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Does willingness-to-pay for weather index-based insurance follow covariant shocks?

Abstract

Purpose – The purpose of this paper is to investigate the role that weather shocks can play in the livestock mortality microinsurance take-up when the insured risk has a prevalent covariant component.

Design/Methodology/Approach – The sample consists of 360 rural Ethiopian households. Data were collected in a panel-structure at the end of three agricultural seasons (2011-2013). In the questionnaire, a specific section on insurance was meant to collect information on the farmer's willingness-to-pay (WTP) for a set of insurance products, including livestock mortality insurance. Two OLS regression models and a quantile regression model are employed to estimate the impact of weather anomalies on the WTP for the insurance product.

Findings - We find that weather anomalies contribute to changes in the WTP to a large extent. Negative (positive) changes in precipitation (temperature) anomalies can lead to more than a 30% reduction in the WTP. This general finding is complemented with the analysis of the conditional distribution of the WTP which shows that other elements can prevail for low values of the conditional distribution. In this case, the WTP seems to be explained more by the interviewee's age and basic knowledge of insurance, and village fixed-effects. Basic knowledge of insurance, in particular, can increase WTP by about 60%.

Practical implications - This paper has straightforward implications from a policy perspective. It suggests that farmers would prefer an insurance premium that follows the changes in the systemic component. On the contrary, insurance as well as reinsurance

companies are usually reluctant to frequently revise their premiums. Financial education programs, farmer-driven design, trust building, and bundling insurance with other financial and non-financial products can increase the value proposition perceived by the farmers. From a marketing perspective, the overall findings suggest that continuous fine tuning of the contract, transparency, and targeted information campaigns can contribute to increase and stabilize potential customers' WTP.

Originality/value – To the best of our knowledge, this is the first paper that considers the impact of weather shocks on the WTP for a livestock mortality insurance product. Livestock is one of the most strategic assets of poor rural households in Africa. This study contributes to the theoretical and empirical literature on the determinants of weather insurance take-up in developing countries and, in particular, the role of spatiotemporal adverse selection and basis risk (e.g. Jensen et al., 2016).

1. Introduction

Incomplete and inefficient financial markets prevent rural households in developing countries from optimally dealing with risk. In particular, formal risk transfer mechanisms and insurance markets are mostly non-existent in rural areas (Dercon, Ed., 2004), and households rely on a set of informal risk management and risk coping strategies (e.g. Fafchamps, 1999; Mosley, 2001; Skees et al., 2002; Skees, 2003; Hoogeveen et al., 2004; Dercon, Ed., 2004). As compared to informal risk management strategies, life, health or casualty formal insurance may represent an effective risk management tool provided that basic conditions for implementation are met. Obstacles to the development of insurance markets in developing countries descend from classical critical issues in insurance contracts: covariant risks, adverse selection, moral hazard, high transaction costs and contract enforcement. These issues are further more relevant in poor economic environments.

This paper deals with the livestock microinsurance demand in an African country. In Africa, despite recent optimistic views on the growth potential for insurance (Financial Times, 2016), the limited penetration of insurance is still evident. KPMG (2014) reports that, in 2012, while in terms of penetration rate (Gross Insurance Premiums -GIPs- over GDP) Africa is below the global average (3.56% as compared to 6.5%) but not at the bottom of the list, the insurance density (GIPs per capita) in Africa is the lowest (66.4 USD compared to a world average of 655.7 USD), with South Africa, Namibia, Mauritius and Botswana considerably pushing upwards this average. In 2013 the insurance density decreased further (64.4 USD, and 17.7 USD excluding South Africa) (KPMG, 2015).

Microinsurance can be considered as a hybrid case between formal and informal insurance since it is offered by commercial insurers through formal, semi-formal or even informal providers, such as microfinance organizations, NGOs, or local groups and networks. As these providers are physically and socially closer to the potential customers, they are hence expected to achieve a

greater outreach than traditional formal intermediaries. However, although size is a less relevant limiting factor in microinsurance transaction, growth is constrained by lack of information technology and high administration costs. Microinsurance outreach is indeed still low and very far from its potential. Matul et al. (2010) estimate that the target African population is minimally reached by microinsurance products (2.6% in terms of population and 1% in terms of GIPs,) as compared to the potential values. Recent data provided by Munich Re Foundation and the Micro Insurance Centre (MIC, 2016), based on a survey of 200 microinsurance providers in 36 African countries, show an increasing, but still limited, overall coverage in 2015 (5.4% of the population), with a prevalence of life insurance (46.4% of total microinsurance clients).

Critical points in the development of insurance markets as well as microinsurance in Africa include the customers' understanding of the product, the lack of transparency, and the mismatch between offered and demanded contractual conditions (Castellani et al., 2014; Matul et al., 2010). The types of risk insured influence the understanding of insurance products and, at the same time, the capacity of insurers to offer suitable solutions. For example, the predominance of life insurance in Africa and the rapid growth of the life microinsurance market in recent years (see, among others, the experience in Ghana as described in Churchill and Matul, 2012) are explained by a limited presence of asymmetric information problems, a greater capacity of risk assessment (statistics of life expectancy are increasingly reliable), and the possibility to bundle the life insurance with other financial products (e.g. credit life insurance). On the contrary, casualty insurance still represents a challenge, especially when risks are weather-related and so with a major covariant component. This is particularly the case for agricultural insurance. KPMG (2015) finds an overall very low access to agricultural insurance in Africa and the Middle East (6% of the population). The incidence is even more reduced if we consider the outreach to smallholder farmers. Matul et al. (2010) argue that agriculture microinsurance covers only 0.1% of the potential market in Africa. MIC (2015) finds a growing but still weak agricultural microinsurance penetration rate of 1.1% (including government subsidized programs).

Over the last two decades, to deal with the problems of moral hazard, high transaction costs, high loss adjustment expenses and covariance in agricultural insurance, many initiatives have focused on the development of index-based insurance schemes. Index-based insurance entails that losses are estimated according to the performance of parameters beyond the control of the policyholders. In agricultural index-based insurance, the weather index has a statistically significant correlation with crop yields or livestock mortality. As further explained in the section below, these products seem quite promising for their specific characteristics. However, take-ups are still meagre and volatile. The low take-up rate seems to be mainly related to the product design that follows from a poor knowledge of the demand (Brown, 2001; Matul et al., 2010).

The literature on the demand for index-based insurance in developing countries is quite vast but still not conclusive. This study aims to contribute to the literature by looking at a specific driver of the willingness to pay (WTP) for weather-related microinsurance in poor countries. In particular, we are interested in the role that common shocks can play in the insurance take-up when the insured risk has a prevalent covariant component such as in agricultural insurance. The simple intuition is that when common shocks occur, all potential policy holders, at the same time, perceive an increasing risk. This leads to a general increase in the WTP for insurance. On the other hand, when there are no common shocks or the effects of shocks are sufficiently limited, WTP decreases. Even though this behavior can be expected, we believe that from a policy perspective, it is important to analyze to what extent covariant shocks drive WTP. Results can contribute to the understanding of why the demand for weather index-insurance is low and, in particular, volatile. We tested our hypothesis with data from an experiment with oxen mortality insurance in rural Ethiopia. We chose to focus on livestock insurance because of the still limited number of experiences and studies on it in developing countries, and the important role of livestock raising in the livelihood of small-holder farmers in Africa. As compared to crop insurance which is a zero-sum game (i.e. it protects against an income risk), livestock insurance cover potential asset losses, where livestock, and assets in general, are at the base of future income generation (Chantararat et al., 2013). We find that negative

weather anomalies have a relevant depressing effect on the WTP for oxen mortality insurance. A one-standard deviation in a weather anomaly can reduce the WTP by more than one third. Combined weather anomalies can have an even larger negative effect on the WTP. These findings have straightforward implications for the design of a real livestock index-insurance scheme.

The remaining part of the paper is organized as follows: section 2 reviews the literature and discusses the main drivers of the willingness to pay for index-based insurance; section 3 deals with the Ethiopian insurance sector, presents the main experiences with index-based insurance, and provides motivations for the development of a livestock insurance market; section 4 offers examples of index-based livestock insurance in developing countries; sections 5 and 6 describe the data, the insurance experiment, and the empirical approach; section 7 discusses the results; and section 8 concludes the paper.

2. Factors affecting the demand for index based insurance

The most common types of index-based insurance contracts are linked to weather indicators (such as precipitation, temperature, wind speed, vegetation greenness) as well as average area yield and average area livestock mortality indexes. In the two latter cases, average (crop or livestock) losses in a given area are estimated; and compensations are paid to policy holders when the average loss or mortality rate is beyond a given threshold. The link of the compensation to an objective measure, not directly related to individual performance, reduces asymmetric information problems, transaction costs, and claim assessment costs. However, index-based insurance is more subject to basis risk which occurs when the triggered amount of compensation is either larger or smaller than the loss suffered by the policy holder. This can happen because payments are based on the index realizations and not on the actual losses incurred by the policy holder (Skees, 2003; Castellani, 2015).

The literature has identified several factors that affect the WTP for agricultural insurance and, in particular, index-based insurance in developing countries (see Figure 1). The first group of

factors affecting WTP relates to technical elements. On the one side, the households' technical characteristics matter. Hill and Robles (2011) find that Ethiopian farmers with poorer soil quality buy more insurance. Sakurai and Reardon (1997) stress that the demand for drought insurance in Burkina Faso differs according to the agro-climatic zone. Furthermore, the nature and types of different disaster risks are also important factors in the insurance participation decision. We contribute to this stream of literature by considering the impact of an increasing perceived systemic risk exposure on WTP.

[FIGURE 1 HERE]

A second set of factors that explain the WTP is connected with the economic and financial characteristics of a household which affect its risk management strategies. In the case of the Australian wheat industry, an old study by Fraser (1992) finds that WTP is relatively insensitive to price volatility but strongly positively related to yield variability. Akter et al. (2009) state that the crop insurance demand in Bangladesh varies according to farmers' risk management strategies, land holdings and ownership, the household head's occupation, and farm size. Gautam et al. (1994), in their study in Tamil Nadu (India), empirically test for the joint hypothesis of risk avoidance and welfare smoothing, with the aim of studying the latent demand due to inadequate risk management strategies. Their results prove that the demand is high. Sakurai and Reardon (1997) show that wealthier, more self-insured farmers demand less formal drought insurance. Negative significant effects of off-farm income and livestock holdings on the demand for formal insurance emerge because both allow the implementation of self-insurance mechanisms and diversification. Nevertheless, this depends on the wealth stratum of the sample analyzed; for example, in the upper wealth stratum, neither off-farm income nor livestock holdings have a significant effect on farmers who are better-off. The effects of wealth on WTP can indeed be ambiguous. Patrick (1988), in a study on rainfall insurance for Australian wheat producers, finds that higher rainfall insurance premiums (higher WTP) are positively associated with greater land holdings and with more conservative farmers; whereas higher levels of net worth are positively associated with lower

premiums. Asset accumulation increases the farmer's capacity to absorb income shocks and can then reduce incentives to use insurance; however, greater asset holdings can induce farmers to take risky investment decisions and, as a consequence, to buy insurance. Akter et al. (2009), in areas of Bangladesh exposed to different types of natural hazards, find a positive relationship between land holdings and insurance. Greater land extension may not necessarily lead to better diversification; and households that depend primarily on crops for their livelihood have a greater demand for crop insurance. Clarke and Kalani (2011) also show that the relationship between WTP for insurance and wealth is not linear. They discover that Ethiopian farmers with intermediate wealth levels have the highest take-up ratio. This finding suggests that very low-wealth farmers have nothing at stake and do not need to insure, while very high-wealth farmers have access to effective risk management strategies and would not benefit from weather index insurance (Castellani et al., 2013).

Similar to wealth, cash holdings can also have contradictory roles depending on how cash is generated. Cole et al. (2013) show that the insurance demand by farmers in Andhra Pradesh and Gujarat (India) is extremely sensitive to cash on hand, since more cash implies higher purchasing power. On the other hand, credit constraints limiting cash availability appear to be an impediment to the purchase of insurance as portrayed by Giné et al. (2008) in India. However, being already indebted can negatively affect the WTP for insurance if cash is to be used to repay the loan. In several index-based insurance schemes, cash is provided also by donors as initial endowments or, indirectly, as cost saving, i.e. discounts on the premium. When cash is made available by donors, demand distortions may take place. Sarris (2013), based on different studies analyzed, points out that subsidies or initial endowments distort the results of experiments because they become the main driver that induces farmers to subscribe to insurance. Sakurai and Reardon (1997) find that even other forms of subsidies, in terms of public food aid, imply moral hazard effects and have a significant negative effect on the demand for drought insurance and discourage self-insurance as well.

The behavioral, psychological, and cognitive characteristics of farmers are also important drivers of WTP. Trust is found to be a relevant factor in financial decisions across cultures, not only in traditional communities. For example, trust affects internet banking access decision in Jordan (Alalwan et al., 2015) and customer satisfaction may be affected by the relevant cultural background (Parahoo et al., 2015). In rural areas, Patt et al. (2009) stress that emotions—self-confidence and trust in the product and suppliers can matter most in the insurance take-up decision. This suggests that customer satisfaction can be more important than optimal risk coverage. A farmer’s attitude toward risk is one of the key behavioral factors. Hill et al. (2013) confirm a positive relationship between perceived risk exposure and WTP for insurance. However, a negative correlation between risk aversion and WTP is found, under specific conditions, by Hill et al. (2013) in a sample of Ethiopian farmers. Giné et al. (2008), in India, find that risk-averse households are less likely to purchase only if unfamiliar with the insurance contract or with the supplier¹. Fraser (1992) finds that lack of knowledge coupled with risk aversion can reduce the farmers’ WTP.

Based on the previous findings, marketing strategies and the identification of distribution channels should consider individual, household, and geographical characteristics. The type of distribution channel as well as the strategy for offering insurance makes a difference, both in terms of accessibility and potential customer’s understanding and trust. In this respect, Cole et al. (2013) observe, in India, a positive influence on WTP generated by the association of the insurance product with individuals or symbols (for example, religious ones) that the household trusts; when local individuals that are trusted by the community endorse the contract, the probability of others to buy the contract increases by 40%. Cole et al. (2013) notice that sale strategies, such as marketing visits, can help to build trust and knowledge about the product, whereas other “subtle marketing treatments” have no statistically significant effect on insurance participation. This result is supported by Hill and Robles (2011) who analyze the impact of visits from extension agents on

¹ In India, Paluri and Mehra (2016) studied women’s attitude towards financial products based on variables reflecting their behavioral, cognitive and psychological characteristics. Interest in financial matters is the most relevant factor affecting choices concentrated on savings and insurance policies.

program participation. A study on motor insurance in Thailand (Chupun et al., 2016) finds that, in order to start a mobile claim system, external factors such as preference for face-to-face contact may affect the acceptance of such service. Along with marketing strategies, social groups involvement is also important; potential customers seem to be more likely to participate if they subscribe to the contract as a group. Hill et al. (2013) find in Ethiopia that group insurance can make individuals decide to subscribe to a contract that they would not buy individually². They observe that this behavior is more likely among those people who have more difficulty in understanding the contracts (such as less educated women). However, this is not the case when the trust level in the community is generally low.

Financial education is considered a key element of financial products promotion, and may be adapted in the so-called contextualized approach (Brimble and Blue, 2013). However, it may have controversial effects on WTP. Knowledge and understanding of products are explored by Akter et al. (2009), who find that greater familiarity with insurance (related to education) makes purchases more likely. Giné et al. (2008), show that understanding of the contract (by the young, for example) as well as advice from others increases WTP, but do not find a significant correlation between education and take-up. Cole et al. (2013) confirms that the provision of a small amount of additional financial education is not statistically significant in modifying WTP, as a consequence of a sufficient education level in the sample or of too low an education level. On the contrary, Hill et al. (2013) explain higher take ups by the young with a higher level of education. Patrick (1988) shows a different perspective as he finds that education is negatively correlated with take-up and suggests that a high education level can lead to low risk aversion. Similarly, Jensen et al. (2016) find a negative relationship between take-ups and education (experimental knowledge about the product) when basis risk increases. In this paper, besides considering the role of common shocks, we also focus on the role of education and, in particular, on the *ex-ante* customer's knowledge of

² In a study on Korea and Taiwan, Hong and Lee (2012) find that cross-cultural values, such as “collectivism”, can affect customers' attitude towards banking services, as they affect factors such as trust and satisfaction.

insurance. We find that financial education is more important than farmer's literacy. Farmers without an *ex-ante* knowledge of insurance are barely willing to pay as they may not understand the value proposition of an insurance product.

The complexity of the contractual conditions of index-based insurance (price, maturity, delivery method, index, trigger, and threshold) requires a huge effort by prospective customers to fully understand the product design. According to Dalal and Morduch (2010), small adjustments to the microinsurance scheme can allow the potential customer to better understand the product and increase the WTP. Dalal and Morduch (2010) recommend taking the context into account, keeping the product simple, and making potential customers aware of the value proposition. They suggest also that traditional marketing strategies can be applied in the supply of microinsurance. The contractual conditions directly affect the WTP, and their effect is often combined. Cole et al. (2013), state that the demand can be barely reactive to the price per se, but to the combination of the price and other product characteristics, such as the type of index.

In particular, contractual conditions and product design are at the origin of potential basis risk (Hill et al., 2013). Fuchs and Wolff (2011), empirically prove this in a study on weather index insurance in Mexico; they find that basis risk is one of the major problems in product design and they stress the importance of setting suitable thresholds to trigger the insurance compensation. In a pilot study in Ethiopia by Volpi (2005), farmers explicitly express the fear of a low correlation between rainfall patterns at the weather station and rainfall patterns at their farms. A recent study on Kenya (Jensen et al., 2016) confirms that the demand is negatively related with basis risk, especially among purchasers of index-based insurance with better understanding of the product. They provide evidence that the effects of spatiotemporal adverse selection and basis risk prevail over other factors such as price or households' characteristics. Jensen et al. (2016) suggest that demand seems to increase in response to signals of coming covariate shocks.

Similar to the study by Jensen et al. (2016), we also want to contribute to understand how common shocks affect the demand for index-based insurance. However, whereas Jensen et al.

(2016) analyze the demand in a real index-based livestock insurance scheme, we implement an experiment with a sample of rural Ethiopian farmers and we estimate the impact of common shocks on their WTP, that is the price that they would pay, for a hypothetical livestock insurance product.

3. Insurance Markets in Ethiopia and the Case for Index-based Livestock Insurance

The insurance sector in Ethiopia has experienced dramatic development over the last decade. Between 2004 and 2015, the number of insurance companies increased from 9 to 17 and the number of branches from 133 to 377 (NBE, 2005; NBE, 2015). In the same period the overall capital of the insurance companies increased by about 6.6 times. The bulk of branches (82.5%) and capital (77.6%) belongs to the private sector. Despite the recent advances, the Ethiopian insurance sector is still underdeveloped and the operational outreach is almost completely limited to the main urban areas. Although the percentage is decreasing, 47% of branches are located in the capital city (NBE, 2015).

The resistance of the formal insurance suppliers to expand into rural areas is related to logistical obstacles, high transaction costs, and to the difficulty in properly assessing risk and making actuarial analysis. Constraints on the demand side derive from difficulties in fully understanding complex insurance contracts, from the awareness of being exposed to multiple perils, and high expected transaction costs sometimes coupled with basis risk (Volpi, 2005; Castellani, 2015). Despite all these, however, there seems to be a sizeable latent unmet demand for insurance expressed by small and micro-scale Ethiopian farmers (Viganò, ed., 2007).

In contrast to the insurance sector, the microfinance sector is quite developed, with 35 Microfinance Institutions (MFIs) operating as of 2016 (AEMFI, website), an increasing capital base, and an exceptional growth in total assets, deposits and outstanding loans portfolios (NBE 2015). While MFIs are currently the main providers of formal financial services in Ethiopian rural areas, the MFIs' supply of insurance products is still meagre and basically limited to life insurance.

In the absence of formal insurance mechanisms, rural Ethiopian households developed alternative informal solutions to deal with risk. Group-based arrangements that provide informal financial services are widespread in Ethiopia: *Iqqub*, a kind of ROSCA (Rotating Savings and Credit Association) and *Iddir*, a local insurance mechanism. *Iddir*, in particular, is commonly meant to provide life insurance and cover funeral expenses but also unexpected health expenses, fire, or livestock mortality (oxen insurance). Ethiopian smallholder farmers often establish labor exchange

arrangements in order to reduce crop failure risk due to rainfall volatility (Dejene, 1993, 2003, 2004a, 2004b). Informal arrangements do offer some advantages to farmers, but they however suffer from several limitations such as a restricted range of services, the lack of flexibility and, in particular, the exposure to covariant risks.

In the last two decades, in order to provide formal instruments to deal with covariant risks, the public and private insurance sectors have collaborated with international development agencies to design and implement several weather index-based insurance schemes intended for Ethiopian small-holder farmers. Among the earliest initiatives is the Ethiopian Project on Interlinking Insurance with Credit in Agriculture (EPIICA) offered by Nyala Insurance Company (NISCO) and Dashen Bank in Amhara region (McIntosh, 2013). Araya (2011) describes several index-insurance programs in Ethiopia. A macro-level weather derivative program against drought risk developed by the World Food Program (WFP), allowed the Government of Ethiopia to buy coverage by AXA Re in 2006 in order to obtain eventual financial resources for food aid. A product developed by the World Bank in 2008 is offered by the Ethiopian Insurance Corporation (EIC). Other programs described in Araya (2011) are the pilot Double Trigger Multiple Peril Crop Insurance (DTMPCI) and Weather Index Crop Insurance in the frame of the R4 Rural Resilience Initiative (R4-RRI), both offered by NISCO. The former is an area yield insurance scheme started in 2007 in Oromia State; the latter started in 2009 and was developed by OXFAM America and WFP in the Tigray and Oromia regions, then extended in the South and in Amhara Region. It consists of four components: insurance, credit, savings and the promotion of risk-reduction strategies. The insurance product is bundled with credit. Premiums are highly subsidized but partially paid by the farmers as a deduction from the cash that they would receive in the cash-for-work program of the Ethiopian Government. Araya (2010) points out the low take-up ratio of these programs so far with the exception of the R4-RRI. The number of insured farmers has increased from 200 in 2009 to more than 29,000 in 2016 (R4 Rural Resilience Initiative, 2016).

The decision to focus this study on the potential WTP for oxen insurance is justified by the importance of livestock for rural households in Ethiopia. Recent NBE (2015) statistics show that the animal farming and hunting sector contributes to one fifth of the primary sector and to one quarter of the GDP growth. After a reduction in 2013-2014, the growth rate of the livestock-related activities increased to 4.7% in 2014-15, but still lower than 5.2% in 2012-2013. Continuous growth in this sector would be vital for the livelihood of many rural Ethiopian households.

A pair of oxen is the main draft power of Ethiopian smallholder farmers and the number and size of oxen is also perceived as a measure of household status.³ During plowing periods, farmers lend oxen to each other through oxen sharing arrangements. When a household is very low-income and cannot afford to buy a whole ox, the ox is bought with other households and ownership is so shared. Oxen are also the main source of meat but, apart from the *Meskel* feast in September, rural Ethiopian households rarely consume any meat during the rest of the year. However, cattle raising is often a complementary source of cash income when animals are bought to be fattened and sold. Overall, oxen, and livestock in general, are considered as an investment of the household's savings. This is motivated further by the presence of incomplete and inefficient financial markets: most of households borrow or save through informal actors or invest in real assets.⁴ However, livestock is also a risky investment, due to epidemics and drought shocks.

Local livestock markets are incomplete and inefficient because they are tiny and dispersed. The price of oxen is therefore variable and spurious. When some localized systemic shocks, such as drought or low-rainfall, occur, the price can drastically go down implying remarkable liquidity costs. In fact, foraging difficulties (Heady et al. 2014) could reduce the animal's weight and lead the household to purchase extra food and sell livestock at a low price, which also weakens the possibility to sell or lend the related labor (Viganò, Ed., 2007)⁵. Thus, oxen appear to be a good

³ For example, during the interviews, many farmers stated that they were poor because they had no or few oxen.

⁴ According to our data, only 15-20% of households are a client of a formal financial institution and the drop-out ratio is also high.

⁵ However, when the effects of the shock are over, the price of surviving oxen can increase due to a lower density of the oxen population.

buffer against idiosyncratic shocks, but can barely protect against systemic shocks. As stressed in this paper, a mechanism to transfer the implied systemic risk can be through an index-based livestock insurance scheme. Viganò (Ed., 2007) reports the awareness of Ethiopian insurance companies about the prevailing need to insure crops and cattle, but still at present such contracts are barely offered to remote rural areas.

4. Examples of Index-Based Livestock Insurance Schemes

Pilot projects as well as real schemes of index-based livestock insurance are still limited in number but are increasing all over the world. In Africa, a study by Chantarat et al. (2013) presents a pilot project of an index-based livestock insurance product intended for pastoralists in Northern Kenya, implemented by the International Livestock Research Institute (ILRI), in collaboration with Cornell University and the University of California, Davis. The project is developed in partnership with insurance and reinsurance companies and NGOs. The insurance scheme focuses on drought risk. It aims to be viable even in very difficult logistic conditions with little communication and transport facilities, and with limited data on livestock mortality (Greatrex et al., 2015). A Normalized Difference Vegetation Index (NDVI) was built upon satellite-based data and correlated with forage availability, then calibrated with livestock mortality data. The NDVI is used to predict herd mortality rate and cluster analysis is applied to identify locations with similar characteristics. Out-of-sample forecasting performance evaluation shows that the index performs very well in comparison with other indexes, and that index-based livestock insurance is effective in protecting specifically against catastrophic losses (Chantarat et al., 2013). Clients are allowed to choose the risk protection level. Several positive impacts of the purchase of insurance have been recorded (reduced asset sale, consumption smoothing, increased savings and reduction in mortality risk). The project was launched in three regions of Northern Kenya. It was then extended to one region in Southern Ethiopia. Almost 4,000 pastoralists have been reached over the life of the project

(Greatrex et al., 2014). The Kenyan project is used by Jensen (et al., 2016) in their study on the effects of spatiotemporal adverse selection and basis risk on demand.

In Asia, the Mongolian initiative is well known as a successful real scheme of index-based livestock insurance offered to herders (Mahul and Skees, 2007; Goodland and Mahul, 2011). The main risk protected through this contract is the “dzud,” which is extreme winter weather, occurring every 5-8 years. This project was in fact developed after a very severe event taking place over three years (1999-2002) with millions of livestock losses, making the existing livestock insurance system collapse (Greatrex et al., 2015). Mongolian private insurance companies operate in partnership with the government with the support of the World Bank and cover larger systemic losses incurred by insured herders (mortality rates higher than 6%). Given the catastrophic component, the government intervenes to protect insurers in case of major losses (higher than 30%). An international reinsurance company is also involved. The index is based on the average livestock mortality rate at the local region that is regularly recorded by the National Statistical Office. The index is closely linked to losses, thus reducing basis risk. The product is fully loaded and the scheme is self-sustainable. It has recently undergone a transformation from a donor funded project into a private company. Launched in 2005, the 2010-2011 season implied large payments which involved the intervention of a contingent credit provided by the World Bank. In the following years, the provinces covered by the scheme increased in number even when market conditions were not optimal for livestock products, probably because payouts occurred several times, showing the benefits of insurance. In 2014, it reached 15,000 insured herders. It is interesting to notice that since “dzud” affects herders of different wealth classes, take-ups are also diversified according to the wealth status of the herders, with a predominance of wealthy and middle-income classes (Greatrex et al., 2015).

In Latin America, a major initiative operates in Mexico (Sagarpa, 2015). This municipal scheme is offered by Agroasemex insurance company in order to protect against extreme climatic events like drought, excess of humidity, extremely hot or icy weather and others which affect the

availability of forage. The scheme is based on a NDVI. Gradual protection is forecasted according to the growth stage of the forage and the severity of the climatic hazard. Special allowances are foreseen in cases where there is an unusually severe loss of vegetal biomass due to climatic risk.

The reported cases, show that under specific circumstances, although not abundant, weather index-based insurance products that cover livestock mortality risk can be suitable and show positive effects on the customers' productive patterns and living conditions. However, the government (or other external) support in terms of reinsurer of last resort is key to the sustainability of the program.

5. Project description and data

The data were collected in the frame of the MicroRiMI (Microfinance, Risk Management and Innovation) project⁶. MicroRiMI consisted of six infra-annual data collection rounds, from March 2011 to November 2013, at the end of each agricultural season: the rainy season (April to November); and dry season (December to March). For the sake of this study, we employ only the data collected at the end of the rainy season, that is in November of each year. The data collection was conducted in three Ethiopian *kebele* ("villages") in the Wolayta zone in Southern Ethiopia.⁷ The villages are representative of three different agro-ecological areas (high, medium and low lands); and indeed differ in terms of altitude and type of main crops. The sample is made up of around 360 randomly selected households (120 households per village). The total number of observations is 1,070. However, we are interested only in oxen-owning households. Moreover, since oxen are frequently traded in the surveyed area, the number of oxen-owning households at the time of the interview changes over the three waves of data collection. The number of observations with non-zero oxen holdings values is 609. After considering the missing values in the explanatory variables, the sample shrinks to 561 observations.

⁶MicroRiMI is a research project of the *Finance and Development Group* of the *Research Centre on International Cooperation* (University of Bergamo). Partner: Wolayta Sodo University. Sponsors: Giordano Dell'Amore Foundation-Milan; Government of Lombardy Region, CARPILO Foundation, Milan.

⁷ *Kebele* is the smallest administrative unit in Ethiopia. For the sake of simplicity, in the paper, we improperly refer to it as village.

The households were surveyed through a semi-structured questionnaire with questions that cover most of the personal, social, financial and economic characteristics. The questionnaire also included a section with questions on the WTP for different hypothetical insurance products. We employed an open-ended elicitation methodology whereby interviewees were directly asked to state their WTP. According to the literature on the measurement of the WTP, even though this methodology is easy to implement and produces straightforward results, it however suffers from different pitfalls (Pearce and Özdemiroglu, 2002): large non-response rates, protest answers, zero answers and outliers. One of the main motivations of such pitfalls is that it might be very difficult for interviewees to provide their true WTP on the spot for a product they are unfamiliar with and have never thought about valuing before. Moreover, this decision process might be different from most market transactions of the respondents that involve deciding whether to buy a product at a fixed price, rather than stating WTP values.

However, we believe that the design of the project allows us to address most of the potential biases of the open-ended elicitation methodology. First, the insurance product proposed to farmers is very simple. The negligible rate of non-response and zero answers confirms that the farmers were able to understand the question. Second, we use a data collection approach where the farmer's WTP is asked over time. This approach allows control for both cross-sectional differences and time-related changes in weather risk and farmer's characteristics. Finally, in order to control for the effect of potential outliers, we conduct a robustness check using a quantile regression methodology. Furthermore, the quantile regression analysis allows us to study how the impact of weather risk varies along the conditional distribution of the WTP as compared to non-weather factors.

6. The Empirical Approach

The main objective of this paper is to analyze how covariant shocks influence the willingness of low-income farmers to pay for a livestock mortality insurance product. In rain-fed agricultural systems such as the one analyzed in this study, the climate-related factors play an

important role in determining the performance of the agricultural and livestock production. Oxen, in particular, have greater fodder and water requirements than other animals and so, in cases of drought shocks, suffer the most. When drought occurs, two mechanisms unfold: plummeting oxen prices and increasing oxen losses. The drop in oxen price is related, first, to a reduction in the weight and productivity of the animal. Second, drought can cause fire sales of oxen to compensate for a decrease in the overall farm's income, and this widespread destocking in the affected area further depresses prices.

Drought is a consequence of abnormal weather conditions, usually characterized by prolonged high temperatures combined with very low or failing rainfall. In this regard, following the approach in Maystadt and Ecker (2014), we construct measures of precipitation and temperature anomalies as follows:

$$PA_{i,m,y}^n = \sum_n \frac{R_{i,m,y} - \mu_{i,m}^R}{\sigma_{i,m}^R} \quad \text{and}$$

$$TA_{m,y}^n = \sum_n \frac{T_{m,y} - \mu_m^T}{\sigma_m^T} \quad (1);$$

where $R_{i,m,y}$ denotes the monthly total rainfall tracked at the weather station i during the month-year (m, y) time period. The reference weather station for each village is located at the respective *woreda*, i.e. district town.⁸ All the three weather stations track rainfall but only the station in the administrative town of the Wolayta zone tracks temperature as well. In order to maximize the available information, we assume that the temperature variable is the same for all the villages even though it originates from just one weather station⁹. In this regard, in Equation (1), $T_{m,y}$ denotes the monthly average maximum temperature at the Wolayta weather station. The long-term monthly means are $\mu_{i,m}^R$ and μ_m^T and the long-term monthly standard deviations are $\sigma_{i,m}^R$ and σ_m^T , respectively. The time frame for the analysis of the temperature and precipitation anomaly is

⁸ The *woreda* are composed of a number of *kebele*.

⁹ This is a strong assumption because temperature patterns can dramatically differ from village to village. We though believe that this is key weather information that can support our analysis since it comes from actual available data that can eventually be used to develop a real insurance product.

1988–2013. Figure (2) offers the distribution of the precipitation anomalies in the three villages over the time considered.

[FIGURE 2 HERE]

In the surveyed areas, farmers usually associate the onset of drought with failing rainfall in both the “small rains” (*Belg*) and “big rains” (*Meher*) sub-periods of the rainy season. This suggests that the cumulative effect over the rainy season is more important than the anomaly in a single month. Therefore, as indicated in Equation (1), we sum the monthly anomalies over n , that is the number of months in the rainy season (March to September).

Moreover, we use the precipitation anomaly to build two other variables to proxy for the intensity and length of drought. The first variable is the summation of only the negative monthly precipitation anomalies (*NegPA*), and the second variable is the number of monthly negative anomalies (*#NegPA*). Maystadt and Ecker (2014) focus on temperature-based variables as indicators of drought and use a precipitation-based variable to control for potential additional effects that might arise from abnormal rainfall alone. In our case, we do the opposite because of the unavailability of temperature data for two of the three villages. However, the results suggest that the precipitation-based variables have a sizeable explanatory power.

Apart from the weather-risk variables, we include several controls to account for the village’s and interviewee’s characteristics. As for village-level controls, we consider the share of perished oxen in the rainy season (*DIEDOX*), and village fixed-effects. The former variable controls for non-weather related hazards that can affect oxen mortality, whereas the latter variables account for time-invariant village characteristics.

As measure of the indemnity amount of the hypothetical insurance policy, that is the market price of the asset to be insured, we consider the unitary average stated market value (in thousands of Ethiopian Birrs (ETBs)) of the oxen holdings (*OXVALUE*). Besides the insurance indemnity, we include a proxy of the expected monetary loss per ox (*EXPLOSS*). We construct *EXPLOSS* as the product of the variables *DIEOX* and *OXVALUE*. *EXPLOSS* can hence be defined as the expected

monetary loss per ox in the dry season of $t+1$ due to an increase in oxen mortality risk in the rainy season of t . In simple words, if OXVALUE is the indemnity in case of insurance, EXPLOSS is the expected loss in case of no insurance. In the estimation process, OXVALUE, DIEDOX and EXPLOSS variables are demeaned in order to avoid multicollinearity problems¹⁰.

The interviewee's characteristics have been selected assuming that two main drivers can have affected the farmer's WTP. The first driver is risk aversion. Risk aversion can be interpreted as the farmer's perception of the oxen mortality risk, as well as the level of trust in the insurance product. The second driver is the ability of the farmer to understand the insurance contract and the utility of insurance. Risk aversion and understanding of the insurance product are then interrelated. Education, age, and gender can influence risk aversion. Age (*AGE*) is an integer variable. For education and gender, we consider two dummies that take the value of 1 if the interviewee is illiterate (*ILL*) or male (*MALE*), respectively, and 0 otherwise. Illiteracy can also affect the interviewee's ability to understand insurance. Besides this, we include a more straightforward variable to account for the interviewee's understanding of insurance. This variable is a dummy that takes the value of 1 if the interviewee is not able to provide a proper definition of insurance (*KNOWINS*), and 0 otherwise.¹¹ We expect this variable to contribute to a reduction in the effect of potential biases of extreme values that are caused by a misunderstanding or non-understanding of the insurance product.

In the empirical model, we avoid including variables that measure the household's wealth or ability to pay. The empirical literature suggests that liquidity constraints are among the main factors that explain the low demand in microinsurance (Matul et al., 2013). However, in our experiment we offer a hypothetical product where the monetary transaction does not take place. As a further consideration, our focus is on the role of weather-related risks and we assume the impact of weather

10 In particular, the correlation coefficient between DIEDOX and EXPLOSS is greater than 0.8.

11 If the interviewee stated that he/she was unable to provide a basic definition of insurance or the definition was incorrect or ambiguous, the enumerator provided a definition of insurance before posing the question on the WTP.

shocks on the WTP to be strongly exogenous and independent of other factors. We then believe that liquidity constraints in general are important but of limited relevance for this study.¹²

The dependent variable of the empirical models is *WTP*, defined as the premium in ETBs that the farmer is willing to pay for the hypothetical insurance product where the indemnity is the average market value of one ox, that is *OXVALUE*. In particular, the hypothetical insurance product covers the mortality risk of one ox over the next dry season, that is from November to March of year $t+1$. The question about the WTP for this hypothetical insurance product was posed to the same farmers during each of the three waves of data collection. Given that the number of farmers with non-zero oxen holdings in each wave is smaller than the total number of surveyed farmers, the data is unbalanced panel data.

We assume that if drought risk increases (due to a decrease in rainfall anomalies and/or an increase in temperature anomalies) in the agricultural (rainy) season, then the probability of death of oxen increases in the dry season and the farmer would pay a greater premium.

We take the log of *WTP* ($\log(WTP)$) so that the estimated coefficients are to be interpreted as percentage change in the dependent variable. The logarithmic transformation of the WTP should further reduce the influence of the outliers in the model estimation.

[TABLE 1 HERE]

We estimate three different econometric models. The first model is a reduced-form OLS with village fixed-effects where $\log(WTP)$ is regressed on all the weather-related variables and controls. The reduced-form model is as follows:

$$\begin{aligned} \log(WTP)_{i,v,t} = & \alpha_t + PA_{v,t} + TA_{v,t} + NegPA_{v,t} + \#NegPA_{v,t} + EXPLOSS_{i,v,t} + DIEDOX_{v,t} \\ & + OXVALUE_{i,v,t} + ILL_{i,v,t} + AGE_{i,v,t} + MALE_{i,v,t} + KNOWINS_{i,v,t} + \vartheta_{v,t} + \varepsilon_{i,v,t} \quad (2) \end{aligned}$$

Where $\vartheta_{v,t}$ are village fixed-effects and $\varepsilon_{i,v,t}$ are i.i.d standard errors.

¹² For instance, the results of an alternative specification of the empirical model point out that the log of household's total savings are not statistically significant. These results can be shown upon request.

In order to have a more straightforward interpretation of the role of the weather-related variables, we also estimate a two-stage regression model. At the first-stage, we regress our proxy of the expected monetary loss per ox (*EXPLOSS*) on only the weather-related variables. The first-stage equation of the two-stage regression model has then the following estimation equation:

$$EXPLOSS_{i,v,t} = \alpha_t + PA_{v,t} + TA_{v,t} + NegPA_{v,t} + \#NegPA_{v,t} + \epsilon_{i,v,t} \quad (3)$$

Where $\epsilon_{i,v,t}$ are i.i.d standard errors.

It follows that the predicted value of *EXPLOSS* ($\widehat{EXPLOSS}$) is a proxy of the share of the expected loss that is explained by changes in the underlying weather risk. $\widehat{EXPLOSS}$ is included in the second-stage equation. In contrast to the reduced-form equation (Equation (2)), in the second-stage equation we exclude the weather-related variables. The second-stage equation is as follows:

$$\begin{aligned} \log(WTP)_{i,v,t} = & \alpha_t + \widehat{EXPLOSS}_{i,v,t} + DIEDOX_{v,t} + OXVALUE_{i,v,t} + ILL_{i,v,t} + AGE_{i,v,t} + MALE_{i,v,t} \\ & + KNOWINS_{i,v,t} + \vartheta_{v,t} + \theta_{i,v,t} \quad (4) \end{aligned}$$

Where $\theta_{i,v,t}$ are i.i.d. standard errors.

As a final exercise, we estimate Equation (2) with a quantile regression methodology for several percentiles (5%–95%). With a quantile regression, we can analyze the impact of the weather- and non-weather-related variables on the conditional distribution of $\log(WTP)$. This analysis allows us to identify conditional quantiles of the WTP where the anomalies in the precipitation and temperature performance play a major role with respect to village or household characteristics. Moreover, quantile regression provides a robustness check of the results because it is a more robust methodology to non-normal errors and outliers than OLS.

7. Results

Table 1 reports the estimates of the reduced-form and two-stage OLS models. In terms of explanatory power of the weather-related variables, the two-stage model seems to perform better than the reduced-form. Whereas in the reduced-form only the negative temperature anomaly

variable is statistically significant, in the two-stage model three of the weather-related variables have a statistically significant (indirect) influence on the WTP. The different relevance of the two models seems to suggest that the WTP is influenced more by greater expected losses of oxen holdings than directly by weather shocks. In simple words, the more a farmer is exposed to weather-related oxen mortality risks, the more he/she is willing to pay for insurance.

In general, the coefficients have the expected signs, that is, as drought risk heightens, (decreasing precipitation anomalies; increasing temperature anomalies) the WTP increases. Moreover, the impact of the weather-related variables appears to be economically important. For instance, a one-standard-deviation increase in the negative precipitation anomaly in the rainy season is associated with an increase in the stated WTP of about 30.5% in the reduced-form model, and 6.7% in the two-stage model. Similarly, when considering only the two-stage regression model, a one-standard-deviation decrease in the precipitation anomaly is associated with an increase of 16% in the stated WTP, whereas a standard-deviation increase in the temperature anomaly is associated with an increase of about 23.7% in the stated WTP. The coefficient of the variable that proxies for the share of perished oxen at the village level, i.e. *DIEDOX*, further confirms that covariant shocks that affect livestock holdings can dramatically influence the farmer's WTP. This variable is statistically significant only in the reduced-form model but its economic impact is sizeable.¹³

With regard to the household's characteristics, only age and the interviewee's preliminary understanding of insurance are statistically significant. The coefficient of the age variable is negative. For instance, an oxen-holding farmer that is 54 years old has a WTP that is 26% lower than a farmer with the average sample age of nearly 41 years¹⁴. Older farmers can be more averse to risk implied in the adoption of innovative risk management solutions and they can be less able to understand the value proposition of insurance. On the other hand, farmers that have a preliminary understanding of insurance are more willing to pay for it. In particular, insurance-aware farmers

¹³ A one-standard-deviation increase in the share of died oxen is associate with an increase of about 37% in the WTP.

¹⁴ 54 years is about the average sample age (41 years) plus on standard deviation (13 years).

have a WTP that is on average about 60% greater than non-aware farmers. It follows that financial education programs intended for non-insurance-aware farmers can dramatically improve the take-up ratio of ox mortality insurance. This result is consistent with the international literature on microinsurance (e.g. Matul et al., 2013).

Finally, the estimates of the village fixed-effects suggest that farmers in the medium and high lands have a stated WTP that is roughly between 55 and 78% greater than the stated WTP of farmers in the low lands. This result seems rather counterintuitive because the village in the low lands seems to be the most exposed to drought risk. Even though this finding can be important in the design of an ox mortality insurance scheme, it would require further investigation because fixed-effects account for village-level unobservables that can measure differences in terms of social, economic as well as financial development.

[TABLE 2 HERE]

The limited explanatory power of the weather-related variables in the reduced-form hints that non-normal-errors and extreme values of the WTP variable can limit the capacity of the OLS models to generate robust estimates. Moreover, the OLS regression model does not provide any information about the factors that explain the extreme values of the WTP. The analysis of the structure of the conditional distribution of the WTP can offer an understanding of the heterogeneity in the demand for insurance. Moreover, this kind of analysis can provide some guidance on how a real insurance program should be designed. Quantile regression analysis allows us to study the conditional distribution of the WTP and is less sensitive to the presence of outliers. Table 2 reports the estimates of the quantile regression model for several percentiles (5%–95%). One of the main results is that the weather-related variables become statistically significant starting from the median percentile. A more in-depth analysis, that is not reported in this paper, shows that this is verified starting from about the 40th percentile. More in general, both the economic and statistical significance tends to increase with the increase in the percentile. For instance, a one-standard deviation increase (or decrease for the precipitation anomaly) in one of the statistically significant

weather-related variables is associated with a decrease in the WTP of 33-43% in the case of the median percentile and 37-68% in the case of the 90th percentile. However, for very high extreme values of the conditional distribution of the WTP, the weather-related variables show a lower explanatory power. Moreover, these extreme values of the distribution of the WTP are not related to interviewee and village-level variables. We then assume that randomness is the main driver of very high extreme values. On the other hand, for low conditional values of the WTP, the interviewee's characteristics (in particular, age and understanding of insurance) are the key explanatory factors as compared to weather shocks. As suggested by the estimates of the quantile regression models for the 5th, 10th and 25th percentiles, whereas the size of coefficient of the KNOWINS variable is almost 30% greater than the coefficient in the OLS models, the size of coefficient of the AGE variable can be up to two times greater than in the OLS models. Older farmers and those with a limited understating of insurance tend to be less willing to pay for oxen insurance coverage. For this category of prospective customers, weather shocks are either irrelevant or, to some extent, have the opposite effect on the WTP as compared to those surveyed farmers that would pay a higher amount for insurance.

The results of the quantile regression analysis further hints that village fixed-effects are statistically significant where weather-related variables are not and *vice versa*. In particular, as for AGE and KNOWINS, village fixed-effects are statistically significant for low values of the conditional distribution of the WTP.

[TABLE 3 HERE]

As a final exercise, we study how each covariate's effects vary across quantiles, and contrast them with the (fixed) OLS estimates¹⁵. Figure (3) illustrates how the coefficient of each variable varies over quantiles. The first finding is that the coefficients of the weather-related variables at various quantiles differ considerably from the OLS coefficient. In particular, the signs change between the 20th and 40th percentile. Moreover, apart from extreme right values of the conditional

¹⁵ We use the Azevedo's routine *grqreg* in Stata.

distribution of the WTP, starting from the 30th/40th percentile, the economic and statistical significance of the precipitation and temperature anomaly coefficients increases with the quantile. On the other hand, for values below the 30th/40th percentile, the respondent's characteristics (in particular, age and understanding of insurance) and village's fixed effects become both economically and statistically significant.

[FIGURE 3 HERE]

8. Conclusions

This paper provides an analysis of the weather-related demand for ox mortality insurance in Southern Ethiopia in order to contribute to the international literature on the WTP for index-based insurance in developing countries. While there are tens of index-based crop insurance programs (even if their outcomes and long-term sustainability are still debated), livestock index-based insurance can be still considered at an infant stage. The few existing programs show some positive and encouraging results but many open issues are still to be addressed. Apart from the technical aspects of the product design, the financial sustainability of these insurance schemes is still uncertain. From the supply side, suitable design, effective risk coverage, and relatively high operational costs can be reflected into unaffordable premiums. From the perspective of the potential policy-holders, the take-up depends on the perceived value of the product with respect to the price. The value, in turn, depends on the exposure to risk and risk perception of farmers, as well as on their ability to fully understand the added utility that insurance can provide.

Investigating the main drivers of insurance take-up is then key to the design of successful initiatives. Since index-based insurance is meant to protect farmers from weather covariant risks, we focused on the role in insurance take-up of an increased risk perception that follows from *ex-ante* covariant shocks. In particular, we investigated how common weather shocks influence the WTP of a sample of Ethiopian farmers for a simple oxen mortality insurance product. We find that

weather anomalies contribute to changes in the WTP to a large extent. Negative (positive) changes in the precipitation (temperature) anomalies can lead to more than a 30% reduction in the WTP.

The results of a quantile regression analysis suggest that the relationship between weather covariant shocks and WTP is economically and statistically significant only for conditional values of the WTP greater than the 30th–40th percentiles, and smaller than very extreme positive values. For values smaller than the 30th–40th percentiles, the WTP seems to be explained more by the interviewee's age and basic knowledge of insurance, and village fixed-effects. Estimation results of the OLS models suggest that basic knowledge of insurance, in particular, can increase WTP by about 60%. It follows that financial education programs, intended for prospective customers, can contribute to increasing the sustainability of a real index-based insurance scheme.

We cannot reject the hypothesis that the results are partially driven by wealth effects or liquidity constraints. However, also according to previous literature, we believe that wealth and liquidity effects are almost irrelevant in WTP experiments that do not imply real cash transactions. Furthermore, weather shocks can be considered as strongly exogenous and we expect that the results would barely change even allowing for further controls in the empirical analysis. As potential limitations to the generalization of the results, it should be stressed that our experiment was conducted in areas with specific agro-climatic characteristics, and where livestock raising is an important income generating activity, but not the only economic activity.

This paper has straightforward implications from a policy perspective. In an agrarian system where livestock raising is an important but risky economic activity because of high covariant risks, index-based livestock mortality insurance schemes can contribute to increase the expected utility of livestock holdings. From our analysis, it emerges that the WTP for index-based livestock insurance can be dramatically affected by the type and severity of the underlying covariant shocks. Since the systemic component of risks can be very variable over time, continuous changes to contract conditions might be necessary, especially in order to reduce basis risk. Our research shows that farmers would prefer a premium that follows the changes in the systemic component. On the

contrary, insurance as well as reinsurance companies are reluctant to frequently revise their premiums.

Furthermore, our results demonstrate that in market segments which are unfamiliar with insurance, such as uneducated and older farmers, the contract complexity can discourage insurance take-up. Some evidence from weather index-based insurance schemes and empirical studies hints that financial education programs can increase insurance take-up rate.

Practical policy initiatives should focus on offering a real value proposition to farmers (Hess and Hazell, 2009). As emphasized by Jensen and Barrett (2016), the preliminary issue is that the intended population have very little experience with insurance and no experience with index-based insurance. A first initiative should then be the carrying-out of educational programs. Such educational programs should also provide the involvement of farmers in the design of the index product (Greatrex et al., 2015). Financial education and direct design involvement would in turn build trust and develop a product that is fine-tuned to the needs of the farmers. Trust building can be further facilitated through the collaboration with local organizations that are close and well-considered by the prospective policy-holders (Greatrex et al., 2015). Moreover, a characteristic of insurance is that it provides tangible benefits only when payouts are made. Since weather index-based insurance offers protection against future extreme events that occur with a very low frequency, the benefits for the insured can be much less tangible than traditional insurance. Our results provide some evidence also to the inverse of such issue, that is demand (and so the perceived benefits of insurance) can be strongly influenced by the farmers' experience with *ex-ante* covariant shocks. Preliminary lessons from some of the most promising index-based insurance schemes suggest that this issue can be partially addressed by interlinking insurance with other financial products, such as credit and savings, as well as non-financial products or programs, such as new productivity-enhancing technologies, that increase the farmers' expected income in the short-term (e.g. Hess and Hazell, 2009; Carter et al., 2010; Greatrex et al., 2015). Another approach that would allow farmers to gain experience with the benefits of index insurance is to start with a meso-level

scheme and, over time scale up to a micro-level scheme. With meso-level index insurance, a risk aggregator (producers' cooperative; input supplier; food processor firm; etc.) is the policy holder. The risk aggregator can transfer part of the risk-transfer benefits of insurance on to the farmers in different forms (Skees, 2008).

From a marketing perspective, the overall findings suggest that continuous fine tuning of the contract, transparency, and targeted information campaigns can increase and stabilize potential customers' WTP. Clientele's loyalty, in turn, can assure more stable revenues from premiums and allow the insurance supplier to make the necessary further investments in product design and financial education programs.

Future research should focus on how these policies can minimize swings in the demand. In this paper, we demonstrate that such swings can be prompted by the same covariant shocks that insurance is meant to cover.

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Annex : Tables and Figures

Figure 1 – Factors that influence the WTP for weather index insurance

The factors that influence the WTP can be grouped into two main categories: technical, financial and economic factors; and behavioral factors, that can be influenced by marketing strategies. Other factors fall into a “blended” category. For example, contractual terms can affect the customers’ WTP through wealth effects and as behavioral incentives (“nudge” effects); or behavioral characteristics such as risk preferences are affected by technical, financial and economic factors.

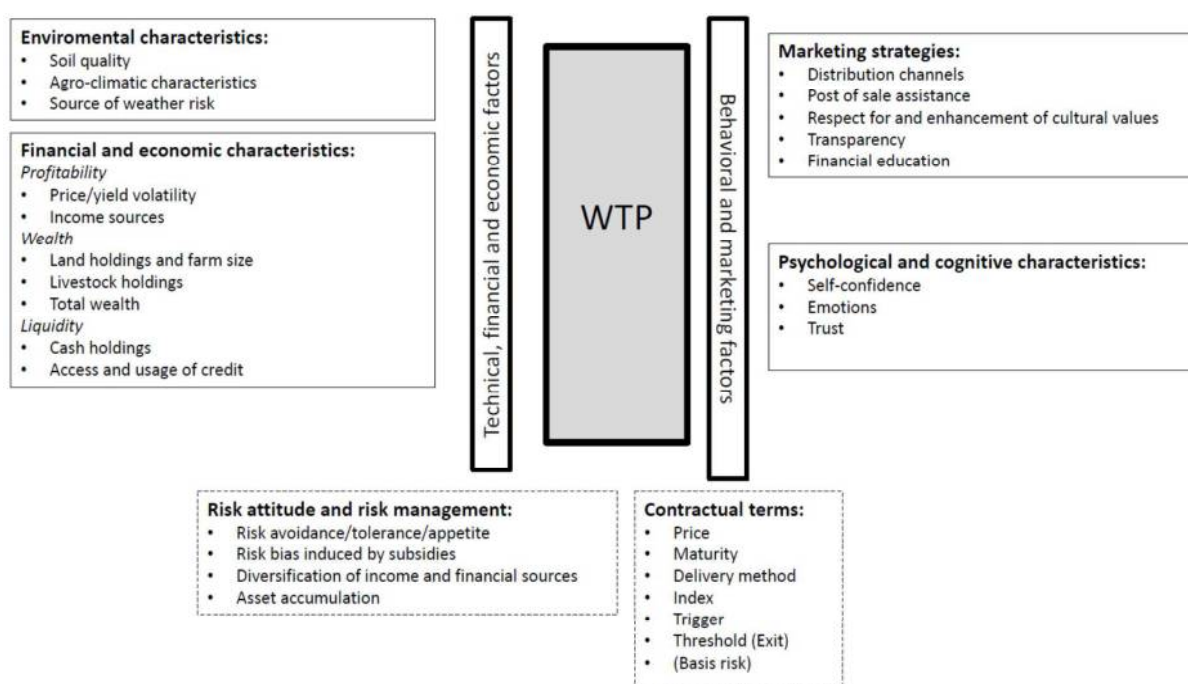


Figure 2 – Monthly precipitation anomalies between January 2011 and December 2013

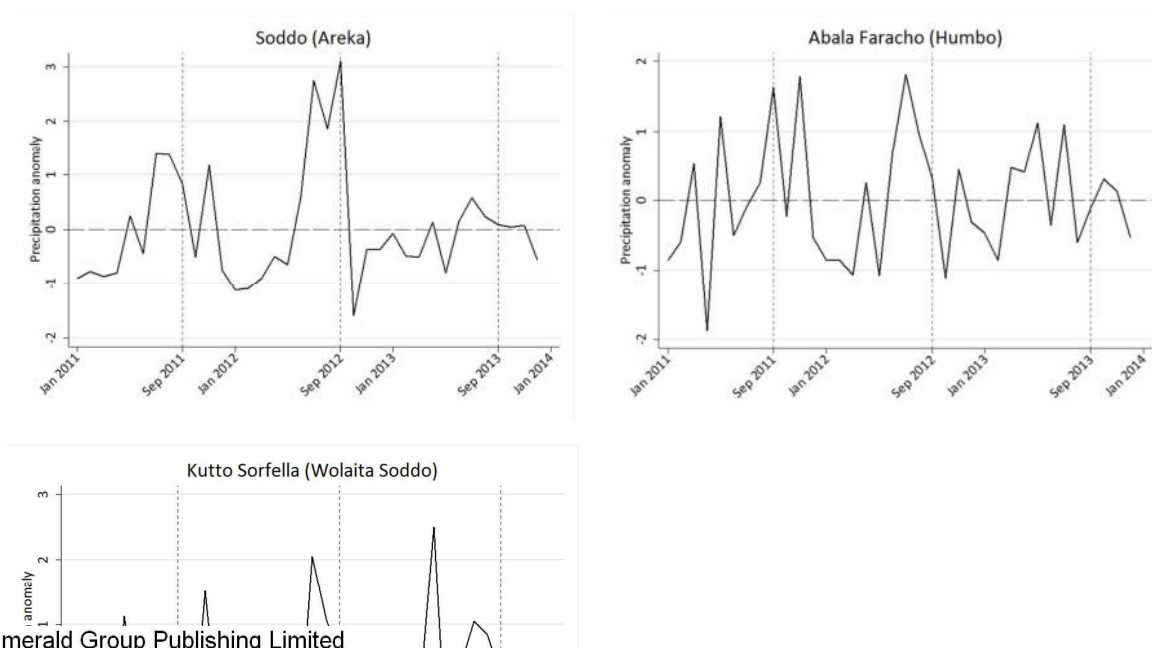


Table 1 – Summary statistics

<i>Variable</i>	<i>Description</i>	<i>Obs</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
<i>Dep. Var.</i>						
log(WTP)	Willingness-to-pay (log; ETBs)	561	4.201	1.862	0	9.210
<i>Weather-related var.</i>						
PA	Precipitation anomaly	561	2.540	1.859	-0.194	7.171
TA	Temperature anomaly	561	-0.703	2.849	-3.957	1.971
NegPA	Negative prec. Anomaly	561	-1.368	0.432	-2.462	-1.061
#NegPA	Number of negative prec. anomalies	561	2.053	0.764	1	3
<i>Controls</i>						
EXPLOSS	Expected loss (ETBs/1,000)	561	0.205	0.156	0.005	1.000
DIEDOX	Share of perished oxen	561	0.055	0.036	0.020	0.112
OXVALUE	Average oxen value (ETBs/1,000)	561	3.848	1.687	0.250	9.000
ILL	Illiterate (dummy)	561	0.275	0.447	0	1
AGE	Age	561	41.292	13.054	15	100
MALE	Gender (dummy)	561	0.870	0.337	0	1
KNOWINS	Understanding of insurance (dummy)	561	0.362	0.481	0	1

Table 2 – Estimation results of the reduced-form and two-stage regression models

<i>Regression</i>	<i>Reduced-form</i>		<i>Two-stage</i>	
	(1)	(2)	First	Second
<i>Dep. Var.</i>	log(WTP)	log(WTP)	EXPLOSS	log(WTP)
<i>Weather-related var.:</i>				
PA		-0.102 (-1.87)	-0.023*** (-7.38)	
TA		0.061 (1.36)	0.022*** (7.92)	
NegPA		0.707* (2.58)	0.041* (2.10)	
#NegPA		0.153 (0.92)	0.004 (0.81)	
<i>Controls:</i>				
EXPLOSS	3.021 (1.95)	1.438 (0.83)		3.778* (2.05)
DIEDOX	11.100*** (4.51)	10.290** (2.67)		5.917 (1.67)
OXVALUE	0.077 (1.43)	0.066 (1.13)		0.099 (1.73)
ILL	-0.140 (-0.72)	-0.136 (-0.70)		-0.146 (-0.72)
AGE	-0.020** (-2.75)	-0.020** (-2.80)		-0.020** (-2.61)
MALE	0.354 (1.40)	0.331 (1.33)		0.338 (1.30)
KNOWINS	0.592*** (3.77)	0.601*** (3.66)		0.619*** (3.83)
<i>Village fixed-effects:</i>				
Village (medium lands)	0.557* (2.33)	0.664* (2.46)		0.565* (2.28)
Village (high lands)	0.608** (3.29)	0.778** (3.03)		0.769*** (3.90)
<i>Constant</i>	4.179*** (12.95)	5.057*** (6.69)	0.325*** (8.80)	2.656*** (5.32)
Observations	561	561	561	561
Adjusted R-squared	0.104	0.119	0.149	0.089

Source: Authors' estimation

Note: t-statistics in parentheses; Asterisks *, **, *** indicate that the coefficient is statistically significant at the 5%, 1% and 0.1% levels, respectively.

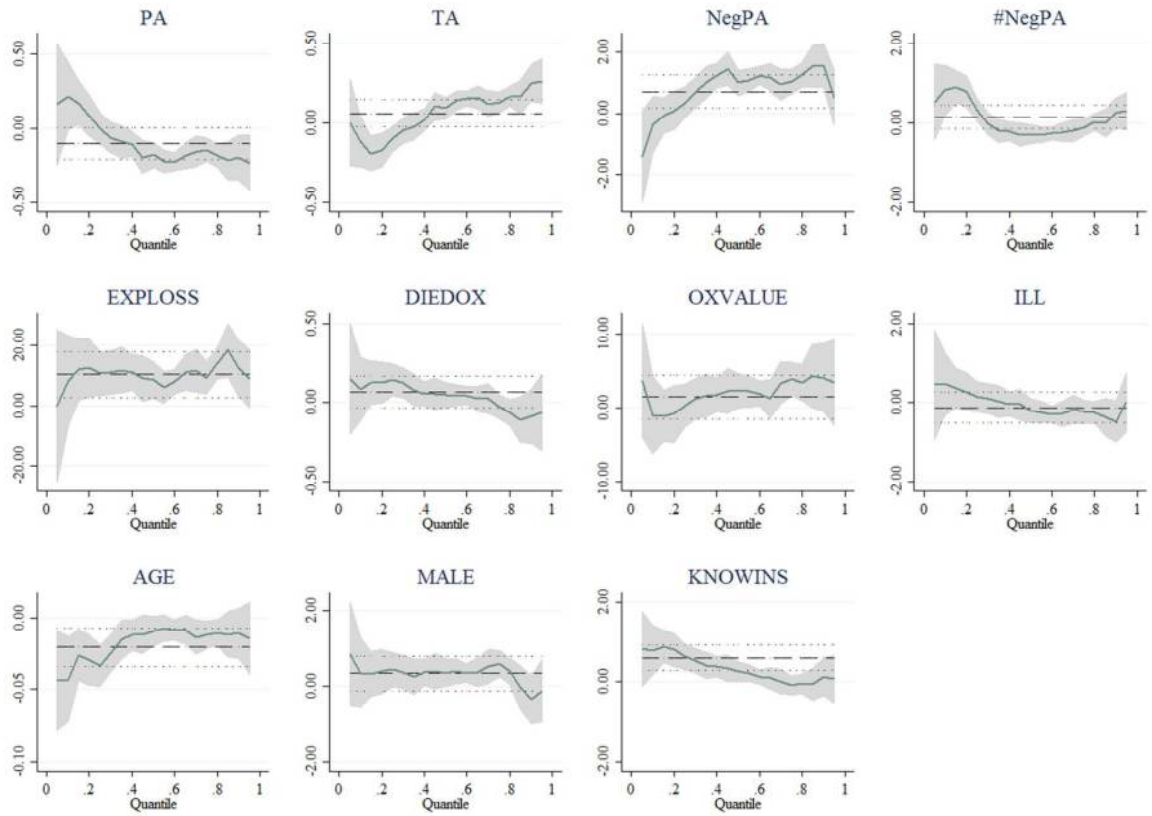
Table 3 – Estimation results of the Quantile Regression model (Dep. Var.: log(WTP))

<i>(quantile)</i>	<i>Q(0.05)</i>	<i>Q(0.10)</i>	<i>Q(0.25)</i>	<i>Q(0.50)</i>	<i>Q(0.75)</i>	<i>Q(0.90)</i>	<i>Q(0.95)</i>
<i>Weather-related var.:</i>							
PA	0.162 (0.94)	0.217 (1.79)	-0.001 (-0.02)	-0.179** (-3.03)	-0.144* (-1.99)	-0.199* (-2.18)	-0.233* (-2.14)
TA	-0.001 (-0.01)	-0.116 (-1.23)	-0.100 (-1.71)	0.094* (2.03)	0.132* (2.33)	0.251*** (3.51)	0.263** (3.10)
NegPA	-1.422 (-1.70)	-0.391 (-0.66)	0.331 (0.91)	0.995*** (3.46)	1.026** (2.91)	1.567*** (3.52)	0.516 (0.98)
#NegPA	0.519 (1.11)	0.824* (2.51)	0.333 (1.63)	-0.278 (-1.73)	-0.104 (-0.53)	0.255 (1.03)	0.303 (1.03)
<i>Controls:</i>							
EXPLOSS	3.647 (0.77)	-0.996 (-0.30)	0.202 (0.10)	2.347 (1.44)	3.900 (1.95)	4.062 (1.61)	3.397 (1.14)
DIEDOX	-0.061 (-0.01)	8.167 (0.98)	10.600* (2.05)	8.455* (2.07)	9.304 (1.86)	12.730* (2.02)	8.808 (1.18)
OXVALUE	0.149 (0.95)	0.084 (0.76)	0.143* (2.09)	0.046 (0.85)	-0.029 (-0.44)	-0.089 (-1.06)	-0.064 (-0.64)
ILL	0.449 (0.73)	0.470 (1.09)	0.153 (0.57)	-0.218 (-1.03)	-0.238 (-0.92)	-0.486 (-1.49)	-0.007 (-0.02)
AGE	-0.044* (-2.09)	-0.043** (-2.92)	0.033*** (-3.65)	-0.009 (-1.30)	-0.012 (-1.35)	-0.011 (-0.96)	-0.014 (-1.07)
MALE	0.847 (1.16)	0.348 (0.68)	0.426 (1.34)	0.349 (1.39)	0.584 (1.90)	-0.373 (-0.96)	-0.139 (-0.30)
KNOWINS	0.826 (1.63)	0.793* (2.22)	0.636** (2.87)	0.252 (1.45)	-0.094 (-0.44)	0.122 (0.45)	0.069 (0.21)
<i>Village fixed-effects:</i>							
Village (medium lands)	0.570 (0.74)	0.819 (1.51)	1.097** (3.27)	-0.045 (-0.17)	-0.172 (-0.53)	0.702 (1.72)	0.610 (1.26)
Village (high lands)	1.358* (1.99)	1.631*** (3.39)	1.112*** (3.72)	-0.077 (-0.33)	0.017 (0.06)	0.999** (2.75)	0.663 (1.53)
<i>Constant</i>	-2.293 (-1.20)	-0.654 (-0.49)	2.887*** (3.46)	6.923*** (10.55)	7.416*** (9.21)	8.836*** (8.71)	8.046*** (6.67)
Observations	561	561	561	561	561	561	561
Pseudo R-squared	0.121	0.151	0.092	0.077	0.115	0.164	0.206

Source: Authors' estimation

Note: t-statistics in parentheses; Asterisks *, **, *** indicate that the coefficient is statistically significant at the 5%, 1% and 0.1% levels, respectively.

Figure 3 – Quantile regression estimates and confidence intervals by quantile



Note: dashed lines are OLS estimates