Working Paper Series

#2017-028

Willingness to pay for agricultural risk insurance as a strategy to adapt climate change

Tigist Mekonnen

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: **info@merit.unu.edu** | website: **http://www.merit.unu.edu**

Maastricht Graduate School of Governance (MGSoG)
email: **info-governance@maastrichtuniversity.nl** | website: **http://www.maastrichtuniversity.nl/governance**

Boschstraat 24, 6211 AX Maastricht, The Netherlands
Tel: (31) (43) 388 44 00

UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology
UNU-MERIT

Maastricht Graduate School of Governance
MGSoG

Willingness to Pay for Agricultural Risk Insurance As a Strategy to Adapt Climate Change

Tigist Mekonnen (PhD)
Maastricht University and UNU-MERIT

June, 2017

Abstract

Agricultural production is subject to high risk associated with environmental and agro-ecological conditions. Farmers continuously make decisions to mitigate the various adversities. This study evaluates farm households' willingness to pay for agricultural risk insurance intervention introduced in Ethiopia in 2009. A bidding game approach is used to elicit willingness-to-pay. We use a unique data collected on farmers' willingness to pay for production risk insurance covering 1500 farm households. The result from the first willingness to pay response model shows that on average, farmers are willing to pay a premium of 55 Ethiopian *Birr*. By increasing the efficiency of our estimation, a double-bounded dichotomous choice model is estimated in the follow-up willingness to pay response question. It indicates that farmers are willing to pay about 67 Ethiopian *Birr* to insurance coverage. The use of modern agricultural technologies such as high-yielding variety and inorganic fertilizer, low rainfall, large family size, and high rainfall type are potential indicators that determine farmers' decision to adopt financial insurance. We also found farmer's demand for insurance increases due to the changing extreme weather events. Therefore, the study provides information to agricultural policy makers and private companies to promote agricultural insurance and set the premium and enrollment unit.

JEL Codes: D22, D81, G22

Keywords: Risk, uncertainty, technologies, insurance, contingent valuation methods, Ethiopia

1 Introduction

In the modern agricultural production system, producer's ability to withstand extreme weather events is of the paramount importance. Given the importance of new agricultural technologies in improving food security and the livelihood of the poor, yet the use of improved technology may be subject to high risk associated with environmental and agro-ecological conditions (Dercon and Christiaensen, 2011; Tambo and Abdoulaye, 2012; Asfaw et al., 2016). High investment technological use should be supplemented with risk mitigation and coping mechanisms to overcome the effects of risk. There is a need to adapt and find ways in mitigating the damage caused by climate change. Asfaw et al. (2016) argue that the variability of weather is one of the main reasons for farmers to adopt a new innovation.

Including drought tolerant crop varieties, the development of production risk insurance such as crop insurance are some of the innovations introduced by international development organizations to withstand extreme weather events. For instance, according to Barnett and Mahul (2007), innovations in risk transfer for natural disasters in lower-income countries such as weather index insurance products, can be used to shift various weather-related risks.[1] The financial and technological innovations in the insurance market provide an alternative for dealing with agricultural risk, especially in relation to climate change (Iturrioz, 2009).

Risk is unavoidable, but a manageable element in the agricultural production and marketing businesses. Recently the World Bank implements risk financing and insurance solutions within the broader agricultural risk management agenda to reduce agricultural producers' financial vulnerability to production losses (World Bank, 2013). In order to create profitable risk portfolios, governments, development organizations and private markets operate formal risk management strategies in a larger scale (Dercon et al., 2008). This provides a safety-net and absorbs the risk of potential hazards. Like any effective risk management instrument, microinsurance helps the poor against specific shock (Cohen, 2006; Botzen et al., 2009). From the financial management perspective *ex-post* microfinance and *ex-ante* microinsurance are the two important components to cope up with the risk (Cohen, 2006). For the last few decades, microfinance has attracted academicians, governments and multilateral agencies across the world.

The intervention of microinsurance such as crop insurance draws more attention. It is a contract that could be performed between farmers and insurance company where farmers are willing to pay a premium with an agreement of receiving a claim in case of crop failure due to natural disaster (Yazdanpanah et al., 2013). Since agriculture is vulnerable to multiple risks; the adverse effect of climate change such as drought, pests, diseases, excessive rains, and storms

[1] Some of the developing countries where drought index insurance has been implemented are China, India, Ethiopia, Malawi, and Mexico.

negatively affects crop production. Insurance builds the financial resilience as it helps them to access credit assistance (Yazdanpanah et al., 2013). Moreover, in the extent to which farmers have benefited from the adoption of improved agricultural inputs, but the adaptability of the new technology is a challenge to farm households (Adesina and Zinnah, 1993; Marra et al., 2003). Reducing the risk relieves the economic stresses of farm households' (Cohen, 2006).

In many parts of the developing world, the agricultural insurance market for catastrophic risk has grown considerably. Including livestock, fisheries, and forestry, agricultural insurance essentially geared to covering losses from adverse weather events, which is beyond farmers' control (Power, 2008). Falco et al. (2014) argue that agricultural insurance market is available more than ever before to hedge the natural hazards. However, in African countries, these markets are lagging behind where the majority of the rural households are employed in agriculture and farming is the main economic driver (Hill, 2010).

In Ethiopia, agricultural insurance started in 2009. Since the intervention of crop insurance helps farmers to alleviate the natural disaster and stifle adaptation of the new technologies, it is impressive to analyze in terms of take-up by farm households and product design. Therefore, this study examines farmers' willingness to pay for agricultural risk insurance and the drivers of the adoption of insurance which ultimately leads to a better understanding of why farm households decide to adopt or not to adopt agricultural insurance. The analysis also assesses whether farmers' use of modern inputs increases their willingness to pay for insurance protection.

An extended body of empirical literature examined factors affecting adoption of crop insurance. However, despite the increasing importance of improved agricultural technologies to boost productivity, there are scant empirical researches on the willingness to pay for insurance protection for the adoption of new technologies and demand for insurance coverage. Indeed, Holloway and Ehui (2001); Holden and Shiferaw (2002); Asrat et al. (2004); Ajayi (2006) looked at farmers' willingness-to-pay for agricultural extension advisory service on dairy marketing and soil conservation practices. This study examines farm households' willingness to pay for agricultural production risk insurance associated with climate change and technology adoption in Ethiopia.

Despite the highly variable growth rate caused by periodic drought and soil degradation, agriculture continues to be an important sector of Ethiopia's economy. The sector accounts for 45 percent of GDP, more than 70 percent of employment and over 80 percent of export (UNUDP, 2015). Most of the rural households depend on the sector for its livelihood, however, their livelihood is frequently threatened by crop failure (Yesuf and Bluffstone, 2008). Climate-related and other risks affect the production and socioeconomic conditions and the economy of the country at large. According to the recent United Nation agency 2015 report, around 4.5 million rural farm households in Ethiopia are affected by drought and they are in need of food aid after poor rains (UN, 2015).

In view of the importance of agriculture in the Ethiopian economy and its vulnerability, the need for adequate and sustainable risk management system has been duly recognized. Although insurance may not be the only adaption tool, yet it gives a broader adaptation strategy by improving farmers' financial resilience.

Recently the Rural Resilience Initiative Program (R4) in Ethiopia and Senegal supports smallholder farmers by consulting on the needs to be insured, time and on the elements of insurance contract such as the frequency of payment. Besides production risk, the R4 program is integrated insurance through work program allowing the financially constrained farmers who are unable to pay the upfront premium to pay for insurance with their labor. In East Africa, the collaboration of crop insurance with agricultural credit from microfinance institutions by Agriculture and Climate Risk Enterprise (ACRE) gives the opportunity for smallholders in accessing credit (Yazdanpanah et al., 2013). Thus, the development of insurance market can help the rural poor against any specific shock. Producers, adoption of innovative agricultural insurance enables them to better deal with bad events when they occur. This is essential to improving their livelihood in the short-run and their opportunities in the long-run in the use of new agricultural technologies (Hill, 2010).

2 Crop Insurance Scheme at a Glance in Ethiopia

Since the introduction of agricultural insurance program in 2009, the program has been providing insurance protection to agricultural producers against loss of crops and livestock on account of natural calamities such as extreme weather, crop damaged by pests, disease, heavy rain and other perils.[2] The Horn of Africa Risk Transfer for Adaptation (HARITA) established in 2009 provides 17,392 dollars to 1,800 farmers in seven villages in the Northern part of Ethiopia which is one of the areas affected by drought in the earlier years. The project has extended its scope from 200 enrolled farm households in one village to 13,000 farm households in forty-three villages. The other private crop insurance companies in the country which are partner with Oxfam America and the Earth Institute-affiliated International Earth Institute for Climate and Society (IRI) are Relief Society of Tigray (RST), Dedebit Credit and Savings Institute (DCSI), Nyala Insurance Company (NIC) and African Insurance Company (AIC). The Horn of Africa Risk Transfer for Adaptation (HARITA) which is the Rural Resilience Initiatives (R4) also enables smallholder farmers to strengthen their food and income security by managing risk through a four-part approach such as improving natural resource management, accessing microcredit, risk transfer gaining insurance coverage and increasing savings. Moreover, the United Nation World Food

[2]According to Ethiopian Rural Household Survey, Ethiopian insurance company developed insurance product and is offering it to farmers by making a twelve monthly payments. Farmers will have a written insurance contract that the company will pay 3000Birr in October in case the level of rainfall recorded in the weather station during Kiremt rains that run from July to September is less than 350 mm.

Program (UNWFP) and Oxfam America which is supported by United States Agency for International Development and Swiss Re are committed to extending the Horn of Africa Risk Transfer for Adaptation (HARITA) program in the country.

3 Literature on Agricultural Insurance

A review of empirical literature on agricultural risk insurance demonstrates farming is one of the perilous and stressful activities (Spiewak, 1994; Roberts, 2005; D'Alessandro et al., 2015). The costs of uninsured risk for low-wealth agricultural and pastoral rural households are shown by an emerging literature (D'Alessandro et al., 2015; Burke et al., 2010; Dercon et al., 2008; Barnett and Mahul, 2007). Carter et al. (2008) argue that risk depresses the development of the agricultural finance markets in a region that can be important to the growth and development of the small-farm sector. Miller et al. (2004) also indicated that farmers face risk due to the various source of change or uncertainty.

Some of the uncontrollable factors such as unpredictable weather, time constraint, untimely equipment breakdowns and financial market are among the causes of stress in the lives of farm families. Spiewak (1994) categories such kind of factors into financial, weather, workload and social. The rural poor are exposed to such risk at a higher level, but usually, insurance is absent in these areas (Carter et al., 2008). Traditionally farmers practice various risk mitigation mechanisms such as using local crop varieties to withstand weather-related risks. However, this kind of risk coping mechanism may not protect them against common weather shock where all agricultural producers in a village or region experience a drought (Burke et al., 2010). Besides, local varieties may treat crop productivity. Especially in low-income countries where farm families face fiscal constraints, traditional agricultural production systems are not sustainable in the long run (Iturrioz, 2009). Thus, the poor and the vulnerable face substantial risk in everyday life (World Bank, 2015).

From the experience of high-income countries such as Europe, USA, and other developed countries, agriculture is well developed through innovation and technologies and it's more of commercial agriculture. A well established agricultural insurance market guarantees produce on production and price related risk (Iturrioz, 2009; Wenner and Arias, 2003). In these countries, the government provides subsidies on premium to farmers and some operational subsidies to private insurers to cover some of the administrative costs associated with agricultural insurance contract (Wenner and Arias, 2003). For instance, the participation of producers in a multiple-peril crop yield insurance is around 70 percent in Spain (Miller et al., 2004). The US crop insurance program coverage in 2002 was around 75 percent of the planted acres of the major field crops and around 100 different crops are insured (Dismukes et al., 2004); the same is true for crop yield shortfalls insurance in Europe (Meuwissen et al., 2003). However, agricultural insurance market in developing countries, especially in Sub-Saharan Africa (SSA) is at infant stage (Hill, 2010; Iturrioz, 2009).

As part of the UN Millennium Development Goals, in some SSA countries,[3] the low-cost drought and excessive precipitation insurance program are started. The "Food Early Solution for Africa (FESA- microinsurance", by the Netherlands Ministry of Foreign Affairs initiative started in 2009 (Rosema et al., 2014). However, studies indicate that elements in scale and costs, access to weather information, take-up of the scheme and trust in private insurance company are the challenges to promoting agricultural insurance on a wider scale (Rosema et al., 2014; Clarke and Kalani, 2011; Burke et al., 2010). In another study Phélippé-Guinvarc'h and Cordier (2006) argue that it is impossible for private crop insurer to offer insurance contracts without government support. This indicates that producers' attitude towards crop insurance results in the reliability of the insurance company. Drawbacks in terms of product design such as recording the level of rainfall at weather station than nearby at farmer's field and innovation in insurance design are also the challenges in promoting agricultural insurance market (Burke et al., 2010).

4 Data and Descriptive Statistics

4.1 Data

This study used household level data from Ethiopian Rural Household Survey (ERHS) collected by International Food Policy Research Institute (IFPRI) in 2009. Covering 1500 farm households which are from predominantly rain-fed areas, information on agricultural production risk data was collected from four regions and fifteen rural villages. A comprehensive survey covering socioeconomic, demographic, household assets and production of food and cash crops were included in the data. Information on farmers' use of improved agricultural technologies such as new high-yielding varieties and inorganic fertilizer was covered by the survey. Detailed information on weather related variables and occurrences of shock in previous years is gathered. Focusing on the most important staple food crops, farmers' were interviewed on the willingness to pay for formal agricultural risk insurance. Farm households' were interviewed on their willingness to pay on a given amount of money to the insurance company. Depending on their response (yes or no), a follow-up question was followed. The maximum willingness to pay varies from household to household. If the household responds yes to the initial bid, a higher bid amount is given. If the given amount (initial

[3] Countries where FESA has been successful in developing and providing low-cost drought and excessive precipitation insurance are Senegal, Mali, Burkina Faso, Benin, Kenya, Tanzania, Rwanda, Uganda, Malawi, Mozambique, and Botswana. According to Rosema et al. (2014), it is expected that the number of insured farmers grows to one million in the next three to five years.

bid) is higher than a given household's maximum willingness to pay and they respond no, a lower bid amount is given. Farm households' participation in other public programs to overcome any form of shock is also included in the survey.

Table 1: Definition of variables

Variables	Definition
Age of head	Years of age
Educational level of head	Educational level in years of schooling
Gender of head	=1 if the household head is Male, 0 if Female
Household size	Number of person in the household
Farm size	Farm size of the household in hectare
Improved seed	=1 if households used of improved seed, 0 otherwise
Inorganic fertilizer	=1 if Households used chemical fertilizer, 0 non-use
Crop type	=1 if households prefer insurance for cereal crop, 0 if fruit and vegetable
Credit taken	=1 if households taken credit, 0 otherwise
Design of insurance	=1 if households indicates problem in insurance design, 0 otherwise
Preference in insurance	=1 if households prefer individual insurance, 0 otherwise
Occurrence of shock	=1 if households reported shock happened for the last five years, 0 otherwise
Severity of shock	=1 if households reported the shock affect households asset, 0 otherwise
Low rainfall insurance	=1 if households received insurance during shock, 0 otherwise
Participate in PSNP	=1 if participate in Productive Safety Net Program (PSNP), 0 otherwise
Insurance demand	=1 if households need future agricultural insurance, 0 otherwise

4.2 Descriptive analysis

The summary statistics of the date are presented in Table 2. The average age of the sample households is nearly 53 years, with an average of two and half years of schooling. Most of the sample household heads are male (77.7 percent), with an average household size of five members. The average land holding size of the sample household is 1.4 hectare. The proportion of farm households who use high-yielding varieties and inorganic fertilizer are 26.3 and 57.5 percent, respectively. Most of the sample households produce food crops (92.5 percent) and only a small share is engaged in the production of cash crops (4.5 percent). Those preferring individual insurance than group insurance (a traditional type of informal local group insurance) are 49 percent. Around 78.6 percent of farm households reported that there is a problem with the design of insurance, concerning the fact that the payment system is based on the rainfall recorded at weather station (and that payments are guaranteed only if the level of rainfall is below 350mm). This may create ambiguity on the insurance company, thus, the trust may be an issue to farmers' willingness to pay for insurance. However, the descriptive statistics of our dataset show that around 66 percent of the sample farm households demand agricultural insurance (see Table 2).

Farm households were interviewed about the occurrence of a shock for the last five years, 95.6 percent reported the occurrence of shock, and 92 percent indicated the severity of the shock inflicted damages to their assets such as livestock and crop failure on the farm field. Due to such shock, 15.3 percent of the rural farm households indicated that they participate in government Productive Safety Net Program (PSNP), which is in-kind and/or cash transfer program. Our sample farm household who accesses credit assistance is also 63.1 percent. As we can see from Figure 1, nearly 43 percent of the interviewed farm households provided a positive response to the first willingness to pay response question. We expect that farmers may be sensitive to the bid amount: when the bid amount increases, the proportion of farmers who give a positive answer may decrease. However, nearly 71 percent of farm households provide a positive response to the second willingness to pay response question, which is higher than the previously determined bid amount. The average initial, higher, and lower bid amounts offered to farmers are 25, 30, and 20 Ethiopian *Birr* per household, respectively for the first and second willingness to pay response questions. Farmers were also interviewed about the reliability of their answer on the willingness to pay question. Around 71.2 percent of farmers reported that they are very sure, 24.7 percent reported that they are sure, and 4.1 percent said not very sure (see Figure 1). In the next section, we econometrically estimate farm households' willingness to pay for agricultural risk insurance intervention by controlling for the various factors affecting producers' willingness to pay.

Table 2: Characteristics of the sample households

Characteristics	Mean	Std.dev.	Min	Max
Age	52.8	14.9	20	120
Educational level of head	2.3	2.81	0	12
Gender of household (1 if Male)	77.7	0.41	0	1
Household size	4.6	2.3	1	13
Farm size	1.4	5.3	0	35.25
Improved seed use (1 if yes)	26.3	0.44	0	1
Inorganic fertilizer use (1 if yes)	57.5	0.49	0	1
Crop type (1 if cereals)	92.5	0.26	0	1
Credit taken (1 if yes)	63.1	0.48	0	1
Problem in insurance design (1 if yes)	78.6	0.41	0	1
Insurance preference (1 if individual)	49.0	0.50	0	1
Occurrence of shock (1 if yes)	95.6	0.20	0	1
Severity of shock (1 if yes)	92.5	0.26	0	1
Low rainfall insurance received (1 if yes)	88.8	0.31	0	1
High rainfall insurance received (1 if yes)	0.19	0.39	0	1
Households asset loss (1 if yes)	95.1	0.21	0	1
Demand for insurance (1 if yes)	65.6	0.47	0	1
Participate in PSNP (1 if yes)	15.3	0.36	0	1
Initial bid WTP	24.90	10.05	2	40
Lower bid WTP	19.89	10.02	1	35
Higher bid WTP	29.8	10.06	4	45
Households reliability by their answer: Very sure	71.16	0.45	0	1
Sure	24.73	0.43	0	1
Not very sure	4.11	0.19	0	1

Source: ERHS 2009

5 Empirical Analysis

5.1 Contingent valuation method

The need to place monetary values on non-market goods and services is challenging. In environmental and health economics literature, these values are estimated using contingent valuation method (CVM) in which survey questions elicits respondents' willingness to pay (WTP). Empirical studies also indicated that the design of the survey questionnaire and its application is the fundamental part of the contingent valuation method (Carson et al., 2003; Whittington, 2002; McLeod and Bergland, 1999). The CVM has been applied to issues such as estimating demand for clean rainwater for domestic use (Amoah and Adzobu, 2013), the economic values for environmental quality (Blumenschein et al., 2008), health care programs (Dong et al., 2004; Chestnut et al., 1996), and the non-use value loss associated with the Exxon Valdez oil spill (Carson et al., 1992). Others have used it to estimate the willingness to take agricultural insurance by cocoa farmers in Nigeria (Falola et al., 2013) and index-based crop microinsurance in India (Ramasubramanian, 2012).

The CVM is also increasingly being used to evaluate private market goods or services (Gustafsson-Wright et al., 2009; Donaldson et al., 2006; Asfaw and Von Braun, 2004). In the empirical economics literature, the CVM for non-market goods or services is divided into direct and indirect methods. The direct CVM entails directly asking to a sample of the population about their WTP for the provision of a given goods or services. However, the indirect methods such as hedonic pricing approach, estimate based on the observed behavior of individuals in the market of goods or services. Thus, the direct contingent valuation methods are the only ones capable of capturing information on the willingness to pay for goods or services. We applied single-bounded dichotomous choice CVM in the first willingness to pay response question. To increase the efficiency of our estimation, we also employed a double-bounded dichotomous choice CVM in the follow-up WTP response question to elicit information from households' WTP for the value of non-marketed agricultural insurance intervention. Analyzing how the public values of goods or services which are not traded in the marketplace are measured is also the interest of policy makers. Therefore, this study evaluates farm households' WTP for a newly introduced crop insurance program in Ethiopia that can be interpreted as a measure of support for the program. In Table 3 below, we first show how the bids are chosen in each variant of the contingent valuation methods. Then after, we discussed the estimation procedure of both the single-bounded and double-bounded contingent valuation methods.

Table 3: Bids in the contingent valuation methods

First (initial) bid	2nd (follow-up) higher bid	2nd (follow-up) lower bid
2-10	4-15	1-5
11-20	16-25	6-10
21-30	26-35	11-25
31-40	36-45	16-35
Max. WTP 2nd higher bid	45	
Max. WTP 2nd lower bid		35

5.2 Estimation procedure of the single-bounded method

In the single-bounded dichotomous choice CVM, respondents are only asked one dichotomous choice question and a monitory value for the good or service is treated as a threshold (Hanemann et al., 1991). When contingent valuation questionnaire is applied, the information that directly elicits from households is a dichotomous answer (yes or no). Let's say household i answers *yes* to the first *WTP* question, thus *yi=1;* if the answer is *no*, *y*i=0 instead of, given a question about paying a previously determined amount m_i which varies randomly across the households. Thus, the *WTP* can be estimated as

$$WTP_i(z_i, u_i) = z_i\beta + u_i \tag{1}$$

where z_i is the set of explanatory variables determining *WTP*, β is the vector of parameters to be estimated, *ui* is the error term which is normally distributed with mean *0* and constant variance, σ^2. Assuming that households accept to pay the bid amount or provide a positive response (yes) if the amount of *WTP* is greater than the previously determined amount *mi*. Given the values of exogenous factors, the probability of observing a positive answer is given by

$$\begin{aligned} Pr(y_i = 1|z_i) &= Pr(WTP_i > m_i) \\ &= Pr(z_i\beta + ui > m_i) \\ &= Pr(ui > m_i - z_i\beta) \end{aligned} \tag{2}$$

Assume that u_i is normally distributed with mean *0* and constant variance ($u_i \sim N(0, \sigma^2)$),

$$\begin{aligned} Pr(y_i = 1|z_i) &= Pr(u_i > \tfrac{m_i - z_i'\beta}{\sigma}) \\ &= 1 - \Phi(\tfrac{m_i - z_i'\beta}{\sigma}) \end{aligned}$$

$$Pr(y_i = 1|z_i) = \Phi(z_i'\frac{\beta}{\sigma} - m_i\frac{1}{\sigma}) \quad (3)$$

where $u_i \sim N(0,1)$ and $\Phi(x)$ is the standard cumulative normal distribution function. Using maximum likelihood estimation, we can solve for β and σ. From normality assumption and using equation (1) above, the expected value for the willingness to pay is given by $E(WTP_i|z_i\beta = z_i'\beta)$. Since the true value of β is not known, a consistent estimate can be obtained from using $\hat{\alpha}$ and $\hat{\delta}$ which is $\hat{\beta} = -\frac{\hat{\alpha}}{\hat{\delta}}$. Thus, the WTP for each household with a certain characteristics is given by

$$E(WTP|\hat{z}, \beta) = \hat{z}'[-\frac{\hat{\alpha}}{\hat{\delta}}] \quad (4)$$

where $\hat{z}'$ is a vector with the values of interest for the explanatory variables.

5.3 Double-bounded contingent valuation method

In the Double-Bounded Dichotomous Choice approach, a follow-up dichotomous question is asked after the first willingness to pay response question. The Double-Bounded Contingent Valuation (DBCV) method is more efficient than single bounded method (Hanemann et al., 1991). Kanninen (1993) also indicated that the DBCV generate a more efficient estimation result than the conventional single bounded approach. This is because, according to Hanemann et al. (1991) if the value of the goods or services is valued more highly than the threshold amount, the respondent answers yes, otherwise no. Nevertheless, in the case of the single-bounded dichotomous choice approach, respondents provide less information about their willingness to pay. It is also easier for respondents; thus it may need large survey data to get precise estimation result (Hanemann et al., 1991).

Applying a more efficient DBCV method in which survey households are asked a sequence of questions that progressively narrows down the willingness to pay. Studies indicated that the DBCV is generally preferred to ask an open-ended question for respondents WTP (Watson and Ryan, 2007). However, there is also a limitation in the DBCV method. For instance, respondents may become indignant, this is because they believe that they struck a deal with their answer to the first question but now are being asked a follow-up question with a different amount or may feel guilty at having said *no* to the first amount and therefore may be more likely to say *yes* to the second amount which is lower than the previously determined amount (Watson and Ryan, 2007).

Therefore, if the second follow-up double-bounded dichotomies choice question and offered amount is made sufficiently large when the response to the first amount is a *yes* and sufficiently small when the response to the first amount is *no*, this ensures that it yields no additional information beyond that already contained in the response to the first amount. Thus, one can always mimic the outcome of a single-bounded question by choosing sufficiently extreme follow-up bids in a double-bounded dichotomies choice question. This implies that when the bid in single and double-bounded dichotomies choice questions are optimally designed, the most efficient design for the double-bounded model can yield more efficient estimates than the single-bounded model (Hanemann et al., 1991). Therefore, each household is presented with two bids. The level of the second bid is contingent upon the response to the first bid. If a household answers *yes* to the first bid, the second bid is some amount larger than the first bid. If the household answers *no* to the first bid, the second bid is some amount smaller than the first bid. Thus, the four possible outcomes would be: *yes, yes; yes, no; no, yes; and no, no.* Table 4 below also shows description of the bidding game variable.

Table 4: Bidding game

Bidding game	Description
Bid 1	Initial bid amount in Ethiopian *Birr*
Bid h	Higher bid amount in *Birr*
Bid l	Lower bid amount in *Birr*
yy	=1 if households answer to the WTP questions was yes,yes
yn	=1 if households answer to the WTP questions was yes,no
ny	=1 if households answer to the WTP questions was no,yes
nn	=1 if households answer to the WTP questions was no,no

5.4 Estimation procedure of the double-bounded method

In economic theory, the maximum amounts of monetary values individuals are willing to pay for a good or service is an indicator of consumers satisfaction level for the goods or services provided. It is usually elicited by a contingent valuation approach which circumvents in the absence of actual markets by presenting consumers with hypothetical markets in which they have the opportunity to buy a good or service. Hanemann et al. (1991) indicates that one of the most common ways to elicit *WTP* is using contingent valuation method. In a bidding game, assuming that if households answer the WTP x amount of money for the first bid, his or her WTP must be greater than the bid (i.e $WTP_i > x_i$). If the household declines to pay from the previously determined amount x, then their WTP must be less than the bid in the second bid ($WTP_i < x_i$).

Let's say the first bid amount is x_1 and the second bid x_2 (to make simple, we skip the subscript i). Then, each household will be in one of the following categories: (i) the household answers *yes* to the first question and *no* to the second, then $x_2 > x_1$. In this case we can infer that $x_1 < WTP < x_2$. The household answers *yes* to the first question and *yes* to the second, then $x_2 < WTP < \infty$ (ii). The household answers *no* to the first question and *yes* to the second, then $x_2 < x_1$. In this case we have that $x_2 < WTP < x_1$ (iii). The household answers *no* to both the first and second questions, then we have $0 < WTP < x_2$ (iv).

Assuming that there is a single valuation function we discussed earlier, the double-bounded model allows the efficient use of the data to estimate households' willingness to pay (Haab and McConnell, 2002; Cameron and Quiggin, 1994). Let's say y_i^1 and y_i^2 are the dichotomous choice variables that capture a household's answers to the first and closed questions, then the probability that the household answers *yes* to the first question and *no* to the second can be explained as $Pr(y_i^1 = 1, y_i^2 = 0|z_i) = Pr(k, n)$. Given this and under the assumption that $WTP_i(z_i, u_i) = z_i^{'}\beta + \mathrm{u}_i$ and $u_i \sim N(0, \sigma^2)$, the probability of each of the four cases are shown as follows:

$I.\ Y_i^1 = 1\ and\ Y_i^2 = 0$

$$\begin{aligned} Pr(k,n) &= Pr(x_1 \leq WTP < x_2) \\ &= Pr(x_1 \leq z_i^{'}\beta + u_i < x_2) \\ &= Pr(\tfrac{x_1 - z_i^{'}\beta}{\sigma} \leq \tfrac{u_1}{\sigma} < \tfrac{x_2 - z_i^{'}\beta}{\sigma}) \\ &= \Phi(\tfrac{x_2 - z_i^{'}\beta}{\sigma}) - \Phi(\tfrac{x_1 - z_i^{'}\beta}{\sigma}) \end{aligned}$$

Thus, using symmetry of the normal distribution:

$$Pr(k,n) = \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_1}{\sigma}) - \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma}) \tag{5}$$

$II.\ Y_i^1 = 1\ and\ Y_i^2 = 1$

$$\begin{aligned} Pr(k,k) &= Pr(WTP > x_1, WTP \geq x_2) \\ &= Pr(z_i'\beta + u_i > x_1, z_i'\beta + u_i \geq x_2) \end{aligned}$$

Using Bayes rule, it says that $Pr(X, Y) = Pr(X|Y) * Pr(Y)$, we have

$$Pr(k,k) = Pr(z_i'\beta + u_i > x_1 | z_i'\beta + u_i \geq x_2) * Pr(z_i'\beta + u_i \geq x_2)$$

Herewith the definition $x_2 > x_1$ and then $Pr(z_i'\beta + u_i > x_1 | z_i'\beta + u_i \geq x_2) = 1$ This implies that:

$$Pr(k,k) = Pr(u_i \geq x_2 - z_i'\beta)$$

$$= 1 - \Phi(\tfrac{x_2 - z_i'\beta}{\sigma})$$

Thus, by symmetry

$$Pr(k,k) = \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma}) \tag{6}$$

$III.\ Y_i^1 = 0\ and\ Y_i^2 = 1$

$$Pr(n,k) = Pr(x_2 \leq WTP < x_1)$$

$$= Pr(x_2 \leq z_i'\beta + u_i < x_1)$$

$$= Pr(\tfrac{x_2 - z_i'\beta}{\sigma} \leq \tfrac{u_i}{\sigma} < \tfrac{x_1 - z_i'\beta}{\sigma})$$

$$= \Phi(\tfrac{x_1 - z_i'\beta}{\sigma}) - \Phi(\tfrac{x_2 - z_i'\beta}{\sigma})$$

$$Pr(n,k) = \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma}) - \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_1}{\sigma}) \quad (7)$$

$IV.\ Y_i^1 = 0\ and\ Y_i^2 = 0$

$$Pr(n,n) = Pr(WTP < x_1, WTP < x_2)$$
$$= Pr(z_i'\beta + u_i < x_1, z_i'\beta + u_i < x_2)$$
$$= Pr(z_i'\beta + u_i < x_2)$$

$$\Phi(\frac{x_2 - z_i'\beta}{\sigma}) \quad (8)$$

$$Pr(n,n) = 1 - \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma}) \quad (9)$$

Therefore, the maximum likelihood estimation of the double-bounded CVM is described as

$$\textstyle\sum_{i=1}^{n}[d^{kn}_i ln(\Phi(z_i'\frac{\beta}{\sigma} - \frac{x_1}{\sigma}) - \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma})) + d^{kk}_i ln(\Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma}))$$

$$+d^{nk}_i ln(\Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma}) - \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_1}{\sigma})) + d^{nn}_i ln(1 - \Phi(z_i'\frac{\beta}{\sigma} - \frac{x_2}{\sigma}))] \quad (10)$$

where $d^{kn}_i, d^{kk}_i, d^{nk}_i andd^{nn}_i$ are indicator variables that take the value of 1 or 0 depending on the relevant cases for each respondent, which implies that a given respondent contributes to the logarithm of the likelihood function in only one of the four cases above. Therefore, contrary to the single bounded approach, in the double bounded model, we directly obtain $\hat{\beta} y \hat{\sigma}$, and hence we can estimate WTP.

6 Estimation Results

This section discusses the contingent valuation model results: single-double and double-bounded contingent valuation models using maximum likelihood estimator to maximize the likelihood of the parameter estimation.

6.1 Single-bounded model result

The result from the first willingness to pay response model shows that on average, farmers are willing to pay a premium of 55 Ethiopian *Birr* for agricultural production risk (see Table 6). A negatively significant effect of WTP indicates that as the premium payment increases, the probability of positive response to WTP declines (see Table 5). Similarly, Mishra and Goodwin (2003) found that higher premium rates discourage farmers' participation in the insurance market. The amounts of premium payment matter to promote agricultural insurance. Falola et al. (2013) reported that around 78 percent of farm households are aware of agricultural insurance; however, only 50 percent of them are willing to take it. This suggests that subsidizing agricultural insurance market may encourage producer's participation in the program. Mishra and Goodwin (2003) shows the positive correlation between producers' participation in a government program, and crop and revenue insurance. Subsidy increases the likelihood of farmers' WTP and insurance delivery.

Understanding the incentives and financial constraints farm households face in their decision-making process to adopt insurance is the key element. Goodwin and Smith (1995) pointed out that government programs are intended to decrease the risk of agricultural producers. Agricultural insurance under public-private partnership encourages farmers' participation. According to World Bank (2015), sustainable and scaled-up agricultural insurance are based on a strong partnership between the public and private sectors with engagement, innovation, and actions from both sectors. It also increases trust on insurance provider (Hill et al., 2013). If farmers are satisfied by the services, the willingness to purchase increases (Yazdanpanah et al., 2013). Producers' view on the program determines how they evaluate perceived the quality of service and influences their decision to purchase crop insurance (Mojarradi et al., 2008). Agricultural insurance is not only providing farmers' with risk management tool but also improving farmers' access to credit and providing more stability to agriculture and related industries. It creates linkages between the agricultural sector and the industries such as insurance companies (Yazdanpanah et al., 2013), and help farmers smooth out the rough spots (Carter et al., 2008).

6.2 Effect of technology adoption on the willingness to pay for insurance

The positively significant correlation between farm households agricultural technology adoption and their WTP for insurance protection indicates that improved inputs are more profitable, but riskier. This suggests the extent to which farmers have benefited from the availability of new technologies, yet adaptability of the new technology might be challenged by the changing environmental conditions. Thus, more support is needed in areas like insurance coverage to invest in yield increasing technology and overcome adoption constraints. The finding by Simtowe and Zeller (2006) shows that hybrid seed adoption is lower for farmers with higher inferred risk aversion.

Innovation adoption ranging from insurance coverage to production technology choice such as new varieties (drought tolerant crop variety) enables farmers to continue investing in productivity-enhancing technologies (Tambo and Abdoulaye, 2012). According to Hill et al. (2013), risk aversion is associated with low insurance take-up, hence agricultural technology adoption can inform the willingness to purchase insurance. Since there is enormous weather variability within regions and between regions, production risk is the major source of fluctuation in income of farmers. Farm households unwilling to bear consumption fluctuation may decide not to adopt new agricultural technologies. Asfaw et al. (2016) reported that the probability of using modern agricultural inputs is negatively and strongly correlated with the variability in rainfall and temperature. This suggests that production risk mitigation mechanism helps farm households to adopt yield increasing agricultural technologies.

Recently many empirical studies in economics literature reported that extreme weather events threaten agricultural and food production in a complex way (Asfaw et al., 2016; Reynolds, 2010; Brown et al., 2007; Lobell et al., 2008; Rosenzweig et al., 1994). Farm households are more likely to be located in environments where their livelihoods are highly susceptible to weather and price variability. When these risks are uninsured, the rural poor not only reduce their current consumption level but also threaten future income growth and thus perpetuate poverty. This indicates that agriculture is a risky business and a large shock can devastate the life of the rural poor. According to Hill (2010) when households have little access to insurance, weather shocks not only affect farm households well-being by directly affecting their crop production, they also impact the decisions poor households make about their livelihood. Qaim and De Janvry (2002) found a positive correlation between farmers' adoption of improved agricultural input and their willingness to pay for insurance protection.

The result also shows other factors that determine farm households' willingness to pay for production risk insurance. Older headed households are less likely to be responsive and buy agricultural insurance than younger household heads, yet larger family size is positively correlated with the willingness to purchase insurance coverage. This shows that since agricultural households mainly access food and income from farming activities, their production risk affects not only households' consumption, but also children's education. Lobell et al. (2008) argue that Southern Africa and South Asia are the two regions that, without sufficient adaptation measures, are likely to suffer negative impacts on several crops that are important to the large food-insecure populations in the region.

The effect of weather variability indicators such as high rainfall type and low rainfall significantly affect farmers' WTP for insurance, indicating that the variability of climatic conditions affect agricultural producers WTP. High rainfall adversely affects crop production, which is erratic to the poor and vulnerable.

Singh et al. (2014) found that comparatively large decline in rainfall is observed in high rainfall area than low rainfall area. The later one is the indication of the occurrence of drought. Thus, agricultural producers need to take actions in response to climate change. Recently Asfaw et al. (2016) reported that a delayed onset of rainy season negatively affects crop production. Giné et al. (2008) also shows that risk-averse households purchase risk insurance for the expectation of product uncertainty due to rainfall pattern. The same is reported by Fraser (1992) regarding producer's willingness-to-pay for crop insurance for price and yield uncertainty. The demand for insurance indicator positively and significantly affects farmers' willingness to pay for insurance protection. Similarly, Cole et al. (2013) reported that insurance take-up is substantially higher (27 percent) among the same sample of farmers in Andhra Pradesh and a take-up of 23 percent of another standalone rainfall insurance policy in rural Gujarat, India. This suggests that production risk increases farmers' demand to purchase insurance coverage.

Table 5: Single-bound model result

Households WTP	Coefficient	Std. Err.
Initial bid	-0.024***	0.004
Age	-0.006*	0.003
Educational level of head	0.021	0.017
household size	0.033*	0.019
Farm size	0.000	0.006
Improved seed use	0.162*	0.096
Inorganic fertilizer	0.308***	0.099
Credit taken	0.098	0.090
Crop type	0.057	0.386
Low rainfall	0.196	0.150
High rainfall	-0.484***	0.118
Insurance preference	-0.038	0.087
Demand for insurance	0.802 ***	0.091
Occurrence of shock	-0.875	0.622
Household asset loss	0.069	0.573
Participate in PSNP	-0.188	0.122
Constant	1.359***	0.584
Probit regression		
Number of obs	1005	
LR chi2(16)	192.40	
Prob > chi2	0.000	
Log likelihood	-599.65	
Pseudo R2	0.1382	

Table 6: Average willingness to pay

Willingness to pay (WTP)	Coefficient	Std. Err.	P-value
Premium amount	55.254	23.424	0.018

Source: ERHS 2009

6.3 Double-bounded dichotomous choice model result

The behaviors of farm households in the first and follow-up WTP response questions are shown in Figure 1. The result from the second WTP response model shows that around 71 percent of farm households are willing to pay the higher amount. This indicates that households may consider the first given amount as being the average social cost of the resources and balk at being asked whether they would be willing to pay more than it costs. We expect that the probability to get the *yes* answer to the smaller amount would be higher if they respond *no* to the first WTP response question. However, we found 79 percent chance of a *no* response. The response from the first and follow-up WTP response questions indicates that farm households who answered *yes* in the first WTP response question are inclined to persist in answering *yes* even with higher amounts they offered. This indicates that, from the evaluation of contingent valuation survey from the single-bounded dichotomous choice model with follow-up questionnaire, it is expected that once a household has made a commitment that they are willing to pay the first offered amount, the likelihood to say that they are also willing to pay the higher amount would be positive. Initially, farm households who answered *no* in the first WTP response question are also inclined to persist answering *no*. This indicates that there are other factors that determine farmers WTP. The same message is conveyed by the low relative frequency of *yes/no* and *no/yes* responses (see Figure 1).

Controlling for potential variables such as weather variability indicators, socioeconomic, and demographic characteristics of farm households, the result from the second WTP response model indicates that farmers are willing to pay an average premium of 67 Ethiopian *Birr* (see Table 8). Nevertheless, contrary to the existing literature indicating that the introduction of the second bids tends to lower mean WTP than the first; we found a higher mean WTP in the second bid. Perhaps due to a frequent occurrence of weather risk and there is no formal crop risk insurance in the study area, produces badly demand insurance coverage. As we can see from Figure 1, farm households who are willing to pay the second higher bid are higher (70.62 percent) than those who are willing to pay the second lower bid (20.26 percent). Equal mean WTP for the first (single-bounded) and second (double-bounded) WTP also reported in Calia and Strazzera (2000) study.

The other explanatory variables such as the age of the households head, application of inorganic fertilizer, demand for insurance, high rainfall, and low rainfall type, appear to be determining factors on the probability to adopt insurance coverage. The positively significant effect of weather related variables on the WTP for insurance indicates that insurance would support farmers' yield variability associated with environmental conditions. Similar studies Salimonu and Falusi (2009) and Le and Cheong (2009) reported that most of the risk faced by farmers are production related such as drought, erratic rain, pests, disease attack, and price fluctuation. World Bank (2013) also indicates that agricultural insurance in the worst year provides claim payments that could complement mitigation and coping mechanisms by reducing vulnerability and providing a foundation for production enhancing inputs that could help to lift hundreds of millions out of poverty.

Application of improved agricultural inputs such as inorganic fertilizer is also found to significantly affect farmers' WTP for insurance. Inorganic fertilizer is the most commonly used impact indicator to determine the performance and effectiveness of the agricultural sector of an economy. However, farm households' inorganic fertilizer use in Ethiopia at the national level is around 46 percent (CSA, 2015). This indicates that more than half of the cultivated lands are either without fertilizer application or through organic fertilizer. Nevertheless, it is widely documented that the volume of total agricultural production is directly determined by the amount of fertilizer application and quality of seed (Feder et al., 1985; Green and Ng'ong'ola, 1993; Croppenstedt et al., 2003). This suggests that either lack of efficient access to inorganic fertilizer or farmers risk aversion behavior is associated with the low adoption of inorganic fertilizer. Kassie and Holden (2007) and Croppenstedt et al. (2003) found that production risk deters adoption of inorganic fertilizer. Tambo and Abdoulaye (2012) also show that improved inputs have high yielding and the potential to resists diseases, but not drought tolerant. Insurance would be complementary inputs in the adoption of the new technologies. It also increases smallholders' financial resilience for those located in drought-sensitive areas. Other studies Nhemachena and Hassan (2007) and Tambo and Abdoulaye (2012) show that innovation adoption such as *ex-ante* insurance and drought tolerance crop varieties are some of the climate change adaptation mechanisms. Lobell et al. (2008) indicate changing variety and crop, application of irrigation, and fertilizer to be among the measures taken to respond to the worst climate change scenarios.

The double-bounded model result also shows that high and low rainfall type significantly affects farmers' WTP for insurance protection. Similarly, Falola et al. (2013), Mishra and Goodwin (2003) and Skees et al. (1998) found insurance against any combination of low yield and/or price enables producers to afford the production cost and revenue coverage. Nhemachena and Hassan (2007) also show adaptation measure including insurance, improving climate information forecast and crop development help farmers adapt to change in climate conditions. This indicates that insurance looks into how risks and uncertainties can be effectively managed to the producer's advantage in the present as well as in the future. Farmers' demand for insurance is found to be significantly correlated with farm households' WTP, indicating that insurance coverage reduces smallholders' economic stress. Giné et al. (2008) and Lybbert et al. (2010) reported that demand for insurance decreases with risk aversion across the range of risk aversion. Farmers would be more willing to adopt improved technologies if their production risks were reduced through insurance to protect against crop failure.

Table 7: Double-bounded model result

WTP	Coefficient	Std. Err.
Beta		
Age of household head	-0.096*	0.055
Educational level of head	0.309	0.301
Households size	0.377	0.334
Farm size	0.024	0.127
Improved seed	2.635	1.676
Inorganic fertilizer	7.034***	1.732
Credit taken	-0.900	1.586
Crop Type	-3.074	6.798
Low rain-fall	4.819*	2.649
High rainfall	-8.239***	2.049
Insurance preference	-1.312	1.531
Demand insurance	15.006***	1.721
Occurrence of shock	-11.742	11.161
Household asset loss	-2.030	10.433
Participation in PSNP	-1.670	2.152
Constant	39.610***	9.813
Sigma		
Constant	19.300***	0.903
Number of obs	=	1005
Wald chi2(15)	=	127.92
Prob > chi2	=	0.0000
Log likelihood	=	-1201.36
First-Bid Variable:	Bid 1	
Second-Bid Variable:	Bid 2	
First-Response Dummy Variable:	Response 1	
Second-Response Dummy Variable:	Response 2	

Table 8: Average willingness to pay

Willingness to pay (WTP)	Coefficient	Std. Err.	P > z
Premium amount	67.216	9.793	0.000

Source: ERHS 2009

7 Conclusion

This study analyzes farm households' willingness to pay for agricultural production risk insurance intervention. In the rain-fed agricultural production system of Ethiopia, the sector is vulnerable to multiple risks associated with environmental, agroecological, and input usages. Using farm household level data from Ethiopian Rural Household Survey collected on agricultural production risk in 2009, Contingent Valuation Methods (CVM) are applied. The result of the analysis shows that farmers are willing to pay a premium payment to start the insurance contract, yet the amount of premium determines farmers' willingness to participate in the agricultural insurance market. From the first WTP response model result, we found evidence that on average, farmers are willing to pay a premium of 55 Ethiopian *Birr*. By increasing the efficiency of our estimation, a follow-up willingness to pay response model is estimated after the first willingness to pay response model. From the second willingness to pay response model result, their willingness to pay slightly increases to 67 *Birr*. The demand for insurance indicator also exerts a significant effect.

The study revealed that improved agricultural technology adoption and weather related variables positively and significantly affect farmers' decision to adopt financial insurance. The likelihood of older farmers participating in agricultural insurance is lower; however large family size households are willing to purchase insurance protection. This suggests that reducing the rural poor smallholder farmers' vulnerability to extreme weather events through policy intervention is not only essential for poverty reduction but also potentially growth-enhancing. Hence, agricultural insurance is a necessary part of the institutional infrastructure essential for the development of agriculture, which is mainly a high-risk enterprise. It is also the interest of policy makers to understand how the public value of goods or services which are not traded in the marketplace is measured. Therefore, promoting agricultural insurance should be one component of agricultural policy which mitigates the climate change risk in the process of sustainable agricultural intensification.

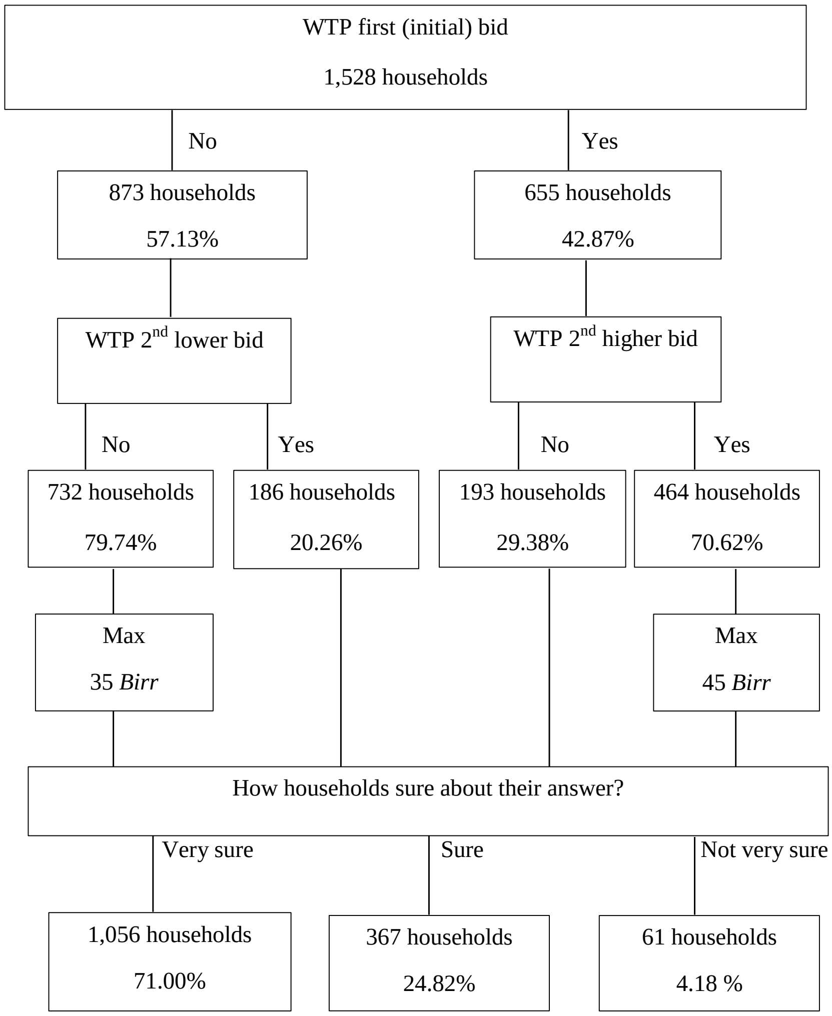
Appendix

Table 9: Double-bounded model result without control variables

Households WTP	Coef.	Std. Err.	z	P > z	95 percent Conf.	Interval
Beta						
Constant	19.000	0.750	25.33	0.000	17.53	20.47
Sigma						
Constant	23.76	1.02	23.16	0.000	21.75	25.77
Number of obs.	=	1522				
Wald chi2(0)	=	.				
Prob > chi2	=	.				
Log likelihood	=	-1816.03				

Source: ERHS 2009

Figure 1: Contingent Valuation Method



Source: ERHS 2009

References

Adesina, A. A. and M. M. Zinnah (1993). Technology characteristics, farmers' perceptions and adoption decisions: A tobit model application in sierra leone. *Agricultural economics 9*(4), 297–311.

Ajayi, A. (2006). An assessment of farmers' willingness to pay for extension services using the contingent valuation method (cvm): The case of oyo state, nigeria. *Journal of Agricultural Education and Extension 12*(2), 97–108.

Amoah, A. and C. Adzobu (2013). Application of contingents valuation method (cvm) in determining demand for improved rainwater in coastal savanna region of ghana, west africa. *Journal of Economics and sustainable development 4*(3).

Asfaw, A. and J. Von Braun (2004). Can community health insurance schemes shield the poor against the downside health effects of economic reforms? the case of rural ethiopia. *Health policy 70*(1), 97–108.

Asfaw, S., F. Di Battista, and L. Lipper (2016). Agricultural technology adoption under climate change in the sahel: Micro-evidence from niger. *Journal of African Economies*.

Asrat, P., K. Belay, and D. Hamito (2004). Determinants of farmers' willingness to pay for soil conservation practices in the southeastern highlands of ethiopia. *Land Degradation & Development 15*(4), 423–438.

Barnett, B. J. and O. Mahul (2007). Weather index insurance for agriculture and rural areas in lower-income countries. *American Journal of Agricultural Economics 89*(5), 1241–1247.

Blumenschein, K., G. C. Blomquist, M. Johannesson, N. Horn, and P. Freeman (2008). Eliciting willingness to pay without bias: evidence from a field experiment*. *The Economic Journal 118*(525), 114–137.

Botzen, W., J. Aerts, and J. C. van den Bergh (2009). Willingness of homeowners to mitigate climate risk through insurance. *Ecological Economics 68*(8), 2265–2277.

Brown, O., A. Hammill, and R. McLeman (2007). Climate change as the 'new'security threat: implications for africa. *International Affairs 83*(6), 1141–1154.

Burke, M., A. de Janvry, and J. Quintero (2010). Providing index-based agricultural insurance to smallholders: Recent progress and future promise. *University of California: Berkeley, CA, USA*.

Calia, P. and E. Strazzera (2000). Bias and efficiency of single versus double bound models for contingent valuation studies: a monte carlo analysis. *Applied economics 32*(10), 1329–1336.

Cameron, T. A. and J. Quiggin (1994). Estimation using contingent valuation data from a" dichotomous choice with follow-up" questionnaire. *Journal of environmental economics and management 27*(3), 218–234.

Carson, R. T., R. C. Mitchell, M. Hanemann, R. J. Kopp, S. Presser, and P. A. Ruud (2003). Contingent valuation and lost passive use: damages from the exxon valdez oil spill. *Environmental and resource economics 25*(3), 257–286.

Carson, R. T., R. C. Mitchell, W. M. Hanemann, R. J. Kopp, S. Presser, P. A. Ruud, et al. (1992). A contingent valuation study of lost passive use values resulting from the exxon valdez oil spill. Technical report, University Library of Munich, Germany.

Carter, M. R., C. B. Barrett, S. Boucher, S. Chantarat, F. Galarza, J. McPeak, A. Mude, and C. Trivelli (2008). Insuring the never before insured: explaining index insurance through financial education games. *Basis Brief 7*, 1–8.

Chestnut, L. G., L. R. Keller, W. E. Lambert, and R. D. Rowe (1996). Measuring heart patients' willingness to pay for changes in angina symptoms. *Medical Decision Making 16*(1), 65–76.

Clarke, D. and G. Kalani (2011). Microinsurance decisions: evidence from ethiopia. *Clarke, DJ DPhil thesis*.

Cohen, M. J. (2006). The demand for microinsurance. In *Protecting the poor: A microinsurance compendium*, Volume 25, pp. 25–44. International Labour Organization (ILO) in association with GSE Research.

Cole, S., X. Giné, J. Tobacman, P. Topalova, R. Townsend, and J. Vickery (2013). Barriers to household risk management: Evidence from india. *American Economic Journal: Applied Economics 5*(1), 104–135.

Croppenstedt, A., M. Demeke, and M. M. Meschi (2003). Technology adoption in the presence of constraints: the case of fertilizer demand in ethiopia. *Review of Development Economics 7*(1), 58–70.

CSA (2015). Crop yield for major grain crops , private small holder farms, main season. Technical report.

D'Alessandro, S. P., J. Caballero, J. Lichte, and S. Simpkin (2015). Agricultural sector risk assessment.

Dercon, S., T. Bold, and C. Calvo (2008). *Insurance for the Poor?* Springer.

Dercon, S. and L. Christiaensen (2011). Consumption risk, technology adoption and poverty traps: Evidence from ethiopia. *Journal of development economics 96*(2), 159–173.

Dismukes, R., J. L. Bird Jr, and F. Linse (2004). Risk management tools in europe: agricultural insurance, futures, and options. *US-EU Food and Agriculture Comparisons. Mary Anne Normile and Susan E. Leetmaa*, 28.

Donaldson, C., H. Mason, and P. Shackley (2006). Contingent valuation in health care. *The Elgar companion to health economics*, 392.

Dong, H., B. Kouyate, J. Cairns, and R. Sauerborn (2004). Differential willingness of household heads to pay community-based health insurance premia for themselves and other household members. *Health Policy and Planning 19*(2), 120–126.

Falco, S. D., F. Adinolfi, M. Bozzola, and F. Capitanio (2014). Crop insurance as a strategy for adapting to climate change. *Journal of Agricultural Economics 65*(2), 485–504.

Falola, A., O. E. Ayinde, B. O. Agboola, et al. (2013). Willingness to take agricultural insurance by cocoa farmers in nigeria. *International Journal of Food and Agricultural Economics 1*(1), 97–107.

Feder, G., R. E. Just, and D. Zilberman (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change 33*(2), 255–298.

Fraser, R. W. (1992). An analysis of willingness-to-pay for crop insurance*. *Australian Journal of Agricultural Economics 36*(1), 83–95.

Giné, X., R. Townsend, and J. Vickery (2008). Patterns of rainfall insurance participation in rural india. *The World Bank Economic Review 22*(3), 539–566.

Goodwin, B. K. and V. H. Smith (1995). *The economics of crop insurance and disaster aid.* American Enterprise Institute.

Green, D. A. and D. Ng'ong'ola (1993). Factors affecting fertilizer adoption in less developed countries: An application of multivariate logistic analysis in malaŵi. *Journal of Agricultural Economics 44*(1), 99–109.

Gustafsson-Wright, E., A. Asfaw, and J. van der Gaag (2009). Willingness to pay for health insurance: An analysis of the potential market for new low-cost health insurance products in namibia. *Social Science & Medicine 69*(9), 1351–1359.

Haab, T. C. and K. E. McConnell (2002). *Valuing environmental and natural resources: the econometrics of non-market valuation.* Edward Elgar Publishing.

Hanemann, M., J. Loomis, and B. Kanninen (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American journal of agricultural economics 73*(4), 1255–1263.

Hill, R. V., J. Hoddinott, and N. Kumar (2013). Adoption of weather-index insurance: learning from willingness to pay among a panel of households in rural ethiopia. *Agricultural Economics 44*(4-5), 385–398.

Hill, V. (2010). Agricultural insurance in sub-saharan africa: Can it work. In *communication présentée au symposium politique du quatrième programme sur les marchés agricoles en Afrique (AAMP)*, pp. 6–10.

Holden, S. T. and B. Shiferaw (2002). Poverty and land degradation: Peasants' willingness to pay to sustain land productivity. *Natural resource management in African agriculture: Understanding and improving current practices*.

Holloway, G. J. and S. K. Ehui (2001). Demand, supply and willingness-to-pay for extension services in an emerging-market setting. *American Journal of Agricultural Economics*, 764–768.

Iturrioz, R. (2009). Agricultural insurance. Technical report.

Kanninen, B. J. (1993). Optimal experimental design for double-bounded dichotomous choice contingent valuation. *Land Economics*, 138–146.

Kassie, M. and S. Holden (2007). Sharecropping efficiency in ethiopia: threats of eviction and kinship. *Agricultural Economics 37*(2-3), 179–188.

Le, T. C. and F. Cheong (2009). Measuring risk levels and efficacy of risk management strategies in vietnamese catfish farming'. pp. 23–25.

Lobell, D. B., M. B. Burke, C. Tebaldi, M. D. Mastrandrea, W. P. Falcon, and R. L. Naylor (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science 319*(5863), 607–610.

Lybbert, T. J., F. Galarza, J. G. McPeak, C. B. Barrett, S. R. Boucher, M. R. Carter, S. Chantarat, A. Fadlaoui, and A. G. Mude (2010). Dynamic field experiments in development economics: Risk valuation in morocco, kenya and peru. *Agricultural and Resource Economics Review 39*(2), 176–192.

Marra, M., D. J. Pannell, and A. A. Ghadim (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve? *Agricultural systems 75*(2), 215–234.

McLeod, D. M. and O. Bergland (1999). Willingness-to-pay estimates using the double-bounded dichotomous-choice contingent valuation format: a test for validity and precision in a bayesian framework. *Land Economics*, 115–125.

Meuwissen, M. P., R. Huirne, and J. R. Skees (2003). Income insurance in european agriculture. *EuroChoices 2*(1), 12–17.

Miller, A., C. Dobbins, J. Pritchett, M. Boehlje, and C. Ehmke (2004). Risk management for farmers. *Staff paper*, 04–11.

Mishra, A. K. and B. K. Goodwin (2003). Adoption of crop versus revenue insurance: a farm-level analysis. *Agricultural Finance Review 63*(2), 143–155.

Mojarradi, G., G. Zamani, and K. Zarafshani (2008). Analysis of factors influencing farmers' attitude toward private crop insurer using path analysis. *Americ.-Eurasian J. Agric. Environ. Sci 3*, 247–2552.

Nhemachena, C. and R. Hassan (2007). *Micro-level analysis of farmers adaption to climate change in Southern Africa*. Intl Food Policy Res Inst.

Phélippé-Guinvarc'h, M. V. and J. E. Cordier (2006). A private management strategy for the crop yield insurer: A theoretical approach and tests. *Insurance: Mathematics and Economics 39*(1), 35–46.

Power, N. (2008). *Farm-level Adaptation to Climatic Variability and Change: Nova Scotia Farmers' Perceptions, Risks, and Response Strategies*. ProQuest.

Qaim, M. and A. De Janvry (2002). Bt cotton in argentina: Analysing adoption and farmers' willingness to pay. In *American Agricultural Economics Association annual meeting, Long Beach, CA*.

Ramasubramanian, J. A. (2012). Willingness to pay for index based crop insurance in india. *DPhil candidate (Economics), University of Sussex, United Kingdom.*

Reynolds, M. P. (2010). *Climate change and crop production*, Volume 1. CABI.

Roberts, R. A. (2005). *Insurance of crops in developing countries*, Volume 159. Food Agriculture Organization.

Rosema, A., J. van Huystee, S. Foppes, J. van der Woerd, E. Klaassen, J. Barendse, M. van Asseldonk, M. Dubreuil, S. Régent, S. Weber, et al. (2014). Fesa micro-insurance: Crop insurance reaching every farmer in africa. scientific final report. Technical report, EARS Earth Environment Monitoring.

Rosenzweig, C., M. L. Parry, et al. (1994). Potential impact of climate change on world food supply. *Nature 367*(6459), 133–138.

Salimonu, K. and A. Falusi (2009). Sources of risk and management strategies among food crop farmers in osun state, nigeria. *African Journal of Food, Agriculture, Nutrition and Development 9*(7).

Simtowe, F. and M. Zeller (2006). The impact of access to credit on the adoption of hybrid maize in malawi: An empirical test of an agricultural household model under credit market failure.

Singh, S., K. M. Singh, R. Singh, A. Kumar, and U. Kumar (2014). Impact of rainfall on agricultural production in bihar: A zone-wise analysis. *Environment & Ecology 32*(4A), 1571–1576.

Skees, J. R., J. Harwood, A. Somwaru, and J. Perry (1998). The potential for revenue insurance policies in the south. *Journal of Agricultural and Applied Economics 30*(1), 47.

Spiewak, R. (1994). Farm stressors: the hazards of agrarian life. *life 1*, 23–27.

Tambo, J. A. and T. Abdoulaye (2012). Climate change and agricultural technology adoption: the case of drought tolerant maize in rural nigeria. *Mitigation and Adaptation Strategies for Global Change 17*(3), 277–292.

UN (2015). United nation agency.

UNUDP (2015). Key economic and social indicators.

Watson, V. and M. Ryan (2007). Exploring preference anomalies in double bounded contingent valuation. *Journal of health economics 26*(3), 463–482.

Wenner, M. and D. Arias (2003). Agricultural insurance in latin america: Where are we? In *International Conference: Paving the Way Forward for Rural Finance*, pp. 2–4.

Whittington, D. (2002). Improving the performance of contingent valuation studies in developing countries. *Environmental and resource economics 22*(1-2), 323–367.

World Bank (2013). The agricultural insurance development program (aidp). Technical report.

World Bank (2015). Agricultural risk management. Technical report.

Yazdanpanah, M., G. H. Zamani, S. Hochrainer-Stigler, N. Monfared, and J. Yaghoubi (2013). Measuring satisfaction of crop insurance a modified american customer satisfaction model approach applied to iranian farmers. *International Journal of Disaster Risk Reduction 5*, 19–27.

Yesuf, M. and R. Bluffstone (2008). Risk aversion in low-income countries: Experimental evidence from ethiopia. Technical report, International Food Policy Research Institute (IFPRI).

The UNU-MERIT WORKING Paper Series

2017-01 *The economic impact of East-West migration on the European Union* by Martin Kahanec and Mariola Pytliková

2017-02 *Fostering social mobility: The case of the 'Bono de Desarrollo Humano' in Ecuador* by Andrés Mideros and Franziska Gassmann

2017-03 *Impact of the Great Recession on industry unemployment: a 1976-2011 comparison* by Yelena Takhtamanova and Eva Sierminska

2017-04 *Labour mobility through business visits as a way to foster productivity* by Mariacristina Piva, Massimiliano Tani and Marco Vivarelli

2017-05 *Country risk, FDI flows and convergence trends in the context of the Investment Development Path* by Jonas Hub Frenken and Dorcas Mbuvi

2017-06 *How development aid explains (or not) the rise and fall of insurgent attacks in Iraq* by Pui-Hang Wong

2017-07 *Productivity and household welfare impact of technology adoption: Micro-level evidence from rural Ethiopia* by Tigist Mekonnen

2017-08 *Impact of agricultural technology adoption on market participation in the rural social network system* by Tigist Mekonnen

2017-09 *Financing rural households and its impact: Evidence from randomized field experiment data* by Tigist Mekonnen

2017-10 *U.S. and Soviet foreign aid during the Cold War: A case study of Ethiopia* by Tobias Broich

2017-11 *Do authoritarian regimes receive more Chinese development finance than democratic ones? Empirical evidence for Africa* by Tobias Broich

2017-12 *Pathways for capacity building in heterogeneous value chains: Evidence from the case of IT-enabled services in South Africa* by Charlotte Keijser and Michiko Iizuka

2017-13 *Is innovation destroying jobs? Firm-level evidence from the EU* by Mariacristina Piva and Marco Vivarelli

2017-14 *Transition from civil war to peace: The role of the United Nations and international community in Mozambique* by Ayokunu Adedokun

2017-15 *Emerging challenges to long-term peace and security in Mozambique* by Ayokunu Adedokun

2017-16 *Post-conflict peacebuilding: A critical survey of the literature and avenues for future research* by Ayokunu Adedokun

2017-17 *Effects of health insurance on labour supply: A systematic review* by Nga Le, Wim Groot, Sonila M. Tomini and Florian Tomini\

2017-18 *Challenged by migration: Europe's options* by Amelie F. Constant and Klaus F. Zimmermann

2017-19 *Innovation policy & labour productivity growth: Education, research & development, government effectiveness and business policy* by Mueid Al Raee, Jo Ritzen and Denis de Crombrugghe

2017-20 *Role of WASH and Agency in Health: A study of isolated rural communities in Nilgiris and Jalpaiguri* by Shyama V. Ramani

2017-21 *The productivity effect of public R&D in the Netherlands* by Luc Soete, Bart Verspagen and Thomas Ziesemer

2017-22 *The role of migration-specific and migration-relevant policies in migrant decision-making in transit* by Katie Kuschminder and Khalid Koser

2017-23 *Regional analysis of sanitation performance in India* by Debasree Bose and Arijita Dutta

2017-24 *Estimating the impact of sericulture adoption on farmer income in Rwanda: an application of propensity score matching* by Alexis Habiyaremye

2017-25 *Indigenous knowledge for sustainable livelihoods: Lessons from ecological pest control and post-harvest techniques of Baduy (West Java) and Nguni (Southern Africa)* by Leeja C Korina and Alexis Habiyaremye

2017-26 *Sanitation challenges of the poor in urban and rural settings: Case studies of Bengaluru City and rural North Karnataka* by Manasi Seshaiah, Latha Nagesh and Hemalatha Ramesh

2017-27 *Heterogeneous effects of bilateral investment treaties* by Rod Falvey and Neil Foster-McGregor

2017-28 *Willingness to pay for agricultural risk insurance as a strategy to adapt climate change* by Tigist Mekonnen