1)}) \\ E(\widehat{R}_{it}) &= f(R_{i(t-1)}, Y_{i(t-1)}, X_{it}, L_{it}, O_{it}, A_i) \end{aligned} \right\} \quad (17)$$

We include lagged moments and the estimated risk parameter as explanatory variable in the diversification model. Diversification could also be influenced by the previous experience in diversification and the income levels in the preceding periods. In addition to their empirical meanings, the lagged data inclusion in the model helps to control for some unobservable effects (Wooldridge, 2010, Kim et al., 2014, Zuo et al., 2014).

## 4. Result and Discussions

### 4.1. Estimation of risk parameters

The main objective of the first stage estimation is to capture the risk attitude of farm households from the profit moments. 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, Finger and Sauer, 2014). Most covariates used in the estimation have got the expected sign and the overall statistical significance of the estimated model is good. We have also used the Feasible Generalized Least Squares (FGLS) estimation and the result is similar to the one estimated with the fixed effect procedure. The Hausman specification test rejected the null hypothesis that the random and fixed effect model give similar results. Accordingly, we use the fixed effects estimator for the profit moments estimation. The results

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<sup>3</sup> We use the lagged risk estimate and income of the household, household specific socio-economic variables, farm land quality and fragmentation and organizational and institutional factors as instruments in the first stage.

of the fixed effect estimation of the first moment (mean), second moment (variance) and third moment (skewness) are presented in table 2.

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 use the estimation in table 2 to estimate the marginal effects of each input for each individual observation. Following this procedure, we estimate the first order condition described in equation 6 using three stage least squares (3SLS) procedure. We have also employed Seemingly Unrelated Regression approach for the first order condition for consistency reasons are the result remains the same. The coefficients of these functions are used to estimate the Arow-Pratt absolute risk aversion (AP) and downside risk aversion (DS) which then will be used to estimate the relative risk premium (RRP).

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
$\theta_2$	0.685***	0.024	-1.263***	0.016	0.849***	0.008

$\theta_3$	-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	23533.49		24740.17		12493.40	
equality	p> x <sup>2</sup> =0.0000		p> x <sup>2</sup> =0.0000		p> x <sup>2</sup> =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						

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). Farmers are willing to cost some of their profit to avoid risk related to seed and other intermediate inputs.

The coefficients in the estimation of FOC for family labor come up with an interesting result. The negative values in the AD and DS indicates that farmers seem risk loving with respect to family labor. This could be due to the limited off-farm and non-farm employment opportunities on the one hand and low level of wage rate for the available ones in rural Ethiopia. Most farms in rural Ethiopia use family labor for the production activities and sometimes use hired labor in peak seasons. Given the low level of opportunity cost they experience in family labor, they would likely choose to employ the available labor though remained risky.

We find that an average sample relative risk premium of 18.27%<sup>4</sup>, 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*. Most of the previous studies are done in developed or transition economies where the insurance and other risk mitigation mechanisms are relatively developed. Hence, the relative risk premium of farmers in developing countries with underdeveloped

<sup>4</sup> 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).

insurance and risk mitigation schemes is expected to be higher than those in the developed and transition economies. Given the higher level of unemployment condition and the low wage rate condition of the available options, the difference in the risk behavior related to family labor used is expected. Groom et al (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. Vollenweider et al (Vollenweider et al., 2011) and Kumbhakar and Tveteras (Kumbhakar and Tveteras, 2003) have got RRP estimate of 16% and 18% in Irish Dairy sector and Norwegian salmon famers respectively.

#### 4.2. Role of risk behavior on farm portfolio

The research hypothesis of the study is whether farmers opt to diversify their farm activities in order to mitigate risk. The overall model adequacy of the two-step Tobit model with endogenous regressors is good and the results of the model are illustrated in table 4. The Wald test of exogeneity rejects the null hypothesis of no endogeneity and hence, our use of the two stage least squares estimation technique is justified.

Table 4: Estimation of two step Tobit (dep. Var. = diversification)

Variables	Coeff.	Std. err	T
Relative Risk Premium (RRP)	-0.620**	0.282	-2.20
Relative Risk Premium lagged (t-1)	-0.014	0.022	-0.64
Concentration index lagged (t-1)	0.202***	0.038	5.30
Income lagged (t-1)	-0.003	0.009	-0.28
Age	-0.001	0.003	-0.45
Education level	-0.027*	0.016	-1.68
Landholding	0.027	0.028	0.96
Land fragmentation (Simpson index)	-1.003***	0.224	-4.47
Slope index of land	0.142	0.092	1.54
Soil fertility index	-0.018	0.075	-0.24
Slope*fertility	-0.013	0.014	-0.92
Off/non-farm income	0.006*	0.003	1.94
Access to credit	-0.200**	0.087	-2.30
Extension contact (frequency)	0.010	0.016	0.62

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Regional dummy_Amhara	0.383**	0.188	2.03
- Oromiya	1.069***	0.219	4.88
- South	-0.294*	0.175	-1.68
Constant	2.471***	0.378	6.53

Number of observations= 947      \* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01

Model: Two-step least squares Tobit model with endogenous regressors<sup>5</sup>

Model adequacy: Wald-chi2 (17)=247.3    prob>chi2=0.0000

Wald test of exogeneity chi2 = 5.32    Prob > chi2 = 0.021

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Regional dummy is found significant in our estimation. Different regions could have different physical, agro-ecological and bio-diversity, socio-economic and institutional conditions. In addition to the above mentioned features, the level of risk and the associated risk parameters are different across regions. The diversification level of farms is different in different regions of the country. Some of the variability in diversification level of farms across regions is related to the existing physical, agro-ecological, climatic, and socio-economic situations. The production structure, occurrence of climate extremes and the organizational structure of markets is quite different in those regions, and this in turn might have an implication for risk aversion behavior of farm households. These concepts will further be explained in detail with the following paragraphs.

Education level of the household negatively influences the concentration index. People with better education are more likely to opt for more diversified farms. The benefits of diversification might outweigh to the benefits of concentrated farms in smallholder agriculture (Coelli and Fleming, 2004). Farmers with better education could likely adjust their farm portfolio easily as compared to the illiterate counterparts. Mintwab and Sarr (Mintewab and Sarr, 2012) have also found education level of household head positively associated with the on-farm diversification level.

The coefficient of the lagged concentration index is positive and significant. Finger and Sauer (Finger and Sauer, 2014) have got similar findings. Concentration level of farms is influenced by past experience in concentration. The important feature of panel data format is the ability of

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<sup>5</sup> We use livestock ownership, frequency of extension contact and income of the previous period as instruments

inclusion of lagged variables to explain some of the variability. This otherwise could happen to be explained by other covariates in a cross-sectional data types.

Households' access to credit is negatively associated with concentration index of farms. In smallholder agriculture, where farmers are frequently facing liquidity related constraints, access to credit might influence the farm portfolio related decisions. Households will have more flexibility in allocating resources to different production schemes based on their liquidity conditions.

Land fragmentation influences the land allocation decision of farm households. The more the land is spatially fragmented, farmers are likely to diversify their production activities. It in fact matters if there is a difference in the suitability of the farm plots<sup>6</sup> for different production activities. There might also be a tradeoffs in labor and other production inputs among the production activities. Accessibility of the plots for routine farm management, supervision or transportation are also essential in the decision making process. Benin et al (Benin et al., 2003) find out contradicting results of diversity across different slope levels and access to irrigation water.

Off-farm/ non-farm income is negatively associated with the on-farm diversification level of the household. This is in line with previous researches 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 (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. They highlighted that farms may prefer to stay specialized, though risky. Such farms might involve in off-farm activities to mitigate risk of extreme events. Based on our finding, we could argue that farmers might use their off-farm income to invest in a more specialized farm portfolio with higher expected profit. They might prefer to specialize and use the off-farm income as a safety net in case of extreme events. There could also a possibility for competition of labor among these two and engagement in off-farm and non-farm income and on farm diversification could be seen as substituting strategies when it comes to agricultural risk mitigation.

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<sup>6</sup> 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.

We verified the research hypothesis of the paper and relative risk premium is positively associated with on-farm diversification. The lagged relative risk premium has also got the expected sign, though remained insignificant. Given the long gap between the two time frames in the panel data, these estimation is fairly good. This is in line with both the theoretical literatures in applied economics and empirical works. Mintwab and Sarr (Mintewab and Sarr, 2012) have found similar result using the application of experimental risk elicitation technique. Finger and Sauer (Finger and Sauer, 2014) have got an evidence on the association of lagged flood occurrence and the level of diversification.

## **5. Conclusion and Policy Implications**

We have used 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 have estimated 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.

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