The London School of Economics and Political Science

Whether to Insure Against the Weather: Demand for Extreme Weather Insurance in Developing and Developed Country Contexts

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Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I declare that my thesis consists of 112,302 words**,** including footnotes, but excluding appendices, bibliographies, and prefatory statements.

Statement of conjoint work

I confirm that the design and implementation of the Uganda survey (not including the “Complex Dice Game”) were completed in conjunction with Karl Muth. I contributed 50% of this work. The resulting chapters were single authored by the candidate.

I confirm that the data analysis on coping strategies presented in Chapter 6 of this thesis is the product of joint work with Dr. Stefan Hochrainer-Stigler. I contributed 80% of this work. The resulting chapter was single authored by the candidate.

I confirm that the design of the Hurricane Sandy survey presented in Chapter 9 of this thesis was done in conjunction with Dr. Alessandro Tavoni. I contributed 85% of this work. The resulting chapter was single authored by the candidate.

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I confirm that my thesis was checked for conventions of language, spelling and grammar by Brad Spencer of Spencer Linguistic Consulting.

Statement of inclusion of previous work

A version of Chapter 6 has been previously published: Helgeson, J., S. Dietz, and S. Hochrainer-Stigler. 2013. Vulnerability to weather disasters: the choice of coping strategies in rural Uganda. *Ecology and Society* 18(2): 2.

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Abstract

Many households in developing and developed countries will face increased extreme weather events due to climate change. Insurance could be a key coping strategy against the associated impacts of extreme weather. There is value in better understanding the characteristics that make insurance an appropriate means of coping for some sub-groups over others. The framework for household decisions to insure used in this research focuses on four factors: 1. economic, 2. social and cultural, 3. structural, and 4. personal and demographic.

This thesis considers two case studies: agricultural index-based microinsurance in rural Uganda and home flood insurance in the USA It seeks to understand intended demand and the related drivers for insurance in these settings through the use of large-N surveys, field games, and on-line simulations.

The rural Ugandan survey tool was implemented using innovative smart-phone technology and yielded 3000+ observations of expressed willingness-to-join (WTJ) and willingness-to-pay (WTP) for agricultural microinsurance. This tool also obtained information concerning propensity to engage with alternative coping strategies, both formal and informal. It also obtained household indicators of the factor classes noted above.

A separate field game in Uganda investigated attitudes towards basis risk arising from index insurance using a novel, iterative game involving farmers allocating their wealth between insurance and crop production. The game is played in partner sets to gauge the relative influence of others' decisions and outcomes on one's choice to insure.

The USA study compares propensity to purchase flood insurance between those affected and unaffected by Hurricane Sandy in the same geographic areas. We obtained 800 observations from an online survey tool, combining survey questions and a flood insurance purchase simulation. In the simulation we include as a treatment a more extensive (graphical) presentation of expected losses to assess the effect on insurance uptake rates.

In the Ugandan case, WTJ is over 95% and the average WTP is moderate relative to household wealth. For our sample there is evidence that microinsurance and loans are substitutes and the most frequently chosen traditional coping strategy is selling cattle. In the American study, respondents insure in just over 50% of the presented simulations and over 60% have a positive stated WTJ. Notably, there is little insurance demand difference between cohorts affected and unaffected by Hurricane Sandy. In both studies, a significant proportion of respondents with disparate personal characteristics chose to always or never insure, regardless of the details of the simulation scenarios, though WTJ varies positively with expected losses; this behaviour may be related to affect from the feeling of insurance.

In the Ugandan study, occurrence of basis risk reduces WTJ in the following period and respondents clearly are affected by the choices made by their partners. In the American study, insurance adoption is greater for the cohort exposed to the more extensive (graphical) presentation of expected losses.

In both cases we find that of the four factor classes social and cultural as well as structural factors are frequently significant in regression models for intended insurance demand.

As weather-related covariate risks increase in the future, households need coping mechanisms that are culturally viable and conform to individuals' preferences. This thesis demonstrates methods by which to determine intended demand for extreme weather insurance in the developing and developed country contexts. Such information can inform the development of insurance tools consistent with consumer preferences and help identify households that may be the best candidates for use of insurance.

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"אם אין אני לי, מי לי? וכשאני לעצמי, מה אני? ואם לא עכשיו, אימתי?"

(-הלל--פרקי אבות,א:יד)

Abbreviations

ACA	Affordable Care Act
ACE	U.S. Army Corps of Engineers
ACRE	Agriculture and Climate Risk Enterprise
AIC	Akaike's information criterion
BBC	Bogardi Birkmann Cardona (vulnerability model)
BIC	Bayesian Information Criterion
CDC	Centers for Disease Control and Prevention
CDKN	Climate and Development Knowledge Network
CEA	Comité Européen des Assurances
CHIRPS	Climate Hazards Group InfraRed Precipitation
CKW	Community Knowledge Worker
CM	Choice Modeling
CRRA	coefficient of relative risk aversion
CRS	Community Rating System
CT	Connecticut
CV(M)	Contingent Valuation (Method)
DCE	Discrete Choice Experiment
DBDC	double-bounded dichotomous choice
D.C.	District of Columbia
DE	Delaware
DEFRA	Department for Environment, Food and Rural Affairs
DHAP	Disaster Housing Assistance Program
ECA	Economics of Climate Adaptation (working group)
EU	European Union
EU(T)	Expected Utility (Theory)
ELCE	Equally Likely Certainty Equivalent
ELRO	Equally Likely Risky Outcome
FAO	Food and Agriculture Organisation of the United Nations
FEMA	Federal Emergency Management Agency
FMA	Flood Mitigation Assistance
FGD	Focus group discussion(s)
GDP	Gross Domestic Product
GIZ	Deutsche Gesallschaft für Internationale Zusammenheit
GLM	generalised linear models
GoU	Government of Uganda
GRP	Group Risk Plan
HARITA	Horn of Africa Risk Transfer for Adaptation
HMGP	Hazard Mitigation Grant Program
HSRTF	Hurricane Sandy Rebuilding Task Force
IBLI	index-based livestock insurance
IBMS	index based microinsurance scheme
ICT	Information and communications technology
IEA	Instituto de Estudios Ambientales
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFW	insurance-for-work
IFRC	International Federation of Red Cross

IIA	independence of irrelevant alternatives
III	Insurance Information Institute
IJWM	Insurance Journal West Magazine
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
IRAU	Insurance Regulatory Authority of Uganda
IRICP	International Research Institute for Climate and Prediction
IRM	integrated risk management
IRS	Internal Revenue Service
LCA	Latent Class Analysis
LCM	Latent Class Model
MAAIF	Ministry of Agriculture, Animal Industry, and Fisheries
MFI	Microfinance Finance Institution
MPCI	Multiple Peril Crop Insurance
MFPED	Ministry of Finance, Planning, and Economic Development
MOTF	(FEMA) Modeling Task Force
MTN	Mobile Telephone Networks
MWE	Ministry of Water and Environment
MPCI	multiple peril crop insurance
NAAS	National Agricultural Advisory Services
NEMA	National Environment Management Authority
NFIF	National Flood Insurance Fund
NFIP	National Flood Insurance Program
NGO	non-governmental organization
NJ	New Jersey
NOAA	National Oceanic and Atmospheric Administration
NPA	National Planning Authority, Republic of Uganda
NRC	National Research Council
NY	New York
NYC	New York City
NYU	New York University
PA	Pennsylvania
PDM	Pre-Disaster Mitigation
PT	Prospect Theory
R4	R4 Rural Resilience Initiative
RAMPP	Risk Assessment, Mapping, and Planning Partners
RFC	Repetitive Flood Claims
RI	Rhode Island
RWI	Research World International, LTD
SBC	Schwarz Bayesian Criterion
SEU	Subjective Expected Utility
SFHA	Special Flood Hazard Area
SfP	Solutions for the Poorest (programme)
STEP	Sheltering and Temporary Essential Power
TASAI	African Seed Access Index
TAMSAT	Tropical Applications of Meteorology using SATellite
TARCAT	TAMSAT African Rainfall Climatology And Time-series
TTT	Time to think

UBOS	Uganda Bureau of Statistics
UGX	Ugandan Schilling
UHRC	Uganda Human Rights Commission
ULI	Urban Land Institute
UMLG	Uganda Ministry of Local Government
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNISDR	United Nations International Strategy for Disaster Reduction
UNODRR	United Nations Office of Disaster Risk Reduction
UNPF	United Nations Population Fund
UNU-EHS	United Nations University Institute for Environment & Human Security
USA	United States of America
USAID	United States Agency for International Development
USCB	United States Census Bureau
USD	United States Dollars
USDA	United States Department of Agriculture
WFP	World Food Programme
WHO	World Health Organization
WTA	Willingness-to-accept
WTJ	Willingness-to-join
WTP	Willingness-to-pay
ZIP	Zone Improvement Plan

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1 Introduction and Contextual Background

1.1 Background/Context

Extremes in weather, including hurricanes, floods, and drought, are occurring with alarming regularity. When extreme weather occurs, affected households need to manage associated impacts, choosing from a variety of coping strategies. The option set from which households can choose is influenced by contextual circumstances, such as the existence of social support systems, availability of disaster aid, and household liquidity, among others. In terms of risk management strategies, different forms of diversification are commonly observed–often through activities undertaken or the manner of asset holdings. But, risks arising from extreme weather tend to be covariate in nature, meaning that a significant number of individuals grouped spatially are affected simultaneously. Consequently, covariate risks tend to be relatively more difficult to cope against due to the nature of occurrence and the magnitude of impact.

Insurance could be a key strategy employed to cope with the extreme weather impacts categorised as low-risk, high-consequence; however, it is sometimes the case that households that may benefit from coverage the most do not engage with insurance. In the literature, it is often claimed that in the developing context, insurance is largely undersubscribed when supplied (e.g., Warner & Spiegel, 2009). Furthermore, though insurance is more readily available in the developed country context, it is also often noted to be undersubscribed and often those facing the greatest risks are not insured (Kunreuther & Michel-Kerjan, 2009). The basic structure of insurance is premised on the ability to obtain customers and pool risk effectively. Yet, the optimal level of insurance enrolment given regional circumstances and potential consumers' profiles is debated. Some studies look at enrolment rates to determine success without accounting for characteristics that may (not) make a given household a good candidate given the structure of the given insurance scheme. It should not be a goal in itself to create high demand for insurance products, but rather to develop products that are well matched to the market and act as complements for other potential coping mechanisms.

In the analysis of insurance use, many empirical studies look at theoretical willingness-to-join (WTJ) an insurance scheme and respondents' willingness-to-pay (WTP) for hypothetical or pilot insurance tools to indicate suitability of the proposed scheme. This is a useful approach; however, it is important that, to the extent possible, insurance is seen as one option among many potential coping strategies and is analysed as such. The level of intended demand (and ultimate enrolment) for a given extreme weather insurance scheme is driven by the extent to which insurance effectively targets a risk that falls outside the household's alternative available risk coping mechanisms (e.g., Hazell et al., 2010). The level of demand is further mediated by available household resources, as well as preferences and perceptions about the insurance product and risk probability (Botzen & van den Bergh, 2009).

There is a developing academic literature as well as market research that examine insurance use and why it may (not) be attractive to households given socio-economic and attitudinal constraints with consideration for bounded rationality. There is considerable empirical evidence that insurance purchasing behaviour is often guided by households' perceptions of the risk at hand; this is especially pronounced for low-probability, high-consequence events. Additionally, the use of System I (intuitive) and System II (deliberative) thinking is beginning to be incorporated further into insurance research and planning (e.g., Kunreuther & Pauly, 2014, 2015). Yet, given the characteristics of decisions that involve insurance purchase under uncertainty, many of the popular examples studied in behavioural economics, especially regarding purchasing defaults, do not directly apply.[1] There is some debate–while these factors play a role in insurance demanded, failure to purchase insurance for extreme weather events could also be rational in some cases (Kousky & Cooke, 2012) .

There are areas for further research that are relevant across both the use of insurance for coping against extreme weather in both the developing and developed country contexts. There is differentiation in the specific relevant knowledge gaps between the two contexts. Furthermore, the most appropriate research methods to be employed may differ by context, given the dissimilarities in: policy environments, existing extreme weather insurance structures, the potential consumer base, and the existing research to date. This thesis addresses relevant knowledge gaps in each context through empirical research conducted in two case study areas. The first is a case study of agricultural microinsurance uptake in rural Uganda, which uses mobile technology to obtain stated preferences and integrates two field games related to perceptions of insurance and risk. The second is a case study of households in the area hit by Hurricane Sandy in the United States (USA) and comprises an online survey and simulation related to home flood insurance. Our specific research aims and objectives differ between the two studies given the fact that insurance is often location and issue specific; however, we draw parallels between the two cases, which may help build further understanding around general tenets of insurance purchasing behaviour.

The remainder of this section describes general background for agricultural microinsurance in the developing country context and home flood insurance in the developed country context. Section 1.2 notes knowledge gaps and areas for further research in the application of insurance against extreme weather generally and in the two specific contexts. Section 1.3 discusses the aims and objectives of the research presented in this thesis and covers policy-related and methodology-oriented aims. Attributes of the two case studies used in this research are summarised in Section 1.4. Section 1.5 provides an overview of research methods used throughout the thesis. Section 1.6 overviews the main limitations in this research. The contribution to knowledge this thesis offers is summarised in Section 1.7. The structure of the rest of the thesis is discussed in Section 1.8.

1.1.1 Agricultural microinsurance (Developing Context)

In the developing country context, findings suggest that coping strategies (both ex-ante and ex-post) against extreme weather provide some protection against risks and shocks; however, considerable risks often remain (Morduch, 1998; Dercon, 2002; Collins et al., 2009). Thus, there

[1] Many field and controlled experiments in behavioural economics have demonstrated that consumers are sometimes more likely to select a default option, rather than to take the effort to opt out (e.g., Johnson & Goldstein, 2003; Thaler & Benartzi, 2004; Thaler & Sunstein, 2008). Yet, for decisions under uncertainty that involve insurance adoption, the benefits of coverage are only realised when (low-probability) loss-producing events occur. Thus, it is unlikely that most households who fail to purchase insurance reverse course if a loss did not occur nor purchase coverage in the next period if insurance were the default option (Kunreuther & Pauly, 2014a, 2015).

is a place for formalised insurance within protection schemes that fill the gaps left by informal coping mechanisms in addressing extreme weather effects. Enabling the best mix of coping mechanisms is important, given that most of the world's rural poor depend, directly or indirectly, on agriculture for their livelihoods and are highly vulnerable to extreme weather. Agriculture is a source of livelihoods for approximately 2.5 billion people and provides the main source of income for 1.3 billion smallholders and landless workers (World Bank, 2008; Jatta, 2013).

Throughout the last decade, agricultural microinsurance, targeting small-scale farmers has been increasingly employed in developing countries as a means by which to address residual risks from extreme weather that are otherwise insufficiently addressed by other available coping mechanisms (Radermacher & Roth, 2014). Microinsurance, which is a subset of microfinance, is a financial product that mitigates risks by charging relatively low premia to a large relatively poor population in order to fund greater payouts when a risky disaster occurs (Churchill & McCord, 2012). Agricultural microinsurance comes in various forms and covers a range of the agro-business scope, from planting to delivering farm produce to market.

The use of indexed microinsurance has gained traction and is now routinely employed by most providers of agricultural microinsurance (Parada et al., 2014). The use of an index generally allows for agricultural microinsurance products to be offered to a wider range of farmers (Sandmark et al., 2013). Indexed agricultural microinsurance offers an approach to insurance provision that pays out benefits on the basis of a pre-determined index (e.g., rainfall levels) for loss of assets and investments, primarily working capital, resulting from weather and catastrophic events.

The inherent existence of basis risk is often characterised as a drawback in the use of indexed microinsurance. Basis risk refers to the differences that may occur between the actual loss incurred by the farmer and the loss determined by the index (e.g., based on rainfall levels close to, but not on a given farm). Basis risk entails claims for non-existent losses and no claims for actual losses. Individuals may suffer losses, and not receive payouts, or not suffer losses and get payouts. The concept of basis risk is difficult to explain to consumers of indexed insurance (e.g., Johnson, 2013) and to date there appears to be little analysis as to the extent which *positive* basis risk,[2] in the form of entailing claims for non-existent losses, affects insurance enrolment and retention rates (Sandmark et al., 2013).

There is considerable debate as to whether the claim that there is *disappointing demand* for agricultural microinsurance is an appropriate characterisation of the market. A frequent claim in the literature is that adoption (i.e., take-up) rates for index-based weather microinsurance are low among smallholder farmers in developing countries. Studies on willingness to engage with microinsurance given options that involve other mixes of insurance, savings, or investment through randomised field experiments and trials have hinted towards low adoption rates and note a number of potential barriers to demand, such as high price elasticity, liquidity constraints, and trust (Giné et al., 2008, 2012; Cole, Giné, Tobacman et al., 2013). It should be noted, however, that there are also examples in the literature stating that demand for index-based

[2] In our research we termed the outcome under which an individual entails claims from a payout being triggered at a weather station without incurring losses on their land to be "positive basis risk." This is due to the fact that this type of basis risk favours households; households gain monetarily, while avoiding actual losses.

microinsurance is relatively substantial. For example, Karlan et al. (2014) find that demand for index microinsurance is strong and its uptake leads to significantly greater productive agricultural investment and riskier production choices. Norton et al. (2014) find a high take-up rate for an expensive commercial insurance product over other risk management options, such as high interest savings and insurance characterised by lower premia payments and less frequent payout periods. Suarez & Linnerooth-Bayer (2010) find high adoption and retention rates for an index-based insurance system paired with loans that provides Malawian farmers with incentives to change cultivation practices to become more resistant to drought.

Agricultural microinsurance faces unique challenges compared to microinsurance policies against idiosyncratic risks, such as life and health. Biener & Eling (2012) provide a systematic analysis of microinsurance markets (covering 131 policies) based on a set of nine fundamental insurability criteria proposed by (Berliner, 1982)[3] and adapted for microinsurance. Their findings suggest that what is often thought of as a market failure in the literature on agricultural microinsurance stems from two issues that are inherent to the product: 1. low-frequency, high-severity risks (i.e., uniqueness of the product) and 2. small risk pools (e.g., market uniqueness).

There is the claim that the general structure of microinsurance schemes and/or the related distribution channels may justify policy intervention (e.g., Churchill & McCord, 2012) in order to reach the optimal households and be socially effective. This is a complicated issue as a number of regions standing to benefit the most from agricultural microinsurance simultaneously suffer from poor policy environments (Turral et al., 2010; Jack, 2011). Research that may provide insights for practical improvements in applied indexed microinsurance projects can be achieved a number of ways. Climate, extreme weather, and resilience have become increasingly urgent and interconnected issues on the development agenda in recent years. There is a high degree of interest in the evolving role of agricultural microinsurance as a tool for effective adaptation (Hellmuth, Osgood, Hess, Moorhead & Bhojwani, 2009; Chatterjee, 2012).

1.1.2 Home Flood Insurance (Developed Context)

There is some debate as to whether rising costs from extreme weather in the developed country context are due to increasing frequency of such events or increasing value at risk. Yet, there is agreement that financial losses will increase significantly in the developed country context into the future from extreme weather conditions (Webster et al., 2005; Botzen, 2012a). Webster et al. (2005) find that the number of severe hurricanes[4] worldwide has nearly doubled since the early 1970s. An increase in the number of severe hurricanes over a short period of time is likely to translate into damage to a much greater number of residences and commercial buildings into the future (Mills, 2005). Furthermore, there are claims that the combination of increased infrastructure, less than optimal insurance enrolment, and the financial strain of insuring risks

[3] The original requirement by Berliner (1982) for Criterion 6 (insurance premium) is that a sufficient return on capital should be provided. However, sufficient return on capital does not mean maximising returns. Instead, coverage of all relevant costs (claims costs, administrative costs and capital costs) is desirable to maintain the risk of insolvency at a reasonable level. See Vaté and Dror (2011) for a discussion. One aspect that is not addressed by Berliner (1982) is the availability of insured services to the target population, which is of particular relevance in microinsurance markets.

[4] Severe hurricanes in this analysis include those rated as Category 4 or 5 on the Saffir-Simpson Hurricane Wind Scale.

of increasing magnitude makes North America particularly vulnerable to extreme weather losses (e.g., Munich Re, 2012).

It is important to deepen understanding of the dynamics of consumer uptake for home flood insurance, especially in light of potential severe flooding increases. Underinsuring against flooding in the developed country context, especially in the residential sector, has been noted throughout the literature for decades (Cook & Graham, 1977; Camerer & Kunreuther, 1989). It is widely accepted that households tend to underinsure against low-probability, high-loss events relative to high-probability, low-loss events (Slovic et al., 1977); this is reflected by home flood insurance uptake patterns (Hsee & Kunreuther, 2000). Yet, the caveat stands that high rates of insurance uptake are not a goal in itself, but rather home flood insurance should be designed to target those with the greatest need, taking into account households' perceptions and preferences as well as limiting factors (e.g., budget constraints). It should be noted that we consider household flood insurance that is indemnity-based in structure.

There are mediating factors that bound the extent to which households choose to protect against vulnerability to natural disaster effects; in addition to budget constraints, perception of risks and subjective understanding of insurance should be considered. Camerer & Kunreuther (1989) and Kunreuther et al. (2013) offer a review of decision processes for low-probability, high-impact events and the relevant biases in probability judgement. Such heuristics include optimism bias, availability, ignoring low probability risks (Slovic, 1987), mental accounting (Thaler, 1985), reframing, endowment effects, regret (i.e., hindsight bias) (Fischhoff, 2003), status quo bias, and emotional dimensions of risk (Loewenstein & Thaler, 1989).

There is a developing literature addressing home flood insurance uptake and influencing factors, such as learning, risk perception, and the application of simple heuristics within the decision process to insure. Within the subset of simulations and games centred on this topic, the majority focus on a single aspect of insurance demand and do not always take into account a rich set of personal characteristics for respondents. For example, there are simulations and games focused on patterns of insurance uptake in a simulated flood scenario (e.g., Zahn & Neuss, 2012) in isolation, while others look exclusively at (generalised) risk-seeking behaviour after home flooding (Cameron & Shah, 2012; Page et al., 2014). Turner et al. (2014) combine post-flood survey data with behavioural experiments in Pakistan to find that experience with a past severe flood (both personal losses and observations of other's losses) has a significant positive effect on the WTJ flood insurance.

Prior to an extreme weather event, many households perceive its occurrence likelihood to be sufficiently low that it does not meet their threshold for requiring purchase of flood insurance. It is only following flood occurrence that these same individuals say that they would have liked to have invested in insurance ahead of time (Kunreuther, 2006); however, after some period they revert back to uninsured status (Michel-Kerjan et al., 2012). Botzen et al.'s (2015) study of New York City homeowners' risk perception revealed that they underestimated the likelihood of water damage from hurricanes, which may explain why only 20% of those who suffered damage from Hurricane Sandy purchased flood insurance before the storm occurred (Bloomberg, 2013). An in-depth analysis of the USA's National Flood Insurance Program's (NFIP) portfolio revealed that the median tenure of flood insurance was between two and four years, while the average length of time in a residence was seven years in the sample. This indicates that a significant number of homeowners cancelled their policies after some years (Michel-Kerjan et al., 2012).

Some studies take into account the effect of policy environments in various developed countries, specifically publicly available provisions for coping and required purchase of insurance, in the analysis of take-up of home flood insurance. For example, economic analyses demonstrate that although public compensation limits liability for financial losses, it also removes individual incentives to insure in many cases (Lewis & Nickerson, 1989; Kaplow, 1991; Kelly & Kleffner, 2003; Kim & Schlesinger, 2005; Brunette & Couture, 2008; Raschky et al., 2013). It should be noted that the debate as to whether there is *disappointing demand* for flood insurance is less pronounced in the data due to the underlying policy environment.[5]

As the future will likely be characterised by less frequent, but much more intense hurricanes and associated flood events (Knutson et al., 2008; IPCC, 2012), it is important that uptake of appropriate flood insurance coverage is achieved. In turn, increased adoption of residential flood insurance can arise from tools that are designed and marketed based upon better understanding of consumer attitudes and preferences for it.

1.2 Knowledge gaps–overview

This section notes a number of areas in the knowledge base for the demand for extreme weather insurance that could benefit from increased research. The main areas for extension specific to the developing and developed country contexts are summarised in the Sections 1.2.1 and 1.2.2.

There is debate as to whether there is *disappointing demand* for extreme weather insurance. It often appears to be the case that insurance products offered: 1. cover areas/risks that may be addressed through the use of other coping mechanisms or 2. aim at potential consumers of the product that perceive it is an unnecessary precaution, which at least partially explains so-called *disappointing demand*. The latter point may stem from the influence of existing (non-existing) public policies and/or the view of insurance as an investment opposed to a protective activity (Michel-Kerjan et al., 2012).

1.2.1 Agricultural Microinsurance (Developing Context)–Knowledge Gaps

A solid foundation for the development of agricultural microinsurance products requires attention to the circumstances and perceptions of the target population, such that innovative solutions addressing provider access gaps and incentives can be addressed. There are two main knowledge areas regarding agricultural microinsurance that would benefit from further research efforts: 1. aspects related to basis risk and perception that may affect take-up rates and 2. understanding of the potential market for agricultural microinsurance, especially its relationship to a set of alternative coping mechanisms. These are broad topics of research; in this section we distil specific areas of inquiry we strive to address.

[5] There are four principle types of flood insurance models around the world, differentiated by who backs the insurance (government or private markets), and whether it's bundled or separate from other property insurance coverage (e.g., flood and fire insurance are frequently bundled together). Lamond & Penning-Rowsell (2014) provide a review of flood insurance structures worldwide.

Cole et al., (2012) indicate a number of potential gaps in the literature, especially concerning take-up and the impact of index-based microinsurance in terms of effective coping. There are knowledge gaps about issues such as the impact of financial literacy, consumer education, and the potential for group influence on households' perception/awareness of basis risk and subsequent effects on take-up rates. It is often unclear how potential consumers understand and interact with basis risk (Mechler et al., 2006; Eling et al., 2014). This can be related to whether households perceive indexed microinsurance as an investment or a protective activity/coping mechanism (e.g., Clarke & Dercon, 2009). In some studies, insurance is presented as an option among other formal savings or hybrid products; however, in such studies, it is often not explicitly situated within a wider group of informal coping mechanisms that are available to the farmers (e.g., Patt, Suarez et al., 2010).

Many products have demonstrated that indexed agricultural microinsurance (as a full product or as a component of a mixed-microfinancial product) can help manage agricultural risks. Yet, there is still work to be done in perfecting their design–in particular, in reducing basis risk, and improving farmers' understanding of the products (Sandmark et al., 2013). One concern is that there has been a transfer of some products that show signs of relatively high uptake elsewhere, but which are not appropriate for local conditions. To this point there is desire for a research tool that can be standardised between regions and cost-effectively applied to a relatively large-N sample of potential consumers (R. Kariuki 2015, per. comm., 13 March).[6]

It is difficult to discern specific attributes that may influence adoption of index-based insurance across contexts. Across studies there is simultaneous variation in indices, vulnerability, and cultural norms in the applied experimental structures. Previous studies investigate various aspects of the rate of uptake of indexed insurance, such as lack of financial literacy and exposure to financial markets (e.g., Giné et al., 2008), lack of trust (Cole, Giné, Tobacman et al., 2013), and liquidity constraints (Barnett et al., 2008; Collier et al., 2009). In their meta review, Azad et al. (2013) isolate 24 key variables related to adoption of agricultural index insurance; he groups them into categories through factor analysis. Among those that are most important on the demand side are: revealed uncertainty, riskiness of environment, empowerment, education, and training. Collective inclusion of these topics in market studies to the extent possible could help provide an indication of relative importance to different segments of the potential consumer market for agricultural microinsurance. In this manner increased knowledge can be built up around benefits for potential clients—for which risks and for whom agricultural microinsurance may provide better value in terms of appropriateness of enrolment (demanded protection coverage), affordability (total cost), and accessibility (simplicity, physical access, convenience) compared to or in combination with other risk management mechanisms (including credit, savings, informal coping strategies, safety nets, social security).

Empirical evidence suggests that risk aversion has a significant effect on WTJ indexed insurance; however, the direction of this relationship remains unclear. In short, there is evidence that risk aversion often has a significant and negative effect on insurance demand (Giné & Yang, 2009; Cole et al., 2011; Dercon & Christiaensen, 2011). In the literature there is some evidence that WTP is increasing in risk aversion; however, for the most averse individuals demand for

[6] Mr. Rahab Karanja Kariuki is the Head of Sales and Marketing at Acre Africa, formerly known as Kilimo Salama, which covers a market share of agricultural microinsurance in Kenya and is slated to start pilots in Rwanda and Tanzania in 2016.

insurance appears to fall (e.g., Clarke, 2011). There is need to further address the dynamics of risk aversion and related aspects on WTJ and WTP for agricultural microinsurance. For example, drawing relationships between the relative risk aversion and risk preferences in farming-specific realms (e.g., seed choices) may provide insights as to novel approaches to microinsurance that better serve various groups of farmers.

There are research strands that look at household perceptions of extreme weather in comparison to actual weather patterns; however, results of such a comparison do not often appear in academic analyses of potential agricultural microinsurance enrolment via WTP. It is potentially important that this consideration be made. For example, Osbahr et al. (2011) find that in southwest Uganda long-term weather observations are relatively consistent within-sample between farmers and that there are subtle patterns in the weather data that correlate with these perceptions. In a study of two regions in semi-arid Zimbabwe, Moyo et al. (2012) find that farmers were characterised as highly risk-averse and in turn they perceived climatic and weather pattern changes over the past two decades to be more extreme than the data would suggest. It is important to consider local farmers' perceptions on climate risk, as it greatly influences on-farm investments and decision-making (e.g., Moyo et al., 2012).

Since the majority of the agricultural microinsurance market is based on the use of indexed microinsurance, we base our research on assessment of indexed insurance. Yet, to the best of our knowledge there is not much in the literature that compares the potential use of index-based insurance and indemnity-based policies for a given agricultural microinsurance scheme. This is likely due to the fact that there is little in the way of dissemination channels for indemnity-based microinsurance that can remain economically feasible (e.g., R. Kariuki 2015, per. comm., 13 March).

As noted previously, there is debate as to whether or not agricultural microinsurance should be characterised as *undersubscribed*. Strengthening the knowledge base on the effect of factors related to agricultural microinsurance demand could provide insights into this debate. This type of research can help inform formulations of agricultural microinsurance schemes that appropriately address the potential consumer base and helps facilitate creation of a tool that households are interested in purchasing and that has clear value-added above other coping mechanisms available to them.

1.2.2 Home Flood Insurance (Developed Context)–Knowledge Gaps

There is a long-standing and growing academic literature on home flood insurance; however, there are few empirical studies that look at iterative flood insurance choice, especially for a sample divided between cohorts of those recently affected by an extreme flood and those who were not (but live in a similar area). Few of these empirical studies take place temporally close to the realisation of an extreme event. It is difficult to gain access to affected individuals immediately after a severe flood event occurs; in cases when it is possible, execution of a large-N study that accounts for patterns of flood insurance uptake, related attitudes, and demographic details is difficult to achieve (e.g., Petrolia et al., 2013). Several studies that examine longitudinal datasets for the influence of disaster experience on ex-post insurance demand and mitigation behaviour find that individuals commonly have a higher flood insurance demand after recent experiences of flooding (Browne & Hoyt, 2000; Kriesel & Landry, 2004; Zahran et al., 2009; Michel-Kerjan & Kousky, 2010).

Seifert et al. (2013, p. 1691) note that a “possible obstacle for an adequately functioning flood insurance system is that individuals need to *play their role* in the system and buy insurance.” Several studies have shown that in practice many households do not make the rational trade-offs between the costs of insurance and its expected benefits in terms of reduced risk, as has been assumed by Expected Utility (EU) Theory (Kunreuther, 1984; Kunreuther & Pauly, 2004; Krantz & Kunreuther, 2007). For instance, many homeowners in the USA do not purchase flood insurance even for premia close to the expected loss or even those that are subsidised (Dixon et al., 2006), while expected utility theory predicts that risk-averse individuals would purchase insurance for such premiums. There has been much written on why this may occur; however, there is room for further analysis as to the underlying drivers and to the extent possible consideration for the role of System I and System II thinking in home flood insurance decisions.

Some studies to date undertaken in person with a sample affected by flooding make claims about insurance behaviour based upon experimental gambles (i.e., potential gains). Two such studies are Page et al. (2014) and Eckel et al. (2009); both report that direct experience with flooding decreases risk aversion in comparison with a control group of less- and unaffected households. However, the tenets of Prospect Theory suggest that individuals likely conceptualise these types of gambles differently than they do insurance purchases (i.e., potential losses) (Kahneman & Tversky, 1979). Thus, further empirical investigation as to the potential correlation between gambling behaviour and intended insurance behaviour controlling for other factors would be useful.

There are some findings as to how the presentation/framing of data related to a potential extreme weather event affects the insurance purchase. It is widely accepted that graphical descriptions and experience affect households’ ability to more accurately understand risk, i.e., one’s subjective probability is closer to the objective probability value function (Budescu et al., 1988; Hertwig et al., 2004). To date, findings on the effects of the graphical display of risk probabilities and expected value of risk taking are heterogeneous; many are applicable to insurance, but have not been explicitly tested in that context. For example, Hertwig et al. (2004) find detailed numerical descriptions about outcomes and probabilities lead to reductions in risk seeking behaviours. There are few empirical studies that look at household’s stated preferences while considering responses in a simulation of flood insurance purchase, especially for a relatively large-N and representative sample. A notable exception is the study by Petrolia et al. (2013), which combines household-level data on the choice to purchase flood insurance with experiment-based risk preference data and subjective risk perception data for the USA Gulf Coast. It remains relatively unclear how the (flood) insurance purchase is affected by an individual’s attitudes regarding insurance and risk, controlling for socio-economic and demographic factors. It would be ideal to trace evolving preferences for flood insurance through a longitudinal empirical study that can review the use of System I and System II processes over a number of years.

The next section addresses aims and objectives of the research presented in this thesis.

1.3 Aims and objectives

Potential areas for continued research differ between the developing and developed country contexts due to variation in market structures (e.g., prevalence of index-based versus indemnity insurance products), as well as underlying policy and social structures (e.g., available coping mechanisms outside of insurance). In the following sections we note policy-relevant and methodological objectives of our research and classify them as relevant to insurance against extreme weather[7] in the developing or the developed country context. There are limitations between the two contexts given characteristics, such as literacy, which we strive to incorporate into the research approach taken. Section 1.5 will provide an overview of the methods employed in order to explore the outlined aims and objectives.

1.3.1 Agricultural Microinsurance (Developing Context)– Policy-Relevant Objectives

Estimates that climate change will lead to a 50% drop in agricultural production in Africa by 2030 (IPCC, 2007) continue to motivate further research into the efficient and effective use of agricultural microinsurance and necessitate further inquiry into areas of thin knowledge to date that may be applicable to policy innovations specifically.

We look for key features that may influence index-based agricultural microinsurance to make it useful to specific groups of potential users, defined by heterogeneous characteristics. As noted previously, there is much research that looks at WTP for agricultural microinsurance. Often this research compares WTJ and WTP across options that are composed of combined savings and insurance products and/or those that undertake other forms of risk transfer or reduction. We aim to lend some insight as to whom agricultural microinsurance can provide better value in terms of appropriateness of use/enrolment, affordability (total cost), and accessibility (simplicity, access) taking into account other potentially available risk management mechanisms (e.g., loans, informal coping strategies, savings).

We look at households' WTJ and WTP for a hypothetical index-based microinsurance product; however, this is done within a larger context of information about the surveyed households, which range from socioeconomic indicators to perceptions of weather risks. We attempt to draw relationships between stated preferences for agricultural microinsurance, available means of coping (informal and formal), as well as loans required for risk management in relationship to insurance demand.

To the extent possible we aim to account for perceptions of loss frequency, attitudes towards risk, and other relevant socio-economic factors in this analysis. Furthermore, we try to control for households' bounded rationality by accounting for perceptions and preferences that may influence household insurance enrolment choices. For example, we take account of the *feeling of insurance*, under which a household gains utility from the feeling of protection from insurance, even if there is no net financial gain from taking on the insurance coverage.[8] Further focus on these topics may allow for a more complete understanding of the relevance of index-based insurance as a policy solution and contribute to the debate as to whether there is disappointing demand for agricultural microinsurance. Findings may provide insights into key features of an indexed insurance tool that relate to consumers' perceptions and attitudes that may make it more (less) useful to different subgroups of smallholder farmers.

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[7] Dependent on which case study we used to study them.
[8] See Chapter 3 for a full description of the *Basic Dice game*.

Among other reasons, agricultural microinsurance has been indexed in an effort to offer products to the widest range of consumers at the lowest cost possible (Thom et al., 2014). Frequently it is the case that available dissemination channels have not been structured in a manner amenable to the requirements of indemnity-based coverage.[9] However, we strive to look at some aspects of indemnity-based insurance and perceptions of households in our sample for both indexed and indemnity-based agricultural microinsurance options. This makes sense because the potential distribution network for insurance in our case study is suitable to offer indemnity-style insurance (C. Nestor 2010, per. comm., 15 January).[10]

We strive to obtain a better understanding of how households in the developing country context may perceive index-based microinsurance and understand basis risk. In our research we aim to learn about responses to the realisation of basis risk via retention rates into the next period in a game setting. In particular, we address two elements of basis risk that, to the best of our knowledge, tend to be minimally addressed to date: 1. households' responses to the realisation of *positive basis risk* and 2. households' responses upon observation of the realisation of basis risk for neighbours. These findings may have implications for the use of index-based insurance and provide some insights related to retention rates. There have been advances in the calculation of indices based on weather data and yield; however, indices may be better formulated if they extend the extent to which they take into account these types of demand-side factors.

1.3.2 Home Flood Insurance (Developed Context)–Policy-Relevant Objectives

We strive to add to the knowledge about the circumstances surrounding uptake of home flood insurance. Many studies that consider a relatively large-N sample and trace variability in insurance uptake between periods tend to address socio-economic and demographic factors, but look less at households' attitudes and preferences regarding insurance and risk. We aim to research whether (or not) households that express a greater desire for flood insurance and perceive the greatest subjective risk to their household from flood will tend to purchase insurance more frequently, *ceteris paribus*. Furthermore, we aim to determine if more recent experience with extreme flooding has an effect on households' propensity to insure in our sample throughout the simulation of flood.

Extreme weather events highlight the challenges policymakers face in encouraging residents in hazard-prone areas to protect themselves against future disaster losses (Michel-Kerjan, 2012). Kunreuther et al. (2013) recommend some methods to encourage greater home flood insurance enrolment and means by which to make insurance more favourable to the public largely based on the concept of libertarian paternalism (Thaler & Sunstein, 2003). Yet, there is room for further exploration of System I and System II considerations that may influence households'

[9] Indemnity-based insurance requires extensive networks of claims adjusters who assess individual losses following an event. Additionally, it requires investments for marketing to individual farms and controlling moral hazard (Linnerooth-Bayer et al., 2011). Traditional indemnity-based agricultural insurance programs are costly, which is driving reason why many such programs have failed in developing countries and the market has tended towards index-based insurance (Kapur, 2005).

[10] The Community Knowledge Worker (CKW) Network is introduced in the next Section and in Chapters 3 and 4. It is a network of local farmers who are elected by the community to deliver Grameen Foundation's mobile app surveys and tools. Trusted by the community and have a structure that they could assess on-farm losses during biweekly visits to the farmers they serve.

decisions to insure (or not). Specifically, there is not a great deal of supporting research as to how the description of potential loss affects the uptake of insurance; the finding of such research may influence the manner in which insurers present such information to potential consumers. To this point, we aim to determine if and how the presentation (i.e., visualisation style and level of detail) of probability data related to a potential extreme weather event affects insurance purchase, *ceteris paribus*.

There is a developing literature on insurance choices immediately following extreme weather events. Some of this research strives to obtain data on households' willingness to gamble (Page et al., 2014). We aim to further consider if questions framed as a gamble provide an appropriate proxy for risk aversion and indicate households' insurance purchase behaviour. In turn, findings may help extend our understanding of how potential consumers perceive insurance and subsequently how this view may affect the choice to insure.

1.3.3 Agricultural Microinsurance (Developing Context)–Methodological Objectives

At the time our research related to the developing country context was under development and executed (2009-2012) the use of mobile technology was not as common in field research as it is at present and had a greater level of novelty to the approach. We strove to develop a methodology that would allow us to combine a large-N survey with field games in order to address our policy-relevant objectives for the developing country context, as noted above. We designed this survey work such that it could be administered through the Community Knowledge Worker (CKW) Network, members of which we trained extensively in order to carry out the individual interviews of the rural farmers in their local languages.[11] Employment of the CKW Network helped ensure that we obtained the most representative sample of farmers possible; this was especially important since reliable population statistics are not easily obtained (C. Nestor 2010, per. comm. 18 January).

We aimed to the extent possible to create a survey questionnaire and related games that could be applied across regions, especially those in which agricultural microinsurance will be introduced for the first time, as there is demand for such a tool expressed by agricultural microinsurance providers (e.g., C. Nestor 2009, per. comm., 18 December; R. Kariuki 2015, per. comm., 13 March). Many regions of smallholder farmers represent relatively new markets for agricultural microinsurance and face similar issues–in terms of wealth distribution and challenges from extreme weather; the caveat being underlying policy environments and traditional coping (ibid.). The survey tool was designed to assess insurance demand ahead of product development in the context of other household factors that have previously been shown to significantly affect WTJ and WTP (e.g., Cole et al., 2012; Eling et al., 2014).

The rural Ugandan survey tool comprised of a series of stated preference questions related to socio-economic issues, means of coping, as well as expressed WTJ and WTP for agricultural microinsurance. It also included two incentivised field games, addressing: 1. risk aversion (*Coin game*) and 2. utility from the *feeling of insurance* (*Basic Dice game*). We aimed to provide field games that could: 1. be easily understood by a sample characterised by low formal education,

[11] Launched in Uganda in 2009, Grameen's CKW Network serves farmers in remote communities through a network of peer advisors. The initiative combines mobile technology and human networks to help smallholder farmers get accurate, timely information to improve their businesses and livelihoods.

2. be played in different settings (e.g. table top or dirt field), and 3. those administering the games could explain the rules and record the outcomes accurately. The methodological objective related to the *Coin game* was to extend the ease with which risk aversion can be estimated through a simple game following on from past work (Binswanger, 1982) and to contextualise it within farming decisions, to the extent possible. The *Basic Dice game* in turn was meant to address the utility they gained when there was no effective marginal benefit to that coverage, which to the best of our knowledge is not explored frequently in insurance for extreme weather and has not been incorporated in research the addresses the developing country context.

There are a number of field studies that look at propensity to insure, WTJ, and WTP for index-based agricultural microinsurance. Our aim in the development of the set of survey questions used in the survey tool was to determine potential relationships between households' indicated WTJ and WTP for indexed-microinsurance and household characteristics, available potential coping strategies (e.g., loans and remittances), and perceptions of risk. In particular, in the context of loan behaviour, there is little that has been done to compare insurance demanded with data on historical household loan behaviour. In developing these questions, we strove to employ methods that provided precise responses that also could be applied by the rural sample.

A separate field game was developed in order to investigate attitudes towards basis risk arising from index insurance using a novel, iterative game involving farmers allocating their wealth between insurance and crop production. The *Complex Dice game* was designed to meet the objective of determining patterns of iterative choice for insurance coverage under a simple index-based insurance field game. The game was designed to provide a method to gauge small-scale farmers' reactions to and attitudes towards index-based agricultural insurance. There are field games and experiments that look at understanding of and reaction to basis risk (e.g., Patt, Suarez et al., 2010; Elabed & Carter, 2015a). To the best of our knowledge, incorporating players' considerations of basis risk, both in positive and negative directions was novel in our game structure. Additionally, to the best of our knowledge, there is no reported field studies of reactions to basis risk in a group setting. There is some research on the trusted neighbour effect which suggests knowing peers with claims implies that trust is built ex-post an extreme weather event (e.g., Morsink & Geurts, 2012). One methodological aim of our research was to develop a protocol for farmers to play in a group in order to gauge the effect of social interactions, specifically observation of a neighbour experiencing basis risk, on one's choice to insure.

Research that may provide insights for practical improvements for applied indexed microinsurance projects can be achieved a number of ways. We use a large-scale field survey tool and games to look at how household characteristics, choice of coping mechanisms, and perceptions may affect WTP and in turn, the possible implications of these factors on households' integration within indexed insurance. We have provided an overview of the methodological aims of our research, which are specific to the developing country context; an overview of the study methodology is found in Section 1.5.1 and a detailed methodology is provided in Chapter 3.

1.3.4 Home Flood Insurance (Developed Context)–Methodological Objectives

In order to address the issue, we highlight for home flood insurance in the developed country context, we created an online survey tool, comprising: 1. a survey tool, 2. a flood insurance purchase simulation, and 3. an incentivised gambling activity. In the simulation we include as a treatment a more extensive (graphical) presentation of expected losses to assess if this affects insurance uptake rates. The structure of our study for the developed country case study strives to address some key issues about learning from experience in the context of a flood simulation exercise, while also controlling for recent experience with such an event. We chose to focus on household flood insurance as opposed to other weather disaster insurance because many covariate weather hazards culminate in extreme flooding and flood insurance has received attention as being undersubscribed without extensive understanding of uptake patterns and the associated relationship with underlying factors.

There is little empirical study of iterative flood insurance choice, especially for a sample divided between cohorts of those recently affected in reality by an extreme flood and those who were not (but live in a similar area). We pair an experiment on the effects of recent real-life experience with storm-induced flooding on flood insurance purchase with a detailed survey regarding attitudes and perceptions of flood-related and other risks. To the best of our knowledge this is an extension of the use of an online platform, as many ex-post simulations and games in the developed country context still take place in-person and are paper-based because of lack of connection and representative sample (Page et al., 2014). Generally, empirical studies of propensity to insure against extreme flood events have been based on laboratory experiments that trace the ability of respondents to learn from experience to invest in protection against extreme weather events (Meyer, 2012; Zahn & Neuß, 2012).

Incorporating a gambling exercise related to the outcomes of the flood simulation section is meant to help clarify the extent to which risk behaviour is transferable between the two contexts. There are some tenuous claims in the literature about the relationship between experience with flooding, insurance behaviour, and gambling choices. Often such studies have a respondent set that has been recently affected by such an event in real life who are asked a brief set of questions related to risky behaviours (e.g., gambling) in order to gauge their insurance appetite in the future (Page et al., 2014). Our methodology of having the respondent place a gamble based on the outcome of her insurance simulation is meant to indicate if there is a connection between the two concepts and if so, to look at potential implications for how to better offer and structure home flood insurance.

We have provided an overview of the methodological aims of our research which are specific to the developed country context; a further overview of the methodology is noted in Section 1.5.2 and Chapter 3 provides a detailed methodology.

1.4 Case studies–overview

As previously noted, there are significant differences between the developing and the developed country contexts for insurance employed against low-probability, high-impact events. The differences fall along various dimensions, from the underlying social security policies and the types of alternative (formal and informal) coping strategies available to the current structure of insurance schemes. We strove to choose a case study in each context that is representative of pressing low-probability, high-consequence events faced by a relatively large proportion of each population that may benefit from improvements in the structure of insurance tools provided.

A case study was chosen in each of the two contexts in order to assess influence on insurance demanded by aspects related to households' 1. economic (e.g., budget constraints), 2. social and cultural (e.g., trust and peer effects), 3. structural (e.g., perceived risk exposure), and 4. personal and demographic factors. These are the main factor groupings that form our conceptual framework, presented in full in Chapter 2. The case study for agricultural microinsurance took place in rural Uganda. The case study for home flood insurance took place in the northeast USA following Hurricane Sandy. In the developing country context we were interested in locations that did not yet have formal agricultural microinsurance in place,[12] and were highly dependent on small-hold agricultural development. In the developed country context we strove to find an area with a sample recently affected by home flooding. A brief description of both case studies is offered below; Chapter 4 provides further details on the case studies and relevant descriptive statistics for our samples.

1.4.1 Demand for agricultural microinsurance in Uganda

Our mobile survey and field games related to agricultural microinsurance were conducted in two regions of rural Uganda, Oyam and Kapchorwa, yielding over 3,000 usable observations. The two regions were chosen for their relative differences in available coping strategies outside of microinsurance, variations in crop choice, and variation in extreme weather faced (i.e., flood vs. drought). Oyam district is in northern Uganda, bordering the Gulu region, which was plagued by civil war from 1986 to 2006 and is still in the beginning stages of recovery (UHRC, 2006). The second district studied is Kapchorwa, in eastern Uganda, bordered by Kenya and encompasses Mt. Elgon. In relative terms, Kapchorwa is a wealthier region than is Oyam due to its proximity to the Kenyan market and location near Mt. Elgon National Park (e.g., E. Chelangat 2010, per. comm., 18 March). Many sources of risk additional to weather variability faced by Ugandan small-hold farmers is not easily mitigated, e.g., inflation risk, price volatility, local events of instability, which makes a cross regional comparison of interest.

Uganda is a country characterised by small-plot, small-village farming, and limited infrastructure. Almost 40% of the Ugandan population is estimated to live below the Ugandan national poverty line and the majority of Ugandans receive their money in non-regular intervals due to variations in the farming productivity (Uganda FinScope, 2007). It is difficult for farmers to diversify and some inputs such as fertiliser are unaffordable in these regions (J. Matovu 2011, per. comm., 20 March). These farmers tend to be price-takers and markets for the commodity crops produced are nationally-stable, but locally-volatile in wholesale price terms (e.g., AGRA, 2013). Given these market characteristics, as well as the structure of Ugandan legislation guiding insurance[13] (GIZ, 2013) at the point in time the research reported in this thesis was undertaken, there was no formal agricultural microinsurance offered in Uganda (IRAU, 2013).

1.4.2 Demand for home flood insurance in the northeast USA

The American case study compares demand for home flood insurance between those affected and unaffected by Hurricane Sandy. We obtained 800 household responses for our online survey

[12] This decision was taken in part because it is documented (Radermacher & Roth, 2014) and anecdotes (e.g. R. Kariuki 2015, per. comm., 13 March) indicate that households that have dropped out of a microinsurance scheme tend to be unlikely to enter into another.

[13] The main law governing insurance business in Uganda is the *Insurance Act (1996)* as amended by the *Insurance (Ammendment) Act (2011)*.

tool in a representative sample of those affected. Hurricane Sandy occurred in October 2012 and affected residents on the east coast of the USA The storm caused an estimated USD 65 billion in economic losses to residence, business owners, and infrastructure owners (Aon Benfield, 2014), making it the second most costly natural disaster since 1900 in the USA (NOAA, 2012). At least 650,000 houses were either damaged or destroyed as a result of Hurricane Sandy, with the vast majority of the damage caused by storm surge and/or waves (Hurricane Sandy Rebuilding Task Force, 2013). This case study is especially relevant to the debate surrounding *disappointing demand* for extreme weather insurance, as it is estimated that only 20% of American homes at risk for floods are covered by flood insurance (Smith & Matthews, 2015).

The USA Federal Government is not directly involved in provision of natural disaster insurance; however, flood damage is a notable exception. The NFIP was established in 1968 and is operated by the Federal Emergency Management Agency (FEMA) to make flood insurance available in vulnerable communities and requires homes located in high flood-hazard areas to purchase flood insurance as a condition for a federally backed mortgage. Yet, after major floods it is often apparent that affected households either did not purchase or let their policies lapse; Kunreuther et al. (2011) report that following Hurricane Katrina, the number of affected households holding flood insurance ranged from 7.3 to 57.7% across counties. Furthermore about 20% of NFIP flood insurance holders pay discounted rates, making their perception of flood probability artificially low (Kousky & Michel-Kerjan, 2012).

There have been attempts to correct faults with the NFIP, such as improved flood plain mapping and increasing artificially low rates through the *Biggert-Waters Flood Insurance Reform Act of 2012*. Yet, sections of Biggert-Waters, especially rate increases, were prohibited by the *Consolidated Appropriations Act, 2014*. Thus, relatively weak regulation of residential zoning in flood plains, among other factors, make supplying flood insurance ever more expensive for insurance suppliers in flood-prone areas of the USA, but also puts a greater onus on the consumer to obtain appropriate insurance coverage for her property. Greater understanding of factors that motivate purchase of home flood insurance could help better match levels of insurance and improve channels of insurance provision.

1.5 Research framework and methods–summary

In this section we provide an overview of the methods used to assess influence on insurance demanded by aspects related to households' 1. economic (e.g., budget constraints), 2. social and cultural (e.g., trust and peer effects), 3. structural (e.g., perceived risk exposure), and 4. personal and demographic factors. The appropriate methods of delivery and structures for research analysis differed between the developing and developed country case studies.

In both cases we use typical surveys using questions that ask respondents to provide statements or to respond to multiple-choice questions about their preferences, attitudes, and demographic details. In development of those questions related to preferences and attitudes we were cognisant of matching preferences as a good measure of utility per Parfit's (1986) account of well-being and utility. Furthermore, we kept in mind that respondent attitudes and perceptions (ahead of the survey and arising from the survey tool itself) may affect their expressed preferences and choices. Incentivised field games and simulations were also employed to gauge intended behaviour to the extent possible with regards to insurance purchase and risk appetite.

Finally, questions were chosen in a manner to facilitate comparison between direct statements about preferences and revealed (intended) behaviour, especially with regards to risk attitudes.

1.5.1 Survey and field games in Uganda

To the best of our knowledge the Uganda study is the largest of its type undertaken in sub-Saharan Africa to date. It utilises smartphone mobile-technology to disseminate a survey of 125 questions to over 3,000 respondents. Two simplistic field games were incorporated into the survey to gauge respondents' risk aversion (*Coin game*) and their revealed utility from feeling insured (*Basic Dice game*). We also conduct a separate more complex field game, which investigates attitudes towards basis risk arising from index insurance, called the *Complex Dice game*.

The smartphone survey, the *Coin game*, and the *Basic Dice game* were conducted by members of the CKW Network. This approach allowed us to obtain a more representative sample in our research, as many farmers are willing to talk to a known local intermediary, as opposed to an outsider, especially regarding personal information (Amadu, 2014). This is especially important in the Ugandan context because population data upon which to base sample selection is scarce and there is no recorded information for a large majority of statistics of importance to this study (J. Matovu 2011 per. comm., 20 March; C. Nestor 2010, per. comm., 15 January). We trained the CKWs extensively on the survey tool which we developed and programmed for the Grameen Foundation's AppLab during 2010-2011. This followed a series of focus groups in Kapchorwa and Oyam as well as analysis of preliminary pilots conducted in Uganda and India.

The order and types of questions asked in the mobile survey were informed by process mapping for microinsurance (e.g., Steinmann, 2012). Findings from the focus groups and pilots helped us to develop successful ways to introduce agricultural microinsurance to a sample in which some respondents did not have previous knowledge about it. Questions were included that relate to 1. economic, 2. social and cultural, 3. structural, and 4. personal and demographic factors. It was important to involve questions that could be employed in analysis of influences of bounded rationality on choices expressed within the survey; i.e., those that allowed us to gauge differences between perceptions and actualised behaviours, where possible. Furthermore, questions specific to insurance preferences were included, such as WTP, pay-out timeframes, policy type, etc.

We elicit the stated WTP for hypothetical index microinsurance using a double-bounded price ladder approach; this approach was adopted after respondents showed trouble engaging with payment cards during the pilots.

The incentivised field games are played and responses are noted in the smart phone application by the CKW; the incentives matched performance in the games and the average payment was equivalent to a day's salary. The *Coin game* measures the respondent's risk aversion through a triple-bounded dichotomous choice structure between two coins representing crops with varying levels of risk. This offers an improvements on (Binswanger, 1980, 1982)[14] study of rural Indian farmers' choices among a series of gambles with non-trivial payouts.[15] The *Basic Dice*

[14] Binswanger's sample size was 330; however, only 220 responses were used in the majority of his data analysis.
[15] The experimental payoff scale was increased in Binswanger's experiment, such that in later rounds the payout level was comparable to potential real world returns from agricultural investments.

game tests the respondent's preferences for purchasing insurance in an environment characterised by weather uncertainties[16] and provides a measure for feeling of insurance, as discussed previously, by keeping the probability of loss consistent whether or not insurance is selected by the player. The final sections of the survey ask farmers to reflect on farming practices, as well as social and cultural factors (e.g., worry).

To the extent possible, we look at differences between directly stated responses and preferences revealed by the game sections and questions that indirectly assess preferences. For example, we examine if a respondent who is willing to take large risks (i.e,. endure large variance) in the *Coin game* is also willing to take similarly large risks in real-life decisions (i.e., farming inputs). We also review the extent to which respondents' perceptions of extreme weather frequency compare with recorded weather data for their region.

In the *Complex Dice* game, we strive to isolate players' experience of basis risk and subsequently, better understand the effects has on perception of and willingness to adopt or renew index insurance. Given the complexity of the game structure it we administer it to the CKWs, who have been tested for their understanding of indexed insurance. The original contribution to knowledge of our field experiment is the incorporation of basis risk, both in positive and negative directions, in the game. We also have farmers play in a group setting in order to gauge the effects of observing the realisation of basis risk for another (e.g., a neighbour).

1.5.2 Survey and simulation following Hurricane Sandy

The survey and simulation work undertaken regarding households in the region affected by Hurricane Sandy strive to extend the literature on risk aversion and insurance uptake after an extreme event. We programmed an online interface using the Qualtrics© platform and Java script. Qualtrics© was contracted to provide a representative sample of respondents. The total sample size was 800 households; 500 of who experienced losses from Hurricane Sandy whilst 300 were not directly affected by the Hurricane, but lived in the same areas.

The survey garnered demographic information and posed direct questions about risk perceptions and attitudes towards insurance purchase to respondents. The simulation was iterative; respondents started with the same hypothetical endowment in each of the ten scenarios and faced a different probability of household flooding. There was a treatment in the simulation that exposed half of the sample to graphical (opposed to written) descriptions of potential outcomes. Finally, all respondents were exposed to a gambling exercise that we use to explore potential parallels with respondents' insuring behaviour in the simulation.

1.6 Research Limitations

There are limitations inherent to the work undertaken in this thesis. Generalisability of findings is one that comes up in much empirical study of factors affecting insurance demand (Eling et al., 2014) due to the underlying social and political structures. Furthermore, assuring measurement accuracy for these factors between settings can be difficult to achieve (e.g., due to cultural

[16] Our Complex Dice Game is specific to the study of indexed insurance and obtains data on respondent's reactions to and preferences for basis risk. This field experiment is conducted with a smaller pool of respondents, as described in Chapter 8.

norms), especially as appropriate metrics may differ between contexts (e.g., Dragos, 2013; Outreville, 2014). Though we can draw some comparisons between the two cases and identify factors that affect insurance demanded across relevant categories, the two case studies are not directly comparable via the same underlying model. The model of insurance demanded is inherently different between contexts due to variation in insurance policy structures (i.e. indexed versus traditional indemnity) as well as available coping mechanisms outside of insurance. As described previously, the specific type of insurance against extreme weather in each context was chosen because it: 1. addresses covariate weather concerns relevant to a large section of society that may arguably benefit from coverage and 2. about which there is some debate as to whether (or not) there is sufficient demand for existent products.[17]

To date there is a good understanding of overarching factors that may influence demand for extreme weather insurance (e.g., Kunreuther & Pauly, 2004; Dercon et al., 2008); however, the interdependence and relationships between contributing aspects is not always clear, especially since studies may look at just a few factors in isolation. For example, the relationship between risk aversion and insurance demand may be mediated by the perceived possibility of non-performance of the insurance tool (Doherty & Schlesinger, 1990; Wakker et al., 1997). Thus, multicollinearity is something that must be checked with great care in regression models. To the extent possible factors that have been noted in the previous literature to potentially have confounding inter-relationships have been treated separately in the analysis. For example, relationships between factors affecting contract performance, basis risk, and trust appear to be inherently linked (e.g., Cole, Giné, Tobacman et al., 2013; Dercon et al., 2015). Given the nature of factors influencing insurance uptake, we are conscious that endogeneity may arise from potential mismeasurement of regressors, sample selection, and correlated random effects (in panel data) and do our best to address it.

The two contexts we study inherently require differentiated approaches to data collection methods (e.g., access to the internet) and the metrics used to proxy factors that may affect insurance demand. Furthermore, in a review of the literature it is clear that certain factors potentially relevant to insurance demanded are more easily researched in one context relative to the other (e.g., Cole et al., 2012; Eling et al., 2014). Furthermore, there are severe limits on population-level data, especially in Uganda due to standards of national recordkeeping and public reporting.[18] Thus, comparing representativeness of sample data to population data is not always possible for all factors upon which empirical data is gathered.

The field games and flood simulation activities were incentivised and scenarios drew upon experiences familiar to respondents (e.g. crop loss and home flooding). Yet, the scenarios have hypothetical details, which make responses prone to hypothetical bias (e.g., Ash et al., 2005; Loomis, 2014). This is a common limitation of such exercises and to the extent possible we strive to check validity through comparison with valuations of similar metrics based in real world data

[17] Consideration was made as to whether index-based agricultural microinsurance in the developed country context could be pursued as the focus of the developed country case study; however, the structure of agricultural subsidies in the USA and the E.U. make it difficult to provide policy-relevant recommendations (e.g., Blandford et al., 2011) and furthermore this type of insurance is applicable to a very small segment of the population.

[18] A number of direct in-person discussions (e.g., M. Musheshe 2011, per. comm., 22 March) as well as contact mediated through Grameen Foundation Uganda (e.g., J. Matovu 2012, per. Comm., 14 January) with relevant Ugandan ministries throughout 2010-2011 did not yield regional population data suitable to our research interests. In some cases, the requested payments for data did not fall within ethical research guidelines. The "National Population and Housing Census 2014: Provisional Report (UBOS, 2014) yields little relevant data.

for the respondents, e.g. comparing risk data from the *Coin game* (revealed risk aversion) to risk profiles in farming practices. Furthermore, games and simulations offer some insight about iterative behaviour, but issues such as the long time horizon of actual insurance relationships (e.g., payouts) make the replication of actual circumstances in brief, simulated settings (Dercon, Gilligan et al., 2008).

The use of an experimental framework in field games can induce exogenous variation that helps avoid the problem of unobserved heterogeneity when studying causal effects of insurance uptake on agricultural production (e.g., Cai & Song, 2013). Initially the field games conducted in Uganda were designed as part of an experimental structure that would be administered to only a section of the overall sample. Yet, in the pilot stages there were vehement complaints of unfairness from the farmers to the point of disruption of the CWK Network. Ultimately we were forced to abandon the experimental treatment had to be abandoned in order to maintain trust within the wider services administered by the CKW Network and Grameen Foundation.[19]

We strive to take into account respondents' bounded rationality and potential differences between System I and System II processing in our approach. A study of the understanding of risk and of insurance purchase may well have to go beyond standard economic, business, or insurance analysis into the realm of psychology or anthropology. Yet, it is difficult to discern the use of heuristics and breakdown the process of financial decision-making, especially in the developing country context, when data is based on surveys, rather than longitudinal records of observed behaviour (Collins et al., 2009). Due to timing and other limitations we obtained cross-sectional data over relatively large-N samples. When data is gathered at a single point in time and some responses are hypothetical in nature, information cannot be expected to map directly to future actualised behaviours. It is argued that social phenomena have "histories" that should be considered to the extent possible in analysis (Payne & Payne, 2004). Respondents in the Ugandan study had been registered members of the CKW Network for at least a year previous to our research; thus, relevant responses were spot-checked against CKW data records (e.g., number of past loans). We have kept records of respondents for both case studies that would allow for follow-up to determine how closely actualised behaviour mirrors intended behaviour expressed in our study. [20]

1.7 Contribution to knowledge

Our research moves forward the knowledge base and adds to the literature focused on empirical approaches to determining intended insurance demand. We take into consideration the fact that households face bounded rationality in the decision-making process and develop appropriate approaches in both the developing and developed country contexts given relative constraints. Specifically, we offer a manner of assessment that captures aspects of the

[19] Social networks in Uganda are strong and would discuss the basic structure of the survey tool. Thus, many of those who were in the control group without the field games ultimately expressed disappointment and accused administering CKWs of unfair treatment. Investigation showed that it was not the financial incentives driving this response, but rather the act of not getting to play the games that felt unfair (J. Matovu 2010, per. comm., 6 April). Under the regulations of the CKW Network providing incentives for participation was already a major exception to guiding regulations; thus, we were required to repeal the experimental treatment.

[20] Farmers served by the CKW Network are provided Farmer ID numbers, these ID numbers allow for future data to be matched to the empirical data gathered for this research. Furthermore, Qualtrics© kept records of respondents to the Hurricane Sandy data tool; respondents to that study were required to provide approval for potential future follow-up contact.

households' underlying economic, social and cultural, structural, and personal and demographic factors. Unlike much previous research, especially on WTP for microinsurance, we offer a formulation that controls for constituent factors in each of these four factor classes. We also provide insights on possible approaches to the use of a combined survey tool and games/simulations to obtain this data, both in the field (in-person) and via an online interface. In development of the methods we strove to use structures that may be applicable to similar cases in different locations in the future and potentially allow for cross-referencing with results in this thesis.[21]

Agricultural microinsurance is a relatively new tool in many developing country communities and it is important to examine feelings surrounding the tool and how households may gain utility from related aspects that have gotten some attention in the developed country context to date, such as the *feeling of insurance*.

Specific to the study of index-based microinsurance, we further the knowledge base concerning response to basis risk in the *positive* direction as well as potential effects from observation of basis risk experienced by a neighbour, which we believe to be a relatively novel addition to the literature.

We offer a valuable step in the study of intended insuring behaviour ex-post an extreme weather event (e.g., flood), though this is hypothetical it captures changes in insuring behaviour between periods. Furthermore, we test the assumption made in previous empirical studies that gambling behaviour is a reasonable proxy for risk-taking and maps onto intended insuring behaviour. We also add to the knowledge base on effective presentation of data relevant to the decision to insure.

The contributions to knowledge from this thesis are relevant to intention to insure against extreme weather and address identification of household characteristics that make some households more prone to insuring. In turn this information can be applied to create tools that most appropriately target households with characteristics indicating greatest interest in use of insurance, but also those most in need of risk transfer.

1.8 Thesis structure

A schematic of the thesis structure is presented in Figure 1.1. Table 1.1 describes the content of the appendices. Note that in the analysis chapters there is a review of relevant literature specific to the discussion of that chapter.

This thesis comprises of 10 chapters including the present *Introduction and Contextual Background* (**Chapter 1**).

Chapter 2 provides the conceptual framework for this thesis. We discuss decision processes related to household vulnerability and the use of risk reduction and risk transfer tools. Specifically, we review literature related to the key factors that have been shown to affect

[21] A secondary goal in the development of the mobile survey and field games used with the rural Ugandan sample was to make it as applicable as possible to similar environments defined by small-holder farmers relatively new to the use of agricultural microinsurance. The first preliminary pilots took place in India during late 2009 and early 2010. Additionally, the online simulation section of the work related to Hurricane Sandy was generalised and could be applied to a wider audience of those previous affected and unaffected by flood events.

household demand for extreme weather insurance. We review past literature related to our specific research aims and present the conceptual framework of insurance demand, which guides our research and analysis.

Chapter 3 presents the methodology used to gather the empirical data through the use of stated preferences and contingent scenarios to elicit willingness to insure. The other elicitation techniques used, the field games used in the Ugandan study, as well as the iterative flood simulation and the insurance gamble, are described. This chapter also discusses sampling and piloting phases for both case studies. The econometric and statistical models used to analyse the data are presented.

Chapter 4 describes both case studies in terms of rationale for their selection and the underlying contextual situation in each case. The descriptive statistics for data collected in each area is presented and, where possible, is compared to population-level data.

Chapter 5 provides results of the field games that were administered by the CKWs as part of the mobile survey. These results are compared to directly stated survey question responses addressing similar issues in order to discern potential patterns of bounded rationality in the sample.

Chapter 6 reviews findings on coping strategies that the rural Ugandan sample may implement outside of potential indexed agricultural microinsurance and assesses the groupings common in our sample. We develop regression models for the use of identified traditional coping strategies and look specifically at models for propensity to sell livestock and willingness to take children out of education.

Chapter 7 presents interval data model to assess the WTJ and WTP for agricultural microinsurance by our rural Ugandan sample implementing factors from our conceptual framework of insurance demand. This is compared to frequency data and an interval model propensity for WTP for loans. There is discussion as to the extent to which WTP for agricultural insurance relates to bounded rationality. The potential for microinsurance as a complement to other available coping strategies is discussed.

Chapter 8 employs a mixed effects model to findings about our rural Ugandan sample's attitudes towards basis risk from our *Complex Dice* game. There is discussion about the influence of observing basis risk (not) experienced by a playing partner as well as the realisation of basis risk, both in the negative and positive directions.

Chapter 9 provides a detailed discussion of our findings from the survey and on-line flood simulation undertaken with a sample located in the area recently affected by Hurricane Sandy. A mixed logit model is applied. There is discussion of the effect of the graphical treatment in the simulation. Results from the flood simulation are compared to the respondents' choices in the gambling game.

Chapter 10 provides a discussion of our findings and compares factors that appear to be significant to the expressed desire to purchase insurance in each case study context. Relevant policy implications are highlighted, as well as areas for continued research.

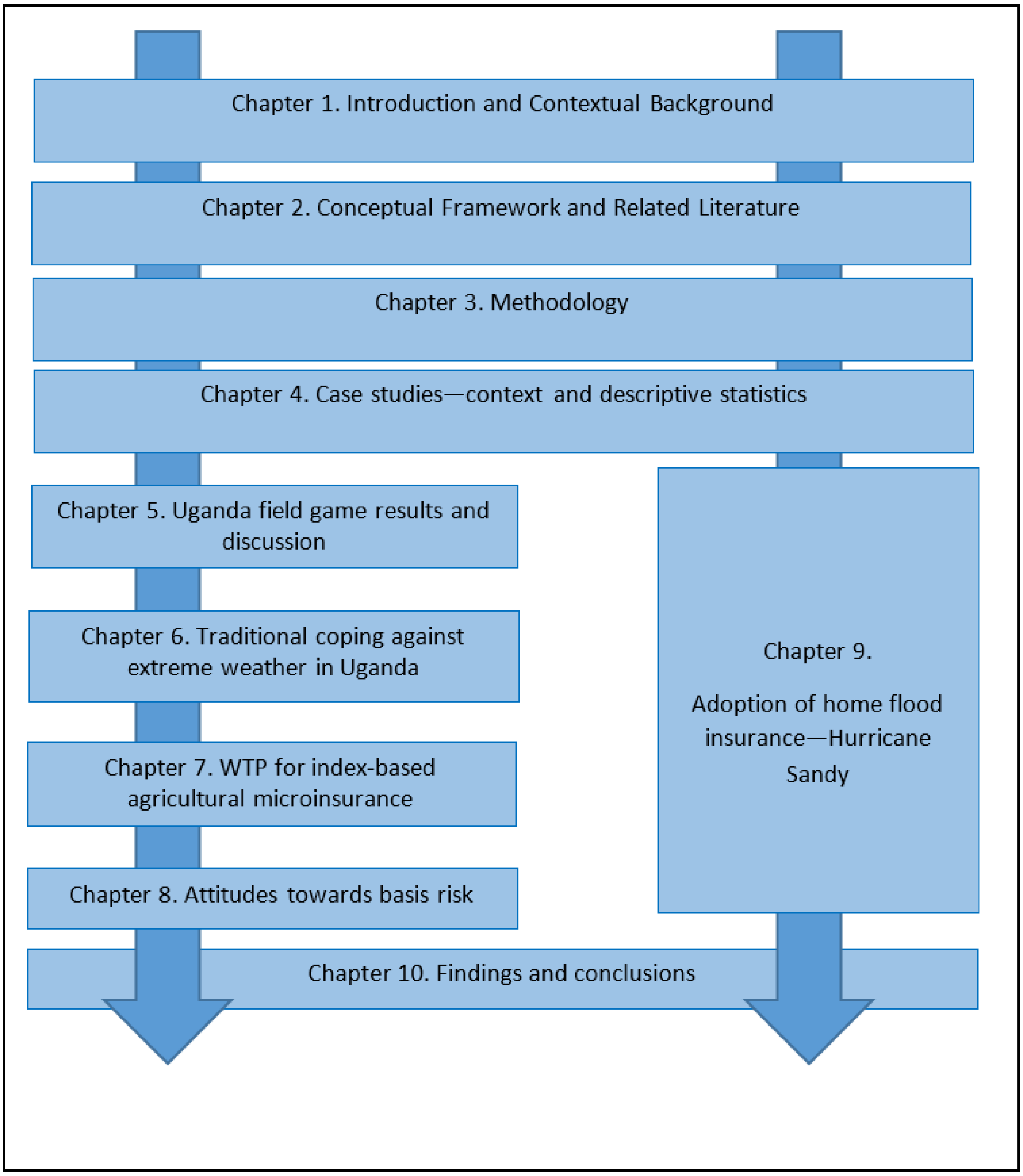

Figure 1.1 Schematic of thesis structure

Table 1.1 List of thesis appendices and relevant chapters

Appendix	Content summary	Most relevant related chapter(s)
A1	Rural Uganda survey & field game mobile app	2, 3, 4, 5, 6, 7
A2	Field discussion group notes (short version)	4, 5, 6, 7, 8
A2	*Complex Dice* game scorecard & survey	3, 8
B	Online Hurricane Sandy survey & simulation	2, 3, 4, 9
C	Heuristics relevant to the decision to insure	2, 3
D1	Sample comparisons for large-N Uganda survey	4, 5, 6, 7
D2	Sample vs. population comparisons for large-N Uganda sample	4, 5, 6, 7
D3	Sample & population comparisons for Hurricane Sandy analysis	4, 9
E1	TAMSAT rainfall data analysis	4, 5, 7
E2	CHIRPS weather data	4, 9
F	Supplementary analysis—coping strategies	6
G1	Supplementary analysis—WTP for microinsurance and loan analysis	7
G2	Excerpt from Grameen findings	7
H	Supplementary analysis for *Complex Dice* game	8
I	Supplementary analysis for Hurricane Sandy survey and simulation	9

2 Conceptual Framework and Related Literature

2.1 Introduction

In this chapter we discuss the conceptual framework underlying the methodology and analysis of this thesis. Section 2.2 introduces household vulnerability to extreme weather conditions. Section 2.3 provides a discussion of risk reduction and risk transfer, specifically focused on the role of insurance as one element in a suite of potential ex-ante and ex-post forms of coping from which a household may choose. This discussion is divided between coping strategies that are relevant to the developing and developed country contexts. In Section 2.4 we provide an overview of index-based versus indemnity-based insurance products. We provide a general schematic outline for insurance demand related to compensating and equivalent variation in Section 2.5. Section 2.6 presents a generalised staged model of the intended decision to insure. Factors that have been found to have significant effects on the decision to insure in both the developing and developed country contexts (e.g., Eling et al., 2014) are discussed in Section 2.7. These factors form the basis for the conceptual framework that guides the methodological approach taken in this thesis to gather and analyse data on factors affecting households' WTJ (micro)insurance with consideration for the use of alternative coping strategies.

2.2 Extreme weather and vulnerability

In the past decade, average economic losses from extreme weather equated to about USD 190 billion per year and average insured losses were recorded to be about USD 60 billion per year (Swiss Re, 2014). Statistical analyses of the period 1980–2011 show that flooding accounts for the greatest percentage of (financial) losses from extreme weather events world-wide (e.g., UNODRR, 2011, 2012). Insurance is a risk transfer tool that can assist with the ex-post management of extreme weather effects, by removing or reducing the anticipated financial risks through ex-ante planning (e.g., Surminski & Oramas-Dorta, 2013). To this point, the efficacy and uptake of any (micro)insurance tool depends on the extent to which it matches consumer interests and fills a gap that may not be addressed by other available coping mechanisms.

2.2.1 Covariate versus idiosyncratic risks

Risks arising from extreme weather are covariate, affecting a number of households simultaneously. Consequently, they are often difficult to manage (due to nature of occurrence and impact magnitude), especially through ex-post informal means of coping (e.g., Dercon, 2002). On the other hand, idiosyncratic shocks relate to uncorrelated risks that affect households unilaterally (e.g., illness, loss of employment). Coping, either formally (e.g., microinsurance) or informally (e.g., sell of household goods) tends to be easier for idiosyncratic than covariate risks.[22] The literature hints that due to communal structures for coping and support, informal coping after an idiosyncratic risk is realised may be carried out more effectively in the rural developing context than in the developed country context (Fafchamps, 1992; Townsend, 1995). Luthar (2006) and Alderman & Paxson (1994) provide a review of resilience following idiosyncratic risks in the developing context. Dercon (2002) provides an overview of consumption smoothing with regard to both covariate and idiosyncratic risks in the

[22] Especially in the case of selling goods on a market that may be disadvantaged ex-post a disaster and can be flooded.

developing country context. Berkhout et al. (2006) and Satterthwaite (2013) provide discussion on adaptation for resilience in the developed country context, especially in cities.

2.2.2 Vulnerability, coping capacity, and extreme weather

Predominant definitions of vulnerability[23] (e.g., Füssel, 2007; Birkmann, 2013) account for characteristics (of a person or group) related to capacity to anticipate, cope with, resist, and recover from impact(s) of a natural hazard. Birkmann (2013) provides a thorough discussion of different conceptual and analytical frameworks by which to index vulnerabilities at different scales. The major differences between frameworks arise from the extent to which vulnerability is endogenous or exogenous to the other stressors in the system (e.g., how factors like reduced exposure affect vulnerability levels).

A combination of factors determine vulnerability levels; some social groups are more prone to damage, loss, and suffering for a given hazard. Figure 2.1 provides a schematic of the *Risk Triangle*, which researchers from multiple disciplines use to conceptualise and assess natural hazard risks (e.g., Crichton, 1999; Kron, 2002). It states that the risk level faced is a function of hazard, exposure, and vulnerability–all must be spatially coincident for a risk to exist. The three elements of the *Risk Triangle* may be defined as follows:

- *Hazard*: The temporal and spatial aspects of an event that may cause the realization of risk, as well as the magnitude directly related to the relevant risk (e.g., Huppert & Sparks, 2006).
- *Exposure*: The spatial coincidence between what is exposed and the level of exposure. For example, buildings (with corresponding type and value) can be exposed, as well as people (e.g., Tomlinson et al., 2011).
- *Vulnerability*: Those aspects of the exposed elements that are relatively susceptible to a given hazard. The UNISDR (2004) distinguishes four vulnerability categories related to disaster reduction and resilient coping: 1. physical, 2. economic, 3. social, and 4. environmental.

[23] The existence of competing conceptualisations and terminologies of vulnerability has become particularly problematic in climate change research, which is characterised by intense collaboration between scholars from many different research traditions, including climate science, risk assessment, development, economics, and policy analysis. For a further review, see: Adger (1999), Kelly and Adger (2000), Downing et al. (2001, 2004), and O'Brien et al. (2004).

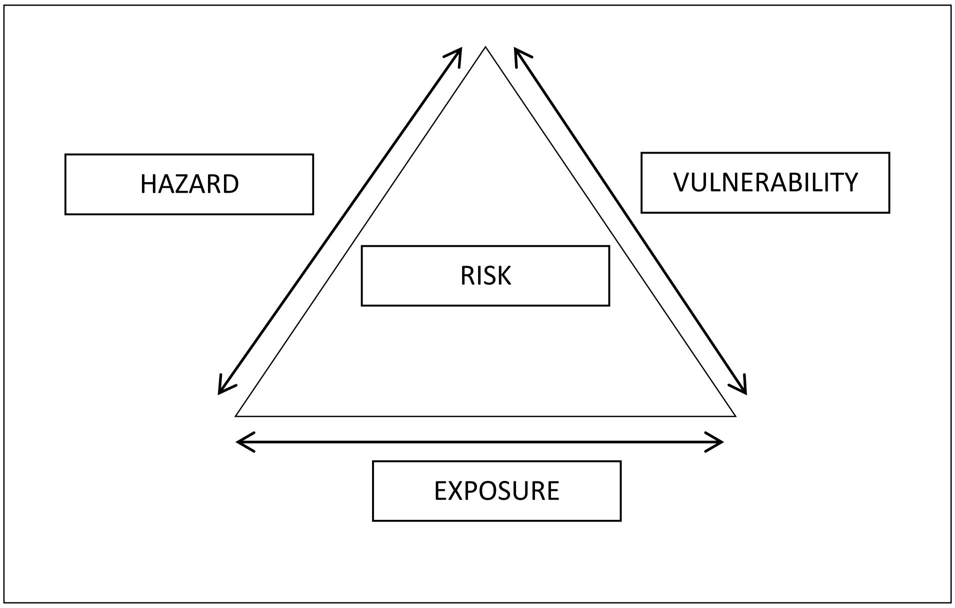

Figure 2.1 Risk Triangle; adapted from *Crichton (1999) and Kron (2002)*

Of the three components of the *Risk Triangle*, households can reduce vulnerability and exposure with appropriate management (e.g., Amendola, 2004; Amendola et al., 2007). Increased focus on addressing households' economic and social vulnerabilities is noted for both the developing country context (e.g., Warner et al., 2009; UNODRR, 2011)[24] and the developed country context (e.g., White & Howe, 2002; NRC, 2006). Insurance is a useful tool and, in many cases, the primary one that can enable resilience[25] following extreme weather events (e.g., Klein et al., 2003; Mirza, 2003; Mills, 2007).

Insurance only fosters resilience if it fits the needs of potential consumers and targets those who may benefit most from its use. Complementing other available means of coping is one way in which it meets consumers' needs. Empirical demand-side studies for insurance are conducted, but could more frequently be aimed at the goal of matching user requirements for coping with extreme weather risks, especially in the developing country context (e.g., Whalley & Yuan, 2009).

2.3 Coping strategies against extreme weather

Greater integration of risk reduction and risk transfer to effectively address vulnerabilities to extreme weather events is gaining traction within the insurance industry's planning processes (e.g., Warner et al., 2009; Beynon, 2013) and public policy planning (e.g., EU, 2013). For example, risk pricing for flood insurance can incentivise households to retrofit for risk reduction (via exposure) and lead to lower damage costs (Di Falco et al., 2014). In the developing context,

[24] A significant segment of the literature touches upon vulnerability of the rural household dependent on farming in the developing world and attempts to provide normative implications from empirical observation, especially in studies of coping against idiosyncratic risks (e.g., Ellis, 1994; Collins et al., 2009; Banerjee & Duflo, 2011).

[25] We note resilience to be "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions" (IPCC, 2012, p. 5). In this thesis we are primarily concerned with recovery on the household-scale following an extreme weather event through adoption of relevant insurance ahead of occurrence.

insurance tools, such as HARITA,[26] allow the insured to partially pay premiums by proving implementation of risk reduction activities (World Bank, 2013).

Ranger and Fisher (2012) note that there is ample evidence to support the claim that risk transfer in general, and via insurance specifically, can boost resilience more effectively than ex-post disaster aid. To obtain ex-post benefit from insurance, one must engage in ex-ante planning. Yet, "poorly designed insurance products and ill-structured insurance markets can drive economic inefficiency and maladaptation to future risks" (Surminski, 2013, p. 229). The goal of getting households to employ insurance as a means of coping against extreme weather is not simply one of obtaining high penetration rates, but rather of effective policy design that complements households' alternative coping strategies.

The remainder of this section focuses on coping available to households before and after an extreme weather event. There is a particular emphasis on highlighting the differing coping strategies that households adopt depending on the type of risk realised and their socio-political context (developing or developed country).

2.3.1 Integrated risk management: Coping decisions

Integrated risk management (IRM) is a "continuous, proactive, and systemic process… structured through on-going learning and evaluation" (Radermacher et al., 2010, p. 8) and can be employed at different levels. We are interested in the household level of analysis. IRM is a series of target-oriented efforts to manage the potential (adverse) consequences of extreme weather events, which may otherwise prevent a household from achieving its medium- and long-term potentials. The extent to which a given household follows the steps associated with IRM (Figure 2.2) may limit effectiveness of coping. For example, if the perceived likelihood of occurrence is below the household's threshold for action, it may not seek to prepare for the potential risk before it occurs.

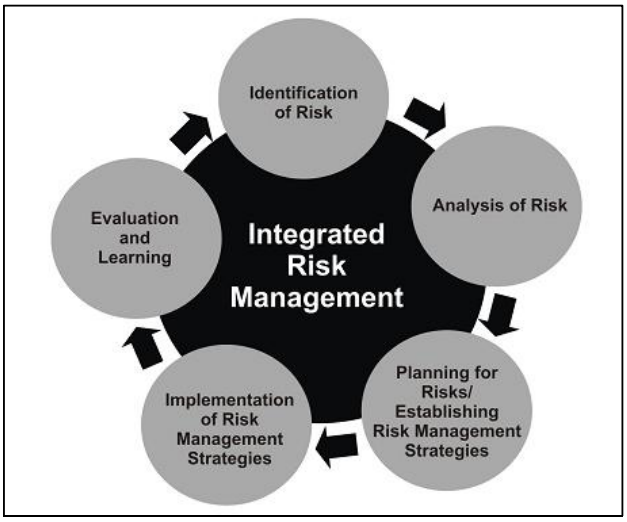

Figure 2.2 Integrated risk management process, *adopted from Radermacher et al. (2010)*

[26] The Horn of Africa Risk Transfer for Adaptation (HARITA) works in the Tigray region of Ethiopia, and is coordinated through Swiss Re and Oxfam America. It covered 1300 families in 2010 for indexed microinsurance against drought.

One of the most proximate determinants of household vulnerability to extreme weather-related risks is the choice of strategies to manage the outcomes, as coping is a cyclical process. (Alderman & Paxson, 1994) discuss the distinction between risk-management (ex-ante) and risk coping strategies (ex-post) in household consumption smoothing. We consider insurance as an ex-ante risk-management strategy with benefits that accrue ex-post.

There are two distinct *decision moments* for the household in a given cycle; the first occurs when there is still unrealised risk (i.e., a potentially large number of different possible events or circumstances), and the second when a shock (i.e., a realisation of one of these possible events or circumstances) has occurred. These decision points in the potential pathways for ex-ante planning and ex-post responses to extreme weather are illustrated in Figure 2.3. The decisions that need to be taken in the face of potential risk (i.e., risk management or ex-ante strategies) are different from those options that may be selected in the face of a shock (i.e., risk coping or ex-post strategies). Nevertheless, they cannot be viewed independently, as risk management decisions have implications for the possible set of risk coping strategies, while ex-post risk coping has implications for the set of risk management tools from which the household may choose in the subsequent period.

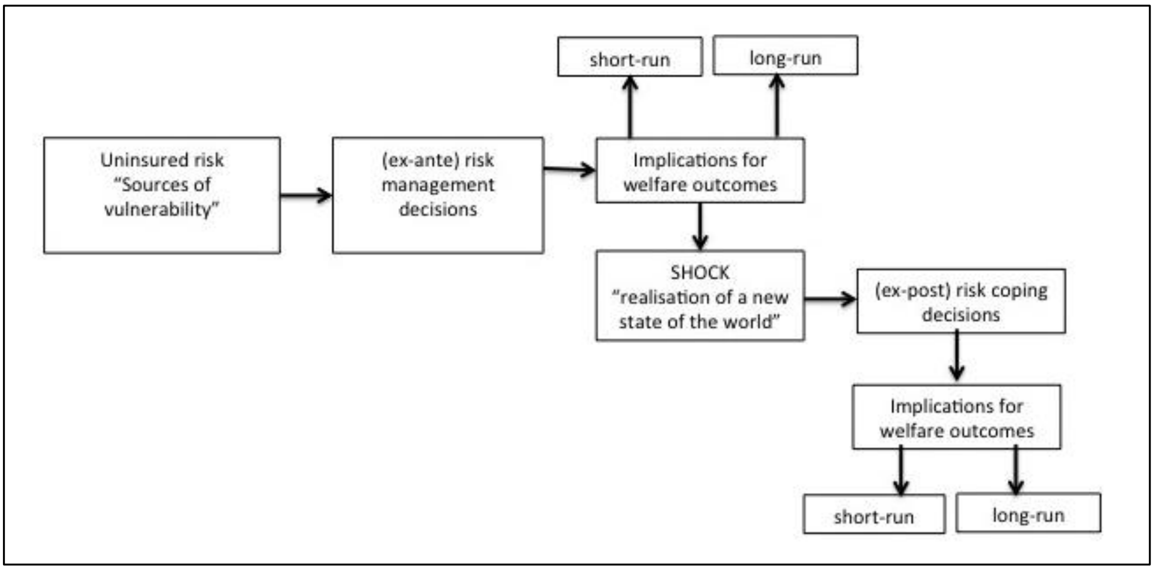

Figure 2.3 Pathways for ex-ante planning and ex-post responses to extreme weather risks; single period in the cyclical process of risk coping

It is generally accepted that rural households in developing countries have a very limited portfolio of formal coping strategies relative to developed country households (e.g., Hazell et al., 2010). This specific cohort of extreme poverty is covered in our research.[27]

Vulnerability to extreme weather and coping capacity are highly variable among and within populations, embedded in local ecology and weather conditions, as well as political and cultural contexts (e.g., Gitz & Meybeck, 2012). Further, interactions among extreme weather conditions, societal vulnerability, and risk management decisions are often most prominent at the household- and community-scales. Thus, understanding how to best reduce residual

[27] For further reading on the issue, see O'Brien & Leichenko (2000) for an overview. Rygel et al. (2006) provide a discussion in the context of hurricane storm surges.

vulnerability from extreme weather requires integrated studies of extreme weather risk and opportunities in specific situations.

It is noted that well-structured insurance tools can trigger risk reduction activities in both the developing context (e.g., Surminski & Oramas-Dorta, 2013) and in the developed context (Crichton, 2008).[28] Paudel (2012) characterises how insurance can encourage those enrolled to actively reduce their risk vulnerability (ex-ante) in addition to risk transfer through insurance cover itself, as to reduce the residual risks with which the household must cope ex-post; see Figure 2.4.[29] One clear example is by allowing for *prudent risk taking*, which can provide access to credit through insurance bundling, offsetting lenders' concerns over high risk or insufficient capital (Poole, 2014).[30]

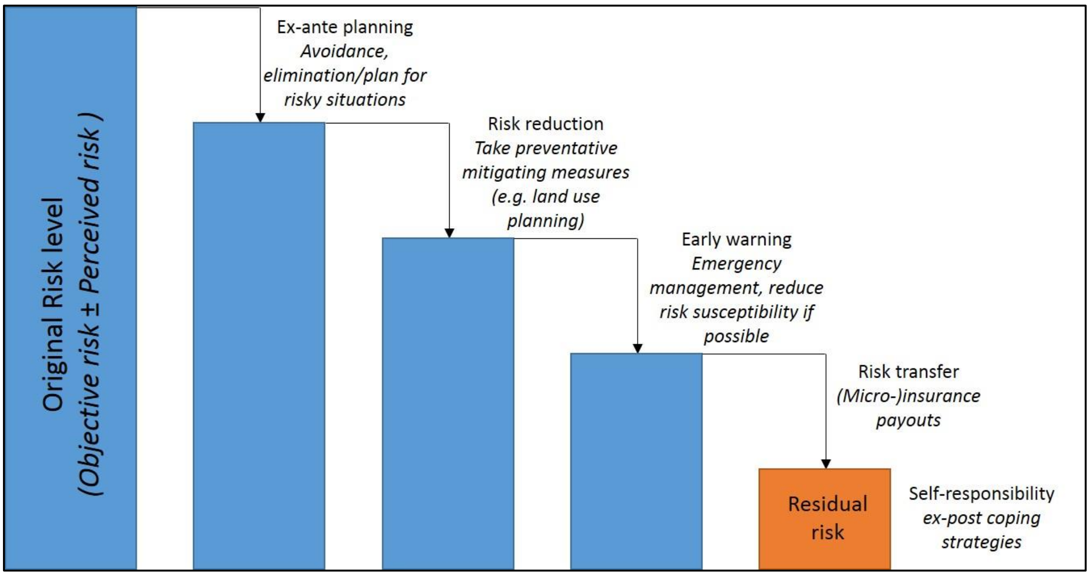

Figure 2.4 Pathway approach to ex-ante risk reduction and risk transfer, leading to ex-post residual risks

Yet, insurance premia may also be conceptualised as sunk costs by households, the opportunity costs of which could have been spent on short-term productive capital. Households often view insurance as an investment, rather than protection (or lack thereof) against risk (Schoemaker & Kunreuther, 1979). Lacking an insurance culture and subject to extreme wealth constraints, households that opt into microinsurance may expect refund of their paid premia if extreme weather does not occur in the period.[31] This is understandable, as premia payments can reduce money available in a given time period for basic household functions, e.g., food consumption or livestock investment (e.g., Collins et al., 2009). Clarke (2011) argues that the price of many

[28] Crichton (2008) provides a comprehensive list of how insurance could lead to physical flood risk reduction.
[29] Paudel (2012) differentiates between: 1. risk assessment and mapping; 2. policies and regulations that are integral to the insurance system; and 3. (financial) incentives that the insurance provides to policyholders to invest in mitigation measures specifically.
[30] Another option is to bundling insurance with seed purchase directly. This approach has shown increased medium-term household wealth in the insurance-for-work (IFW) programme of HARITA (WFP, 2012), as well as within options in the Kenyan Kalimo Salama project (Kayser et al., 2014).
[31] Note that we saw this in our work/survey and that it is noted in other analyses.

unsubsidised index-based insurances is such that many expected utility maximisers are better off not purchasing insurance.[32]

In the following subsections we provide an overview of relevant coping strategies in the developing and developed country contexts against risks posed by extreme weather.

2.3.2 Coping strategies–rural developing country context

Households in poor, rural developing contexts have adopted a range of strategies to deal with risks in the absence of government-led programmes, such as rotating savings and credit associations, depleting savings, informal borrowing from friends and relatives, selling assets, and taking children out of school. Yet, there is a growing understanding that many informal mechanisms developed by the poor offer short-term protection at long-term costs, preventing escape from poverty (e.g., Morduch, 1998). In the absence of effective ex-ante planning (e.g., microinsurance, savings), realisation of a covariate extreme weather hazard may cause the poorest households to resort to coping strategies that tip them towards chronic poverty; this is sometimes recognised as a *poverty trap* (Carter & Barrett, 2006)[33] or is acknowledged as *failed coping*. The poorest are most vulnerable to covariate risks and it is this vulnerability that is a key driver of underdevelopment (Mearns & Norton, 2010; World Bank, 2010a). In our research we do not analyse the mechanisms associated with *poverty traps*, but rather look at which coping strategies are employed in the aftermath of a covariate weather disaster and the factors which lead to the choice of coping strategies that involve various kinds of disinvestment.

Evidence suggests that the use of portfolio diversification to limit income risk varies greatly across households, even when they face common risks and are given access to the same production technology (e.g., Hazell & Hess, 2010). It may be assumed that the rational approach to coping with a natural disaster is for a household to initially choose coping strategies that do not erode productive assets at present or in future periods; disinvestment would be only a last resort. Corbett's (1988) well-known review of the literature on coping with famine interprets a number of case studies that reflect this general finding (e.g., Ravallion & Chen, 1997; Ellis & Mdoe, 2003); it is also consistent with the explanation of *poverty as vulnerability* (Banerjee & Duflo, 2005, 2011). Some recent empirical studies yield findings that challenge the traditionally accepted ordering for employment of coping strategies based upon their relative long-term prospects for disinvestment (e.g., Jacoby & Skoufias, 1997; Duryea, 1998; Skoufias & Parker, 2002).

Strategies which increase productivity in rural developing contexts in normal years can increase risk during periods of extreme weather (e.g., Norton et al., 2013). Households that perceive they may be more credit-constrained in the future are more willing to sacrifice income in the current period, hoping to reduce future risks (e.g., Eswaran & Kotwal, 1990; Morduch, 1998). Furthermore, there is evidence that the closer a farmer finds himself to a *poverty trap* (i.e., failed coping) threshold, "the less willing he is to give up some of his expected income in exchange for

[32] Moreover, also on the side of the insured there can be substantial transaction costs, which implicitly increase the price of the insurance, such as the difficulty of purchasing or renewing the insurance, the opportunity cost of time and the complexity of filing a claim, and the ease with which premiums can be paid and pay-outs received.

[33] A *poverty trap* exists if a household's assets fall below a certain level, under which income growth cannot be supported and low growth paths go on after disaster events (Carter & Barrett, 2006).

a reduction in income variance" (Osgood & Shirley, 2010, p. 4) through means such as microinsurance. Such behaviour is to be expected due to the combination of household budget constraints, the lack of a long-standing *insurance culture*, as well as the complications that arise from index-based insurance (e.g., basis risk). Explanations of poverty and development in the face of covariate risks arising from extreme weather events depend largely on assumptions made about individuals' risk preferences and their willingness to engage in strategic risk coping.

One of these three typologies is often used to describe a given coping strategy employed at the household level in the developing context:

1. Resource utilisation (Mingione, 1987, 1994);
2. Intensity of use of households' human, physical, financial, and social capital (e.g., Lokshin & Yemtsov, 2001); or
3. Combination of resource types and intensity of use (e.g., Maxwell & Caldwell, 2008)

In the development literature, traditional coping strategies are often labelled as either non-erosive (i.e., short-term reductions in household consumption) or erosive (i.e., influences the household's medium- to long-term wealth) (e.g., WHO, 1999; Schrimpf & Feil, 2012), with the final stage being *failed coping*. Many studies demonstrate that this stage is reached more often than would be expected due to the impact of extreme weather on farming and the fact that most traditional coping strategies are further challenged when there are successive years of particularly poor weather (e.g., Linnerooth-Bayer et al., 2005; White, 2005). Table 2.1 gives an accepted categorisation of a number of common coping strategies employed in the developing country context.[34]

[34] Note that the coping strategies we analyse for our sample include a slightly different option set. The coping strategies upon which we focus our analysis were chosen based on field observations and responses from the FGDs.

Table 2.1 Stages of coping strategies, developing country-specific; *adapted from WHO (1999)*

Coping Stage	Examples
Non-erosive coping *(short-term reductions in consumption; risk-minimising loss management)*	Social support systems, whereby the less vulnerable assist the more vulnerable members of society Change selection of crop types and varieties in the next period Increased food processing and storage of cultivated harvest Purchase cheaper foods Consume less food Loans Sell small livestock and non-productive assets
Erosive coping *(disposal of productive assets, which impacts the household's medium- to long-term wellbeing)*	Shark loans Sell large livestock Sell land Sell tools Child labour Bonded labour arrangements Partial or phased out migration (i.e., migrant labour)
Failed coping *(destitution and complete dependency)*	Charity-dependency Migration (total family) Sell children

In their study of East African small-scale farmers, Kristjanson et al. (2012) found that many households implement coping strategies on at least a bi-annual basis. But, coping tends to take the form of marginal activities, rather than being transformational in nature. Their sample expressed relatively little uptake in permanent farming changes, such as improved soil, water, and land management practices. There was a strong negative relationship between the number of food deficit months and innovation; in other words, the least food secure households are making few farming practice changes as part of their coping strategy.

As documented by Scoones (1996), African farmers continually meld traditional knowledge and practice with modern farming methods whenever possible. Yet, given the constraints in the use of modern farming techniques in a time that is not characterised by covariate farming risks–Ugandan farmers use among the lowest levels of fertilisers in Africa due to low affordability (Ariga et al., 2006; Smaling et al., 2006)–this is not easily achieved (e.g., Thomas et al., 2007). This extends to the low use of seasonal forecasts via technological advancements by farmers to prepare for seasons characterised by poor weather conditions (e.g., IRICP, 2001; Klopper et al., 2006). There are documented disappointments in such programmes (e.g., Tarhule & Lamb, 2003), but there are field trials, such as the CKW Network, which report recent success. Mworozi et al. (2012) report on the use of information and communications technology (ICT) tools and meteorological data by Ugandan cattle herders. Other examples are reported by: Diarra & Kangah (2007), Roncoli et al. (2009), and Suarez & Patt (2004). The caveat is that in most documented cases, to the best of our knowledge, technological and financial support by a third party has been necessary.

It should be noted that in the context of social safety nets, remittances are one coping mechanism that may be operable immediately after an extreme weather covariate risk is realised. As mobile banking has taken hold throughout sub-Saharan Africa, remittances have surged (Blumenstock et al., 2011; Jack & Suri, 2011). Yet, there are still severe limitations to access by the poorest households. Use of mobile money requires ownership of a mobile phone and often requires the recipient to go to a geographically remote banking station to receive physical notes. Donovan (2012) shows that institutional and technological arrangements that are most likely to maximise the development potential of mobile money are far from being realised in the most remote rural areas.[35]

Finally, government safety nets are not readily available throughout the developing country context as a reliable means by which to mitigate a significant portion of covariate risks; many developing country governments depend on humanitarian relief in the event of an extreme weather event (e.g., Lavell et al., 2012). There is some extension work, but it cannot be counted upon to maintain funding throughout the entire recovery process or at the most critical period in the process (e.g., IFAD, 2010). Humanitarian relief has only provided a small fraction of total losses and delivery of funds is generally slow: Official Development Assistance to affected countries increases by an average of 18% after a disaster; however, on average such assistance only represents 3% of total estimated damage costs (Becerra et al., 2012). Despite the emergence of some schemes, outreach is still low and it is considered unlikely that those schemes would provide effective protection for medium-term recovery (e.g., Easterly, 2009; Salami et al., 2010; IPCC, 2012). Failure of informal schemes and government-led programmes opens a significant window of opportunity for microinsurance to decrease low-income households' vulnerability to covariate risks and help smooth consumption.[36]

2.3.3 Coping strategies–developed country context

There appears to be relatively less literature on household coping strategies against extreme weather in developed countries; this may be the case because of the availability of government interventions and social programs, especially ex-post flood events (e.g., Keating et al., 2014). Furthermore, within developed countries, outside of those in poverty ex-ante an event (e.g., Rygel et al., 2006), savings and credit tend to be sufficient for short-term household recovery efforts. Additionally, there is a salient *insurance culture*[37] (i.e., general recognition of insurance as a meaningful and viable coping mechanism throughout society) in developed opposed to developing contexts. The comparative market shares exemplify this with only 3% of natural disaster losses insured in developing countries, compared to 40% in developed markets (Warner & Spiegel, 2009).[38] So, proportionally, families in developed countries use insurance as a coping mechanism much more frequently than families in developing countries.

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[35] Our study areas fall within the context of remote rural areas. For example, a number of CKWs based in Oyam reported that the closest mobile money collection center to their homes was approximately 20 km away (W. Okello 2010, per. comm.16 April).

[36] Chapter 6 reviews our empirical findings on coping strategies that households in our rural Ugandan sample may implement aside from the potential use of index-based agricultural microinsurance.

[37] This type of insurance culture may be useful in cases when it is socially optimal for greater home flood insurance demand.

[38] We note that the development of an "insurance culture" in transition countries is unique (e.g., Pye, 2005; Sharku & Bajrami, 2008); however, in this thesis we consider examples relevant to the developed and developing contexts.

Krysanova et al. (2008) note a number of measures that benefit household coping under structural and social measures. Structural measures can be taken at the household-level (e.g., storm shutters) and are often motivated by insurance government subsidies or in exchange for reduced insurance premia (Cutter et al., 2012). Household coping also benefits from public structural measures, such as dams, land-use schemes, and new land-use policies (Krysanova et al., 2008). Social coping measures include: advanced alarm and warning systems, increased awareness campaigns, and education programmes (ibid.), which are also essentially provided by government to improve overall community emergency planning, but benefit individual households. Furthermore, coping strategies may be employed through financial assistance from voluntary organisations, church, or charity groups immediately ex-post a flood event, though these tend to drop off in the mid- and long-term recovery periods (e.g., Cords, 2014).

Analyses have demonstrated that although public compensation limits liability for financial losses following floods, it also removes household incentives to insure (e.g., Kaplow, 1991; Kelly & Kleffner, 2003; Kim & Schlesinger, 2005; Brunette & Couture, 2008; Kousky et al., 2013; Raschky et al., 2013). Prior to a disaster, many individuals perceive its likelihood as sufficiently low that flood insurance is unnecessary. It is only after a flood occurs that these same individuals say that they would have liked to have invested in insurance ahead of time (e.g., Kunreuther, 2006).

2.4 Index-based versus indemnity-based insurance

The manner by which insurance against extreme weather risks is offered, structured, and adopted differs between the developing and developed country contexts.[39] In our study, we are concerned with household insurance policies. Throughout many developing countries, household insurance falls under the umbrella of index-based microinsurance; thus, in our developing country case study analysis we address index-based insurance. Microinsurance is a financial product which mitigates risks by charging relatively low premia from a large, relatively poor population in order to fund greater payouts when a risky disaster occurs (Churchill, 2006).[40] In turn, natural disaster catastrophe insurance, an indemnity-based insurance which includes home flood insurance, is a means to protect residences against risks associated with extreme weather (Daniels et al., 2006; Kunreuther et al., 2013). In line with our discussion of covariate risks, catastrophe insurance is different from other types of indemnity insurance because of the difficulty associated with estimating insured losses and the realisation of an extreme weather event results in a large number of simultaneous claims.[41]

While microinsurance involves lower premia and coverage overall, there are other structural differences between it and traditional indemnity-based insurance; see Table 2.2.

There are two main types of indemnity-based agricultural insurance available: 1. damage-based indemnity insurance (i.e., peril crop insurance), under which claim payment is based on the

[39] The contexts and level of development of these tools is so disparate that we were unable to find a direct comparison of them in the literature to date. We treat them as their own entities and do not seek to draw extensive comparisons between the two.

[40] Biener & Eling (2012) provide a comprehensive analysis for the insurability of risks in microinsurance markets to date.

[41] This is relevant on the supply-side, and ultimately makes catastrophe insurance issuers susceptible to risk. Thus, reinsurance and retrocession are used along with insurance for extreme weather events to manage the associated uncertainty of the risks.

actual loss incurred by the policy owner and 2. multiple peril crop insurance (MPCI), under which coverage for an insured yield is established as a percentage of the household's historical average yield. This type of insurance protects insured parties from the consequences of low yields, low prices, or a combination thereof.

Mahul and Stutley (2010) determine that many MCPI programmes rely on government support or other means of subsidies to survive in a review of 104 countries. A contributing difficulty is the shift of such traditional crop insurance from public to market-based mechanisms, which has inherent transaction costs (e.g., high administrative costs for remotely located farms). Barnett et al. (2005) compare the performance of MPCI and Group Risk Plan (GRP) contracts–based on area yield. This analysis compares the performance of MPCI and GRP contracts using farm-level yield data for almost 70,000 developed country farms.[42] The study stresses that when comparing GRP to MPCI, MPCI is also subject to basis risk; results support previous findings that area yield insurance is most appropriate in regions that are relatively homogenous in the crops produced (Skees et al., 1997).

[42] The study analyses findings from 66,686 corn farms from 10 states in the Corn Belt and 3,152 sugar beet farms from two states in the upper Midwest of the USA.

Table 2.2 General comparison between indemnity insurance (developed country context) and microinsurance (developing country context) for extreme weather related risks

	Indemnity-based Insurance	***Index-based Microinsurance***
Clients	• (Relatively) low risk environment • Established insurance culture in society.	• (Relatively) higher risk exposure / high vulnerability • Weak insurance culture
Distribution models	• Sold by licensed intermediaries or by insurance companies directly to (wealthy) clients or companies with a reasonably good understanding of insurance	• Sold by non-traditional intermediaries to clients with little experience of insurance
Policies	• Complex policy documents with many exclusions	• Relatively simple language • Few exclusions
Premium calculation	• Based on good statistical data (e.g. past weather events) • Pricing adjusted to individual risk characteristics	• Little, if any, historical data • Group pricing (potential) • Often premium higher to cover ratios of high frequency events • Extremely price-sensitive market
Premium collection	• Monthly or yearly payments, often by post or debit orders	• Frequent and irregular payments adapted to clients' volatile cash flows
Control of insurance risk (e.g., adverse selection, moral hazard)	• Limited eligibility • Significant documentation required	• Link to indices • Broad eligibility • Limited, but effective controls (to reduce costs) • Insurance risk included in premia, rather than controlled by exclusions • Link to other services (e.g. microcredit)
Claims handling	• Complicated processes • Extensive verification of events	• Simple and fast procedures through indexed payouts • Efficient fraud control through structure • Potential basis risk[1]

Currently there are two types of index agricultural insurance products employed in the developing country context: 1. area yield and 2. weather index. Under area yield index insurance (i.e., direct-index), the index for payout is based on the realised average yield of an area (e.g., district) opposed to the actual yield of the insured party. The indemnity paid for weather index insurance is based on the actual weather parameter measured over a pre-specified time period at a given weather station. As it is not directly linked to area yields, it is considered an indirect-index tool (World Bank, 2011a). The use of area-yield indices has been experienced for many years; its approach and application appear to be acceptable to most farmers compared to weather indices (IFAD & WFP, 2011). In recent years there has been significant advancements in the use of weather-based index insurance and reduction of basis risk under such policies (e.g., Carter et al. 2014). Many agricultural microinsurance schemes throughout sub-Saharan Africa are based on weather indices (e.g., Kilimo Salama); thus, we consider weather-based index insurance in our analysis.

It should be noted that index-based agricultural microinsurance has been studied in the developed country context in the past (i.e., weather derivatives) (e.g., Miranda, 1991; Smith et al., 1994; Mahul, 1999; Turvey, 2001; Vedenov & Barnett, 2004; Woodard & Garcia, 2008).

Index-based insurance tends to be appealing because of the advantages associated with lower average costs on both the supply- and demand-sides; see Figure 2.5.

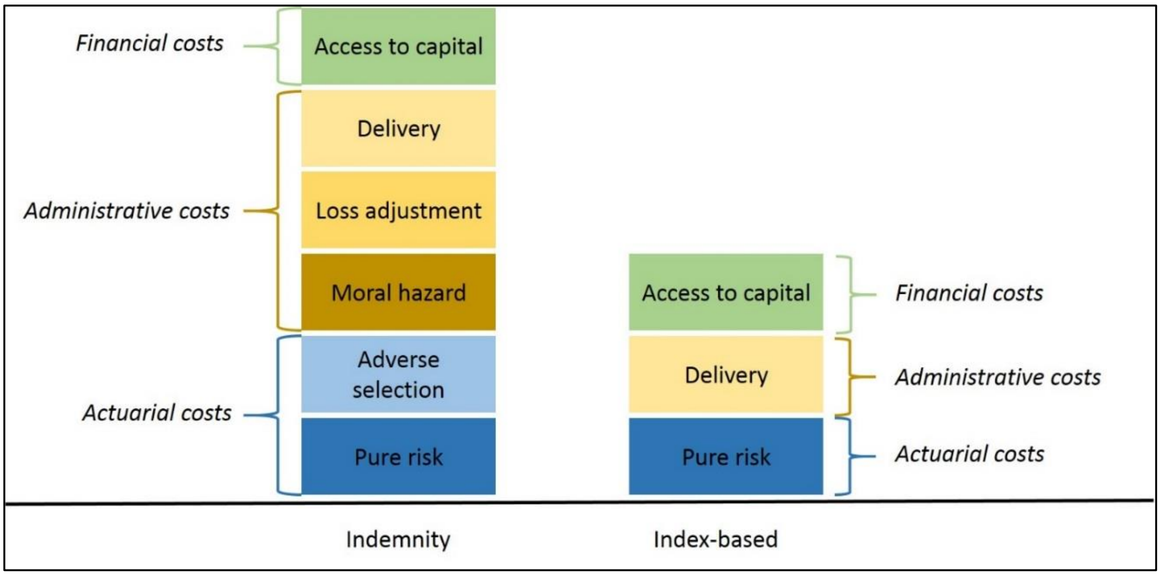

Figure 2.5 Costs associated with indemnity and index-based insurance; adapted *from De Janvry et al. (2011)*

Indemnity policies encompass well-known structural issues, including moral hazard and adverse selection. These risks are largely reduced by the structure of index insurance (e.g., Norton, 2013). Opportunity for adverse selection is present when households recognise that their expected indemnities exceed their premium payments and are therefore relatively more likely to purchase insurance. In turn, adverse selection can lead to a vicious cycle, as efforts by the insurer to raise premiums only then result in a smaller, more adversely selected participant pool.[43] Index-based insurance also reduces the moral hazard that arises when those covered by indemnity insurance alter their production practices in order to increase the potential of collecting on indemnity.[44]

The main disadvantage associated with index-based insurance is the existence of basis risk. Basis risk is measured as the difference between the indemnity payout, as measured by the index

[43] For further discussion see: Akerlof (1970); Just et al. (1999); Makki & Somwaru (2001); and Skees & Reed (1986).
[44] For further discussion see: Hölmstrom (1979); Shavell (1979); and Smith & Goodwin (1996).

(e.g., at a nearby weather station), and the actual loss incurred by the insured. For example, in a simple model of drought risk, based on a single parameter of precipitation recorded at a local weather station, the realised amount of rainfall as r and the trigger amount of rainfall as r*. No indemnity is paid if the realised value of rainfall at the weather station is greater than or equal to the trigger. If the actual rainfall, *r*, is less than the trigger, *r**, the insured are paid an indemnity.

Furthermore, insurance indexed on weather may not be suitable for some complex risks. For example, where crop types are susceptible to multiple risk factors; in such instances, an area yield index may be more effective (e.g., Morduch, 1998; Clarke & Kalani, 2012). It should be noted that there are methods for enhancing product design for an index-based tool when there is little existent past meteorological data (e.g., Osgood et al., 2007) and for improving the robustness of indices themselves when there is little direct meteorological data (e.g., Greatrex et al., 2015).

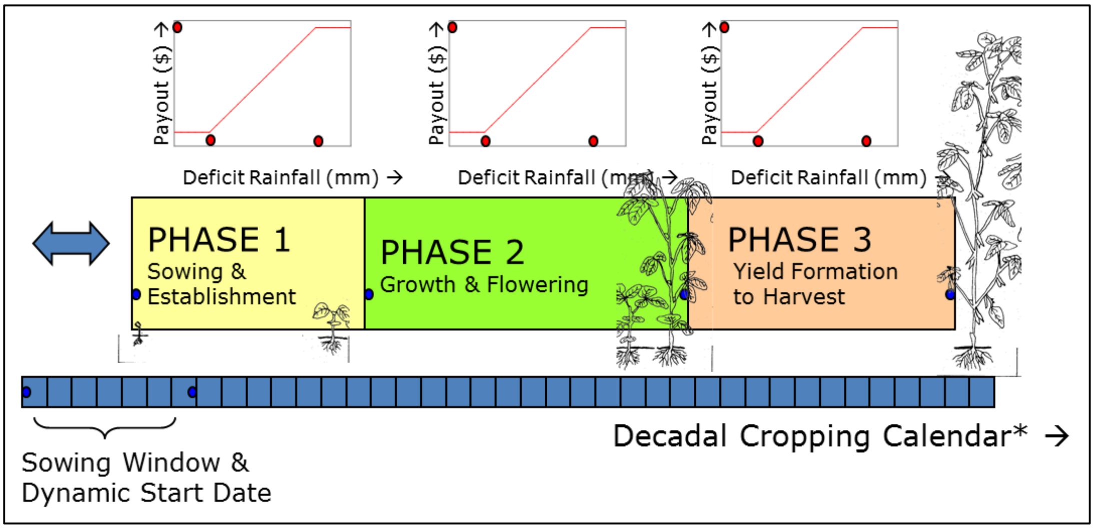

Figure 2.6 Schematic of pay-out system from index-based agricultural microinsurance[45]

2.5 Insurance demand—WTP conceptual framework

In this section we discuss demand for (micro)insurance under the EU framework with specific consideration for consumers' willingness-to-pay (WTP) for (micro)insurance which arises from surplus-based welfare measures, such as equivalent and compensating variation. Fenn (1987) looks at this issue from the standpoint of consumers' compensating or equivalent variation in assessment of uncertain loss.

The surplus-based welfare measures one obtains out of a WTP survey are linked to the economic model of insurance choice. Details about the use of contingent valuation (CV) are given in Chapter 3; in this section we introduce the stated preferences conceptual framework.

Under EU insurance demand can be translated as a demand for certainty—households largely use insurance to assure a certain level of wealth[46] instead of the actuarially equivalent uncertain

[45] This schematic is based on cumulative rainfall per ten-day period (decadal) at a representative weather station and standard decadal growth patterns for a given crop.
[46] May also be thought of as a guarantee of lower losses.

one. Households largely perceive insurance based on pricing, individual preferences (e.g., risk aversion), and their budget constraint (e.g., Kunreuther & Pauly, 2005).

As Fenn (1987) notes, when there is uncertainty related to outcomes this discontinuity is treated as state-dependent and the consumer may consider the use of insurance to maintain utility across states. In the case of the loss state, welfare loss may be monetised by transferring wealth that restores the original utility level (i.e., compensating variation) or by deducting an amount of wealth that brings about utility reduction equivalent to the (wealth) loss (i.e., equivalent variation).

Hazell (1992) notes that the condition for a sustainable insurance contract on the supply-side is loosely given by: $\frac{A+I}{P} < 1$, where *A* is the average administrative costs per insurance contract, *I* is the average indemnities paid in a given period, and *P* is the average premiums paid in a period.

Even when the insurer is able to provide actuarially fair policies, a rational consumer under EU may not fully insure. Figure 2.7

gives an example of a state preference diagram, where state 1 is the non-loss state and state 2 is the loss state. Thus, w_1 is wealth in the non-loss state and w_2 is wealth in the loss state with the wealth certainty locus given line defined by $w_1=w_2$. In each state there is value, h, assigned to a good that is significant to the household and not easily replaced, such that $h_2<h_1$ and is treated as continuous. In our research *h* may be conceptualised as home value or the expected value from a seasonal crop.

The utility certainty locus is along the curve defined by $u(w_1,h_1)=u(w_2, h_2)$, where u(w,h) is a utility function defined over levels of *w* and *h* and there is a monotonic relationship between wealth and the consumer's value of loss. In the illustrated example the consumer is risk averse as indicated by a concave utility function—with diminishing marginal utility of wealth.

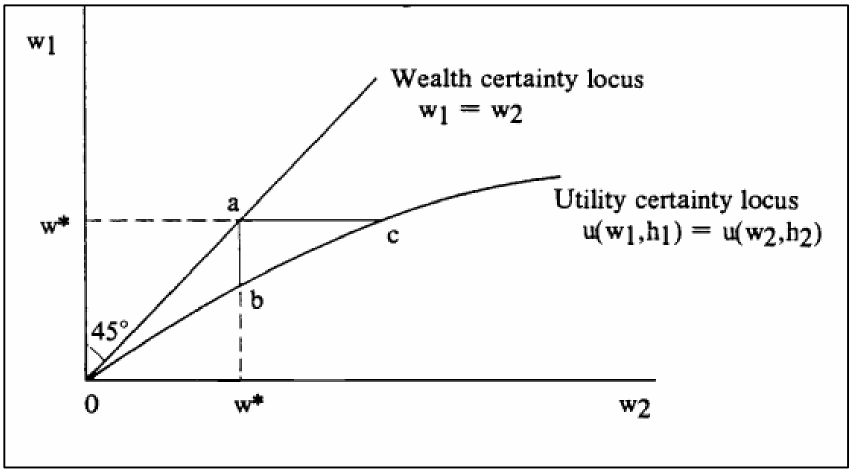

Figure 2.7 State preference diagram—wealth and utility between states: *adapted from Fenn (1987)*

Given initial wealth w* the consumer's equivalent variation of the loss is given by ab and ac gives the relevant compensating variation. When the marginal utility of wealth in state 2 is less than that in state 1 (i.e., the utility certainty locus falls below unity) equivalent and compensating variation are unequal.

Figure 2.8 illustrates the consumer choice to (not) employ insurance between the two states when there is uncertainty about the likelihood of loss, given the situation as depicted in Figure 2.7. By employing insurance the consumer can bring the compensating and equivalent variation values closer together.

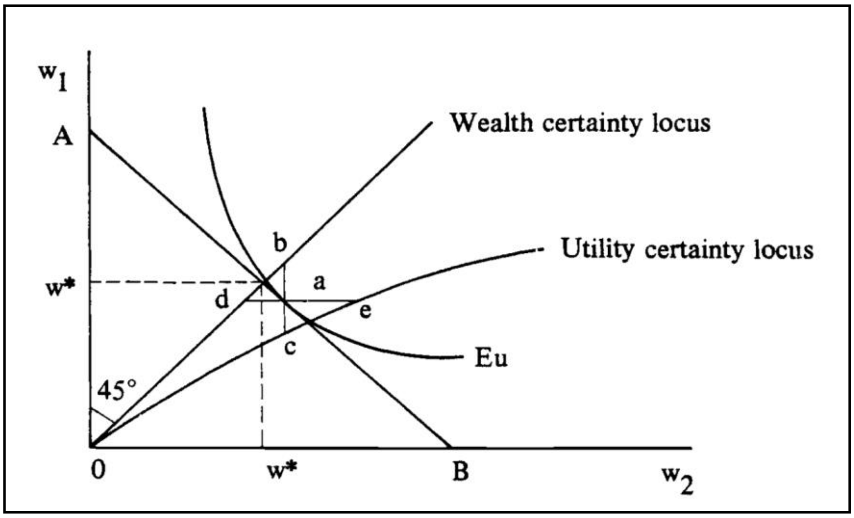

Figure 2.8 Transfer of wealth by insurance between 'good' and 'bad' states; *adapted from Fenn (1987)*

In Figure 2.8, *AB* gives the consumer's budget constraint. In the illustrated case the optimal transfer is given by *a* to maximise the household's expected utility, for a given loss probability. In general terms this is the point at the point (w*-pi, w*-pi+i), where w* is the original wealth endowment, pi is the fair insurance premium, and i is the wealth insured. In Figure 2.7, the equivalent variation is given as *bc* for a household with certain wealth equal to (w*-pi+i). The compensating variation is given by *de* for a household with certain wealth of (w*-pi).

The consumer will only insure if EU_i(insured)≥EU_u(uninsured).

Subsequently, the consumer's optimal insurance would require that the following equivalency be satisfied: $u_w(w^*-p_i, h_1)= u_w (w^*-p_i+I, h_2)$ (2.1)

Introducing the equivalent variation of the potential loss, given insurance:

$u_w (w^*-p_i+I, h_2)< u_w (w^*-pi+i-e, h_1)$ (2.2)

where e is the equivalent variation of the potential loss.

And in the case illustrated in Figures 2.7-2.8 *e>i*—that is the required equivalent variation is greater than the wealth actually insured. Thus, a rational consumer will employ less than full insurance in this case. In other words, WTP to avoid the insured loss exceeds the insurance value of that being insured and the relative magnitude of the change in marginal utility of wealth is affected by the (potential) loss, *ceteris paribus* (Fenn, 1987). Cook & Graham (1977) demonstrate that the insurance value of the good is bounded by the compensating variation (bc) and equivalent variation (de) values and that the difference between them is dependent upon the wealth effect of the household if affected by loss.

As applied to (micro)insurance, compensating variation is the level that one is WTP in order to obtain a payout in the 'bad' state in order to still maximise household expected utility. Formally this WTP is defined as the amount that must be taken from one's income while keeping utility constant (e.g., Fujiwara & Campbell, 2011).

The household's indirect utility function is given as v=v*f*(p, q, y), where p is a vector of prices faced by the household for insurance, but also for substitutes for insurance, i.e., alternative coping strategies that are expected to achieve the same final utility as an insurance product, q is the level of insurance, and y is household income.

$$V(y\text{-}WTP, p, q_1) = V(y, p, q_0) \tag{2.3}$$

Formally, WTP is defined as the amount that must be taken away from the household's income while keeping utility constant in the next period should a 'bad' state occur.

Specific to indexed insurance we can account for compound-risk attitudes. In this case, WTP_x is the difference between the certainty equivalent of the index insurance contract (CE_x) and the certainty equivalent of the income lottery the household faces if it takes no insurance (CE_a),[47] such that:

$$CE_x \equiv \rho^* - P_x, \tag{2.4}$$

where ρ^* is net revenue (final wealth) from the insurance contract and P_x is the compound lottery premium for index insurance.

$$CE_a \equiv \rho_a^* - P_a \tag{2.5}$$

P_a is the expected final net wealth the household receives without insurance.

Therefore, $WTP_x=(\rho^*-\rho_a^*)+P_a-P_x,$ (2.6)

such that the magnitude of WTP for index insurance depends on the household's risk aversion, compound-free aversion, and on basis risk.

See Elabed & Carter (2015b) for further expansion on households' certainty equivalent for a given level of basis risk and risk aversion.

The concepts of compensating variation and equivalent variation allow us to estimate the expected values of indemnity and household's WTP for an insurance premium through use of a large-N household survey.

Gautam et al. (1994) provide a model that treats household choice for efficient use of drought management strategies over two periods.

To capture the existence of prospective insurer default on rational purchase, Doherty and Schlesinger (1990) employed a four-state world for the choice to insure. Clarke (2011) parameterises basis risk, *r*, as a special case of the probability of insurance payout as measured by the index and the actual loss incurred by the insured to demonstrate rationality of not (fully) insuring.

[47] Also noted as the autarkic situation, i.e., he purchases no insurance.

2.6 Intended demand

According to EU Theory applied to choice under uncertainty, the rational individual chooses the optimum course between probable losses and gains; the optimal amount of insurance would be determined by relating the cost of the insurance premium to the chance of the disaster occurring and to the magnitude of the disaster. Yet, research illustrates the difference between revealed preferences–the actual costs people are ready to incur, and expressed preference–their stated preferences (Kunreuther et al., 1978, 2013). This difference likely arises from the use of heuristics; for example, Kunreuther and Pauly (2004, p. 18) state that “events that have a low expected value also have a low expected return from searching for information on the benefits of insurance relative to its cost,” which ultimately goes towards development of a low attention threshold for questions related to catastrophe insurance. These individuals are not necessarily irrational. They likely have other risks to provide against and the choice problem at hand is relatively complex. Thus, under the paradigm of Simon (1955) these insurance choice problems are faced by individuals with limited knowledge and are characterised by bounded rationality.

In the remainder of this section we first introduce Prospect Theory, which helps to unpack choices under expected utility that may not maximise utility for a rational agent. We then provide a staged model of intended behaviour applicable to the intension to insure and linked to the choice to ensure under expected utility.

2.6.1 Prospect Theory and Dual-process thinking

Covariate low-probability, high-impact risks are largely *un-situated* (Hulme, 2009), meaning the associated direct effects are not observable until they are realised. In this fashion, temporal saliency confounds the formation of households’ subjective risk estimates and coping responses (Fischhoff et al., 1998). Such risks are challenging for households to objectively value, which in turn challenges standard frameworks (e.g., EU Theory). We contend that there are five dimensions that underlie, influence, and help shape individuals’ perception of risks: 1. cognitive; 2. subconscious; 3. affective; 4. socio-cultural; and 5. individual factors.[48] In turn, a mental model[49] of a phenomenon is the internal, personalised, intuitive, and contextual understanding of how the event comes to pass (Kearney & Kaplan, 1997) influenced by these factors, which are heterogeneous across households.

As noted by Kahneman & Tversky (1979), EU Theory (von Neumann & Morgenstern, 1944) fails to predict actual behaviour in many household decisions under risk, such as fully insuring when it is not optimal. In short, EU theory makes two major assumptions, which are often at odds with the nature of the demand for extreme weather insurance; namely: 1. that probabilities used to calculate risk are well defined; and 2. the structure of preferences relates to rational actors (Frank, 2000).

Prospect Theory (PT) is one alternative approach to EU Theory, which reports on simplifying procedures that people make when faced with complex choices and recognises that decisions

[48] These dimensions are an extension upon Hillson & Murray-Webster's (2007) “triple strand” model.

[49] Mental models have three major functions: 1. they offer framework into which people fit new information; 2. they definition of how individuals approach and solve problems; and 3. they help formulate actions and behaviours (e.g., Morgan et al., 2002).

are not focused on final outcomes, but upon incremental choices at stages within a larger complex process (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992); this view reflects the process of ex-ante and ex-post coping we presented in Figure 2.3. The theory suggests that actors engage in two main phases when considering risky prospects, editing and evaluation. PT focuses heavily on the framing of risk-related questions and related effects on individuals' responses (i.e., it takes into account use of biases and heuristics).[50]

PT begins to integrate the social psychology concept of two-system thinking (Stanovich & West, 2000) and dual process theories concerning decision-making. As Epstein (1994, p. 710) observed, there is "no dearth of evidence in everyday life that people apprehend reality in two fundamentally different ways." Under this paradigm there is a clear distinction between automatic heuristic-style thinking (i.e., System I) and effortful information processing (i.e., System II). In evolutionary psychology, System I thinking accounts for intuition–drawing quick, effortless, but cautious assessments of situations in order to provide decisive conclusions from small clues. System II is better at balancing probabilities and possibilities logically, but requires greater time for decision-making. In short, emotion precedes cognition in facing decisions over risks, especially where ambiguity is concerned (Libet, 1993) . Yet, it is the interplay of the two systems that ultimately creates *ecological rationality*; Todd & Gigerenzer (2003) note that the ecological rationality of a given decision is dependent on the circumstances under which it takes place.

2.6.2 Staged model of intended behaviour

Staged models from the social psychology literature offer ways to structure relationships between elements that reflect System I and System II thinking relevant to households' expressed behavioural preferences. For example, the *Theory of Reasoned Action* (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980) provides a schematic linkage of behavioural intention with the elemental attitudes and subjective norms with which the actor is faced. Triandis' (1971) *Model of Interpersonal Behavior* provides a linking of social aspects to influencing conditions, attitudes, experience, and emotions. According to Triandis (1977), behaviour is a comprehensive function of intention, habitual responses, and situational constraints and conditions. Thus, intention is influenced by social and affective factors in addition to rational processing. Behaviour is influenced by moral beliefs; but there is moderation by both emotional drives and cognitive limitations. Triandis (1977) describes roles as "sets of behaviours considered appropriate for persons holding certain positions in the group" while self-concept is defined through the individuals' own assessment of engagement in certain behaviours and goals. Affect is a response to System I emotions and is defined by Triandis (1980, p. 220) as "beliefs that link emotions to the act, occurring at the moment of action." Using the weighting approach, the probability of an actor undertaking a specific act is dependent on three major factors: 1. strength of the habit; 2. behaviour intention towards the act; and 3. presence/absence of the conditions to facilitate the act to occur.

Figure 2.9 gives a staged model extending Triandis' (1971) model;[51] it is applicable to structuring decisions related to climate change-related risks (Helgeson et al., 2010; Helgeson et al., 2012),

[50] For a full summary of PT see: Edwards (1996).

[51] The *Theory of Intended Behaviour* (TIB) takes into account habits and facilitating conditions as intervening between intention and behaviour, while Fishbein and Ajzen (1975) emphasises that behaviour is a direct function of intentions. The TIB considers roles, self-image, and interpersonal agreements, which are not considered in Fishbein and Ajzen

and reflects relevant steps in the decision to insure against extreme weather events. In Table 2.3 we provide a working definition of constituent element in the proposed staged model and note relevant theoretical frameworks from various disciplines that offer approaches to measurement/categorisation of the element. Our application of some of these theoretical frameworks in the design of our research is noted in methodological discussion (Chapter 3). These constituent elements are also brought into our conceptual framework (Figure 2.11) that looks at factors that have been shown to be significant in the choice to insure for both extreme weather index-based microinsurance and indemnity insurance in the developed country case in past literature.

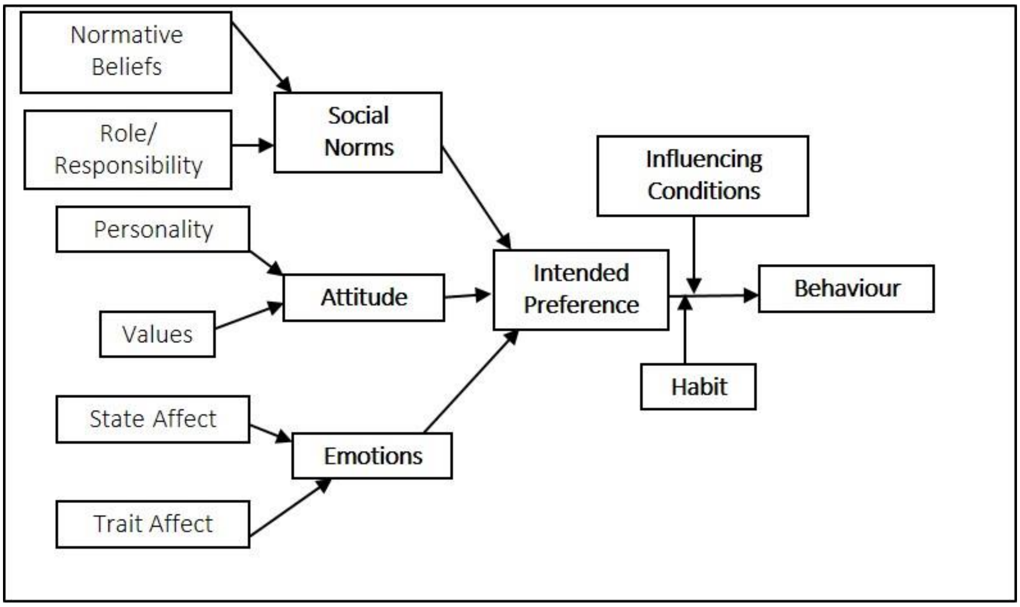

Figure 2.9 Staged model for formation of household intention to insure; *adapted from Helgeson et al. (2010) and Helgeson et al. (2012)*

Through this type of model it may be possible to account for System I and System II thinking in a more specific manner than much of the previous work in economics (e.g., Thaler & Sunstein, 2008; Ariely, 2010). In this formulation we recognise the factors from which bounded rationality in facing insuring decisions may arise. Through application of approaches from theoretical frameworks relevant to various elements identified in the staged model (Figure 2.9) we provide consideration of bounded rationality in the methods used to obtain and analyse data for determinants of insurance demand.

The elements in this model were chosen to encompass psychological barriers to development of preferences over climate risks generally and insurance decisions, more specifically. There exist debates in the literature concerning the meaning and constituents of the primitive elements identified in the model as well as the relationships between elements and contributing factors (e.g., attitude and emotion). Generally, the model, as presented below, serves to simplify definitions of complex concepts as to reasonably be included within behavioural economic

(1975); rather Fishbein and Ajzen (1975) states that the influence of those factors will be felt through other factors that inform an individual's attitude toward the behaviour. Finally, the TIB uses affect towards behaviour as a separate factor, whereas, Fishbein and Ajzen (1975) assume that affect is the sum of the perceived consequences multiplied by the perceived value attached to these consequences (Triandis, 1977).

modeling. Each element is explained in Table 2.3 with a working definition taken from social psychology, identification of relevant frameworks, and clarifying notes, as appropriate.

To the best of our knowledge there are few instances in which elements of such a staged model have been explicitly operationalised in research on extreme weather insurance demand. One such example is the *Goal-based model of choice* (Krantz & Kunreuther, 2007; Carlson et al., 2008), which was developed around insurance decisions. This is a theory of decision-making in which preferences are constructed based upon the decision context and household basing decisions on pre-set goals to be fulfilled, as opposed to maximising utility or value. This theory depends largely on the idea that preferences are constructed, as opposed to revealed, a finding emerging from empirical studies of PT (e.g., Tversky et al., 1990; Slovic, 1995; Chapman & Johnson, 1999).

Under the *Goal-based model of choice* goals can be emotion-related or be defined to conform to social norms. To this point, Kunreuther et al. (2013) give the example that under this model of choice, individuals may buy insurance coverage to reduce their anxiety about experiencing a large financial loss and stress the importance of separating financial protection from the loss and reduction of anxiety about the loss (the *feeling of insurance*). Many of the steps under the *Goal-based model of choice* reflect those highlighted in the planning process for ex-ante and ex-post response to coping (Figure 2.3), but take elements of bounded rationality into account specifically. These steps include: 1. problem recognition, 2. activating relevant goals, 3. searching for or designing alternative action plans, 4. evaluation of alternatives, 5. making trade-offs by determining the achievement (level) of the original goal (Krantz & Kunreuther, 2007).[52]

[52] Throughout this thesis we reference the *feeling of insurance* which arises from the *Goal-based model of choice* as the utility obtained by having the perception of being insured even in cases where insurance does not increase expected utility or coping ability.

Table 2.3 Elements of the staged model for formation of household intention to insure

Element	***Working definition***	***Relevant frameworks discussed***	***Notes***
Social Norms	"An understanding of a phenomenon or construct based upon the opinions held by a group of humans, which are broadly distinguished from other groups by mutual interests, shared institutions, or a common culture" (Moscovici, 1988, p. 214).	Since its inception, the social norms approach has been referred to as the *proactive prevention model* (Berkowitz, 1997, 1998), *social norming* (Hunter, 1998), the *perceived norms model* (Thombs, 2000), *norms correction*, and the *norms challenging model* (Peeler et al., 2000; Far & Miller, 2003). There is an emerging consensus in favour of the term *social norms theory* to describe the underlying theory and the *social norms approach* to describe interventions based on the theory, which encompasses: 1. injunctive norms and 2. descriptive norms. Injunctive norms involve perceptions of which behaviours are typically approved (or disapproved) by the larger society and assist an individual in determining what is acceptable social behaviour (e.g., accounting for the morals of one's interpersonal networks and surrounding community). Descriptive norms involve perceptions of which behaviours are typically performed in the majority of society. They normally refer to one's perception of others' behaviour through observations, not the objective behaviours themselves (e.g., Cialdini, 2003).	Social norms interventions arose from studies on addiction and maintain a focus on peer influences, which appear to have a greater impact on individual behaviour than do biological, personality, familial, religious, cultural and other influences (Kandel, 1985; Berkowitz & Perkins, 1986; Borsari & Carey, 2001; Perkins, 2002). The *good neighbours approach* is directly relevant to demand for index-based microinsurance. It hypothesises that especially informal trust, built through knowing peers with insurance claims, positively affects demand (Morsink & Geurts, 2012).

Normative beliefs	"Subjective perceptions of the acceptance of a given behaviour by those close to an individual" (e.g., close friends and family members) (Ajzen & Fishbein, 1980). Thus, an individual develops normative beliefs based on her perception of social normative pressures, indicating that she should (not) perform a given behaviour.	The concept of the *social environment* arises from (Sheth, 1973). The social environment includes all social factors that are likely to impinge on and provide a set of normative beliefs to the individual about how she should act towards the decision at hand. Markus & Kitayama (1991) identified two self-construals: 1. independent view of self and 2. interdependent view of self. These self-construals account for the extent to which individuals see themselves as separate from or connected to others in the wider community and in turn, inform normative beliefs. There are inherent cognitive, emotional, and motivational consequences of holding a view of the self under each of the self-construals (Markus & Kitayama, 1991; Kashima et al., 1995).	Normative beliefs may play a strong role in defining one's role in society. Examples of elements in the social environment which in turn inform the social norms to which an individual may be bound include: gender, age, education, wealth, and life style (e.g., Hernandez & Blazer, 2006).

Attitude	"The degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question" (Ajzen, 1991, p. 188).	In some staged models, attitude is taken to represent the weighted values (i.e., importance) of the summed attributes of an alternative. For example, Eagly & Chaiken (1993) and Triandis (1994) incorporated attitude toward the targeted decision objective into their models, explaining that a behaviour may seem attractive because the attitude towards the target came to mind, without consideration for the "rationally calculated" potential outcomes of that behaviour. We follow the *Elaboration Likelihood* theory (Petty & Cacioppo, 1986) as a model of how attitudes are formed and changed. Central to the model is the "elaboration continuum," which goes from low elaboration (i.e., low thought) to high elaboration (i.e., high thought). The level of elaboration is determined by two routes of persuasion: 1. the central route, where ideas are considered logically (i.e., System II); and 2. the peripheral route which relies on cues or feelings (i.e., System I). The theory suggests that true attitude change only happens through the central processing route (Petty & Cacioppo, 1986). It has been argued that broad attitudes and personality traits have an impact on specific behaviours only indirectly by influencing some of the factors that are more closely linked to the behaviour in question (e.g., Ajzen & Fishbein, 1980).	Attitude is often conceived as arising from pure System II thinking, but this is not necessarily the case. The process of utility valuation over attitudes can be very fast and potentially processed through System I, since it is often argued that attitude interacts with some level of emotional aspects. (e.g., Borman et al., 2003). Wicker's review, along with others (e.g., Deutscher, 1973), led to considerable scepticism over the attitude component in many staged models (Wicker, 1971). Although it cannot be denied that a large number of studies suggest that attitudes do not influence behaviour, they have been shown to predict actualised behaviour (e.g., Kelley & Mirer, 1974).

Personality	“Dynamic organisation, inside the person, of psychophysical systems that create a person’s characteristic patterns of behaviour, thoughts, and feelings” (Carver & Scheier 2000, p. 5).	The *Five Factor Model* of personality (Digman, 1990) notes five broad domains or personality that cover variants of personality; the relative factors are openness, conscientiousness, extraversion, agreeableness, and neuroticism. (For a review of the *Five Factor Model*, see Wiggins, 1996) Douglas & Wildavsky (1982) propose four personality types that relate specifically to the risk domain and apply to culture: planner, entrepreneur, fixer, and fatalist. The *Cultural Theory of Risk* suggests that individuals can be placed on a typology of risk culture, i.e., the “group-grid” system by way of their personality traits. One’s relative position on the group-grid scale is determined by feelings of belonging and solidarity (group) and the amount of control and structure in their social roles (grid). It should be noted that empirical tests are mixed in their support of the Theory. For example, O’Riordan & Jordan (1999) have noted limitations in empirical testing, while there is support for the Theory from how individuals perceive the same risks within a societal grouping (e.g., Steg & Sievers, 2000).	As personality forms an inclination towards certain characteristic reactions in any given situation, personality traits are likely to influence attitude (formation) and behaviour in an information-seeking context (Heinström, 2003) and thus create a more complex feedback loop to the formation of intended behaviour choices. Dessai & van der Sluijs (2007) look at the profiles identified by Douglas & Wildavsky (1982) in the context of microinsurance demand. They find that the household heads tend to exhibit personality elements across all four categories.

Values	“At the individual level, values are internalized social representations or moral beliefs that people appeal to as the ultimate rationale for their actions. Though individuals in a society are likely to differ in the relative importance assigned to a particular value; values are an internalisation of sociocultural goals that provide a means of self-regulation of impulses that would otherwise bring individuals in conflict with the needs of the groups and structures within which they live” (Oyserman, 2015, 37).	Oyserman (2015) also indicates that the discussion of values is intimately tied with social life and that values can also be held at the group-level. At this level, values are scripts or cultural ideals held in common as the group’s *social mind*. Kohlberg and Gilligan (1971) and Kohlberg (1973) understand values as a critical component of the right as in being universally valid across societies (i.e., *moral universalism*) in his theory of *stages of moral development*. Kohlberg's scale takes into account how individuals justify behaviours; the general hypothesis is that moral behaviour is more responsible, consistent and predictable from people at higher levels (Crain, 2011). In this manner morals are not natural features of the world; they are prescriptive, but they can be evaluated in logical terms of truth and falsity (Colby et al., 1983). Modern theories of values are grounded in the work of Kohn (1977) (class and values), the *Rokeach Value Survey* (general value systems) (Rokeach, 1968), and the Values Orientation method (group level) (Kluckhohn & Strodtbeck, 1961).	The basic individualistic and collectivistic views of people as either independent or interdependent lead to contrasting sets of values. Nearly three-fourths of the world’s cultures can be described as collectivistic (Triandis, 1989). Yet, collectivism and individualism are not dichotomous, but lie upon a spectrum. (Hofstede, 2001).

Emotions	It should be noted that there is no agreed definition for emotions. Kleinginna & Kleinginna (1981) provide an overview of the prominent definitions of emotion and relevant debates.[53] We take emotional responses to be a mental state that arises through a non-conscious effort in response to a stimulus without direct consideration for welfare or utility. This follows from the generally accepted definition of Allport (1935, p. 810) of attitude as "a mental and neural state of readiness organized through experience, exerting a directive or dynamic influence upon an individual's response to all objects and situations with which it is related." Emotion is often intertwined with attributes of mood, temperament, personality, disposition, and motivation (e.g., Gaulin & McBurney, 2004; Schacter et al., 2014).	The major theories of emotions can be grouped into three main categories: physiological, neurological, and cognitive. Physiological theories suggest that responses within the body are responsible for emotions. Neurological theories propose that activity within the brain leads to emotional responses. Finally, cognitive theories argue that thoughts and other mental activity play an essential role in the formation of emotions (e.g., Izard, 1980; Scherer & Peper, 2001). The James-Lange theory of emotion (James, 1884; Lange, 2013) notes that emotion is not directly caused by perception of an event/trigger, but by the bodily response caused by the event. The Cannon-Bard theory (Cannon, 1927) proposes that the experience of the emotion and the bodily response occur at the same time independently of each other. The *Opponent-Process Theory* of emotion is predicated on our experience of emotions in relation to the opposite emotion (Solomon & Corbit, 1974). Solomon (1980) states that all processes have an affective balance (i.e., is pleasant or unpleasant), is followed by a secondary, "opponent process". This opponent process sets in after the primary process is quieted. With repeated exposure, the primary process becomes weaker while the opponent process is strengthened; in this way emotion is learned in a manner similar to habit.	A good review of the differences between evaluative and affective judgments is given by Ajzen & Timko (1986). Through the "constructionist" lens, the emotion one feels in response to a stimulus or event is "constructed" from elemental biological and psychological ingredients. Two hypothesized ingredients are "core affect" (characterized by, e.g., hedonic valence and physiological arousal) and conceptual knowledge (such as the semantic meaning of the emotion labels themselves, e.g., the word "anger") (Barrett, 2006).

[53] Kleinginna & Kleinginna (1981) identify 92 definitions and 9 sceptical statements from the literature on emotion; these were classed into an outline of 11 categories based on the emphasis placed on theoretical issues. This analysis is still relevant to the debate over emotions today (e.g., Parkinson, 1995; Cabanac, 2002; Frijda, 2008).

State affect	State affect is similar to the part of emotions that has been termed: *activation* (Thayer, 1989), *affect* (Watson & Tellegen, 1985), and *mood* (Morris, 1989; Russel, 2003).	At a given period in time, one's conscious experience (the raw feeling) is a blend of two dimensions and provides a feeling as the "assessment of one's current condition" (Russel, 2003). One dimension ranges from pleasure to displeasure and the second ranges measures the level of arousal.	To the best of our knowledge there is little empirical work done related to emotions, especially state affect, and insurance demanded; however, Kunreuther & Pauly (2014) provide results from an iterative game that suggest uninsured loss adversely affects how individuals report feeling (i.e., emotion), which in turn predicts changes in the uninsured players' insurance behaviour in future periods.
Trait affect	Trait affect is an overall tendency to respond to situations in a stable, predictable manner; a general disposition to situations. Thus, trait affect is less related to the situation than to overall view of the world. (e.g., Watson & Tellegen 1985).	A common classification for trait affect assumes a combination of pleasantness level and activation (Watson & Tellegen, 1985). The *Positive and Negative Affect Schedule* is frequently used to assess positive and negative trait affect to obtain a general sense of an individual's general outlook (Watson et al., 1988). A number of measures of trait affect have been shown to be internally consistent (e.g., Zuckerman & Lubin, 1965; Spielberger et al., 1983), as well as to show cross-situational consistency (Diener & Emmons, 1984).	Dispositional affect is different from emotion or state affect; it arises from personality, while emotion is a general concept for subjective responses of individuals to certain situations. The strength of emotions a person feels can stem from his level of dispositional affect (Watson & Tellegen, 1985).

2.6.3 Demand for insurance: a schematic

In this section we discuss insurance demand as it relates to the staged model presented above. This takes into account the presentation of insurance demand under expected utility, while accounting for the influence of heterogeneous household attributes, especially those potentially affected by bounded rationality.

Household demand for insurance mainly depends on two factors: 1. need for risk transfer–with insurance comprising a major form of (formal) risk transfer; and 2. attitude towards insurance. These two are mediated by limiting factors (e.g., affordability, accessibility, and delivery of the product), as well as the households' available liquid assets. *Ceteris paribus*, the greater the need and more positive the attitude towards insurance use, the greater will be demand. One factor driving insurance demand is the extent to which the product effectively targets a risk that is not addressed by available alternate coping mechanisms.

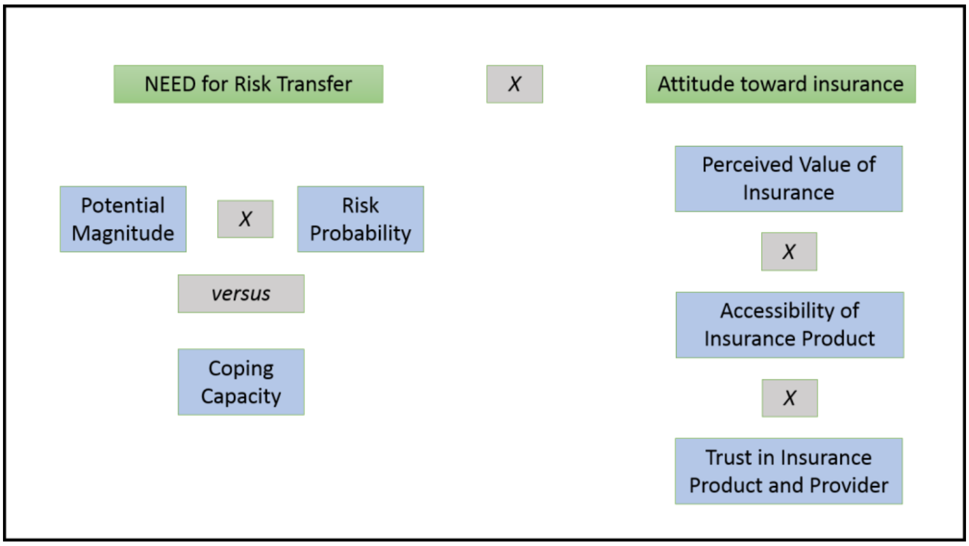

Figure 2.10 Demand for (micro)insurance; *adapted from Tadesse & Brans (2012)*

The need for risk transfer arises when the severity and probability of the extreme weather risk the household faces exceeds its coping capacity.[54] Under this framework (see Figure 2.11), the greater the severity or probability of risk, the greater the coping capacity must be for dealing with it. In this schematic determinates for need are: 1. potential magnitude of risk: severity of loss in wellbeing in both the short- and long-term; 2. probability of risk (likelihood a loss will occur), and coping capacity (ability to decrease the probability of risk ex-ante or ex-post severity of loss).

The level of demand for insurance is a function of the amount of need for risk transfer offered by insurance combined with the attitude towards available insurance products. Attitude depends upon three factors: 1. perception of the value of insurance as a concept (including knowledge of how insurance works in general); 2. accessibility of insurance products (including

[54] A household's coping capacity is determined by the appropriate coping strategies available for them to implement or adopted (Tadesse & Brans, 2012).

affordability and delivery mechanisms); and 3. the trust would-be consumers have in the quality and delivery of available product offerings and providers.

For (micro)insurance products to be accessible, they need be affordable and exclusively relevant to potential consumers' risk transfer needs (e.g., McCord, 2012; King, 2013). Yet, there are well-documented cases, especially in the developed country context, under which affordable premia do not adequately reflect true probabilities and encourage adoption of inappropriate insurance levels (Kunreuther, 2000; Kousky, 2014). Other studies have found that consumers may opt for more costly insurance coverage if they prefer relevant attributes (e.g., higher frequency payouts) (e.g., Norton et al., 2014). Thus, it is viable that many would-be consumers of insurance are interested in factors such as reliability of products opposed to being price-driven.

As demonstrated in the schematic for insurance demand (Figure 2.10), there is an underlying vector of factors affecting a household's attitude towards insurance, which ultimately affects demand and provides rationale as to why empirical studies of demand may deviate from the values expected under EU. This is further compounded by updating preferences between periods based on past outcomes in coping with risk (Figure 2.2). The conceptual framework presented in the next section strives to provide a structured manner to assess factor classes that directly and indirectly effect intended insurance demand.

2.7 Conceptual Framework: Contributing factors to insurance demand

2.7.1 Overview

We propose the following conceptual model for insurance demand (Figure 2.11) which accounts for elements that contribute to households' bounded rationality in considering insurance demand. This model takes into account underlying processes which have been discussed earlier in this chapter, such as: IRM (Figure 2.2); ex-ante planning and ex-post response (Figure 2.3); schematic demand for insurance (Figure 2.10); and the staged model for intention to insure (Figure 2.9). The conceptual model accounts for a single period in the cyclical pattern of insuring and coping decisions that may be informed by past experiences–effects of these experiences are encompassed through heterogeneity in the contributing factors between households. We propose that this conceptual framework for demand is applicable to both agricultural index-based microinsurance in the developing country context and indemnity home flood insurance in the developed country context. This is true in part because of the mediating effects of social policies and legal frameworks under which households formulate decisions, as well as the alternative coping strategies available.

In the remainder of this section we present the constituent factors for the framework which fall under the factor categories of: 1. economic, 2. social and cultural, 3. structural, and 4. personal and demographic. The factors chosen have been identified as significant factors in past studies of both index-based microinsurance and indemnity insurance policies in the developing and developed country contexts, respectively.

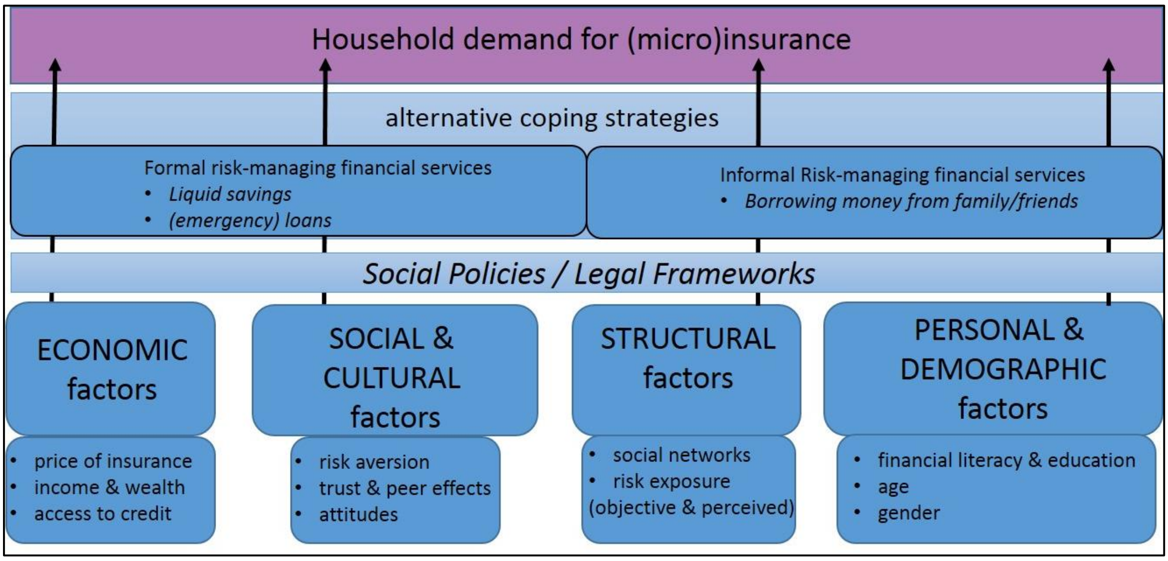

Figure 2.11 Conceptual framework: factors determining demand for (micro)insurance

As previously noted, there is broad literature on demand for insurance against extreme weather; however, there is disagreement in the literature as to whether there is truly *disappointing demand* for insurance products offered. Many of these studies look at relevant factors in order to identify those which may significantly influence insurance demanded. To the best of our knowledge there is little formal discussion of or consideration for bounded rationality in the majority of studies, especially those conducted in the developing country context. There is relatively more literature that addresses the outcomes associated with households' combined use of System I and System II thinking for the developed country context (e.g., Kunreuther et al., 2012) as opposed to the developing country context to the best of our knowledge.

Identification of the process for complex combinations of System I and System II thinking is difficult, especially for a large-N study under which one does not have the ability to conduct a thorough, long-term study of individual households' decision patterns (G. Gigerenzer 2010, per. comm., 18 June). As a starting point we look at indicators for which a given household's subjective opinion deviates from objective data on the phenomenon (e.g., the difference in weather records and self-reported weather conditions).

In our review of determinants of insurance demand, we considered a variety of papers and cross-referenced these findings with papers that had done similar reviews. In their meta review, Azad et al. (2013) isolate 24 key variables related to adoption of agricultural index-based microinsurance; these are grouped into categories through factor analysis to find that those that are most important on the demand-side are: revealed uncertainty, riskiness of environment, empowerment, education, and training. Eling et al. (2014) review of the academic literature on microinsurance demand between 2000 and 2014 builds on Biener and Eling (2012) systematic analysis of microinsurance markets (covering 131 policies) based on a set of nine fundamental insurability criteria proposed originally by Berliner (1982) and adapted for microinsurance. Biener and Eling (2012) identify twelve key factors affecting demand for index-based microinsurance that has been studied throughout the literature to date, but often have inconclusive effects on demand. These determinants overlap the categories identified by Azad et al. (2013). We determine that ten of these factors have been shown to affect demand for both index-based microinsurance and indemnity insurance and could benefit from further research, especially in trying to isolate the potential effect of a single factor controlling for the others to the extent possible.

In the discussion that follows we summarise factors shown to be significant determinants of insurance demanded in past literature for both index-based microinsurance (developing country context) and indemnity insurance (developed country context). In Table 2.4 we categorise select papers that have addressed the effects of these determinants on insurance demand by the sign of determination. There is the caveat that across studies there are differences in the underlying environments, the characteristics of the products under consideration, as well as in the approach the studies take to obtaining data concerning relevant determinants.

Outreville (2013) identifies factors, which fall under four categories within the empirical literature that provide a framework for household decisions to insure: 1. economic (price and wealth influences); 2. social and cultural (proxies for utility functions); structural (response to underlying market conditions); and 4. personal and demographic (representations of loss exposure) factors. These categories appear to be relevant to the microinsurance market, but the magnitude and direction of the effects vary due to differences in market conditions. Some variables, such as trust and peer effects may be less relevant in the developed country context due to differences in the political backdrop against which insurance is provided. Furthermore, it is important to consider that there is relevant interconnectedness between some factors with regards to motivating factors. For example, past experience with insurance, which is affected by price and payout, in turn affects trust levels, which ultimately may affect insurance demand. There is little research on the pathways of these complex effects opposed to the magnitude of the effect itself (e.g., Cole et al., 2012; Mobarak & Rosenzweig, 2012). In the sections below we highlight key studies and findings for microinsurance[55] and indemnity insurance[56] structures across these four factor categories, which we use to guide our research methodology.

2.7.2 Factor components

2.7.2.1 Economic Factors

2.7.2.1.1 Price of Insurance

Microinsurance

In most circumstances insurance price is inversely related to microinsurance demand; see de Bock & Gelade (2012) for a thorough discussion. Patt et al. (2009) make the case that it is the poorest farmers in any context–developing or developed–who are likely to accept a lower certainty equivalent since the risk of receiving no income from their harvest would be relatively more detrimental than it would be to farmers in a higher wealth bracket or with greater income stream diversification. The empirical findings related to this claim are mixed. Cole et al. (2011) find that a certain percentage increase in premium price leads to roughly the same decrease in WTJ across wealth levels. In comparison, Mobarak & Rosenzweig (2012) find a price elasticity of 0.44, which is similar to that reported by Karlan et al. (2013). Dercon et al. (2015) have a similar experimental design and find that a 10% increase in premium price leads to a relatively lesser decrease in adoption of the insurance product. Yet, Norton et al. (2014) find a surprisingly high uptake rate for an expensive commercial insurance product over other risk management

[55]Note that where we mention microinsurance, index-based agricultural microinsurance is implied.
[56] Where we mention indemnity insurance, indemnity home flood insurance is implied unless otherwise noted.

options, such as high interest savings and insurance characterised by lower premia payments and less frequent payout periods.

Many studies claim that fair-rate insurance instruments tend to have a much lower rate of WTJ than expected ex-ante. *Ceteris paribus*, the literature suggests that the greater the absolute premium rate (even when actuarially fair), the greater the reduction in participation in crop insurance programmes; fewer farms purchase insurance and those that do so tend to have a decreased WTP (e.g., Coble et al., 2000; Coble et al., 1996; Goodwin & Smith, 2003). Increasingly, there are examples in the literature stating that demand for index-based microinsurance is relatively substantial. For example, Karlan et al. (2013) find that demand for index insurance is strong and the uptake of insurance leads to significantly greater productive agricultural investment and riskier production choices. Norton et al. (2014) find a surprisingly high take-up rate for an expensive commercial insurance product over other risk management options, such as high interest savings and insurance characterised by lower premia payments and less frequent payout periods.

Furthermore, some studies suggest that initial subsidies may help stimulate demand for microinsurance products (e.g., Cole, Giné et al., 2013). But retention rates following subsidy expiration suggests that familiarity does not improve demand (e.g., Thornton et al., 2010; Fitzpatrick et al., 2011). And subsidies may break down informal coping strategies that were in place ahead of the introduction of insurance (e.g., Latortue, 2006).

Indemnity Insurance

As expected, demand for indemnity products is sensitive to pricing and relevant transaction costs; price elasticity of demand in developed markets are in the range 0.2-0.4 (Marquis et al., 2004). Kunreuther & Pauly (2004) note that USA flood insurance consumers have a tendency to believe they are routinely being overcharged. In turn this is related to claims of under purchase due to many policies having loss probabilities and premia that fall under the threshold for households to undertake rational search and thought processes. In their survey of nine coastal USA counties, Kriesel & Landry (2004) find that demand is negatively-related to price.

Price sensitivities in this context are also largely affected by social and political factors that have historically made discounted premia available to low- and middle-income households in the USA which were not means tested (e.g., Kousky & Kunreuther, 2014), opposed to risk-based premia. This simultaneously sends the wrong message about the true risk faced as well as allowing people to opt to use subsidies opposed to insurance. Thus, there is a push for voucher programmes that encourage risk reduction-risk transfer discounts to such households (e.g., Kunreuther, 2008).

2.7.2.1.2 Wealth (Household-level)

Microinsurance

Many studies find that household wealth provides greater access to credit and/or liquidity, which ultimately allows for insurance purchase (e.g., Giné et al., 2008; Cole, Giné et al., 2013). *A priori* it is unclear the direction of effect wealth via the channel of credit access has on microinsurance demand. Cole, Giné et al. (2013) find that when given enough money to pay for insurance, household's uptake increased by 140%, which supports the claim that households lacking access to credit may place greater value on insurance as a means to reduce volatility;

extreme weather may be more damaging to them relative to less economically-constrained households.

Households that are not credit constrained, when offered actuarially fair premia may purchase less than full insurance in part due to the expectation of basis risk. Ito & Kono (2010) and Karlan et al. (2013) find minimal effect between wealth and insurance demand.

Families hold wealth in a number of (liquid and non-liquid) forms and it fluctuates greatly at different periods in the farming and work cycles in the developing country context (Collins et al., 2009). In turn, this challenges the one-size fits all assumption and requires that different designs continue to be tested. For example, Liu et al., (2013) find that insurance uptake increases three-fold when households can pay insurance premia at the end of a period.

Indemnity Insurance

Household income and wealth have been noted to be significant drivers of insuring in indemnity markets. Due to multicollinearity concerns, most studies consider either wealth or income. These determinants are often proxies for potential loss; the larger the potential loss, the greater the insurance purchased, assuming non-decreasing relative risk aversion (e.g., Mossin, 1968).

Findings indicate that income elasticity of demand for residential flood insurance is relatively high; higher income individuals are more likely to purchase flood insurance and purchase greater levels of coverage than are relatively lower income individuals. Browne & Hoyt (2000) find that demand for residential flood insurance, measured by policies purchased, is sensitive to (disposable personal) income in the positive direction. Kriesel & Landry (2004) find that demand is positively-related to income.

In traditional markets household wealth is thought to be a proxy for potential loss; the greater the wealth, the greater the loss potential and the greater level of insurance purchased; but this is not to say that lower-income households may have a greater relative need for insurance. Kőszegi & Rabin (2007) look at reference-dependent risk attitudes and suggest that different household circumstances may encourage different ways of setting the reference point against which losses and gains to the household are valued.

2.7.2.2 Social and Cultural Factors

2.7.2.2.1 Risk aversion

Microinsurance

Empirical evidence suggests that risk aversion has a significant effect on WTJ; however, the direction of this relationship remains unclear. Cole et al. (2011) and Giné et al. (2008) find risk aversion to be negatively correlated with WTJ. Galarza & Carter (2011) find a non-monotonic relationship between the insurance demanded and risk aversion. In short, there is evidence that risk aversion often has a significant and negative effect on insurance demand (e.g., Giné & Yang, 2009; Dercon & Christiaensen, 2011). It is likely that this negative association is related to the framing of the lotteries on risk aversion (e.g., Binswanger, 1981), which address only gains or maintaining the status quo. But there are other potential causes; Giné & Yang (2009) found opposite effects of microinsurance and explained that the bundling of a loan with formal insurance effectively increases the interest rate on the loan and the risk of default.

Tadesse & Brans (2012) identified that risk averse borrowers may prefer planting a traditional seed variety that does not require credit and the provision of insurance should, in principle, raise the adoption rate for a riskier variety among them. There is some evidence that WTP is increasing in risk aversion; however, for the most risk averse individuals demand for insurance falls (e.g., Clarke, 2011). It may be that the effect of risk aversion on WTP (once one has a positive WTJ) is mediated by other factors, such as budget constraints and basis risk (e.g., Doherty & Schlesinger, 2002; Clarke, 2011; Dercon et al., 2015). The use of indices in the majority of products may lead consumers to respond to compound risk (i.e., risk aversion to basis risk), as opposed to risk aversion to weather-related hazards (e.g., Giesbert et al., 2011; Giné et al., 2008). There are indications in the literature (e.g., Cardenas & Carpenter, 2008) that empirical evidence does not support the idea that poor households in the developing context have relative different risk profiles compared to their richer counterparts in the developed country context.

Indemnity insurance

In the developed country context there has been research related to latent risk aversion–regret over ex-post (uninsured) losses (e.g., Petrolia et al., 2012) and through learning processes. There has been consideration for subjective perception of flood risk, which in turn is dependent on previous experiences and communication of risk, on insurance demand in this context. Rational consumers (fully informed of the risk they face) who maximise their expected utility would purchase full flood insurance.[57] Behavioural studies imply that individuals' risk taking behaviour can be best explained by subjective measures such as risk perception and related perceived returns.[58] Specifically, when individuals are in an environment whereby optimal actions (e.g., decision to insure) are met with reliable 'rewards,' then (over time) decisions should converge to optimality (e.g., Kalai & Lehrer, 1993; Meyer & Hutchinson, 2001). But, this effect seems to disappear when the decision environment is not ideal for iterative learning (i.e., feedback is rare and noisy) and risk aversion does not adjust (e.g., Camerer et al., 2004).

2.7.2.2.2 Trust and peer effects

Microinsurance

Some studies find that trust in microinsurance is associated with perceived household risk of non-performance (e.g., Cai et al., 2010; Eling, 2013). Cai et al. (2010) find that adoption rates increase when heavily subsidised by the government and individuals express a feeling of trust towards the government. Bryan (2010) finds that the negative effect of risk aversion on WTJ in the Giné & Yang (2009) study is primarily driven by ambiguity aversion. Dercon et al. (2015) specify a model in which doubt in the trustworthiness of the insurer is the main motivation for ambiguity and subsequent risk aversion, and ultimately a relatively low WTJ. Empirically, when they control for trust, the effect of price variations on insurance adoption is strongest for less trusting individuals.

Familiarity with the concept of insurance seems to have a positive relationship with WTJ; however, trust and familiarity are strongly linked. For example, Morsink & Geurts (2011, 2012) demonstrate that potential insurers depend on the claim payout experiences reported by trusted peers and Karlan et al. (2011) report that insurance demand increases when the farmer

[57] This outcome assumes that insurers are able to perfectly bear the risk with no transaction costs.
[58] For a more detailed overview see: Sarin & Weber (1993) and Nosic & Weber (2010).

and trusted friends have received an expected payout in a given period. In much of the literature on familiarity, however, a direct effect (i.e., one that is not mediated by trust) is hard to discern between familiarity and WTJ. Cole, Giné et al. (2013) and Giné et al. (2008) find that the negative effect of risk aversion seems to be concentrated among the sample cohort that has no familiarity with the offering institution, which is also the group that is expected to be least trusting. In his Ivory Coast study, (Kouamé, 2010) makes the case that low uptake of microinsurance arises from limited trust in the credibility of the indexed policy, which in turn arises from unfamiliarity with the proposed insurance tool.

Indemnity Insurance

There is limited data concerning a direct relationship between peer effects on flood insurance demand in the developed country context; however, there is evidence of some effects documented in the choice of health insurance (e.g., Sorensen, 2006). Furthermore, due to the structure of the programme, some communities have greater access to the NFIP than do others; there are community engagement programmes which provide aid to communities in applications for coverage (FEMA, 2011).[59] It should be noted that the Community Rating System (CRS) of the NFIP appears to encourage increased insurance demand through peer effects and increased trust (A. Gowans 2015, per. comm., 20 May).[60] There is a relationship between transparency of insurance products and consumer trust; in some cases it appears that trust in the insurance tool reduces uncertainty (e.g., Erbas, 2004).

2.7.2.2.3 Attitudes

Microinsurance

The effect of attitudes are considered widely to mediate through perception of risk or worry with regards to microinsurance (e.g., Mosley et al., 2003); furthermore, attitudinal changes to insurance purchase can be made through increased trust (e.g., (Patt, Suarez et al., 2010; Abebe & Bogale, 2014) and financial literacy (Patt, Suarez et al., 2010). In some research, religion has been studied in order to better understand attitudes, especially those towards risk. For example, Gheyssens & Günther (2012) find that those who ascribe to religious beliefs are less risk averse in their investment choices. Cole, Giné et al. (2013) also find that associating with similarity (difference) in religion between groups affect insurance demanded positively (negatively); though these results likely are also associated with peer effects and increased trust (Morsink, 2012).

The concept of *fatalism*[61]—the belief that events are out of your control – has been studied as a related factor to religion. Dessai & van der Sluijs (2007) look at the profiles identified by Douglas & Wildavsky (1982) in the context of microinsurance demand. They find that the household heads tend to exhibit personality elements across all four categories.[62] Cole et al. (2011) find that fatalism has a positive effect on insurance use. Dror et al., (2012) find that in some cases the belief proliferates that the act of planning for a risk invites the risk to occur; thus,

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[59] There are also NFIP training and programmes (https://www.fema.gov/national-flood-insurance-program-training-workshops-and-conferences), as well as "The National Flood Insurance Program Community Status Book," which indicates the status of the uptake within communities with availability.
[60] Amanda Gowans is the Maryland State ISO/CRS Specialist for FEMA.
[61] Fatalism is likely considered a more consistent measure across cultures characterised by different religions, as it takes into account individual preferences and a general worldview.
[62] The four worldview typologies identified are: fatalist, heirarchist, individualist, and egalitarian.

in many cultures there is lower WTP for insurance due to cultural orientation to superstitions (Dalal & Morduch, 2012).

Indemnity Insurance

There are some studies which look at the effect of attitudes in the form of religion on the purchase of indemnity insurance, though many of these focus on the purchase of life insurance. For example, Eisenhauer & Halek (1999) find self-identified religious people to demonstrate higher risk aversion. Though in some studies that look across countries find a negative correlation between the two factors (e.g., Noussair et al., 2012).

Many studies of flood insurance emphasise the importance of the cultural background against which the decision to insure is made, opposed to individual attitudes. (Konstantinou, 2014) highlights risk management as a function of one's regional culture. Botzen (2013) notes that insurance demanded is largely predicated on geographical and cultural perspectives as attitudes.

2.7.2.3 Structural Factors

2.7.2.3.1 Social networks

Microinsurance

Informal risk-sharing, as in social networks, is an important form of coping in the developing country context. The extent of available informal coping available has a significant impact on demand for formal risk transfer, such as insurance (e.g., Arnott & Stiglitz, 1991). Cai et al. (2013) note that networks set-up for informal coping can help spread knowledge of insurance to the wider community. Mobarak & Rosenzweig (2012) make the observation that communities with strong risk-sharing networks use these to complement index-based insurance; even in the event of realised basis risk the network adjusts to indemnify on the household-level. Dercon et al. (2014) likewise find evidence of a link between index insurance more highly demanded by groups that informally can share risk in the case of idiosyncratic risks that extend beyond the aggregate shock facing a community, e.g., in agricultural circumstances.

Indemnity insurance

In the developed country context it is social security and government programmes that act as a complement to formal flood insurance. Kousky et al. (2013) find that ex-post federal aid grant amounts are positively correlated with crowding out effects on flood insurance in the USA They furthermore find that government loans as opposed to grants appear to have no effect. Browne & Hoyt (2000) find that receipt of disaster aid is positively correlated with future insurance purchase. Raschky & Weck-Hannemann (2007) provide a theoretical review of the effect of *charity hazard* from governmental and private aid following natural hazard events.

2.7.2.3.2 Risk exposure

Microinsurance

Many of the findings relating (perceived) risk exposure to insurance demand do not explicitly trace direct effects between the two concepts. Akter et al. (2008) find that the direct effect of risk exposure, controlling for past shocks, has a significant positive effect on microinsurance purchase. Yet, Arun et al. (2012) find that experience of a covariate hazard is negatively associated with purchase of insurance after a shock. This may be related to the fact that shocks may also affect households' ability to cope with loss by reducing availability of (liquid) assets to pay premia; thus, decreasing demand. Giesbert et al. (2011) look at subjective measures of risk exposure to find a correlation between households that believe themselves in greater risk of exposure and purchase less insurance.

There are a few studies which take into account the use of heuristics in determination of perceived risk. For example, Cai & Song (2013) find that outcomes from a recent hypothetical insurance game have a greater impact on the decision to insure than does disaster experiences in real-life experienced a year previous. Yet, Galarza & Carter (2011) find that those who experience many shocks tend to over-estimate relative likelihood of occurrence and purchase less insurance by assuming better outcomes in the future.

Quality of service and basis risk can also affect levels of assumed risk exposure through compounding ambiguity. Actual uptake rates tend to differ greatly from relatively large estimates in some theoretical and simulation models of optimal hedging strategies using index microinsurance (e.g., De Nicola, 2012; Miranda & Farrin, 2012). For example, Giné & Yang (2009) report that uptake was 13 percentage points lower when their sample of Malawian farmers were offered insurance with their loan, as opposed to credit in isolation. Other studies that find basis risk to limit initial demand by rural farmers include: China (e.g., Giné et al., 2008; Göncü, 2011; Cai & Song, 2012), India (e.g., Seth et al., 2009; Cole, Jagnani et al., 2013), and Bangladesh (e.g., Brouwer & Akter, 2010; Akter & Fatema, 2011). Yet, in other studies, index insurance appears to serve a valuable function in managing weather-related risks and enjoys relatively high levels of demand (e.g., Turvey, 2001; Osgood et al., 2007; Collier et al., 2009; Norton et al., 2013).

Indemnity insurance

Evidence points towards households in the developed country context temporarily purchasing greater insurance following disaster experiences, due in part to availability bias (e.g., Hogarth & Kunreuther, 1992; Kunreuther & Pauly, 2005). Hogarth & Kunreuther (1992) present information that there is higher uptake of insurance when there is reduced uncertainty about event probabilities and magnitude of potential losses. This makes sense in light of the claim that insurance may be attributed to increased ambiguity in the system (e.g., Dacy & Kunreuther, 1969; Froot, 2007). Individuals may have difficulty in determining whether or not to buy insurance against low-probability, high-loss events. This ambivalence would cause preference uncertainty and decrease homeowners' interest in voluntarily buying insurance.

There are other factors that may affect attitude towards insurance that are relevant in this discussion. For example, Loewenstein et al. (2001), assume the *risk-as-feelings* hypothesis. They show that emotional reactions to risky situations often diverge from cognitive assessments of those risks. When such divergence occurs, emotional reactions often drive behaviour. The *risk-as-feelings* hypothesis explains a wide range of phenomena that have resisted interpretation in cognitive–consequentialist terms.

2.7.2.4 Personal and Demographic Factors

2.7.2.4.1 Financial literacy and education

Microinsurance

The relationship between financial literacy and microinsurance is not straightforward; many studies that strive to make this link report heterogeneous findings. For example, Giné et al. (2008) note that a lack of product understanding is the most commonly cited reason for not adopting microinsurance. Yet, Dercon et al. (2014) note a positive impact on the link between financial literacy and risk management, especially insurance.

Some studies suggest that the use of insurance games to improve financial literacy may positively affect insurance demand (e.g., Patt, Suarez et al., 2010; Cai & Song, 2013). Clarke & Kalani (2012) find no significant impact on financial literacy and demand; and in modules on financial literacy there is no notable association in Schultz et al. (2013) and Cole, Jagnani et al. (2013), among others.

Education has been used as a proxy for financial literacy in some studies, but in others the two concepts are considered to be differentiated from one another. In relation to financial risk-taking behaviours, risk literacy appears to be of greater relevance than general educational attainment (Bayer et al., 2009; Lusardi & Mitchell, 2011). As is the case with financial literacy, the relationship between education and microinsurance demand appears to be ambiguous across studies: some report a negative association (Akter et al., 2008; Liu et al., 2013); and some report no significant relationship (e.g., Cole, Giné et al., 2013). Lin (2009) finds a negative relationship between educational attainment and relative risk aversion.

Indemnity insurance

There is an extensive literature on the relationship between financial literacy and the use of financial services in the developed country context; however, the relationship to insurance demand is somewhat less studied (e.g., Tennyson, 2011). Studies on the topic demonstrate a positive association between financial literacy and insurance demand (e.g., Masci et al., 2007; Cappellettia et al., 2013). Ludy & Kondolf (2012) demonstrate that even homeowners with high educational achievement have trouble understanding the risk of home flooding.

Empirical and experimental studies that focus specifically on consumers' insurance decisions find several features that are not consistent with rational choice theory. One tendency is to prefer low deductibles and to choose deductible levels inconsistently across purchases (e.g., Sydnor, 2010; Barseghyan et al., 2011), seemingly ignoring the price and risk trade-offs implicit in the use of deductibles. The evidence also tends to demonstrate that potential consumers do not have a good estimation of probabilities and treat losses and gains asymmetrically. This behaviour potentially indicates the effects of low financial literacy (e.g., Tennyson, 2011); however, these behaviours are consistent with bounded rationality (Slovic et al., 1977; Kunreuther et al., 1978) and likely arise from factors outside of financial literacy alone.

2.7.2.4.2 Age

Microinsurance

Age is included in a number of studies of microinsurance demand, but is often a control variable. In the literature to date, age appears to have an ambiguous effect–some studies find it to have a positive effect (e.g., Liu et al., 2013), while others find no effect (e.g., Cole, Giné et al. 2013) or a negative effect (e.g., Giné et al., 2008).

Indemnity insurance

Most studies of indemnity insurance that consider effect of age on demand are based on life or health coverage and tend to find a U-shaped relationship (e.g., Halek & Eisenhauer, 2001; Cohen & Einav, 2007).

Some studies look at the effect of age on risk aversion in the context of extreme weather. A positive association between age and risk perception is noted in a number of studies of natural disaster risk perceptions (e.g., Lazo et al., 2000; Armaş, 2006; Plattner et al., 2006). Burningham et al. (2008) and Knocke & Kolivras (2007) note that there is a point in older age (unique across individuals) at which the impact of age on risk perception decreases sharply. Studies that look at the relationship between risk perception and probability judgement specifically have found no significant age effects (e.g., Lindell & Hwang, 2008).

2.7.2.4.3 Gender

Microinsurance

The majority of studies demonstrate that women tend to have lower risk tolerance compared to men. This result is often more pronounced in field studies than in laboratory work (e.g., Eckel & Grossman, 2008). Ahmed and Ramm (2006) posit that women face more overall vulnerable situations in the developing country context than do men, leading to greater risk aversion.

The mediating results are complex. As noted previously, the effect of risk aversion on microinsurance demanded is not straightforward. Controlling for risk aversion, Clarke & Kumar (2015) find no significant differences between men and women on WTJ or WTP for microinsurance in their Bangladeshi field study. Alam et al. (2011) and Deressa (2008) find that men are expected to have a greater WTP for microinsurance since they have greater access to household resources in many traditional developing country settings.

Indemnity insurance

As is the case with age, to the best of our knowledge, there is little consensus on the direct effect between gender and insurance uptake. It is, rather, the relationship between gender and risk perception, which may mediate the demand for insurance. The empirical findings relating gender and risk perception in a developed world context are mixed. Many studies find a positive relationship between being female and risk perception (e.g., Armaş, 2006; Plattner et al., 2006; Lindell & Hwang, 2008), while others observe a negative relationship (e.g., Lazo et al., 2000). Furthermore, some studies report (e.g., Schubert et al., 1999; Knocke & Kolivras, 2007; Burningham et al., 2008) no difference in risk-taking behaviour between the genders when they control for other demographic variables, such as education and income.

2.7.3 Summary

We have summarised major findings for each factor category in our conceptual framework (Figure 2.11). The effects of these factors are further mediated by the underlying social and legal frameworks available in the context of the study, as well as household accessibility to formal and informal risk-management services.

As evident in our summary of findings to date across the ten factors, it is difficult to discern which specific attributes may influence adoption of both microinsurance and indemnity insurance products directly. Differences in suggested effect directions and magnitudes may also relate to the structure of the underlying research. Most studies to date only consider some of these factors.[63] Previous studies have tended to investigate various aspects of the rate of uptake of index insurance, such as: lack of financial literacy and exposure to financial markets (Giné et al., 2008); lack of trust (Cole, Giné, Tobacman et al., 2013); and liquidity constraints (Barnett et al., 2008; Collier et al., 2009), without controlling for the other factors. Nor do they incorporate the concept of bounded rationality.

Studying factors that have been found to be determinants of insurance demand in past literature with additional consideration for bounded rationality and relating them to psychological and social considerations may help clarify the general debate as to whether there is *disappointing demand* for extreme weather insurance. There are ambiguous findings in the literature as to the direction of determination for many factors relevant to insurance demand in both the developing and developed country contexts. Wealth effects and risk aversion are examples of factors that have clear expected directions of determination under EU Theory, but that often have unclear effects in empirical studies.

By striving to account for subjective characteristics that may arise from the use of Systems thinking, attitudes, and preferences it may in turn be possible to improve the structure of insurance tools, such that they meet the needs of potential consumers and fill gaps left by alternative coping strategies. Insurance ultimately is a risk transfer strategy that supports individual households, but provides for robust social policy insomuch that governments and communities are not left trying to help communities cope ex-post disaster. Insurance responses to extreme weather need to be aligned with national and regional strategies for development, poverty alleviation, economic growth, and the enhancement of human wellbeing, while increasing resilience to the physical impacts of extreme weather; we contend that this is best achieved through matching household profiles to the most effective insurance and coping strategies as possible.

As "the difference between insurance and microinsurance refers merely to the targeted clients and the context in which they are embedded and does not refer to: the size of the risk-carrier; the scope of the risk; or the delivery channel" we are interested in identifying, as possible, potential overlaps in the two insurance types (Morsink & Geurts, 2012, p. 3). In the next chapter we describe the research and data analysis methods employed based on this conceptual framework for insurance demand. We strive to address the current debate as to whether there is indeed *disappointing demand* for microinsurance and indemnity insurance with regards to extreme weather events or if, perhaps, other structures of coping are better suited for households with certain characteristics.

[63] A summary of the research methods for studies looking at relevant factors for microinsurance can be found in Cole et al. (2012).

Table 2.4 Literature on determination of demand for (micro)insurance against extreme weather

Variables	**Agricultural index-based microinsurance (developing country)**			**Indemnity insurance (developed country)**		
	Sign of determination			***Sign of determination***		
	Positive	*Negative*	*Not significant/ ambiguous*	*Positive*	*Negative*	*Not significant/ ambiguous*
1. **ECONOMIC factors**						
price of insurance (including transactions costs)		Cole, Jagnani et al. (2013) Dercon et al. (2012) Fitzpatrick et al. (2011) Karlan et al. (2014) Mobarak & Rosenzweig (2012)	Gaurav et al. (2011)	Marquis et al. (2004)	Landry and Jahan-Parvar (2011) Dixon et al. (2006)	
household wealth (access to credit / liquidity) & income	Cole, Jagnani et al. (2013) Giné et al. (2008) Huber (2012) Liu et al. (2013)		Ito & Kono (2010) Karlan et al. (2013) Fitzpatrick et al. (2011)	Bouwer et al. (2007) Browne & Hoyt (2000) Kriesel & Landry (2004)		
2. **SOCIAL and CULTURAL factors**						
risk aversion		Cole, Giné et al. (2013) Giné et al. (2008) (Hill & Viceisza, 2011) Kouame & Komenan (2012)	Dercon et al. (2015)	Petrolia et al. (2013)		

	Positive	*Negative*	*Not significant/ ambiguous*	*Positive*	*Negative*	*Not significant/ ambiguous*
non-performance/ basis risk		Mobarak & Rosenzweig (2012)				
trust	Chantarat et al. (2009) Cai et al. (2010) Cole, Giné et al. (2013) Dercon et al. (2015) Karlan et al. (2011)	Kouamé (2010)		Erbas (2004)		
trust cont.	Giné et al. (2008) Liu et al. (2013)					
peer effects	Cai et al. (2011) Giné et al. (2011) Karlan et al. (2013) Morsink & Geurts, (2011)	Dercon et al. (2012)				Weinstein (1980)
attitudes	Cole et al. (2011)				Noussair et al. (2012)	

	Positive	Negative	Not significant/ ambiguous	Positive	Negative	Not significant/ ambiguous
***3.* STRUCTURAL factors**						
Informal risk sharing (ability)	Cai et al. (2011) Dercon et al. (2014) Mobarak & Rosenzweig (2012)	Landmann et al. (2012)			Skees & Barnett (1999)	
risk exposure (perceived)	Chantarat et al. (2009)	Galarza & Carter (2011)	Cole, Giné et al. (2013)		Kousky et al. (2013)	
	Positive	*Negative*	*Not significant/ ambiguous*	*Positive*	*Negative*	*Not significant/ ambiguous*
***4.* PERSONAL and DEMOGRAPHIC factors**						
education	Akter et al. (2008) Liu et al. (2013)	Akter et al. (2008) Liu et al. (2013)	Cole, Giné et al. (2013)			
financial literacy	Cole et al. (2011) Giné et al. (2008)			Cappellettia et al. (2013) Masci et al. (2007)		Ludy & Kondolf (2012)
financial training	Cole et al. (2011) Giné & Karlan (2014) Dercon et al. (2014) Hill & Robles (2011)	Schultz et al. (2013) Cole, Giné et al. (2013)				
insurance games /training	Cai & Song (2013) Norton et al. (2014) Patt et al. (2009) Patt, Suarez et al. (2010)		Clarke & Kalani (2012)			

	Positive	Negative	Not significant/ ambiguous	Positive	Negative	Not significant/ ambiguous
Age	Cao & Zhang (2012) Liu et al. (2013)	Giné et al. (2008)	Cole, Giné et al. (2013)	Armaş (2006) Lazo et al. (2000) Plattner et al. (2006)	Burningham et al. (2008)* Knocke & Kolivras (2007)*	
gender	Alam et al. (2011) ¥ Deressa (2008)¥		Clarke & Kumar (2015)	Armaş (2006)* Plattner et al. (2006)* Lindell & Hwang (2008)*	Lazo et al. (2000)*	Burningham et al. (2008)* Knocke & Kolivras (2007)* Schubert et al. (1999)*

¥ greater effect for men, mediated through greater access to household resources
** mediated through effects on risk perceptions*

3 Methodology

3.1 Introduction

In this chapter we describe the methodology employed in the research reported in this thesis. The research is focused around preferences for insurance demand in both the developing and developed country contexts against low-probability, high-consequence extreme weather events. In particular we strive to employ elements in accordance with our conceptual framework related to insurance demand (see Chapter 2) 1. economic, 2. social and cultural, 3. structural, and 4. personal and demographic factors. An overview of the surveys, games, and simulation activities that constitute the whole of this research are summarised in Figure 3.1.

In the developing country context we examine the potential for weather-indexed microinsurance in two districts of rural Uganda, Kapchorwa and Oyam, which have no previous experience with such products. The rural Ugandan survey tool was administered via mobile device by the CKW Network; it comprised a series of questions related to: socio-economic issues, means of coping, and expressed WTJ and WTP for agricultural microinsurance. It also included two incentivised field games, addressing: 1. risk aversion (*Coin game*) and 2. utility from the *feeling of insuran*ce (*Basic Dice game*).

A separate analysis was undertaken in the Ugandan context with a sample drawn from the CKW population of the two study regions to examine reactions to the realisation of basis risk. This study included a brief survey–administered in written form–followed by a presentation and a field game (*Complex Dice game*). We designed the *Complex Dice game* to observe patterns of iterative choice for insurance coverage under a simple index-based microinsurance scheme. To the best of our knowledge it was novel to incorporate: 1. play with a partner to gauge the potential effects of neighbours' decisions to insure and experience of basis risk; and 2. potential realisation of basis risk in both the positive and negative directions (from the farmer's perspective).

In the developed country context, we study household flood insurance behaviour in the area affected by Hurricane Sandy in the USA. This tool is administered online and comprises: a survey section; an iterative simulation related to home flood insurance purchase; and a gambling exercise. The flood simulation examines the general propensity to insure against flood following a specific experience with extreme weather and whether it differs significantly based on differences in recent flood experience. Additionally, we include a treatment to gauge the effect of graphical representation of potential outcomes (use of tables) on risk perception and insurance uptake. We include the gambling exercise to examine potential relationships between a household's gambling behaviour (i.e., potential gains) and insurance purchases (i.e., potential losses). It should be noted that we are not interested in gambles as such, but rather gambles/lotteries are a standard way to elicit risk preferences (e.g. Charness et al., 2013).

In both case studies we use typical questionnaire-style inquiries–requesting statements about or responses to multiple-choice questions concerning respondents' preferences, attitudes, and demographic details. As our research was interested specifically in attitudes and perceptual factors that may motivate expressed preferences and behaviours for risk and insuring, we did our best to ask supporting survey questions that disentangle these concepts. In the development of questions we kept in mind the elements noted in the staged model for formation of household intention to insure (Section 2.6.2 and Figure 2.9); however, the structures of the surveys in both case studies dissuaded us from undertaking a detailed analysis of each factor. We strive to consider bounded rationality and differentiation between System I and System II thinking in the structure of our survey questions; where possible we strive to compare respondent-reported perceptions with more objective data (e.g., perception of extreme weather frequency). Additionally, in our data analysis we strive to develop models that take account of these factors to the greatest extent possible.

In Section 3.2 we provide an overview of stated preferences and contingent valuation methods. The rationale for the Ugandan Large-N survey tool, as well as related sections and field games are described in Section 3.3. Section 3.4 describes our assessment of reaction to basis risk with a sample in Uganda through the *Complex Dice* game. The methodology underlying the Hurricane Sandy case study is described in Section 3.5. Each section notes relevant related theories for: the estimated welfare measures; steps in the methodological development (e.g., survey pilots); data analysis methodologies employed;[64] and relevant limitations.

[64] The employed analysis methodologies are expanded in the relevant analysis chapter (Chapters 5-9). In most cases this is to provide appropriate context for the reader to understand the variable definitions.

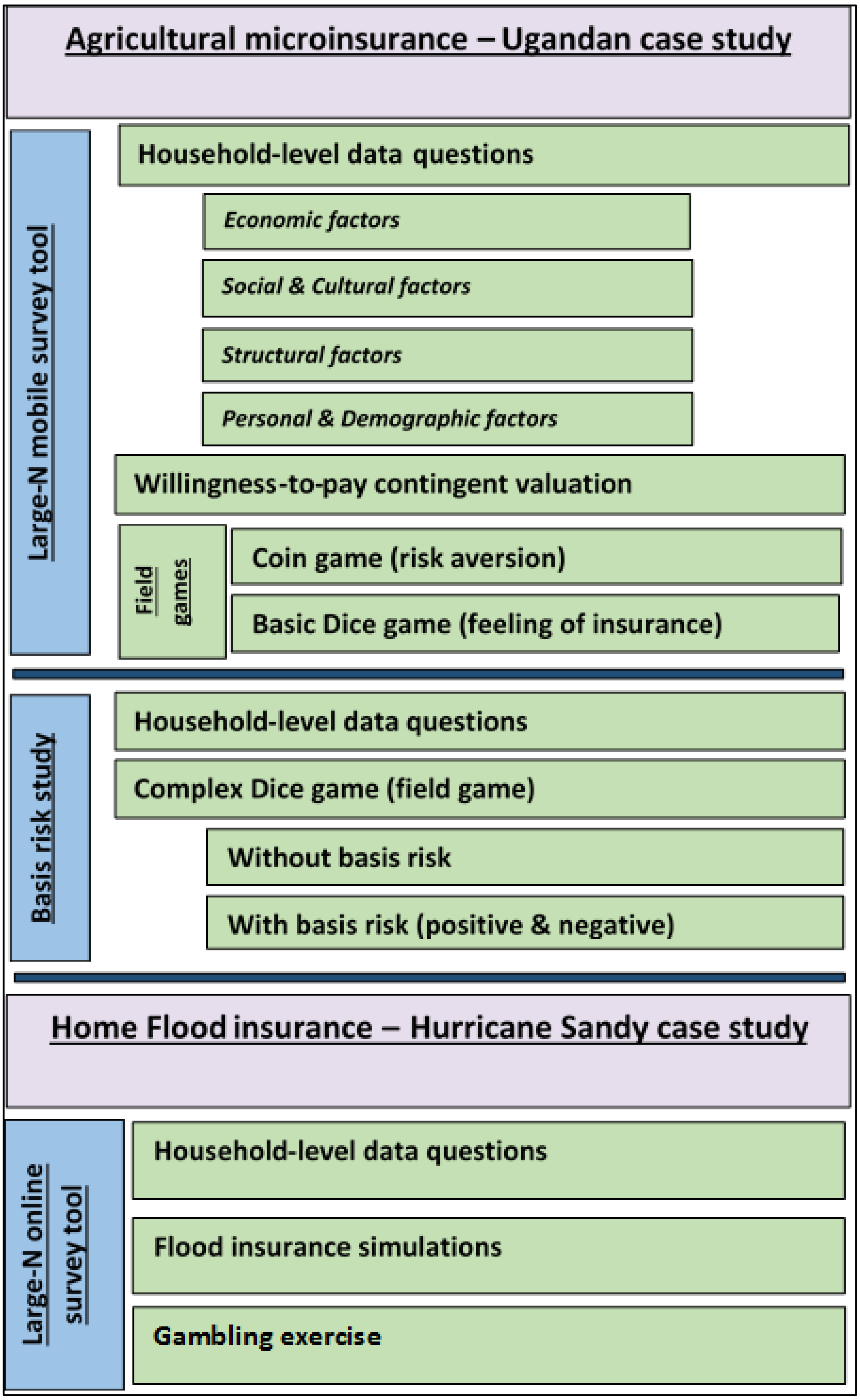

Figure 3.1 Schematic of the low-probability, high-consequence case study survey tools

3.2 Stated Preferences–Overview

Stated preference methods (i.e., contingent valuation and choice modelling) use specially constructed questionnaires and scenarios to directly elicit estimates of hypothetical willingness-to-pay (WTP) (compensating variation) for or willingness-to-accept (WTA) (equivalent variation) a particular outcome (e.g., Bateman et al., 2002).

Although using revealed preferences may be preferable considering the research goals of this project,[65] the lack of any relevant market data in Uganda combined with the limitations of our post Hurricane Sandy study prevents it. Therefore, we use stated preferences as an alternative, despite its limitations.[66] At the start of our research there was no agricultural microinsurance market in Uganda and, just recently, there have been pilots in certain regions of the country, but not Oyam and Kapchorwa. Additionally, the sample and timeframe for our study of insurance behaviour post Hurricane Sandy does not lend itself to the use of revealed preferences arising from insurance market or housing market data.

The remainder of this section outlines the use of stated preferences with a focus on the contingent valuation method, which we use. We make brief mention of the relevant modes of delivery for the questionnaires designed to elicit stated preferences. An overview of the limitations to the use of stated preferences rounds out the section.

3.2.1 Contingent Valuation

Stated preference methods allow use, non-use, and option values to be determined; as appropriate, hypothetical and future WTP/WTA values may be elicited across all these value types. Generally, stated preference techniques are used to garner individuals' valuation of use- and/or non-use values associated with resources that provide utility, but do not have a well-established market value. There are two main categories of stated preference methods: contingent valuation (CV) and choice modelling (CM), the latter including discrete choice experiments (DCE). In many cases, DCE is a preferred method over CV, especially since it allows for value estimation of specific attributes of a given good (e.g., (Hanley et al., 1998; Banzhaf et al., 2001; Bateman et al., 2002). Dichotomous choice CV and DCE modelling share a common theoretical foundation of random utility theory.[67]

Under CV, individuals are asked to state their WTP (WTA) to obtain (or be compensated for the loss of) a good, contingent upon the nature of the constructed market for the good described in the survey scenario (Carson & Louviere, 2011). Scholars have increasingly employed this method in recent decades, first used by Ciriacy-Wantrup (1947), to value environmental goods and services. CV is the most widely used method to estimate use and non-use values (Carson et al., 2001), but it is also one of the most controversial and widely debated (e.g., Diamond & Hausman, 1994). The generalised aspects in development of a CV survey, which we follow are provided in Box 3.1.

[65] Bockstael and McConnell (2007) provide a general review using revealed preferences to value non-market goods.

[66] These limitations include the following assumptions: that all individuals involved in the market transactions are well-informed; that the market is in equilibrium; the market behaviour reflects that of individuals focused on utility maximisation. For a review these limitations, see: Kroes & Sheldon (1988), Wong (2006), and Beatty and Crawford (2011).

[67] See Foster and Mourato (2003) for a comparison of the elicitation format and sensitivity to scope between CVM and DCE.

Box 3.1 General steps for development of a CV survey/questionnaire we follow

- Define the valuation scenario, “market scenario,” or payment vehicle (via focus group sessions and stakeholder consultations, if applicable)
- Determine sample design (e.g., population, randomisation of respondents, randomization of questions)
- Determine CV elicitation method (e.g., direct question, open-ended question, discrete choice, bidding game, payment card)
- Design the questionnaire that contains the CV question(s)
  - Introductory questions: present the CV concept and develop respondents’ understanding of the potential product and market. Obtain knowledge of the respondents’ relevant knowledge about or interest in the issue.
  - Central questions: reiterate key details and explain the consequences of non-WTJ (i.e., zero WTP). Remind respondents to take into account their budget-constraints and personal circumstances. Ask the relevant (series of) valuation question(s).
  - Final questions: collect relevant feedback on the CV scenario (e.g., reasons for non-response). Determine other socio-economic, demographic responses.
- Determine mode of elicitation (e.g., in-person, online)

Adapted from Kontoleon, Pascual and Swanson (2007)

CV is based on utility and assumes that the respondent can translate the value obtained from a good (or service) to monetary terms. The manner by which the actual WTP responses are elicited in a CV study may take one of many possible formats. Some CV methods are considered to produce more precise estimates by providing greater guidance to respondents’ thought process, especially with unfamiliar goods (e.g., Fischhoff & Furby, 1988; Carson & Hanemann, 2005). The valuation typically may take the form of a single open-ended question about the WTP level, a bidding procedure through ranking of alternatives, or referenda that ask respondents to indicate yes/no responses to different WTP value levels (i.e., payment ladders). The use of specified format is preferred over the open-ended format for elicitation of WTP because it reduces incentives for strategic bias in responses (e.g., (Bateman et al., 2005). In the dichotomous choice bidding method, the researcher offers the respondent increasingly higher offer prices until she refuses a given price level. This provides a range for the respondent’s valuation of the good/product (Alberini & Cooper, 2000).

3.2.2 Limitations

One of the main issues with the use of stated preferences as a standalone technique is that determination of the correct values and obtaining valid estimated demand levels can be complex. A number of limitations and biases in the use of stated preferences and CV methods in particular, are noted in Box 3.2. Note that the NOAA panel convened by Arrow and Solow in 1991 (Arrow et al., 1993) outlines recommendations to combat the main weaknesses of CV. Alberini & Kahn (2009) provide guidance on implementation of CV techniques.[68]

[68] For a compendium of past CV studies and advice on the design of such studies, see Carson (2012b).

Familiarity has been debated since the first applications of CV (e.g., Carson et al., 1992, 2003). Too little familiarity with the product/resource in question is often highlighted as a potential pitfall of the CV method (e.g., Diamond & Hausman, 1993; Cummings & Taylor, 1998). The predominant reasoning by economists on this issue is that respondents are limited in their ability to give meaningful valuations of unfamiliar goods. Yet, Bateman et al. (2002) contend that unfamiliarity may not be as problematic as the literature often makes it out to be. It becomes less of an issue when the good at hand is not solely hypothetical and does not rely entirely on valuation for non-use or existence values.[69]

Yet, respondents are often unfamiliar with the good or service in question; thus, the study designer must be cognisant of scenario framing and development of the respondents' understanding of the product in question. Generally, with the use of visual aids and a well-developed description of the situation, most respondents appear able to envision the issue and understand its salient features, especially when WTP is for a market good or service (e.g., Hammitt, 2013).

Box 3.2 Selected limitations of the stated preference technique we consider in our application[70]

1. Construct validity: controversy as to whether stated preference techniques adequately measure nonmarket valuation, as most respondents are unfamiliar with placing monetary values on nonmarket goods and services.

2. Response bias: biased answers from respondents expressing their feelings about the valuation exercise itself, as opposed to the actual good or service in question.

3. Hypothetical bias: differentiating between hypothetical and actual decisions can be difficult for respondents.

4. Embedding effects: the respondent may value a part and the whole of a good in question similarly.

5. Ordering problems: how a good or service is placed on a list or in a framework may affect how it is valued by respondents.

6. Strategic bias: respondents may provide a biased answer in order to influence the outcome of the study.

7. Information bias: the amount and detail of information presented to respondents likely affect their valuation of goods (attributes) with which they have little or no previous experience.

8. Non-response bias: motivation for non-response remains unclear to the researcher (without extensive pre- or post-survey work) and is difficult to differentiate from *true zero* valuations.

Technical validation of CV studies is challenging and the calculation of compensating variation (equivalent variation), as noted in Chapter 2, can be complicated. Mitchell and Carson (1987) and Carson, Flores & Meade (2001) provide guidance on validity evaluation of CV study results. Many CV studies will estimate responses by investigating respondents' WTP (WTA) bids by estimating a bid function and calculating the total WTP (WTA) over the relevant population from

[69] Bateman et al. (2002) make the argument that consumers are faced by new markets and goods consistently (e.g., mobile phones throughout sub-Saharan Africa); thus, they are faced by a continual (cost-benefit) analysis of such goods.

[70] Source: Bennett et al. (1998); Kontoleon et al. (2007)

mean/median responses. Furthermore, internal validity of WTP responses can be assessed by regressing relevant respondent characteristics on WTP and showing that WTP correlates in predictable ways with socio-economic variables (Alberini & Cooper, 2000).

Compensating variation implies the consumer of insurance must be compensated for a loss, whereas equivalent variation implies the consumer has to pay to avoid it; both are effectively based on different wealth/utility positions and sensitive to wealth effects (Fenn, 1987). The analysis of wealth effects under uncertainty leads to potentially different measures of loss to the consumer: compensation demanded in exchange for a certain insured loss; WTP to avoid a certain insured loss; and the insurer's WTP for a marginal reduction in the probability of an insured loss. The disparity between these measures depends on the extent of the wealth effect (i.e., the extent to which marginal utility of wealth is affected by the loss)*, ceteris paribus.*

3.2.3 Modes of delivery

The mode of delivery chosen for a CV study affects the type of respondents attracted and elicits different responses (Jäckle et al., 2010). CV studies do not typically take place in a laboratory environment. The choice of survey mode has been shown to affect results garnered in terms of types of bias and magnitude in some cases (e.g., Carson, 2012a). We use face-to-face surveys in the Ugandan context with results reported by mobile device, as this is the most practical choice given the social constraints faced by our sample.[71] Furthermore, given that agricultural microinsurance was a new product to our sample, face-to-face discussion and clarifications were important for validity of survey responses. We use an online interface for the Hurricane Sandy survey tool, as this is an ideal way to recruit an appropriate sample; furthermore, it offers a useful platform for our dynamic simulation. We provide an overview of these general modes of delivery below.

3.2.3.1 Field surveys and mobile device reporting

Field surveys constitute the traditional structure by which researchers conduct large-N CV surveys, despite a general recognition of face-to-face interviews as the *gold standard* for stated preference techniques (Mitchell & Carson, 1989; Arrow et al., 1993).[72] Field surveys differ from observation studies because there is interaction with respondents through use of questionnaires and interviews. This approach allows researchers to study and describe large populations fairly quickly at a relatively low cost (e.g., Bergstrom & Stoll, 1989; Kagel & Roth, 1995).

The use of mobile devices to deliver field surveys has gained traction in recent years and is particularly relevant to the research design of our large-N Ugandan survey tool. The context of developed country health initiatives provides the setting for the majority of studies that assess the value added by using mobile devices. The formal literature oriented specifically towards

[71] For example, a posted written survey is not viable due to the sample's limited literacy. Furthermore, though access to mobile phone is high, the majority were not smart phones and literacy was limiting to individuals filling in their own online survey.

[72] In their review of CV studies, Mitchell and Carson (1989) argued that the mode of choice is face-to-face interviews conducted in the respondents' home environment. The three main reasons they cite are: 1. the need to explain complex scenarios benefiting from use of visual aids with control over pace and sequence; 2. the need to motivate the respondent to exert a greater-than-usual effort to answer the WTP question; and 3. the importance of avoiding unit nonresponse for extrapolation to the population. Yet, in post-Internet studies there is little evidence that face-to-face studies elicit "better" responses than face-to-face interviews; social desirability bias is at about the same level for both modes (e.g., Lindhjem & Navrud, 2011).

applications for insurance or agricultural research is quite sparse. Paudel et al. (2013) report that in large-N field surveys undertaken in Nepal, the use of mobile reporting has improved data quality by: guiding field agents through the survey tools in a manner that minimises data-entry errors (e.g., automatic skip-patterns); allowing the interviewer to select the appropriate interview language; and reducing data collection times. In their study of mobile reporting for a large-N South African health study, Tomlinson et al. (2009) find that one major advantage is the ability for real-time detection of probable data falsification. Challenges associated with the use of mobile technology to gather survey data do exist, including storage and transport of the devices by field workers and consistent availability[73] (Paudel et al., 2013). Overall, the benefits appear to outweigh the costs of using mobile technology for large-N survey data collection and reporting. Schuster and Brito (2011) found that a mobile-phone-based survey proved highly superior in terms of cost, quality control, and implementation speed when compared to its paper-based counterpart conducted a year earlier.

3.2.3.2 Online tools

The use of the Internet for stated preference tools has gained significant popularity in recent years.[74] Lindhjem and Navrud (2011) provide a full review of the relative merits and drawbacks of the use of online tools as opposed to other modes of delivering surveys. Section 3.5.2 contains a more detailed description of our application of online tools for the flood simulation and survey in our study of insurance behaviour following Hurricane Sandy.

Use of the online platform may reduce the effects and biases arising from social desirability.[75] This has been found to be the case in comparison to both telephone surveys (e.g., Kreuter et al., 2008; Chang & Krosnick, 2009) and face-to-face delivery (Heerwegh, 2009).

Internet-based surveys have a fast turn-around; large samples do not cost much more than smaller ones (except to acquire the sample). Online tools can use complex question skip logic and randomisations, which ultimately assure better data. Use of the Internet by the public is growing, but far from universal; thus, online tools may produce a more skewed sample of the population without planned sampling (e.g., Couper, 2005). This is especially the case in research specific to developing or rural contexts. Most online tools allow unlimited time for responses; thus, avoiding heuristics related to response time (e.g., Schwappach & Strasman, 2006). One important advantage of online tools is the updated background information related to socio-economics, attitudes, etc. they provide, which can then function as control variables in data modelling. In our case, access to individuals recently affected by Hurricane Sandy was most viable via online.

There is considerable literature concerning the merits of remote online interface experiments in comparison to traditional laboratory settings. We took account of the relative merits and drawbacks before using this mode; advantages appear to outweigh disadvantages in the use of online interfaces (e.g., Reips, 2000; Evans & Mathur, 2005; Granello & Wheaton, 2011). Online labour markets have potential for use in experiments, since they provide immediate access to a

[73] This can be due to scarce electricity sources among other factors.

[74] It should be noted that "low and middle-income countries lack the infrastructure in many research field settings to accommodate adequate fixed line internet access, whereas wireless networks allow access to telecommunications in a region where fixed lines remain limited" (Tomlinson, Silberman et al., 2011). Thus, the use of online tools remain largely based in the developed country context except in computer laboratories set-up for this type of testing in the developing country context (e.g., the Busara Center for Behavioral Economics in Nairobi, Kenya).

[75] These include providing responses that conform to *Sunday best* attitudes among others.

large and diverse subject pool (Horton & Chilton, 2010). Horton and Chilton (2010) claim that internal and external validity for online experiments can equal that of laboratory or field experiments, while requiring less money in the design and conduct phases. Self-selection is an issue for sample bases recruited online; but this is true of all experimental formats which recruit in this manner, whether the final experiment is online or not (Charness et al., 2007).

3.3 Ugandan context—Large-N survey, willingness-to-pay, and field games

The rural Ugandan survey tool comprised a series of questions related to economic, social/cultural, structural, and personal/demographic factors, and expressed stated preferences for WTP (WTJ) for index-based agricultural microinsurance. It also included two incentivised field games, addressing: 1. risk aversion (*Coin* game) and 2. utility from the feeling of insurance (*Basic Dice* game). A visual representation of this structure appears in Figure 3.1. The CKW network reported the results through a mobile app platform we programmed in Java, which the Grameen Uganda AppLab made useable for their smart phone platform. In the remainder of this section we discuss the development of each constituent case study research element noted above and how they fit together and serve to address our proposed conceptual framework. The mobile app contained about 125 questions including those covering the WTP CV scenario and field game scenarios.

3.3.1 Sampling and delivery mode

As of 2011, a team of 272 CKWs trained and experienced in administration of surveys had registered 10,618 farmers using mobile phone technology, which fed the data they collected into a central database (J. Matovu 2011, per. comm., 15 March). Our research leveraged this existing human capital and infrastructure for the deployment of both qualitative (i.e., focus groups) and quantitative (i.e., survey and field game) tools.

The CKW network consists of a number of highly-skilled local Ugandans nominated by local farmer associations. In addition to being vetted for their potential as information service providers, the farmers in the area they serve must approve them. They undergo training on the use of advanced mobile technology for dissemination and collection of agricultural information to become local Information and Communication Technology (ICT) experts in the field. The Grameen Foundation designed the CKW network to address gaps in the development of agricultural tools that fulfil demand-side desires by providing an efficient channel for learning about the needs, challenges, and practices of local farmers (C. Nestor 2010, per. comm., 28 January).

CKWs are highly trusted within the community of farmers with whom they work since they act as the vehicle through which rural Ugandan farmers receive expert approved information (e.g., weather reports and crop diseases information). As direct employees of the Grameen Foundation, they are ideal candidates to become “insurance adjustors” should organisations decide to offer agricultural microinsurance (indemnity- or index-based) in these communities in the future.[76] Using the pre-existing CKW Network to implement our case study field research

[76] As noted previously, Grameen was interested in the potential for insurance-based tools since the transaction costs of implementation through the CKW network in the future would remain relatively low. Multiple researchers (e.g., Patt, Suarez et al., 2010; Linnerooth-Bayer et al., 2011; Cole, Jagnani et al., 2013) have cited high transaction costs as a limitation to the use of traditional indemnity products in the developing country context.

allowed for low additional costs, since CKWs already visited these farms on a weekly or bi-weekly basis.

Population-level data available for Ugandan districts is limited, but we strove to obtain a representative sample in both Kapchorwa and Oyam.[77] In 2010, the estimate for the farming population of Kapchorwa was 190,391 individuals and for Oyam was 336,400. We were able to obtain 3,258 usable responses in our dataset; 1,858 are from households in the Kapchorwa region and 1,400 are from Oyam. Given that the CKW network was still in an extended pilot phase at the point that our research commenced, the population registered with Farmer ID cards under the CKW system was about 10% of the population in each region.[78] The CKWs interviewed nearly all registered households in Kapchorwa, but were only able to interview about 50% of registered households in Oyam.[79] Samples from both districts were checked for representativeness and completeness. During the survey phase this took the form of mapping the spread of GIS locations recorded and to ensure that the automatically recorded time to complete each interview was within one s.d. of the average.

3.3.2 Pre-tests and focus groups

There were three phases in the Ugandan large-N research effort. The first phase consisted of qualitative focus group discussions (FGDs) with a small sample of 70 households; 45 households in Kapchorwa and 25 households in Oyam. Villages were targeted based on getting a cohesive and fairly representative picture of households' pre-existing knowledge of agricultural microinsurance and potential for use of the tool, as well as farmers' perspectives on risks associated with farming.

Feedback from this phase was used to inform the final development of the mobile survey tool app. The FGDs were researcher-led; each included between eight and twelve farmers (men and women) and three CKWs to aid with translation. The FGDs took the form of a needs assessment survey following guidance from sustainable development practitioners in structure and goals (e.g., Watkins & Guerra, 1993; Swanson et al., 1998). The FGDs included primarily open-ended discussion questions and were audio-recorded. The sessions explored the following themes: the nature of poverty in the farming communities; the risks associated with farming and their impacts on the farmer and his processes; existing risk management and coping mechanisms; and farmers' attitudes towards (agricultural) microinsurance.

The second phase comprised a series of pilots for the development of the final mobile survey app. Grameen India conducted informal pilots with a convenience sample in the northwest of India; these occurred during the Ugandan FGDs to ensure that mobile reporting of the types of issues to be included in our tool was viable. We supervised the CKW training ahead of the pilots

[77] Sample representativeness and limitations surrounding population-level data are discussed in Chapter 4.

[78] At the time of our research, only about 15% of households in each district had been approached to register to CKW network and these were selected primarily for geographic spread as well as crop and farm-size diversity (C. Nestor, 2010, per. comm., 28 January). In Kapchorwa some farmers did not register because they farm for large cash crop (e.g., coffee) exporters directly and were uninclined to be involved with the Network since they thought the company for which they produce would not find this to be positive. In Oyam households that refused to register most typically cited being too busy with on-farm activities (J. Matovu 2011, per. comm. 16 April).

[79] Completion of the survey/interview phase took considerably longer in Oyam than in Kapchorwa. This was primarily due to mobile phone technology challenges, which usually entailed CKWs having a hard time finding ways to charge the devices. To facilitate the process we provided solar chargers in the district center and money for CKWs further afield to rent car batteries from neighbours to charge their phones overnight.

in both Oyam and Kapchorwa and accompanied some CKWs on field visits during the pilot stage, especially to observe translation skills into the local language. After coding the tool, we downloaded it on the Android phones the CKW network uses and tested them for compatibility. We then trained the CKWs to use the tool and how to answer interviewee questions about the tool and insurance; the training of CKWs took a week in each region. The sample groups which CKWs asked questions from the tool's pilot version comprised 100 farmers in each region.

Following the initial pilot stage we made changes to the tool; we only mention the significant ones here. First, we modified the psychometric question section primarily because respondents became confused in this type of questionnaire environment and lost interest in continuing the survey.[80] Additionally, we added questions regarding perceptions and general worry; the rationale being that they were easier for respondents to answer on the spot–in the pilot of the final survey these questions had a near 100% response rate. Furthermore, by using metrics for respondent perceptions that could be compared with objective information in the analysis phase (e.g., weather records) we were able to account for bounded rationality to the extent possible (e.g., Erev et al., 2010). Additionally, the experimental structure was cut due to concerns related to research ethics arising from (violent) disagreements caused when some farmers were not asked to play the game(s).[81]

The final phase was the data gathering with the mobile survey tool. The CW network administered it to a sample of about 3,500 registered households. Results were automatically transmitted to the AppLab (Grameen Uganda) when a survey was completed. Raw output was sent through to the offsite researchers twice weekly in order to check data quality and consistency in reporting.[82]

3.3.3 Large-N survey tool

Infra, we provide relevant details about each of the main sections of the mobile survey tool. To the best of our knowledge the Ugandan large-N survey tool is the largest of its type undertaken in sub-Saharan Africa to date based on demand for agricultural microinsurance. We present and discuss the questions in roughly the same order in which they appear in our survey tool; the full printed version is available in Appendix A. Table 3.1 presents the types of questions in the survey

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[80] In particular this applied to original questions that were based on the *Rokeach Value Survey* (Rokeach, 1968, 1973), which other researchers (e.g., Cheng & Fleischmann, 2010) had lauded as a viable solution to the attitude-behaviour discrepancies often highlighted in the literature. We also replaced the original metrics related to the concept of personality. For example, our application of Douglas and Wildavsky's (1982) Cultural Theory "group-grid" structure supported past studies that question empirical tests of the Theory (e.g., O'Riordan & Jordan, 1999). Since this theory has proven productive in understanding views of risk, we implemented other measures of risk aversion and risk perception that we could more readily validate using other respondent information.

[81] We realised the benefits of a field experimental structure (e.g., List, 2011) and tried to work around this by splitting the sample between treatments that were exposed to only one of the two games – with some respondents playing the *Coin* game and others playing only the *Basic Dice* game with all incentivised in a similar manner. Field reports back from this second pilot noted increasingly worse outcomes from this structure, which confused the CKWs and led the farmers to complain about *unfair* treatment (J. Matovu 2010, per. comm., 6 April). This experimental structure proved to run contrary to the goals of the CKW network (C. Nestor 2010, per. comm., 16 April), since it risked eroding the farmers' trust in the system (K. Druschel-Griffin, 2010, per. comm., 3 June).

[82] This took the form of a Skype meeting between the staff in Kampala and the LSE during which I provided comments on the quality of data collection and we discussed mobile money transfers to CKWs in order to allow them to undertake the next series of field research. The incentive system was complex and required serious oversight; in order to reduce the inducement for moral hazard on the part of the CKWs they were entrusted with only enough cash at any given time to provide incentives to 15 households.

tool and mentions the germane theoretical frameworks and conceptual framework factors that are relevant to a given question (set) in the tool.

The WTP sections were placed towards the survey's end and were contained within a larger section of questions designed to obtain insight regarding the rationale underlying the farmer's specified WTJ and WTP responses. Responses to this wider question set provide us with data for the dependent variables used in our regressions to describe WTP for microinsurance, WTP for borrowing, and coping strategies in relationship to the factors in our conceptual framework. The WTP survey section followed a number of other questions concerning insurance, as well as the *Basic Dice* and *Coin* games. As noted in the previous section we were compelled to adjust our application for aspects of the proposed staged model for household intention to insure in order to maintain valid survey responses in this single period field survey tool that is largely quantitative in nature. As noted in Table 2.4 there is some debate with regards to the direct relationship between measures of the central pre-behavioural elements of such models (e.g., the Theory of Reasoned Action), which are used in stated preference research, and intended choice behaviour (e.g., Wicker, 1969; Fishbein, 1981; Foxall, 1983).

Section divisions were noted through displaying a new set of sub-instructions for the CKW that described the rationale for that specific question set. A progress bar (based on the progression through the total survey) was provided for the CKW for reference throughout the survey process.

To the extent possible, we use multiple choice and drop down menus in the survey tool – this serves two purposes: 1. aiding efficiency in completing the survey process;[83] and 2. aiding consistency in responses provided across the sample (e.g., Krosnick, 1999). In many cases, the CKWs asked open-ended follow-up questions in order to allow for clarification and to give some indication of underlying motivations for responses (e.g., individual's understanding of insurance). In developing the survey we were sensitive that it would be largely verbal[84] and the directions provided to the CKW concerning her/his presentation of information was important, as the same information presented differently can lead to different outcomes depending on how it is acquired (e.g., Hertwig et al., 2004, 2006).

Our mapping of survey tool data to factors in the proposed conceptual framework for determining microinsurance demand and our staged model of intended demand are described in Table 3.1.

[83] Conducting the surveys in a timely fashion was important because conducting the survey was additional to the CKWs normal workload and farmers were generally keen to complete the survey quickly since the survey period overlapped busy farming periods for many households.
[84] In most cases the respondents are not literate; thus, aside from the literacy question (Q152) they were not invited to read any part of the survey.

Table 3.1 Question types and specifications for the large-N Ugandan survey tool

Question(s)	***Relevant conceptual framework factor***	***Specification***	***Relevant relationship to element(s) of the staged model for formation of household intention to insure***	***Question Format***	***Notes on approach or purpose***
Q2-Q6	Personal & demographic	*Location data*	*n/a*	multiple choice	Allows us to study location effects and cluster data by geographic entity in analysis regressions.
Q7-Q12	Economic: income & wealth	*Household conditions, based on the material and condition of living area*	*n/a*	multiple choice on a rating scale; reported based on CKW observations	Response options developed based on CKW observation to ensure consistency and to conform to cultural norms (Matovu, 2010), avoiding embarrassment to farmers with poor living conditions
Q13	Personal & demographic: age	*Age*	Normative beliefs: social factor that has been shown to determine social norms to which an individual may be bound (e.g., Hernandez & Blazer, 2006).	drop-down menu	It was difficult to determine age for some farmers. In these cases we instructed CKWs to ask the farmer when he remembers his circumcision ceremony taking place.
Q14-Q15	Personal & demographic: education	*Highest level of education completed*	Normative beliefs: social factor that has been shown to determine social norms to which an individual may be bound (e.g., Hernandez & Blazer, 2006).	multiple choice	
Q16-Q19	Structural: social networks (family structure)	*Family size, marital status*	Normative beliefs: social factor that has been shown to determine social norms to which an individual may be bound (e.g., Hernandez & Blazer, 2006).	multiple choice and drop-down menu	

Q20	Economic: income & wealth	*Ownership of common goods held by Ugandan farming households (e.g., radio, mobile phone)*	Role: Ownership profile may have possible implications for role/responsibility in the community.[85]	multiple choice checklist (i.e., multiple selection possible)	Likely indicative of access to formal credit. List of common goods for ownership determined by findings from the FGDs.
Q21-Q23	Structural: risk exposure	*Ownership of land and percentage farmed*	*n/a*	open-ended, drop-down menu	Provides a baseline indication of household financial dependence on farming activities.
Q24-Q25	Structural: social networks	*Shared farming area*	Social norms: by sharing land, farmers are likely influenced in their perceptions of injunctive or social norms (e.g., Cialdini, 2003) related directly to farming or land care techniques.	multiple choice	
Q26, Q30	Economic: income & wealth Structural: risk exposure	*Percent of income from farming activities, surplus crops sold*	*n/a*	multiple choice	Provides a baseline indication of household financial dependence on farming activities.
Q27-Q29, Q31	*Reference/framing information*: farming details	*Busiest time for farming and seed selection preferences*	Attitude: following from the Ajzen and Fishbein (1980) concept of broad/overarching attitudes – attitude towards farming inputs/methods may help shape specific motivations to engage with agricultural microinsurance.	multiple choice	Provides reference information about farmers' preferences for microinsurance that is relevant to design and delivery of microinsurance schemes.
Q32	Alternative coping strategies (household preferences)	*Alternative coping strategies (as a mediating factor in the household demand for microinsurance)*	Normative beliefs: beliefs about the social environment and available support mechanisms in times of need.	multiple choice checklist	The choice list was determined through findings from the FGDs and consideration of past research on the topic (e.g., Corbett, 1988; Ravallion & Chen, 1997; Ellis & Mdoe, 2003).[86]

[85] This type of interaction between ownership and social role was found in Banthia et al.'s (2012) analysis of microinsurance developed specifically for female consumers.

[86] The options were determined in light of literature that challenges the traditionally accepted ordering for employment of coping strategies based upon their relative long-term prospects for disinvestment (e.g., Jacoby & Skoufias, 1997; Duryea, 1998; Skoufias & Parker, 2002).

Q33-Q34, Q36-Q38	Structural: risk exposure (farming)	*Perceived farming issues/challenges by the household concerning climate aspects. Baseline information for the risk perceived by the household*	Personality and Attitudes: Following from Heinström (2003), personality is likely to influence attitude (formation), which may provide a more complex feedback loop on the formation of intended behaviour.	multiple choice and open-ended	
Q35, Q39-Q40, Q43-Q45	Economic: access to credit / use of formal and informal risk-managing financial services	*Use of borrowing, especially for weather-related farm losses*	n/a	open-ended, multiple choice, multiple-choice (rating scale), and open-ended	Provides baseline information for: household money borrowing activities; level of coping; vulnerability; and need for monetary borrowing through formal (e.g., banks) or informal (e.g., loan sharks) means.
Q41-Q42	Social & cultural: attitudes (towards on-farm adaptation practices)	*Assuming that there were effective changes that could be made to farming, gauge respondent's willingness to adapt farming methods/practices to prevent future losses*	Attitudes: gauge beliefs that adjustments in farming methods can affect level of future on-farm losses Role/Responsibility: to adapt or change farming practices	multiple choice and open-ended	
Q46-Q48, Q54	Background knowledge of insurance	*Gauge basic respondent knowledge and understanding of insurance coming into the survey*	Normative beliefs: gauge the extent to which the respondent's concept of social environment (Sheth, 1973) includes the use of insurance	multiple choice and open-ended	Help the administering CKW gauge how best to explain the concepts associated with insurance to the particular respondent.
Q49-Q50	Social & cultural: trust & peer effects (general indicator)	*Gauge respondent interaction with neighbours on issues pertaining to farming and the extent to which these opinions influence his own viewpoint*	Normative beliefs: self-controls of both the independent and interdependent views of self (Markus & Kitayama, 1991) as based on actions taken through interaction with close community members. Notably there are related cognitive, emotional, and motivational consequences associated with views of self and direction of causality that are	multiple choice checklist (i.e., multiple selection possible)	Provide baseline information on this topic; typical interaction with neighbours and friends.

			difficult to determine (e.g., (Kashima et al., 1995).		
Q51-Q53	Social & cultural: trust & peer effects (specific to insurance-use)	*Gauge respondent's knowledge of insurance and perception of its value as based on information obtained through his extended social circle*	Social norms: Perceived norms about the use of insurance from experience of those in the respondent's social circle. *Trusted neighbour effect* (Rogers, 2003; Morsink & Geurts, 2012): knowledge of positive experiences of trusted neighbours with microinsurance in local peer networks can play a significant role in building trust in the concept of insurance.	multiple choice and open-ended	There are suggestions that perceived social norms may impact individual (intended) behaviour greater than biological, personal, cultural or other influences (Kandel, 1985; Berkowitz & Perkins, 1986; Perkins, 2002).
Q55-Q56, Q77	Structural: risk exposure (perceived specific to farming)	*Respondent's perceived vulnerability to extreme weather (i.e., localised flood and drought)*	Trait affect: likely influenced by the respondent's general outlook (e.g., (Watson et al., 1988). State effect: likely influenced by self-assessment of experiences with risk and extreme weather. Combination of concern over personal exposure and visceral reactions to remembered (versus objective) risks (Weber, 2006).	multiple choice	
Q57, Q78	Economic: income & wealth (specific to value of crop, reference valuation)	*Perceived monetary value of average crop*	Potentially affected by state and trait affect (emotional responses) related to fairness. e.g., riddle of experience vs. memory (Kahneman et al., 2004)	open-ended	Provide a baseline for valuations made in other questions related to crop values.
Q58	Economic: access to credit	*Expected interest rate on loan*	Potentially affected by state and trait affect (emotion)	open-ended	
Q59-Q75	Economic: (reaction to) price of loans/borrowing	*Gauge WTP for borrowing money through use of a double-bounded price ladder*	*See Section 3.3.4 for further information.*		
Q76, Q95-Q96	*Reference/framing information*: Preference for insurance structure	*Preference for payout based on weather or crop yield*	Attitude: following from the Ajzen and Fishbein (1980) concept of broad/overarching attitudes–attitude towards farming inputs/methods may	multiple choice	Provides reference information about farmers' preferences for microinsurance that is relevant to design and delivery of microinsurance schemes

			help shape specific motivations to engage with agricultural microinsurance.		
Q79-Q94	Economic: (reaction to) price of microinsurance	*Gauge WTP for microinsurance through use of a double-bounded price ladder*	*See Section 3.3.4 for further information.*		
Q97	Social & Cultural: attitudes (towards insurance structures for the community)	*Preference for group or individual-level agricultural microinsurance product*	Role/responsibility: extent to which the respondent values agricultural security of the (collectivistic) society.	multiple choice	Group insurance premia is suggested throughout recent literature (e.g., Sandmark et al., 2013; Gehrke, 2014) . To the best of our knowledge, there is little information about the underlying motivations steering individuals (dis)preferences for such a structure.
Q98-Q111	Social & Cultural: risk aversion	*Coin game*	*See Section 3.3.5.1 for further information*		
Q112-Q125	Social & Cultural: risk aversion and attitudes	*Basic Dice game*	*See Section 3.3.5.2 for further information*		
Q126-Q127	*Farming factors/preferences*	*Time of year during which respondent harvests and sell crops*	*n/a*	multiple choice	
Q128-Q130	*Farming and liquidity factors/preferences*	*Preference for financial liquidity; business acumen*	*n/a*	multiple choice	Liquid capital available to the farmer may have implications for his access to credit.
Q131-Q134	Structural: risk exposure (perceived specific to farming)	*Perceived risk exposure on-farm.*	State affect: likely influenced by self-assessment of experiences with risk and extreme weather. Combination of concern over personal exposure and visceral reactions to remembered (versus objective) risks (Weber, 2006). Attitude: self-predicted behaviour against perceived risk (e.g., Fishbein & Ajzen, 1973)	multiple choice	
Q135	Social & cultural: risk aversion Structural: risk exposure	*Reference for crops farmed by respondent.*	Attitude: following from the Ajzen and Fishbein (1980) concept of broad/overarching attitudes – attitude towards selection of crops farmed may have some indication of risk aversion and		Possibly reflective of farmers' risk-aversion in other realms.

			help shape specific motivations to engage with agricultural microinsurance.		
Q136-Q142	Social & cultural: risk aversion Structural: risk exposure	*Worry in different realms, perceived risk*	Personality: likelihood and intensity of worry is related to personality, specifically the intolerance of uncertainty (Freeston et al., 1994).[87] Emotions: related to the finite-pool-of-worry (Linville & Fischer, 1991)	multiple choice check list	The list of areas for worry used arose from outcomes in the FDGs. In determining these categories, we also referenced work done by Hansen et al. (2004) on the finite-pool-of-worry in the context of climate change in the developing country context.
Q143	Social & cultural: trust	*Placing trust in someone not previously known (directly or by association)*	Personality: *Subjective trust* is arises in part from personality traits and has been noted in some cases to act as a mirror image of perceived risk (e.g., Das & Teng, 2004). Values: related through internalized social representations or moral beliefs that cause an individual to place trust in an individual.	multiple choice	
Q144-Q147	Structural: social networks	*Remittance behaviour (availability to the household and extent to which the household provides to others)*	Role/responsibility: whether the household feels that it is their (socially acceptable) role to either send or receive remittances.	multiple choice	
Q148-Q149	Structural: social networks Personal & Demographic	*One's own role/responsibility in the community: perception of what others in the community think of the respondent's community role and responsibilities.*	Role/responsibility: linked to one's position and experiences within the group context.		

[87] Subjects believe that worrying can prevent negative outcomes from happening and minimize the effects of negative events by decreasing guilt and avoiding disappointment.

Q150	Moral hazard	*Question framed around another's use of bicycle insurance to see the respondent's feeling in the social context without pressure to make himself look socially responsible.*	Social norms: dictated in part by what is socially accepted as well as what the respondent thinks they can get away with doing in the social context.	multiple choice	Useful in gauging perceived likelihood of moral hazard occurring – relevant to potential hybrid and indemnity-based products.
Q151, Q153-Q155	Personal & demographic: financial literacy and education (numeracy)	*Indicators for numeracy skills*		multiple choice (scale)	We use a series of simplified numeracy questions and provide a context that relates to Ugandan culture (e.g., use of "mangoes" for counting exercises, as opposed to "apples") (Cokely & Galesic, 2012).
Q152	Personal & demographic: literacy and education	*Ability to read basic words*		multiple choice	Use a basic question for reading a comment Uganda first name, provides a snapshot of ability (E. Cokely 2010, per. comm., 6 December) without embarrassing the respondent by asking directly if they can read (Matovu, 2010).
Q156	*Farmer feedback and comments*			open-ended	

3.3.4 WTP ladders

In the following subsections we present the WTP ladder approach taken, discuss applications of CV in empirical studies on demand for agricultural insurance in past studies, and note limitations.

3.3.4.1 WTP–CV scenario and ladder structure

Price ladders offer a structure that inherently helps the respondent focus his response and consider his utility from the product (e.g., Pearce & Moran, 1994). We use price ladders to consider WTP for agricultural microinsurance and borrowing as opposed to other CV methods, such as open-ended bidding. As noted, agricultural microinsurance is a new product in Uganda and has not been marketed to our samples previously. Thus, throughout the survey it was necessary to familiarise respondents with the concept of insurance and to be aware of their pre-existing and updated perceptions. To this point, during training we provided CKWs with alternative ways of explaining insurance and gave them access to description panels throughout the survey every time they administered it.[88]

We designed our WTP ladder such that most households would accept the lowest (100 UGX) bid and few would accept the highest bid (100,000 UGX). WTP responses of zero were infrequent in our sample. We note that 100 UGX is significantly different from zero, as those households that were not interested in insurance at all expressed this view and often expressed a WTP of zero.[89] Qualitative data sessions held in June 2011 and a pilot of the survey tool in both Oyam and Kapchorwa of 150 respondents in each region helped in determining these bounds.[90]

It should be noted that consideration was made as to whether WTP could be accurately valued in terms of labour (i.e., person-hours) or other metrics aside from cash. Many respondents took considerable time on the WTP sections of the survey, as the local economy in both places is based more on barter than exchange of cash and familiarity with cash value can be limited. However, given the variation in utility equivalents calculated from responses made in person hours, it appeared that this method may actually doubly confound[91] valuation so we used monetary valuation in the final survey. Furthermore, respondents were anchored to the value of their own average crop (in cash terms) and showed poor performance on questions that framed WTP for microinsurance in terms of farm output by weight or cash value that was not in some manner directly linked with the individual farm's output.

The contingent valuation scenarios were framed around the farmers' own crop yield to reduce hypothetical bias. The exact probability of extreme weather (i.e., flood or drought) is not known to our respondents in the presented scenarios, as is the case when one decides whether to take up hazard insurance in real life. When deciding whether to adopt insurance, it is the risk probability perceived by the individual, rather than the objective risk value, that informs the decision whether or not to insure (e.g., Kunreuther & Pauly, 2006). As a point of reference, we

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[88] CKWs could access a supplemental guide to the survey on their mobile devices that we placed on the online CKW data-clearing portal. This contained organised topics of interest for data-sharing within the community since the CKW acted as the focal point for obtaining information from weather forecasts to livestock illness symptoms.

[89] This was corroborated by the follow-up, open-ended question prompting respondents to indicate why they gave the valuation.

[90] Note at that time the exchange rate was 100 UGX=0.025 GBP.

[91] It was challenging to determine if the valuation was being done by translating to monetary units and back to human hours or not, but through follow-up questions we suspected this was the case.

elicit the farmer's estimation of values for his entire crop and how often a flood or drought takes place on his farm that would lead to the loss of his crop in a growing season. Though this estimate may not be perfectly aligned with the actual on-farm weather occurrences, these are the risks upon which the respondent is basing his WTJ and WTP answers.

We asked the CV question concerning borrowing before the one concerning microinsurance– since most respondents understand loans and have some experience with them, this allowed them to get used to the WTP ladder format before taking on a more cognitively taxing question on a less familiar topic. We asked for WTP on a loan in terms of a lump sum value opposed to an interest rate per se; this arises since: 1. most informal loans are settled in this fashion in our study areas (J. Matovu 2010, per. comm., 18 February); and 2. percent values are rarely used as a concept in discussion by Ugandan farmers (e.g., Saxe, 1991), opposed to ratios.[92]

Prior to this point in the survey, a series of questions about past borrowing behaviour helped to set the general framework. The CV question on borrowing reiterates the need to take a loan to cover the loss of the farmer's crop and, therefore, asked him to estimate his WTP additional money towards interest on the loan. We kept the CV question somewhat general; during the pilots we tried to frame these more specifically, but the respondents were often unfamiliar with the details of these frames. For example, we tried to frame borrowing as a savings mechanism, but since most respondents do not have bank accounts, this concept was unfamiliar to them.[93]

We transition to the CV question related to WTP for microinsurance premia by reiterating that the hypothetical extreme weather event has affected the entire village including his own entire crop so that loans would not be an option. The CKW would explain that it was possible for the farmer to pay for insurance coverage in advance of the extreme weather. The CKW then asked them to express their WTP for insurance to cover the value of the crop as a monthly payment.

We used a double-bounded approach to administer the price ladders in order to gauge the subject's internal consistency over responses.[94] We would start with a WTP number after asking the framing valuation question, ask for a yes/no response, and then increase/decrease the valuation range until indifference is reached. The CKW administered these WTP sequences verbally, though respondents could look at questions on the phone if they desired.[95] Table 3.2 provides a schematic of how we structured the price ladder for microinsurance. The CKW asked the respondents whether they were willing to pay a given amount per month, increasing from 100 UGX to 100,000 UGX. At the point that the respondent indicated he would not accept the stated price, he was then asked the question "would you definitely not pay" for each bounded ladder level, descending back to 100 UGX.

[92] As a form of cross-referencing, we asked an open-ended question about percentage interest the farmer thinks a lender would ask to be paid of a loan for the value of the farmer's crop.

[93] Although mobile banking is becoming increasingly popular in Uganda, most individuals use it for one-off transfers, as opposed to holding a traditional savings account.

[94] Question 59 marks the start of the WTP price ladder sequence for borrowing and question 79 marks the start of the WTP price ladder for microinsurance premia.

[95] In most cases, participants' literacy levels prevented this from being a viable option.

Table 3.2 Structure of the double-bounded WTP price ladder applied to agricultural microinsurance

Question		Response input options
Q79	Would you pay 100UGX per month in exchange for insurance cover for the value of your entire crop?	1. Yes 2. No
Q80	Would you pay 200UGX per month in exchange for insurance to cover the value of your entire crop?	1. Yes 2. No
Q81	Would you pay 500UGX per month in exchange for insurance to cover the value of your entire crop?	1. Yes 2. No
Q82	Would you pay 1000UGX per month in exchange for insurance to cover the value of your entire crop?	1. Yes 2. No
Q83	Would you pay 5000UGX per month in exchange for insurance to cover the value of your entire crop?	1. Yes 2. No
Q84	Would you pay 10000UGX per month in exchange for insurance to cover the value of your entire crop?	1. Yes 2. No
Q85	Would you pay 50000UGX per month in exchange for insurance to cover the value of your entire crop?	1. Yes 2. No
Q86	Would you pay 100000UGX per month in exchange for insurance to cover the value of your entire crop?	1. Yes 2. No
Q87	Would you definitely NOT pay 100000UGX per month in exchange for insurance to cover the value of your entire crop?	1. I would definitely not pay that much to insure my crop. 2. I might pay that much to insure my crop.
. .	. .	. .
Q94	Would you definitely NOT pay 100UGX per month in exchange for insurance to cover the value of your entire crop?	1. I would definitely not pay that much to insure my crop. 2. I might pay that much to insure my crop.

One of the main reasons for double-bounding the price ladder was to ensure respondents were cognisant of their appraisal of the situation and remained consistent in their responses. As an internal check of the data gathered we later found that for each respondent, his stop-points of bidding both ascending and descending the WTP ladder were nearly 100% matched for consistency. At the point that the WTP ladders appear in the survey, respondents had already been reminded of the incentive schemes accompanying the field games that came later in the survey, which may have also increased their focus.

3.3.4.2 WTP in other agricultural microinsurance studies

Abebe & Bogale (2014, p. 131) note that "there are very few studies relevant to agricultural insurance that use the CV approach."[96] A number of studies look at WTP through structured field experiments based on theoretical microinsurance schemes (e.g., Elabed & Carter, 2013) or provide respondents the choice between microinsurance and other factors that augment farming capacity, such as fertilizer vouchers (e.g., Cole, Giné et al., 2013)

To the best of our knowledge many of the studies that employ CV over hypothetical agricultural microinsurance use variations on bidding games. Schuman (1996, p. 87) notes that "presenting respondents with a set of values to choose from is now seldom used because of recognition that

[96] Sarris et al. (2006) also make this claim.

this type of framing and anchoring is quite likely to create bias to and away from certain values." Vandeveer and Loehman (1994) applied both dichotomous choice and ranking of activities in a study of farmer response to modifications in crop insurance where they used ranked responses in a ranked logit model to derive WTP.

In the developing country context, both McCarthy (2003) and Sarris, Karfakis & Christiaensen (2006) examined WTP for rainfall index based microinsurance scheme (IBMS) using single and one-and-a-half CV questions based on farming examples in Morocco and Tanzania, respectively. Heenkenda (2011) looks at a hypothetical IBMS for paddy crops in eastern Sri Lanka and models demand for IBMS over four distinct choices. Bid questions were constructed for insurance applied to different irrigation types and each farmer was asked if s/he would be willing to pay an upper bound contract, and then offered an open-ended follow-up question. Akter et al. (2009) use a variation on bidding through a double-bounded dichotomous choice (DBDC) structure. Seth et al.'s (2009) research in Rajastan, India focused on a hypothetical bidding game that solicited responses to premiums in a hypothetical market. They analyse the results with probit and logit models to determine probabilities of *yes* responses to various bid levels and the mean WTP.

3.3.4.3 Limitations to our WTP approach

Whittington (2002, 2010) provides an overview of shortcomings in stated preference studies conducted in the developing country context. He identifies two situations in which stated preference results often differ from actual behaviour:[97] 1. stated preference studies that ask for voluntary contributions; and 2. comparisons against stated preference questions that are purely hypothetical and occur in a laboratory setting. The most pervasive issue identified specific to the developing country context is a tendency for respondents to say *yes* too easily to the presented choice task(s) in-person (e.g., Whittington, 1998; Whittington et al., 2000).

Researchers have developed ways to reduce *yea-saying* tendency. In our case, we piloted cheap-talk scripts, which have been shown to mitigate hypothetical bias in cohorts of samples who are the least familiar with the good in question (e.g., Cummings & Taylor, 1999; List & Gallet, 2001; Lusk, 2003; Carlsson et al., 2005; Murphy et al., 2005; Carlsson & Martisson, 2006). These took the form of explicit warnings from the CKW about the problem of hypothetical bias provided prior to application of the WTP questions. Yet, in many cases this "talk" had the unintended consequence of leading respondents to think that the CKW did not trust them and suspected they would lie in their answer (purposefully).[98] To prevent deteriorating trust between farmers and the CKWs we dropped these scripts from the final survey.

During initial pilots we also tested a CV payment card approach; however, we came up against a series of practical and methodological issues which required changing the final WTP format. "The payment card approach offers one method for increasing efficiency over dichotomous choice, however it may also introduce a number of biases" (Kerr, 2001, p. 2). In our setting, as noted previously, individuals had trouble assessing a purely hypothetical loss situation that was not tied to their own crop. In testing payment cards that reflected valuations used in our final

[97] Scholars determine this "actual behaviour" through revealed preferences or measurable actualized behaviour identified after respondents indicate their intended behaviour.

[98] In about 15% of cases, the CKW had to convince the respondents to continue the survey and about 50% asked the CKW "why they thought they may lie."

payment ladders (all and half one's crop), individuals provided haphazard responses that did not follow from expected utility nor any identifiable heuristic (e.g., anchoring bias).

Increasing the number of cells on the payment card resulted in non-response and biased responses in response to uncertainty. Furthermore, the payment card was difficult for the CKW to administer: 1. smart phone screens made it difficult to show the respondents a properly formatted card; 2. respondents were only comfortable engaging in verbal discussions with the CKWs (J. Matovu 2010, per. comm., 12 February) and were not interested in printed payment cards; and 3. in dealing with a sample that is largely illiterate and numeracy challenged, CKWs were able to more effectively guide and keep respondents on track by discussing a value bounds one-by-one ad as opposed to presenting and guiding a series of simultaneously varying values.

Studies have indicated that dichotomous choice CVM results in higher WTP estimates compared to open-ended and payment card approaches (e.g., Hannemann, 2002). Yet, past studies (e.g., Hanemann, 1984; Cameron & James, 1987; Arrow et al., 1993) have criticised this elicitation format for simplifying the cognitive task the respondents face. Cognitive simplicity of the WTP section was a concern with our sample–to get a meaningful response under random utility, we employed the double-bounded method.[99] Double-bounding allowed us to increase the number of responses over single-bounded methods, such that the demand function can be considered over more observations (e.g., Haab & McConnell, 2002).

Starting-point bias is relevant to our double-bounded payment ladder as it reflects a type of bidding. To the extent possible, we tested the starting point for our bids during the pilot stage and determined the ranges between "bid steps" through determining a reasonable demand curve based on the pilot values for compensating variation. While this issue can also be a drawback to the use of payment cards for valuation, since initial provided ranges may introduce information and truncation biases; Rowe et al., (1996) provide a discussion of mechanisms for circumventing these issues. Notably, responses are largely insensitive to other design issues when the range of values is large enough to include most potential WTP values (e.g., Carson & Groves, 2007).

Alam (2006) notes problems of framing the valuation question in the application of CVM in developing countries. Some of these differences (e.g., difficulty applying cash values to goods) imply that there may be corresponding limitations in the relative importance of specific sources of benefits based on how respondents perceive economic valuation of resources and willing to express their preferences for potential improvements (e.g., Russell, 2001).

3.3.5 Field Games

We use the term *field game* as an extension of the field survey concept, as playing games/activities that relate to local issues in the respondent's typical environment, dealing with issues over which the respondent has knowledge. In comparison to field surveys, field experiments usually address a smaller sample in a more controlled environment (e.g., Charness, Gneezy & Kuhn, 2012). Given the issue of research ethics posed by the push-back from

[99] Double-bounded models increase efficiency over single dichotomous choice in three ways. First, the answer sequences yes-no or no-yes yield clear bounds on WTP. For the no-no pairs and the yes-yes pairs, there are also efficiency gains. These come because additional questions, even when they do not bound WTP completely, further constrain the part of the demand distribution where the respondents' WTP can lie.

respondents on the CKW Network relating to the initially proposed experimental structure to both the *Coin* and *Basic Dice* games, creation of a within sample comparison through an experimental approach was not viable. Our field games were structured to obtain useful information, while being concise and easily understood. For a more detailed discussion of field experiments and the relevant positives and negatives in their use as a mode of research, communicating a stated preference tool, see Harrison & List (2004).

We aimed to provide field games that could: 1. be easily understood by a sample characterised by low formal education; 2. be played in different relative local settings (e.g., table top or dirt field); and 3. allow those administering the games to explain the rules and record the outcomes accurately with limited time and materials.

These games appear following the WTP CV exercises. A narrative in the survey app guides the CKW through the steps of both field games prompting them to input relevant information (e.g., respondent's coin choice). For the field games the CKW uses objects from a kit we provided; each containing: written guidance on the mobile app; specially designed coins; dice; and information on storing the cash payments for the game incentives. The games were designed specifically to use tactile objects which would be familiar to the farmers.[100]

3.3.5.1 Coin game

The aim of the *Coin* game was to isolate the specific issue of risk-taking (aversion) in a context familiar to the farmer that would help him think about uncertainty, probability, and risk in a structured and guided format. This was done to obtain values as consistent as possible with true risk aversion (in the realm of farming choices).

The *Coin* game is a variation and extension of Binswanger's (1980) framework and conforms to three design elements expressed as helping to increase validity in similar work (e.g., Post et al., 2008):

- The gamble stakes are high and wide-ranging (large variance).
- Understanding the rules of gameplay requires no formal education (e.g., literacy and numeracy).
- The probability distribution is simple and known with near-certainty.

3.3.5.1.1 Contextual background

There have been few games or experiments in the developing country context that directly determine coefficients of risk aversion. In original field experiments on farmers' risk aversion in developing contexts, agricultural economists measured parameters of utility functions, such as partial risk aversion coefficients, by gambling simulations and thought experiments, rather than gambles with real payouts. These approaches are based on utility theory and the elicitation of certainty equivalents (e.g., Officer & Halter, 1968; O'Mara, 1971; Dillon & Scandizzo, 1978; Roth et al., 1991; Kachelmeier & Shehata, 1992; Henrich et al., 2001; Barr, 2003; Ashraf et al., 2010).

Binswanger's (1980, 1982)[101] study of rural Indian farmers' choices among a series of gambles with non-trivial payouts[102] is a seminal field game on farmers' risk aversion. Subjects were faced

[100] Coins are often flipped to determine outcomes and dice are used in some traditional Ugandan games.

[101] Binswanger's sample size was 330; however, only 220 responses were used in the majority of his data analysis.

[102] The experimental payoff scale was increased in Binswanger's experiment, such that in later rounds the payout level was comparable to potential real world returns from agricultural investments.

with gambles in a manner similar to those used by Allais (1953), but the riskier alternatives were designed as a mean-preserving spread of the less risky gamble. The risky gambles were designed to have a greater variance in potential payouts around the same payout mean as less risky gambles. Other studies that employ a risk aversion field experiment in a small-N study of farming behaviour are: Sillers (1980); Walker (1980); Binswanger and Sillers (1983); and Grisley and Kellogg (1983, 1987). Overall, these studies suggest that farmers in developing countries tend to exhibit moderately risk averse preferences,[103] but risk aversion is often not correlated with household wealth levels. There is little documentation of what attitudes may underlie risk aversion, especially in the context of available microinsurance.

3.3.5.1.2 Game structure

The *Coin* Game was designed as a triple-bounded dichotomous choice over a series of three path-dependent gambles made on the outcome of coin flips by the respondent. We designed these coins in order to depict images of ears of maize (see Figure 3.2). The coin that the farmer chooses to flip in a given round determines which coins, if any, he will be presented with in the following round of play.

Figure 3.2 Example Coin design: two coins offered to the farmer in the first round of the *Coin* game

At the outset, the CKW gives the farmer an overview of the game in general including its incentive scheme. The CKW hands him two fairly-weighted coins telling him that each represents a crop that he may choose to grow in the coming season. We name each of the five coins with the Greek letters, Alpha through Epsilon; this coding helps the CKWs keep track of the correct coin and as the letters are unrecognisable to the majority of subjects, they do not bias preference to a given coin. One flip of the chosen coin indicates the crop (i.e., coin) yield. The farmer has the ability to examine and handle the coins. The graphical yields are expressed in arbitrary units with icons resembling ears of maize to minimise cultural, linguistic, or numeracy skews in the data. If the icon showed a more risky type of crop (e.g., tobacco) this

[103] Upwards of 70 % of total responses fit in categories of experimental stated preferences in the "moderate" and "intermediate" risk aversion bands, as the aggregate of the samples in the following studies: Sillers (1980); Walker (1980); Binswanger and Sillers (1983); and Grisley and Kellogg (1983).

would have shifted farmers' choices towards crop type preferences rather than risk aversion and acceptable variance.

Anderson et al. (1977) note that certain individuals may exhibit preferences for particular probabilities, introducing bias and distortions into the utility assessment. Thus, we use questions that vary outcomes of events and use fixed neutral probabilities throughout (e.g., Makeham, Halter & Dillon, 1968; Dillon, 1971).[104]

Table 3.3 Structural design of the coins and related results for the *Coin* game

Coin	Heads ÷ Tails	APRA	$Z = \Delta E b \Delta SE$	Possible Coin Payout *(incentive payment)* High Payout	Low Payout
				(2012 UGX)	
A	1.0	∞ to 7.51	1 to 0.80	2500	2500
Δ	0.5	7.51 to 1.74	0.80 to 0.66	4000	2000
B	0.3̄	1.74 to 0.81	0.66 to 0.50	4500	1500
Γ	0.2	0.81 to 0.32	0.50 to 0.33	5000	1000
E	0.11	0.32 to -∞	0.33 to -∞	5500	500

Binswanger (1980) noted the moral issues inherent in conducting gambling experiments in the developing world with an impoverished sample. His game was a minimum-payoff-of-zero game, which is the standard in this literature (e.g., Gertner, 1993).[105] We set the worst possible outcome of the *Coin* game to be a gain of 500 UGX. The values for potential gains were set to be very high.[106] These were consistent with the experimental design of (Binswanger, 1980, 1981) and Kachelmeier and Shehata (1992). The money that the subject would receive was not visible when a choice was made between the certain payout or taking a risk and money was not given to the participant until the conclusion of the full game and interaction with the CKW to avoid endowment effects (e.g., Kahneman et al., 1990).

Table 3.3 and Figure 3.3[107] provide details as to the structure of the game and the risk aversion bounds associated with various choice paths. To start the game, the subject was given the option to take a certain 2,500 UGX or to opt for a risk, betting on a coin flip with variance ranging from low (2,000 UGX for heads and 4,000 UGX for tails) to high (500 UGX for heads and 5,500 UGX for tails). The game is iterative and follows the decision tree with the farmer expressing a

[104] Anderson et al. (1977) called this procedure the Equally Likely Certainty Equivalent (ELCE) approach; Dillon (1971) refers to it as the modified von-Neumann Morgenstern method. Officer & Halter (1968) show that the ELCE is superior to the standard reference contract approach. We tested the Equally Likely Risky Outcome (ELRO) procedure, which mitigates bias for whether an individual has a (dis)liking for gambling, *per se*, such that his certainty equivalents are potentially influenced by the fact that questions are asked involving risky versus sure prospect. Yet, in line with the findings by Officer and Halter (1968), the ELRO procedure introduced a more complicated questioning procedure that yielded more consistent results for participants with high analytical skills, but less consistent results for a large proportion of our respondents who found that structure to analytically taxing.
[105] There are very few studies (e.g., Hersch & McDougall 1997) in this type of research where participants are asked to put their own wealth at risk in gambles, likely due to ethical concerns.
[106] One of the poorer Ugandan farmers in the sample receiving 6,500 UGX would receive in excess of three days' earnings for playing a game that lasts less than five minutes in nominal terms. Figures were derived from a combination of informal discussions during the focus group sessions in Oyam and Kapchorwa and well as data from (UBOS, 2010a) and IFAD (2013).
[107] In Figure 3.3, the notation X/Y denotes a coin with a heads payout of X and a tails payout of Y.

preference between one pair of coins at each decision point, beginning with the certain 2,500 UGX versus a 1,500 UGX (heads) or 4,500 UGX (tails) coin flip.

We note that in both of our study regions, the probability of successfully exceeding subsistence-level farming (i.e., farm output is a substantial contribution to household income) is between 40 and 60% across crop types. The driving difference between different crops is not their probability of success, but rather the variance that separates success and failure. It follows that the structure of the *Coin* game is applicable to this situation, since is encompasses variations in variance spread, opposed to that of expected values, in our study areas.

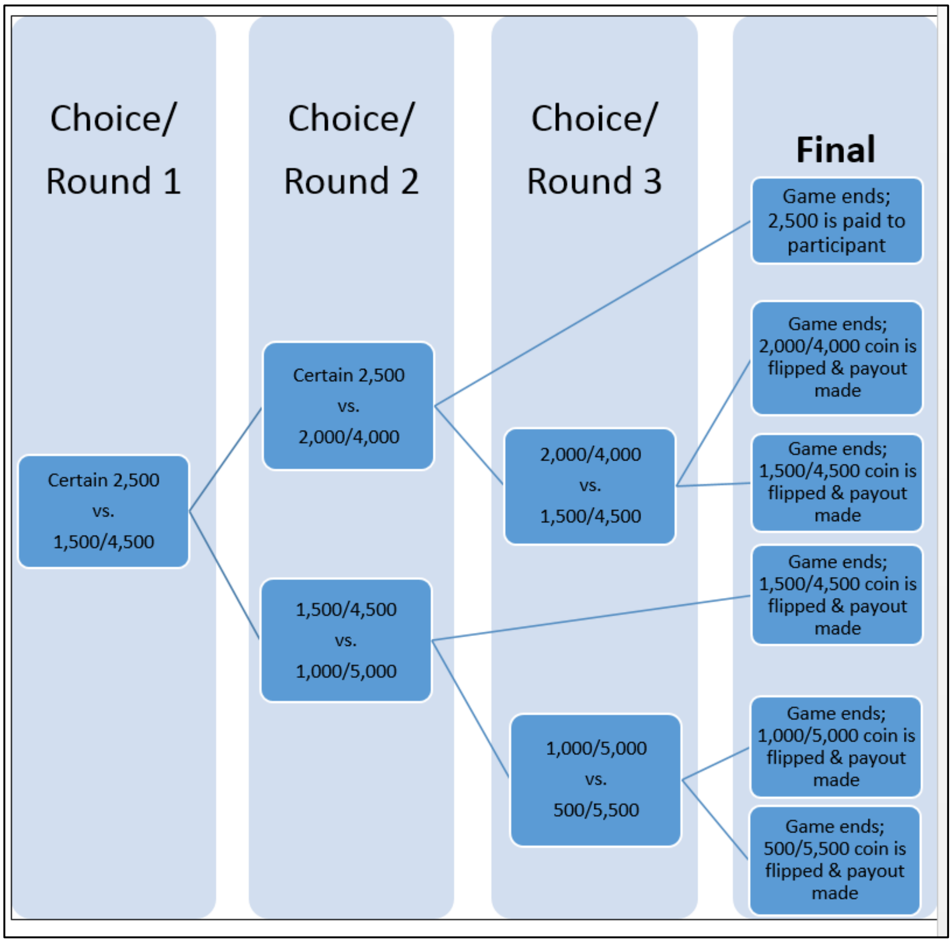

Figure 3.3 Structural design of the iterative choices in the *Coin* Game

3.3.5.1.3 Interpreting game results

The *Coin* game is a classic risk aversion classification exercise. Under constant relative risk aversion, the utility of consumption *u(c)* is given by the following function:

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} \tag{3.1}$$

Where σ is the coefficient of relative risk aversion, a parameter that controls the curvature of one's utility function and measures risk aversion.

Where the player chooses the 9:3 coin (*Alpha*) rather than the 5:5 coin (*Beta*) in the first game round, his choice is mathematically equivalent to an inequality between probabilities where the player prefers one probability to the other. The choice of the 9:3 coin can be represented as:

$$5^{1-\sigma} < \frac{1}{2}(9^{1-\sigma} + 3^{1-\sigma}) \rightarrow \sigma_{9:3} \qquad (3.2)$$

Since the context of each decision is a choice between two coins and the probabilities of any given outcome at any given time are equal, this follows for all other values in the opportunity set, e.g.:

$$\therefore 5^{1-\sigma} < \frac{1}{2}(8^{1-\sigma} + 4^{1-\sigma}) \rightarrow \sigma_{8:4} \qquad (3.3)$$

and

$$\therefore\ 5^{1-\sigma} < \frac{1}{2}(10^{1-\sigma} + 2^{1-\sigma}) \rightarrow \sigma_{10:2} \qquad (3.4)$$

This method allows the player to be quickly categorised according to the variance he will tolerate with two choices at a mutual probability of 0.5. The coins represent variances of the following values (each of which represents a comparison of a coin's two sides expressed as a fraction): 1, 1/2, 1/3, 1/5, 1/11. Hence, the participants are classified into five categories of risk tolerance with these variances as the bounds for the ranges.

Given our large-N sample and concerns about learning effects we do not consider iteration of the game with our sample. The extensive nature of the large mobile app survey surrounding the *Coin* Game would require repetition if the game was repeated in order to control for variations over time and learning effects regarding understanding of risk and insurance. Furthermore, the survey and field experiments were conducted at a time when farmers are preparing their fields and have little spare time.

3.3.5.2 Basic Dice game

3.3.5.2.1 Background

The *Basic Dice* game tests insurance purchasing preferences in an environment characterised by weather uncertainties[108] and strives to measure what we term utility from the *feeling of insurance*. Under the *feeling of insurance*, a household gains utility from the feeling of protection from holding insurance, even if there is no net financial gain from taking on the insurance coverage. To the best of our knowledge this concept has not been explored in the developing country context in relationship to microinsurance in general or agricultural microinsurance in particular. We base our understanding on studies related to this topic from the developed country context.

Under the *Goal-based model of choice*, goals can be emotion-related or be defined to conform to social norms. Kunreuther et al. (2013) give the example that under this model of choice, individuals may buy insurance coverage to reduce their anxiety about experiencing a large financial loss and stress the importance of separating financial protection from the loss and reduction of anxiety about the loss (the feeling of insurance). Many of the steps under the *Goal-based model of choice* reflect those highlighted in the planning process for ex-ante and ex-post

[108] Our *Complex Dice* Game is specific to the study of indexed insurance and obtains data on respondent's reactions to and preferences for basis risk. This field game was conducted with a smaller pool of respondents, as described in Chapter 8.

coping responses,[109] but take elements of bounded rationality into account specifically. These steps include: 1. problem recognition; 2. activating relevant goals; 3. searching for or designing alternative action plans; 4. evaluation of alternatives; 5. making tradeoffs by determining the achievement (level) of the original goal (Krantz & Kunreuther, 2007).[110]

There are other factors that may affect attitudes towards insurance that are relevant in this discussion. For example, Loewenstein et al. (2001), assume the *risk-as-feelings* hypothesis. They show that emotional reactions to risky situations often diverge from cognitive assessments of those risks. When such divergence occurs, emotional reactions often drive behaviour. The risk-as-feelings hypothesis is shown to explain a wide range of phenomena that have resisted interpretation in cognitive–consequentialist terms.

Hsee & Kunreuther (2000) also introduce the idea of the affection heuristic in insurance purchase, which is largely overlooked in normative analyses of insurance (Hogarth & Kunreuther, 1995). They find that individuals have a greater WTJ insurance for an object, the more affection they have for it, holding constant the amount of potential compensation. This finding is related to the fact that few individuals engage in cost-benefit analysis implied by expected utility theory (Hogarth & Kunreuther, 1995), but rather base decisions on factors such as *peace of mind* and relief from anxiety. In our research we refer to this concept as the *feeling of insurance* and look at its relationship to willingness to insure in the developing country context.

3.3.5.2.2 Game structure

The *Basic Dice* game measures feeling of insurance, as discussed previously, by keeping the probability of loss consistent whether or not the player selects insurance. The framing of this game is not specific to indemnity or indexed insurance, but is a general treatment of insurance in the context of extreme weather events familiar to the farmers.

There is no mathematical difference between the state of holding and not holding insurance in this game; utility ultimately arises from the player's feeling of insurance (or not). This game tests whether the preference for insurance exists even in a scenario where the actuarial advantage of insurance is offset by additional endemic risk or, stated differently, when insurance is so expensive that it completely offsets any gains to be enjoyed from coverage.

[109] See Figure 2.3.

[110] Throughout this thesis we reference the *feeling of insurance* which arises from the *Goal-based model of choice* as the utility obtained by having the perception of being insured even in cases where insurance does not increase expected utility or coping ability.

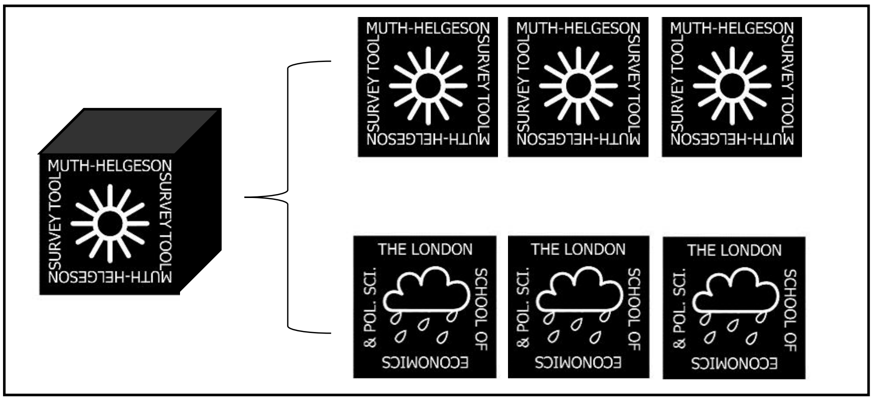

Figure 3.4 Fair die with three sides showing rain and three sides showing sun

This is a three-round iterative game with the goal of looking at patterns across individuals in the uptake of insurance.[111] The dice used in the game were six-sided, fairly weighted dice. Three sides of each die depict sun and three sides depict rain; see Figure 3.4. In the game the farmer incurs losses to his crops when extreme weather occurs: 1. Flood—all four dice in a roll show up as rain; or 2. drought—all four dice in a roll show up as sun.

In each round, the farmer can elect to give up one die of the four dice in order to *purchase* insurance against the outcome of drought (i.e., roll of the remaining three dice resulting in all sun); however, the insurance will not cover him against a roll of three dice resulting in all rain (i.e., flood). The player was paid 500 UGX for each round he did not experience a loss through 1. flood or drought event (if he was uninsured and rolling four dice); or 2. flood event (if insured and rolling three dice).

The insurance offered in this game only covers a drought event while those without insurance are vulnerable to both flood and drought. Thus, given that the *purchase* of insurance is worth one die in this game, the potential combinations of dice outcomes is specified by 2^3 while it remains 2^4 for those who opt for no insurance in a given round. Thus, the probability of an uninsured loss for each roll for uninsured players is $\frac{2}{2^4}$ and for insured players is $\frac{1}{2^3}$.

This game is rooted in a statistical equality: the probability of rolling four dice and receiving four rain icons or four sun icons is identical to the probability of rolling three dice and receiving all rain icons. The following equality is true of the two outcome possibilities that result in a loss in the Basic Dice game, $\frac{2}{2^4} = \frac{1}{2^3}$. Hence, the choice to insure or not in this game is not one of mathematical advantage, but rather purely one of consumer preference. The player who enjoys some utility from *peace of mind* being protected from drought will trade one die for insurance, even though the coverage of the insurance is imperfect. Other players will not choose to trade one die for insurance against drought.

[111] The full *Basic Dice* game directions, as seen by the CKW, are available in Appendix A; the game starts at question 115.

3.3.6 Large-N survey–Related data analysis

We gather data on a number of relevant topics in the survey tool; not all of these responses are used in the final econometric models, but many are used in pre-analysis investigations of the data in order to develop income and risk profiles that inform our analysis of loan and insurance behaviour. We are primarily interested in questions that relate directly to variables that encapsulate factors in our conceptual model of microinsurance and comparing findings for WTP for borrowing and coping behaviours.

3.3.6.1 Assessing the field game results and respondent perceptions

To the extent possible we compare outcomes from the field games to similar metrics obtained through the large-N survey and data that is objective/verified (e.g., extreme weather records). There are three major instances of these comparisons, summarised in the following sub-sections: 1. respondent-reported extreme weather events versus historical satellite-recorded weather variation data; 2. *Coin* game choices versus riskiness of farmers' crop profiles; 3. *Basic Dice* game choices versus reported worries in various realms. Chapter 5 provides further details of these analyses.

3.3.6.1.1 TAMSAT weather data comparison

We use the Tropical Applications of Meteorology using SATellite (TAMSAT) data to generate data on extreme weather anomalies (via rainfall) to compare against respondent-reported observations about frequency of extreme weather events that impact crop yields. We follow guidance in papers that look at climate (average statistical expectation) and weather (what occurs in the short-term) from historical weather data in sub-Saharan Africa and compare these trends to farmers' claims of poor crop yield years.[112]

Variations in the extreme weather respondents perceive does not typically match the weather data trends. Osbahr et al. (2011) look at a sample in southwest Uganda. In this case, the farmers perceived that a change in the regional climate over the last 20 years–temperature had increased and seasonality and variability had changed. Temperature has been increasing in the weather data; however, rainfall measurements do not show a downward trend in the amount of rainfall or a shift in the start and end of the rainy season, as claimed. Moyo et al. (2012) demonstrate that climatic data show no evidence that corroborates farmers' perceptions of climate risk, with only temperature showing a clear signal, indicating the influence of other non-climatic factors. The climate data show rainfall variability to be a normal characteristic of the study sites,[113] with slight deviations from the climatic rainfall means being cyclical and occurring about once in every three seasons in the last 40 years.

[112] Farmers used the term "poor season" to refer to any year with reduced crop production due to insufficient rainfall and other crop production constraints. Perceptions of climate tend to be based on the livelihood impacts the climate has on individual farmers, i.e., the social and economic impacts (Slegers, 2008).
[113] In other words, there are slight variations in rainfall, but not enough to indicate frequent extreme weather events.

We tabulate responses to questions 55[114] and 56[115] in the large-N survey that deal with the type of extreme weather farmers generally face (i.e., drought or flood) and their perception of historical frequencies experienced on-farm.

We downloaded historical data on decadal rainfall anomalies from TARCAT (TAMSAT African Rainfall Climatology And Time-series).[116] We look at monthly rainfall estimates and anomalies, with each month characterised by three decadal (i.e., 10 days) data points. Our large-N survey took place in 2011. In order to compare rainfall information from TAMSAT with the responses from the survey data, we selected decadal rainfall data from 2009 to 2001, which provides information on rainfall levels and anomalies every two years starting from 2011.[117]

The CKWs recorded GIS coordinates of the farms for each survey conducted, which allowed us to match to TARCAT data on a 10-by-10 km grid, as suggested by TAMSAT researchers (e.g., I. Tarnavsky 2015, per. comm., 15 May).[118] We group samples according to latitude and longitude; the coordinates for each household were converted into km measurements from the district centre. Farms were grouped based on 10-by-10 km grids. Farmers from Kapchorwa were separated into five geographical groups and farmers from Oyam were separated into six geographical groups, respectively. The algorithm for this calculation is given in equations 3.5-3.9.

$$d\_lon = lon_2 - lon_1 \tag{3.5}$$

$$d\_lat = lat_2 - lat_1 \tag{3.6}$$

$$a = {}_{lon} = \sin\left(\frac{d\_lat}{2}\right)^2 + (\cos(lat_1))(\cos(lat_2))\sin\left(\frac{d\_lon}{2}\right)^2 \tag{3.7}$$

$$c = 2\left(\tan^{-1}\left(\sqrt{a}\,,\sqrt{(1-a)}\,\right)\right)^2 \tag{3.8}$$

$$d = R(c) \tag{3.9}$$

Where R is the radius of the Earth, lon_1 is longitude 1, lon_2 is longitude 2, lat_1 is latitude 1 and lat_2 is latitude 2. The final distance in km is given by d.

Data from farmers' responses were compared to variable rainfall in TARCAT for each response, with special consideration for the main seasons for the majority of crops farmed by our sample, March-May and October-December.

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[114] Text of Q55: "In your farming, are you more concerned about flooding or droughts?" response options: 1. Flood or 2. Drought.

[115] Text of Q56 "In your opinion, what is the likelihood that a flood/drought would occur that would eliminate half of your total crop in a given season?" 1. 1 out of every 2 years; 2. 1 out of every 4 years; 3. 1 out of every 5 years; 4. 1 out of every 10 years; or 5. 1 out of every 50 years

[116] Used v2.0 Online Database in a NetCDF format. Available at: http://www.met.reading.ac.uk/~tamsat/data/

[117] Similarly rainfall information from 2007 and 2003 provide information of rainfall data for every four years starting from 2011. Rainfall data from 2006 and 2001 provide information for every five years starting from 2011; and rainfall data of 2001 provide information on 10 years from 2011.

[118] This appears typical, as Osbahr et al. (2011) selected their study area as close to the weather station (40 km) as possible to minimise the impact of spatial variability in comparing recorded and reported daily weather patterns.

3.3.6.1.2 Correlations between coin risk and crops farmed

We are interested in the explanatory power of the risk aversion estimates arising from the *Coin* game in comparison to real-world market indicators of risk aversion for our sample. The structure of the field game was domain specific to crop choice. Seed choice maps onto relative risk of crop maturation. Thus, we consider the correlation between respondents' risk aversion expressed in the *Coin* game versus risk aversion as expressed by respondents' indicated risk aversion by intended market behaviours over crop choice for the coming season.

3.3.6.1.3 Correlations between feeling of insurance and worry

We look at correlations between respondents' indicated *feeling of insurance* in the *Basic Dice* game and responses from the categories of worry respondents are asked to rate in the survey tool. Metrics on worry are as close as we have to information about potential regret after-the-fact for not taking insurance. We are interested if worry related to agricultural shows greater significant correlations with feeling of insurance opposed to worry over unrelated aspects, such as injury of a family member. We base the seven categories of worry on findings from the FGDs and use the information in a manner consistent with the Finite-pool-of-worry theory (Linville & Fischer, 1991).

3.3.6.2 Modeling coping strategy choices

As discussed previously and noted in the conceptual framework, coping strategy choices likely influence both the option to and interest in engaging with microinsurance as a means of coping. To this point we are interested in our sample's use of traditional coping strategies in order to better understand determinants of adoption of different forms of coping strategies and the groupings into which traditional coping fall. Furthermore, this analysis allows us to assess whether households engaged in one form of traditional coping are relatively more prone towards use of loans and/or microinsurance. We provide an overview of approaches used in this analysis below; further details are provided in Chapter 6.

Since households can choose several strategies in the survey question upon which we base our analysis of household preference for traditional coping strategies,[119] we examine frequently chosen strategy combinations. We do this through exploratory Principal Components Analysis (PCA) and Latent Class Analysis (LCA), the results of which agree in our analysis. The PCA creates an orthogonal transformation of our data to create a linearly uncorrelated set of principal components, which are ranked minimising variance (e.g., Travaglini, 2011). In our case, a component is an overarching strategy choice, which is achieved by choosing specific coping strategies. We follow the well-known criterion for interpretation of PCA results where only components with eigenvalues greater than one are retained in the model (Kaiser, 1960). The LCA related an observed set of variables to a set of latent variables; in our case, underlying coping categories (Bartholomew, 2002). The LCA classifies respondents into homogeneous groups with similar response patterns for coping, based on characteristics, opposed to *proximity* of responses which is the case in the PCA.

We estimate three models related to the coping strategy classes determined through the LCA and PCA: 1. multinomial probit model across identified coping classes, 2. probit model for selling livestock, and 3. probit model for willingness to take children out of school. We give the

[119] Based on Q32 in the Large-N survey.

generalised specification for these classes of models below; specific variable definitions and equations are given in Chapter 6 for context.

In the multinomial probit model, a series of observations Y_i, for *i=1...n*, of the outcomes of multi-way choices from a categorical distribution defined by *m* possible choices; with each observation Y_i there is a set of j observed values: $x_{1,i},\ldots,x_{j,i}$ of explanatory variables (Wooldridge, 2010). Then Y_i are categorically-distributed; each outcome k for observation i occurs with an unobserved probability *p(i,k)* that is specific to the observation *i* at hand because it is determined by the values of the explanatory variables associated with that specific observation, such that:

$$\Pr[Y_i = k | x_{1,i}, \ldots x_{j,i}] = p_{i,k,} \tag{3.10}$$

for i=1,...,n for each of the m possible values of k.

The multinomial probit model can be expressed as a latent variable model, as follows (e.g., Cameron & Trivedi, 2005):

$$Y_i^{1*} = \beta_1 x_i + \varepsilon_1 \tag{3.11}$$

$$Y_i^{2*} = \beta_2 x_i + \varepsilon_2 \ \ldots$$
$$Y_i^{m*} = \beta_m x_i + \varepsilon_m \ \text{, where } \ \varepsilon \sim N(0, M)$$

The error terms have a joint multivariate normal distribution with a zero mean and an arbitrary variance-covariance matrix (Greene, 2011).[120]

Then

$$y = \begin{cases} 1 & \text{if } Y_i^{1*} > Y_i^{2*}, \ldots, Y_i^{m*} \\ 0 & \text{if } Y_i^{2*} > Y_i^{1*}, Y_i^{3*}, \ldots, Y_i^{m*} \\ & \ldots \ldots . \ldots \\ & m \ otherwise. \end{cases} \tag{3.12}$$

We estimate probit models for two coping strategies of specific interest: 1. willingness to sell livestock and 2. willingness to take children out of education. We look specifically at sale of livestock because it is the most frequently chosen strategy in our sample. Furthermore, reduction of human capital through taking children out of school is considered to erode long-term household welfare.

We base our probit model on the general binary outcome (e.g., Cameron & Trivedi, 2005), such that the dependent variable y takes one of two values, where

[120] The multinomial probit has a number of advantages over other possibilities, e.g., greater statistical robustness and the ability to avoid the independence of irrelevant alternatives (IIA) assumption (van Lierop & Nijkamp, 1984).

$$y = \begin{cases} 1 & with\ probability\ p \\ 0 & with\ probability\ (1-p) \end{cases} \tag{3.13}$$

We assume there is a latent variable y* which is generated from

$$y* = \beta' x + \varepsilon \tag{3.14}$$

where β is a K-vector of parameters, x is a vector of explanatory variables and e ~ N(0, 1). We observe y=1 if y* > 0 and y=0 otherwise.

Conditional probability is given by:

$$p_i \equiv P_r[y_i = 1|x] = F(x'_i\beta) \tag{3.15}$$

where F(.) is a specified function; to ensure $0 \leq \mathrm{p} \leq 1$ F(.) is the standard normal cumulative distributive function.

3.3.6.3 WTP interval model

The data collected in the Large-N survey is analysed through the use of descriptive statistics and the development of econometric models. We first review the data distribution for respondents' choices between the two WTP questions. We develop a number of basic bivariate correlations to determine potential relationships between respondents' wealth and risk profiles and subsequent indicated WTP. The intuition being that microinsurance is not necessarily the most appropriate coping strategy across household types, which is contrary to much literature that seems to support the inherent value in a (near) universal uptake of microinsurance products. This may arise because of a combination of factors that are related to the households': 1. ability and/or 2. preferences. To date this is not clear in the literature and we strive to address this debate.

3.3.6.3.1 Intuition of the interval model

There are different econometric models used throughout the literature to fit WTP; the choice of model is largely based on the initial question framing and response data. For example, use of the Heckman model (Heckman, 1979) is most relevant in cases under which it is important to deal with self-selection, e.g., a relatively high level of respondents are non-WTJ. There is research that effectively uses models outside of the Tobit regression or Heckman modelling approach for WTP analysis. Some analyses use only observations greater than zero (e.g., Rozan, 2004), while other research takes the logarithm of the positive observations after dropping the zero responses or adds a very small number to the zeroes which are then included in the regressions in order to prevent negative predicted WTPs (Bateman et al., 1995). Other methods for dealing with zero responses include the Spike Model (Reiser & Shechter, 1999), symmetrically-trimmed least squares estimation (Kwak et al., 1997), and least absolute deviations estimation Yoo et al. (2000).

We consider an interval regression model, where WTP is an interval censored variable. WTP data is often analysed using interval regression, which is a generalisation of the Tobit model. This is a regression model estimated by maximum likelihood; it assumes a normally distributed error term (e.g., Tobin, 1958; Amemiya, 1985; Howe, Lee et al., 1994). The method assumes that the true distribution of WTP bidding is censored at zero, hence Tobit regression is used frequently when there is a high frequency of WTP equal to zero in a dataset or if it is unrealistic that actual WTP may negative (e.g., Halstead et al., 1991). In which case, it is unclear whether responses of zero indicate protest-no responses or if that respondent's true valuation falls between zero and the lowest offered bound. The model assumes that the response variable has a lower or upper bound and that this limiting value is common across a substantial number of respondents. In our response set individuals place themselves within censored bounds–an advantage of the double-bounded structure was that the large majority of respondents match their identified bound going both directions on the WTP ladder. Thus, in the interval bounds in the model are given by the lower and upper bounds in our WTP question.

The basic assumption behind the interval regression model is that the true WTP of the farmers lies somewhere between the lower and upper bounds and these bounds have a Gaussian distribution. Given a variable of interest y*; the assumption is that variable y* is unobserved. Truncation from above arises when we have observations of y=y* for y*<U only; where U is upper bound. This means that in a population, there are individuals for which y*<U but we do not have them in our sample.

Censoring from below arises when we have observations of y*>L, and d = (y*<L), where d is what we observed. In the population there are individuals for which y*<L; we have these individuals in our sample, but we do not observe a point estimate of y* for them, we just know that y*<L. Censoring from above arises when we have observations of y*>U, and d = (y*<U), where d is what we observed. In the population there are individuals for which y*<U; likewise, we have these individuals in our sample but we do not observe y* for them, we just know that y*<U.

Thus, we consider the latent model (Cameron & Trivedi, 2005; Wooldridge, 2010):

$$y^* = xb+u \text{ with } u \sim N(0, \sigma^2) \tag{3.16}$$

and we observe: *d=0 if y*<0, d = 1 if y*>0, and y = y* if y*>0*

Interval data arises when we observe just the interval in which of y* belongs and there is a known threshold of values for these intervals (e.g., a_1, a_2, a_3, . . ., a_j). For variable q, our observation is defined as:

$$q = 0 \text{ if } y^*<a_1,\ q = 1 \text{ if } a_1 \le y^* < a_2 \ldots q = J\text{-}1 \text{ if } a_{j-1} \le y^* < a_j,\ q=J \text{ if } a_j \le y^* \tag{3.17}$$

Interval regression is used to model outcomes that have interval censoring. The dependent variable poses a partial censoring problem, since the dependent variable of interest y_i* is unobserved; what is observed is an interval that contains it. Interval regression is appropriate when we know into what interval each observation of the outcome variable falls, but we do not know the exact value of the observation.

The censored regression model (generalization of Tobin model; Tobin, 1958) is given by equation below. The dependent variable can be either left-censored, right-censored, or both left-censored and right-censored, where the lower and/or upper limit of the dependent variable can be any number.

$$y_i^* = \chi_i'\beta + \varepsilon_i \tag{3.18}$$

where i = 1, . . ., N indicates the observation, y_i* is an unobserved (latent) variable,

χ_i is a vector of explanatory variables, β is a vector of unknown parameters, and ε is an error term.

Relationships between observed variable y_i and y_i* is an unobserved *(latent)* variable is given by the relationships summarised in:

$$y_i = a \text{ if } y_i^* \leq a \quad (3.19)$$

$$y_i = y_i^* \text{ if } a < y_i^* < b \quad (3.20)$$

$$y_i = b \text{ if } y_i^* \geq b \quad (3.21)$$

where a is the lower limit and b is the upper limit of the dependent variable.

We cluster responses in our model to take into account that certain cohorts in the population might possess similar characteristics, which is detrimental to the robustness of the model. The clustered standard error variance estimator for our model is given by:

$$V_{CL} = (X'X)^{-1} \sum_{j=1}^{n_c} u_j' u_j (X'X)^{-1} \quad (3.22)$$

where n_c is the total number of clusters.

Variable specifications related to the interval regressions for WTP for agricultural microinsurance and to obtain a loan are given in Chapter 7.

3.4 Complex Dice game for basis risk–Ugandan case study

The *Complex Dice* game is a field game that strives to disentangle respondents' attitudes towards and responses to basis risk in an iterative hypothetical rain-index crop insurance scheme. To our knowledge, it is the first such experiment in Uganda and one of the first in the developing country context.

3.4.1 Contextual background

Many field games to date that address the demand for index-based microinsurance do so in the context of several other risk management options, but do not explicitly incorporate the experience of basis risk into the game. In our opinion, doing so may provide some insight into the debate as to whether uptake of indexed based insurance is too low. In the *Complex Dice* game, we strive to isolate players' experience of realised basis risk and better understand the effect risk has on perception of and willingness to adopt or renew index insurance. The original contribution to knowledge of our field experiment is the incorporation of basis risk, both positive and negative directions. We also have farmers play in a group setting in order to gauge potential influences of such social interactions.

Within the fairly narrow relevant literature, there is a wide range of findings on uptake of index insurance by rural farmers in developing countries. Actual uptake rates tend to differ greatly from relatively large estimates in some theoretical and simulation models of optimal hedging strategies using index insurance (e.g., De Nicola, 2012; Miranda & Farrin, 2012). For example, Giné & Yang (2009) report that uptake was 13 percentage points lower when their sample of Malawian farmers were offered insurance with their loan, as opposed to credit in isolation.

Other studies that find basis risk to limit initial demand by rural farmers include those conducted in: China (e.g., Giné, Townsend & Vickery, 2008; Göncü, 2011; Cai & Song, 2012), India (e.g., Seth et al., 2009; Cole, Jagnani et al., 2013), and Bangladesh (Brouwer & Akter, 2010; Akter & Fatema, 2011). Yet in other studies, index insurance appears to serve a valuable function in managing weather-related risks via high-demand (e.g., Turvey, 2001; Osgood et al., 2007; Collier et al., 2009; Norton et al., 2014).

In our *Complex Dice* game, we take account of group dynamics including a brief overview of findings for group premia. There are mixed results in preliminary field studies of group index insurance policies and real-life applications of group insurance. The rate of uptake appears to be highly dependent on designs that assure that the poorest of the poor are not further marginalised, especially in the case of index insurance. Examples include Dercon et al.'s (2014) study in rural Ethiopia and the study of cotton producers in Mali from Bellemare et al. (2012). Santos and Barrett (2011) found a middle-class bias in offering reciprocal lending arrangements.

3.4.2 Game structure

The *Complex Dice* game was played with a sample of 128 farmers; 64 respondents were based in each study district. The rational for this audience is that we are able to use the game as a form of reinforcing understanding of insurance–to catch misunderstandings before we send them out to the field. All respondents in this sample were CKWs and the Complex Dice game is used to look at attitudes towards and responses to basis risk.

3.4.2.1 General structure

The *Complex Dice* game is structured to mirror the functions of index insurance, whereas the *Basic Dice* game provides a simplified view of insurance. During the Complex Dice game, the player is endowed with playing chips, which represent his total resources for investment during the season. To maintain consistency with the real-world structure of index insurance and with the tenets of expected utility, there are a number of design constraints:

- Expected loss should not decrease the farm size. Accounting for exogenous risk, there must be a control for consistency, or even a slightly upward sloping relationship between expected loss and farm size;
- Probability of (extreme weather) disaster should be exogenously determined;
- The player’s income should be restored (at least) to the level it was at the beginning of the turn without regard for appreciation or expected growth; and
- The player should be unable to over-insure relative to the size of his hypothetical “game” farm in any period.

This game is played with six-sided dice, playing chips,[121] and a playing board, Figure 3.5. The number of chips represents wealth/resources available to the farmer in a given round of play. Chips may be invested in: 1. farming activities (e.g., purchase of seeds), thereby increasing farm size; or 2. insurance purchase.

3.4.2.2 Situating the player–playing without basis risk

The game is first explained to players without introducing basis risk; they play a practice round under this assumption to check comprehension of the rules and general knowledge of

[121] i.e., typical casino or gaming chips

insurance. In this formulation, the player begins with an endowment of eight chips, which represents his entire wealth to invest in farming activities or purchase insurance. Payment towards insurance represents that year's premium. The insurance contract pays out when there is a drought or flood event. In each turn, all of a player's chips must be allocated on a combination of farming activities and insurance cover, but investment in insurance cannot exceed the number of chips put towards farming.

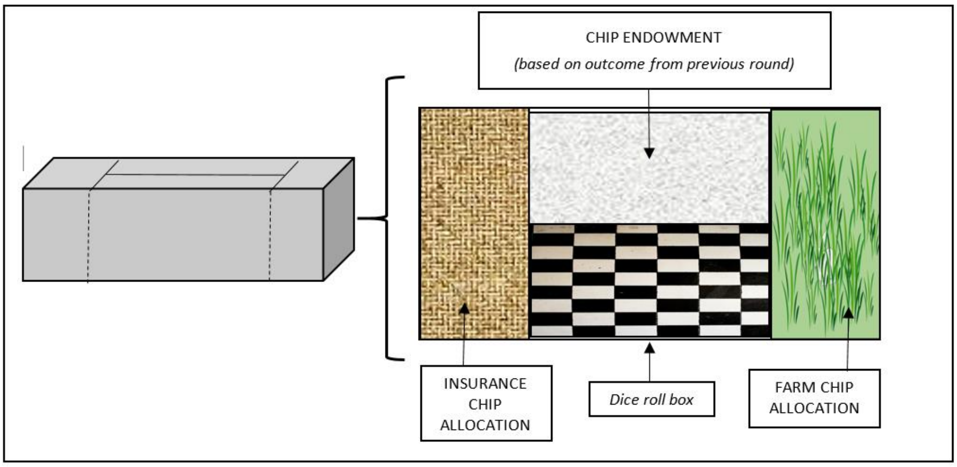

Figure 3.5 Schematic of playing board for each individual in the *Complex Dice* game[122]

Once the farmer has allocated his chips, he rolls the dice, determining *weather* on his hypothetical farm for that season. Note that the dice are the same used in the *Basic Dice* game; each die has three sides depicting sun and three sides depicting rain. The realisation of an extreme weather event occurs when all three dice rolled show sun (i.e., drought) or rain (i.e., flood). Thus, the probability of extreme weather warranting a payout from insurance equals $\frac{2}{2^3}$. This level of probability was chosen because it is aligned with the perceived (and verified) chance of extreme weather destroying a given crop in our two study regions. The basic algorithm for chips obtained after the chips are allocated and the dice rolled is as follows:

- If there is no extreme weather event, the farmer obtains double the chips initially allocated to farming
- If an extreme weather event occurs, the farmer obtains double the chips initially allocated to insurance and loses all chips initially allocated to farming.

We present the farmer with a pictorial chart depicting the potential payouts associated with various chip allocations, using icons similar to those on the coins, rather than numerical digits as to avoid biases arising from limited literacy or numeracy, before he decides how to allocate his chips between farming inputs and insurance coverage. Table 3.4 provides the outcomes of various combinations of chip allocations and weather events; we use numbers here for ease of the reader.

[122] Left: birds' eye view; Right: table-top view

Table 3.4 Game payout grid (training version without basis risk) with an initial endowment of eight chips

Initial Chip Allocation *(by farmer at start of round, before dice roll)*		Outcome *(number of total chips for next round)*	
Farming	Insurance	No Extreme Weather Event	Extreme Weather Event
8	0	16	0
7	1	14	2
6	2	12	4
5	3	10	6
4	4	8	8

3.4.2.3 Playing with basis risk incorporated

Following the training round, respondents play five rounds of the game incorporating basis risk. The general rules remain unchanged; however, *conditions* at a hypothetical weather station are included via the use of playing cards designed to show how weather differs at the weather station opposed to on one's farm, simulating weather-based index microinsurance.[123] In each pair, participants play their own *hand*, and observe the play and outcome of their neighbour.[124] The player selects from a deck of 18 playing cards; there are six cards of each type: (i) good, (ii) neutral, (iii) bad, as depicted in Figure 3.6.[125] Jensen et al. (2014) note that to date, no study associated with index agricultural microinsurance in the developing country context has provided the magnitude of basis risk on a household-level, [126] despite the frequent citation of basis risk as a likely cause of low agricultural microinsurance demand (e.g., Smith & Watts, 2009; Hazell & Hess, 2010; Miranda & Farrin, 2012). The values we use are likely on the high side; we assign evenly distributed probabilities for all three states of the *weather* at the weather station in the game given the frequency of losses reported by our sample; plus, we wanted the players

[123] We considered framing the game around area-based yield insurance, since it has been advocated as a "compromise between weather index insurance and indemnity-based crop insurance" and noted to be potentially less subject to basis risk than the weather index insurance (Sandmark et al., 2013, p. 61). On the other hand, Carter et al. (2007, 1 n. 3) note that "weather index-based insurance can be viewed as a sub-set of area-based yield insurance in which predictors of average yields (e.g., rainfall and temperature) are measured instead of realized average yields."

[124] We piloted a version in which the weather outcomes for each player was linked in a pair of players; however, this caused disagreements and confusion about the "fairness" of the game; thus, although they observed their partner's outcomes, the outcomes for each individual player were independent.

[125] It should be noted that we tested a number of symbols to use on these playing cards before deciding upon these. Furthermore, the colours chosen in the creation of the game pieces were done so as to be sensitive to political tensions, especially in the North.

[126] They go on to note that "in fact, few studies explicitly include any measure of basis risk at all. The lack of empirical attention to basis risk is especially disturbing because without it, there is no guarantee that index insurance is risk reducing" (Jensen et al., 2014, p. 2).

to experience basis risk in a way that was observable for a statistically significant proportion of rounds.

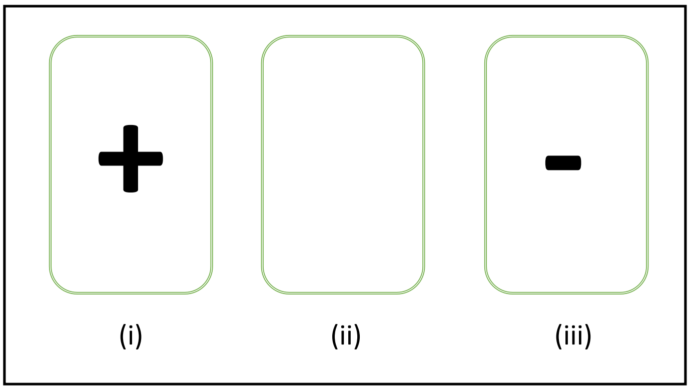

Figure 3.6 Playing cards representative of weather conditions at the weather station; 18 card deck with six of each card type: i, ii, and iii

This formulation allows accounting for the realisation of basis risk that does not favour the farmer (i.e., negative) and that which is in his favour (i.e., positive). Basis risk is often noted in the literature in the negative direction, i.e., the insured does not receive a (full) insurance payout when weather conditions on his farm warrant it due to differences at the point at which the index is measured. It is feasible that basis risk is realised in the “positive” direction such that the respondent receives an insurance payout when weather conditions on his farm do not warrant it. This would occur when conditions reported by the index at the weather station indicate extreme weather, while the on-farm weather is not extreme. Figure 3.7 provides a graphical example of basis risk realised in the negative direction in a round of play of the *Complex Dice* game.

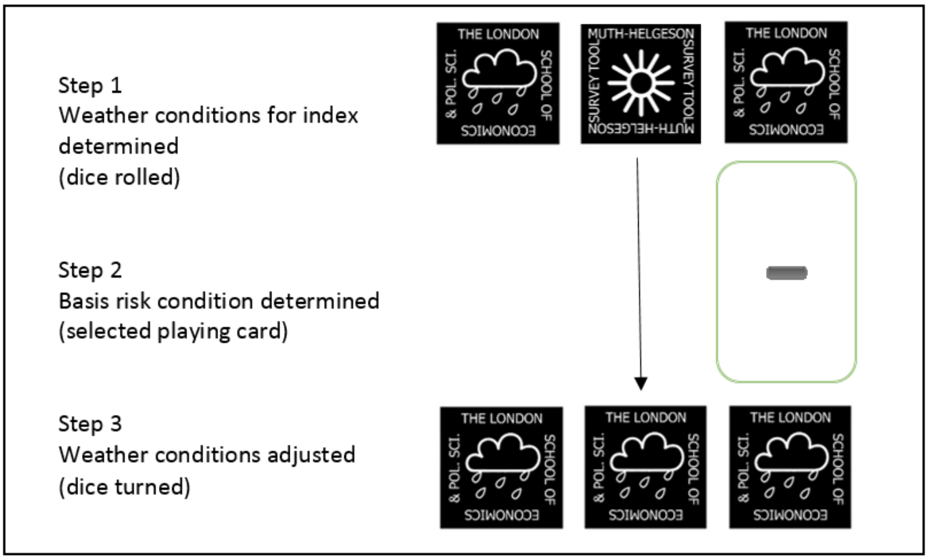

Figure 3.7 Graphical example of realisation of basis risk in the *Complex Dice* game

The algorithm for the number of chips obtained at the end of a given round is the same as indicated for the game without basis risk. Yet, if there is extreme weather on the farm and not at the weather station, there is no payment from chips allocated to insurance. Furthermore, in the case when there is extreme weather at the weather station and not the farm, there is payment from both the chips allocated to insurance and farming.

3.4.3 Survey and debriefing

Participants complete a short written numeracy activity before playing the *Complex Dice* game.[127] We recognised the importance of time-to-think (TTT) in reducing hypothetical bias in questionnaire activities and provide an overview of the task and time to think before answering (Whittington et al., 1992; Cook et al., 2012). Following the *Complex Dice* game, the respondent is asked a series of socio-economic questions, recorded on paper. See Appendix F for a copy of this questionnaire and associated game scorecard. We provide multiple choice answer options with some follow-on questions that ask the respondent to explain his/her choice or to provide details of why (s)he feels or acts in a certain manner. This questionnaire mirrors the major sections of the large-N survey delivered by mobile devices. We obtained the respondent's age, highest completed level of education, and the number of household members. Furthermore, we asked a series of questions about farming choices and outcomes. We obtained data on the percentage of household income that arises from farming, an index of what productive assets are owned, as well as what crops are grown. Finally, we garnered information about the respondent's knowledge of and attitudes towards insurance.

We administered the *Complex Dice* game with this sample during the second CKW field training, at which point they were trained extensively in how to administer the mobile survey tool and the associated games. This field training taught the CKWs about both index and indemnity insurance products. The structure of the CKW network lends itself to the potential for indemnity-based agricultural microinsurance; hence this is the first and primary structure of insurance the CKWs learn about during field training. The first training session had covered basis risk and index insurance along with the definitions of these types of insurance. We reiterated these points before teaching the CKWs the rules of the *Complex Dice* game. In the questionnaire that follows the *Complex Dice* game, we make it clear that questions related to insurance are related to agricultural index insurance. The index in this case is associated with rainfall levels at a nearby weather station.

3.4.4 Analysis of results–mixed effects linear regression

Due to the iterative nature of the *Complex Dice* game, we obtain a strongly balanced panel dataset characterised by both within- (e.g., realisation of basis risk) and between-subject time-invariant (e.g., socio-economic factors) variation. We use a linear specification with a mixed effects modelling approach[128] since we are interested in the effects of within- and between-subject variation on the respondents' choice as to the extent to which to insure (i.e., the percent of the endowment allocated to insurance in a given period). As a special case of a fixed effects model, random effects are able to deal with unobserved heterogeneity and the effect on propensity to insure in each round. Each scenario counts as a single period for which we have information about the respondents' decision to obtain insurance.

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[127] These questions are a truncated version of simplified questions based on the Berlin Numeracy test (Cokely & Galesic, 2012).

[128] The Heckman test for the model fit provides evidence that our data is best fit using random effects, as opposed to fixed effects.

Since we are training the CKWs, they likely play the *Complex Dice* game in a manner consistent with demonstrating their knowledge (and interest in) agricultural microinsurance to us as researchers specifically interested in microinsurance. It is also likely that we observe learning effects between the initial training round (with no basis risk) and the *Complex Dice* game with basis risk–we only analyse the basis risk rounds in our regression model.

We used a mixed effects linear modelling approach with a response variable of the percent of chips allocated to insurance in a given round. The mixed model is a statistical model containing both fixed and random effects and is particularly useful when repeat measurements are taken on the same individuals (e.g., Greene, 2011). The matrix notation for a mixed effects linear model is:

$$y = x(\beta) + Zu + \varepsilon, \tag{3.23}$$

Where Y is a known vector of observations, with mean E(y) = $X(\beta)$;

β is an unknown vector of fixed effects (time invariant);

u is an unknown vector of random effects (time variant in nature), with mean E(u)=0 and a variance-covariance matrix given by var(u)=G;

ε is an unknown vector of random errors, with mean E(ε)=0 and variance var(ε)=R;

X and Z are matrices relating the observations y to β and u.

The estimation of the model is given through Henderson's "mixed model equations" (MME), maximising the joint density for β and u. The solutions to the MME being $\hat{\beta}$ as the best linear unbiased estimates and $\hat{u}$, the best linear unbiased predictors.

The joint density of y and u is given as f(y,u) = f(y|u)f(u), assuming normality, such that u~N(0,G), εN(0,R) and cov(u, ε)=0. The MME is given as

$$\begin{pmatrix} X'R^{-1}X & X'R^{-1}Z \\ ZR^{-1}X & Z'^{R^{-1}}Z + G^{-1} \end{pmatrix} \begin{pmatrix} \hat{\beta} \\ \hat{u} \end{pmatrix} = \begin{pmatrix} X'R^{-1}y \\ Z'R^{-1}y \end{pmatrix} \tag{3.24}$$

Chapter 8 gives the detailed variable specifications and model.

3.5 Hurricane Sandy case study

3.5.1 Introduction

To the best of our knowledge, household-level flood risk and insurance valuation studies using direct questioning techniques with a simulation of flood events are rare in the developed country context (e.g., Brouwer et al., 2009). Meyer et al. (2013) provide a review of current methods to assess costs of natural disasters (e.g., flood events from extreme weather) over various impacted sectors. They note that most applications have been carried out in the context of floods (e.g., Daun & Clark, 2000; DEFRA, 2004);[129] however, (Green et al., 2011) highlight the

[129] The particular characteristics of droughts, such as long duration and much slower onset than other natural hazards, make it more difficult to estimate their costs through stated preferences (Markantonis et al., 2011). Examples are: Howe et al. (1994); Griffin and Mjelde (2000); Koss and Khawaja (2001).

relative lack of studies that look at underlying motivations to insure and perceptions of flood impacts.

Our empirical research takes the form of an online simulation and survey of 800 households; 500 which were impacted financially by Hurricane Sandy and 300 who live in the affected area, but experienced no losses. Our research is novel, as we are able to address a large-N sample just recently affected by an extreme weather event. In this chapter we look at how individuals' attitudes regarding insurance and risk affect insurance purchase in our flood simulation, controlling for socio-economic and demographic factors. We employ an experimental treatment that provides some respondents with *visualisation* of the expected financial outcomes of different combinations of flood occurrence and insurance purchases. Finally, we address the use of gambles in past literature to draw conclusions about insurance purchase behaviour through a comparison of respondents' insurance uptake in the simulation activity and their choice in a (relatively) high-stakes gamble.

Figure 3.8 provides a schematic of the structure of our online tool and the terminology we use to refer to various sections of the tool throughout our presentation of the methods employed.[130] We begin with the collection of key demographic information in a survey format, which is then followed by our experimental section. The experimental section is divided into: 1. the flood simulation, which encompasses ten scenarios; and 2. the gambling exercise. Finally, we return to the traditional stated preference survey section of the tool in order to obtain information about attitudes, preferences for risk and insurance, and more detailed demographic information about respondents.

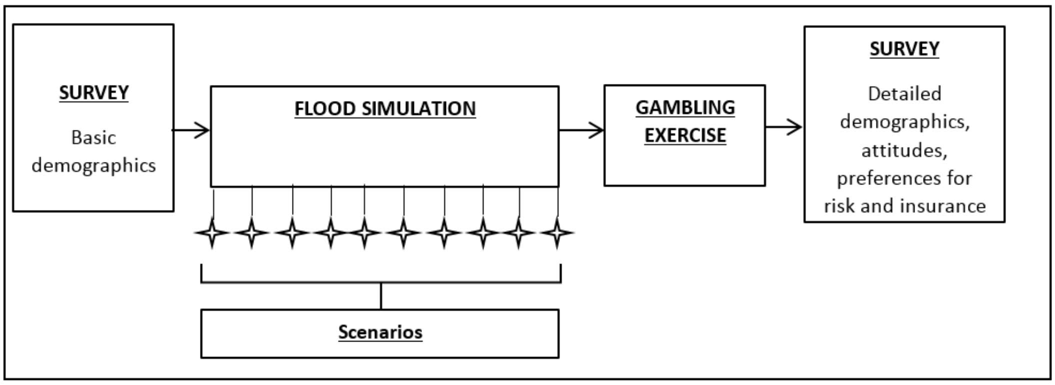


Figure 3.8 Structure of online tool

3.5.2 Our use of the online interface

Given the geographic location[131] of those affected by Hurricane Sandy, among other considerations (e.g., experimental controls), we chose to conduct our survey and experiment online. We coded the survey and simulation on the Qualtrics© user-interface and added

[130] To ensure clarification, extended definitions of these constituent sections of the online tool are provided in Appendix B.
[131] We collect the data remotely from London.

additional Java script for options that were not covered by the embedded interface (Snow, 2010).

We considered the use of crowdsourcing through Internet marketplaces for survey respondents. A number of articles (e.g., (Paolacci et al., 2010; Buhrmester et al., 2011) explore the viability of such clearinghouses (e.g., Mechanical Turk) for subject recruitment, agreeing that they are effective for random population sampling,[132] but much less suitable for studies that require more precisely defined populations.

Our research required a sample from the population directly (financially) affected by Hurricane Sandy; we employed the Qualtrics© Panel Management system to recruit our desired sample to ensure representativeness. In order to address some of the major issues related to the use of online interfaces for this type of research, we check the time that it takes each respondent to complete the survey and for uniqueness of IP addresses. Furthermore, we included a series of debriefing questions and allowed respondents to give their impressions and feedback about their understanding of the online task.

We followed guidance from Duflo (2004) in our calculation of necessary sample size and the division between sub-samples and treatment cohorts in order to ensure appropriate statistical power when analysing the garnered data; see Table 3.5. The treatment of presenting respondents with graphical explanation (i.e., tables) is discussed at length in Section 3.5.2.2. The nature of the survey was such that about 30% more data was collected from those affected by Hurricane Sandy; thus, within statistical limitations we sought to obtain the most information possible by skewing the number of respondents for the sub-sample towards those affected.

Table 3.5 Sample division between sub-samples and treatment cohorts

	Table treatment	No Table treatment	Total
Flood experienced	250	250	500
NO flood experienced	150	150	300
Total	400	400	

The base rate cost per interview was 7.20 USD. Respondents were additionally paid for the outcome of the flood simulation based on their choice in the gambling exercise. We ran a first pilot off-line with a convenience sample during the last week of February 2013. Once the online version of the tool was coded, a pilot of 80 responses for both cohorts (affected and unaffected) was run in the first week of May 2013. After rearranging some questions in the online tool, the actual data collection period lasted throughout the last two weeks of May 2013.

3.5.2.1 Flood insurance simulation

The flood simulation is situated immediately after we ask the user to provide basic demographic information (e.g., ZIP code), which we use to ensure that they fit the correct sample profile. The flood simulation starts with a detailed explanation of the activity, as reproduced in Figure 3.9.

[132] Found that while the sample of respondents obtained through Mechanical Turk does not perfectly match characteristics of the U.S. population, it doesn't present a wildly inaccurate view either.

Flood return periods
In each scenario, there are two possible outcomes: either there is a flood, or there isn't. The chance of a flood varies from one scenario to the next. It is described by the 'return period' of a flood: i.e. how many years would you expect to wait to experience a flood. For example, a flood that occurs once in 100 years is equivalent to having a 1% chance of flooding in any particular year.

What you should assume about government help and deductibles on the insurance policy
In order to keep the simulation simple, please assume that (1) there will be no government funds to compensate you for flood damage and (2) there is no deductible on the insurance policy.

Lab dollars
Before each scenario you will be given an endowment of 'Lab Dollars'. This endowment represents your property and belongings. 1 US Dollar is worth 10,000 Lab Dollars. The endowment in each scenario is Lab$ 30,000.

Our hope is that you will answer the questions as if you are thinking of the best course of action to take with your real money and property.

Simulation activity EXPLANATION

What is the aim of this activity?
Floods can damage your property and other belongings, but it is possible to purchase insurance to cover your losses. We would like to know how much you are willing to pay for flood insurance. We will present you with several scenarios.

Let's describe the simulation activity in more detail.

Figure 3.9 Detailed explanation of the flood simulation activity, as presented in our online tool

The simulation consisted of ten separate flood insurance scenarios. The scenarios were developed in five sets of pairs such that the expected loss was equal between the two, with variation in both the probability of flood and magnitude of loss from such a flood. In other words, we calculated a value $\hat{P}$, probability of flood, and $\hat{D}$, magnitude of flood damages for which in each of the five pairs of scenarios, the expected value with no insurance was equal; see Table 3.6. The calculated anchoring points were $\hat{D}$=7000USD and $\hat{P}$=0.14. This particular design allows us to look at whether individuals respond more to magnitude of potential damages or magnitude of probability, holding expected losses constant.

Table 3.6 Underlying flood scenario structure; pairing of risks and magnitudes

Probability	Magnitude of effect		Probability	Magnitude of effect		
P_1	$\hat{D}$	$(P_1, \hat{D})$	$\hat{P}$	D_1	$(\hat{P}, D_1)$	$E(P_1, \hat{D}) = E(\hat{P}, D_1) = A$
P_2	$\hat{D}$	$(P_2, \hat{D})$	$\hat{P}$	D_2	$(\hat{P}, D_2)$	$E(P_2, \hat{D}) = E(\hat{P}, D_2) = B$
P_3	$\hat{D}$	$(P_3, \hat{D})$	$\hat{P}$	D_3	$(\hat{P}, D_3)$	$E(P_3, \hat{D}) = E(\hat{P}, D_3) = C$
P_4	$\hat{D}$	$(P_4, \hat{D})$	$\hat{P}$	D_4	$(\hat{P}, D_4)$	$E(P_4, \hat{D}) = E(\hat{P}, D_4) = D$
P_5	$\hat{D}$	$(P_5, \hat{D})$	$\hat{P}$	D_5	$(\hat{P}, D_5)$	$E(P_5, \hat{D}) = E(\hat{P}, D_5) = E$
						where A > B > C >D > E

Respondents received a new and equal endowment of Lab$ 30000 at the start of each of ten scenarios, independent of the outcome in the previous scenario. Before the simulation began, respondents were told that the results from each scenario would be stored and used in the gambling exercise to calculate their final participation payment. Thus, though the budget across the simulations was hypothetical, Lab$ equated to USD values and the respondents were aware that they would receive an actual payout based on their actions with the hypothetical budget.

An example scenario was presented at the start of the simulation. This follows from findings on the importance of training sets that provide clarity about the task, but do not provide too great an up-front learning effect (e.g., Alexander & McKenzie, 1998; Le et al., 2010).

The subjective perception of risk plays a significant role in determining one's demand for insurance–this holds particularly true for disaster risks, for which people normally do not know the exact probabilities associated with the relevant outcomes. We provide respondents with full information–they are given the exact probability that a flood will occur and the magnitude of such a flood in terms of financial losses in Lab$–in order to try to reduce noise in the response data that would be attributable to uncertainty.

We included a loading of 15% on top of the actuarially fair price for insurance in each scenario in order to make the simulation more realistic. Furthermore, under EU Theory, any rational risk-neutral agent would purchase actuarially fair insurance; thus, the loading allows us to further differentiate the type of individuals who purchase insurance (Kunreuther & Pauly, 2004; Beider, 2009; Michel-Kerjan, 2010).

Table 3.7 gives the probability and damage magnitude values for the scenarios that constitute the flood simulation. The scenarios were presented in the same order to each respondent to reduce noise in the data. We avoided presentation of the scenarios in perfectly increasing or decreasing order (based on expected value) to ensure that respondents do not employ heuristics based on ordering.

Table 3.7 Details of flood scenarios within the flood simulation

Scenario	Probability Damage	Magnitude	Actuarially fair cost of insurance	Mark-up (15 %)	Insurance Cost	Expected Value from no insurance	Expected Value from insurance
		(Lab$)	*(Lab $)*	*(Lab $)*	*(Lab $)*	*(Lab $)*	*(Lab $)*
1	0.30	7000	2100	315	2415	27900	27585
2	0.14	15000	2100	315	2415	27900	27585
3	0.10	7000	700	105	805	29300	29195
4	0.14	5000	700	105	805	29300	29195
5	0.50	7000	3500	525	4025	26500	25975
6	0.14	25000	3500	525	4025	26500	25975
7	0.20	7000	1400	210	1610	28600	25975
8	0.14	10000	1400	210	1610	28600	25975
9	0.40	7000	2800	420	3220	27200	26500
10	0.14	20000	2800	420	3220	27200	26500

The respondents were informed of the percent probability of a flood occurrence and the Lab$ loss that would occur in the case that a flood event occurs. An example of the wording and structure used for each scenario is given in Figure 3.10.

Simulation #1

You start with Lab$ 30,000.

There is a **10%** chance that a flood will occur **(i.e. it will occur, on average, every 10 in 100 years)**.

In the case of a flood, you would experience damage of Lab$ 7,000.

The cost of insurance to cover the flood is Lab$ 805.

Please indicate if you would like to:

- a. Purchase NO insurance cover.
- b. Purchase insurance cover against a flood.

Figure 3.10 Example of the wording structure used to describe each scenario in the flood simulation

3.5.2.2 Graphical treatment

We developed a treatment to observe the impact of how information is presented visually to the respondent and the level of detail provided (relevant to risk probability and expected loss) on respondents' choices to insure throughout the flood simulation. The sample was divided into two cohorts based on the presentation of the flood scenario information: 1. narrative format with numeric details; and 2. graphical format through the use of tables which presented the potential outcomes of each scenario numerically for the respondent. As shown in Table 3.5, 400 respondents were exposed to the "Table treatment," 250 from the cohort that had experienced flooding from Hurricane Sandy and 150 who had not. Figure 3.11 infra provides an example of the flood simulation as presented to those in the "Table treatment" cohort. Figure 3.10, supra provides the non-treatment presentation of information for an example flood scenario.

Simulation #1

You start with Lab$ 30,000.

There is a **10%** chance that a flood will occur **(i.e. it will occur, on average, every 10 in 100 years)**.

In the case of a flood, you would experience damage of Lab$ 7,000.

The cost of insurance to cover the flood is Lab$ 805.

This table sets out the possible outcomes, depending on whether you purchase insurance:

	NO Flood	**Flood**
NO insurance	Lab $ 30,000 - 0 **30,000**	Lab $ 30,000 - 7,000 (damage) **23,000**
Insurance	Lab $ 30,000 - 805 (premium) **29,195**	Lab $ 30,000 - 805 (premium) **29,195**

Please indicate if you would like to:

- a. Purchase NO insurance cover.
- b. Purchase insurance cover against a flood.

Figure 3.11 Example of the structure used to describe each scenario in the flood simulation to those in the Table treatment group

3.5.3 Survey questions

Immediately following the experimental section of the online tool, we engage the respondent in a survey related to their past experiences with flooding (both generally and in the context of Hurricane Sandy), experience with insurance and risks, and demographic information.

In comparison to the Large-N survey tool used with our Ugandan sample there are less questions that are direct psychological inquiries in the Sandy survey. The flood simulation took significant time for respondents to complete and may have caused some cognitive fatigue; thus, it is likely that the inclusion of psychological questions would have caused response quality to suffer. With surveys much longer than 15 minutes in length response rates tend to decrease (M. Monroe 2013, per. comm. 12 January). In our case data quality appeared to decline as the survey length increased (questions are skipped, open-ends are less complete, less effort is devoted to questions at the end of the survey compared to the start) (Rathod & LaBruna, 2005).

In our early piloting we received overwhelmingly neutral responses–the respondents simply choose the middle choice with extremely high frequency.[133] One example is questions related

[133] This occurred whether we implemented a sliding scale or multiple choice response mechanism.

to Douglas and Wildavsky's cultural theory scale; to the best of our knowledge there are very few applications of this measure in online tools and none related to flood insurance demanded. Goebbert et al. (2012) administer telephone and online interviews tracking Americans' changed perceptions of weather over time–they report similar results for their panel data using both the phone and online processes. Lazo et al. (2014) conduct a small-N survey on communicating hurricane warnings and find cultural theory to not be a significant factor in the stated likelihood of evacuation.

A full copy of the survey is available in Appendix B. The major survey sections are described in brief, below.

3.5.3.1 Attitudes and perceptions–flood and insurance experiences

In this section of the survey we ask questions related to past experiences with flooding in addition to their relatively recent experience with Hurricane Sandy. The majority of the questions relate to flood damage and respondents' use of insurance.

We note that the claim may be made that past experiences affect insurance choices via the attitudes that they shape; we take this fact into consideration in the inclusion and structure of the questions in our survey, from the responses to which we then extrapolate attitudinal and perceptual factors. It is difficult to discern how attitudes towards risk are developed and altered; as noted in Chapter 2, there are a number of competing models and relatively little consensus between disciplines on this point. We have attempted to be holistic in our treatment of attitudes towards risk. Within the general EU Theory specification for risk attitudes, in our survey we have attempted to address findings from the cultural cognition of risk (Kahan & Braman, 2010), psychometric aspects (e.g., Slovic et al., 1985; Finucane et al., 2000), and social dimensions (e.g., Pidgeon et al., 2003).

All respondents are asked if they have experienced flooding (from natural disasters or other reasons) previous to that related to Hurricane Sandy. The cohort financially affected by Hurricane Sandy is then asked about the manner in which they were affected. We ask about disruption of services[134] and the type of direct (financial) losses they experienced.[135] We ask respondents to indicate their household's perceived risk of flooding compared to the average household in their area.[136]

In each loss category we ask those who have indicated a loss to estimate its magnitude. We also ask if insurance was held related to the loss type ahead of Hurricane Sandy and, furthermore, if they made an insurance claim on the loss. We ask respondents to indicate if they have experienced problems with claims made against Hurricane Sandy-related losses. Furthermore, we seek to understand if those affected filed claims with FEMA and sought assistance through FEMA claims or any other public programme, in lieu of or in addition to privately held insurance.

Risk perception has been noted to vary between risk categories; thus, we are interested in gauging the extent to which insurance purchases vary similarly. We ask all respondents regardless of their losses from Hurricane Sandy to indicate which types of insurance they hold

[134] From question 59 in the online tool; addresses loss of electricity, loss of water, loss of Internet, disruption of public transport.

[135] From question 121 in the online tool; addresses losses to home structure, home contents, automobile, health/life (of self or family)

[136] From question 80 in the online tool; area is defined as the 5-digit ZIP code.

at present, to rate their risk aversion in the financial realm on a Likert scale, and if they could adopt "insurance that completely covers flood damage on [his/her] house and home contents at an affordable rate, would [their] household be willing to pay for it?" This again relates to the fact that some people genuinely believe that they do not need insurance or, even if there is a risk, they are not interested in the coverage. Following from the finite pool of risk concept (Linville & Fischer, 1991) we ask respondents to provide estimated probabilities (0-100%) that their household will suffer from a number of different risks in the future.[137]

3.5.3.2 Demographic and socio-economic data

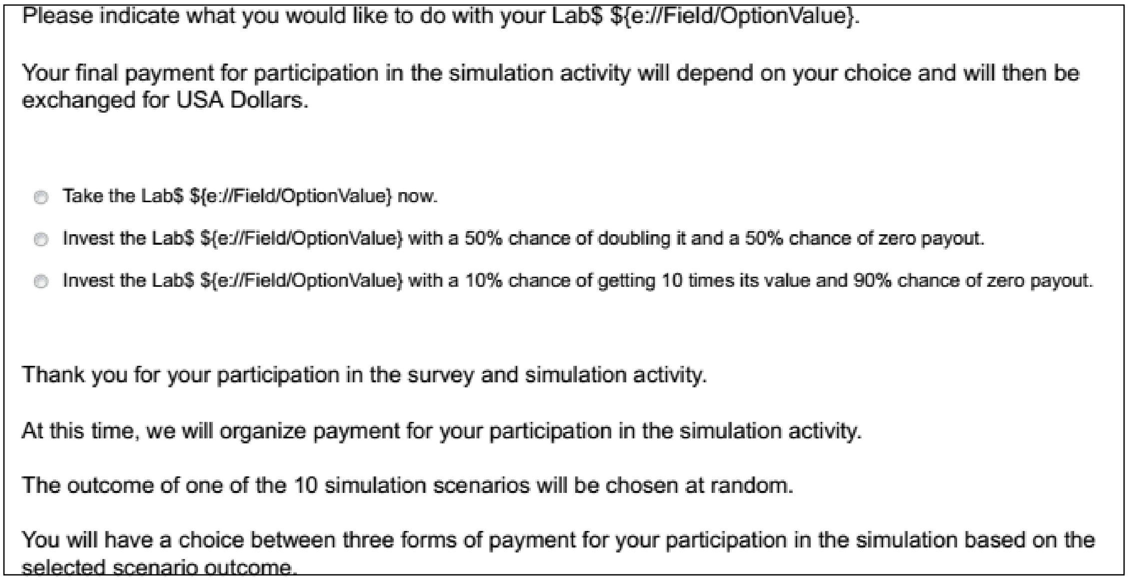
In this section of the survey we gather demographic and socio-economic data. The majority of questions are related to respondents' residential property with regards to its construction year and material, as well as how long the respondent has resided there. We obtain demographic and socio-economic details of the respondent, such as gender, age, terminal education level, and income (bracket). Furthermore, we take account of respondents' numeracy ability using selected questions from the Berlin Numeracy Test (Cokely & Galesic, 2012).

3.5.4 Gambling exercise

In order to look at the connection between insurance uptake and choices made in an exercise framed as a gamble we include an incentivised gambling exercise in our online tool after the survey questions. In Chapter 9 we further review past studies of gambling exercises relevant to our work.

The gamble is the last section of our online tool; the parameters of the gambling exercise are specific to the results of each individual's flood simulation activity. Meyer (2012) offered respondents a real payout based on their final net worth in his game, which accumulated over rounds of play. We make a variation on this payment mechanism–we treated the financial outcome of each scenario in the simulation singularly in order to encourage respondents to treat each scenario as a unique insurance purchase. Furthermore, this format was meant to discourage respondents from conceptualising the activity as a compound profit maximising game across rounds; though, resetting the endowment cannot completely negate this effect. Respondents are made aware at the start of the flood simulation that the outcome of one of the scenarios will be chosen at random for the gamble and final payout at the end of the survey section. In the final gamble section, the respondent is given one of three possible gambles on the USD value that equates to the Lab$ value of a scenario outcome: 1. take the payout with certainty; or 2. invest the endowment with a 50% chance of doubling it and a 50% chance of a zero payout; or 3. invest the endowment with a 10% chance of getting 10 times its value and 90% chance of zero payout. Figure 3.12 provides the gambling exercise as presented to respondents.

[137] From question 79 in the online tool; addresses terrorist attack, burglary, house fire, car theft, fire in car, flood/water inside dwelling, traffic accident. Each risk type is assessed separately, e.g., on its own scale.


Please indicate what you would like to do with your Lab$ ${e://Field/OptionValue}.

Your final payment for participation in the simulation activity will depend on your choice and will then be exchanged for USA Dollars.

- Take the Lab$ ${e://Field/OptionValue} now.
- Invest the Lab$ ${e://Field/OptionValue} with a 50% chance of doubling it and a 50% chance of zero payout.
- Invest the Lab$ ${e://Field/OptionValue} with a 10% chance of getting 10 times its value and 90% chance of zero payout.

Thank you for your participation in the survey and simulation activity.

At this time, we will organize payment for your participation in the simulation activity.

The outcome of one of the 10 simulation scenarios will be chosen at random.

You will have a choice between three forms of payment for your participation in the simulation based on the selected scenario outcome.

Figure 3.12 Gambling exercise in the online tool

3.5.5 Analysis of results—Hurricane Sandy

3.5.5.1 Perceived and actual weather

We compare respondents' perception of flood risk probability for their residence with rainfall records in a fashion similar to the comparison we undertake with the large-N Ugandan survey data against the TAMSAT weather data. To do so we look at self-reported household impacts from Sandy against: 1. the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS)[138] data (Funk et al., 2014) and 2. FEMA Modeling Task Force (MOTF)-Hurricane Sandy Impact Analysis data.

In order to compare rainfall information from CHIRPS with the responses from the survey data, we downloaded pentad (i.e., five-day average)[139] rainfall in NetCDF format from 2001 to 2014. The units of CHIRPS is in total mm/pentad. This data was organised by postal ZIP code and matched to the ZIP code information given by each respondent in our dataset and cross-referenced to geo-coordinates to obtain latitudes and longitudes (OpenGeoDB project)[140] for each state. Samples were matched by GIS coordinates (latitude and longitude) from CHIRPS rainfall data according to latitude and were converted into kilometres. In each state samples were grouped based on the area of 10 km x 10 km. CHIRPS pentad data used to compare responses from survey to Hurricane Sandy came from October pentad 6, and November pentads 1-4, 2012.[141] Apart from Hurricane Sandy, some participants reported that they were affected by other floods, such as river floods, sea floods, etc. Yet, no information on when these floods occurred was given. Most of the homeowners in the survey had been in their residence about ten years. We used CHIRPS rainfall data from 2001 to 2014 to compare with responses from these survey data.

[138] http://chg.geog.ucsb.edu/index.html

[139] Each of the first pentads in a month have 5 days, and the last pentad contains all the days from 26th to the end of the month.

[140] http://opengeodb.org/wiki/OpenGeoDB

[141] For CHIRPS rainfall data points to qualify as a flood, the average of the three consecutive pentads must be greater than or equal to 10 mm of rainfall.

Secondly, we look at reported home flooding in comparison to the FEMAMOTF Hurricane Sandy Impact Analysis data, which gives the relative impact zones in which survey households are situated. The MOTF integrates observed information throughout disasters to "ground-truth," and verifies impact assessments that are multifaceted.

3.5.5.2 Modeling flood simulation insurance choices—Mixed logit model

We create an econometric model for behaviour in a given round of the flood simulation. The simulation exercise yields a balanced panel dataset across respondents and ten scenarios to which we apply a mixed logit model. Each scenario counts as a single period for which we have information about the respondents' decision to insure; yield time variant data. Other observations (e.g., age) remain time invariant consistent for each respondent throughout the scenarios and as such are individual-specific, time-invariant effects.

The mixed logit is a highly flexible model that can approximate any random utility model (McFadden & Train, 2000; Train & Sonnier, 2005). Use of the mixed logit model alleviates three limitations associated with the standard logit by allowing for: 1. random taste variation, 2. unrestricted substitution patterns, and 3. correlation in unobserved factors over time. Additionally, unlike probit, the mixed logit is not restricted to normal distributions (Train, 2009).

In the standard logit model, the coefficients are fixed across respondents. In the mixed logit the estimated coefficients differ across individuals; in the form:

$$U_{njt} = \beta'_n \beta x_{njt} + \varepsilon_{njt} \tag{3.25}$$

Where x_{njt} is a vector of observed variables, the coefficient vector β'_n is unobserved for each person, n and varies in the population with density $\beta_n \sim f(\beta|\theta^*)$ where θ are the true parameters of the distribution, and ε_{nji} ~ idd and is an unobserved random term, independent of β_n and x_{njt}.

Then conditional on β_n is the probability that person, *n* chooses alternative *i* in period *t* under the standard logit formulation:

$$L_{ni}(\beta_n) = \frac{e^{\beta'_n x_{nit}}}{\sum_j e^{\beta_{n'} x_{njt}}} \tag{3.26}$$

Since, β_n is random and unknown, the unconditional choice probability is the integral of this logit over the density of $\beta_n$and is dependent on the distribution parameters of β_n.

$$Q_{nit} \int L_{ni}(\beta_n) f(\beta_n|\theta^*) d\beta_n \tag{3.27}$$

Then to use maximum likelihood estimation the probability of each individual's sequence of observed choices is needed, such that *i(n,t)* give the choice to insure the individual *n* makes in period *t*.

Conditional on β_n individual n's sequence of choices I s the product of standard logit estimations:

$$S_n(\beta_n) = \Pi L_{ni(n,i)t}(\beta_n) \tag{3.28}$$

The unconditional probability for the sequence of choices for the individual being:

$$P_n(\theta^*) = \int S_n(\beta_n) f(\beta_n|\theta^*)\, d\beta_n \quad (3.29)$$

The vector β_n varies over individuals in the sample, representative of their tastes. The goal of the mixed logit model is to then estimate θ^* such that it is the population parameters that describe the distribution of individual parameters. The log-likelihood function is:

$$\text{LL}(\theta)=\sum_n ln\, P_n(\theta) \quad (3.30)$$

Exact maximum likelihood estimation is not possible since this integral (3.29) cannot be solved analytically (Revelt & Train, 1998).

The simulated log-likelihood (SLL) function is given as:

$$\text{SLL}(\theta)=\sum_n \ln(SP(\theta)) \quad (3.31)$$

Use of the mixed effects model allows us to control for the different treatments in the simulation as well as the fact that there is variation in how each individual reacts to the treatment as well as the specification of a given scenario. Chapter 9 provides the specification of model variables and discussion of the estimated mixed effect model on insuring behaviour.

3.5.5.3 Comparing gambling and insurance choices

As noted previously, there has been research in post-flood behaviour that extrapolates expected insuring behaviour from stated preference responses to questions structured as a gamble (e.g., Page, Savage & Torgler, 2014).

We look at the correlations between choice of gamble and various scenario (financial) outcomes from the simulation in order to assess if these two measures are well-aligned. We then fit a model based on the same variables used in our model of flood simulation behaviour to the gambling choice in order to compare significant factors that are common to both and differ between the two.

The multinomial logit regression uses the same general set-up as the logistic regression; the difference is that for a multinomial logit the dependent variables are categorical in nature, opposed to binary (Wooldridge, 2010a). Use of the multinomial logit also relies on the assumption of independence of irrelevant alternatives (IIA) (ibid.).

We have a series of N observations and each data point *i* ranges from 1 to *N* and consists of a set of *M* explanatory variables: $x_{1,i}…x_{M,I}$ as well as an associated observed outcome, y_i which can take on one of K potential values that are separate categories (i.e., levels of gamble). We use the linear predictor function to predict the probability that observation I has outcome *K*:

$$f(k,i) = \beta_{o,k} + \beta_{1,k}x_{1,i} + \beta_{2,k}x_{2,i} + \cdots + \beta_{M,k}x_{M,i} \quad (3.32)$$

Where $\beta_{M,k}$ is the mth explanatory variable and the kth outcome.

This can be specified as a vector $f(k,i) = \beta_k(x_i)$ (3.33)

So, $\beta_k$is the set of regression coefficients associated with outcome *k* and x_i is the set of explanatory variables associated with observation *i*.

We look at *K* possible gambling outcomes, running *K-1* independent binary logistic regressions, in which there is a chosen reference category against which the other K-1 outcomes are separately regressed. The process takes the following form assuming that category *K* is the reference:

$$\begin{cases} ln\frac{\Pr(Yi=1)}{\Pr(Yi=K)} = \beta_1(x_i) \\ ln\frac{\Pr(Yi=2)}{\Pr(Yi=K)} = \beta_2(x_i) \\ \dots\dots\dots.. \\ ln\frac{\Pr(Yi=K-1)}{\Pr(Yi=K)} = \beta_{K-1}(x_i) \end{cases} \tag{3.34}$$

It is then possible to solve for the probabilities for the separate sets of regression coefficients introduced in 3.33:

$$\begin{cases} \Pr(Yi=1) = \Pr(Yi=K)\, e^{\beta_1 x_i} \\ \Pr(Yi=2) = \Pr(Yi=K)\, e^{\beta_2 x_i} \\ \dots\dots\dots.. \\ \Pr(Yi=K-1) = \Pr(Yi=K)\, e^{\beta_{k-1} x_i} \end{cases} \tag{3.35}$$

Chapter 9 provides variable specifications and a further discussion of the regression model.

4 Case Studies–context and descriptive statistics

4.1 Introduction

In this chapter we provide an overview of the two case studies (Section 4.2): 1. the rural Ugandan case study for index-based agricultural microinsurance (Section 4.3); and 2. the Northeastern USA case study of areas affected by Hurricane Sandy for indemnity-based home flood insurance (Section 4.4). Each case study is introduced in terms of geography and weather-related details. The context for each case study is provided with relevant details about available coping strategies, including the potential use of insurance and the social and political backdrops against which the coping and insurance decisions are made.

Descriptive statistics are provided for samples in each location (Section 4.5 for Uganda and Section 4.6 for Hurricane Sandy). The descriptive statistics were chosen such that, to the extent possible,[142] the details could be checked against population information to gauge sample representativeness.

4.2 Case study choices

Two case study areas were chosen in order to assess knowledge gaps relevant to the adoption of agricultural microinsurance in the developing country context and the adoption of home flood insurance in the developed country context. In each context, we strove to choose a case study where a relatively large proportion of each population faces pressing low-probability, high-consequence events in an effort to identify possible improvements in the structure of insurance tools provided.

The first case study focuses on agricultural microinsurance uptake in rural Uganda; there we use mobile technology to obtain stated preferences and integrate two field games related to perceptions of insurance and risk. The second case study examines households in the area affected by Hurricane Sandy in the USA; it includes an online survey and simulation related to home flood insurance. In the developing country context we were interested in locations that did not yet have formal agricultural microinsurance in place,[143] but were highly dependent on small-hold agricultural development. In the developed country context, we strove to find an area with a sample recently affected by home flooding.

The case studies were employed in order to assess influence on insurance demand by aspects related to households' 1. economic (e.g., budget constraints); 2. social and cultural (e.g., trust and peer effects); 3. structural (e.g., perceived risk exposure); and 4. personal and demographic factors. These are the four main factor groupings that form our conceptual framework for insurance demand, as presented in Chapters 2 and 3. Our specific research aims and objectives differ between the two case study locations given the fact that insurance is often location and

[142] A number of direct in-person discussions with the Head of the National Agricultural Advisory Service (e.g., M. Musheshe 2012, pers. comm., 27 September) as well as contact mediated through Grameen Foundation Uganda (e.g., J. Matovu 2011, pers. comm., 26 August) did not yield regional population data suitable to our research interests. Furthermore, publicly available data sources, such as the "National Population and Housing Statistics: Preliminary Report" (UBOS, 2014), yield little relevant population data.
[143] This decision was taken in part because it is documented (e.g., Radermacher & Roth, 2014) and anecdotes (M. Karanji Kariuki 2015, per. comm., 16 February) indicate that households that have dropped out of a microinsurance scheme tend to be unlikely to enter into another.

issue specific; however, we draw some parallels between the two cases, which may help build further understanding around general tenets of insurance purchasing behaviour.

4.3 Rural Uganda–context

4.3.1 Geography and overview

Our mobile survey and field games in rural Uganda were conducted in two districts: Oyam (north) and Kapchorwa (east). Uganda is divided into 111 districts and one city across four administrative regions (UMLG, 2015).[144] Figure 4.1 provides the location of Oyam and Kapchorwa within Uganda. In 2010, the estimated population of Oyam and Kapchorwa was 340,000 and 87,000, respectively (UBOS, 2010b). Our survey yielded 3,178 useable responses: 1,360 from Oyam and 1,818 from Kapchorwa .

Oyam is part of the Lango sub-region of Uganda in an area called Ascholiland. Oyam town lies at: 02 14 04N and 32 23 06E at an altitude of 900 m. Oyam district is in northern Uganda, bordering the Gulu region, which was plagued by civil war from 1986 to 2006 and is still in the beginning stages of recovery, which affects productivity (Finnström, 2008; Kapferer & Bertelsen, 2012).

Kapchorwa, in eastern Uganda, borders Kenya and encompasses Mt. Elgon (NEMA, 2007). The district is 5,197 km^2, with altitudes ranging from 1,000 m in the lowlands to 2,000 m in the highlands (NEMA, 2007). Kapchorwa town lies at the coordinates: 01 24N, 34 27E (ibid.).

Figure 4.1 Rural Uganda case study regions: Oyam (02 14N and 32 23E) and Kapchorwa (01 24N and 34 27E)

These two regions differ in terms of perceived average budget constraints and geographic location. Features of the two regions cover the gamut of characteristics of other areas within rural Uganda making them representative communities (J. Matovu 2010, per. comm., 15 December). Furthermore, the CKW Network exists in both of these regions which facilitates the

[144] The geographic divisions of Uganda are in flux. At the time of the 2002 Census, there were only 56 districts. County and sub-county data was used to determine figures for the districts created or altered since this census.

conduct of the studies and was necessary for the methodological approach we chose. The major economic activity in both areas is small-scale subsistence farming. Though tourism around the Mt. Elgon region and neighbouring Kenya allows Kapchorwa (at the aggregate opposed to farm-level) to act in the capacity of establishing prices relative to the regional supply curve (e.g., M. Musheshe 2011, per. comm., 3 April). In comparison, Oyam's farmers tend to demand lower prices for their crops on the market, as the area is geographically remote and borders poorer regions. Kapchorwa's position as a tourist destination means that more detailed information is publicly available on the region and relatively more development projects are in existence there (J. Matovu 2010, per. comm., 15 December).

The structure of the Ugandan economy is slowly changing; since 2007 services have been the leading sector, accounting for 52% of the GDP (Namakonzi & Inanga, 2014). Yet, the country is among the poorest nations, with 37.7% of the population living on less than 1.25 USD a day (MFPED, 2005) . Despite making enormous progress in reducing the countrywide poverty incidence from 56% of the population in 1992 to 31% in 2005, Uganda's Human Development Index score (UNDP, 2014) places it at 164 out of 187 countries (and territories). Poverty remains deep-rooted in the country's rural areas, where more than 85% of the population resides (Kisamba-Mugerwa, 2013).

Agriculture is widespread throughout Uganda; recent trends indicate that the contribution of agriculture to total GDP has decreased from 46% (1996) to 30% (2009). Agriculture remains the main contributor to total employment in the country–increased from 66% (2003) to 73% (2006) (ibid.). These two facts—less GDP from farming and relative increases in employment in the farming sector—indicate that farmers in Uganda are likely becoming poorer on average.

4.3.2 Farming methods and crops

Almost all Ugandan districts cultivate maize, beans, and groundnuts as staple crops (Kiconco et al., 2013). Coffee is also cultivated in most districts, and is a popular cash crop in Kapchorwa, the average holding is 0.33 ha per household (MAAIF, 2010). Generally, maize and beans are intercropped and are therefore similarly exposed to extreme weather effects.

Maize is a staple crop with relatively low-level risk and is grown in two seasons throughout the year in both areas: March/April to July and September/October to December (FAO, 1997; Kiconco et al., 2013). Uganda has an equatorial climate, experiencing humid conditions and moderate temperatures throughout the year, with mean daily temperatures of 28°C (MFPED, 2000). Its climate is bimodal, exhibiting two rainy seasons appropriate for cultivation (March-June and October-January). Table 4.1 provides a list of the predominant crops and livestock in each region.[145]

Farming methods in these two areas are traditional and have not seen much technological change. This is consistent with findings in the literature on technological advancement in farming methods in poor rural developing areas (Reardon et al., 1998). Limited water resources and financial resource constraints prohibit active field irrigation and widespread use of mechanised ploughs. There are extreme limits on active mitigation against climate change related risks. For example, boreholes are invaluable; however, in our study only 1% of

[145] Though the average crop-mix farmed may appear more diverse in Oyam, generally the market value of these crop-mixes is lower than most holdings in Kapchorwa.

respondents had ownership over one due to financial constraints. In his assessment of Ugandan borehole drilling capacity, Sloots (2010) notes that the implementation environment (fragmented market, unfavourable tax environment, and lacking regulation) is unfavourable.

Yet, the seed sector relies on a relatively low-performing public breeding programme—foundation seed is low quality[146] and there are few active breeders as a product of a weak seed policy and regulatory framework (TASAI, 2015).[147] In turn, Uganda has a clear problem with fake seed sales (Joughin, 2014). At present, Uganda has released only 12 varieties of the TASAI index's key crop, maize, while Kenya has released 35 and South Africa, 221. In Uganda it takes three years for new seed varieties to be transferred from breeders to farmers, whereas it is two years in Kenya and one year in South Africa (TASAI, 2015). There is momentum in the Ugandan private seed sector that could provide timely improved varieties to smallholder farmers at affordable prices; however, this remains dependent upon developments in regulation and the potential for enhanced access to credit by farmers (Mabaya et al., 2015). One co-benefit of agricultural microinsurance in Uganda may be provision of greater confidence by creditors, allowing for development of a more robust seed sector.

Table 4.1 Predominant crops and livestock types by region

Predominant Crops Farmed	
Kapchorwa	**Oyam**
(Irish) Potatoes	Cotton
Coffee	Bananas
Simsim	Matooke
Beans	Beans
Millet	Millet
Wheat	Yams
Sunflower	Pineapples
Tomatoes	Maize
Cabbage	Groundnut
Cassava	Cassava
Groundnut	
Passion Fruit	
Predominant Livestock Kept	
Kapchorwa	**Oyam**
Cattle	Cattle
Goats	Goats
Sheep	Sheep
Pigs	Pigs
Chicken	Chicken
	Rabbits

Most farming households have a source of secondary income outside of small-scale sale of crops on the local markets. The main source of supplementary income comes from small shop ownership, local participation as an educator, working at the local level for an NGO, community moneylending, and renting personal assets (e.g., J. Matovu 2011, per. comm. 16 April;

[146] Foundation seed is designated by an agriculture experiment station. It is the source of all other certified seed classes, either directly or through registered seeds.

[147] The African Seed Access Index (TASAI) monitors the state of Africa's seed sector and highlights problems that prevent seeds from reaching farmers. TASAI is a partnership between Cornell University and the development organisation, Market Matters. The pilot stage of TASAI has assessed seed markets in Kenya, South Africa, Tanzania, and Uganda.

Mazurana et al., 2014). In the empirical data we see that one grouping element is clearly the percentage of income that a household obtains from activities outside of farming.

4.3.3 Challenges to resilience in agriculture

4.3.3.1 Extreme weather

There are two climatic variables of central importance in determining agricultural success: rainfall and temperature, which have been fairly monitored and recorded throughout Uganda over the years with some gaps in on-the-ground weather records (MWE, 2010). The Ugandan Meteorology Department under the Ministry of Water and the Environment (MWE) originally had 1,000 on-the-ground weather stations spread throughout the country to provide a dense network of climatic data (MWE, 2010). Yet, due to political turmoil throughout the 1970s, most got damaged or were neglected; thus, by 2001, only 60 weather stations were operational (NEMA, 2007). These were too scarce to provide enough climatic data to cover the country, and even those still running (e.g., one near Kapchorwa town) were not recorded in a manner viable for longitudinal datasets (MWE, 2007).

Osgood and Shirley (2012) demonstrate the value of improved data in allowing lower insurance prices and the value of remote sensing in determining the index value for index-based agricultural insurance applications in Africa. There are tools that help get around the issues posed by poor on-the-ground weather records. In recent years satellite datasets have been employed to help determine appropriate weather-based indices. One such data source is TAMSAT (Tropical Applications of Meteorology using SATellite data and ground-based observations) (Maidment et al., 2014), which uses satellite imagery, calibrated against ground observations for estimating rainfall across the African continent.

Climate related events in Uganda are estimated to contribute to over 70% of natural disasters and destroy an average of 800,000 hectares of crops annually producing economic losses in excess of 120 billion UGS (~37 million USD) (NEMA, 2008). In a review of studies-predicted rainfall in East Africa, Goulden (2006) notes a likely increase of at least 7% by 2080, and changes in the seasonal distribution.

There are a number of minor localised flood and drought events that reduce productivity on individual farms, reported to occur as frequently as one in four years. It has been reported that 7% of the country's 3.95 million agricultural households are prone to flooding, with most incidences in Eastern Uganda (MAAIF, 2010). Though, in 2007, floods followed the heaviest rains in 35 years in the northern regions near Oyam with reports of major crop destruction and water-borne illness. Further, of the 2 million agricultural households that experienced food shortages, over 1.8 million (91.5%) experienced drought and 1.3 million (66%) were beset by pests or diseases (MAAIF, 2010). Crop production has been negatively impacted by these weather hazards; an average of 800,000 ha of crops are destroyed annually by climate-related effects, resulting in losses exceeding 47 million USD (NEMA, 2009).

Impacts of these events are long-lived and, due to their covariate nature, make it increasingly difficult for affected households to recover. Generally, due to differentiated topography and climate, farmers in Oyam tend to be more exposed to drought (though localised floods occur),(J Matovu 2011, per. comm., 6 April), while farmers in Kapchorwa tend to be more exposed to floods, especially flash floods due to heavy rains and landslides associated with Mt. Elgon (IISD, 2013).

There are a number of well-documented cases of extreme weather events for Kapchorwa.[148] The lower parts of Kapchorwa are generally drier than the more mountainous peaks, as they lie under the Karamoja climatic belt (IISD, 2013). Yet, since 2007 there has been a departure from normal weather patterns conditions with the occurrence of floods followed by prolonged intense periods of drought in this area (MAAIF, 2010). The Kapchorwa District experienced massive soil erosion on a large number of farms as a result of the 2007/2008 floods (NEMA, 2009). In September 2010, further flood disasters in the area lead to rotting cassava and groundnuts with losses estimated at over 3.1 million USD (UNPF, 2009).

Droughts are less frequent than localised flood events in Uganda, but, when they occur, they tend to be severe. The last major drought was during the 1999/2000 growing season, during which the drying of wells and boreholes lead to cattle deaths and food insecurity throughout the northeast cattle corridor (NEMA, 2009) These extreme events demonstrate the long-term damage that can be done when there is not sufficient means of coping provided immediately after and justify the need for agricultural microinsurance to be available to rural Uganda farmers.

4.3.3.2 Land Tenure

Land tenure is an issue in some Ugandan regions and is a particularly salient in areas that may not be covered by land titles (ECA, 2005), which is common in areas with customary land ownership – where land is partitioned to individuals through clan leaders, such as Oyam. Land tenure affects farming practices and the scope of coping through use of new land, as it controls land availability and assignments within clans. In practice, this method makes land acquisition relatively elastic, as there is always a supply to someone in good-standing with the clan for low or no cost (W. Okello 2011, per. comm., 18 April). There is limited formal tenure security; only 18 percent of land is registered and titled in accordance with government regulation throughout Uganda (World Bank, 2012). There are assurances against land reclaim embedded in the *Land Act 1998* and the *Land (Amendment) Act 2010* to reduce land right uncertainties; however, land-grabbing by individuals and conglomerates outside Uganda has begun in the areas just north of Oyam (e.g., Gulu) (ibid.).

The main objective of the 1998 Land Act was to operationalise land reforms (Wandukwa, 2004); the act recognises a number of land tenure types, e.g., customary, freehold, and leasehold. Customary tenure is by far the most widespread tenure type in Uganda (Uganda Land Alliance, 1997; Xavier, 1997; Bomuhangi et al., 2011); this is true in both Kapchorwa and Oyam. Respondents to a large-scale survey by Bomuhangi et al. (2011) indicate that farmers in Kapchorwa feel that they have relatively secure land-use rights. There are significant discrepancies between self-reported land rights and documented land rights, especially for women (Bomuhangi et al., 2011).

The majority of traditional export crops (e.g., coffee, tea) as well as locally consumed food crops (e.g., maize, beans, ground nuts) are produced on customary land by smallholder farmers (ECA, 2005) on farms averaging 0.5 to 1.0 hectares (NEMA, 2007). Larger farms tend to be more

[148] Due to greater dependence on cash-crop farming than in Oyam, losses in Kapchorwa tend to be recorded at the national level (M. Musheshe 2011; per. comm., 13 November).

commercial; however, land constraints in Uganda are among the most extreme globally, at about 0.07 ha per capita (World Bank, 2011b).[149] Yet, it should be noted that median Ugandan household classified as *non-poor* cultivates 2.2 ha of land on average, which is only 0.6 ha more than the average poor household (NEMA, 2007). To this point, current calls for reforms within Uganda focus less on land holdings, but rather other structural changes that can be made to help increase farming resilience (World Bank, 2012).

Land scarcity is an emerging threat as the Ugandan population continues to grow. Yet, encouragement of better use and spread of technologies to increase farm productivity and insurance to safeguard income from farming can aid in this issue (César & Wolf, 2013).

4.3.3.3 Cyclical poverty, barriers to competitiveness, and idiosyncratic challenges

The most frequently self-reported causes of poverty in Uganda are noted as: poor health, limited access or shortage of land, lack of market access for produce, unemployment, high taxes, lack of education, large family size, low productivity and lack of credit facilities (NEMA, 2007; RWI, 2014).[150] As noted previously, the rural poor are highly vulnerable to hazards associated with extreme weather events, in part, because they have limited means by which to diversify their resources and technology. Coping capacity is already low and the frequency, severity, and/or scale of impacts from covariate hazards often exceeds their traditional coping mechanisms. In addition, there are often cascading effects from the underlying structures or idiosyncratic risks that may occur in the same time period.[151]

Proper storage for crops can be relatively costly and household budgets depend upon income immediately following harvesting periods. Since they cannot afford to wait one to two months to sell, when they would receive prices three to five times higher, these post-handling problems cause them to sell immediately after harvesting when the prices are low and exploitative because the supply is so much higher than the demand (Mubiru et al., 2009). This poor post-harvest handling presents a major barrier, which prevents Ugandan farmers from escaping cyclical poverty (Roothaert & Muhanji, 2009; IFAD, 2010).

Transport infrastructure is lacking throughout much of Uganda–the maintenance of most rural roads has been inadequate (Ranganathan & Vivien, 2011), which affects both farmers' access to inputs and forces low prices for crops on the market. Some farmers pool money to rent a truck to transport crops to a central market area – this is especially important in Oyam, which is somewhat isolated. Yet, this can be expensive and depends on simultaneous harvesting. Most farmers tend to sell their surpluses to middlemen who take the crops to village trading centres, which reduces the farmer's profit margin (Roothaert & Muhanji, 2009).

There are reports that fertilizers, seeds, and chemicals in Uganda can be up to 50% more expensive than the same product in Kenya for a comparable farmer (Matsumoto & Yamano, 2009). The rational response eastern Ugandan farmers take to this unfavourable output/input price ratio is to apply fertilizer in very small amounts, if any, to their maize fields in contrast to their counterparts in western Kenya (World Bank, 2011b). Acquisition of credit under volatile

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[149] This land endowment is about 4.5 times lesser than the average per capita across sub-Saharan Africa.
[150] Not listed in any particular order.
[151] The focus in this thesis is not on idiosyncratic risks, but they deserve some mention given their prevalence in the rural Ugandan sample and the fact that their realisation can compound effects from covariate hazards.

weather and output price unpredictability is too costly for many Ugandan farmers, irrespective of their scale of production (Roothaert & Muhanji, 2009).

There is a correlation between environmental degradation and resource-based conflicts and insecurity (e.g., Masari, 2006; Onuoha, 2009);, which is exemplified by the example of the Karamojong agro-pastoral herders living mainly in Nnortheastern Uganda. Despite an increasing shortage of grazing land, many residents consider livestock rearing the most reliable and lucrative supplement to farming activities (Himmelfarb, 2007). The cattle corridor of Uganda runs through the lower regions of Kapchorwa and across the Karamoja region. Given low-level rainfall and poor soil fertility, there is chronic food insecurity in the area (IISD, 2013).The Karamojong have been involved in various conflicts centred on the practice of cattle raids in Kapchorwa, which has implications for Kapchorwan farmers' risk perceptions over ownership of cattle. Moyini (2004) documented water and pasture use conflicts as the key causes of insecurity in the regions bordering the Karamoja region, which include both Kapchorwa and Oyam.

4.3.4 Coping and the potential use of insurance in Uganda

In developing countries, ex-ante and ex-post coping strategies may provide some protection against the devastating results of extreme weather; however, considerable risks often remain (Morduch, 1998; Dercon, 2002; Collins et al., 2009). As noted previously and further discussed in Chapter 6, holding cattle for capital is a prevalent practice for ex-post coping that requires ex-ante planning. There are limitations, however, on the potential sustainability of this practice (e.g., Mubiru et al., 2015). There appear to be low-levels of both formal and informal financial engagement throughout Uganda. The statistics bear this out. Only 18% of Ugandan households use formal financial services (e.g., bank accounts) and 3% report using semi-formal financial services (e.g., micro-financing or savings and loan cooperatives). This minority contrasts with the 62% of households who report not using of any type of financial service (Uganda FinScope, 2007; World Bank, 2010b).

A number of on-farm practices may be applicable for medium-term coping, such as: increased mulching; intercropping; increased planting of food security crops; and water harvesting for domestic consumption (Mubiru et al., 2015). However, NGOs, intergovernmental organisations, and the Ugandan government increasingly recognise the need for farmers to have access to capital that enables greater use of technologies and advisory services to cope with the negative impacts of extreme weather events (e.g., UNDP, 2013; M. Musheshe 2011; per. comm., 13 November). While the introduction of indexed insurance schemes would help farmers manage these risks, those schemes need to be tailored to the needs of the potential consumers–which does not necessarily mean universal adoption of insurance. Furthermore, ideally, preventive measures based on new information technologies, (including social networks, information and communication technology [ICT] such as mobile phones, and other technological penetration methods) should accompany them.

Mobile phone technology is one of the few technologies that has permeated the Ugandan market in recent years and is being leveraged for financial services (e.g., mobile money) and dissemination of farming information (e.g., weather forecasts). In 2008, 8.56 million mobiles were in use, making Uganda sixty-eighth in terms of countries having the most mobile phones. The private-public ownership agreement that lead to sharp telecommunications reforms starting in the late 1990s through Mobile Telephone Networks (MTN) Uganda Limited assured cellular towers in all counties (IFC, 2011). Providing better communication and strengthening interconnectedness of social networks with a greater geographic spread has created a more efficient market for remittances, for example.

4.3.4.1 Regulatory backdrop and current status of agricultural microinsurance in Uganda

Differing regulatory backdrops across countries in eastern Africa is cited as a challenge in the transfer of successful microinsurance tools to Uganda (Smith & Watts, 2009). Setting up partnerships between farmer aggregators, government, and insurance companies differs between countries. Furthermore, regulations limit the nature of the role agricultural service providers can take on and allowable fee structures (Njenga, 2015).

Bank sector regulation in Uganda provides a tiered structure for the use and provision of loans and credit, which may explain households' low-level use of formal credit, but also has implications for the channels of distribution available to insurance providers (Smith & Watts, 2009). These regulations, the *Financial Institutions Act 2004*, the *Micro Finance Deposit-Taking Institutions Act 2003*, and the *Cooperative Societies Act 1991* have restricted banks and MDIs to distribution on loans only that they have given and well as providing guidance on acceptable intermediaries in the process.

Uganda has developed insurance sector-specific regulation and has started to implement it during the last decade in order to drive development of the formal market and to make it more appealing to foreign participation (Smith & Watts, 2009). Since the formal insurance sector regulation[152] and supervision are relatively new throughout Uganda until recently there was hesitation in agricultural microinsurance development, as there is no precedent in Uganda (M. Mushshe 2010, per. comm., 19 November; N. Jazire 2015, per. comm., 4 June).[153] At the point in time the research reported in this thesis was undertaken, there was no formal agricultural microinsurance offered in Uganda (IRAU, 2013).

Recently there have been advancements in plans to deploy indexed agricultural insurance in Uganda. The government has formed a National Weather Index Insurance Task force to develop the Agricultural Insurance Strategy (MAAIF, 2014). The agriculture insurance potential for Uganda is estimated to exceed 150 million USD, making it an appealing market for both farmers and insurance firms (I. Kaddunnabi 2015, per. comm., 21 January).[154]

The Kungula agroinsurance[155] scheme is in the early stages of offering limited coverage of the country's farmers for crop and pasture losses due to drought and/or excessive rainfall. It is a system based on microinsurance indexed by rainfall data collected at the nearest weather station and remote sensing satellite data[156]. The programme has been structured to implement indexed microinsurance to aid in increased availability of "quality seeds and plant materials to enhance productivity and production of strategic agricultural commodities" by enhancing access

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[152] The main law governing insurance business in Uganda is The *Insurance Act 1996* as amended by the *Insurance (Ammendment) Act 2011*.

[153] Newton Jazire is a Managing Director for Lion Assurance.

[154] Ibrahim Kaddunnabi is the Executive Director of the Insurance Regulatory Authority. It is unclear if the noted email communication came directly from Mr. Kaddunnabi or another individual in his office.

[155] Kungula means to "harvest" in the Luganda dialect of Uganda. This product is supported by six Ugandan insurance companies: Lion Assurance, APA Insurance, First Insurance, NIC, NIKO, UAP and aBi Trust. It is supported by data from SwissRe and EARS BV, Netherlands. In addition to indexed crop microinsurance, livestock all risks mortality (ARM) insurance is offered by the group.

[156] Satellite data collected by EARS Earth Environment Monitoring.

to credit (D. Munyaradzi 2015, per. comm., 18 May). This step is of great importance due to previous limitations on loan access from banks; with the linking of credit and insurance, if rainfall is not enough for healthy crop growth during any part of the growing period, the farmer should receive an insurance payout that will be offset against his outstanding loan amount (ibid.). Given the early stage of product rollout and current (late 2014/early 2015) drought conditions (WFP, 2015a)[157] first estimates of market conditions for Kungula were not available (L Forichi, 2015, per. comm., 12 May).[158]

4.3.4.2 Insurance models in neighbouring areas

The R4 Rural Resilience Initiative (R4) has demonstrated that in their sample insured farmers save more than twice compared to the uninsured; furthermore, the insured have higher investments in seeds, fertiliser, and productive assets (e.g., ploughs and cattle) (WFP, 2015b). R4 was created as a strategic partnership between the UN World Food Programme (WFP) and Oxfam America in 2011 and is currently active in Senegal and Ethiopia with pilots in Malawai and Zambia. R4 builds on the Horn of Africa Risk Transfer for Adaptation (HARITA) project, which was created in 2009, in Ethiopia (Greatrex et al., 2015).[159] The goal of the partnership is to enhance the resilience and food security of rural households that are vulnerable to climate risks (Greatrex et al., 2015).[160] One of the highlights of the product is that farmers can access insurance by paying with their labour through Insurance-for-Assets (IfA) schemes; IfA schemes are built into either existing government social safety nets or the WFP's food assistance for assets programme (WFP, 2015b) The concept is that creating rural financial markets builds long-term security. Having the farmers make cash payments for these insurance tools fosters sustainability without the need for outside donors.

The Agriculture and Climate Risk Enterprise (ACRE) is the largest index insurance programme in the developing world where farmers pay a market premium, and the largest agricultural insurance programme in sub-Saharan Africa (operating primarily in Kenya and Rwanda) (Greatrex et al., 2015). The project was formerly known as the Kilimo Salama, but developed into its current form as a for-profit social enterprise in June 2014. The program is expected to reach 3 million farmers across ten countries by 2018 (B. Njenga 2014, per. comm., 15 November).[161]

ACRE is characterised by its use of a wide range of products based on several sources of data, including: automatic weather station data and data from remote sensing technologies; its role as an intermediary between insurers, reinsurers, and distribution channels including

[157] To the best of our knowledge the Kungula agroinsurance was not yet piloted in our sample regions (J. Matovu 2015, per. comm. 14 May).

[158] Lovemore Forichi is Vice President (Property and Specialty) at Swiss Re Insurance. Note that it is unclear if the noted email communication came directly from Mr. Forichi or another individual in his office.

[159] HARITA was developed by Oxfam America and the Relief Society of Tigray (REST) with input from Ethiopian farmers, and a number of national and global partners. The program has grown from 200 farmers in 2009 to over 26,000 in 2014.

[160] R4 represents four integrated risk management strategies: 1. Risk reduction: in terms of access to improved climate change risk management tools such as crop rehabilitation and agricultural extension techniques to reduce the impact of years without adequate precipitation; 2. Risk reserves: access to personal or community savings to either build a larger financial base for investing in livelihoods or to provide a buffer for short-term financial needs due to shocks; 3. Risk transfer: the transfer of risks that cannot be reduced through other means (i.e., low-frequency, high-impact extreme weather events); and 4. Prudent risk taking: access to microcredit where micro-financing institutions may be unwilling to provide credit because of high risk or insufficient capital to prevent the risk of default.

[161] Benjamin Njenga, Head of Business Analytics, ACRE Africa.

microfinance institutions; and its links to the mobile money market (M-PESA[162] scheme in East Africa) that allows farmers to enrol via mobile telephone. Farmers can trial the product by insuring as little as one bag of seed. Insuring one acre of maize against drought costs a farmer about 37 USD (i.e., 10% of harvest value) (B. Njenga 2014, per. comm., 15 November). Any payout is transferred to the farmer's "mobile phone wallet" at the end of the season. ACRE's new hybrid product combines a weather index and MPCI; unlike current pure MPCI products, the new hybrid product provides a full season of cover, including during crop germination (ibid.). ACRE has plans to run a market analysis for Uganda in order to assess client demand and feasibility of launching a tool in that market (M. Karanji Kariuki 2015, per. comm., 16 February).

The differing insurance regulatory environment across countries in eastern Africa presents a challenge for setting up index insurance markets (Njenga, 2015); regulations on the role of agricultural insurance service providers and allowable fee percentages vary widely making partnerships with government institutions, farmer aggregators, and insurance companies who carry part of the risk complex (L. Forichi 2015, per. comm., 12 May).

In Uganda in the past agricultural microinsurance schemes were suggested that were transfers of products that showed signs of relatively high uptake elsewhere, but which are not appropriate for local conditions (N. Jazire 2015, per. comm., 4 June). For this reason, the Kungula agroinsurance scheme has started on a limited level and only covers maize production at present (ibid.). There seems to be awareness of the need to develop indexed microinsurance tools that are appropriate for differing cohorts, opposed to pushing for universal application of insurance.

4.3.5 Community Knowledge Worker (CKW) Network

As noted previously, the structure of the CKW Network–well-respected farmers within their own communities and chosen by their peers–afforded us a potential network to roll out microinsurance. These CKWs would then act as conduits sharing new agricultural information with their local community, including: improved agricultural practices; service/input providers; and weather and market conditions. "Since CKWs are invested in their community, they often take an active role in diagnosing their neighbours' farming challenges and following up with farmers on the implementation of new agricultural practices" (Culbertson, 2013). Although similar to the use of argovets (i.e., agro dealers) by ACRE, the advantages of using the CKW network include the fact that they have fewer self-interested conflicts with both the individual farmer and the Grameen Foundation in addition to lower transaction costs (e.g., disbursement of compensation).

The CKW pilot phase was launched in Uganda during 2009 and our research depended upon the use of this network. Therefore, Uganda was the natural choice for the research locations. And our research leveraged off of this existing human capital and infrastructure for the deployment of both qualitative (i.e., focus groups) and quantitative (i.e., survey and field experiments) tools. The CKW networks in Oyam and Kapchorwa were among the longest running, which provided the advantage of increased trust in Grameen and its advisors by the CKWs and the wider communities, as well as the greatest pool of pre-registered farmers with IDs. Among the districts

[162] M-PESA (M for "mobile," "pesa" is Swahili for money) is a mobile-phone based money transfer and microfinancing service, launched in 2007 by Vodafone.

served by the CKW network in 2010-11, Oyam and Kapchorwa were the two most geographically diverse,[163] while still maintaining high ratings for CKW responsiveness, which was important in our choice of study areas.

4.4 Northeast USA and Hurricane Sandy–context

The American case study compares demand for home flood insurance between those affected and those unaffected by Hurricane Sandy. This choice of case study allowed us to address the goal of examining elements of our proposed conceptual framework in addition to having access to a sample temporally close to the occurrence of extreme weather, which is often a challenge due to displacement and households' focus on adapting. Furthermore, we were able to compare those directly affected versus those not directly affected in the same geographic area. The case study also lent itself to studying the claim that one can draw legitimate parallels between insurance behaviour and experimental gambling behaviour (e.g., Eckel et al., 2009; Page et al., 2014) and the potential effects of insuring information on intended behaviour.

4.4.1 Areas affected and damages/losses sustained

Hurricane Sandy occurred in late October 2012; the Storm affected 24 states across the Northeastern and mid-Atlantic regions of the USA. The Federal government made major disaster declarations during the event in: New Jersey, New York, Connecticut, Rhode Island, Delaware, Maryland, Virginia, West Virginia, New Hampshire, Massachusetts, Pennsylvania, Ohio, and the District of Columbia (FEMA, 2013). The ZIP codes associated with surveyed homes are provided in Figure 4.2.

The storm caused an estimated 65 billion USD in economic losses to residences, businesses, and infrastructure (Aon Benfield, 2014), making it the second most costly natural disaster since 1900 in the USA. (NOAA, 2012). Hurricane Sandy damaged or destroyed at least 650,000 houses, with the vast majority of the damage caused by storm surge and/or waves (HSRTF, 2013). About 8.5 million households lost electricity as a result of Sandy or its remnants, with power out for weeks or even months in some areas.[164] In the immediate aftermath, over 23,000 people sought temporary shelter since they did not have access to their dwelling (FEMA, 2013). The proportion of populations in the six most heavily affected states is provided in Table 4.2.

[163] The CKWs were not yet serving Southwestern Uganda.
[164] Though electricity loss is not direct damage, it does represent hardship to families and potential outlay of funds and loss of utility through the need to obtain temporary shelter.

Table 4.2 Population affected by Hurricane Sandy from DE, NJ, NY, PA, RI, and CT

State	Population affected[165]	Population 2010 census[166]	Proportion of population affected by Sandy
Delaware[167]	25,104	897,937	0.027
New Jersey[168]	437,309	8,791,894	0.049
New York[169]	821,030	19,378,102	0.042
Pennsylvania[170]	171,653	12,702,379	0.014
Rhode Island[171]	6,000	1,052,567	0.005
Connecticut[172]	57,000	3,574,097	0.015

There were at least 162 direct deaths recorded across the Atlantic basin due to Sandy, 72 of which occurred in the mid-Atlantic and Northeastern USA (FEMA, 2013),[173] and at least 87 additional indirect deaths (ACE, 2015),[174] some of which may have been avoided through better mitigation strategies by households through systems such as insurance reward programmes (FEMA, 2013).

The effects of Sandy combined with other extreme weather caused the realisation of cascading risks in many areas. Strong winds directly associated with the post-tropical cyclone occurred as far west as Wisconsin, and generated rather large waves on Lake Michigan and some coastal flooding on its southern shore (Blake et al., 2013). It is understandable that insurance against complex risks may not be adopted (or even offered in some places); however, it was estimated that only 20% of American homes at risk for floods were covered by flood insurance (Smith & Matthews, 2015). Ex-post this is a staggeringly low level in comparison with the reported extent of damage and how many residences were affected that have always been situated in a known flood plain. Again, it is not to be advocated that insurance uptake is a universal goal; however, when the social structure is such that insurance is a primary coping mechanism it is important that adoption is considered, assuming that the available products are conducive to the hazard and household preferences to the extent possible.

165 (Marketsmith, 2012)
166 (USCB, 2010)
167 (FEMA, 2012a)
168 (FEMA, 2012b)
169 (FEMA, 2012c)
170 (FEMA, 2012d)
171 (FEMA, 2012e)
172 (FEMA, 2012f)
173 This is the greatest number of USA direct fatalities related to a tropical cyclone outside of the southern states since Hurricane Agnes in 1972.
174 About 50 of these deaths were the result of extended power outages (e.g., hypothermia) and disproportionately affected senior citizens. The remaining deaths resulted from storm clean-up efforts (e.g., fallen trees).

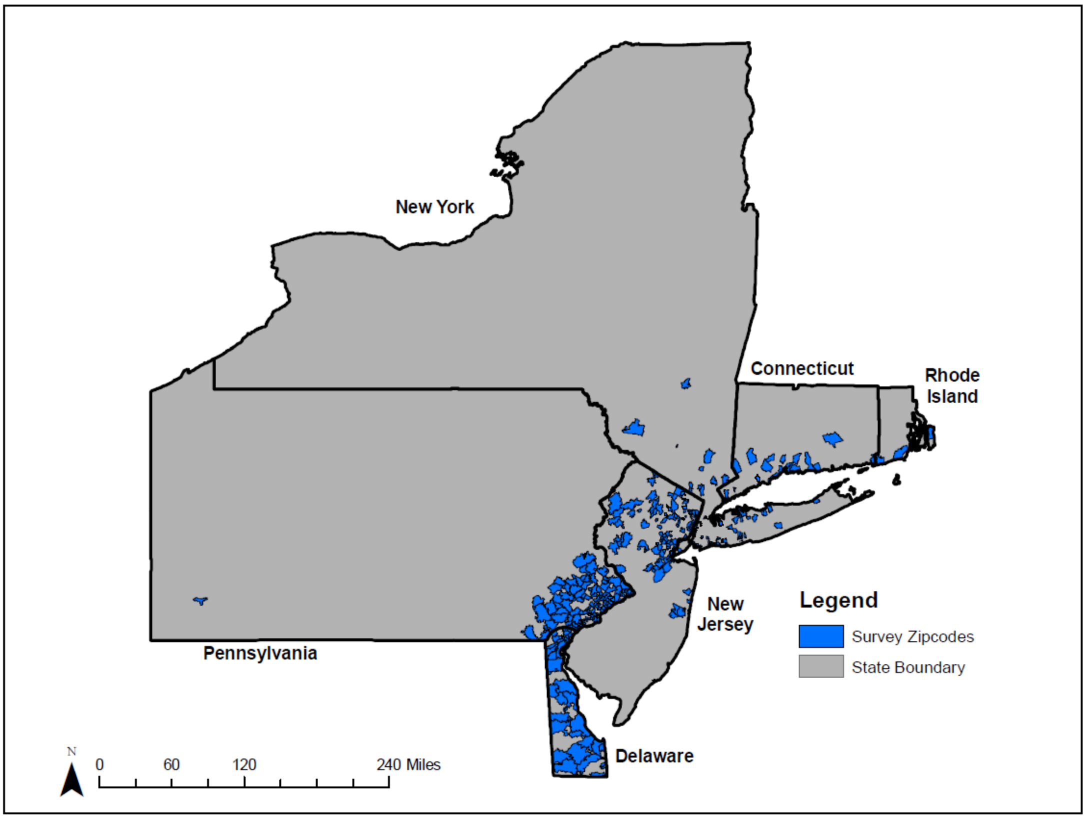

Figure 4.2 ZIP codes surveyed[175]

FEMA Modeling Task Force (MOTF)-Hurricane Sandy Impact Analysis data was used to determine the impact zones in which survey households were situated; see Figure 4.3. The MOTF integrates observed information throughout disasters to "ground-truth," and verify impact assessments that are multifaceted. In the case of assessments for Hurricane Sandy, the composite MOTF Impact Ranks for surge/precipitation/wind were defined as:

- Very High (Purple): Greater Than 10,000 of County Population Exposed to Surge
- High (Red): 500 – 10,000 of County Population Exposed to Surge, or Modeled Wind Damages > 100M USD or High Precipitation (>8 in. / 20.32 cm)
- Moderate (Yellow): 100 - 500 of County Population Exposed to Surge, or Modeled Wind Damages 10 – 100 M USD, or Medium Precipitation (4 in. to 8 in. / 10.16 – 20.32 cm)
- Low (Green): No Surge Impacts, or Modeled Wind Damages<10 M USD, or Low Precipitation (<4 in. / 10.16 cm)

[175] *Map created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved.*

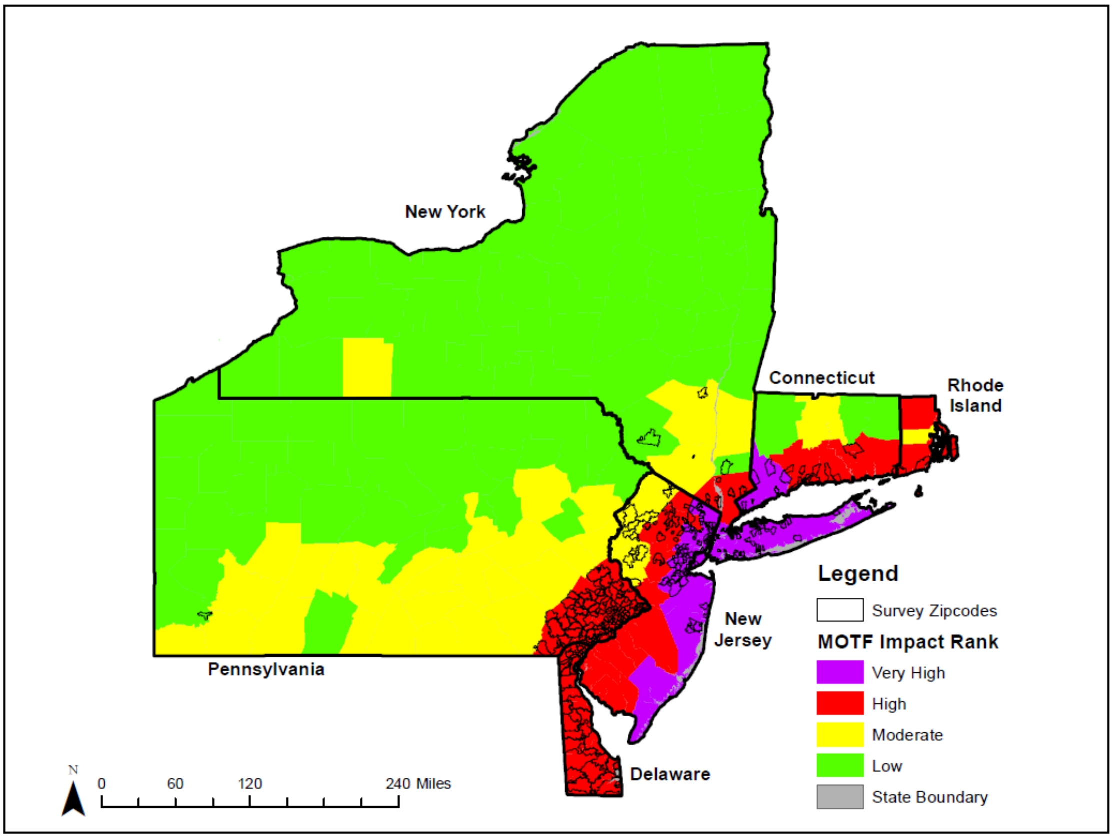

Figure 4.3 ZIP codes surveyed overlaid by MOTF impact rank data by location[176]

The value-at-risk from flooding appears to be increasing given that there is relatively low incidence of insuring or other means of risk-transfer or risk reduction for households built in floodplains (e.g., Webster et al., 2005; CDKN, 2012). In the case of Hurricane Sandy, many losses were the result of the storm and increased development (insured and uninsured) within the vulnerable coastal zone (Cutter et al., 2014). Outcomes in New Jersey provide a good example of this phenomenon; the shoreline of the state is intensely developed and includes year-round residents, several urban centres (e.g., Atlantic City), and a significant number of seasonal/tourism residences and facilities (HSRTF, 2013). 370,000 properties (i.e., 17% of the state's total housing) in New Jersey are situated lower than nine feet (2.47 m) above high tide levels; the value of these households exceeds 187 billion USD (Strauss et al., 2014). In New Jersey alone, Hurricane Sandy resulted in more than 30 billion USD in property damages, 34 fatalities, and 346,000 homes destroyed or seriously damaged (Cutter, 2014).

4.4.2 Coping ex-post Hurricane Sandy

As noted previously, the main coping strategies in the developed country context for extreme weather events outside use of formal savings, are related to insurance and the availability of social programmes; overall, dependence on informal social safety nets is less likely in comparison to the developing country case. There is limited evidence that similarities exist between informal economic activities of poor individuals in the developed country context and

[176] *Map created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved.*

the poor in developing countries (e.g., Leonard, 2001). Yet, given social structures, ex-post a covariate disaster the main providers of social security in the developed country context may be more skewed towards government programmes, whereas social networks of private households and informal transfers of good and finances for coping are rarely reported (e.g., Jütting, 2000).[177] As expected, the very poor in the developed country context are more vulnerable to such events (e.g., Cutter, 1996) and least likely to hold property insurance (e.g., Anderson & Woodrow, 1998). In the discussion that follows, we focus on the formal mechanisms provided in context of the Hurricane Sandy case study.

4.4.2.1 The National Flood Insurance Program

The USA Federal Government is not directly involved in the provision of natural disaster insurance; however, flood damage is a notable exception. Operated by FEMA, the NFIP was established in 1968 to make flood insurance available in vulnerable communities. Yet, major floods highlight the number of affected households, which either did not purchase policies or let them lapse; Kunreuther (2011) reports that following Hurricane Katrina, the number of affected households holding flood insurance ranged from 7.3 to 57.7% across counties. Furthermore about 20% of NFIP flood insurance holders pay discounted rates, making their perception of flood probability artificially low (Kousky & Michel-Kerjan, 2012). There are criticisms levelled against the execution of the NFIP process (e.g., Best, 2005). For example, households relocating to disaster-prone areas may be unaware of or underestimate the hazards that they will face due to inaccuracies in NFIP maps,[178] and hence do not focus enough on the importance of having a well-designed dwelling or residing in a less vulnerable area.

In the USA, most private insurers will not insure against flood peril due to the prevalence of adverse selection; thus, FEMA works with over 80 private insurers to administer the NFIP to homeowners, renters, and businesses (e.g., Bagstad et al., 2007). To obtain home flood insurance a household must be situated within a community that has joined the NFIP, the primary requirement of which is to enforce floodplain management standards. NFIP rates are determined nationally and are consistent between companies that partner with FEMA. Only homes in high-risk flood areas with federally regulated mortgages are legally required to hold flood insurance[179]–as defined by FEMA flood insurance rate maps (FIRMs), which note special hazard areas and risk premium zones. Due to the structure of the programme, some communities have greater access to the NFIP than do others, especially through differentiation under the Community Rating System (CRS) (FEMA, 2011).[180]

4.4.2.2 Extended and additional government-led ex-post coping

There is some disagreement in the empirical literature as to the effect of ex-post coping through social safety nets on future insurance behaviour (see Browne & Hoyt, 2000; Kousky et al., 2013). Seifert & Lindberg (2012) note that a "possible obstacle for an adequately functioning flood insurance system is that individuals need to play their role in the system and buy insurance." To

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[177] Identifies four main providers of social security: 1. the State, 2. the market, 3. member-based organisations, and 4. private households.

[178] *Biggert-Waters Flood Insurance Reform Act of 2012* called for FEMA to make changes to the NFIP in response to such criticisms. A key provision that was, in part, later overturned was the requirement that NFIP rates must reflect true flood risk and improve floodplain maps.

[179] In high-risk areas are defined as having a 25% chance of flooding once during a 30-year mortgage.

[180] There are also NFIP training and programmes (https://www.fema.gov/national-flood-insurance-program-training-workshops-and-conferences), as well as "The National Flood Insurance Program Community Status Book," which indicates the status of the uptake within communities with availability.

this point, there are a number of grant programmes administered by FEMA meant to stimulate ex-ante flood risk reductions. Historically these programmes depend on action at the community level[181] which leave individual households without control. The Repetitive Flood Claims (RFC) program (FEMA, 2004) was designed to reduce or eliminate the long-term risk of flooding to NFIP-insured structures by individual homeowners, reducing the claims paid from the National Flood Insurance Fund (NFIF). Yet, the RFC program was eliminated under the *Biggert-Waters Flood Insurance Reform Act of 2012*.

In light of the severity of damages from Hurricane Sandy, FEMA in particular provided a series of new and temporary public supports which filled the gaps left by the absence of other forms of coping available to most homeowners in the short- and medium-terms. For example, the USA President signed the *Disaster Relief Appropriations Act 2013* into law to provide 50.5 billion USD in aid for those affected by Hurricane Sandy.

Furthermore, ahead of adjuster inspections the NFIP authorised partial pay-outs of up to 30,000 USD to cover house repairs (when deemed necessary to preserve health and safety) (U.S. Senate, 2014). Furthermore, the timeframe for NFIP-insured households to submit proof of loss was extended from 60-days to one year. FEMA instituted a claims process for households to claim up to 5,000 USD against their contents coverage–these advanced payments constituted 1.2 billion USD of the 4.8 billion USD paid out by the NFIP against Sandy claims as of March 2013.

FEMA also developed the Sheltering and Temporary Essential Power (STEP) program which funded essential emergency residential repairs (e.g., wheelchair ramps) in New Jersey, New York, and Connecticut. By March 2013, the STEP program completed 18,700 household repairs in New York (FEMA, 2013). "FEMA and the Department of Housing and Urban Development (HUD) entered into a Sandy-specific interagency agreement to deliver the Disaster Housing Assistance Program (DHAP)" (FEMA, 2013). The DHAP was unique and initiated primarily because of the high cost of renting temporary housing and inconvenient required lease lengths throughout New York. The DHAP-Sandy was structured based on lessons learned from outcomes of similar work following Hurricanes Katrina and Ike (Zimmerman, 2013).

4.5 Rural Uganda–representativeness of sample

The most recent Ugandan population and housing census was conducted in 2014; however, only the provisional results have been released (UBOS, 2014). Thus, we have looked at results from the 2010 Statistical Abstract (UBOS, 2010b) and the 2002 Population and Housing Guide (UBOS, 2006). The majority of data is presented in these sources as percentages or proportions, so we use Z-tests to look at whether our sample proportions differs significantly from the reported population proportion.

There are a total of 3,178 usable responses in our dataset; 1,818 are from households in Kapchorwa region and 1,360 from Oyam. 119 responses were dropped from the dataset (53 from the Kapchorwa region and 66 from Oyam), either because they were incomplete and key pieces of information were missing, or because responses were judged by the authors to be implausible and likely due to mistakes in data entry or misunderstandings between the respondent and the CKW. During the survey process, there was a non-response rate of about

[181] Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance (FMA) program, and the Pre-Disaster Mitigation (PDM) program

6% reported by the CKWs. The main reason given for non-response was that potential respondents were busy farming.

The mean age of the household head is 40.4 years (s.d. 13) and all respondents were male. In this region it is still considered more socially acceptable to approach the man concerning household "business." (e.g., Mackinnon & Reinikka, 2000; Verma, 2001). The mean number of household members in addition to the survey respondent is 4.9 (s.d. 2.9). The average land holding is 5.1 acres (s.d. 70.7), but more than 60% of the sample farms less than two acres of land and nearly all own the land they farm. The skew in the distribution of the size of land farmed is thus clear.

The percentage of those married did not differ significantly between Kapchorwa and Oyam—it is above 90% in both districts. The majority of farmers stop after secondary school (O-level), at which point they get married, as being married is considered stable (J. Matovu 2010, per. comm., 15 March).

The division of years of schooling completed is given in Table 4.3. The majority of respondents (64%) leave formal education at the end of elementary/primary school, at the latest, while a further 26% of respondents leave school at 'Ordinary level' (i.e. O-level), and only 9% of respondents remain in school thereafter to complete Advanced-level secondary education (i.e., A-level). There are no significant differences between the population and sample proportions in both regions with regards to school attendance (see Appendix D2). There were no significant differences between sample and population data for the highest levels of education for both regions (see Appendix D2).

Table 4.3 Years of schooling of the household head

Region	Educational Level Attained by Household Head (Percent of Sample)			
	None (formal)	Primary School	A-Level equivalent	Above A-level
All	18.78	45.76	26.30	9.15
Kapchorwa	20.61	38.37	31.16	9.85
Oyam	16.36	55.57	19.86	8.21

Roughly a third of all respondents (30% in Kapchorwa and 36% in Oyam) reported familiarity with insurance and having a friend or acquaintance who has held insurance for something other than crops (e.g., motorbike, life).

The majority of farmers obtain funds in a time of disaster from friends and family, though if the disaster is covariate then this is only of value if the help is obtained from outside the community. As expected, the proportion of those receiving remittances from outside their village is correlated with the percentage of those with close family living outside their village. Looking at the opposite flow, upwards of 70% of the sample sends remittances outside the village on a regular basis (23% by means of mobile money). Chapter 6 provides an analysis of the coping strategies employed by the sample at present outside of potential agricultural microinsurance.

It is rare that households in our sample share land; only 20% do so for any part of the growing season. 52% of the sample generates more than half of their total household income through farming (Table 4.4), while 80% have surplus crops to sell on the market. Throughout our analysis of the data garnered from the survey tool, we use the percentage of the household's income from farming as a grouping variable across the sample. These percentages are relatively consistent across regions.

Table 4.4 Percent of household income from farming activities

Region	Percent income from farming			
	0-25%	25-50%	50-75%	75-100%
All	19.4	18.1	27.7	33.2
Kapchorwa	20.3	19.5	26.7	32.0
Oyam	18.1	16.3	29.1	34.9

Radios are the household amenity most frequently owned by our samples in both locations, and there was no statistical difference in ownership between regions (see Table 4.5). Kapchorwan farmers in our sample hold a significantly higher percent of cows, chicken, and vegetable gardens compared to Oyam. There is a greater percent of holdings for bicycles in Oyam compared to Kapchorwa.[182]

There are no significant differences for household ownership of goods for the Kapchorwa sample in comparison to the population, aside from the proportion of radio and chicken ownership; see Appendix D2. Our sample has a much higher proportion of radio ownership (80%) compared to the region's population (35%). There are no significant differences for household ownership observed for the Oyam sample, except for the percent of radio and goat ownership. Again the results suggest that overall the samples are representative of the populations of the two regions.

Table 4.5 Test for equality of proportions for household ownership

Household ownership over common household goods	***Kapchorwa***		***Oyam***		***p-value***
	Freq.	%	Freq.	%	
Bicycle	16	6.0	150	82.3	<0.001
Radio	213	80.1	142	78.4	0.876
Mobile phone	141	53.0	81	44.6	0.106
Cow	207	77.8	84	46.4	<0.001
Goat	176	89.8	120	66.3	0.9993
Chicken	239	7.9	140	77.3	<0.001
Pig	21	43.6	10	5.5	0.436
Vegetable garden	116	4.1	37	20.0	<0.001
Water pump	11	10.5	1	1.0	0.0452
Plough	28	10.5	10	5.5	0.0913
None	1	0.3	1	1.0	1

There are no significant differences observed for proportions of all crops grown Kapchorwa; exceptions are banana, beans (typical) and maize (see Appendix D2). In Oyam, the proportion

[182] Kapchorwa is located along Mt. Elgon; the steep terrain may be a reason there are relatively few farmers with bicycles.

of sweet potatoes, rice, and sim-sim were significantly different (see Appendix D2). Overall, the results show that the samples are representative of the populations.

As shown in Table 4.6, the busiest times for farming were identified as: operation, planting, and weeding in our sample. Farmers in Kapchorwa had higher percentage for weeding (42.7%). While farmers in Oyam spend more time in field preparation, planting, and weeding, 28.2, 33.1, and 29.9%, respectively. This division of labour is consistent with the main crops in each region, as the growth of coffee requires meticulous weeding (e.g., Brown & Hunter, 1913; Njoroge, 2008) and upkeep; additionally, coffee does not require planting annually, especially when intercropped with other crops, e.g., passion fruit and banana (Jassogne et al., 2013).

Table 4.6 Test for equality of proportions for busiest time for farming

Busiest time for farming	Kapchorwa	Oyam	p-value
Field preparation	381 (20.5)	395 (28.2)	0.105
Planting	615 (33.1)	464 (33.1)	<0.010
Weeding	794 (42.7)	419 (29.9)	0.017
Harvesting	64 (3.4)	124 (8.8)	0.024

In Chapter 5 we present outcomes of the Uganda field games, as well as findings for attitudes related to weather and risk, as described in Chapter 3.

4.6 Northeast USA and Hurricane Sandy–representativeness of sample

In order to determine the representativeness of our sample for the Northeastern USA, we look at population information from each state in the sample (New Jersey, New York, Pennsylvania, and Delaware)[183] in addition to the total population for all areas in the aggregate sample. This data comes from the 2010 United States Census and FEMA.

There were 800 responses obtained, 500 households of which sustained direct damages from Hurricane Sandy. The breakdown of responses per state is found in Table 4.7. The majority of respondents came from New Jersey (31.0%), New York (24.5%), and Pennsylvania (31.4%), which makes sense as these were the most hard-hit areas by Hurricane Sandy in aggregate terms from (Blake et al., 2013). Overall results suggest that the samples are representative of the populations from all six states for the variables we are able to compare.

The average age across respondents was 42.8 (s.d. 16.4) years. The aggregate sample consisted of 45% male and 55% female respondents. Furthermore, the average household in the dataset reported to have 1.78 (s.d. 1.07) children. There are no significant differences observed for marital status between the total population and sample proportions; over 45% of the total population and sample were married.

[183] Connecticut (39 responses) and Rhode Island (5 responses) had relatively small sample sizes. They were considered as a part of the aggregate sample, opposed to separate sample components.

Table 4.7 Breakdown of survey responses per state

State	Sample households
Delaware	61 (0.076)
New Jersey	248 (0.310)
New York	196 (0.245)
Pennsylvania	251 (0.314)
Rhode Island	5 (0.006)
Connecticut	39 (0.049)
Total	800 (1.0)

With regards to educational attainment: 34% of the aggregate sample have a Bachelor's degree and 17% have obtained a Master's degree or higher. This educational breakdown is close to the reported statistics for the USA public (USCB, 2012). There are no significant differences observed between total sample and population proportions for levels of education; see Appendix D3.

Average (gross) household income falls within the band 70,000–99,999 USD for the sample. Note that the reported 2011 median Income of USA households was 50,054 USD per annum (DeNavas-Walt et al., 2012). However, note that the states in which the effects of Hurricane Sandy were most pronounced, and subsequently the states that we included in our study, are in the upper two quartiles of USA states by median income, as measured in 2011 USD (USCB, 2013) and average income exceeds the National reported average. For example, New Jersey, which accounts for over 30% of our sample, ranks third among the states by median income.

There is no significant difference between samples and population means for home values (Table 4.8). The variation of home values in New Jersey are the greatest (s.d. 668,142 USD), which is sensible due to the extreme losses reported for Jersey Shore residences from Sandy paired with the fact that households at both ends of the income spectrum tend to be situated in coastal flood zones (e.g., (ULI, 2013; Kousky & Kunreuther, 2014).

Table 4.8 Estimated value of primary dwelling

State	Home value USD (mean) Population	Home value USD (mean) Sample (s.d.)	*P-value (Z-test)*
Delaware	235,800	183,846 (137,087)	0.705
New Jersey	327,100	507,218 (668,142)	0.788
New York	288,200	507,216 (300,250)	0.289
Pennsylvania	164,700	269,999 (185,240)	0.570
Total sample	256,617	354,946 (417,337)	0.814

No significant difference was observed between the sample and population proportions holding home flood insurance (building/structure/contents) (Table 4.9). Less than 30% of the total sample held home flood insurance ahead of Hurricane Sandy, which is consistent with the findings of Smith and Matthews (2015) regarding the percent of Americans holding such policies.

There is a significant with-in sample difference ($p<0.01$) in households insured against floods before Hurricane Sandy that experienced a loss versus those that did not experience a loss. This difference between the two cohorts is likely explained in part by the fact that those experiencing a financial loss were in a more vulnerable location, therefore, causing owners to consider insuring or in some cases required to insure by the NFIP.

Table 4.9 Home flood insurance; comparison of sample and population proportions insured

State	Population Insured	2010 Census Popl'n.	Popl'n Insured (%)	Sample insured (s.d.)	Sample insured (%)	P-value (z-test)
DE	26,274	897,937	0.029	6 (0.27)	0.09	0.85
NJ	239,830	8,791,894	0.027	69 (0.44)	0.28	0.58
NY	195,144	19,378,102	0.011	54 (0.44)	0.27	0.54
PA	68,936	12,702,379	0.005	57 (0.40)	0.23	0.61
Total Sample	588,392	46,396,976	0.013	197 (0.43)	0.25	0.58

Source USCB (2013b)

The majority of the sample holds health insurance, which is not surprising considering that health insurance is directly tied to employment in the USA[184] (Table 4.10). This structure is a key difference between health insurance in the USA and in the majority of other developed country contexts, which have some level of socialised healthcare and has an effect on labour supply (e.g., Feng & Zhao, 2014), but likely the perception of insurance provision for other types of insurance. For example, in our sample more than 90% of those who drive have automobile insurance, since some minimum level of liability insurance is required in the states included in our study (Insurance Information Institute, 2015). Although mandatory insurance has a significant effect on coverage adoption, there continues to be debate as to its net societal value; especially whether it encourages those who are uninclined to insure to insure (e.g., IJWM, 2004; III, 2015).

[184] Since the survey and experiment reported in this thesis took place the Affordable Care Act (ACA) has introduced major health care coverage expansions throughout the U.S. (e.g., Blumenthal & Collins, 2014).

Table 4.10 Healthcare insurance; comparison of sample and population proportions insured

State	Population Insured	2010 Census Popl'n.	Popl'n Insured (%)	Sample insured (s.d.)	Sample insured (%)	P-value (z-test)
DE	766,000	897,937	0.853	51 (0.37)	0.82	0.96
NJ	7,309,000	8,791,894	0.831	219 (0.32)	0.88	0.87
NY	16,347,000	19,378,102	0.843	173 (0.33)	0.88	0.92
PA	11,004,000	12,702,379	0.866	219 (0.33)	0.87	0.98
Total Sample	39,556,688	46,396,976	0.853	673 (0.33)	0.84	0.95

Source USCB (2013b)

5 Ugandan field game results and discussion

5.1 Introduction

In this short chapter we present data from two field games in our large-N mobile survey. The *Coin* game measures respondents' risk aversion through a triple-bounded dichotomous choice structure. The *Basic Dice* game tests respondents' preferences for purchasing insurance in an environment characterised by weather uncertainties in relationship to the feeling of insurance. The main purpose of presenting these data here is the important role they play in modelling coping strategy choice (Chapter 6) and WTP for microinsurance and loans (Chapter 7). The results provide a better understanding of the utility obtained from the feeling of insurance and the underlying motivations for it as they play out in the developing context. This revised understanding should provide organizations a framework for improving the design and implementation of microinsurance as a coping mechanism in the developing world.

Individuals exhibit a wide range of different responses to risky situations, generally arising from associated perceptions (Slovic & Lichtenstein, 1971). Feelings often impact risk perceptions; as in the concept "risk as feelings" as articulated by Slovic and his colleagues (Slovic et al., 2004, 2005; Slovic & Peters, 2006). There is some discussion that the feeling of insurance (regardless of its monetary value) reduces anxiety about potential loss and increases utility (e.g., Tykocinski, 2008; Kunreuther et al., 2013). To our knowledge, researchers have not studied the feeling of insurance in the developing country context. This chapter is organised as follows. Section 5.2 analyses the results of the Coin Game for what they reveal about the risk aversion of our sample;[185] Section 5.3 compares the Coin Game outcomes with which crops the respondents chose to farm; Section 5.4 compares historical TAMSAT weather data to our sample's perceived extreme weather risks; Section 5.5 presents the outcome from the Basic Dice game; and Section 5.6 summarises the field game results.

5.2 *Coin* game results–risk aversion

In deciding to insure, risk aversion (e.g., Gheyssens & Günther, 2012) and the coping strategies available to the family/individual (Alderman & Paxson, 1994) play key roles. Though households consider other practical mediators in making this decision (e.g., budget constraints), risk tolerance is a large relative contributor often interlinked with other identified factors (e.g., Eling et al., 2013). Grothmann & Patt (2005) note two highly significant cognitive factors underlying the coping decisions of individuals: 1. risk perception; and 2. perceived coping capacity. Given that risk preferences may affect allocation decisions, it is useful to gauge household risk aversion in developing countries and which personal attributes affect expressed risk aversion. Given that risk aversion affects coping decisions, we measured the risk aversion across households based on a standardised scenario via the *Coin* game.

We chose to represent the results of the *Coin* game with the coefficient of relative risk aversion (CRRA), assuming constant relative risk aversion, the standard measure of risk aversion accepted in economics (e.g., Gollier, 2001). Table 5.1 presents these results.

[185] This analysis serves as a backdrop to subsequent regression models of coping.

Just under one-third of respondents in each region exhibit moderate risk aversion (CRRA between1.3–3.2). The mode for responses in the overall sample (35.38%) falls into the greatest risk aversion category. There appears to be a geographic influence on responses in the Coin Game. Only 27.8% of respondents from Kapchorwa fall into the highest category as opposed to 45.86% from Oyam. These findings are not surprising given that Oyam is a poorer region and households in the lowest-income brackets tend to be relatively more risk-averse (e.g., Binswanger, 1981; Alderman & Paxson, 1994). Conversely, the least risk averse category comprises nearly one-fifth (18.42%) of the Kapchorwa respondents, versus 7.82% of respondents from Oyam.

Table 5.1 Division of sample (%) across CRRA intervals, as estimated from the outcome of the *Coin* game

	CRRA frequency (%)				
	< 0.1	0.1 – 1.3	1.3 – 3.2	3.2 – 5.0	> 5.0
All	444 (14.0)	242 (7.6)	977 (30.7)	392 (12.3)	1124 (35.4)
Kapchorwa	335 (18.4)	159 (8.7)	566 (31.2)	253 (13.9)	505 (27.8)
Oyam	106 (7.8)	82 (6.1)	410 (30.1)	138 (10.2)	624 (45.9)

5.3 Estimated risk aversion–correlation with seed selection

As noted in Chapter 3, we are interested in the correlation between respondents' expressed risk aversion in the Coin game and their indicated risk aversion in their market decisions concerning which crops to plant in the coming season.

In the survey tool, farmers were asked to their coming season's crops. The survey structure also allowed farmers to specify the seed type (e.g., improved versus heirloom varietals) within a specific crop, as subtle differences in seed result in large differences in yield and response to extreme weather.[186] The weather in these two regions is difficult to predict, as noted in Chapter 4. Experts estimate that weather variations including extreme dry seasons cause a failure rate of up to 40% even in genetically-improved crops (e.g., Edmeades & Smale, 2006). The magnitude of failure is what varies from crop to crop (i.e., the variance), which is consistent with the Coin game's design.

To form a risk index, the game divided the crops into four categories based on their variance of success as defined by germination and maturation. The high variance category included crops for which failure means a total loss, while those in the lowest variance category represent a windfall success (i.e., in excess of subsistence levels). High variance, no subsistence value crops (e.g., cash crops) belong to the highest variance cohort. Qualitative findings from farm site visits confirmed this categorisation method. Our null hypothesis for this correlation analysis is there is no general component of risk preferences that translates between these two domains. To reject this null hypothesis, we would have to determine that selection of the risk-free coin is significantly correlated with intended selection of the lowest-risk crops.

[186] It became evident during our FGDs that the selection of modified crops is a major concern for most farmers, especially as seed providers have begun to sell 'fake' improved seeds.

The results of the *Coin* game reveal a positive correlation between those who selected high-variance coins and those who intend to plant high yield-variance crops. Conversely, there is a positive correlation between a preference for the certain payout coin (i.e., highest risk aversion) and the choice to plant low yield-variance crop. Thus, we can reject the null hypothesis. Table 5.2 provides full details of these cross-domain correlations.

The risk-free (i.e., certain-payoff, zero variance) coin is significantly correlated ($p<0.05$) with the lowest-risk crops: cassava, cotton, groundnuts, sweet potatoes, sesame seeds, and improved soybeans. The coin paying half as much on heads compared to tails is significantly negatively correlated with groundnuts, sweet potatoes, and sesame seeds.[187] Interestingly, each of these crops has a striking variance-limiting attribute in its growing pattern, e.g., they are unaffected by pests and require little weeding, due to the plant's subterranean structure (Iyagba, 2010; Okello et al., 2013). Cotton's heavy subsidies and ancillary benefits to the farmer household essentially hedge nearly all yield risk (USAID, 2014). Sesame plants are extremely drought-resistant and the seeds can be pressed for oil even when they are extremely small. Throughout the world, sesame is grown at the desert's edge[188] where few crops reliably succeed. Improved soybean is one of the few third-generation genetically-engineered crops affordable to poor farmers in Africa.[189]

The choice of the risk-free coin is significantly ($P<0.01$) and negatively correlated with planting Irish potatoes, which are susceptible to both drought and flood[190] and vulnerable to insects, worms, wild hogs, and other animals. At this latitude (equatorial ±3), the anticipated yield-variance of Irish potatoes[191] is almost three times that of sweet potatoes or improved soybeans.[192]

Some authors suggest farmers with smaller land holdings become more conservative and sensitive to variance (or risk) (e.g., Binswanger, 1986; Hazell & Hess, 2010). This does not hold true for our sample, possibly due to the nearly-uniform poverty of the sample. In both corrected-for-inflation and nominal terms, the average household wealth in the Binswanger (1981) study far exceeds the wealth of our Ugandan sample. While farmers choosing the certain payout or smallest-variance coins did have smaller farms on average (4.03 acres for the higher-variance coins versus six acres for the two least-variance coins), the difference is not significant ($p=0.43$).

187 Due to the decision tree structure of the game, these farmers are not likely to ever encounter the two highest-variance coins.
188 Oyam and Kapchorwa are immediately south of the Sudanese desert.
189 In our field interviews it appears that the combination of 100/80 soy (technical designation: Cargill Series III) is particularly popular. This seed should provide 100 % of typical yield with only 80% of typical rainfall.
190 Irish potatoes rot in the ground when it is too moist, and fail to mature when the soil is too dry (Lutaladio et al., 2009).
191 We compare this to documented meteorological risk only (USDA, 1993; Habyarimana, 2014).
192 In reality this variance would be even greater if there was sufficient availability of fertilisers, pest controls, and ground fencing in the regions.

Table 5.2 Correlation between crops farmed and CRRA values from the *Coin* game

	CRRA bounds from the *Coin* game				
Main crop grown	**< 0.1**	**0.1 – 1.3**	**1.3 – 3.2**	**3.2 – 5.0**	**> 5.0**
Banana	- 0.079 ***	0.021	0.017	0.043 *	0.026
Typical Bean	0.020	0.027	0.032 *	- 0.044 *	- 0.045 *
Improved Bean	0.072 ***	- 0.041 **	- 0.016	- 0.027	- 0.006
Maize	- 0.001	- 0.006	- 0.027	- 0.037 **	0.064 ***
Cassava	0.095 ***	0.011	- 0.036 **	- 0.063 ***	- 0.058 **
Cotton	0.090 ***	0.023	- 0.046 *	- 0.039 *	- 0.081 ***
Groundnut	0.117 ***	0.013	- 0.031 *	- 0.081 ***	- 0.076 ***
Peas	0.068 ***	0.000	- 0.020	- 0.053 **	- 0.027
Irish Potato	- 0.053 ***	0.021	0.002	- 0.016	0.057 ***
Sweet Potato	0.082 ***	- 0.006	- 0.045 *	- 0.086 ***	0.011
Rice	- 0.007	- 0.013	- 0.036 *	- 0.048 **	0.099 ***
Sesame Seed	0.120 ***	0.002	- 0.060 ***	- 0.091 ***	- 0.034 *
Typical Soya	0.050 **	0.038 **	- 0.048 ***	- 0.055 ***	- 0.030
Improved Soya	0.084 ***	0.011	- 0.032 *	- 0.063 ***	- 0.044 *
Sunflower	0.059 ***	0.041 **	- 0.014	- 0.067 ***	- 0.060 ***

5.4 Perceived weather risks–comparison with historical weather data

Loss frequency from extreme weather is region-specific and highly variable across Uganda. The evidence from our large-N survey matches qualitative observations, both in our FGDs and reports on the four major Ugandan regions (UBOS, 2010c; Tall, 2012). Farmers in Kapchorwa estimated a weather disaster that would destroy half their crops occurs every 3-4 years. Meanwhile, a majority of Oyam farmers (60%) estimated such a disaster occurs every 2 years. The majority of respondents indicated greatest sensitivity to and worry about droughts as opposed to floods.[193] Drought events are a main weather concern for the Kapchorwa (75%) and the Oyam (79%) samples. Furthermore, about 50% of farmers in both locations indicated that crops have been lost to non-weather events, primarily pests or non-germination of (fake) seeds. This makes a case for potential exploration of yield-based indexed microinsurance to be further explored in these locations.

We use TARCAT data from the TAMSAT weather data collection to compare respondent-provided (perceived) risk of on-farm extreme weather. We match the TARCAT data to respondents' reported likelihood in farm groupings based on 10x10 km land areas.[194]

Responses from farmers in Kapchorwa and Oyam on the likelihood of a flood/drought affecting their crops are presented in Tables 5.3 and 5.4, respectively. Summed across groups, the majority of farmers from both regions indicated that there is a likelihood that they would

[193] The intensity of (localised) flooding is highly sensitive to the topography of agricultural lands in comparison to droughts (e.g., Rossi et al., 1994), which suggests that droughts may be slightly more covariate in nature; thus producing a most cogent memory of (unfulfilled) need to cope and a greater likelihood to report on past droughts in areas sensitive to both weather events.

[194] Our data analysis with regards to localised flooding involves greater assumptions than drought-based inferences due to lack of knowledge about the underlying topography of individual farms and 10x10 km plotting areas (E. Tarnavsky 2015, per. comm., 6 May).

experience extreme drought conditions one in every two years. In Oyam a majority reported the same frequency for localised floods; however, in Kapchorwa, a majority reported a flood frequency of one in four years. Significantly fewer farmers from Kapchorwa and none from Oyam indicated a perceived likelihood that a flood/drought would occur in only one of every ten or 50 years.[195]

The mean and standard deviation for TAMSAT data by decadal yearly and bi-yearly for years analysed and the results of the multiple regression analysis for each period are given in Appendix E. The regression coefficients (betas) and the p-values associated with regressing rainfall data per decadal to responses for Kapchorwa and Oyam regions yield F-statistics that are significant ($p<0.05$) for both regions. Overall, it appears that there is a strong relationship between TAMSAT decadal rainfall data and farmer responses on the likelihood of both flood and drought.

Table 5.3 Responses from Kapchorwa farmers to the likelihood of extreme weather

GIS-indicated 10 x 10 km grouping						
Drought frequency	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	Sum *(by frequency)*
1 out of every 2 years	121	24	262	93	85	585
1 out of every 4 years	113	21	178	69	51	432
1 out of every 5 years	59	13	126	43	39	280
1 out of every 10 years	7	0	26	9	5	47
1 out of every 50 years	1	0	8	4	3	16
Sum *(by group)*	301	58	658	818	401	

Flood frequency	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	Sum *(by frequency)*
1 out of every 2 years	2	67	1	1	37	108
1 out of every 4 years	6	63	4	23	25	121
1 out of every 5 years	17	33	8	32	0	90
1 out of every 10 years	25	40	25	12	29	131
1 out of every 50 years	1	2	0	1	3	7
Sum (by group)	51	205	38	69	94	

Rainfall variability appears to be a normal characteristic of the study areas, with deviations from the climatic rainfall means that are cyclical, but frequent within the growing seasons of a calendar year. We look at drought and flood thresholds not only based on the trends in the TAMSAT data, but also through comparison with the long-term monthly averages (1900-2009) reported by the "Climate Change Knowledge Portal" (World Bank, 2015). Roughly, the lowest

195 Given that few farmers have been active for 50 years the concept of 1/50 is more abstract than the other choice options for this question. During open-ended questioning, there has no statistical difference in the number of farmers who responded to extreme weather in 1/25 years versus 1/50 years.

rainfall is around 50mm in both regions and the highest is about 150mm for Oyam and 200mm for Kapchorwa.

Table 5.4 Responses from Oyam farmers to the likelihood of extreme weather

	GIS-indicated 10 x 10 km grouping						
Drought frequency	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**	Sum *(by frequency)*
1 out of every 2 years	133	87	84	68	136	135	643
1 out of every 4 years	132	31	37	36	44	40	320
1 out of every 5 years	15	9	19	12	28	8	91
1 out of every 10 years	3	1	0	5	4	0	13
1 out of every 50 years	0	0	0	0	0	0	0
Sum *(by group)*	283	128	140	121	212	183	

Flood frequency	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**	Sum *(by frequency)*
1 out of every 2 years	0	37	13	37	3	27	117
1 out of every 4 years	4	35	17	21	14	12	103
1 out of every 5 years	3	19	7	22	1	5	57
1 out of every 10 years	1	1	3	5	0	5	15
1 out of every 50 years	0	0	0	0	0	0	0
Sum *(by group)*	8	92	40	85	18	49	

TAMSAT data on drought and mean annual rainfall generally support farmers' reports. TAMSAT rainfall data indicated that there was evidence of drought one in every two years, one in every four years, one in every five years, and one in every six years, respectively, across the data years analysed. Information from individual farmers' reports were compared to TAMSAT rainfall data from Kapchorwa and Oyam (Table 5.5). Reports from 1381 farmers from Kapchorwa and 1120 farmers from Oyam support TAMSAT data. In contrast, reports from only 437 farmers from Kapchorwa and 272 farmers from Oyam did not support TAMSAT data.

Table 5.5 Farmer perceptions versus TAMSAT weather data for perception of flood and drought frequency

Farmer's report matches TAMSAT data	**Yes**	**No**	**Sample Total**
Kapchorwa	1381 (0.76)	437 (0.24)	1818
Oyam	1120 (0.80)	272 (0.20)	1360
Total	2501	709	

Since we follow a 10x10 km grid to assess the weather data reported by farmers, we do not know that exact variation as a point estimate on each farm and are effectively measuring an index for farms in a given land area. Furthermore, in both our regions localised flood conditions are very possible and are relatively harder to determine through an index than is a drought.[196]

It should be noted that some papers that look at farmer perception versus actual weather data frame this consideration as the farmers' perception that climatic conditions are changing, opposed to extreme weather frequencies (e.g., Osbahr et al., 2011; Moyo et al., 2012). For completeness we look at TAMSAT data against responses given by our sample concerning perceptions of increased difficulty of farming due to changing climatic conditions. 55.9% of farmers in Kapchorwa and 47.91% in Oyam believe that climatic conditions are worsening. There is no significance found across perceptions of climatic changes in relationship to the TAMSAT rainfall variation data.

Furthermore, it is important to note that there is no significant association between risk aversion, as measured by both the *Coin* game and the choice of crop, and perception of risk for extreme weather. This is expected since risk aversion may be informed by perceived risk; however, the former measures the curvature of one's utility function, which is independent of event probability. There is a strong correlation between the proportion of income from farming activities and high perception of flood and drought disasters, this is not the case for perception of risk and steps taken to adapt farming practices in our sample.

5.5 *Basic Dice* game–feeling of insurance

The *feeling of insurance* (regardless of monetary value of the insurance) can reduce anxiety about potential loss and increase utility from holding insurance (e.g., Tykocinski, 2008; Kunreuther et al., 2013). To our best knowledge, this has gone largely unrecognised in the developing context. We borrow from recent findings in the psychology of judgment and decision-making (e.g., Slovic & Peters, 2006) to further develop the concept. Feelings (arising from affect) often impact risk perceptions; *risk as feelings* is discussed by (Slovic et al., 2004; Slovic et al., 2005; Slovic & Peters, 2006), among others. In the same vein, the *feeling of insurance* (regardless of monetary value of the insurance) can reduce anxiety about potential loss and increase utility from holding insurance (e.g., (Tykocinski, 2008; Kunreuther et al., 2013). To the best of our knowledge, this has gone largely unrecognised in the developing context. We borrow from recent findings in the psychology of judgment and decision-making (e.g., Slovic & Peters, 2006) to further develop the concept.

> *"The possession of an insurance policy may not only affect the severity of a potential loss but also its perceived probability. Intuitively, people may feel that if they are insured nothing bad is likely to happen, but if they do not have insurance they are at greater peril" (Tykocinski, 2008, p. 1346).*

Insurance provides utility in the sense of inducing *peace of mind* and increases in perceived ability to cope, even if the subject's absolute loss is not altered (Kunreuther et al., 2013). In

[196] "While excess rainfall can be indexed, flooding is a very localised hazard, and it is difficult to index because there is no one-to-one relationship between amount of rainfall at a specific location and amount of flooding," e.g., due to land topography (IFAD & WFP, 2011, p. 28).

literature linking utility and happiness, the dominant hypothesis is that current happiness is equal to utility flow; see: Kahneman (1999), Gruber & Mullainathan (2002), and Layard (2005).[197]

To the best of our knowledge, there are no studies to date that employ field experiments in the developing country context to gauge the *feeling of insurance*. Lab experiments (e.g., Arkes et al., 1988; Nygren et al., 1996) suggest that positive affect can cause subjects to shift from decision rules based on probabilities in risky situations to rules focused on perceived utilities. Arkes et al. (1988) find that, in a situation where potential loss is emphasised, a positive-affect subject demonstrates greater risk aversion. When the potential loss is stated in a way that it is minimised, this is reversed. Similar findings have been indicated by behavioural economics studies looking at affective factors in decision making: affect as a cue for judgement (e.g., Finucane et al., 2000); visceral influences on judgement and fear and worry in facing risky choices (e.g., Loewenstein et al., 2001; Schade & Kunreuther, 2002).

There has been some study of the relationship between insurance behaviour and affective influences in purely monetary decisions in the developed context. Hsee & Kunreuther (2000) run a series of experiments on insurance cover for objects of personal value; they find people are more likely to purchase insurance for an object based on their affection for the object (holding the absolute amount of compensation constant). They explain this finding in part by the fact that different mental accounts are set aside for different types of costs (e.g., Kahneman et al., 1990; Tversky & Kahneman, 1992).

Yet, it is through the *consolation hypothesis* by which people perceive insurance compensation as a consolation token that Hsee & Kunreuther (2000) explain their observations. Furthermore, the consolation hypothesis applies to ex-ante insurance purchases in which the loss is anticipated, consistent with affective forecasting (Hsee, 2000). Hsee & Kunreuther (2000) characterise this type of decision as an expression of gut feelings, expressing anticipatory feelings towards a good by spending money and effort insuring it regardless of cost. Thus, the *feeling of insurance* would explain some seemingly irrational behaviour, such as insuring in all cases and warrantee purchases (e.g., Bosch-Domènech & Silvestre, 1999). There is little mention in the literature as to whether certain individual characteristics appear to motivate one towards or against obtaining utility from the *feeling of insurance*.

As mentioned previously, to our knowledge there has been no empirical research specifically aimed at affective influences on agricultural microinsurance purchases in the developing context. The closest study is that of Wang & Rosenman (2007) who look at *perceived need* as unique from demand in the context of rural Chinese health insurance. They find that factors such as the number of children, education, and wealth level affect *perceived need* differently than they affect demand for insurance.

5.5.1 *Basic Dice* game–Results

We find that the division by percent of sample exhibiting insuring behaviour on the extremes in the *Basic Dice* game is relatively consistent between regions; about two-thirds of respondents

[197] There is a rich debate in the economic and psychological literature around differentiating between utility, as a reflection of one's choices and happiness, as a reflection of one's feelings.

insured in each round; see Table 5.6.[198] Without accounting for the potential influence of outcome in each round, there is a strong and significant ($p<0.001$) correlation between the choice to insure in the current and subsequent rounds. The correlation for insuring in rounds one and two is 0.53 ($p<0.001$) and the correlation for insuring in rounds one and three is 0.51 ($p<0.001$). These findings suggest that individuals who want to insure may do so regardless of the variation of outcomes between rounds; thus, we cannot disentangle positive-affect specifically (outside of e.g., risk aversion) within this cohort.

As to be expected from the game structure, about 1/8th of respondents experience loss in a given round of play. Of those that experience loss, but held insurance, less than 6% change their strategy to no insurance in the subsequent round.[199] Yet, of those that experience loss, but did not hold insurance, about 80% change to holding insurance in the next round. Furthermore, in instances where the pattern arises that there is a loss in the first round and no loss in the second round, if the respondent changed from no insurance to insurance between rounds one and two, he maintains insurance at the start of the third round as well.

Table 5.6 Frequency of insuring across rounds the *Basic Dice* game

Region	Insure in all three rounds	Not Insure in all three rounds	Change in insuring behaviour between rounds¥
All	1457 (0.458)	887 (0.279)	834 (0.262)
Kapchorwa	880 (0.285)	518 (0.285)	420 (0.231)
Oyam	577 (0.424)	369 (0.271)	414 (0.304)

Ψ See Table 5.7 for detailed breakdown of insuring behaviour between rounds.

[198] In this tabulation, we do not account for outcomes in previous rounds, which may have influenced respondents' decisions in a subsequent round.
[199] This is related to analysis between the 1. First and second and 2. Second and third rounds of play.

Table 5.7 Detailed frequency of insuring across rounds the *Basic Dice* game

Insurance Behaviour	Round	Dice outcomes							
	1 2 3	no loss no loss no loss	loss no loss no loss	loss loss no loss	loss loss loss	no loss loss no loss	loss no loss loss	no loss loss loss	no loss no loss loss
Insure in all rounds									
Kapchorwa		501 (0.2756)	133 (0.0732)	82 (0.0451)	36 (0.0198)	45 (0.0248)	31 (0.0171)	30 (0.0165)	22 (0.0121)
Oyam		306 (0.2250)	87 (0.0640)	57 (0.0419)	29 (0.0213)	39 (0.0287)	20 (0.0147)	20 (0.0147)	19 (0.0140)
Insure in 1st-2nd rounds only									
Kapchorwa		191 (0.1051)	15 (0.0083)	3 (0.0017)	2 (0.0011)	2 (0.0011)	13 (0.0072)	5 (0.0028)	6 (0.0033)
Oyam		202 (0.1485)	12 (0.0088)	1 (0.0007)	1 (0.0007)	1 (0.0007)	10 (0.0074)	3 (0.0022)	15 (0.0110)
Insure in 1st round only									
Kapchorwa		36 (0.0198)	2 (0.0028)	5 (0.0028)	1 (0.0006)	3 (0.0017)	2 (0.0011)	7 (0.0039)	5 (0.0028)
Oyam		24 (0.0176)	3 (0.0022)	3 (0.0022)	1 (0.0015)	2 (0.0015)	2 (0.0015)	4 (0.0029)	13 (0.0096)
Insure in 2nd round only									
Kapchorwa		12 (0.0066)	8 (0.0044)	5 (0.0028)	1 (0.0006)	0 (0)	5 (0.0028)	2 (0.0011)	3 (0.0017)
Oyam		8 (0.0066)	9 (0.0066)	5 (0.0037)	1 (0.0007)	1 (0.0007)	6 (0.0044)	2 (0.0015)	2 (0.0015)
Insure in 2nd-3rd rounds only									
Kapchorwa		7 (0.0039)	16 (0.0088)	20 (0.0110)	5 (0.0028)	13 (0.0072)	6 (0.0033)	12 (0.0066)	7 (0.0039)
Oyam		5 (0.0037)	13 (0.0096)	17 (0.0125)	7 (0.0051)	11 (0.0081)	8 (0.0060)	9 (0.0066)	13 (0.0096)
Insure in no rounds									
Kapchorwa		405 (0.2228)	13 (0.0072)	4 (0.0022)	2 (0.0011)	32 (0.0176)	5 (0.0028)	18 (0.0099)	39 (0.0215)
Oyam		279 (0.2051)	10 (0.0074)	3 (0.0022)	2 (0.0015)	23 (0.0170)	3 (0.0022)	15 (0.0110)	34 (0.0250)

We do not measure affect (state or trait) explicitly in our survey tool; however, there are questions to which responses may be directly influenced by the respondent's affect in relationship to the topic, as indicated in Table 3.1. Following from Arkes et al. (1988), we test whether positive-affect subjects demonstrate greater risk aversion. We find a significant difference in *dice feeling* between groups that are classified by CRRA<3.2 and those with CRRA>3.2; the more risk-averse group accounts for the majority of those who change their behaviour from non-insuring and insuring after a round with a negative outcome. Yet, there is not a significant correlation between *dice feeling* and risk from the *Coin* game overall–suggesting that *dice feeling* is not predicated specifically on respondents' desire to reduce risk exposure.

We examine affect related to insuring as anticipatory feelings (e.g., Hsee & Kunreuther, 2000). Household consumption commitments (Chetty & Szeidl, 2007) that cannot easily be adjusted (or are perceived as such) during periods of loss would seem to influence the extent of affect. In our dataset we gather data that are related to these types of feelings in relationship to the role played by the household head. For example, households that serve as net-providers of remittances have a statistically significant ($p<0.05$) propensity towards dice feeling opposed to net-receiving households. More generally, there is a positive statistically-significant ($p<0.001$) difference in *dice feeling* between respondents identifying with fulfilling "the role expected of them by their community" and those who do not. Furthermore, those that have past experiences with saving crops to sell on the market later, but have ultimately lost money from doing so, are four times more likely ($p<0.001$) to insure in all rounds or to change to insuring behaviour after a loss in the game. Furthermore, we see that respondents who compare the cost of insurance to the disaster magnitude have the same pattern, being about three times more likely to have a positive dice feeling value ($p<0.001$).

We also see that *dice feeling* is weakly, but significantly ($p<0.001$) negatively correlated with respondents' perception of extreme weather frequency. This may indicate that households perceiving high-frequency of extreme weather may be better mentally-prepared for potential losses. Yet, there is no significant difference in *the feeling of insurance* in relationship to household income earned through farming nor the number of acres farmed. It is possible that one's affect is sensitive to the magnitude of potential loss (which would be more consistent with state affect); however, the basis of emotion from trait affect arise from the respondent's tendency to respond to general situations/concepts (e.g., Watson & Tellegen, 1985), opposed to indication of the variability in emotions based on various states/levels of loss (which is consistent with state affect). It appears that in the *Basic Dice* game we capture trait affect more so than state affect–as strong correlations tend to be found with factors that are relevant to general dispositions, opposed to variations in loss–since we only look at the possibility of a single type of loss and the loss is consistent in magnitude across rounds.

5.5.2 Correlation of worry across categories

As may be expected, perception of risk for crops planted tends to be correlated with perception of risk in other realms of concern. We collected data concerning stated perceptions of worry over a variety of risk types relevant to the Ugandan sample. From this data, we develop an index for total worry that combines perceived worry for all the risks noted in Table 5.8. Of this set of potential risks, HIV/AIDS is perceived as the gravest (e.g., highest level of average worry), whilst loss of one's home is the lowest.

This may be surprising; however, assuming that the loss of one's home is not covariate in nature, the majority of households in the sample expressed confidence that they could be supported by family or friends in such a situation.[200] Covariate weather risks to one's crop is second, only after HIV/AIDS. This ordering remains consistent when controlling for the amount of land farmed. Higher education is also correlated with lower risk perception for all risks.

[200] Note that in Oyam, land availability is relatively elastic–there is always more supply by the clan; it may not be of the highest quality, but "farmable" (W. Okello 2011, per. comm, 24 April).

Table 5.8 Ordering of worry

Ranking *(decreasing)*	Risk Type
1	Contracting HIV/AIDS
2	Covariate weather risks (e.g. flood and drought)
3	Illness or injury to oneself (non-HIV, e.g. malaria)
4	Illness or injury of a family member (non-HIV, e.g. malaria)
5	Decrease crop price (factors other than weather)
6	Crime and disorder in one's area
7	Loss of home
equally weighted; Cronbach Alpha: total=0.881; Kapchorwa=0.873; Oyam=0.891	

We find that *dice feeling* is weakly, but significantly correlated ($p<0.01$) with responses for worry related to farming conditions (i.e., weather risks and decrease in crop price) and not in other realms, giving some suggestion that in the game, regret was considered in the realm of farming, opposed to more generally. *Dice feeling* is not significantly correlated with other forms of worry. Somewhat surprisingly, there is a very weak negative correlation ($p<0.01$) between the worry expressed over weather risks and the prevalence of extreme weather reported, as discussed in Section 5.5. This fact may hint to the fact that respondents are relatively realistic in their perception of extreme weather and report it accurately, while worry arises from a System I-type response to possible losses from extreme weather.

5.6 Summary

In this chapter we presented results from the field games employed in the large-N Ugandan survey tool. To the extent possible these were compared with real world data (e.g., TAMSAT weather data and seed germination risk) and expressed perceptions in other sections of the survey. Data presented in this chapter is used in our analysis of coping strategies and WTP for microinsurance and loan coverage in Chapters 6 and 7, respectively.

It is notable that risk aversion measures from the *Coin* game correlate with riskiness of the seeds selected by farmers in real life. Though, in future iterations it would be useful to get estimates of CRRA that fall into tighter ranges than those possible to discern in our data – but this requires a balance between efficiency of the game, player fatigue, and learning effects to maintain accuracy.

There are particular limitations in the *Basic Dice* game, as it does not provide a measurement scale of affect towards insurance per se, but rather an indication of circumstances under which respondents make choices that are consistent with affect arising from the desire to feel insured. It is encouraging that responses from the survey that are related to (trait) affect appear to relate to findings from this game in the manner expected. Yet, precision and accuracy are not easily verified given the information available to us. As a first of its type in the developing country context to the best of our knowledge, the *Basic Dice* game appears to warrant further development and the role of affect in driving demand for microinsurance should be extended in the future, as a potential motivator to insure.

6 Traditional Coping against extreme weather in rural Uganda

6.1 Introduction

This chapter presents findings about our sample's expressed desire to use traditional coping against the effects of extreme weather on their farming. We then model propensity to employ certain classes of coping to examine household characteristics that may encourage engagement in particular strategy types. We pay particular attention to motivation to sell livestock and removing children from education as ex-post consumption smoothing options. The former is a prevalent coping choice in our sample; the latter is noted in the literature to be detrimental to future household earnings by reducing long-term growth of human capital (e.g., Rakodi, 1999; Fiszbein et al., 2009; Cockburn & Kabubo-Mariara, 2010). This provides an understanding of our sample's traditional coping strategies, upon which, in Chapter 7, we build analysis and discussion of the potential use of microinsurance and other financial tools and to the extent possible, comparisons are drawn to expressed WTJ and WTP for both agricultural microinsurance and loans to cover farm losses ex-post extreme weather.

The remainder of this chapter is structured as follows. Section 6.2 presents contexts and builds on our review of traditional coping strategies in Chapter 2. Frequencies for our sample's expressed willingness to adopt traditional coping methods and suggestions for strategy groupings based on Principle Component Analysis (PCA) and Latent Class Analysis (LCA) are presented in Section 6.3. Section 6.4 presents and situates the dependent variables for the three regressions performed on the expressed willingness to cope via traditional strategies. The multinomial probit model for coping classes is presented and discussed in Section 6.5. In Section 6.6 probit models specific to 1. selling livestock and 2. removing children from schooling are presented. Section 6.7 summarises and concludes.

6.2 Background and context

6.2.1 Traditional coping in East Africa–empirical findings

Government safety nets are not readily available to most individuals in Uganda and many other developing contexts as a reliable means by which to *mitigate* a significant portion of covariate risks (Alderman & Haque, 2007). There is some extension work, but it cannot be counted upon to reach all affected households and funding is not likely to be maintained throughout or at the most critical periods in the recovery process (e.g., IFAD, 2010). Despite the emergence of some schemes, outreach is still low and it is unlikely that those schemes would provide effective protection for medium-term recovery (e.g., Easterly, 2009; Salami et al., 2010; Lavell et al., 2012). Failure of informal schemes and government-led programmes provides a significant opportunity for microinsurance and other *formal* tools to decrease low-income households' vulnerability to covariate risks and help consumption-smoothing.

Households that perceive greater credit constraints in the future are more willing to sacrifice income in the present, hoping to reduce vulnerability to future risks (e.g., Eswaran & Kotwal, 1990; Morduch, 1998). This effect is magnified for the lowest-income households, which tend to be relatively more risk-averse (e.g., Alderman & Paxson, 1994) – and are reluctant to invest in economic opportunities (Morduch, 1995). Traditional coping for consumption-smoothing may also have significant household costs if assets are needed to generate income in future periods, e.g., if production or human assets, are depleted in the current period (Dercon & Hoddinott, 2005; Kazianga & Urdy, 2006; Barnett et al., 2008). However, without knowledge of how other investments may have ultimately evolved poor households may feel that they missed out on investment opportunities if they do not receive an insurance payout.[201] Alternatively, a household that is aware of insurance and foregoes it may regret this choice in a later period if extreme weather occurs.

In such a situation, if microinsurance has a substitution effect, providing security through ex-ante premium payments against possible future uncertain expenses may provide: 1. an incentive or ability for the household to invest in higher-risk/higher-return activities; and 2. a payout in case of uncertain expenses, preventing households from engaging in consumption-smoothing that have negative consequences on future income possibilities. Yet, in the same situation, microinsurance may have negative impacts on income and/or consumption-smoothing activities. For example, the cost associated premium payments may prevent the household from investing in traditional coping, especially ex-ante, which may be pertinent in instances where the weather-indexed microinsurance does not payout (e.g., pest blight). Furthermore, microinsurance requires payments to be made that will not be recouped if the farmer does not experience extreme weather in the coverage period. Although this is the mechanism by which insurance works by spreading risk, households new to microinsurance may expect that if there is no extreme weather payout trigger in a given period that their money is returned for reinvestment in productive assets or put towards the next period's premium payment (Collins et al., 2010; Njenga, 2015).

There is mixed evidence concerning how to categorise selling livestock as a coping strategy. Some studies (Dercon, 1998; Kinsey et al., 1998) have found that in sub-Saharan Africa, livestock is held as a form of household liquid savings with the intent of being sold in the event of a natural disaster. Other studies (e.g., Fafchamps & Gavian, 1996; World Health Organization, 1999; Kazianga & Urdy, 2006) report that livestock sale takes place as a marginal method of *gap-filling* when households no longer have access to other methods of risk pooling. Two further factors appear to have an effect on the liquidation of livestock: the extent to which households need to augment cash income as opposed to cash needed directly for food consumption (e.g., Maxwell & Caldwell, 2008) and the type of natural disaster from which recovery takes place. Livestock sales make more sense in the case of a drought or flood since they can reduce the arable land available and subsequently the death of livestock holdings.

There is a caveat as selling livestock may flood the market if this is done by many households simultaneously during a covariate disaster.[202]

There is some evidence that coping strategies that specifically reduce human capital formation by sending children to work as opposed to school is consistent with the idea that they fall low in the priority-ordering of strategies to be employed by households (Flug et al., 1998). Other studies (e.g., Jacoby & Skoufias, 1997; Duryea, 1998; Skoufias & Parker, 2002) challenge this finding by noting that the relationship does not hold true for the poorest households, for whom

[201] We see some evidence of this phenomenon in FDGs and in the noted interaction during teaching the CKWs insurance.
[202] However, during the FDGs the sample expressed this was not the case to the best of their recollection.

the immediacy of coping outweighs any long-term view of human-capital investment.[203] It is evident from these studies and the conflicting findings that the choice of coping strategy implementation depends on household circumstances.

The studies highlighted above also offer insight as to the determinants of choice ordering over coping strategies. As expected, household income level plays a strong role; this finding is corroborated by the related literature on differential vulnerability (e.g., Wisner et al., 2004). There are a suite of studies (Anderson & Woodrow, 1998; Eade, 1998) that stress the contribution of social and demographic factors, such as gender, seniority within the community, and ethnicity that appear to affect coping strategy choice The literature addressing this question of vulnerability mentions additional factors that lead to poor coping strategy decisions, such as: lack of livelihood diversification; lack of infrastructure, such as water storage and flood defences; and limited access to insurance and credit (e.g., Stern, 2007).

6.2.2 Research hypotheses

In our literature review, it is clear that in the absence of credit and insurance markets, households attempt income-smoothing by choosing less risky activities by diversifying their portfolio of income-generating activities, by taking the volatility of income as given and smooth consumption, or employing some combination of these two approaches. Asset-based theories predict reliance on coping strategies that avoid disposal of productive assets or investment in means, such as microinsurance, ex ante the realisation of a weather-related disaster. We contend that in order to better understand the potential adoption of agricultural microinsurance by rural farmers in the developing context, it is important to understand their use of currently existent coping mechanisms.

Regarding the adoption of coping strategies following extreme weather event covariate risks we hypothesise that respondents will take up strategies that involve capital disinvestment (i.e., erosive coping) less frequently than other available options. Furthermore, we hypothesise that socio-economic and demographic factors are relatively significant in the decision of how to cope following a covariate disaster. Specifically, we look at motivating factors for the decision to sell (large) livestock and to divest from children's education.

The section of the large-N Ugandan survey related directly to traditional coping was positioned ahead of the main traditional stated preference questions about agriculture microinsurance. This section was intended to get the respondent to reflect upon previously experienced covariate risks and his preferences over traditional coping strategies.[204] Respondents were presented with a scenario in which they fall victim to a hypothetical natural disaster that is covariate in nature (e.g., flood or drought) with no form of recovery assistance available through family or friends (e.g., remittances). Twelve potential coping strategies were presented and the respondent was asked to choose as many as he would be willing to employ in such a situation, as referenced below. This list of potential coping strategies was initially developed through revision of the relevant literature (e.g., Corbett, 1988). Qualitative field interviews in both Kapchorwa and Oyam were conducted to check the relevance of these strategies to the local

[203] As a caveat, note that the option set for the poorest families may already be so limited that pulling their children out of school ranks as one of the first options that is viable.
[204] Questions 33-38 in our mobile survey app.

context. Responses to this question formed the basis for our analysis of preferences for traditional coping strategies.

6.3 Prevalence of traditional coping strategies

6.3.1 Frequency of chosen traditional coping strategies

In this section we review the distribution of respondents' willingness to engage in traditional coping. Frequency data for each strategy, across the whole sample and in the Kapchorwa and Oyam regions, individually, are in Table 6.1.

The result's spread for each coping strategy is similar across the two study regions. Thus, conditional on our presented scenario, region-specific factors appear to be relatively unimportant in the determination of frequency of uptake for each coping mechanism.

Table 6.1 Coping strategies employed after a disaster event for our sample

	Coping Strategy	**Frequency (percent of total)**		
Groupings[¥]		Total Sample	Kapchorwa	Oyam
Non-erosive coping *(short-term reductions in consumption; risk-minimising loss management)* *Low-stress*	Reduction of food intake	738 (23)	419 (23)	323 (23)
	Borrow food	624 (19)	379 (20)	251 (18)
	Reducing expenditures	1250 (38)	697 (38)	558 (40)
	Begging	327 (10)	179 (10)	153 (11)
	Sell household items	336 (10)	182 (10)	157 (11)
	Sell land or home	95 (3)	40 (2)	59 (4)
Erosive coping (disposal of productive assets, which impacts the household's medium- to long-term wellbeing) *Medium-stress*	Sell livestock	2196 (68)	1290 (70)	913 (65)
	Take children out of school	67 (2)	33 (2)	41 (3)
	Send children to live elsewhere	38 (1)	29 (2)	16 (1)
Failed coping *(leading to dependency and remaining in poverty)* *High-stress*	Migrate	44 (1)	37 (2)	10 (1)
	Change profession	294 (9)	157 (9)	138 (10)
	Send children to work	178 (6)	81 (4)	99 (7)

¥ *Adapted from* World Health Organization (1999) *and* Cohen & Sebstad (2005)

An interesting finding from our results is the high frequency with which selling livestock is chosen as a coping mechanism. 68% of respondents indicate that they would use selling livestock while the next most prevalent strategy, reducing expenditures, was chosen by only 38% of respondents. To some extent this is to be expected, since livestock is a commonly held asset amongst the surveyed households.[205]

We note that selling livestock does not reduce the household's productive assets as much as other strategies, such as selling land or disruption of children's education; in a time of covariate weather disaster, livestock may be lost because of lack of access to proper grazing. With this reasoning at least livestock sales following a covariate shock generates income for the

[205] 91% of households reported ownership of (large) livestock.

household when they have reason to fear losing livestock anyway to outcomes of the natural hazard. The high frequency of livestock ownership and willingness to cope via the selling livestock supports the claim that farmers in the rural developing world use livestock as a form of liquid savings (e.g., Kinsey et al., 1998; Dercon, 1998).[206]

Our findings run counter to much of the literature on coping strategies, which suggests that coping strategies are chosen such that the disposal of productive assets is resisted until all other possibilities have been exhausted (e.g., Corbett, 1988). As noted in Chapter 2, much of the previous literature tends to classify selling (large) livestock as an erosive coping strategy (e.g., WHO, 1999). Thus, we would expect that respondents choose possibilities that involve reduction of current consumption or augmenting it through other means to be chosen relatively more frequently in our sample. These include: reduction of food intake (chosen by 23% of the pooled sample); borrowing food (19%); reducing expenditures (38%); begging (10%), and some forms of migration (e.g., temporarily for work, only 1%).

It is possible that food intake and expenditures cannot be reduced without endangering life. Yet, this is likely untrue since 81% of households report being able to sell surplus food in the absence of a shock.[207] Moreover, this does not explain the reluctance to beg and borrow. It remains striking that selling livestock is reported so much more frequently than reducing consumption, or augmenting it through borrowing or begging.

Our finding that other coping strategies that unambiguously erode the household's productive asset stock are seldom chosen is more consistent with previous literature. Amongst these are strategies that inherently disrupt children's education (i.e., *take children out of school*, *send children to live elsewhere*, and *send children to work*). This suggests that households in our sample take education seriously and treat it as a long-term investment in human capital, as theories of household capital formation suggest (e.g., Barham et al., 1995).

6.3.2 Grouping traditional coping strategies

Although a majority of farmers (54.4%)[208] suggest that they are willing to engage in only a single coping strategy, a large proportion of farmers are willing to adopt 2-9 strategies.[209] Thus, we are interested in identification of clusters/segments of the total number of farmers surveyed who are similar with respect to their coping strategies.

We employ two different statistical methodologies: PCA and LCA; relative strengths of these methods are noted in Chapter 3. In short, PCA allows for dimension reduction over a number of observed variables while accounting for the variance in the observed data. Given the pattern of our data, it is possible that there is redundancy[210] in the 12 categories of traditional coping; thus,

[206] We cannot make that claim definitively, however, because our survey response categories do not distinguish between the sale of surplus livestock that may have been accumulated during times of relative plenty precisely for insurance against natural disasters, and the sale of livestock required for subsistence.
[207] Yet, it is possible that for some proportion of this 81%, selling surplus on the market is a main stream of income that enables them to maintain a subsistence level of consumption.
[208] 55.17% in Kapchorwa and 53.46% in Oyam.
[209] It is unclear given data constraints if this reflects simultaneous or sequential adoption.
[210] In this case, redundancy means that some of the variables may be correlated with one another, possibly because they are measuring the same construct.

it should be possible to reduce the observed variables into a smaller number of principal components accounting for most of the variance.

We carry out an LCA, which assumes existence of a latent variable which is unobservable to determine patterns of association in the features of multivariate categorical data (McCutcheon, 1987). LCA highlights specific subtypes of related cases (e.g., latent classes) and the associated probabilities.[211]

6.3.2.1 Principal Component Analysis (PCA)

We conduct an exploratory PCA to identify clustering of coping strategies; in our case an identified *component* is an overarching strategy choice, achieved by choosing specific coping strategies. Figure 6.1 presents a scree plot showing the results of the PCA (Cattell, 1966), which plots the identified principal components against their eigenvalues. We follow the well-known criterion for interpretation of PCA results where only components with eigenvalues greater than one are retained in the model (Kaiser, 1960).

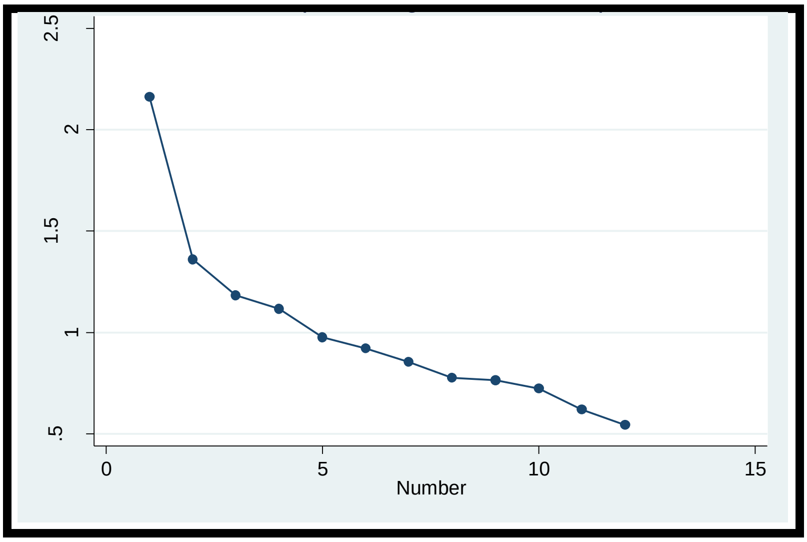

Figure 6.1 Scree plot of eigenvalues for PCA of coping strategies

In the PCA, it is notable how gently the scree plot falls away from the second identified component onwards, due to the large difference between the proportion of variability explained by the first and second component.[212] The eigenvalue of the first component is also relatively low.[213] Thus, there appears to be relatively little clustering of coping strategies in the survey data. This indicates a heterogeneous set of strategy combinations chosen by the sample households, and/or few households choosing strategy combinations at all–strategies are likely to be chosen in unison by the farmers. If certain combinations of strategies were frequently chosen, we would expect to see the relevant components explain more of the sample variance. It should be noted that the structure of the survey question does not allow us to provide insight

[211] Lazarsfeld & Henry (1968) it is useful to note that LCA defines latent classes by the criterion of *conditional independence*–within each latent class each variable is statistically independent of all other variables.

[212] Highly clustered datasets yield scree plots in which the eigenvalues drop off very steeply from the first component and quickly flatten out.

[213] It is not unusual to see eigenvalues of well over five in highly clustered datasets; whereas our first component value is just over two.

as to the order in which respondents would rank responses when indicating they would be willing to engage in more than one.[214]

Table 6.2 gives the component loadings[215] on the first four components (with eigenvalues greater than one) in the PCA. The greater the loading, the higher is the association between a strategy and the overall component, which in our case is the overarching coping strategy approach. The loadings are generally small, which is consistent with the lack of clear clustering seen in Figure 6.1. There is some weak evidence that strategies that reduce current consumption are sometimes chosen together; as the first component has higher loadings on *borrowing food*, *eating less*, and *reduced expenditures*. The second component has higher loadings on *sending children to live elsewhere* and *taking children out of school*, which are similar strategies, but seldom chosen overall. The third component has a very strong loading on *sell livestock* and weak loadings on other strategies, which reiterates the finding that in our sample this most popular coping strategy tends to be chosen in isolation.

Table 6.2 PCA component loadings

Component	**1**	**2**	**3**	**4**
Sell land or home	0.14110	0.37362	-0.06600	0.43784
Sell livestock	-0.15134	0.22887	0.62118	0.22959
Change profession	0.04848	0.00803	-0.69758	0.02116
Begging	0.25422	0.21204	-0.12513	-0.34220
Take children out of school	0.27027	0.34816	-0.01925	0.36908
Send children to live elsewhere	0.23057	0.41338	0.10100	-0.27516
Sell household items	0.32623	0.19043	-0.06193	0.04166
Migrate	0.23251	0.24537	0.13684	-0.53162
Reduction of food intake	0.42126	-0.39377	0.12755	0.03952
Borrow food	0.44088	-0.09887	0.12278	-0.03415
Send children to work	0.32115	-0.02363	-0.10315	0.37140
Reduce Expenditures	0.35849	-0.45721	0.17997	0.03285
% Variance Accounted for by Component	*17.98*	*11.26*	*9.82*	*9.28*

Note: Only principal components with eigenvalues > 1 are shown.

6.3.2.2 Latent Class Analysis (LCA)

The tentative clusterings suggested by the PCA are supported in our use of LCA to note subgroupings based on the characteristics of coping strategies that seem to be chosen together across respondents. The Schwarz Bayesian Criterion (SBC)[216] indicates that the optimum number of classes for our analysis is five; however, correlations of contributing coping strategies are all relatively low[217] in the first class and the BIC value for four classes and five classes were marginally different–thus, there is general agreement with the PCA's suggestion of potential components to number four. The table showing BIC values for the latent class models over different number of classes and the table showing results of latent class model with five classes

[214] We tried a question formulation during the FGDs which required ranking of willingness to engage in traditional coping strategies; however, there was expressed concern about trying to rank them relative to one another. This structure was ultimately not employed because it appeared to increase hypothetical bias in the responses.

[215] A loading is defined as the correlation between the variable and the component.

[216] Also known as the Bayesian Information Criterion (BIC) (Bozdogan, 1987; Sclove, 1987). It is given as the BIC in our analysis; see Appendix F. The model with the lowest BIC indicates the best fit; simulation studies have shown that the BIC outperforms other information criterions in determining the correct number of classes (e.g., Nylund et al., 2007).

[217] Less than 50% is considered low in our threshold analysis.

are provided in Appendix F. In the next section we present the model specifications for our exploration of asset liquidation determinants, specifically the choice to sell livestock or divest in children's education.

The benefit of the LCA is that it classifies respondents into homogeneous groups with similar response patterns for coping, based on characteristics, opposed to *proximity* of responses which is the case in the PCA. Table 6.3 gives the LCM of coping strategy groupings. 14.97% of respondents are expected to fall within the first class, which is characterised by selection of a variety of coping approaches, none dominating the class. There are relatively higher levels of correlation indicated for some strategies that reduce current consumption, such as borrowing food, begging, selling household items, and reduced food intake–supporting the PCA finding that strategies that reduce current consumption are sometimes chosen together. This is similar for Class 2, which includes 36.76% of the sample–there are relatively high correlations for reduced expenditures.

It appears that in our sample, types of reduced current consumption are considered differently. It is also interesting that in Class 2 there is a strong correlation for *selling livestock*–this further suggests that in our sample selling livestock may be considered to reduce current consumption. The third class has higher correlation for *changing professions*, which is classified as failed coping in some literature, but is seldom (4.84%) chosen overall our sample. The fourth class includes 35.23% of the sample and has a very high correlation with *selling livestock*, which reiterates our findings in the PCA and overall claim that this strategy is considered by our sample uniquely from the typical categories of coping noted in the literature. Finally, the fifth class is characterised by selection of a variety of coping approaches. The strategies with the highest correlations are forms of reduced current consumption; however more damaging forms of coping, such as *send children to work* and *send children to live elsewhere* have relatively high correlations. This may be indicative of a class that follows the ordering of coping strategies often noted in the literature–reduce current consumption, but willing to engage in coping that has long-term effects on productivity if required.

Table 6.3 Latent Class Model of coping strategy groupings

Probability of adopting strategies of each subgroup

	Latent Class				
	Class 1	Class 2	Class 3	Class 4	Class 5
	14.97%	36.76%	4.84%	35.23%	8.20%
Sell land or home	0.094	0.014	0.004	0.013	0.082
Sell livestock	0.363	**0.571**	0.220	**1.000**	**0.720**
Change profession	0.045	0.058	**0.998**	0.000	0.170
Begging	0.393	0.022	0.033	0.000	0.405
Take children out of school	0.037	0.010	0.000	0.006	0.141
Send children to live elsewhere	0.033	0.002	0.000	0.000	0.096
Sell household items	0.236	0.094	0.014	0.007	0.394
Migrate	0.026	0.004	0.000	0.000	0.112
Reduction of food intake	0.138	0.395	0.019	0.000	**0.788**
Borrow food	0.269	0.200	0.001	0.030	**0.881**
Send kids to work	0.085	0.034	0.013	0.004	0.359
Reduce expenditures	0.004	**0.876**	0.005	0.002	**0.846**

Note: The probabilities of more than 0.5 for correlations between a particular class and a given response are bolded to emphasise class-response correlations.

6.4 Traditional Coping–Regression model variables

In this section we present the variables used in our regressions models applied to our data on prevalence of coping strategies.

Based on the results of the LCA and PCA, we develop a multinomial probit regression with response categories: non-erosive coping, selling livestock, erosive coping, and failed coping (Section 6.5). These follow from the categorisation of strategies in Table 6.1, in which we see some weak evidence of in our sample. Furthermore, we designate *selling livestock* to its own dependent variable category, as appears to be the case for our sample. Our sample appears to consider selling livestock.

We then look at two specific strategies that indicate asset liquidation to the point that may damage households' utility in the medium- to long-term: 1. livestock sale and 2. strategies that limit children's access to education (i.e., reducing their human capital formation) (Section 6.6). We use the same independent variables in all the regressions in order to make results relatively comparable.

Of the 12 coping strategies amongst which our respondents could choose, six may be categorised under capital disinvestment strategies: *sell livestock*, *sell household items*, *sell land or home*, *take children out of school*, *send children to live elsewhere*, and *send children to work*. Though it is unclear to what extent selling livestock affects a household's future prospects, based on the widespread willingness to do so, it is of interest to analyse potential determinants of this strategy. We construct a binomial variable, *LivestockLiq*, which takes on the value of one for households willing to sell livestock as a coping strategy (in isolation or in tandem with other strategies). We account for the fact that only households that hold livestock can sell it by restricting the sample upon which we conduct our regression analysis to livestock-holding households.[218]

Our second model of coping strategies focuses on the choice of disinvestment strategies that would take children out of education. Given the importance of human-capital formation to development (e.g., Nehru et al., 1995; Noorbakhsh et al., 2001), these strategies can be particularly important with regards to long-run vulnerability. We construct the binomial variable *AssetLiqChild*, which takes on the value of one for households that indicate willingness to take children out of school, send children to live elsewhere, and/or send children to work.

The attitudinal data we obtain in the large-N survey is largely focused specifically on insurance. It does not make sense to apply the same attitudinal variables to our coping strategy models. The coping strategies we look at in-depth (*LivestockLiq* and *AssetLiqChild*) involve immediate ex-post disinvestment of assets; past literature highlights the significance of capital assets in determining vulnerability to natural hazards (e.g., Wisner et al., 2003). We look at socio-economic and demographic variables to which we have access in our dataset to formulate proxy values for capital assets in these two categories: 1. the household's built and financial capital and 2. the household's human capital stock.

[218] It is very common for households in rural Uganda to hold livestock. By limiting our sample to only those households that hold livestock, we reduce the sample by only 290 responses.

Table 6.4 provides a list of the independent variables with associated mean and frequency information. We describe each below in the order they are presented in the table. A correlation matrix for these variables is found in Appendix F.

Region: A concern in the models of coping strategies is the potential for bias arising from unobserved variation. To counter this concern, which is difficult to deal with in cross-sectional data, we include the dummy variable *Region* to account for unobserved variation geographically. It takes on a value of zero for those located in Oyam and one for respondents located in Kapchorwa. In addition, we use 34 dummy variables at the sub-county level.

Education: We account for educational attainment of the household head in the ordinal variable *Education*, defined as the greatest level of education obtained. This is a proxy measure for the household's human capital. Much of the literature on development of children's human capital potential (through education) recognises the importance of considering family backgrounds and characteristics (e.g., Black et al., 2005). Educational differences tend to persist across generations (e.g., Björklund & Jäntti, 2012) likely because environmental factors that contributed to parents' educational levels are shared by children (e.g., Holmlund et al., 2011).[219] Thus, it is likely that *Education* has some bearing on the likelihood of the household engaging in certain types of coping, especially those that involve taking children out of education. Furthermore, *Education* may have indirect effects on the household's overall coping capacity through providing the household wider choice of (higher-level) jobs to augment farming income.

Age: Socio-demographic aspects have influence on perceived risk and willingness to engage in coping strategies that have potentially negative long-term effects on households. Previous studies have found mixed effects of age on risk management strategy adoption (Mishra & El-Osta, 2002), which we include in our model.

FamSize: Family size likely affects the labour capacity of the farm household in which case a larger family size implies greater capacity to assume risks. Dadzie & de-Graft Acquah (2012) note that the larger the number of members in the household, the more risk-averse households tend to be in their choice of coping. The total consumption needs of a large family are greater; however, so is the relative number of individuals participating in the household's income. It is unclear in the literature if the number of children in the household affects the type of coping considered. We include the continuous variable *FamSize* as the number of individuals in the family in addition to the household head.

Acres: The majority of the independent variables considered in the final models are related to land holdings and household income, as these have been noted be highly correlated with coping strategies chosen in previous literature specific to sub-Saharan Africa (Jayne et al., 2003). *Acres* is a continuous variable that accounts for the amount of land held by the household.

We include several additional explanatory variables that are related to the household's wealth level and (on-farm) income. We include them all in the model as they capture relatively different effects, and there is no significant correlation, and thus no significant concern about multicollinearity in the resulting models.

[219] It should be noted that the large majority of the empirical literature on intergenerational educational attainment is premised on developed country examples due to natural experiments through well-documented educational reforms (e.g., Chevalier et al., 2013).

IShare: We include the ordinal variable, *IShare*, which captures the share of household income obtained from farming. The value of *IShare* ranges from zero (0-25 percent) to 3 (75-100 percent), which directly maps to interval values the respondent chose in the survey. It is viable that households with the same income, but differing dependence on farming, would have differing coping strategies within their feasible portfolio from which to choose (e.g., Dercon, 2002). Furthermore, Salimonu and Falusi (2009) identified off–farm work to be a major ex-ante risk management strategy used by Nigerian farmers.

Surplus: This dummy variable indicates whether a household is engaged in farming on the subsistence level or if the household is able to sell surplus crops on the market.[220] Whether a household has enough to sell surplus crops likely eliminates some potential coping strategies that are consumption based, such as reduction in food intake or expenditure.

CoinRisk: It is intuitive that there may be connections between coping strategy choice and attitudes towards risk. According to Tomek et al. (2001), farmers are assumed to select a combination of coping strategies that maximise net expected returns subject to the degree of risk they are willing to accept. Hope & Lingard (1992) note that risk management strategies in agriculture vary with farm characteristics and the risk environment. To gauge the potential effect of risk aversion, we include the ordinal variable *CoinRisk*, the value of which is determined by the outcome of our *Coin* game (see Chapter 5) and provides a measure of household risk aversion, specifically as it applies to agricultural planning. The greater the value of *CoinRisk*, the more risk averse is the household.

NetRem: De Weerdt & Dercon (2006) found that risk sharing was the most frequently mentioned coping strategy; however, in the case of covariate risks this is not always a viable response. Remittances from outside villages are significant means of coping. For example, Rosenzweig & Stark, (1989) found that in order to insure remittances during covariate hazards, Indian families marry their daughters in distant villages. We include the dummy variable *NetRem*, which indicates whether the household is a net-provider or net-recipient of remittances outside of its village.

Table 6.4 Descriptive statistics for independent variables used in multinomial and probit regressions of coping strategies

[220] Note that the dummy variable *Surplus* is coded as zero if the household does have surplus to sell on the market and 1 if the household does not have surplus crops for market sale.

Variable		Type	Mean	s.d.	Categories	Frequency (%)
Region	*Region*	*Categorical*	0.43	0.50	Kapchorwa Oyam	1818 (57.21) 1360 (42.79)
Education	*Educational status*	*Ordinal*	1.28	0.86	No formal education Primary school O-level equivalent Above O-level	558 (17.56) 1470 (46.26) 852 (26.81) 298 (9.38)
Age	*Age*	*Continuous*	40.40	13.0		
FamSize	*Number of family members (in addition to household head)*	*Continuous*	8.50	5.30		
Acres	*Acres owned*	*Continuous*	5.10	70.70		
IShare	*Income share from activities from activities outside of farming*	*Ordinal*	2.77	1.11	Less than 25% 25%-50% 50%-75% More than 75%	619 (19.50) 582 (18.33) 897 (28.25) 1,077 (33.9)
Surplus	*Surplus crops sold on market*	*Categorical*	0.80	0.20		
CoinRisk	*Risk aversion*	*Ordinal*	2.46	1.38	<0.1 0.1-1.3 1.3-3.2 3.2-5.0 >5.0	433 (13.62) 236 (7.43) 1,032 (32.47) 382 (12.02) 1,095 (34.46)
NetRem	*Remittance behaviour*	*Categorical*	1.77	0.64	Net receiver Net provider No remittance behaviour	1,083 (34.96) 1,658 (53.52) 357 (11.52)

6.5 Multinomial probit regression

As noted previously, selling livestock is a prevalent coping strategy employed by our sample. This strategy appears to be its own coping class for our sample, differentiated from other coping strategy classes for our sample; it clearly does not fall within the categorisation of erosive coping as suggested by some previous studies (e.g., Cohen & Sebstad, 2005; Yaffa, 2013). It is important to understand what underlying factors may motivate households to choose livestock sale or other identified coping strategy classes in our sample. this knowledge may translate to other developing country contexts with similar characteristics with groups of households that consider livestokc sale a liquid form of savings that is not necessarily *erosive* in nature.

Specific to our sample, we define four categories in coping strategies: 1. non-erosive coping, 2. sell livestock, 3. erosive coping, and 4. failed coping. Interpretation for alternative-invariant regressors is in comparison to the reference group in the multinomial regression, non-erosive coping, given that all other variables in the model are held constant (Wooldridge, 2010).

Given the complexity of the model, we use marginal effects analysis to explain the predicted probabilities of engaging in a class of traditional coping for a change in the relative value (or category) of an independent variable, assuming all else held constant (Cameron & Trivedi, 2005).[221] In particular we focus on those factors shown to be significant in the estimated model (Table 6.5). Marginal effects are given in Appendix F.

As described in Chapter 3, the multinomial probit model take the following form for the probability that observation *i* will select alternative *j*:

$$p_{ij} = P_r(y_i = j) = \phi(x'_{ij}\beta) \quad (6.1)$$

The alternative *j* is selected from the vector of possible coping strategy classes we identify: non-erosive coping , sell livestock, erosive coping, and failed coping.

β gives a vector of alternative-invariant independent variables, as specified in Table 6.4.

Table 6.5 Multinomial probit regression on classes of coping

Coping Strategy		**Coefficient**		**Std. Dev.**
Non-erosive coping	***(base outcome)***			
Sell Livestock				
Region	*Reference Kapchorwa*			
	Oyam	-0.18248	**	0.07599
Education	*Reference no formal schooling*			
	Primary school	0.04628		0.10018
	O-level equivalent	0.03864		0.11033
	Above O-level	0.07339		0.14083
Age		0.00322		0.00275
Family Size (*FamSize*)		0.00836		0.01364
Acres		0.00630		0.00665
Income share from farming *(IShare)*	*Reference 0-25%*			
	25-50%	-0.54073	***	0.11286
	50-75%	-0.67643	***	0.10576
	>75%	-0.50213	***	0.10184
Surplus	*Reference Yes*			
	No	-0.10250		0.09318
Risk aversion (*CoinRisk*)	*Reference <0.1*			
	0.1-1.3	0.02027		0.15185

[221] Calculated marginal effects are the same regardless of which grouping is used as the base category in the regression (Cameron & Trivedi, 2005).

	1.3-3.2	0.17022		0.11016
	3.2-5.0	0.42498	***	0.13395
	>5.0	0.04359		0.11087
Remittance behaviour	*Reference Net-receiver*			
	Net-provider	-0.11474		0.07375
	No remittance behaviour	-0.27138		0.11945
_cons		0.17972		0.19811
Erosive coping				
Region	*Reference Kapchorwa*			
	Oyam	0.21056	**	0.10362
Education	*Reference no formal schooling*			
	Primary school	-0.31526	**	0.12785
	O-level equivalent	-0.33394	**	0.14426
	Above O-level	-0.57250	**	0.20628
Age		0.00495		0.00373
Family Size (*FamSize*)		0.05710	***	0.01704
Acres		0.00459		0.00907
Income share from farming *(IShare)*	*Reference 0-25%*			
	25-50%	-0.38237	***	0.14832
	50-75%	-0.62550	***	0.14121
	>75%	-0.54270	***	0.13595
Surplus				
	No	0.03867		0.12307
Risk aversion (*CoinRisk*)	*Reference <0.1*			
	0.1-1.3	-0.55814	**	0.24635
	1.3-3.2	-0.11184		0.15332
	3.2-5.0	0.04987		0.18782
	>5.0	0.09769		0.14906
Remittance behaviour (*NetRem*)	*Reference Net-receiver*			
	Net-provider	0.01097		0.10448
	No remittance behaviour	0.14305		0.15446
cons		-1.09611		0.26764
Failed coping				
Region	*Reference Kapchorwa*			
	Oyam	0.07445		0.08539
Education	*Reference no formal schooling*			
	Primary school	-0.11447		0.11310
	O-level equivalent	-0.02615		0.12408
	Above O-level	0.01509		0.15880
Age		-0.00475		0.00314
Family Size (*FamSize*)		0.00626		0.01516
Acres		0.00138		0.00765
Income share from farming *(IShare)*	*Reference 0-25%*			
	25-50%	-0.47028	***	0.12541
	50-75%	-0.62119	***	0.11781
	>75%	-0.53442	***	0.11431
Surplus	*Reference Yes*			
	No	0.04257		0.10322

Risk aversion (*CoinRisk*)	*Reference <0.1*			
	0.1- 1.3	-0.12202		0.18097
	1.3-3.2	0.03078		0.12775
	3.2-5.0	0.18274		0.15626
	>5.0	0.23666	*	0.12574
Remittance behaviour (*NetRem*)	*Reference Net-receiver*			
	Net-provider	-0.18401	**	0.08486
	No remittance behaviour	0.24429	*	0.12543
cons		-0.10834		0.22283
Model fit statistics				
Number of Ob= 3098 DF=54				
Log likelihood=-3680.04 Pseudo R^2*=0.374*				
AIC = 7468.09 BIC= 7794.17				
		=10% sig. ** 5% sig. * 1% sig.*		

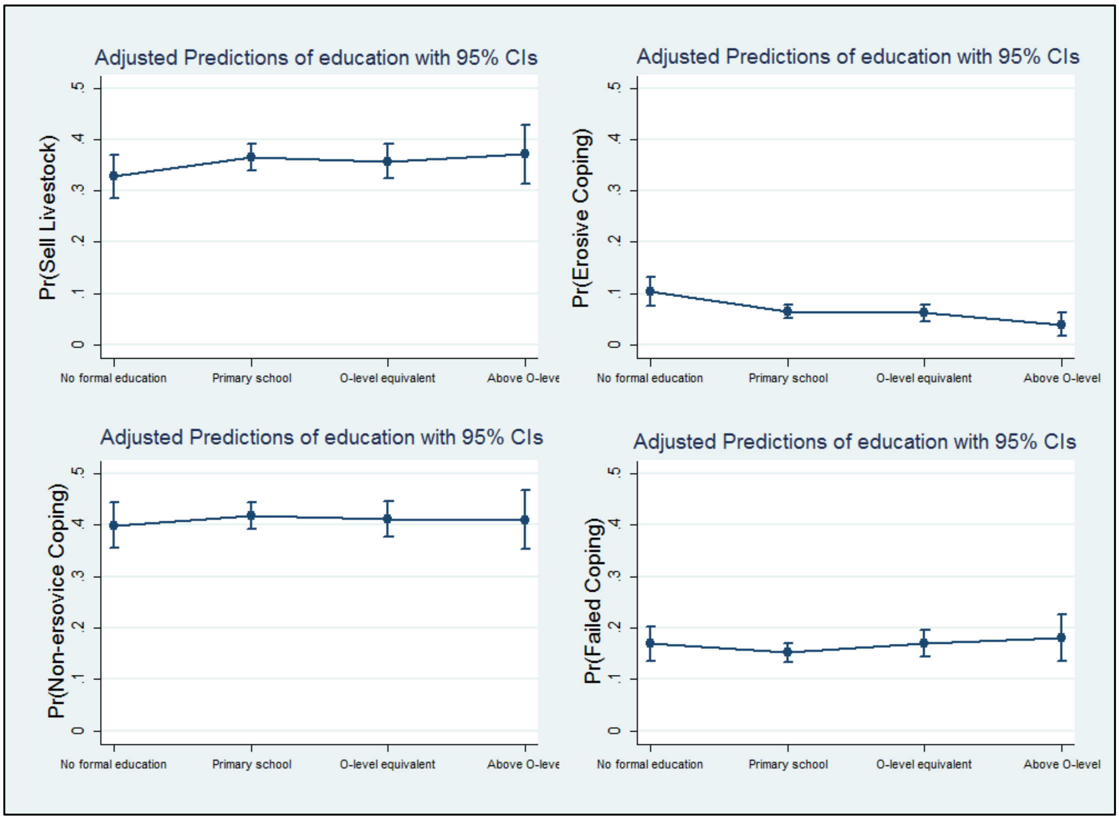

Figure 6.2 Predicted probability of engaging in coping classes based on educational level

Figure 6.2 gives predicted probabilities for different coping strategies across levels of Education. We note that if a farmer has no formal education he is more likely to resort to non-erosive coping (40%) or selling livestock (~33%) compared to erosive coping (~10%) or failed coping (~18%) strategies. Similarly, if a farmer has education above O-level, the probability that he engages in non-erosive coping (>40%) or selling livestock (~37%) is quite high comparatively. It is notable that in most cases the slope of the line joining the predicted probabilities for different education levels is fairly flat. In the case of erosive coping; however, the probabilities are quite small (<10%), which may explain the fact that (in the table of coefficients) education is not a significant factor in predicting this class of coping.

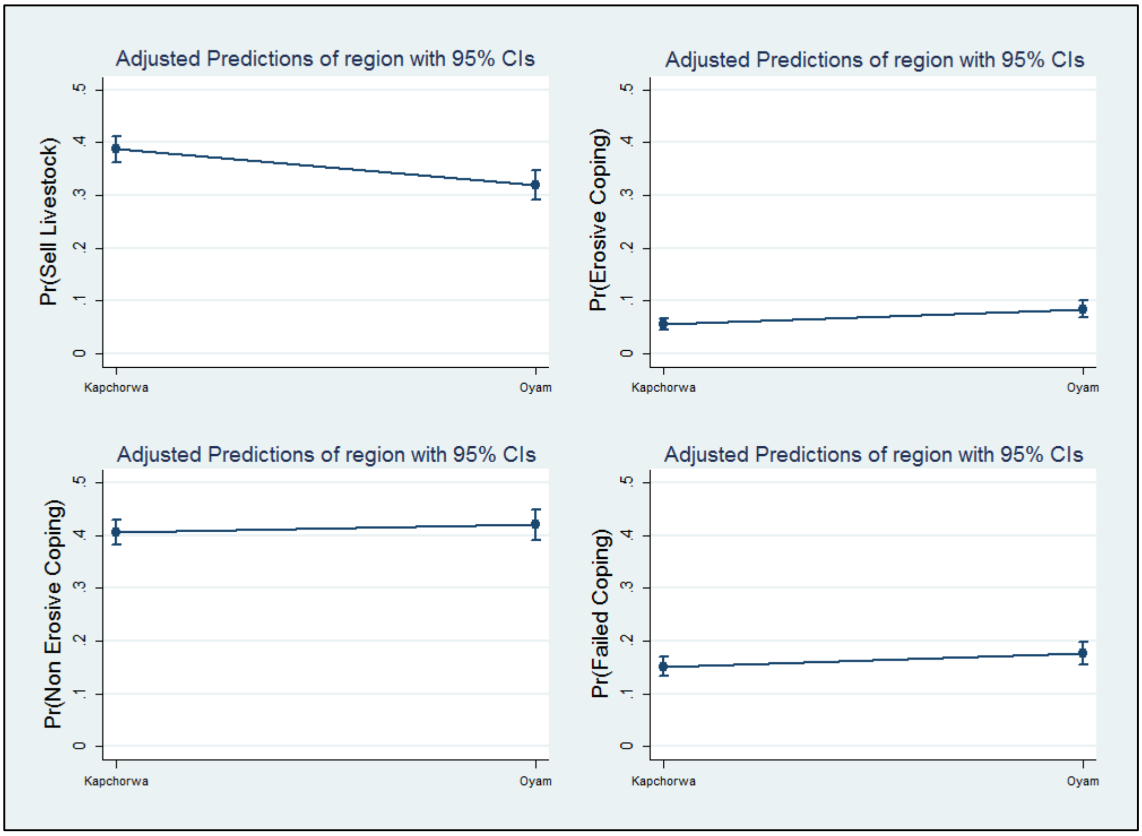

Figure 6.3 Predicted probability of engaging in coping classes based on region

Even controlling for village-level effects, we see in Figure 6.3 that predicted probabilities of employing different types of coping differ between Oyam and Kapchorwa. In Kapchorwa the chances of engaging in selling livestock are significantly higher than in Oyam. This is consistent with the cultural norm in that region; cattle are often raised by inhabitants of Mt. Elgon. Farmers based in Oyam are more likely to engage in non-erosive coping, erosive coping, or failed coping– with non-erosive means of coping (~43%) being the most preferred option.

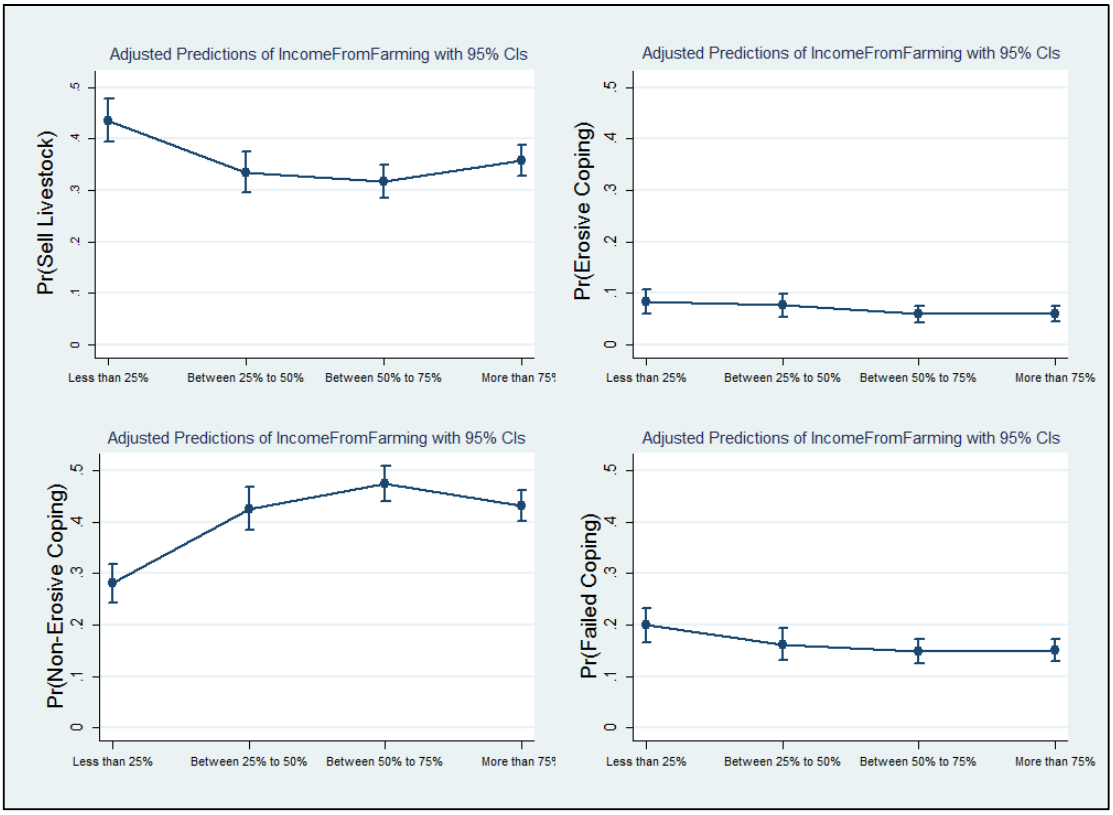

Figure 6.4 Predicted probability of engaging in coping classes based on household income share from farming

In Figure 6.4 farmers with income share from farming less than 25% are relatively more likely (~45%) to opt for selling livestock compared to farmers whose income share fall within the intervals 25%-50% and 50%-75%. In the case of non-erosive coping, the ordering is in contrast – those with income share 50%-75% are most likely (~45%) to engage and households falling within the intervals 25-50% and greater than 75% about equally likely (~40%) to engage. This finding makes sense as households with greater levels of income diversification outside of farming (i.e., <25%) would have alternative income sources in the case of extreme weather. The chances of adopting an erosive coping strategy (~10%) or failed coping strategy (20%) is similar across all income groups.

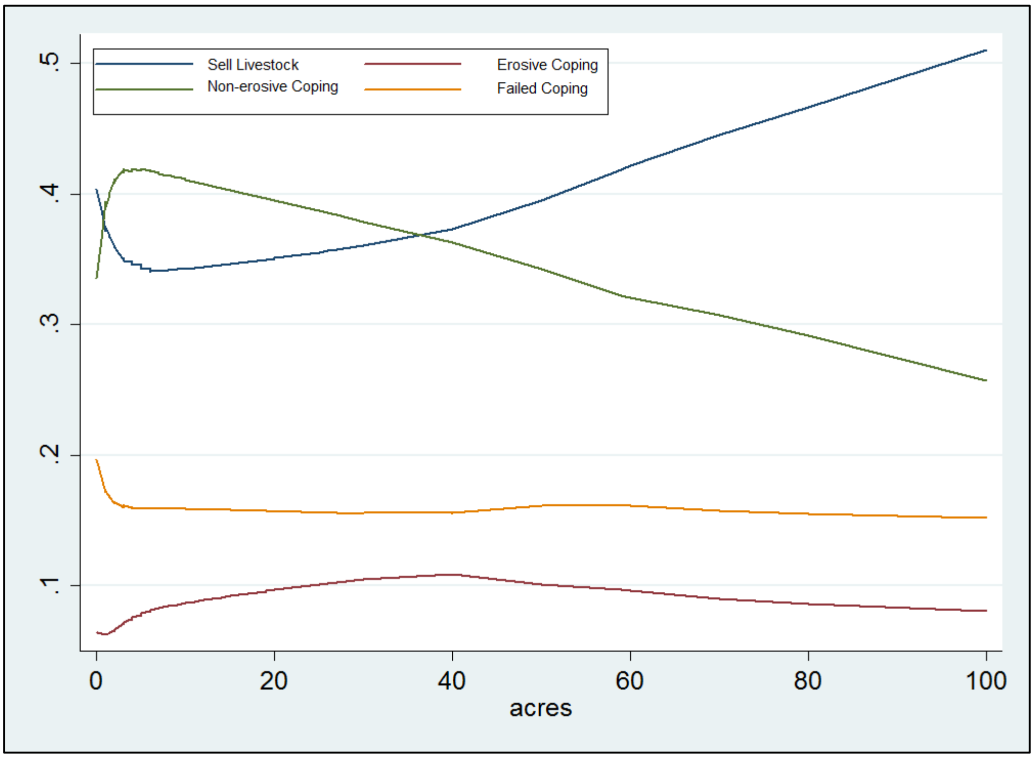

Figure 6.5 Predicted probability of engaging in coping classes based on acres farmed

Figure 6.5 illustrates that the probabilities of resorting to erosive coping and failed coping are quite low across all levels of acres farmed. We observe an interesting pattern of probabilities between likelihood of selling livestock and non-erosive coping. If more than 40 acres of land is farmed by the household, the probability of selling livestock as a coping strategy almost increases in a one-to-one fashion. At this same point, the probability decreases steadily for adoption of non-erosive strategies.

6.6 Probit models

As noted in Chapter 3, we develop two probit models, specific to determinants of selling livestock (*LivestockLiq*) and disinvestment in children's education (*AssetLiqChild*). In our specification of the latent variable y*:

$$y* = \beta' x_i + \varepsilon_i \tag{6.2}$$

β is a K-vector of parameters, as given in Table 6.4 and x is a vector of explanatory variables across respondents. Y* is unobservable, but we observe y=1 if y* > 0 and y=0 otherwise given responses related to engaging in each relative coping strategy.

6.6.1 Determinants of selling livestock

The probit model estimation for the dependent variable *LivestockLiq* is given in Table 6.6, column 1. The proxies for household wealth, *IShare* and *Surplus*, have a significant effect (p<0.01) on *LivestockLiq*. *IShare* has a positive effect and *Surplus* has a negative effect. Households with a higher share of income from farming are more likely to sell livestock after a natural disaster, as are those households that grow surplus crops to sell on the market. This finding hints that the sale of livestock is somewhat more likely to be used temporarily following a covariate weather disaster for households that are more limited in their wealth and ability to reduce consumption. Households that have surplus to sell on the market lose potential income from market sales in the wake of a natural disaster, subsequently creating a greater need for them to cope.

FamSize and *CoinRisk* have significant (p<0.05) positive effects on *selling livestock*. The greater the family size, the more likely it is that the household head is willing to sell livestock in order to cope. It is intuitive that family size is positively associated with vulnerability. Combined with the results for *IShare* and *Surplus*, livestock sales appear to be employed as a first response following a natural disaster. This is consistent with the notion that livestock are held as a liquid (e.g., Fafchamps et al., 1998; Rogg, 2006; Lagos & Rocheteau, 2008; Mogues, 2011) and more vulnerable households cannot cope solely by reductions in consumption.

The positive coefficient of *CoinRisk* indicates that the more risk averse the household head, the less likely he is willing to sell livestock as a coping mechanism. It is difficult to discern the direct implication of this finding, as there is a complex relationship between choice of coping strategies and income risk. This could reflect a correlation between *CoinRisk* and vulnerability (based on income); it is widely considered that relative risk aversion decreases with household income (e.g., Rosenzweig & Binswanger 1993). We should note that we ask respondents to provide a preference over coping strategies, as opposed to tracking their actualised coping. It is possible that greater risk aversion indicates less desire to engage in livestock sales. However, there may be a threshold over which risk aversion has little bearing on whether the household actually sells livestock (i.e., if vulnerability were severe enough based on other factors, the household would sell livestock regardless of measured aversion to risk).

Age is significant (p<0.010) and positive, indicating that households with relatively older household heads are more likely to sell livestock in order to cope. It may be the case that *Age* encompasses an underlying effect that is otherwise not accounted for in our model; increased age in many rural societies correlates with a change in one's community role (Lipton & Maxwell, 1992). Increased age carries a greater reputation cost to coping mechanism such as begging or borrowing and decreased mobility that eliminates some coping strategies from the choice set, e.g., migration.

Table 6.6 Probit models of the determinants of strategies to: 1. Sell livestock and 2. Take children out of education

Variable	(1) *LivestockLiq*		(2) *AssetLiqChild*	
Region	-6.520		-3.140	
Education	0.030		-0.160	***
Age	0.004	*	0.006	*
FamSize	0.025	**	0.042	***
Acres	-0.001		-0.000	
IShare	0.098	***	-0.009	
Surplus	-0.314	***	0.016	
CoinRisk	0.161	**	0.170	
NetRem	0.050		-0.005	
Number of Ob	*2788*		*2935*	
Log likelihood	*-1471.59*		*-726.440*	
Pseudo R^2	*0.134*		*0.166*	

** 10% sig. ** 5% sig. *** 1% sig.*

6.6.2 Determinants of disinvestment in children's education

We now discuss the probit model estimation for the dependent variable *AssetLiqChild* (Table 6.6, column 2). Taking children out of education unambiguously reduces the household's capital investments in future human capital formation. The estimated model has good overall explanatory power.

Education is significant (p<0.01) and negative; the higher the educational attainment of the head of the household, the less likely he is to risk compromising his children's educational attainment. It is possible that those with higher levels of education value investment in human capital development intrinsically, as within our sample there is no significant correlation between education and measures of built or financial capital wealth.

FamSize is positive and significant (p<0.01), which indicates a greater propensity to disrupt children's education following a natural disaster when the family size is relatively large. This is an intuitive finding; when there are more people to care for now it is more likely that a household seeks to stabilise household prospects in the present.

The positive association between *Age* and *AssetLiqChild* (p<0.01) reflects the same consideration discussed above in the model for *LivestockLiq*. As a household head occupies a highly respected community position (correlated with increased age), he is less likely to engage in coping strategies that threaten this position, such as borrowing.

6.7 Summary and conclusions

Our survey results suggest that selling livestock is by far the most frequently chosen coping strategy when farmers are presented with a covariate risk arising from extreme weather. This runs counter to previous studies that indicate that the sale of livestock plays a minor role in coping with extreme weather (e.g., Fafchamps & Gavian, 1996; Kazianga & Urdy, 2006). This also runs counter to the thrust of the literature on choosing coping strategies (Corbett, 1988), such that a reduction in current consumption is always attempted prior to liquidating any assets.[222] We find that strategies reducing current consumption or augmenting it by borrowing/begging[223] would be used fairly infrequently. Our results support the argument that livestock are held like liquid savings, one possible use of which is to recover from a shock (e.g., Dercon, 1998).

Our findings reveal a fairly rich set of determinants of different coping strategy subsets; we chose to focus on drivers of the choice to cope via the sale of livestock, given its prevalence, and the reduction of children's education, given its potential long-term implications. Our findings point to the impact of initial vulnerability on the propensity to disinvest. We found that initial vulnerability is represented by a lack of income diversification, a large family size and, in the case of selling livestock, whether surplus crops are sold on the market (and hence how much of a shock the weather event is to household income). But our findings also point out the importance of attitudinal and social factors (thus consistent with Anderson & Woodrow, 1998; Eade, 1998), notably the effect of educational attainment on educational aspirations for children, attitude to risk and–albeit weakly–age.

There are some limitations to our analysis of coping strategies; primary among them is our survey question, being hypothetical in nature, was one that could yield answers affected by various forms of bias. This potential bias was mitigated by the fact that the survey was administered by local CKWs, who have a pre-existing and trusted relationship with the respondents. It should be noted that in our research areas, large covariate weather shocks (i.e., involving loss of at least half a crop) are reported to occur about once every four years; therefore, respondents are familiar with the issues in question. Furthermore, in neither region is there formalised agricultural insurance, which also serves to make the scenario realistic.

Though our regression models have good explanatory power, the issue of endogeneity, principally through omitted variables, is one in which we need to be aware. We account for this by: 1. specifying a rich set of regressors (none of which is highly correlated with other regressors); and 2. including dummy variables at the sub-county and regional levels to account for unobserved variation.

There has been little empirical study of direct trade-offs between traditional coping mechanisms and the use of microinsurance in the agricultural sector in East Africa. The study by Akyoo et al. (2013) touches upon relative preferences between the two, but does not make direct comparisons. In much of the literature, microinsurance and traditional coping mechanisms are discussed as inherent complements as opposed to substitutes because of differences in structure and means of provision. For example, Hazell (1992, p. 569) notes that "for covariate [weather] risks, local traditional risk coping strategies need to be reinforced by risk pooling arrangements, such as crop insurance, that cut across small rural communities." Furthermore, it is noted that "covariate shocks; however,…cannot be insured by pooling them within a small region, and can be insured only if pooled over a much wider range of potentially affected households" and supported by other strategies (Sarris et al., 2006, p. 1).

By including an analysis of traditional coping strategies used in times of covariate extreme weather disasters, we contribute to knowledge by addressing this gap in the empirical literature.

[222] This is particularly pertinent to response patterns that indicate choice of only a single strategy (that is not classified as non-erosive) from the 12 options possible in our study.

[223] Some literature differentiates between borrowing (from neighbours) and begging (WHO, 1999).

There is an opportunity for agricultural microinsurance to complement traditional coping, especially in sight of low public expenditure compared to the percent of GDP arising from smallholder agriculture throughout East Africa (e.g., Salami et al., 2010). Other options in the literature and in international aid documents suggest improved early-warning communications– but building this infrastructure takes time. Furthermore, with estimations of adaptation costs for weather events and climate change ranging from 3-10 billion USD by the year 2030 (Botzen, 2012a) there is a clear need for more and better coping options in the short-term after a covariate weather related disaster.

In the next chapter we provide an analysis of respondents' expressed preferences for WTJ and WTP for agricultural microinsurance. We also provide discussion in comparison to WTP for a loan to cover agricultural losses to extreme weather. We are unable to directly compare their preferences for agricultural microinsurance with the expressed willingness to engage in traditional coping strategies due to the disparate manner in which the questions are asked within the survey.[224] Yet, there are comparable aspects to the models we develop in each case. To the extent possible we discuss findings on individuals' motivation to engage in agricultural microinsurance in light of their motivations to engage in asset-reducing traditional coping strategies.

[224] The question about traditional coping methods does not include microinsurance coverage as a multiple-choice option.

7 WTP for index-based agricultural microinsurance

7.1 Introduction

Perceived and actual availability of formal risk-management financial services (e.g., liquid savings and emergency loans), informal risk-management services (e.g., remittances), and traditional coping strategies as factors influencing households' microinsurance demand are noted in our conceptual model. Small-scale East African agriculture is largely dependent on informal risk-sharing as opposed to more formalised risk transfer (e.g., Matul et al., 2010). Most rural farmers now have access to remittances and loans, especially since the advent of widespread mobile money tools. Whether demand for agricultural microinsurance is sufficient is debated. High demand is not a universal goal; the objective is matching insurance tools to make it useful to different subgroups defined by heterogeneous factors. The effect of introducing index-based[225] microinsurance into a system and whether it is a complement to or substitute for alternative coping strategies is largely dependent upon pre-existing coping structure. In our large-N Ugandan survey tool the main focus is WTP for agricultural microinsurance. In addition, we obtain information about coping strategies, net remittances, and loan behaviour that are relevant to our sample and gives insights as to motivation behind potential use of microinsurance by households with varying characteristics and preferences.

Situations requiring coping with extreme weather in the poor rural developing country context and the associated limitations to use some traditional coping strategies[226] has led to a call for adoption of additional safety nets (e.g., IFAD, 2010; World Bank, 2010; Ali et al., 2011). The claim is made in policy guidance and academic literature that market-based tools, such as microinsurance, are especially important in the face of weather-related covariate risks, as they allow for the near-immediate in-flow of funds to affected households (e.g., Heltberg et al., 2009; IFAD, 2010). Yet, insurance premia are costly to liquidity-strapped farmers, so the benefits must be greater than the opportunity costs perceived by the farming household to make enrolment worthwhile[227] (e.g., J. Matovu 2011, per. comm. 16 April; E. Chelanget 2011, per. comm. 28 April). The extent to which insurance tools may create improvements[228] is sensitive to many factors (e.g., trust in the offered product) and context dependent (e.g., geography and local government regulatory structure).

Our conceptual framework of microinsurance demand identifies many of these features. When summarising main results of studies that look at the effect of these factors on microinsurance demanded to date there is heterogeneity in the direction of effect for each single factor (e.g., Cole, Bastian et al., 2012; Eling et al., 2014).

[225] Throughout this chapter microinsurance refers to weather index-based microinsurance schemes unless otherwise noted. A further treatment of basis risk specific to index-based products is offered in Chapter 8.
[226] Some forms of coping are especially limited ex-post extreme weather due to limitations in demand. For example, livestock used as a liquid asset is limited as the market goes towards saturation in the case of many households selling simultaneously and region-specific.
[227] As noted previously, farmers may look at premium payments (if they do not receive a payout) in a given period as foregone non-productive income without reason, which complicates the application of standalone index-based microinsurance schemes. This is especially relevant to keeping individuals enrolled following even a period of no crop loss.
[228] On the other hand, microinsurance can improve factors in the consumption channel through reduced income variability, improved consumption smoothing, and protection from shocks to investments made in household well-being in the short-/long-terms (e.g., Cole et al., 2012).

Our large-N Uganda survey tool strove to take into account factors identified in the conceptual model of microinsurance demanded. In their synthesis of thirteen studies[229] on microinsurance demanded, Cole, Bastian et al. (2012) note several non-price factors related to microinsurance demand; in this review they account for aspects such as trust and financial literacy. In our survey and analysis, we also look at factors that have not been included in a holistic review of WTP microinsurance in the past, such as potential influence of feelings of affect towards insurance, which can contribute to a context of bounded rationality for decision-making.

In this chapter we analyse survey findings related to expressed WTP for microinsurance. We consider if factors relevant to microinsurance demanded significantly contribute to demand for a loan in the same situation. We also compare factors relevant to the decision to employ traditional coping strategies through WTP for microinsurance and WTP for loans. Additional preferable attributes of agricultural microinsurance identified by our sample are also highlighted, such as group-level policies.

This chapter is organised as follows. Section 7.2 provides context and introduces the general research. The frequency data for WTJ and WTP for index-based microinsurance from our large-N survey tool sample are presented in Section 7.3. Section 7.4 presents regressors used in the interval regression (as specified in Chapter 3) for WTP for microinsurance mindful of the conceptual framework (as presented in Chapter 2). Section 7.5 discusses findings related to the interval regression of WTP for microinsurance. Information on WTJ and for a loan covering the same loss as the microinsurance is presented in Section 7.6. Section 7.7 discusses relationships between the potential use of microinsurance, loans, and coping strategies to cover on-farm extreme weather-related losses. We review other characteristics of microinsurance structure identified as preferable by our sample in Section 7.8. Section 7.9 notes research limitations. Section 7.10 concludes.

7.2 Context

A frequent claim in the literature is that adoption rates for index-based weather insurance are low among small-holder farmers in developing countries (e.g., (Giné et al., 2008, 2012; Cole, Giné & Vickery, 2013). There is considerable debate as to whether the claim that *disappointing demand* for agricultural microinsurance is an appropriate characterisation of the market (as reviewed in Chapters 1-2). We have primarily noted the impact of microinsurance in terms of potential changes in welfare through the lens of utility maximisation as a means of consumption smoothing via ex-ante planning. It is important to consider that there are inadequacies inherent within existing informal risk-sharing structures that make microinsurance a desirable complement. Yet, choosing to not purchase microinsurance[230] for extreme weather events could also be rational and consistent with expected utility (e.g., Clarke, 2011; Kousky & Cooke, 2012). As noted in Chapter 6, microinsurance is discussed as complementary to traditional coping strategies without a great deal of specificity as to the relative trade-offs (e.g., Sarris & Tinios, 1995; Akyoo et al., 2013).[231]

[229] Eleven of the thirteen analysed studies focused on WTP microinsurance specifically.
[230] Purchasing less than full insurance or none at all.
[231] Additionally, as the ability to obtain loans and remittances from areas geographically removed from the realisation of covariate weather hazard increases (e.g., via mobile money), there is a necessity to consider these more within the potential mix of complementary risk-sharing mechanisms.

We reviewed previous investigations of the impact of agricultural microinsurance based on weather indices in low- and transition-income countries. Many of these studies obtain relevant WTP data through use of single open-ended questions: Berg et al. (2009) in Burkina Faso; Breustedt (2008) in Ukraine, Molini et al. (2010) and Muamba & Ulimwengu (2010) in Ghana, De Bock et al., (2010) in Mali, and Zant (2008) in India. Further ex-post studies of WTP for pilot schemes include: Cai et al., (2010) in China; Fuchs et al. (2010) in Mexico; Hill & Viceisza (2010) in Ethiopia; Karlan et al. (2011) in Ghana; Giné and Yang (2009) in Malawi; Cole et al. (2011) and (Giné et al., 2008) in India, among others. A summary of findings on factors that contribute to the demand for microinsurance and magnitude of WTP was provided in Chapter 2. Reviewing study result syntheses, the effect directions are inconsistent and contradictory in some cases. This arises in part from differences in the approach and analytical methods. For example, in some empirical studies, WTP and household liquidity constraints are not strongly correlated (e.g., Clarke & Kalani, 2011; Cole, Bastian et al., 2012; Eling et al., 2014), such that other factors must be contributing to expressed WTP. To this point we strive to address two relevant gaps in the literature:

- How are households' perceptions and attitudes towards insurance and risk related to WTP for agricultural microinsurance? Is it possible to discern whether these relationships are *rational* or not?

- What relationships may exist between agricultural microinsurance and complementary methods of risk-sharing and consumption-smoothing, specifically loans and informal strategies?

Given the heterogeneous findings for directional effects of relevant factors that may contribute to microinsurance demanded, we do not make specific hypotheses on this point. In our study we strive to account for each constituent factor in the data collected from the large-N sample while maintaining a viewpoint that accepts the fact that households make decisions with bounded rationality.

7.3 WTJ and WTP values: index-based microinsurance frequency data

7.3.1 WTJ Distribution

Expressed WTJ microinsurance in our survey was 96.76% for the total sample. 94.76% of respondents expressed a positive WTJ in Kapchorwa, as did nearly all respondents (99.26%) in Oyam. High WTJ for hypothetical schemes is not unprecedented. For example, Sarris et al. (2006) find substantial demand for rainfall insurance by smallholder Tanzanian coffee farmers; which is substantiated by Akyoo et al. (2013). Ng'elenge (2008) reports the same for smallholder tea farmers in the Tanzania.

The WTP levels offered in our CV questions were within the ability to pay for our sample. Given the fact that the potential tool would be supplied by Grameen Foundation which is highly trusted by the sample, it is not unreasonable that expressed WTJ was high. Many microinsurance tools in reality are initially overwhelmed by demand, especially when priced in accordance with ability to pay (and further subsidised) and it is often renewal rates that present demand challenges (De Bock & Gelade, 2012).[232]

Our high WTJ may be related in part to hypothetical bias from the CV question framing. Respondents who felt that microinsurance could be a useful consumption-smoothing coping option in the future may have responded in a manner consistent even if they had some doubt about their ability to pay at present.

As noted in Chapter 3, we provide a multiple-choice follow-up question to respondents not WTJ the microinsurance scenario.[233] Table 7.1 provides summary responses. Note that the number of total protest responses in Oyam is lower than in Kapchorwa, suggesting that Oyam's households are relatively more interested in microinsurance though it is known to be a poorer region. Interestingly enough, those indicated that the "household cannot afford to pay" was nearly 15% in Oyam, but over 37% in Kapchorwa. Similarly, in Oyam just over 10% of protest responses were due to the fact that the respondent believed that the need for microinsurance "is not a priority." This trend is quite different for the response that "it is not my responsibility to take care of this matter; About 53% of protest responses in Oyam are accounted for by this reason, while the it is only 1.7% in Kapchorwa. It is noted from qualitative interviews that even though the Ugandan government does not intervene financially when crops are lost to extreme weather events, Oyam residents tend to believe it is a governmental responsibility. This could arise from two aspects of land use in the area. First, the relatively stronger clan system in Oyam helps intra-clan redistribution of land (due to a relatively high-elasticity of land supply) in periods ex-post extreme weather (e.g., Matovu, 2011). Secondarily, it may be the case that because of inter-clan rivalries over land in Oyam (Otim & Charles, 2014) individuals feel less rights to land.

For the sample and regionally, about 19% of these respondents indicate they needed more time[234] to consider the WTP question as the main motivation for non-WTJ. This finding corroborates our design of the WTP ladder and surrounding questions in a manner that strove to balance complexity and comprehension within the allotted timeframe.[235]

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[232] A number of private-public experiences demonstrate that crop microinsurance is difficult to sell for a profit (e.g., Cole, 2015). The issue of unsubsidised tools extends to developed country agricultural insurance markets (e.g., (Skees & Barnett, 1999).

[233] Respondents hesitating between the ladder bounds of zero and 100 UGX were also asked this question at the discernment of the administering CKW. The multiple-choice list used was developed from responses in the FGDs.

[234] The CKW network is administered and paid by Grameen Foundation, Uganda. The policy is to have a set payment for each survey conducted by a CKW. Our mobile survey was the longest ever carried out by the CKW network and as such (significant) extra time could not be given to respondents to think about the questions at hand. We note that in qualitative discussions and field checks respondents request for "more time" was on the order of weeks, opposed to additional minutes to think.

[235] This has been a criticism of some tools that attempt to gauge insurance understanding in the past; the complexity of the rules and descriptions are such that someone without past knowledge of insurance cannot understand in a finite amount of time.

Table 7.1 Reasons for unwillingness-to-join the agricultural microinsurance scheme

Reason	Total	Kapchorwa	Oyam
"Our household cannot afford to pay"	80 (29.41)	66 (37.29)	14 (14.74)
"I think that this problem is not a priority"	79 (29.04)	69 (38.00)	10 (10.53)
"I am not very interested in this matter"	9 (3.31)	6 (3.39)	3 (3.16)
"It is not my responsibility to take care of this matter"	53 (19.49)	3 (1.70)	50 (52.63)
"I need more time to think about the question"	51 (18.75)	33 (18.64)	18 (18.95)
N	*272*	*177*	*95*

7.3.2 WTP Distribution

We first consider the absolute values for WTP expressed by our sample. We scaled individuals' WTP by the reported value of their entire crop for a season, to obtain the relative WTP, as this value is of greatest relevance to potential insurance providers and underwriters (e.g., Wipf & Garand, 2010).[236] We are interested in a comparison between the two regions throughout this analysis since Oyam is noted as a poorer region than is Kapchorwa (UBOS, 2010c).

Matches between the WTP responses in each direction were uniformly consistent for a given individual; furthermore, respondents fell into defined valuation intervals. If we assume the upper bound values, the average WTP for the entire sample was 6461.49 (s.e.329.90) UGX/month; for Kapchorwa it was given as 8745.99 (s.e.535.45) UGX/month and 3407.65 (s.e.264.85) UGX/month in Oyam. The modal value for the overall sample (24.01%) and the sub-sample in Oyam (28.46%) fell into the band 500-1000 UGX/month, while the modal value for Kapchorwa (21.84%) fell within the band 1000-5000UGX/month. This WTP frequency distribution by interval is given in Table 7.2 and Figure 7.1.

Table 7.2 Sample WTP frequencies: agricultural index-based microinsurance

	Total Sample		Kapchorwa		Oyam	
WTP interval *(UGX)*	Frequency	%	Frequency	%	Frequency	%
0 – 100	375	11.80	244	13.42	131	9.63
100 – 200	174	5.48	92	5.06	82	6.03
200 – 500	297	9.35	147	8.09	150	11.03
500 – 1000	763	24.01	376	20.68	387	28.46
1000 – 5000	659	20.74	397	21.84	262	19.26
5000 – 10000	456	14.35	258	14.19	198	14.56
10000 – 50000	158	4.97	84	4.62	74	5.44
50000 - 100000	296	9.31	220	12.10	76	5.59
Total	3178	100.00	1818	100.00	1360	100.00

A significant reduction in the frequency of responses for (maximum) WTP occurs for the premium bands of 100-200 UGX/month and 10000-50000 UGX/month. In the former case this may indicate greater sincerity in the intention to join since 200-500 UGX is a more significant sum of money to contribute relatively, as opposed to 0-100 UGX.

[236] There is no statistically significant difference between the WTP in aggregate values and scaled by crop values.

The responses for Oyam increase almost linearly from 100-200 UGX to where they peak at 500-1000 UGX; they gradually decrease until the interval 10,000-50,000 UGX and remain at the same frequency level at 50,000-100,000 UGX. Just over 5% of respondents indicate WTP 50000-100000 UGX/month; this is a relatively high value, but not prohibitive. In Kapchorwa 12.10% of respondents fall into this category. These observations in the data are likely attributable to differences in farm size and wealth between the regions. For example, the range of hectares farmed by households is more narrowly bound in Oyam and the incidence of cash crop farming is much greater in Kapchorwa. The pattern of WTP data is not hugely different from that of Oyam overall. Over 13% fall into the 0-100 UGX interval, 5% falls into 100-200 UGX and 8% in 200-500 UGX. The frequency peaks at 1,000-5,000 UGX for those in Kapchorwa and falls gradually until the minimum at 10,000-50,000 UGX; it increases again in the interval 50,000-100,000 UGX.

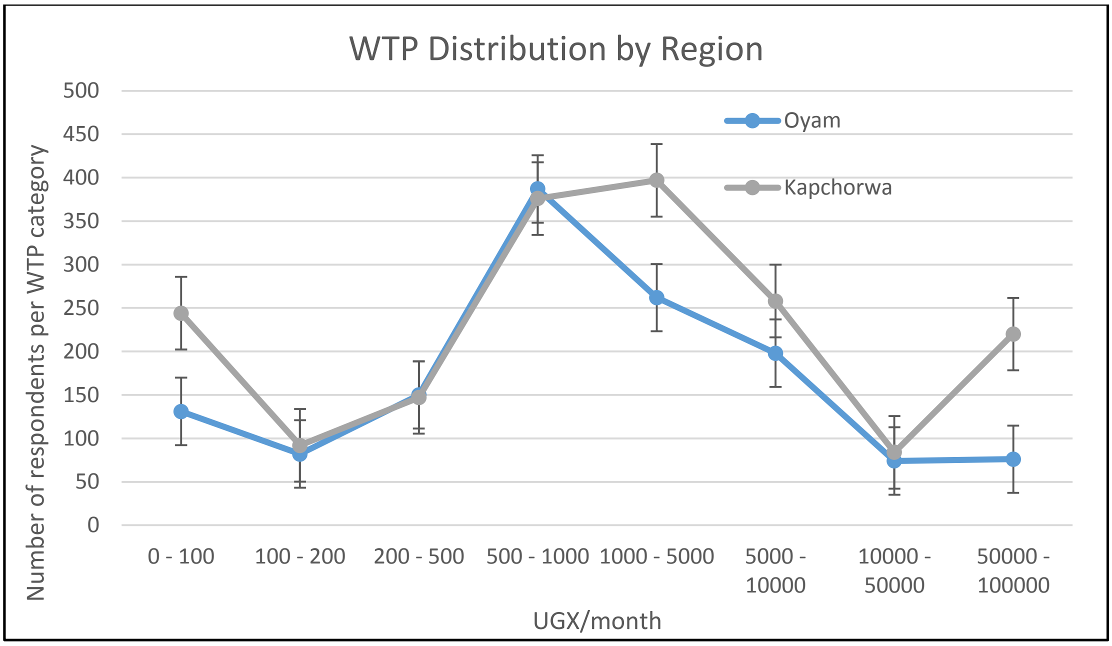

Figure 7.1 Frequency distribution of WTP for microinsurance between Kapchorwa and Oyam

7.4 WTP for microinsurance interval regression

As explained in Chapter 3, we employ an interval regression, motivated because of low non-WTJ in the sample and the censored bounds for estimated WTP. A Heckman selection model and a probit model based on the Double-bounded dichotomous choice (DBDC)[237] method are presented in Appendix G1.

exploring factors affecting WTJ versus WTP is presented in Appendix G. A probit model based on the Double Bounded Dichotomous Choice (DBDC) method is also developed (see Table G.5). The relative results in each model support one another regarding estimated effect directions; however, the interval model indicates the best fit for the data.

[237] Probit models for WTP for microinsurance and WTP for loan based on both the upper and lower WTP bounds are also provided in Appendix G1.

Table 7.3 provides a summary of variable types and descriptive statistics with reference categories indicated for the independent variables. A correlation matrix for bivariate relationships between these independent variables is provided in Table G.2.

In the large-N survey tool, we embedded several questions measuring similar elements of the factors identified as potentially relevant to household demand. This practice was useful in two ways: 1. see if they share a relationship (e.g., correlation) and 2. provide options for useful indicators for a given factor in our modelling efforts. In some cases selection of which to implement in the final model was guided by relative correlations.[238] Other approaches were examined and we used a reductionist process to obtain the most appropriate model.

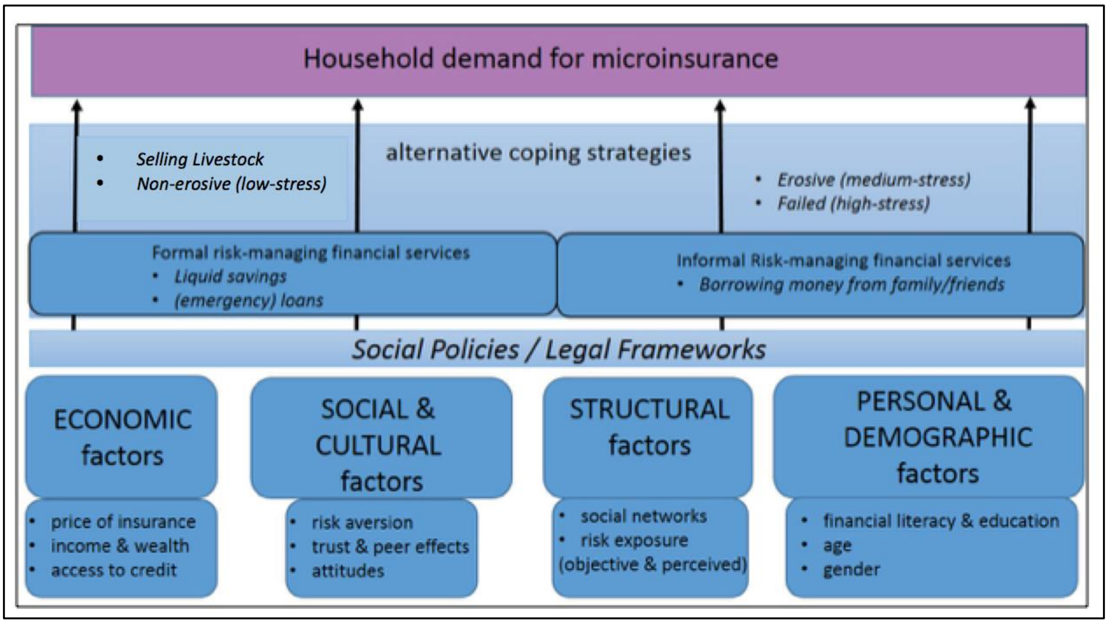

Figure 7.2 Conceptual framework: factors contributing to demand for agricultural microinsurance[239]

With evidence that price and household wealth play only a small part in motivating demand levels, research has examined the potential role of household-specific non-price factors on microinsurance demanded (e.g., Jensen et al., 2014). Across studies, these factors exhibit significant, although sometimes inconsistent, impacts on demand (e.g., Cole, Bastian et al., 2012); see Figure 7.2. It should be noted, as Chapter 2 discussed, that the direction of influence and interlinkages between some factors (e.g., risk and age) are not fully understood (e.g., Eling et al., 2014), which can create challenges in fully recognising the dynamics as well as specification and interpretation of demand models. It is difficult to develop a research design that accounts for social policies and our approach was to control for factors to the extent possible to absorb some of these differences, such as region and clustering models on the village-level. The alternative traditional coping strategy classes specific to our sample (discussed in Chapter 6) are disentangled and implemented in the regression. For each of the four factor-classes (i.e., economic, social/cultural, structural, and personal/demographic) we discuss the

238 For example, to avoid potential multicollinearity no two predictor variables with high levels of correlation--meaning that one can be predicted from the others with a substantial degree of accuracy–were used in the same model specification.

239 This framework is reproduced, from Chapter 2, adding the alternative coping strategies identified in our analysis (Chapter 6).

relevant regression model elements and provide rationale for their inclusion based on past literature and logical potential relationships to microinsurance demand; see summary Table 7.3.

Our equation specification for the interval regression for WTP agricultural microinsurance and to obtain a loan, clustered by villages is given as follows, with independent variables explained in Table 7.3.

Our equation specification for the interval regression for WTP agricultural microinsurance and to obtain a loan, clustered by villages is given as follows:

$$y^* = \alpha + \beta_0 house\_cond + \beta_1 net\_rem + \beta_2 Coin\_risk + \beta_3 worry + \beta_4 IShare + \beta_5 trust + \beta_6 know\_in + \beta_7 save\_sell + \beta_8 wea\_type + \beta_9\ tamsat + \beta_{10}\ coping + \beta_{11}\ num\_loan + \beta_{12}\ in\_mot + \beta_{13}\ env\_ch + \beta_{14} age + \beta_{15}\ education + \beta_{16} dice\_feeling + \beta_{16} region + \varepsilon \quad (7.1)$$

Table 7.3 Description of variables in interval models 1. WTP for agricultural microinsurance and 2. WTP for loan

Factors (conceptual framework)	***Variables in interval model***	***Variable name***	***Type***	***Details***
ECONOMIC factors				
price of insurance (including transaction costs)	Intended WTP	WTP (UGX)	Dependent variable Interval 0. 0 - 100 1. 100 - 200 2. 200 - 500 3. 500 - 1, 000 4. 1,000 - 5,000 5. 5,000 - 10,000 6. 10,000 - 50,000 7. 50,000 - 100,000	Censored by lower and upper bounds in WTP price ladder. For each of the farmers There were two type of questions in the questionnaire: a. "Would you definitely pay a certain amount for crop insurance?" (six iterations) b. "Would you definitely NOT pay a certain amount for crop insurance?" (six iterations) Part (a) responses point towards the lower bound of a farmer's willingness to pay for insuring their crop whereas part (b) sets up their upper bound for WTP.
household wealth (access to credit/liquidity) and income	House condition	house_cond	Ordinal 0. Poor *(reference category)* 1. Average 2. Above average 3. Good	Composite variable (based on Q8, Q9 - Q12) measuring overall household condition as a potential indicator of the overall wealth profile of the farmer (e.g., Chikobvu et al., 2010). Four levels are considered: The value *good* indicates that both the roof and floor (Q9 and Q10) are in *good* shape. The next level is *above average* – which is when either of the roof or floor is in good condition or when roof and floor are in *bad* condition, but the doors and windows (Q11 and Q12) are in *good* shape. *Average* is indicated when the roof and floor are in *average* condition. *Below average* is indicated when all relevant household conditions are classified as *poor*. The variable for electricity (Q8) is found to only be relevant the labels of *good* and *above average* in the data.
	Net remittance behaviour	net_rem	Categorical 0. Net receiver *(reference category)* 1. Net sender 2. No remittance behaviour	If a farmer provides more money than he receives in remittance payments (by mobile or in person) this relates to a relatively higher liquid asset profile (though net remittance is not significantly correlated with other household wealth indicators). Based on Q147.
SOCIAL and CULTURAL factors				

risk aversion	Risk aversion in farming choices	coin_risk	Ordinal 0. < 0.10 *(reference category)* 1. 0.1 – 1.3 2. 1.3 – 3.2 3. 3.2 – 5.0 4. > 5.0	The *Coin* Game provided us with a measure of household risk aversion specifically as it applies to agricultural planning. We calculate bounds assuming CRRA. See Chapter 5 for further details..
	Worry	worry	Continuous (0-35)	Summation of scores across categories of worry. Based on Q136-Q142
	Percent household income from farming activities	IShare	Ordinal 0. Farming accounts for 0-25% of household income. *(reference category)* 1. Farming accounts for 25-50% of household income. 2. Farming accounts for 50-75% of household income. 3. Farming accounts for 75-100% of household income.	Intuitive that the level of income generated from farming has some effect on farmers' WTP for agricultural microinsurance. Based on Q26.
non-performance / basis risk: *Not considered directly in model*				
trust	Trust	trust	Categorical 0. Businessman *(reference category)* 1. Bureaucrat 2. Not sure 3. Neither	There is a sharp division in whom the sample trusts with regards to farming assistance. The category specifications are specific to the Ugandan context. Based on Q143.
peer effects	Knowledge of insurance of friends	know_in	Categorical 0. Self and friends' knowledge of insurance is positive *(reference category)* 1. Self-knowledge/experience of insurance, but no friends' knowledge of insurance 2. No self, but friends' exposure to insurance 3. No prior experience or external knowledge of insurance previously	Four-level variable described by one's self- and friends' knowledge of insurance. Based on Q46 and Q51.
attitudes	Save and sell practices for crops	save_sell	Nominal 0. Farmer sells crops immediately after harvesting; never saves crops. *(reference category)*	Farmers had variable types of experience with regards to saving crops and selling at a later date. For example, while some of the farmers adopt this strategy to make more money, some of them have different motivations in use of this scheme. This variable points toward the attitude of the

			1. Farmer saves crops, but not to try to get a higher price. 2. Farmer saves crops to try to get a higher price later, and has gotten a higher price (than market) in the past. 3. Farmer saves crops to try to get a higher price, and has lost money on this strategy in the past.	farmers with respect to their perception of saving the crop and selling it later in the market in order to gain more profit. Based on Q130.
attitudes	Extreme weather concern	wea_type	Nominal 0. Flood *(reference category)* 1. Drought	Type of weather event with which farmers were most concerned. Based on response to Q55.
attitudes	TAMSAT "agreement"	tamsat	Nominal 0. Agreement between farmer assessment and TAMSAT data *(reference category)* 1. Disagreement between farmer assessment and TAMSAT data.	Indicates (lack of) agreement between respondent indicated extreme weather frequency on-farm and frequency indicated by TAMSAT data. Detailed description in Section 3.3.6.1.1
STRUCTURAL factors				
Informal risk sharing (ability)	Coping strategies employed	coping	Nominal 0. Sell of livestock *(reference category)* 1. Non-erosive coping 2. Erosive coping 3. Failed coping	Based on coping strategy groupings developed from our sample's preferences over traditional coping strategies (based on LCM and PCA). (See Chapter 6). Based on Q32.
risk exposure (perceived)	Number of loans taken in the previous 12 months	num_loan	Ordinal Values from 0 -5.	Number of loans taken by the farmer in the 12 months previous to this survey. Note that we check that the magnitude of loans does not influence results in a significant manner. Based on Q44.
	Motivation when deciding on insurance coverage	in_mot	Categorical 0. Compare to income *(reference category)* 1. Compare to cost of losses from a disaster 2. Compare to both income and disaster losses.	In deciding whether to purchase insurance, we are interested in whether the respondent compares the premium cost to relative household income or the potential loss from a disaster event. Based on Q76.

	(Perceived) change in environment and farming difficulties	env_ch	Categorical 0. Change in environment & Farming became harder *(reference category)* 1. Change in environment & Farming became easier 2. No change in environment & Farming became harder 3. No Change in environment & Farming became easier 4. Farming difficulties are same irrespective of environment	The changes in environment experienced by the farmers due to different type of natural event might entail long-term effects on different dimensions of farmers' livelihoods and subsequently an indirect effect on WTP. Based on Q132.
PERSONAL and DEMOGRAPHIC factors				
age	Age	age	Continuous	Age of respondent in years. Based on Q13.
gender: *not applicable to dataset*				
education	Education	education	Ordinal 0. No formal education *(reference category)* 1. Primary education 2. O-level education completed 3. Above O-level education completed	Level of formal education attained by a farmer. Based on Q15.
financial literacy: *Not considered directly in model*				
financial training: *Not considered directly in model*				
insurance games/training	Affect from holding insurance	dice_feeling	Binary 0. Not feeling of insurance identified 1. Feeling of insurance identified	Based on findings from the *Basic Dice* game. (See Chapter 5).
additional	Region in which household is based	region	Nominal 0. Kapchorwa *(reference category)* 1. Oyam *Clustered model on village-level*	District in which the farmer resides. Based on Q3.

7.4.1 Economic Factors

7.4.1.1 Price of insurance (including transaction costs)

The household's expressed WTP for the microinsurance product is the dependent variable in our regression specification. In studies that consider standalone insurance policies[240] a reported trend is that *ceteris paribus*, the greater the absolute premium rate (even when actuarially fair), the fewer households participate in agricultural insurance (e.g., Coble et al., 1996, 2002; Goodwin & Smith, 2003). Cole et al. (2011) find that a certain percent increase in premium price leads to roughly the same decrease in WTJ across wealth levels. Microinsurance demand is price sensitive, but studies find considerable variation in the price elasticity of demand with ranges from -0.44 to -1.16 across empirical studies Mobarak & Rosenzweig, 2012; Cole, Giné, Tobacman et al., 2013; Hill et al., 2013).

7.4.1.2 Household wealth

Many studies find that household wealth provides greater access/(barriers) to credit and/or liquidity, which ultimately allows (or restricts) insurance purchase, assuming initial positive WTJ the product (e.g., Giné et al., 2008; Cole, Giné & Vickery, 2013). The point being that *ability* to afford microinsurance does not imply household *desire* for the product (at a given price) nor the fact that at a certain wealth level a household *requires* microinsurance. Ito & Kono (2010) and Karlan et al., (2014) find minimal effect between wealth and insurance demanded. Household wealth tends to fluctuate at different periods in the farming season (Collins et al., 2009) ; thus, we include the ordinal variable *house_cond* in the model specification as a proxy for long-term household wealth based on the condition of the main housing on the farming property. As described in Table 7.3, an index was developed based on a series of observations made about the farmer's dwelling by the CKW during the first part of the survey tool.[241]

The household's net remittance behaviour, through the categorical variable *net_rem*, is used as an additional proxy for aspects of liquid household wealth. Households are asked to indicate their actual role in the remittance process, which is predicated on the ability to provide or need to receive remittances. As noted in Chapter 3, remittance behaviour also overlaps with structural and social factors in terms of the role/responsibility the household feels. For example, it is possible that a net-provider of remittances will have a heightened desire for microinsurance to ensure that he can continue to provide this money to those counting on him. Finally, remittances are a form of coping which should be controlled for in the consideration of WTP microinsurance. It is notable that in our sample remittances appear to have no significant relationship to the choice of traditional coping strategies (Chapter 6).

Households that are not credit constrained, when offered actuarially-fair premia, may purchase less than full insurance in part due to the expectation of basis risk.

Relating income and risk, Patt et al. (2009) make the case that it is the poorest farmers in any context–developing or developed–who are likely to accept a lower certainty equivalent, since the risk of receiving no income from their harvest would be relatively more detrimental than it

[240] Only an insurance contract, not tied to a loan or savings tool.

[241] Cronbach Alpha=0.821, p<0.05. It should also be noted that a production index was calculated to determine which households hold relatively more (fewer) productive assets; Cronbach Alpha=0.796, p<0.01. But given the relatively similar structure of productive assets between households (e.g., universal high ownership of mobile phones and low ownership of handplows) this was not a useful way to differentiate households.

would be to farmers in a higher wealth bracket or with greater income stream diversification. The empirical findings related to this claim are mixed; see Chapter 2.

7.4.2 Social and Cultural Factors

7.4.2.1 Risk aversion (perceived)

We differentiate between risk aversion and risk exposure, which is classified as a structural factor, both of which are subject to household perceptions. In general terms, risk aversion is influenced by a number of factors and often stems from past experiences (e.g., Guiso & Paiella, 2005), which may not align with an individual's (current) true or perceived risk exposure.

The variable *coin_risk,* included in our model as WTP, has been shown to vary across levels of household risk aversion (e.g., Clarke, 2011; Tadesse & Brans, 2012) As noted in Chapter 5, the measure *coin_risk* equates to the risk aversion farmers demonstrate in their crop choices for our sample. Inclusion of this variable acts to proxy some farming decisions.

We include *worry* in the model as relating to attitudes towards both perceived risk exposure and risk aversion. As noted in Table 3.1, the main question set surrounding w*orry* is predicated on the finite-pool-of-worry hypothesis (e.g., Linville & Fischer, 1991) which relates to emotional responses as well as personality factors that relate to intolerance of uncertainty (e.g., Freeston et al., 1994). It should be noted that *worry* is not significantly correlated with *coin_risk* or *dice_feeling*, as these are representative of differentiated concepts in the model.

The percent of the household's income arising from farming activities is represented in the model by the ordinal variable, *IShare*. Diversification in employment and household income other than farming is associated with expected income and risk exposure as a means of risk management (e.g., Chavas & Di Falco, 2012).

7.4.2.2 Trust

Trust in insurance providers has been shown to increase WTP in some cases. Cai et al. (2010) demonstrates trust in the government increases WTP for government-subsidised insurance, as would be expected.[242] There is recognition by our sample that the Ugandan central government takes limited action when there are regional crop losses (e.g., IISD, 2013).[243] There is also a relatively low-level of trust in businessmen associated with farming, as there have been a number of recent scandals involving fake seed sells (e.g., Nangoti et al., 2004; Joughin, 2014).[244] Thus, we use the division between (government) bureaucrat and businessman, as these are viable conduits for the provision of microinsurance. The ordinal variable *trust*, is implemented to gauge the effect of trust in certain groups on WTP.

7.4.2.3 Peer effects

The categorical variable *know_in* encompasses respondents' previous knowledge of microinsurance and that of their friends/neighbours. Knowledge of insurance use as a perceived social norm has been shown to induce greater take-up rates. In some cases, peer effects are entangled with building/(lowering) trust in insurance products when individuals hear about positive/(negative) experiences of trusted peers in collecting on insurance claims (e.g., Morsink

[242] It is evident in our sample that trust in the potential provider of insurance, Grameen Foundation is high.
[243] Additionally confirmed in the FDGs as well as informal discussions with Grameen staff from rural areas of Uganda working in the AppLab Kampala.
[244] Noted in the FGDs.

& Geurts, 2012). In our case, there is no previous experience with agricultural microinsurance, so insurance in general is considered.[245]

7.4.2.4 Attitudes

In the staged model we relate to formation of household intention to insure; attitude is an influencing factor with the general understanding of attitude as "the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behavior in question" (Ajzen, 1991, p. 188). In applications to microinsurance demand, attitude is applied to various factor-classes since attitude change towards microinsurance (acceptance) has been identified to work through a number of factor elements, such as perceived risk (e.g., Mosley et al., 2003) and increased financial literacy (e.g., Patt et al., 2009). Furthermore, as an aspect of social factors, attitude is noted through effects of religion on WTP (e.g., Gheyssens & Günther, 2012) and peer effects, among others. Our use of the concept element attitudes under the social & cultural factor class follows from the Ajzen and Fishbein (1980) concept of broad/overarching attitudes applied in the context of farming and microinsurance. This is useful as our measures are interrelated with other desires, but are arguably more standalone in nature than past attitude specifications.

The categorical variable *save_sell* accounts for the respondents' preferred timeframe for selling crops and his experience with that approach–specifically if profit is made by saving crops and selling later. It makes sense this sort of experience will affect attitudes going forward related to savings forms, especially pre-emptive savings serving the function of insurance in lieu of or addition to formal insurance[246].

The categorical variable *wea_type* allows us to control for the type of extreme weather (flood or drought) the farmer is most concerned on their farm. There is an overlap with risk exposure in this variable. Finally, we include *tamsat* in order to account for whether respondent-reported weather extreme frequencies align with recorded weather data or not.

7.4.3 Structural Factors

7.4.3.1 Informal risk sharing

In order to better understand the relationship between microinsurance demand and the use of alternative coping, we include the categorical variable, *coping*, which accounts for the coping classes identified in Chapter 6. It should be noted that in Figure 7.1 alternative coping strategies are indicated separate from structural factors; however, there is a cyclical relationship between traditional coping strategies employed in one period and the (local) structural system under which a farmer makes decisions in the next period. Other forms of risk-sharing and consumption-smoothing are accounted for in the model through *net_rem* and *num_loan*.

7.4.3.2 Risk exposure (perceived)

The categorical variable *env_ch*, accounts for respondents' feelings regarding perceived environmental changes (and associated farming difficulty). This variable measures a relatively different type of risk–indicating long-term gradual baseline changes in the farm land and the ease of farming and is not significantly correlated with other weather risk perception variables in our dataset.

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[245] Including insurance for idiosyncratic issues, such as funerals and health.

[246] We recognise that many respondents hold liquid savings in the form of cattle as well.

The number of loans taken by the farmer in the twelve months preceding the survey is included in the variable specification *num_loan*. Loans are a form of coping with extreme weather. Depending on the source of loans and magnitude of payback, they may be considered as contributing to non-erosive or erosive coping.[247] We also include the categorical variable *in_mot*, which notes the self-described motivation behind the decision to insure with regards to how respondents' think about WTP in reference to their income. An issue that came up in our FGDs was the fact that farmers considered paying premia in a year in which they personally did not experience loss and receive a payout, income *wasted*.[248] It is of interest to understand if respondents consider the relative impact on their typical income or the potential disaster loss when determining WTP for microinsurance.

7.4.4 Personal and Demographic Factors

7.4.4.1 Age

The continuous variable *age* is included in the regression. As noted in Chapter 2, age is often included in WTP analyses as a control variable and the effect direction is largely ambiguous between studies. It does make sense that age may have differing contributing effects depending on the frame of reference ascribed by the respondent. For example, age continues to be reported as significantly positively correlated with increased risk aversion–if microinsurance is considered risky, age may have a different affect than if it is not.

7.4.4.2 Education

Educational attainment of the household head is accounted for in the ordinal variable *education*, defined as the greatest level of education obtained. This is a proxy measure for the household's human capital.[249] Furthermore, taken along with age, education may inform the social norms to which an individual feels obligated (e.g., Hernandez & Blazer, 2006).

7.4.4.3 Affect

There are a number of studies suggesting increased use of insurance games/training and developed financial literacy may increase WTP (e.g., Dercon et al., 2014); see Chapter 2 for further discussion. We do not provide such a treatment, but do look at propensity to insure in a game format through the application of affect. *Dice_feeling*[250] is in the model to account for the propensity to insure even in cases when the relative risk faced is not objectively minimised. See Chapter 5.

7.4.5 Other factors

The direction and path of influence associated with factors potentially related to WTP is unclear across studies (Cole, Giné, Tobacman et al., 2013; Eling et al., 2014). This is to be expected to some extent given the inherent nature of differing policy environments and study goals between case studies.

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[247] In our specification we take into account only the number of loans and not the related magnitude. We tried a specification indexing the number of loans by importance to livelihood.

[248] The concept of risk-spreading geographically to make insurance viable (e.g., receive a payment that is greater than the premia paid in a disaster period) was understood, but it was difficult for respondents to understand paying a premia and not getting back money from the insurer in a given period (if there is no disaster).

[249] It should be noted that measures of numeracy and literacy were closely related to *education*.

[250] For further information about dice_feeling and the feeling of insurance, see Chapter 5.

We look at our regression analysis to determine potential relationships, opposed to a dynamic systemic model of flows. To the extent possible we have measured and included variables that highlight an element of a given factor. As noted previously, household coping is not supported heavily by social policies and legal frameworks in Uganda; thus, this factor is not explicitly specified in the regression analysis. Yet, given that there are many differences inherent between local governance in the two study regions, including *region* as a dummy variable and clustering the regression on the village-level helps control for some of this variation. Furthermore, to the extent possible in this type of large-N cross-sectional survey data, we strive to include consideration for bounded rationality, which to the best of our knowledge is not general practice for this type of study.

7.5 WTP for Microinsurance—Interval Regression Discussion

The interval regression for WTP is presented in Table 7.4. A number of variables are shown to have at least one category with a significant effect on WTP for microinsurance. In the discussion that follows we highlight these findings and also discuss some factors that would be expected to be relevant, but are not significant. The discussion is organised by factor categories. The marginal effects for this model are given in Table G1.10. The overall fit of the model is relatively good with a pseudo-R^2 value of 0.578[251]–the model explains 57.8% of variability of the response data.

We look at the relative WTP for a representative agent from the subsample in each region. The WTP for the farmer profile from Kapchorwa is 24,779 UGX/month; for Oyam it is 19,300 UGX/month. These calculations are based on the profile for an average respondent in each region, as given in Table G1.1.

The estimated coefficient values are discussed by relevant factor category, below.

Table 7.4 Estimated coefficients for the clustered interval model for WTP for microinsurance

Variable		Coefficient		Robust Std. Err.
house_cond				
	1	715.68		1573.36
	2	-15036.56	*	7662.31
	3	-15744.20	**	8002.23
net_rem				
	1	1195.63	*	1607.71
	2	-268.73		2220.18
coin_risk				
	1	212.16		3205.05
	2	3820.20	**	2783.72
	3	2475.64	**	2910.00
	4	1796.15	**	2612.82
worry		-345.59		189.61
lShare				
	1	4190.46		2906.87
	2	5591.65		3400.00
	3	4454.07		3054.83
trust				
	1	-5183.02	**	2666.87
	2	-2758.23		2573.86
	3	-2016.14		2691.90
know_in				

[251] Based on McFadden's R^2 estimation (e.g., Aldrich & Nelson, 1984).

	1	- 14700.72	*	7775.52
	2	- 10554.86	*	6291.45
	3	- 19737.81	**	9393.50
save_sell				
	1	3473.72	**	3206.92
	2	- 715.13	**	1904.03
	3	3454.92	**	3436.00
	4	15180.36		12094.32
wea_type				
	1	- 209.80		2039.98
tamsat				
	1	2445.60		2372.82
coping				
	1	212.72	*	1919.95
	2	2470.11	*	3182.50
	3	7525.68	*	4212.62
num_loan				
	1	7171.40	**	3343.03
	2	5755.67		3622.40
	3	11392.35		7119.96
	4	13432.16		10251.61
	5	13890.13		8664.84
in_mot				
	1	2803.47	*	2273.33
	2	4813.00	*	2752.37
env_ch				
	1	1974.40		2224.75
	2	- 8219.74		4285.61
	3	- 4719.62		6701.28
	4	714.63	**	2638.62
age		80.34		63.02
education				
	1	4198.50	*	2499.28
	2	4476.71		2742.89
	3	7756.52	*	4671.68
dice_feeling				
	1	1901.60	**	2284.52
region				
	1	- 8731.16	*	4235.24
cons.		23801.07		6981.28
N = 3178 DF = 46				
LL (intercept only) = -4268.64				
Pseudo-R^2=0.587 (p<0.0001)				
AIC = 20567.60 BIC = 20831.93				

7.5.1 Economic factors

For individuals in the *above average* and *good* categories of *house_cond*, there is a statistically significant reduction in WTP level compared to those in the below average reference category. Household condition does not display any significant correlations with traditional coping strategies identified for our sample. It makes sense that *house_cond* indicates long-term/established household wealth which may indicate greater savings (i.e., bank accounts); however, a house in good condition does not necessarily indicate high levels of (short-term) liquidity. Certain housing attributes are strongly influenced by an individual's position within his community; clan leadership have houses built from better materials;[252] thus, it follows that they

[252] For example, those households with electricity in the sample were associated with clan leadership in most cases.

have the better land or are relatively less vulnerable to extreme weather in some manner. This claim seems reasonable based on scant academic literature related to the inheritance of Ugandan land through clans (e.g., Rugadya et al., 2007). It is also possible that better housing conditions equate to greater stores of cash or other assets that are not explicitly controlled for in our study.[253]

We find that net-providers of remittances (*net_rem*=1) have a statistically significant higher WTP compared to net-receivers. It may be expected that net-receivers would actually have a higher WTP, as they may have relatively more to gain from microinsurance with payouts used in lieu of remittances. Yet, net-receivers likely do not have high levels of disposable income in a given period for premiums, such that the pattern seen in the data is reasonable based on budget restrictions. It is likely that net-providers have a certain social position to maintain; if affected by extreme weather, it is not only their own household that suffers, but also those remittent-dependent on them. Thus, microinsurance is appealing because it helps hedge against this compound risk to multiple households' wellbeing from the perspective of net-providers. In contrast, net-remittance behaviour is not significant in the regression analysis of traditional coping strategies.

7.5.2 Social and cultural factors

The coefficients for levels of *coin_risk* above CRRA 0.1-1.3 are significant and positive, indicating that at greater levels of risk aversion WTP is likely to be higher. However, there is an interesting pattern for *coin_risk* in that the associated WTP estimate peaks at the 1.3-3.2 interval and is positive and significant, but decreases for each subsequent increasing risk aversion category. It may be that microinsurance is of greatest interest for households at a certain level of risk aversion, but for the most risk averse, preference is for *tried and true* coping strategies due to some level of risk being associated with the use of microinsurance. Though *coin_risk* appears to accord with risk aversion specific to farming activities (Chapter 5) it is possible that more risk averse households pick up on compound risk carried within microinsurance contracts, e.g., non-payment.

Worry is a composite variable accounting for worry about on-farm and off-farm issues; thus, it is not completely surprising that it is not significant in the model. It makes sense that worry specific to farming may have a more pronounced effect and should be further explored[254]. In the Heckman specification, we see that as *worry* increases, the WTP decreases significantly. It may be the case that *worry* captures concern, but not necessary individual's willingness to act to counter those concerns. For example, *dice_feeling* may better capture the sense of *relief* one obtains from microinsurance cover. *Worry* may actually capture the fact that for individuals with high-level worry, concern over failure of payout is an issue.

Somewhat surprisingly, *IShare* is not significant in the model. Logically, those with a greater level of income dependent on farming would be relatively more vulnerable to large-scale farming losses and likely to have greater WTP. In the case of WTP microinsurance it may be that absolute value of crops is a significant motivator, while relative percent of income is not. *IShare* was significant in modelling traditional coping choices for our sample (Chapter 6). In the Heckman

[253] Housing conditions are surprisingly not significantly correlated with productive assets for our sample.
[254] Not that in this model specification, replacing worry with a variable that isolated expressed worry for farming did not create a significant effect.

selection model (Table G.3) we find evidence that farmers with greater income from farming are more WTJ microinsurance. So, *IShare* appears to motivate initial enrolment, but the extent of WTP is sensitive to other factors.

We find that relative to trust in businessmen, those who indicate greater trust in (government) bureaucrats are statistically significantly less likely to invest in microinsurance. In the FDG discussions respondents indicated that dishonesty in businessmen was a risk; while inaction of central government during farming crises is taken as *given*. The findings appear to be rational within the knowledge we have of trust issues within farming decisions in the context of this case study–it makes sense such that those trusting businessmen would be willing to engage in microinsurance as a *business transaction*.

It is logical that relative to the classification of one's self and friends having previous insurance knowledge other categories would have relatively less likelihood of engaging. Interestingly, those with no personal knowledge/experience with insurance, but with friends with knowledge/experience were more likely to have higher WTP compared with the case in which one had personal knowledge, but no friends with knowledge. In cases of friends' knowledge, it may be that relatively many friends (opposed to one) have (positive) experiences; thus, yielding a level of persuasion on par with *social norms*. As a caveat, in this study, our respondents only have previous real-life experience with idiosyncratic indemnity-based policies which may (not) map to experiences with index-based policies for covariate risks in the future due to structural differences in the insurance tools. [255]

Estimated coefficients for all levels of *save_sell* were significant relative to the reference category of "*farmer sells crops immediately after harvesting; never saves crops*." Interestingly those who have saved crops and got a higher price than they would upon selling immediately after harvest[256] were characterised by a decreasing WTP. Those in the categories that saved and received the same market price or lost money on the market are more likely to have a higher WTP value—the magnitude is very similar for the two cases. It should be noted that for a number of crops, especially fresh fruits, which are grown in both regions, there is a major issue with storage. Also, getting them to a larger market before rotting is a problem of transport (Okello, 2010). Difficulties in saving and transport of crops is perceived as a serious production constraint (Sieber, 1999; Christ & Ferrantino, 2011; Tefera et al., 2011).

Wea_type and *tamsat* are not significant in the model. The CKW tailors the WTP question relative to the individual respondent's indication of type of extreme weather most prevalent on his farm by the respondent.[257] Though it is in practicality more difficult to supply microinsurance coverage for flood, the desire to insure likely is not diminished relative to disaster type. Checking TAMSAT data against respondents' estimates was meant to provide a general baseline for potential bounded rationality regarding risk exposure; thus, *tamsat* is not a precise measurement.[258] We use a grid to compare the values, opposed to exact weather history at each

[255] In the FDGs, in general, insurance for indemnity issues was seen as a useful tool, e.g., for a motorbike. One further caveat is that in the local language knowledge and "experience with" are not largely differentiated, so we have to take this into account in understanding the findings.

[256] When there is a glut in the market and prices are temporarily pushed down.

[257] We recognise that providing flood microinsurance is relatively more complicated, especially in terms of dealing with the index such floods tend to be more localised than are droughts. Yet, it is important to target the

[258] There is no significant correlation between the distance from the TAMSAT data point and the farm in terms of (non)agreement between TAMSAT data and the farmer's perceived extreme weather frequency.

specific farm site. In a model where respondents have a better sense of potential basis risk, it would be more realistic for *tamsat* to act as a proxy for basis risk, which is a useful channel for further exploration.

7.5.3 Structural factors

Estimated coefficients for all traditional *coping* classes are significant, relative to the base category of selling livestock. In comparison to the reference of selling livestock, likelihood of greater WTP in all categories is relatively high. All are positive in increasing order from non-erosive coping, erosive coping, to failed coping. The relative difference for failed coping is quite high which makes sense. If a household is willing to consider strategies that may fall into this category, they would likely prefer to engage in ex-ante risk transfer if possible.

There is a significant positive association in the model for the variable *num_loan*, for those who have taken one loan in the past year opposed to no loans. Households that have taken a loan clearly have experienced a need to cope previously and it makes sense that WTP would be higher. It may be the case that households that *regularly* take out (relatively large-scale) loans also are more comfortable with this form of coping. There is some evidence to support this possibility, as there are not significant correlations between the number of loans taken and either traditional coping class preferred nor remittance behaviour. Furthermore, in cross-referencing the number of loans taken with the source of loans, many of those taking just one loan indicate that they borrowed from a local moneylender or bank, which tends to be associated with relatively higher interest rates than borrowing from friends/family/savings groups (e.g., Collins et al., 2010; Mpuga, 2010).[259]

We see that farmers evaluating both their income level and the potential risk of a natural disaster have significantly higher WTP compared to those considering either income or risk of disaster for the variable *in_mot*. It makes sense that an optimal manner of accessing the feasibility of microinsurance coverage is to consider the expected magnitude and probability of loss in tandem with premia costs in the context of household budgeting.[260] It is likely that these households find the relative trade-off between premia cost and coverage worthwhile, but we do not have full information about the analysis they employ to make this consideration.

Interestingly we find that respondents perceiving no change in the environment and that farming has become either harder or easier have a significantly lower WTP compared to the reference category for *env_ch* (i.e., the environment has changed and farming became harder). Somewhat surprisingly, those indicating that farming became harder also have a significantly lower WTP than those indicating farming became easier. This may reflect an emotional response tending towards apathy; with such extreme challenges in farming, microinsurance may not be the most effective risk-transfer mechanism.

[259] This is an issue that was often noted in casual conversation and pointed to in popular news sources, (e.g., Sanya, 2013).

[260] 47% of the sample falls into this category of *in_mot* indicating that these individuals likely take a more time to consider the relative framework under which one decides if microinsurance is *useful* to the household than do their counterparts. The consideration still likely fall under System I–type thinking (e.g., respondents do not make exact calculations); however, the considerations are more complete than those only considering one of the two factors.

7.5.4 Personal and demographic factors

Age is not significant in the model. It is possible that some aspects that are typically proxied by the inclusion of age in a model are accounted for partially by other factors included in our model. In particular, as age reflects a certain social seniority, this may be reflected by *house_cond* as noted previously, as well as other behaviours, such as *net_rem* and *coin_risk*. Factors that directly relate to WTP in some studies also have been shown to correlate with risk aversion.

Regarding *education*, those with primary level or above O-level education have significantly higher WTP relative to those with no formal education.[261] This finding is not necessarily expected, as the relationship between general education obtained and financial risk-taking,[262] and specifically WTP microinsurance is somewhat mixed (e.g., Akter et al., 2008; Lin, 2009; Chen et al., 2013; Cole, Giné & Vickery, 2013).

There may be other factors contributing to this relationship, such as better basic numeracy and literacy skills, which help with understanding insurance. Furthermore, even if the household is not diversified outside of farming in large part, increased human capital allows for the possibility to cope in ways that provides helpful excess income (covers premia, etc.).

Respondents for whom *dice_feeling* is positive have a significantly higher WTP than those for whom it is not. This finding makes sense from the standpoint that individuals who are prone to enjoy the feeling of being covered by insurance will pay relatively more for coverage than those who do not derive utility from the *feeling* of being insured.

Finally, even though the model is clustered on the village-level, we see a significant effect associated with *region*. Those respondents from Oyam are likely to have a lower WTP relative to those in Kapchorwa. This may account for some variation that is specific to the region rather than more localised effects; e.g., general clan effects on farming. It also makes sense from the standpoint of average regional wealth and associated ability to pay that are otherwise not captured in the model.

7.6 WTP Values–Loan

7.6.1 Frequency distributions

We apply the WTP ladder (UGX categories) identified for WTP for microinsurance to the scenario for taking a loan from a local institution.[263] The frequencies for a loan across WTP categories are given in Table 7.5 and Figure 7.3. The WTP frequencies for microinsurance and loans are distributed very similarly within each region.

[261] Those with O-level education also have higher WTP compared to those with no formal education, but this particular difference is not significant in the model specification.
[262] In relation to financial risk-taking behaviours, risk literacy (i.e., numeracy) appears to be of greater relevance than general educational attainment (Bayer et al., 2009; Lusardi & Mitchell, 2011). Refer to Chapter 2 for further details.
[263] It was clear that the provider of the loan would not be Grameen Foundation.

Table 7.5 Sample WTP frequencies to access to loan ex-post extreme weather

	Total Sample		Kapchorwa		Oyam	
WTP interval *(UGX)*	Frequency	%	Frequency	%	Frequency	%
0 – 100	382	12.02	256	14.08	126	9.26
100 – 200	187	5.88	96	5.28	91	6.69
200 – 500	339	10.67	165	9.08	174	12.79
500 – 1000	841	26.46	417	22.94	424	31.18
1000 – 5000	659	20.74	380	20.90	279	20.51
5000 – 10000	399	12.56	251	13.81	148	10.88
10000 – 50000	120	3.78	72	3.96	48	3.53
50000 - 100000	251	7.90	181	9.96	70	5.15
Total	3178	100.00	1818	100.00	1360	100.00

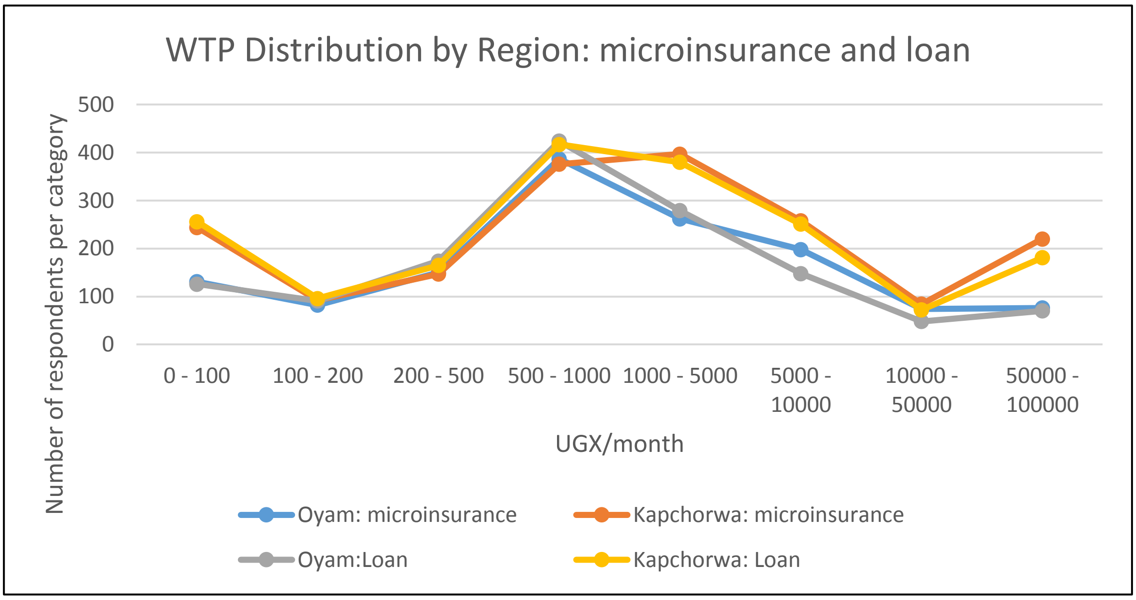

Figure 7.3 WTP Distribution by region: microinsurance and loan per month

The relative distribution of WTP for loans follows a pattern similar to that of WTP microinsurance. This is not surprising because the magnitude of hypothetical loss is consistent between the two WTP ladder questions. Respondents are relatively familiar with the use of loans as a means of ex-post consumption smoothing.[264] Almost 80% of respondents have used at least one major loan in the last five years for coping in a time of farming difficulty; 46% in the twelve months previous to the survey. Furthermore, we cross-reference the WTP reported through CV to the values provided to the open-ended question about the estimated interest respondents would pay for a loan to cover loss of half their crop.[265] These values are in relative agreement and are not statistically significantly different from one another, indicating that bias in the WTP loan is likely not derived to a large extent from the framing or proximity to a similar question set for WTP microinsurance. A paired t-test of the two distributions indicates that we

[264] These loans originate from a number of sources and the sample tends to take loans from sources that require high interest payments (e.g., local moneylenders and banks). Relatively high WTP may do with the fact that the bands on the WTP ladder are relatively *economical* in comparison.

[265] Relates to Q58. It should be noted that the value of half the crop did not correlate with the estimated interest rate.

cannot reject the null that the difference in means is statistically significantly different from zero (t=0.87; p=0.37) (Hsu & Lachenbruch, 2008).[266]

The similarities between loan and microinsurance WTP distributions may indicate respondents consider these tools under the same general umbrella of formalised financial approaches to coping. Furthermore, from the patterns alone we find very similar demand schedules, indicating that the two are implicitly perfect substitutes in respondent utility. Kahneman & Tversky (1979) note that individuals' evaluate losses different than gains, affecting preferences. Since our WTP tool was hypothetical, even though great efforts were made to get respondents to understand the ex-ante planning (and premia payments) associated with insurance, the framing was such that respondents may consider WTP for microinsurance as an ex-post action, in the same fashion they would a loan.

Microinsurance can be bundled with loans to promote investments in measures that reduce vulnerability to extreme events. Furthermore, bundling loans and microinsurance provides greater credit to the most-vulnerable through ensuring access to loans (Suarez & Linnerooth-Bayer, 2011). But there is evidence from some empirical research and field experiments that on the demand side these products are less desirable than stand-alone loans. For example, Giné & Yang (2009) find that uptake of the insured loan is significantly lower than for the uninsured loan.[267] Karlan et al. (2014) find that loan uptake is high among all farmers in their sample; however, the offered indemnity component has little impact on uptake. They further note that in the experiments, farmers were able to independently find the required resources for increased investments for their crop production once they got insured. This highlights that empirically, bundling (indexed) insurance into agricultural loans may not always be the *optimal* choice.

We are not aware of field studies explicitly addressing trade-offs between (unbundled) agricultural microinsurance and loans, making it a challenge to note the extent to which insurance and loans are really seen as substitutes or complements. Norton et al. (2014) use a similar structure–in their Ethiopian field experiment participants divided an initial endowment into several different categories[268] and the greatest allocations were made to high frequency payout insurance. It would be ideal in the future to structure such a game to have a loan as a choice option.[269] In our WTP structure we cannot explicitly discern this type of trade-off information.

Though the frequency distributions for WTP microinsurance and WTP for loan are similar (and the number of individuals in the non-WTJ category), for a given individual, expressed WTP

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[266] We also consider the Wilcoxon signed-rank test (Rey & Neuhäuser, 2011) and alternative dissimilarity tests (Vegelius et al., 1986).

[267] It should be noted that this may have been an artefact of the loan on offer already having a limited liability clause in case of inability of farmers to repay.

[268] The options categories were: 1. receive money immediately; 2. place money in a (simulated) savings account; 3.place money into a group risk pool; and 4. Buy one of two index-based insurance products (high- and low-frequency pay-outs).

[269] We had considered this type of set-up in both the large-N tool and the *Complex Dice* game; however, without previous experience with agricultural microinsurance, weighting relative preference for microinsurance versus loans appeared to introduce an increased level of bias (from asking about each in isolation). For example, deciding on WTP for microinsurance in isolation focused individuals on that particular tool, but asking trade-off questions between microinsurance and loans would likely anchor individuals to a reference point through previous loan experiences. Each individuals' reference point (Kahneman & Tversky, 1979) (i.e., the point where the perception of gain changes into perception of loss) would be based primarily on positive/negative experiences with loans in real-life.

agricultural microinsurance and WTP loan do not necessarily fall within the same interval. We look at this more closely in the summary of characteristics for individuals for each interval for both WTP microinsurance and loans; see Table 7.5. The average values are similar, but the variance is quite high in the case of WTP loans.

As seen in Figure 7.3 the frequencies for each interval are very similar for WTP loan and microinsurance. Thus, the frequency distribution in both cases produces identical histograms, but the regressions differ because of the different groups of individuals. As in regression analysis we consider respondents' attributes and they may be quite different under the fixed WTP intervals for case 1 and 2. Additionally, we see relatively higher levels of variance in the WTP loan data, which suggests that there is large variability in the data and the relative characteristics of those engaging with loans. It is intuitive that if the data points are quite dispersed in different dimensions (i.e., with regard to the different attributes of the farmers), it is hard to make solid inferences and predictions are subject to a higher degree of error/noise compared to data with lower variance.

Breaking the data down by region, significant differences between WTP loan are evident. In Kapchorwa, respondents willing to engage with failed coping have a much statistically significantly different WTP than those who either prefer to sell livestock or adhere to erosive and non-erosive coping. In Oyam, there is a significant difference between WTP loan between the farmers preferring to sell livestock and those willing to resort to erosive coping with that in the later the average WTP is quite higher.

7.6.2 Interval model–WTP for loan

We apply the same interval regression structure used for WTP for microinsurance to the WTP for loan data, again clustering at the village level; see Table 7.6. We purposefully look at WTP loans under the same framework we used for WTP microinsurance.[270] These two financial tools are clearly substitutes for our sample; however, better understanding the comparative motivation for purchase of the two is value in understanding the sub-samples that may benefit most from the use of each tool. Our primary focus is to examine motivations for microinsurance uptake; thus, to compare with WTP loans it is useful to apply the same conceptual framework used for WTP for microinsurance regressions. Yet, looking at empirical literature on general borrowing and savings behaviour in developing countries (e.g., Deaton, 1989; Pitt & Khandker, 1998; Kiiza & Pederson, 2001; Jabbar et al., 2002; Pal, 2002; Muradoglu & Taskin, 2007; Barslund & Tarp, 2008; Kaboski et al., 2014) it is a reasonable assumption that households make an assessment with consideration over the same general set of factors when determining WTP for loans.

The majority of variables significant to the choice of WTP for microinsurance are not significant to WTP loan for our sample; some of which logically relate to loan behaviour. Given that the model was specified a conceptual framework of factors relevant to WTP for microinsurance, one would expect a lesser fit for data based on WTP for loans.

In general, we can make the inference that WTP differs greatly within and across categories of specified variables. In other words, if the household is in the position that they *need* to take a

[270] This is not meant to imply that the effects of determinants are expected to be of the same magnitude, direct, nor significance for loans and microinsurance.

loan, it will likely be taken. There are preferred prices, as indicated by WTP, but these may be predicated more on experiences with loans taken in the past. A Heckman model for WTP loan was generated for exploratory purposes based on the same formulation used for WTP microinsurance.[271]

We see that similar to WTP for microinsurance, net-providers of remittances have a statistically significant greater WTP of loan compared to net-receivers. The same explanation is plausible in the sense that remittances are not generally a one-off commitment, but a semi-permanent financial arrangement, which requires that the provider remain solvent (e.g., Kapur, 2005; Collins et al., 2010). Thus, net-providers have a higher WTP, which is likely tied to willingness, but also (perceived) ability-to-pay–it is reasonable to assume that they have relatively greater levels of held capital in order to be a net-provider in the first place.[272] The pattern for *coin_risk* is similar to that observed for WTP microinsurance. Those in middle categories of risk aversion have statistically-significantly higher WTP, but this is reduced for the most risk-averse category. It is plausible that the most risk-averse households are also relatively averse to risks associated with loans, e.g., potential defaults on risk-interest loans. Again, it is somewhat surprising that *worry* is not significant; as it would seem that those with greater concern would be motivated to take action to cover losses.

IShare is significant and positively associated with WTP for loan for the categories 25-50% and 50-75% of income from farming. It is logical that a higher percent of income from farming would have higher WTP for financial tools to help cover losses. To this point, it was surprising that *IShare* was not significant for WTP for microinsurance. It may be the case that familiarity with the use of loans and traditional coping strategies make *IShare* significant to those decisions and not WTP microinsurance. Furthermore, given our framing, loan is related to ex-post decisions, while microinsurance is an ex-ante decision, which may have an effect on the relationship with *IShare*.

Coping has a relationship similar to that identified in the WTP microinsurance model; estimated coefficients for all levels are significant and positive, relative to the base category of selling livestock. Relative to the base category of selling livestock, the likelihood of greater WTP increases across categories. This is expected, as holding all else constant (and assuming ability to repay), households willing to undertake (non-reversible) erosive coping would logically prefer taking a loan, which has less long-term implications for the household.

Num_loan is significant and positive for the WTP loan across all categories, relative to taking no loan in the year preceding the survey. This makes sense as the number of loans taken may proxy household dependency on coping through the use of loans whether due to preference or necessary for use of loans.

Similar to the model for WTP microinsurance and regressions for coping strategies, *education* is significant and positively associated with WTP loan. At each level relative to the reference category likelihood of greater WTP increases. This finding is expected, especially since education is significantly positively correlated with numeracy ($p<0.05$).

[271] Again, the level of non-WTJ for loans was rather low for use of a Heckman selection model useful.
[272] Note that the level of productive assets held by a household has a significant positive correlation with remittance behaviour ($p<0.001$).

Table 7.6 Interval regression (clustered by village)–WTP for loan (UGX/month)

Variable	Levels	Estimated Coefficients		Robust Std. Err.
house_cond				
	1	-778.17		1520.89
	2	-11155.87		9440.55
	3	21345.09		7553.61
net_rem				
	1	2027.86	*	2067.97
	2	866.62		2042.08
coin_risk				
	1	-22.61		2806.43
	2	2427.79	*	2784.09
	3	3304.84	*	3725.09
	4	768.95	*	2338.62
worry		-309.05		266.62
IShare				
	1	4529.21	*	3944.34
	2	5181.53	*	4476.11
	3	5024.77		4607.12
trust				
	1	-3934.11		3396.98
	2	-5380.68		4532.39
	3	89.61		2773.48
know_in				
	1	-8215.62		7756.70
	2	-3453.95		5386.31
	3	-13201.52		11079.07
save_sell				
	1	4034.35		3959.85
	2	-901.88		1988.83
	3	3156.69		3795.37
	4	10470.56		12364.75
wea_type				
	1	-772.82		2058.49
tamsat				
	1	2568.72		2614.17
coping				
	1	933.46	*	1832.74
	2	2219.13	*	3125.81
	3	7185.04	*	5907.42
num_loan				
	1	5234.16	*	4740.73
	2	5837.32	*	4651.02
	3	11141.00	*	10994.77
	4	12032.41	*	11583.87
	5	12465.61	*	10748.55
in_mot				
	1	3070.13		2807.91
	2	2718.31		2554.90
env_ch				
	1	2482.23		2448.12
	2	-4623.92		4568.12
	3	-4412.75		6407.01
	4	3013.72		3029.44
age		38.45		60.81
education				
	1	3219.30	*	3040.23
	2	3554.69	*	3202.20
	3	8556.35	*	7169.14

dice_feeling			
	1	2443.73	2321.70
region			
	1	-8333.03	6710.74
cons.		16784.38	6928.77
N= 3178	*DF = 46*		
LL (intercept only) = -14330.11			
AIC = 4407.17 BIC = 4601.94			

7.7 Complementary means of coping

It is claimed that "savings, credit, emergency loans, and self-insurance are more flexible instruments than insurance" and are useful in coping with small loss events; while "risks resulting in exceptional losses are considered insurable" (Levin & Reinhard, 2007). Furthermore, Müller et al. (2014) notes that in India, "about 90% of [index-based microinsurance] policies are sold on a *mandatory* basis and tied to agricultural loans, despite the fact that only 40% of all smallholders have a loan." Thus, there is an important question as to how farmers not employing loans can be reached by insurance and how the two standalone products complement one another in the context of other informal coping strategies. In a general sense, Arnott & Stiglitz (1991) and Lin et al. (2014) show that the extent to which formal insurance and informal risk-sharing may act as complements or substitutes depends on (a)symmetry of information about the probability and level of expected losses of the insured compared to the informal risk-sharing (networks). Thus, there is value in exploration of relative relationships between these different types of coping as complementary stand-alone products that make up a portfolio of farmer-chosen coping strategies.

Our analysis of WTP for microinsurance and WTP for loan allows us to put traditional coping strategies into context with regards to implications for WTP for microinsurance and loan as standalone products for those engaging in a specific type of traditional coping strategy. In Table 7.7 we note the margins[273] of traditional coping strategies from our interval regressions for WTP for loan clustered by village.

[273] These determine predicted probability of WTP at each level, holding all other variables in the model at their mean values.

Table 7.7 Marginal Effects related to traditional coping strategies

	WTP microinsurance (UGX/month)			WTP loan (UGX/month)		
	Margin	**s.e.**	95% C.I.	**Margin**	**s.e.**	95% C.I.
Kapchorwa						
Coping						
Sell livestock	21218.32 ***	3305.09	14740.47-27696.18	17637.61 ***	3269.91	11228.71-24046.51
Erosive coping	23777.23 ***	3362.86	17186.15-30368.30	19901.60 ***	3104.46	13816.97-25986.23
Non-erosive coping	21312.27 ***	3346.54	14753.18-27871.36	18558.14 ***	2634.88	13393.88-23722.41
Failed coping	29534.67 ***	3671.11	22339.43-36729.92	25376.62 ***	4111.44	17318.35-33434.89
Oyam						
Coping						
Sell livestock	13594.55 *	7703.57	-1504.17-28693.27	10529.91 *	8646.77	-6417.45-27477.27
Erosive coping	16153.45 **	6864.30	2699.66-29607.24	12793.90 *	7459.16	-1825.79-27413.59
Non-erosive coping	13688.50 *	7755.63	-1512.25-28889.25	11450.45 *	7926.68	-4085.56-26986.45
Failed coping	21910.90 ***	3361.76	15321.97-28499.82	18268.93 ***	3522.05	11365.84-25172.00

We see that the WTP distribution for different types of coping are relatively similar and follow the same pattern across both regions and for WTP for microinsurance and loans. In Figure 7.4 the dotted lines represent 95% confidence intervals for the predicted WTP margins. We observe that the confidence bands in Oyam have a much wider spread compared to those for Kapchorwa. This is due to the fact that in case of Oyam the standard errors of the marginal effects are quite large for both full crop insurance and loan–variation across respondents is significant.

We see slightly lower WTP for a loan than WTP for microinsurance across traditional coping strategy classes. This may be partially explained by the fact that real-life experiences with formal loans are often held in relatively low-regard because repayment is not often easily and interest rates may fluctuate mid-payback for some loan sources (W. Okello 2011, pers. comm., 6 May).

It appears that those who are most willing to liquidate productive assets as a response to extreme weather are relatively more interested in joining an agricultural microinsurance scheme at a greater WTP. Yet, this is mediated by the fact that their WTP, or perhaps ability to pay, is actually negatively related to the willingness to liquidate productive assets in the short-term. This agrees with the arguments noted throughout the literature that the poorest need microinsurance-type protection, but that they are also most limited in affording the tool (e.g., Karlan, 2005).

We highlight some of the socio-economic and demographic variables that are common to both our models for WTJ/WTP as well as willingness to sell livestock. The household income share arising from farming is significant and positive in the decision to sell livestock as well as the decision to engage in agricultural microinsurance. It is to be expected that an individual is more willing to engage in any reasonable coping possible as a greater level of household income is at risk. This rationale also extends to the fact that *fam_size* is significant and positively related to the decision to engage in coping in both models. An extra mouth to feed makes one relatively more willing to engage in any form of reasonable coping available. These types of relationships indicate that agricultural microinsurance is considered a complement to traditional means of coping–farmers are open to engagement with any form of coping that is effective (and minimises long-term losses).

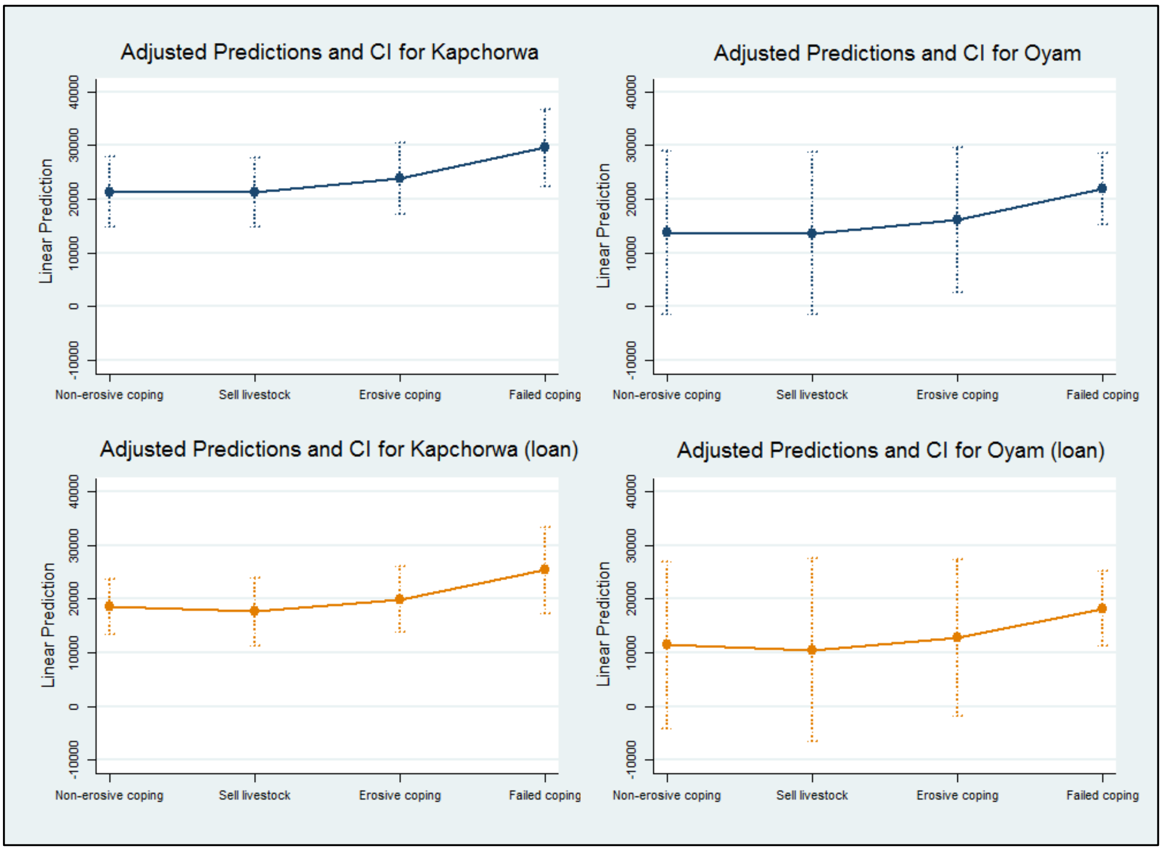

Figure 7.4 Marginal estimates for WTP microinsurance and loan relative to traditional coping strategy classes

Credit as insurance is not a feature of the informal financial market in developing countries alone, but is applicable to loans obtained on the *formal* financial market (e.g., through local banks) (Giesbert et al., 2011). As noted by Eswaran and Kotwal (1989) and Zeller et al. (2001), credit applied to consumption instead of investment can take on the function of insurance, which, in the absence of agricultural microinsurance, seems to be the case for our sample. There are hints that for our sample loans and microinsurance are substitutes: 1. with respect to the frequency distribution of WTP being similar for both products; and 2.the similar relative WTP for loan and microinsurance relative to each traditional coping class. Yet, as Giesbert et al. (2011, 8-9) note: “it is plausible that savings and loans are particularly strongly used as substitutes for insurance when no insurance market exists,…but…there is no reason to expect the motivation for precautionary savings and emergency loans to vanish with the expansion of formal insurance." In the next section we highlight characteristics of standalone insurance products of interest to our sample.

7.8 Other characteristics of and considerations for microinsurance

We see that in both regions, households tend to borrow more money from third party sources, including local moneylenders, microfinance institutions, and local banks, than from their personal connections.[274] This makes sense, as personal connections may not always have money to lend, especially in the case of covariate hazards. We look at the perception of money borrowed by our sample with respect to their related sources. In Kapchorwa, farmers are worried about paying back large sums in comparison to the borrowed capital when borrowing from microfinance institutions (MFIs), in particular. This is also true in Oyam, with households perceiving overall pay-back to be more when borrowing from an MFI, local banks, or local moneylenders compared to close connections or village community.

In Kapchorwa people borrowing from family, friends, neighbours, or local moneylenders have very similar WTP for microinsurance.[275] Yet, in Oyam, farmers who borrow from friends have less WTP compared to farmers who usually borrow from family, neighbours or local moneylenders. In both of the cases; however, we see that people who do not borrow money at all have the lowest WTP microinsurance. The lesser exposure to financial risk might be a plausible explanation for such a behaviour or a preference for informal risk management, opposed to formal loans or insurance.

Group-based models of index-based insurance have been recommended as one means of reducing basis risk via group-based loss assessments and pay-out rules (e.g., Traerup, 2012). Clarke & Kalani (2012) show that theoretically, the overall basis risk facing a group can be broken down into covariate and idiosyncratic components – with the idiosyncratic risk minimised by an informal payment rule based on assessment by the other members of the group.[276] In reality the feasibility of such a group index-based tool rests with the perceptions of communities regarding social norms, as well as emotional and affective responses to fairness of the informal payment rule, for example.

In both regions of our sample, 30% of farmers are willing to contribute to group-based microinsurance while 70% prefer to pay into products that are individual-based. The WTP microinsurance[277] is significantly greater for those willing to contribute towards a community-level product in comparison to those preferring an individual policy ($p<0.001$). To this point, it may be that these individuals feel that microinsurance is potentially a useful coping tool and are willing to spend more on it. It may also be the case that underlying the group-policy are individuals with: 1. more expendable income, 2. personality traits that cause them more concern about the coping ability of the rest of the community, and/or 3. trust in their community. There is a positive significant correlation (corr=0.53, $p<0.01$) between desire for a community-based

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[274] This is calculated in addition to remittance behavior – remittance behavior is not included in these calculations.

[275] The WTP microinsurance varies in a way that is not tractable when comparing across other loan sources.

[276] Traerup (2012) outlines the following steps for operationalising a group-based index microinsurance contract: 1. the informal clients' network pays one collective premium to the insurance provider and also receives a single payout as one insurer, and 2. the network distributes the payout among its members based on the information flow within the network.

[277] To be clear, this WTP microinsurance value is the one analysed throughout this chapter and is based on the CV price ladder question for the farmer's own crop.

tool and belief that individuals will not engage in practices related to moral hazard[278]. Interestingly, when we sub-divide the sample by prior knowledge of insurance, the difference in WTP for those willing to engage with group-insurance is no longer significant. For those who had no prior knowledge, there is higher WTP for those willing to contribute to a group policy. It may be the case that those with experience with insurance realize that application of a group-based premium or payout structure would be extremely complicated.[279]

It is interesting to consider the relationship between the frequencies with which farmers report changing their initial decision inclinations after discussions with their social network.[280] About 60% of Oyam respondents indicate that they change their minds frequently, while it is ~42% in Kapchorwa. We apply a one-way ANOVA to the distribution for significance of difference between WTP of the farmers belonging to different groups of decision-making frequency in each region. In the case of Kapchorwa the null hypothesis that there is no significant difference between WTP for farmers with different frequencies of changing decisions cannot be rejected (at the 5% level); however, the null hypothesis is accepted for Oyam.

Perceptions of farmers as to whether or not their role in the community is in conformity with the expectations of others is almost evenly split between responses of yes, no, and unsure. Assessment with the lower and upper bounds of WTP microinsurance shows no significant difference based on the perception that roles fit within perceptions of others. It is likely the case that as Hernandez and Blazer (2006) point out one's role in society may be directed more by social norms influenced by factors like age and education. Furthermore, Triandis (1972) points out that role perceptions vary by culture, but also is subject to heterogeneity between self- and assessment by others; thus, we may not obtain an accurate picture from this metric.

It is challenging to note the extent to which we can classify the relationship between WTP microinsurance and a given factor element as rational or not in our model. There is a great deal of heterogeneity for a given element (independent variable) between respondents and to determine the optimum mix of coping strategies for household is a complex issue. For example, regarding engagement in traditional coping strategies, some households with relatively similar preferences may be willing to engage with erosive coping while others will not. In many cases this likely has to do with the (dis)connection between potential willingness and past realised experiences; i.e., in our staged model for *formation of household intension to insure* (Chapter 2) we are not able to fully address the link between intended preference and actualised behaviour.

There is also an important distinction between rational intended/desired behaviour based on perceptions and what is realistic given real-world constraints. For example, our analysis via TAMSAT data demonstrates general agreement between individuals' assessment of extreme weather event frequency and real-life weather data, which indicates the desire for relatively high frequency payout microinsurance by our sample. Thus, there is tension between the preferences we see throughout the study and the realistic insurability given circumstances in

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[278] Based on Q150. We ask about moral hazard as an indemnity-based tool was being considered for development. Furthermore, the insurance to which our sample has been exposed in the past is all idiosyncratic for which indemnity-style tools were employed.

[279] During the FGDs it was indicated that group premia and decision rules may cause conflict within the community. Matovu (2011) further noted that in areas with shared labour and land assigned by clans this would likely cause greater conflict exasperated by the fact that individuals in the community would likely get greater payouts based on seniority opposed to equity; this has been the case in some self-organised MFIs in Uganda.

[280] Based on Q49-50.

each region. For example, in our sample there is a preference for relatively high-frequency pay-outs at a reasonable premium level, no group-based insurance, and though individuals have a relatively high WTP for an emergency loan on average, in real life relatively few such loans seem to be taken.[281] A solvent insurance portfolio is possible for regions similar to those studied here (e.g., in terms of loss frequency to extreme weather) assuming relatively high levels of renewal and extremely minimal chance of extreme loss in the first three years.[282] The issue becomes that though we isolate a number of desired attributes on the demand-side and determine a relatively robust model of WTP microinsurance, indicating a number of significant factors the rational steps may be to encourage the community to continue to focus on ex-ante planning and adaptive practices. In many ways it is possible that the conditions for insurability outlined by Skees & Barnett (1999) would be negated, especially since our sample does deal with what they term in-between risks, violating conditions for insurability and ultimately increasing the marginal costs and reducing market supply.

As shown in the literature, household savings often serve an insurance purpose through a precautionary motive, which is greater when income is uncertain and credit constraints are taken into account by the consumer (e.g., Besley, 1995; Browning & Lusardi, 1996; Giles & Yoo, 2007; Lee & Sawada, 2010). We find that for our sample, experience with savings (crops) and the associated outcome of selling at a later date affects WTP for microinsurance – those with negative experiences have greater WTP. Additionally, 60% of the total sample (63% in Kapchorwa and 55% in Oyam) report taking active steps to adapt farming practices ex-post weather-related losses;[283] however the capacity for adaptation is very limited and often does not include relatively cost-effective inputs, such as fertiliser.[284] Thus, the most practical next-step towards provision of ex-post microinsurance may actually be enabling greater ex-ante planning and savings in these communities.

7.9 Limitations

As noted in our discussion of WTP for microinsurance and WTP for loans, there are benefits to asking respondents to consider the two separately; however, it is difficult to discern whether there is a strong preference for one tool over another, especially since the WTP values are quite similar. One motivation for this approach was to separate formal financial tools that the sample had really experienced from those it had not. In future research it would be useful to ask directly about preferences to engage with one over the other or in combination.

At the time of this research there was no indication of a formal weather-based agricultural insurance scheme launched in Uganda and, as noted in Chapter 4, the current one is still under development and applies to a very fixed set of crops and areas.[285] There are positives and negatives associated with conducting demand-side research in such a setting. It presents a challenge to obtain truly representative data since individuals are responding to hypothetical

[281] Measured for the previous 12 months and 5 years.

[282] See summary in Appendix G2 of a potential microinsurance tool under consideration by Grameen Foundation Uganda, as developed by the author.

[283] Based on Q41. It should be noted that adaptation of farm practices is not significantly correlated with WTP microinsurance or loan nor other specific details of a potential microinsurance tool in the large-N survey.

[284] Based on Q42. High frequency responses to how farmers adapt to extreme weather include: adding more manure to the field, attending farming workshops, asking CKWs for information and advice, and early planting. Specific to Kapchorwa, some farmers adjust terraced farming.

[285] Neither Kapchorwa nor Oyam are covered at this time to the best of our knowledge.

situations for which they have very limited real world experience. On the other hand, we face a sample that has not had negative (direct personal) experiences with agricultural insurance.[286] Thus, we need not overcome the complications reported by previous studies of obtaining interest in the potential tool (or participation in the study) after trust in agricultural microinsurance has already been reduced by real life experiences with a poorly designed tool (e.g., Patt, Tadross et al., 2010; Biener & Eling, 2012; De Bock & Gelade, 2012).

The use of a single case study raises questions of comparability and the extent to which the study can be generalised. As noted previously, we chose two regions with relatively different profiles within the larger context of Uganda. In the case of microinsurance studies this is a natural limitation given the requirement for tailoring one's research such that it makes sense within a given context, e.g., social norms and local policies, as the nature of the product under research is sensitive to these factors. It has been noted that research based on specific case studies should not make claims that findings are applicable to diverse populations, except in contingent ways (e.g., George & Bennett, 2005). There is the capability to support empirical generalisations (e.g., Barzelay, 1993), especially as the body of research continues to grow. This is the case within the growing literature surrounding microinsurance structure and implementation to which this research contributes. For example, in their meta-analysis (Cole et al., 2012) include notes on study validity and analytical methods employed, such that there is transparency when comparing studies. To the extent possible we kept the large-N survey tool as generalisable, especially in the design of the field games and generality of the supporting questions.

Comparison with the lower and upper bound of mean values should not make a marked difference in the regression results for WTP microinsurance; since they have a monotonic relationship; i.e., if one increases (decreases) the other does as well accordingly. We can identify this relationship by means of a linear transformation and correlation is independent of the change in origin. To demonstrate we provide probit regressions that separately consider the upper and lower bound values for WTP as response variables (Appendix G1).

We made effort to include theoretical consideration for elements that relate to preference formulation and may contribute to respondents' bounded rationality, as described in Chapter 2. This is reflected in the specification of and response options for some of the regressors in our model, such as *dice_feeling*, *know_in*, *env_ch*, and *worry*. We obtain some interesting insights from this work about potential relationships with WTP microinsurance as well as other aspects of microinsurance important to the sample. Yet, to truly capture the dynamics for use of formal financial instruments it is ideal to work within a framework characterised by multiple time periods so as to track individual's changing preferences. This was not a possible methodology for the research reported here, e.g., due to lack of a pre-existing agricultural microinsurance tool as well as limitations on time and resources. Yet, since the research was first conducted, the CKW programme has continued to collect basic household data which may be used for further research concerning household borrowing dynamics over time. As noted by Collins et al. (2010) structuring analysis of household spending, especially in areas that do not have detailed pre-existing large-N population-based census data, in a manner that may isolate causality takes

[286] Though, it is conceivable that they may have had negative experiences in the past with other types of insurance in other contexts.

it is ideal to repeatedly visit a household to obtain detailed entries in a *financial diary*[287] (e.g., Rutherford, 1999). The large-N survey we structured is a good start on a baseline survey that may be applied to determine key aspects with consideration for behavioural theories that can address a relatively larger-N sample than financial diaries have to date.[288] In this way it may offer a good supplement to the type of research we carry out in the large-N tool in terms of delving into further detail about some key household financial decisions.

7.10 Conclusions

A novel aspect of our study is the ability to account for some behavioural details that are not typically addressed in single-period survey tools for microinsurance. In Chapter 2 we highlight factor classes that have been shown to affect microinsurance demand in past studies–whereas most studies (e.g., Eling et al., 2014) highlight a few select factors, we are able to include a specification in each factor class in our model for WTP microinsurance, which provides a more holistic view.

We note that there is likely some hypothetical bias in the WTP microinsurance data garnered due to the desire of our sample to obtain an insurance product in real-life; however, when further analysed and compared against WTP for loan it appears to be reasonable within the scope of our sample's use of formal financial products for coping. Furthermore, responses for the price ladder and open-ended questions on loans accorded well for a given individual.

It is clear that suppliers are interested in potential clients' wealth profiles to assess feasibility of coverage. Yet, we find that proxies of household wealth have little effect on WTP. This is consistent with a number of studies that report there appears to be little direct relationship between wealth and WTP. Thus, we suggest that if costs and weather-risk profiles allow for a solvent agricultural microinsurance scheme, the supplier should be concerned with factors other than consumer wealth-levels after a threshold of reasonable ability-to-pay/purchase, for example, building familiarity (through past personal or social network experience) with and trust in insurance.

There is a great deal that remains to be studied on the relationship between demand-side factors and WTP for microinsurance as well as their positioning within the portfolio of possible coping strategies (both informal and formal) available to households. Nevertheless, our research highlights some findings as to considerations that should be made in the structure and marketing of such tools and demonstrates the usefulness of taking behavioural aspects more into account, even in single-period surveys.

We looked at WTP index-based agricultural microinsurance in this chapter.[289] For simplicity and to reduce bias we did not explicitly include basis risk in the structure of the WTP question. In the next chapter we discuss aspects specific to index-based microinsurance in greater detail. We

[287] A financial diary often requires a researcher to visit the household frequently (e.g., each fortnight for a year) to gather detailed information on the earning, expenditure earnings, expenditures, loans, and savings of the household in a way that it is clear "why" each transaction took place.

[288] Additionally, though financial diaries such as those noted in (Collins et al., 2009) allow causal insight for some spending structures, they do not necessarily deal with the types of contributing factors we highlighted in our theoretical discussion of formulation of preferences for microinsurance.

[289] Though we collect some data that may be relevant to possible indemnity-based microinsurance, the focus is on index-based insurance.

report on results of the *Complex Dice* game, which isolates respondents' reaction to basis risk in an iterative field game played with a partner.

8 Attitudes towards basis risk

8.1 Introduction

Weather index-based agricultural microinsurance is a relatively recent innovation[290] allowing farmers in developing countries to take appropriate ex-post consumption-smoothing measures in the face of extreme weather (e.g., Skees & Barnett, 1999; Turvey, 2001; Vedenov & Barnett, 2004). The use of an index based on weather observations, such as rainfall, as a proxy for crop loss, serves to reduce (or even eliminate) issues that traditional indemnity insurance produces, but, admittedly, creates other difficulties, such as basis risk. Chapter 2 highlighted the relative positive and negative aspects associated with weather index-based microinsurance.[291]On the positive side, the lower transaction costs as compared with conventional indemnity insurance have the potential to make it more affordable in the developing world; on the negative side, the risk protection at the household-level may prove less effective (e.g., Miranda & Farrin, 2012).[292]

This chapter focuses on the analysis and results of the *Complex Dice* game, hereafter referred to as the *Game.* This field experiment was an iterative, hypothetical, rain-indexed, agricultural microinsurance scheme designed to disentangle respondents' attitudes towards basis risk. To the best of our knowledge, this is the first game whose design takes into consideration the choices an individual makes when seeking *good* basic risk while observing the choices made by a partner seeking a similar outcome.

Inherent basis risk often complicates both the design and output of indexed microinsurance. A review of the literature reveals relatively few empirical studies of the direct effects of basis risk on the uptake of insurance (e.g., Jensen et al., 2014; Elabed & Carter, 2015a).[293] Many theoretical treatments of index-based microinsurance (e.g., Miranda & Farrin, 2012) demonstrate the value in this type of index-based microinsurance as an efficient means of consumption-smoothing in the face of covariate weather risks. Yet, others demonstrate that the combination of basis risk and actuarially unfair prices leads to low demand for such products by rational decision-makers (Clarke, 2011). As noted in Chapter 2, there have been advances in the development of indices (e.g., Norton et al., 2013; Greatrex et al., 2015) and, though we deal with a weather-index example, yield-based indices are increasingly popular and may provide more effective coverage in some cases (e.g., Gehrke, 2014).

Basis risk is an important factor in the general debate as to whether there is under-adoption of indexed microinsurance tools–many studies claiming under enrolment note basis risk as a potential factor (e.g., Giné et al., 2008; De Bock & Gelade, 2012). Norton et al. (2014) found that Ethiopian farmers preferred a high-frequency index-based insurance product, which allows them to allocate an initial cash endowment between different consumption-smoothing and risk-

[290] Halcrow (1948) was the first to propose such indexed crop insurance, but applied it to the context of developed countries.
[291] Chapter 2 also highlights the relative benefit of using of alternative indices (e.g., yield-based).
[292] Miranda & Farrin (2012) also note that insufficient data exists regarding the severity of basis risk at the farm level.
[293] Jensen et al., (2014) look at response to (decomposed) basis risk and spatiotemporal adverse selection for an existent index-based livestock insurance in northern Kenya.

transfer tools including: taking drought index insurance; investing in simulated savings accounts; participating in risk-sharing groups; or simply holding cash.[294] Their research demonstrates that consumers value index-based microinsurance (i.e., a risk-contingent payout mechanism) over interest-bearing savings mechanisms in some cases. This raises the question of how farmers interact with index-based microinsurance over iterative periods and the extent to which basis risk and other factors affect relative insuring behaviour.

Research studies that strive to identify and analyse the factors contributing to indexed insurance demand have been designed (e.g., Patt et al., 2009; Gaurav et al., 2011); however, any it appears that explicit incorporation of the actual experience of basis risk within a game framework is infrequent. "Although basis risk and the possibility of spatiotemporal adverse selection are widely understood as prospective weaknesses of index insurance, the empirical research has thus far not directly explored the role that either of these product-specific factors plays in influencing product uptake," (Jensen et al., 2014, p. 2). The design of the *Game* aims to isolate players' experience of basis risk and subsequently, to better understand how risk effects one's perception of indexed microinsurance along with one's willingness to adopt and maintain it.

This chapter provides insight into the reactions and attitudes of Ugandan farmers towards weather-index agricultural microinsurance. We designed the *Game* to incorporate data relating directly to basis risk, both in positive and negative directions, into the current body of knowledge regarding this category of products. Having the farmers play in pairs allows for gauging the potential social interactions around a game.

This chapter is structured as follows: Section 8.2 provides background and context from relevant studies and notes relevant research questions; Section 8.3 provides relevant empirical data and descriptive statistics; Section 8.4 describes the mixed model regression of the insuring choices the participants made in the *Game*; Section 8.5 presents a separate mixed model regression exploring the effect of basis risk and other socio-demographic and attitudinal factors on the choice to adopt insurance in each game round. Section 8.6 summarises the findings and draws the conclusions that follow from them.

8.2 Context and Background Literature

Though basis risk can be problematic it nevertheless reduces, or even eliminates, significant potential drawbacks to indemnity structures, such as adverse selection[295] and moral hazard as noted in Chapter 2. Absent these issues that lead to high premium costs, many economists argue that the resulting lower (or complete lack of) deductibles with index-insurance provide access to a wider farm customer base in developing countries (e.g., Vedenov & Barnett, 2004).

The discussion and findings in Chapters 6 and 7 demonstrate that coping strategies are limited when a covariate weather risk is realised in developing countries, especially in rural areas. Index-based contracts have often been noted as a *correct* approach to filling gaps left by other coping mechanisms (e.g., Skees et al., 2006). As noted in Chapter 7, however, it is the perceptions of potential consumers, not just theoretical justifications, which determine the truth-value behind this assertion. The results of the present study have found that individuals who engage in

[294] The choices presented to the respondents for index-based insurance were based on real-life options in the area and partial payouts (Norton et al., 2014) .

[295] For further discussion see: (Akerlof, 1970; Skees & Reed, 1986; Just et al., 1999; Makki & Somwaru, 2001).

traditional coping strategies are indeed willing to take on microinsurance, even at a relatively high WTP. Although a calculation of the exact contribution of each coping strategy to create the optimal mix of household coping is not possible, there is evidence that households are interested in diversifying their risk with a portfolio of approaches including microinsurance. Economists often view indexed insurance as a gateway to obtaining greater credit when embedded within other interventions (e.g., loans) (e.g., Hellmuth et al., 2009). Thus, understanding how individuals respond to the realisation of basis risk can inform product design and possibly even the overall composition of coping strategies within a household's portfolio.

In an effort to optimise contract design, models have previously been developed to calculate the relationship between indices and expected crop losses (e.g., Osgood et al., 2007; Osgood & Shirley, 2010; Heimfarth & Musshoff, 2011). But the relationship between farm-level yields and rainfall to assess basis risk due to a lack of historical data from which to infer long-term trends (e.g., Goodwin & Mahul, 2004). Clarke and Kalani (2012) note that a number of existing weather-index insurance products were poorly designed and ultimately constituted a combination of high premia with a low correlation between claims and losses (i.e., high basis risk).

More recent research and reports show significant improvements in the ability of such models to calibrate indices and calculate associated payouts (Paulson et al., 2010; Norton et al., 2013; Stamirova et al., 2013). From a technical point of view, although various products can minimise actual basis risk, one can never completely eliminate it.[296] Previous studies indicate (e.g., Camerer & Kunreuther, 1989) that the uptake of insurance is correlated with perceived risk, as opposed to actual risk. Effectively, basis risk consists of compound risk combined with the risk of farm-level losses with high ambiguity (e.g., Elabed & Carter, 2015a). Previous reviews of the literature note that behaviour towards compound risk is a relatively understudied phenomenon (e.g., Abdellaoui & Baillon, 2011).

It is noteworthy that basis risk is not unique to the developing world and is present in traditional agricultural indemnity insurance in developed countries as well. For example, the USA crop insurance program uses only 4-10 years of yield data to determine mean yield guarantees for individual farms (Barnett et al., 2005).[297] Through sampling and measurement errors, this dearth of historical yield data can cause a form of basis risk under farm-level yield insurance. Goodwin and Mahul (2004) provide an overview both of different types of agricultural insurance in the USA and the complexities related to area-based and parametric-based triggers. Barnett et al. (2005) found that for some crops in some regions in the USA area-level yield insurance (GRP), which carries inherent basis risk (e.g., Wang et al., 1998; Skees & Barnett, 1999), is comparable to the risk reduction offered by farm-level yield insurance (MPCI)[298] in some regions and for some crops. Thus, indemnity-based insurance is not a panacea for the concerns raised around basis risk in index-based products. Furthermore, it is not a universal goal to have higher than appropriate levels of insurance for a given farm.

[296] Techniques include appropriate index definition, contract structuring, and program design. Miranda & Farrin (2012) offer a good mathematical treatment of the minimisation of basis risk.

[297] Seldom do rich yield records exist at the individual farm-level in the developed context, suggesting that rates and protection levels for individual farms are hard to determine. Thus, the use of aggregate data around mean values leads to basis risk (Goodwin & Mahul, 2004).

[298] Multi-peril crop insurance

8.2.1 Field Experiments–Index agricultural insurance

To the best of our knowledge, rarely have field games iteratively exposed the respondent to basis risk as well as disentangled responses to (the effect of) basis risk from other aspects that are related to demand for index-based microinsurance. By contrast, the structure of the *Game* incorporates separable and tractable basis risk –though, admittedly, this occurs in the context of a game contract where the players experience no "real loss" as opposed to a real insurance contract. In this subsection, we review some applicable field games to date.

A group of researchers conducted a rapid customer satisfaction survey in the Adi Ha and Hade Alga villages of Ethiopia to assess satisfaction with the index microsinsurance they received/acquired in the 2011 season (WFP, 2012). Some farmers noted that "they were unhappy with the rainfall measurement" (i.e., the use of satellite data for estimating rainfall) others "indicated that the premiums were too expensive" (WFP, 2012). Furthermore, "62% of farmers who had not purchased insurance that season were *unhappy* that they did not; and 80% noted that they witnessed others benefiting from insurance." This example illustrates the importance of further research into the effects of basis risk on purchasing microinsurance, which takes into account the purchaser's observations about the behavior and attitudes of others in relation to microinsurance and basis risk, in particular.

Elabed and Carter (2015a) looked at WTP as a possible means to eliminate basis risk with a sample of cotton farmers in Mali and their empirical findings support the claim that higher basis risk leads to lower insurance demand. They note specifically that "to the farmer, index insurance appears as a compound lottery with two stages: the first stage lottery determines the individual farmer's yield, and the second stage determines whether or not the index triggers an indemnity payout." In their simulations they set basis risk at 50%[299] and found that the demand for insurance only came to 35% of the target population as opposed to the 60% demand rate that standard utility maximisation predicts.

Jensen et al., (2014) find that both price and the non-price factors studied previously (in line with the factors noted in Chapter 7) play a significant role in the demand for microinsurance; whereas, basis risk[300] and spatiotemporal adverse selection is a major factor influencing demand for index-based livestock insurance (IBLI). The use of proxies for basis risk give an indication of effect, but make it difficult to assess the magnitude of basis risk. For example, Mobarak and Rosenzweig (2012) use the farmers' perceived distance to a rain gauge (weather station) as a proxy for perceived basis risk—the farther one's farm is from the weather station that measures the amount of actual rain to make both predictions and payouts, the greater the discrepancy between the farmers' actual losses and the insurance payouts. Giné et al. (2008), look at a different proxy for basis risk. They examine the proportion of a household's land planted with crops used to generate the index parameters and correlate sensitivity of other crops.[301] Indices tied to completely different crops from those on a given farm are less likely to be able to

[299] Elabed and Carter (2014, abstract) note that this figure is not be unreasonably high "under the kind of rainfall index insurance contracts that have been utilized in a number of pilots."

[300] Jensen et al., (2014) use the difference between the index and covariate losses during seasons that IBLI coverage was available and publicised index values to estimate observed design (basis) risk.

[301] We look at a variable for different crop types sown by our sample in a version of our model in this Chapter, but it was not significant–potentially due to the fact that farmers had no experience with agricultural microinsurance and subsequently did not have a basis understanding of effects on different crops.

coordinate losses with payouts appropriately. Both studies find that basis risk has a statistically significant negative impact on the demand for insurance by farmers.

Within the relevant literature, there is a wide range of findings on the uptake rate for index insurance related to rural farmers in developing countries. When compared side by side, actual uptake rates are markedly lower than the estimates provided by theoretical and simulation models of optimal hedging strategies using index insurance (e.g., De Nicola, 2012; Miranda & Farrin, 2012). For example, Giné and Yang (2009) report that uptake was 13 percentage points lower when their sample of Malawian farmers were offered insurance with their loan, as opposed to credit in isolation. Other studies that find basis risk as a limiting factor of initial demand by rural farmers include those conducted in: China (e.g., Giné et al., 2008; Göncü, 2011; Cai & Song, 2012), India (e.g., Seth et al., 2009), and Bangladesh (Brouwer & Akter, 2010; Akter & Fatema, 2011). Yet in other studies, index insurance appears to serve a valuable function in managing weather-related risks and is relatively highly demanded (e.g., Turvey, 2001; Osgood et al., 2007; Collier et al., 2009; Norton et al., 2014).

In our *Game*, we take account of group dynamics including a brief overview of findings for group premia. Preliminary field studies show mixed results regarding group index insurance policies and real-life applications of group insurance. The rate of uptake appears to be highly dependent on designs that assure that the poorest of the poor are not further marginalised, especially in the case of index insurance; such is the case in Bellemare et al. (2012)'s study of cotton producers in Mali.

In their empirical study of interlinked credit and insurance, Carter et al. (2011) cite multiple layers of understanding and *perceived* hidden costs as additional barriers to index insurance uptake. Confusion over the structure of the insurance tool is generally greater for hybrid insurance mechanisms. Confusion correlated to low uptake in rural farmers in Ethiopia and Malawi in Patt et al.'s (2009) insurance game in the context of other coping strategies and compound risk management tools. In a field study they conducted with Ethiopian farmers, Norton et al. (2014) observed that respondents preferred to diversify their hedging efforts. The primary means by which they did so, however, involved either investing in index insurance or taking the cash option as opposed to using combined credit mechanisms. Furthermore, there are well-noted structural and psychological differences in how individuals perceive and subsequently interact with insurance (i.e., preventing loss) versus credit (i.e., providing gains) mechanisms (e.g., Kahneman & Tversky, 1984; Johnson et al., 1993). In their field experiment, Elabed and Carter (2015b) look at basis risk as compound-risk.[302] They measured compound-risk aversion levels of cotton farmers in Mali under index insurance. They found that compound-risk aversion decreases the demand for index insurance relative to what it would be if individuals had the same degree of risk aversion, but were compound-risk neutral. They do not address the correlation between socio-economic factors and compound-risk aversion (i.e., basis risk).

In the majority of developing areas where organisations have introduced index agricultural insurance, there is no pre-existent "insurance culture" and the general understanding of the tool is tentative. Compound-risk and the ambiguity introduced by basis risk may further complicate

[302] The relationship between attitudes towards compound lotteries and ambiguity aversion was first established by the recursive non-expected utility model (Segal, 1987). Multiple studies (Engle-Warnick et al., 2007; Alpizar et al., 2011; Clarke, 2011; Barham et al., 2014) demonstrate that ambiguity averse farmers will not adopt new technologies. Bryan (2010) shows that households that are both ambiguity averse and risk averse do not value insurance, because they perceive it as increasing risk.

consumers' subjective perceptions. Even making dramatic improvements to the index calculations would not eliminate basis risk entirely. Therefore, before developing hybrid mechanisms of increasing complexity, it may prove helpful to better understand existing interest in and reticence towards index insurance. Ad hoc rules are a common device people use to size up the severity and probability of an event along with the potential value that instruments available to them would have in transferring the onus of that risk elsewhere (Camerer & Kunreuther, 1989). The work presented in this chapter represents an attempt to estimate the effects of basis risk on farmers' agricultural microinsurance choices.

8.2.2 Research questions

The following research questions address farmers' reactions and attitudes towards realised basis risk in weather-based indexed microinsurance.

1. How do attitudes towards insurance and risk affect insurance purchase when a tool is index-based?

We hypothesise that, ceteris paribus, those who express greater stated preferences for insurance and have greater concern over (perceived) risks will purchase insurance more frequently throughout the rounds.

2. What is the pattern of insurance purchase following a period in which basis risk is realised?

We hypothesise that insurance purchase in the current period (relative to the percent of the endowment placed in farm investments) will decrease following a period in which one is not reimbursed for insured losses due to the realisation of both good and bad basis risk.

3. How does insurance purchase in the current period change in response to observed outcomes of other players' insuring behaviours and outcomes in the previous period?

We hypothesise that insurance purchase in the current period (relative to the percent of endowment placed in farm investments) will change in response to observed outcomes of other players' insurance choices and their experience, or lack thereof, with basis risk in the previous period.

8.3 Data

8.3.1 Descriptive statistics–sample

In this section we provide relevant descriptive statistics for the sample who participated in the *Game*. A sample of 128 farmers participated; 64 based in each of the study regions. As noted previously, all respondents in this sample were CKWs; see Chapter 3 for further details.

We collected basic socio-economic and demographic data on the respondents. The average age of players was 36.75 (s.e. 0.77). The average household size was 5.38 (s.e. 0.24) individuals in addition to the respondent. The division of educational attainment is given in Table 8.1; this sample skews higher than the larger sample used in the mobile device survey and games, because we drew from a sample of CKWs. The modal value for the sub-sample from Oyam is completion of O-Level education and for the sub-sample from Kapchorwa is completion of A-level education. Of the total sample, 7.81% had completed formal education beyond the A-level.

In addition to educational attainment we take account of the farmers' numeracy; see Table 8.1. Culturally there is little use of probabilities in either education or informal market interactions in Uganda (e.g., J. Matovu 2011, per. comm. 16 June). We find that educational attainment and numeracy scores are weakly, but significantly, correlated in this sample, at 0.11 ($p<0.01$). There are five categories of numeracy possible arising from our pre-test of numeracy; no farmer received a score lower than two in the sample and the modal score was four.[303]

Table 8.1 Educational attainment and numeracy (frequency and percentage values)

	O-level	A-level	Above A-Level
All	57 (44.53)	61 (47.66)	10 (7.81)
Kapchorwa	22 (34.37)	35 (54.69)	7 (10.94)
Oyam	35 (54.69)	26 (40.63)	3 (5.69)

Numeracy score	1	2	3	4	5
Sample Frequency (%)	0 (0.00)	16 (12.50)	23 (17.97)	48 (37.50)	41 (32.03)

We asked respondents to provide an estimate of the share of their income that arises from farming activities; see Table 8.2. The mode in the sub-samples residing in both Kapchorwa and Oyam was 50–75% of their household income arises from farming activities.

Table 8.2 Share of household income from farming activities

	< 25 %	25 – 50 %	50 – 75 %	75 – 100 %
All	5 (3.91)	10 (7.81)	67 (52.34)	46 (35.94)
Kapchorwa	3 (4.69)	4 (6.25)	33 (51.56)	24 (37.50)
Oyam	2 (3.13)	6 (9.38)	34 (53.13)	22 (34.38)

Furthermore, we tried to gauge their basic understanding of insurance and whether they expressed any desire to engage in agricultural microinsurance; see Table 8.3. There is a relatively weak correlation (0.20, $p<0.05$) between respondents' knowledge of agricultural insurance before our CKW training sessions and their desire to obtain insurance coverage.

Table 8.3 Basic understanding of and desire to engage in insurance

	Previous Knowledge of agricultural insurance		Interested in adopting agricultural insurance	
	No	Yes	No	Yes
All	75 (58.60)	53 (41.40)	18 (14.10)	114 (85.90)
Kapchorwa	35 (54.69)	29 (45.31)	8 (12.50)	56 (87.50)
Oyam	40 (62.50)	24 (37.50)	10 (15.63)	54 (84.40)

[303] The majority of those who scored four as opposed to five (the highest score possible) responded incorrectly to the question that involved translating a ratio to a percent.

To further our understanding of the use of traditional coping strategies, we asked respondents an open-ended question about the nature of their recovery after a weather event (e.g., drought or flood) that destroys their entire crop. In this case, we did not prohibit the respondent from indicating their use of insurance and/or credit, as was the case in the large-N survey tool. We classify the qualitative responses into categories and frequencies, reported in Table 8.4.[304] The modal response reveals that insurance coverage is the primary coping strategy, while the second most popular is to sell off livestock. This finding is in accordance with the data on coping strategies (see Chapter 5) obtained from the mobile survey responses. When limited to choices outside of the use of insurance as a coping strategy, the modal response was to sell livestock. As a caveat, the focus of the workshop on agricultural insurance education partially accounts for the high level of expressed desire to use insurance to cope with the effects of extreme weather. Thus, the CKWs were likely excited by the possibilities of a new and innovative tool. More than half of the sample had no previous knowledge about agricultural insurance, which will likely result in some level of overconfidence concerning their actual use of insurance in the future.

Table 8.4 Frequency of coping strategies for covariate risks associated with extreme weather

Identified coping strategy	Frequency	Percent
Agricultural insurance	46	35.9
Sell livestock	30	23.08
(Formal) loans	16	12.82
Change planting methods and seed choice in the next season	16	12.82
Borrow money (informally)	10	7.69
Borrow food / eat less	10	7.69

8.3.2 Data–insuring patterns

In almost all instances, players allocated some of their endowment to insurance. In the first two rounds this was the case consistently. In the 3rd-5th rounds, only six players in total (all from Oyam) allocated no chips in a given round. Given that the game is visual and interactive, with rounds that are completed quickly (compared to growing seasons), this outcome is not completely unexpected. Hypothetical bias may arise if CKWs rationalise that they *should* invest in the microinsurance tool.[305]

We observe evidence of learning effects between the initial training round (with no basis risk) and the *Game* with basis risk, which accounts for the five analysed rounds of data. During the training about 40% of players did not insure, a percentage of which lost their entire endowment. This occurrence appears to have been instructive to those players, but also partners observing.

[304] Note that because of the structure of the question, the categories garnered are not mutually exclusive and exhaustive.

[305] The patterns of game play do not suggest that they necessarily over-insure and responses to basis risk do appear to reduce insurance purchase in a manner suggesting that hypothetical bias is not an overpowering effect.

The structure of the game seemed to make it clear to players that diversification provides a higher chance of not *losing*.[306]

The relative frequency of insuring in each round is provided in Table 8.5[307] and Figure 8.1.

Table 8.5 Allocation of playing chips to insurance for the total sample and by region

Total, N=128	Playing chips allocated to insurance cover – Frequency by round (%)					
Round	0%	0-10%	10-20%	20-30%	30-40%	40-50%
1	0 (0)	0 (0)	6 (4.7)	50 (39.1)	26 (20.3)	46 (35.9)
2	0 (0)	1 (0.7)	17 (13.3)	41 (32.0)	40 (31.3)	29 (22.7)
3	2 (1.6)	6 (4.7)	11 (8.6)	42 (32.8)	44 (34.4)	23 (18.0)
4	3 (2.3)	6 (4.7)	13 (10.2)	32 (25.0)	45 (35.2)	29 (22.7)
5	1 (0.7)	8 (6.3)	10 (7.8)	38 (29.7)	41 (32.0)	30 (23.4)
Kapchorwa, n=64						
Round	0%	0-10%	10-20%	20-30%	30-40%	40-50%
1	0 (0)	0 (0)	1 (1.6)	29 (45.3)	0 (0)	34 (53.1)
2	0 (0)	1 (1.6)	13 (20.3)	22 (34.4)	13 (20.3)	15 (23.4)
3	0 (0)	4 (6.3)	6 (9.4)	20 (31.2)	19 (29.7)	15 (23.4)
4	0 (0)	4 (6.3)	9 (14.1)	12 (18.8)	25 (39.0)	14 (21.9)
5	0 (0)	3 (4.7)	7 (10.9)	21 (32.8)	22 (34.4)	11 (17.2)
Oyam, n=64						
Round	0%	0-10%	10-20%	20-30%	30-40%	40-50%
1	0 (0)	0 (0)	5 (7.8)	21 (32.8)	26 (40.6)	12 (18.8)
2	0 (0)	0 (0)	4 (6.3)	19 (29.7)	27 (42.2)	14 (21.9)
3	2 (3.1)	2 (3.1)	5 (7.8)	22 (34.4)	25 (39.1)	8 (12.5)
4	3 (4.7)	2 (3.1)	4 (6.3)	20 (31.3)	20 (31.3)	15 (23.4)
5	1 (1.6)	5 (7.8)	3 (4.7)	17 (26.6)	19 (29.7)	19 (29.7)

There is no inherent pattern across rounds, but we can clearly see that there is no linear trend over rounds. In each round, the total sample tends to allocate at least 20% of their endowment to insurance. The between-round results are relatively more heterogeneous in Kapchorwa than in Oyam. The mode for Oyam falls within the 30-40% allocation bracket in all rounds. Furthermore, when we look at the correlations between rounds we see that for Oyam, there is a strong and significant ($p<0.01$) correlation between allocation decisions in the second and

[306] Diversification for a *favourable* on-farm outcome was construed as even allocating a single chip allocated towards insurance, assuming no negative basis risk occurs.
[307] In each bound for percentage of available playing chips allocated to insurance cover, the lower bound is inclusive, while the upper bound is not.

third rounds (corr=0.39) and between decisions in the fourth and fifth rounds (corr=0.41). This indicates relative consistency of insuring between rounds in Oyam.

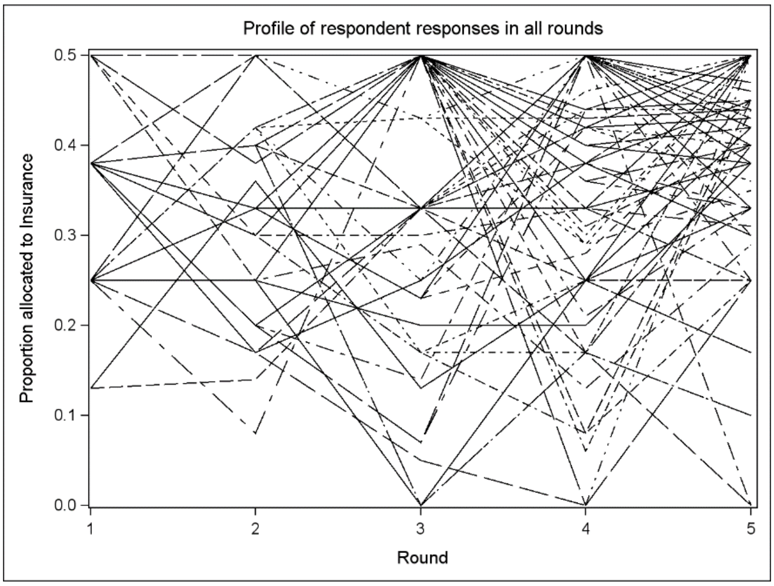

Figure 8.1 Respondent allocations to insurance across rounds[308]

The next section provides a description of regression model variables and directly-related summary data.

8.4 Choice to Insure–regression model variables

In this section we present the variable definitions used in the mixed model explaining the relative percent of resources (i.e., chips) allocated to insuring in a given round of play, *t*, by a given player, *i*. In Chapter 3 we presented the mixed model specification as well as the use of a beta distribution, which we apply here. Each respondent plays five rounds with another partner alternately observing and playing. In each round the respondent allocates some of his *money* between the *purchase* of microinsurance and investing in *farming activities*.

The response variable is *in_perc*, which traces the insurance behaviour in each round as defined by the percentage of chips allocated to insurance relative to the total number of chips with which the farmer starts that round. *In_perc* is a continuous variable, taking values 0-0.5.

[308] Each line represents a player/respondent's insuring choices.

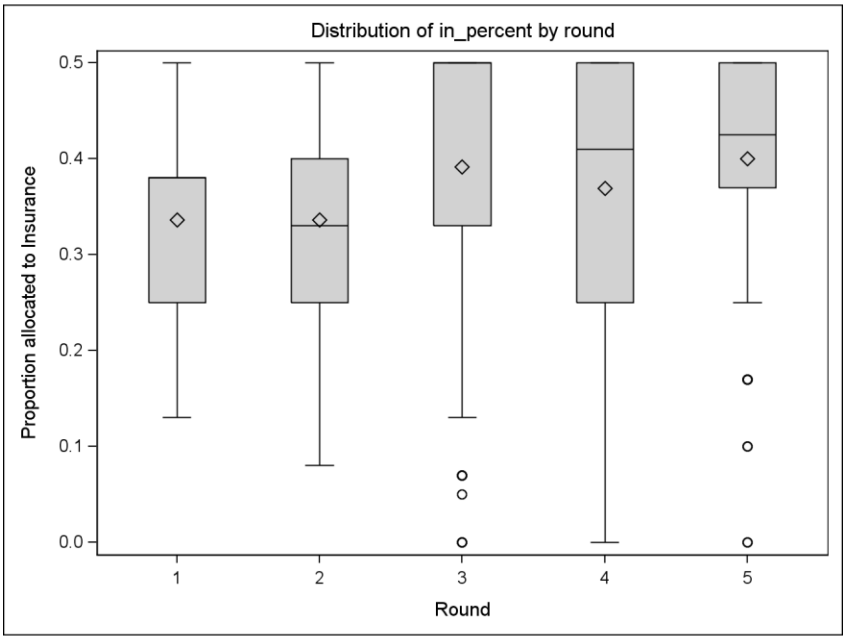

Figure 8.2 Respondent allocations to insurance across rounds; distribution of response variable[309]

Due to the iterative nature of the *Game*, we obtain a strongly balanced panel dataset characterised by both within- (e.g., realisation of basis risk) and between-subject time-invariant (e.g., socio-economic factors) variation, as defined in Table 8.6. As noted previously, given the time constraints and complexity of the *Game*, it was not viable to collect the same level of detail as was obtained through the large-N survey tool. Each respondent plays five rounds, which accounts for five time periods of panel data. This data provides us with a cross-sectional time-series model.[310]

[309] Each line represents a player/respondent's insuring choices.

[310] In econometrics these models are referred to as a cross-sectional time-series because we have time-series of observations at the individual rather than the aggregate level.

Table 8.6 Variable definitions for mixed model for *in_perc*

Variable name	Type	Categories	Meaning
Respondent-specific, time-invariant variables			
region	categorical	0. Kapchorwa *(reference)* 1. Oyam	Dummy variable to control for whether the respondent is based in Kapchorwa or Oyam
age	continuous		Age (in years) of the respondent
fam_size	continuous		Number of individuals in the respondent's household
numeracy	Ordinal	0-5 *(reference=0)*	Index based on responses to numeracy activity given before the game (5=highest level)
IShare	Ordinal	0. 0-25% income from farming 1. 25-50% 2. 50-75% 3. 75-100%	Percent of household income arising from farming activities
know_in	categorical	0. no previous knowledge *(reference)* 1. previous knowledge	Dummy variable based whether a respondent has previous knowledge of agricultural microinsurance before CKW training on the issue
own_index	continuous		Constructed as the sum of for each item owned by the household--rare items (e.g., water pump) were assigned high scores, while common (i.e., higher frequencies/counts) were assigned lower scores
trust	categorical	0. businessman *(reference)* 1. bureaucrat (government)	Based on relative trust respondent has in (government) bureaucrats vs. businessmen
Game-related, time-variant variables			
basis_bad	dummy variable	0. no negative basis risk in previous period *(reference)* 1. negative basis risk in previous period	Accounts for the occurrence of basis risk in the previous round in the negative direction (the respondent does not receive insurance payout when weather conditions on his farm warrant it).
basis_good	dummy variable	0. no positive basis risk in previous period *(reference)* 1. positive basis risk in previous period	Accounts for the occurrence of basis risk in the previous round in the positive direction (the respondent receives insurance payout when weather conditions on his farm do not warrant it).
basisRisk_partner	dummy variable	0. no basis risk experienced by partner in previous period *(reference)* 1. basis risk experienced by partner in previous period	Accounts for occurrence of basis risk for one's partner in the game in the previous period (in either direction).
partnerInvestIns	continuous		Percent of allocated chip invested in insurance by respondent's game partner in the previous round.
disaster	dummy variable	0. no extreme weather in previous period *(reference)* 1. extreme weather in previous period	Occurrence of an extreme weather event in the previous period.

Summary statistics for the model variables are given in Tables 8.7-8.8. Variables that vary by round are grouped by round, while non-round varying variables are not.

Table 8.7 Summary statistics for all variables by round

Round	N	*Variable*	*MIN*	*MAX*	*MEAN*	*STD*
1	128	basis_bad	0	1	0.36	0.48
		basis_good	0	1	0.23	0.43
		basisrisk_partner	0	1	0.59	0.49
		disaster	0	1	0.18	0.39
		partnerInvestIns	0.13	0.50	0.34	0.09
2	128	basis_bad	0	1	0.36	0.48
		basis_good	0	1	0.23	0.43
		basisrisk_partner	0	1	0.59	0.49
		disaster	0	1	0.44	0.50
		partnerInvestIns	0.08	0.50	0.34	0.11
3	128	basis_bad	0	1	0.36	0.48
		basis_good	0	1	0.23	0.43
		basisrisk_partner	0	1	0.59	0.49
		disaster	0	1	0.08	0.27
		partnerInvestIns	0	0.50	0.54	0.30
4	128	basis_bad	0	1	0.36	0.48
		basis_good	0	1	0.23	0.43
		basisrisk_partner	0	1	0.59	0.49
		disaster	0	1	0.25	0.43
		partnerInvestIns	0	0.50	0.37	0.13
5	128	basis_bad	0	1	0.36	0.48
		basis_good	0	1	0.23	0.43
		basisrisk_partner	0	1	0.59	0.49
		disaster	0	1	0.20	0.40
		partnerInvestIns	0	0.50	0.41	0.13

Table 8.8 Summary statistics for non-round varying variables, N=128

Variable	*MIN*	*MAX*	*MEAN*	*STD*
age	22	59	36.8	8.7
education	1	3	1.6	0.6
fam_size	1	13	5.4	2.8
trust	0	1	0.4	0.5
own_index	12	44	23.1	6.0
region	0	1	0.4	0.5
IShare	0	3	2.2	0.7

Bivariate correlations for all model variables are given in Appendix H.

8.4.1 Explanatory variables–time-invariant (socio-economic and attitudinal)

We account for respondent-specific (time-invariant) factors for which we obtain detailed data in the survey related to the *Game*. As a starting point, variables were considered based on those included in our study of WTP for agricultural microinsurance for the large-N survey.[311]

[311] Given that the variables arise from the same conceptual framework and, in many cases, are very similar, we provide an abbreviated justification for their inclusion in this chapter.

Consideration for potentially significant bi-variate correlations were also made in the case of closely related variables, such as measures for education and numeracy.[312]

We include demographic information, such as a*ge* and the number of people residing in the household in addition to the respondent (*fam_size*). We also take account of the *region*. As in WTP microinsurance, we saw significant regional-effects.[313] We also control for *numeracy*, as there was wide variation in this sample. We include numeracy in lieu of educational level[314] since there is a direct relationship of *numeracy* in the manner the *Game* is played with allocation of playing chips, understanding of proportions, and the use of percent.

As a form of controlling for productivity and income given the limited socio-economic data collected, we specify *IShare*, a categorical variable that provides the approximate percent of total household income from farming activities in ranges of 25% from zero to 100%.[315]

We control for respondents' previous knowledge of insurance and expressed WTJ an agricultural microinsurance scheme. The dummy variable *know_in* takes account of whether the respondent has previous knowledge of or experience with insurance, either through their own use or contact with friends and family that hold any insurance policy (e.g., automobile, funeral).[316]

Trust is a categorical variable related to the respondent's trust in certain groups that are relevant to farming decisions and provision of microinsurance in Uganda. The division is between (government) bureaucrat and businessman.

Finally, we look at the productive assets held by the household through ownership of various productive assets in *own_index*. The *own_index* is constructed as the sum over each item owned by the farmer. Given the sample, the various items are weighed based on their relative frequency of ownership with rarer items assigned a higher score.[317] We recode responses from question 20 in the survey tool to determine which households hold relatively more and fewer productive assets. The *own_index* has Cronbach Alpha=0.796 ($p<0.01$).

We use a linear specification with a mixed effects modelling approach, since we are interested in the effects of within- and between-subject variation on the respondents' choice as to the extent to which to insure (i.e., the percent of the endowment allocated to insurance in a given period). Each scenario counts as a single period for which we have information about the respondents' decision to obtain insurance. Other observations (e.g., *age*) remain consistent for each respondent throughout all time periods and, as such, are individual-specific, time-invariant effects--the effect of which we want to garner within our model.

[312] In the present model, we use numeracy as an independent variable.
[313] For this sample, we do not have more detailed locational information, such as village.
[314] Also, given that the sample was comprised of CKWs, the level of formal educational attainment was not greatly varied.
[315] As noted in Table 8.6, defined the same as it was in the models developed in Chapters 6-7.
[316] Throughout the CKW training, we tell the CKWs about the potential for indemnity-based tools to be developed by Grameen Uganda, given their pre-existent on-the-ground structure and services. In alternative formulas of the regression, we look at *ins_want*, a dummy variable which accounts for the respondent's expressed WTJ an agricultural microinsurance scheme.
[317] Household ownership was noted for ownership of: mobile phones, radio, chickens, bicycles, gardens, goats, hand ploughs, water pumps, and pigs.

8.4.2 Explanatory variables–time-variant (game-specific)

We specify a number of variables related to game play and between-round factors that are lagged, as past experiences with microinsurance affect future choices (Gallagher, 2014a; Turner et al., 2014).[318] *Disaster* accounts for extreme weather in the previous round. It takes the value of one if the dice rolled represents a drought or flood in the previous round.

As previously noted, we provide the scope for basis risk in both positive and negative directions. *Basis_bad*=1 if the player draws a playing card that yields basis risk in the negative direction.[319] Whereas, *basis_good=1* if the player experiences a draw of a playing card that yields basis risk in the positive direction (i.e., the weather reported at the weather station has "worse" conditions than on the player's farm).

Furthermore, we take into account group dynamics in insurance choices to the extent possible.[320] In order to investigate how one reacts when observing the experience of basis risk in another, the *Game* was played in groups of two farmers, this is reflected in the regression structure. In each pair, both parties face the same weather conditions, as determined by the initial dice roll outcome; however, each player selects their own basis risk level (with card replacement). The variable *basisRisk_partner* accounts for whether the individual with whom the respondent is playing the game simultaneously experienced basis risk in the previous round of play (in either direction). Finally, the variable *partnerInvestIns* gives the percent (of chips) the respondent's partner invested in the previous round.

8.5 Regression model–results and discussion

In this section, we present two regression models for *in_perc*, a mixed model using the raw data and one based on a beta-distribution transformation.

The first regression fit is a mixed model with random subject/respondent effects and a set of covariates,[321] as described in Chapter 3. Applied here, the model is of the form:

$$Y_{it} = X'\beta + Z_t' b_i \quad \text{where } b_i \sim N(0, \Sigma) \tag{8.1}$$

Where Y_{it} is *in_perc*, X is the matrix of time-invariant covariates and Z is the matrix of round-varying covariates. The fit model, given in Table 8.9, assumes normal errors with homoscedastic variance.

[318] This effect is especially salient to immediate insuring decisions.
[319] i.e., Weather reported at the weather station has "better" conditions than on the player's farm.
[320] We found that in the mobile survey, a large percent of respondents indicated that the farming choices of their neighbours and friends affected them, and this influence likely extended to their choice to insure.
[321] We fit a naïve mixed model using the raw (untransformed) data.

Table 8.9 Estimated mixed model for *in_perc*

Variable		*Coefficient*	*Std. Err.*	
region		0.004	0.012	*
age		-0.002	0.001	
fam_size		0.002	0.002	*
numeracy		0.013	0.013	*
IShare[¥]	1	-0.022	0.036	
IShare	2	-0.002	0.031	
IShare	3	-0.047	0.032	
know_ins		0.014	0.012	*
own_index		0.001	0.001	
trust		0.007	0.012	*
basis_bad		-0.010	0.013	*
basis_good		-0.015	0.015	*
basisRisk_partner		0.004	0.011	*
partnerInvestIns		0.071	0.021	**
disaster		0.028	0.011	***
cons.		*0.329*	*0.049*	
N(obs)=640; N(groups)=128				
Model fit statistics				
AIC=-689.1 BIC=677.7 $R^2 = 0.320$				

[¥] *IShare is estimated at each level relative to the reference level.*

We find significant effects associated with some of the socio-demographic and attitudinal variables. Furthermore, significant effects are found on the model for all independent variables associated with basis risk and insurance behaviour observed from one's "playing partner" in a previous round.[322]

The estimated model appears to fit the data; the pseudo R-squared value indicates that the model explains 32% of the response data around its mean. However, examination of residuals from this fit show departure from normality; see residual plots in Appendix H. This is confirmed by the outcome of numeric tests for normality, which indicate non-normal residuals. The Shapiro-Wilk test (Shapiro & Wilk, 1965) indicates a statistics of W=0.88, p<0.001. The Kolmogorov-Smirnov test (Chakravarti et al., 1967) indicates a test statistic D=0.07, p<0.01.

We re-specify the model on the assumption that the response variable is beta-distributed (Ferrari & Cribari-Neto, 2004).We assume that *in_perc* (denoted as Y) follows a standard beta distribution, defined in the interval (0,1) with two shape variables, α and β. The density function of Y is specified as:

$$f(y|\alpha,\beta) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} y^{\alpha-1}(1-y)^{\beta-1} \qquad (8.2)$$

$$0 \le y \le 1, \alpha > 0, \beta > 0$$

[322] We also fit a model controlling for respondents' wealth (i.e., chips) before each choice is made; the effect of this variable is not significant.

The above function can be re-parameterized by setting $\mu = \frac{\alpha}{\alpha+\beta}$ and $\phi = \alpha + \beta$ such that we can write $Y \sim Beta(\mu, \phi), E(Y) = \mu \; and \; Var(Y) = \frac{\mu(1-\mu)}{1+\phi}$.

Within the framework of generalised linear models (GLM), the logit link is used as a link function. We account for the mixed nature of the model using known vectors of covariates X_i and Z_{it} such that:

$$logit(Y_{it}) = \; Log\left(\frac{\mu_{it}}{1-\mu_{it}}\right) = X'\beta + Z_t' b_i \tag{8.3}$$

where $b_i \sim N(0, \Sigma)$ for the random effects.

The systematic component (linear predictors) is the same as above such that

$$E(Y_{it}|X_{it}, Z_{it}) = \mu_{it} \tag{8.4}$$

$$\mu_{it} = \beta_0 + \beta_1 X_{i1} + \cdots + \beta_{13} X_{i13} + \gamma_1 Z_{t1} + \cdots + \gamma_5 Z_{t5}$$

$$Var(Y_{it}) = \frac{\mu_{it}(1-\mu_{it})}{1+\phi} + \Sigma \tag{8.5}$$

Σ is the covariance matrix for the random effects.

Since we are using the logit link, the beta coefficients are the additional increase or decrease in the log-odds of *in_perc* and the prediction equation is given by Faraway, (2006):

$$\hat{Y}_{it} = \frac{\exp(\hat{\beta}_0 + \hat{\beta}_1 X_{i1} + \cdots + \hat{\beta}_{13} X_{i13} + \hat{\gamma}_1 Z_{t1} + \cdots + \hat{\gamma}_5 Z_{t5})}{1 + \exp(\hat{\beta}_0 + \hat{\beta}_1 X_{i1} + \cdots + \hat{\beta}_{13} X_{i13} + \hat{\gamma}_1 Z_{t1} + \cdots + \hat{\gamma}_5 Z_{t5})} \tag{8.6}$$

The resulting estimated model for *in_perc* assuming a beta distribution is given in Table 8.B. The generalized Chi-square is large, indicating that the model fits well (Brown & Forsythe, 2012). The Pearson residual plot (see Appendix H) shows a close to random pattern, indicating an improved fit. The pseudo R-Squared value is 0.38,[323] indicating that the model explains 38% of the response data around its mean.

[323] Pseudo R-squared is given by the square of the correlation coefficient between the predicted and actual values in the model. that is a square of the correlation coefficient between the predicted values and the actual values, which is 0.626.

Table 8.10 Estimated mixed model for *in_perc*, assuming a beta distribution

Variable		*Coefficient*	*Std. Err.*	
Region		0.03	0.06	
Age		0.02	0.01	*
fam_size		0.00	0.00	
numeracy		0.13	0.12	*
IShare	1	0.19	0.18	
IShare	2	0.05	0.15	
IShare	3	0.33	0.16	**
know_in		0.08	0.06	*
own_index		0.00	0.001	
trust		0.06	0.06	*
basis_bad		-0.02	0.07	*
basis_good		-0.08	0.08	*
basisrisk_partner		-0.01	0.06	*
partnerInvestIns		0.19	0.11	**
disaster		0.13	0.12	***
cons.		*-0.54*	*0.23*	
*scale**		*1.03*		
Model fit statistics				
	-2 Res Log Pseudo-Likelihood =782.0			
	Generalized Chi-Square = 503.0			
	Pseudo R^2=0.380			

**The scale is the parameter ϕ in the model formulation above.*

The same factors are found to be significant in this specification of the model, in addition to *IShare*. We see that all invariant variables show significant effects on *in_perc*, which is not surprising given the structure of the *Game*. We find a number of significant effects related to socio-demographic factors. We discuss each effect in turn, below.

8.5.1 Variables related to game play

The *Game* was structured in a manner consistent with obtaining information about actions in response to experienced basis risk. The risk could be observed either first- or second-hand (i.e., observed basis risk for a playing partner). To this point, we see a number of significant effects on *in_perc* by variables related to basis risk.

Holding all else constant and regardless of the outcome of the previous round, respondents were affected by partners' insurance decisions. *PartnerInvestIns* is positively and significantly ($p<0.01$) associated with *in_perc*, *ceteris paribus*. Observation of one's partner investing a one-percent greater value than they themselves did in a given period equates to an increase of 0.19 in the logged-odds for *in_perc* (assuming no disaster in the previous period). Yet, we find a mediating effect; *basisrisk_partner* is negatively and significantly ($p<0.01$) related to *in_perc*, holding all else constant. If a player observed that his partner experiences basis risk, in either the positive or negative direction, the log-odds of *in_perc* decreases by 0.01.

Ceteris paribus, the log-odds of *in_perc* increase by 0.13 if *disaster* was positive in the previous round. It makes sense that if a disaster occurs the desire to insure increases in the short-term, especially for those who experience an uninsured loss. In the developed country context, Kunreuther & Pauly (2015) note a similar effect in a web-based multi-period insurance purchasing experiment. This finding is also aligned with the findings of Gilovich & Medvec (1995) that decisions made in the present that produce short-term regret lead individuals to immediately take steps to reduce the *pain*.

In the development of our field experiment we were cognisant that few studies examine consumer reaction to basis risk, and even fewer study reaction to *good* basis risk, which favours the consumer. In other words, index-based insurance can also introduce a situation whereby the insured obtains a payout because the index at the weather station reports more severe weather than occurs on the farmer's farm. We were unable to find any statistical information about how often this scenario may occur in real-life, but, in general, it is possible when there is no indemnity verification in place.

We find that the experience of basis risk in either direction–in the farmer's favour or to his detriment–is significantly negatively-related to *in_perc*. *Basis_bad* is significantly ($p<0.10$) negatively related to *in_perc*; holding all else constant if negative basis risk occurs the log-odds of *in_perc* is reduced by 0.02 in the next round. Somewhat surprisingly, *basis_good* is significantly ($p<0.10$) negatively related to *in_perc* as well, holding all else constant; such that if basis risk favours the player, the log-odds for *in_perc* is reduced by 0.08 in the next round.

It is notable that the negative effect of basis risk realised in a given period on *in_perc* in the next period is relatively greater for basis risk realised in the positive direction.[324] There is proof in the literature that would suggest otherwise. For example, in marketing research, people tend to like the feeling of "getting something for nothing" (e.g., O'Brien & Jones, 1995). It is well noted that individuals conceptualise gains differently than losses, especially under uncertainty and compound-risk. Thus, it may be argued that the boost in (absolute) wealth from good basis risk may increase willingness to take risk (e.g., insure less) in the next round.

Effectively, players seem to be mentally prepared to be on the losing side should *bad* basis risk occur.[325] Yet, gaining from the insurance tool unfairly creates an understanding that what they were told about the tool[326] is incorrect, and that the pay-out mechanism is much more divorces for anything they experience on-farm. In a manner, good basis risk may provide the player more clarity about the nature of the tool than does bad basis risk. Basis risk in the positive direction appears to disrupts players' schema of how the insurance tool works and the vector of possible outcomes associated with compound risk in microinsurance. Such a finding is consistent with Carter et al.'s (2011) suggestion that greater complexity in a coping tool involving insurance leads to greater confusion and simultaneously lesser uptake of the tool.

8.5.2 Demographic and attitudinal variables

Given the complex nature of this field game and the time limitations during the CKW training, we strove to obtain the most representative socio-economic and demographic information from

[324] Note that we also developed a model in which we tabulated the number of times the respondent experienced basis risk in the positive (and negative) direction. This did not have a significant effect on the player's responses.
[325] i.e., an outcome that does not favour them unfairly provided past experiences with development projects.
[326] i.e., that it will protect one in the case of a loss.

respondents for inclusion in the model. We see no significant effect of *region* on one's propensity to insure a greater proportion of endowed wealth in the *Game*. Furthermore, there is no significant effect from factors that are often significant in models of microinsurance behaviour (e.g., Eling et al., 2014), such as *fam_size and own_index.*

Holding all else constant, *age* has a positive and significant effect ($p<0.05$) on *in_perc*. The log-odds of *in_perc* increase by 0.2 for each additional year of *age*. This finding relates to the evidence that risk aversion, as well as compound-risk aversion tend to be positively correlated with age (e.g., Janssens & Kramer, 2012). Furthermore, there are findings in multiple settings that engagement with insurance is also positively correlated with age. In our sample, age likely acts as a partial proxy for seniority within the community. As one ages and feels that they set an example for the less senior farmers, it makes sense that they strive to utilise coping strategies that offer to help them maintain their crop yield in the face of extreme weather.[327]

Holding all else constant, *IShare* has a significant and positive ($P<0.001$) effect for the highest category of percent of income arising from farming activities relative to the lowest category. A change from the lowest to greatest category for *IShare* indicates an increase in log-odds by 0.33. This finding coincides with our findings in Chapters 6 and 7. Those with base income exhibiting the least embedded diversification would be more willing to insure than with greater levels of existing diversification.

Numeracy, holding all else constant, has a positive and significant ($p<0.01$) effect on *in_perc*. A change to a greater category of numeracy indicates an increase in log-odds by 0.13. This effect is expected given the nature of the *Game*. There is an upper limit on the relative proportion of wealth one can invest in insurance cover. Up to that point, given the simple algorithm for the payout scheme, it is likely that players with higher numeracy are able to more closely approximate the optimum level of insurance coverage without consideration for the probabilities of compound-risk arising from basis risk.

Trust in a businessman compared to trust in a (government) bureaucrat has a positive significant effect on *in_perc* ($p<0.10$); the log-odds increase by 0.08. This finding is consistent with our findings for trust in the large-N survey data analysis regarding trust.

Previous knowledge of insurance shows a significant positive relationship with *in_perc*, *ceteris paribus*. *Know_in* has a positive significant effect on *in_perc* ($p<0.10$). The log-odds increase by 0.08 for those with past knowledge of insurance. We assume from the high expressed desire to acquire agricultural insurance in real life[328] that past experience with insurance has not been negative, which corresponds with the relationship established between *know_in* and *in_perc*. Furthermore, we must remain cognisant that the CKW respondents are identified and elected as leaders by their individual communities; as such, their previous knowledge about potential coping mechanisms, such as insurance, is likely above average.

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327 This suggestion appears in literature focused on farmers' experiences in the developed context (e.g., van Hook, 1990; Allen, 2011; Gullifer & Thompson, 2011).

328 Based on information garnered in the survey companion to the Game, but not included in the current regression analysis.

8.6 Summary and Conclusions

To date there has been relatively little empirical research on the direct effects of basis risk on insuring behaviour between periods. The majority of field studies give respondents choices between different coping options, but do not ask about the relative percent of wealth they are willing to allocate to such options. The *Game* is a field game that offers such a framework. Weather is a random event and even if the player purchases index insurance, he must still consider basis risk in an explicit manner, as compound risk. Most previous work expresses index insurance from a financial standpoint as an insurance policy. Even when these policies have an actuarially-fair price, they are often conceptualised as investments with a negative net present value. The *Game* incorporates basis risk, both in the positive and negative directions, in relationship to the consumer's financial gain. Furthermore, this field experiment had simple payment rules and was easily played in groups of farmers to discern reactions to insurance choices and the (second-hand) experience of basis-risk through observation of one's subsequent choices.

We find that indicators of greater household wealth are not significant in our model of insurance purchase between rounds; however, factors such as age and numeracy, taken in isolation, do have a significant effect. This is expected as more research notes that household wealth is not necessarily a good indicator of insuring behaviour (e.g., Clarke & Kalani, 2012; Castellani et al., 2013). Given that numeracy scores were related to one's ability to comprehend percent and ratios, high numeracy is an advantage in understanding index insurance. This is specifically so in the *Game*, which incorporates relatively simple rules with calculable probabilities.

We obtain some insight about farmers' personal and observed (through other players) experience of basis risk. Not only do respondents react negatively to self-experienced basis risk, but they are significantly affected by others' experience of realising basis risk (positive or negative) in a given period. We find that people in a community-based farming society, such as those of Kapchorwa and Oyam, pay close attention to coping decisions of their peers. In the data from the mobile survey, respondents frequently stated that they discuss farming decisions with friends and neighbours and would be influenced by them in their own realised decisions. Even though the people in our sample for the *Game* are considered leaders within their communities, they still were greatly influenced by the observed decision of others for insuring in the game.

It is of specific interest that *good* basis risk does have a negative effect on insuring in the next period to a greater extent than *bad* basis risk. As noted in Section 8.5.1 this makes sense from the standpoint of incongruency with expectations – they may not like bad basis risk, but it is expected, while *good* basis risk is not expected given the goals of the insurance product and thus shakes overall consumer confidence. Generally in behavioural economics and social psychology individuals "tend to reject deals they perceive as unfair (towards them) even if they stand to benefit." (Matuschke & Qaim, 2008). It would be of interest to extend the research both empirically and theoretically related to *good* basis risk.[329]

[329] The current relevant literature reveals theoretical models that look at failure to repay as a form of basis risk [citation needed of example of such studies], but not at overpayments.

Furthermore, in future research it would be interesting to measure absolute versus relative risk aversion in the decision to insure.[330] Fluctuation in the percent of endowment placed into insurance in each period occurs, but it does not fall to zero in our results. It is possible that this is related to utility obtained from the *feeling* of insurance and may have to do with the types of bounded rational decisions noted by in Kunreuther and Pauly's (2015) online simulation based on fluctuations in (un)happiness from different levels of insuring over time.

The *Game* provides a useful tool for testing farmers' understanding of index insurance and basis risk. This framework can be easily extended to a field game with simulations of group premia or compound credit-insurance tools in order to look at demand-side responses to account for availability of other risk-transfer tools and combined agreements (e.g., bundled insurance and loans). In an environment where agricultural microinsurance exists in real-life, it would be useful to explicitly mirror real-life policies, as was the case in Norton et al.'s (2014) research.

It would be beneficial to repeat the *Game* with a larger sample and with a sample of greater demographic variance. Furthermore, it would be ideal to have a longer period to play the game to control for respondents playing alone in comparison to playing with a partner.

[330] It should be noted that we trialed playing the *Coin* game with this sample. Yet, responses showed a clear strategic pattern; since the CKWs were trained to administer the Coin game the responses likely were not accurate reflections of risk preferences.

9 Adoption of home flood insurance – Hurricane Sandy

9.1 Introduction

Extreme weather events cause significant impact in the developed world. Natural disasters have been more devastating (financially) since 1990 than in the entire preceding history of insurance (Kunreuther & Michel-Kerjan, 2009). Hurricane Sandy[331] caused damages of 19 billion USD to New York City alone (Blake et al, 2013). In the aftermath of such an extreme weather event the question of how to build capacity against future vulnerabilities is of prime concern. Insurance is a primary coping mechanism available in the developed world against covariate risks arising from extreme weather, as outlined in Chapter 2. In recent years, increasing wealth in developed countries has increased the value at risk from extreme weather events and has been an overall driver of rising loss trends (e.g., IPCC, 2012; Kuczinski & Irvin, 2012).

In this chapter we focus upon residential flood insurance demanded and related attitudes in the developed country context. As Sydnor (2010) points out, there is limited empirical research based in real insurance markets that looks at anomalies in household behaviour concerning risky choice. As noted in Chapter 2, some of these studies look at expressed preferences for home flood insurance ex-post event by extrapolating from behaviour in gambling exercises, the practicality of which we explore in our research.

The literature on flood insurance is extensive; however, to the best of our knowledge, there are few empirical studies that look at iterative flood insurance choice. Among these, we know of none that actually compare those recently affected by an extreme flood with those who experienced it, but were not materially affected by it for intended insurance behaviour in the future. This research seeks to address this gap in the literature. Our research approach obtains a rich set of demographic and attitudinal data for respondents, as described in Chapter 3, the results of which are used to understand the propensity to insure.

In our flood simulation we examine how individuals' attitudes regarding insurance and risk affect insurance purchase, controlling for socio-economic and demographic factors. Furthermore, we examine how 'visualisation' of expected financial outcomes affects respondents' insuring behaviour. Finally, we explore the feasibility of the use of gambling choices to draw conclusions about insurance purchase behaviour through a comparison of respondents' insurance uptake in the simulation activity and their choice in a (relatively) high-stakes gamble.

The balance of this chapter is organised as follows: Section 2 provides an overview of past literature and studies that address uptake of insurance following an extreme flood event (arising from a natural disaster); Section 3 presents research questions framing the research, Section 4 presents data relevant to the analysis of insuring behaviour in the simulation; Section 5 presents the mixed model regression for insuring; Section 6 presents analysis of respondents' gambling behaviour; Section 7 discusses results; and Section 8 concludes.

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[331] We use the term 'hurricane' in reference to Hurricane Sandy. The USA National Weather Service describes Hurricane Sandy as a blend of a downgraded hurricane mixed with two other storms. The hurricane has been referred to as 'Superstorm Sandy,' especially by media outlets. Our use of 'Hurricane Sandy' maintains consistency with our online survey tool storm references. Throughout the chapter reference may be made to Sandy without specification for a hurricane or superstorm.

9.2 Previous literature and background

Chapter 2 provided background and an overview of home flood insurance[332] in the developed country context. This was augmented by a discussion specific to Hurricane Sandy and conditions surrounding home flood insurance in the Northeastern USA in Chapter 4. In this section we review key points and highlight studies relevant to our analysis of insuring behaviour.

Empirical evidence shows flood insurance uptake increases significantly, albeit temporarily, ex-post major flood events, (e.g., Bin & Polasky, 2004; Kunreuther & Pauly, 2006; Kousky et al., 2009; Kousky, 2010; Atreya & Ferreira, 2012). Most studies make this claim based on revealed preferences (e.g., housing and insurance records), whereas relatively few examine such patterns in a tractable experimental setting. Floods (arising from natural disasters) are relatively low-probability events; thus, panel datasets rarely include iterative occurrences of extreme events for the same household. This creates challenges for estimating behaviour over a series of flood events from real-world data accurately (Troccoli et al., 2008). Conducting an iterative simulation addresses this gap in the current knowledge base.

9.2.1 Consumer demand for flood insurance–overview

Consumer demand for insurance is driven by many factors, including budget constraints and latent risk aversion, as noted in Chapter 2. The demand for flood insurance is also influenced by consumer knowledge and perception of risk, which in turn is dependent on previous experiences and risk communication. Rational, fully-informed consumers, maximising expected utility, would purchase full flood insurance.[333] In actuality, consumers are financially limited by circumstances stemming from the insurance market, such as pricing above the actuarially-fair level. Regardless of ability to insure, would-be consumers are further bounded in their rationality due to limited and subjective information and their subsequent application of heuristics and biases. Behavioural studies imply that individuals' risk-taking behaviour can be best explained by subjective measures such as risk perception and perceived returns.[334] Specifically, when individuals are in an environment wherein optimal actions (e.g., decision to insure) are met with reliable 'rewards,' decisions over time should converge to optimality (e.g., Kalai & Lehrer, 1993; Meyer & Hutchinson, 2001). But this effect seems to disappear when the decision environment is not ideal for iterative learning (i.e., feedback is rare and noisy) (e.g., Camerer et al., 2004) – which is characteristic of low-probability, high-loss events.

It is widely accepted that individuals tend to underinsure against low-probability, high-loss events relative to high-probability, low-loss events (Slovic et al., 1977); such as in flood insurance uptake patterns (e.g., Hsee & Kunreuther, 2000). There are mediating factors that bound the extent to which individuals choose to protect against vulnerability of natural disaster effects. Camerer & Kunreuther (1989) offer a review of decision processes for low-probability events and the relevant biases in probability judgement. These decision processes biases include: optimism bias, availability, ignoring low-probability risks (e.g., Slovic, 1987), mental accounting (e.g., Thaler, 1985), reframing, endowment effects, regret (i.e., hindsight bias) (Fischhoff &

[332] Throughout this chapter and thesis, references to home flood insurance in the developed country context indicate indemnity-style insurance policies.

[333] This outcome assumes that insurers are able to perfectly bear the risk with no transaction costs.

[334] For a more detailed overview see: Sarin & Weber (1993) and Nosic & Weber (2010).

Beyth, 1975), status-quo bias, and emotional dimensions of risk (e.g., Loewenstein & Thaler, 1989).[335]

9.2.2 Empirical studies of flood insurance demand

Making individuals aware of their increased exposure to flood damage does not appear to translate into increased insurance coverage (e.g., Schoemaker & Kunreuther, 1979; Pynn & Ljung, 1999; Burby, 2001)[336]. There are three pivotal papers that claim a positive relationship between loss probability and the rate of insurance uptake (holding constant the expected value of the loss and the load): Slovic et al. (1977), McClelland et al. (1993) and Ganderton et al. (2000).

Yet, experimental evidence in the realm of disaster insurance has challenged these claims. Notably, Laury et al. (2009) replicated and extended Slovic et al.'s (1977) experiment and found that insurance adoption does not drop off when occurrence probability is relatively low.

Anecdotal evidence suggests people have a short memory for catastrophic losses (e.g., Gallagher, 2014b). The year after Hurricane Katrina flooded New Orleans (2006), new flood policies with the NFIP increased by 53% nationally; however, within 3 years of the disaster (2008), new purchases dropped back to pre-2005 levels (33% cancellation rate of existing policies). This is consistent with Meyer's (2012) experimental finding that mitigation investments may actually be self-extinguishing over time. Investment in insurance protection seems to be limited by the inability of (direct) experience to cure myopic reasoning (i.e., hyperbolic discounting) biases (e.g., Thaler, 1980; Loewenstein & Prelec, 1992). Indirect learning from the observations of others' experience appears to not mirror the effects of direct experience (e.g., Weinstein, 1980). To this point, the experimental work of Dillion & Tinsley (2008) suggest that close encounters with negative events that did not impose direct damages actually supressed propensity to invest in protection in the future.

It is difficult to gain access to affected individuals immediately after a severe flood event occurs; in cases when it is possible, execution of a large-N study that accounts for patterns of flood insurance uptake, related attitudes, and demographic details is nearly impossible. The studies that have been undertaken in person with a sample affected by flooding tend to make claims about insurance behaviour based upon experimental gambles (i.e., potential gains). Two such studies are Page et al. (2014) and Eckel et al. (2009); both report that direct experience with flooding decreases risk aversion in comparison with a control group of less- and non-affected households. However, the tenets of Prospect Theory suggest that individuals likely conceptualise these types of gambles differently than they do insurance purchases (i.e., potential losses) (Kahneman & Tversky, 1979).

Page et al. (2014) look at the immediate aftermath of the 2011 Brisbane floods as a natural experiment; they conducted a brief in-person survey with about 200 households differentially affected by the floods.[337] They find that homeowners who experienced losses from the flooding

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[335] The purpose of our experiment and survey was not to delve into the mechanics of the heuristics employed by our respondents; however, we did consider relevant rules-of-thumb in order to construct a protocol that was sensible and garnered the most realistic responses possible. Detailed descriptions of select heuristics that are related to flood insurance demand are noted in Appendix C.

[336] This is not to say that individuals have perfect information about all aspects of expected losses in the cited cases.

[337] They interviewed the homeowners approximately eight weeks after the peak flooding period.

were 50% more likely to opt for a risky gamble[338] than are participants from the unaffected group. Eckel et al. (2009) find a similar result in their study of short-term risk-taking behaviour of evacuees following Hurricane Katrina in New Orleans. They suggest that this behaviour is likely attributable in part to the emotional state of participants after the hurricane and the immediacy with which financial losses from the flooding come to mind.[339]

Studies comparable to those of Page et al. (2014) and Eckel et al. (2009) conducted in developing countries have reported the opposite finding; namely, that risk aversion varies positively with level of loss from natural disaster flooding (e.g., Cassar et al., 2011; Cameron & Shah, 2015). This finding may be a remnant of cultural or other underlying factors.

Meyer's (2012) study tracks participants' mitigation decisions with regards to flood protection between time periods via computer interface; purchase of flood insurance is one amongst a number of coping options presented. Decisions in that study were driven by factors such as the simulated hurricane's strength and the magnitude of loss experienced from the last two storms encountered in the game. He found protection investment to be well below optimal levels for both short-term and long-term protection in the game. The level of under-investment was conditioned by recent experience; the greater (or weaker) the previously experienced storm losses, the greater (or weaker) investment in protection in the current period.

There are studies of flood insurance and risk perception that utilise graphical interfaces as a presentation format to communicate risk; however, we do not know of a study that looks at the direct effect of information representation on flood insurance uptake to date. Though, it is widely accepted that graphical descriptions and experience have an effect on people's ability to more accurately understand risk, i.e., one's subjective probability is closer to the objective probability value function (e.g., Budescu et al., 1988; Hertwig et al., 2004).

Findings on the effects of graphical display of risk probabilities and expected value of risk-taking are heterogeneous in those outside of choice to insure. For example, Hertwig et al. (2004) find detailed numerical descriptions about outcomes and probabilities lead to reductions in risk seeking behaviours.[340] This same effect has been noted in other studies (e.g., Barron & Erev, 2003; Weber, 2006; Hau et al., 2008; Kaufmann et al., 2013); though there is little consensus as to the underlying causal mechanism. Benartzi & Thaler (1999) show that respondents were more likely to accept a gamble after seeing the graphical return distribution; they hypothesise that this has to do with the fact that individuals overestimate the probability of a loss until viewing the return distribution.

Generally, empirical studies on propensity to insure against extreme flood events have been based on laboratory experiments that trace the ability of respondents that learn from experience to invest in protection against extreme weather events (e.g., Meyer, 2012; Zahn & Neuß, 2012). Other studies have a respondent set that has been recently affected by such an event in real life who are asked a brief set of questions related to risky behaviours (e.g., gambling) in order to gauge their insurance appetite in the future (e.g., Page et al. (2014). Our study combines these two types of studies in order to address some key issues about learning

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[338] The risky gamble takes the form of a scratch card offer.

[339] Eckel et al. (2009) point out that the extreme poverty which already existed in the areas hit by Hurricane Katrina ex-ante the resultant flooding may have already placed respondents in a more risk-averse category.

[340] The learning treatment in this experiment was based on respondents pushing buttons to sample possible outcomes.

from experience in the context of a flood simulation exercise, while also controlling for recent experience with such an event.

We chose to focus on flood insurance as opposed to other weather disaster insurance because many covariate weather hazards culminate in extreme flooding and flood insurance has gotten attention as being undersubscribed without extensive understanding of patterns of uptake and the relationship to underlying factors. In the developed country context, insurance is often the main means of coping during the recovery immediately following an event; as such it is important that we better understand uptake patterns and associated motivations.

9.3 Research questions

Given the current literature on the uptake of flood insurance and influencing factors, we developed our survey and simulation around four key research questions, as stated below, which we address in the analysis in this chapter.

1. How is the purchase of flood insurance affected by an individual's attitudes regarding insurance and risk, controlling for socio-economic and demographic factors?

   We hypothesise that those who express a greater desire for flood insurance and perceive the greatest subjective risk to their household from flood will tend to purchase insurance more frequently in the flood simulation. Furthermore, those who were recently (negatively) affected by Hurricane Sandy will have a great propensity to insure.

2. How is the purchase of insurance affected by the occurrence of an extreme weather (i.e., flood) event in the previous period?

   We hypothesise that insurance purchase will increase in a period immediately following the occurrence of a flood in our simulation activity regardless of the expected likelihood of flooding.

3. How does the presentation of data related to a potential extreme weather event affect insurance purchase?

   We hypothesise that a more extensive explanation of the risk of flood and expected loss will be positively correlated with the frequency of insurance purchases, ceteris paribus.

4. Do individuals' choices in questions framed as a gamble provide an appropriate proxy for individuals' insurance purchase behaviour?

   We hypothesise that respondents who were recently negatively affected by an extreme flood event in real life will show dissimilar risk behaviour in both a financial gamble and in their expressed interest in insurance purchase.

9.4 Data

This section presents data relevant to insuring behaviour in the simulation. Initially we look at the prevalence of insuring in the simulation and use GIS to consider locational effects.

In Chapter 4 sampled households affected by Sandy were mapped against MOTF data indicating flood impact. We generate Figures 9.1-9.2 to show average insuring in the simulation across the ten scenarios per household for those households affected and unaffected by Sandy, respectively, overlaid by MOTF data. Households suffering financial losses from Sandy have 22% occurrences of 'scores' of six or greater insuring scenario rounds; for those reporting no loss from Hurricane Sandy, there are 24% occurrences. Thus, spatially, it appears that those in both groups are represented relatively equally on the higher end of the *score* for insuring through the scenarios.

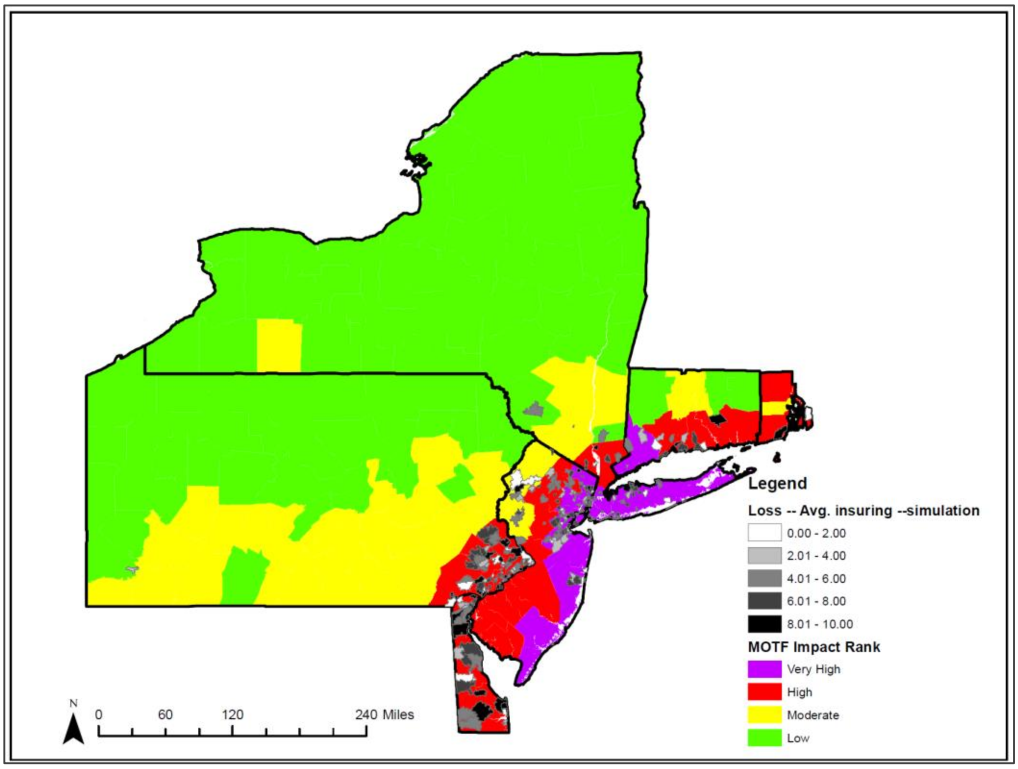

Figure 9.1 Simulation insuring behaviour for households with loss from Hurricane Sandy[341]

[341] *Map created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved.*

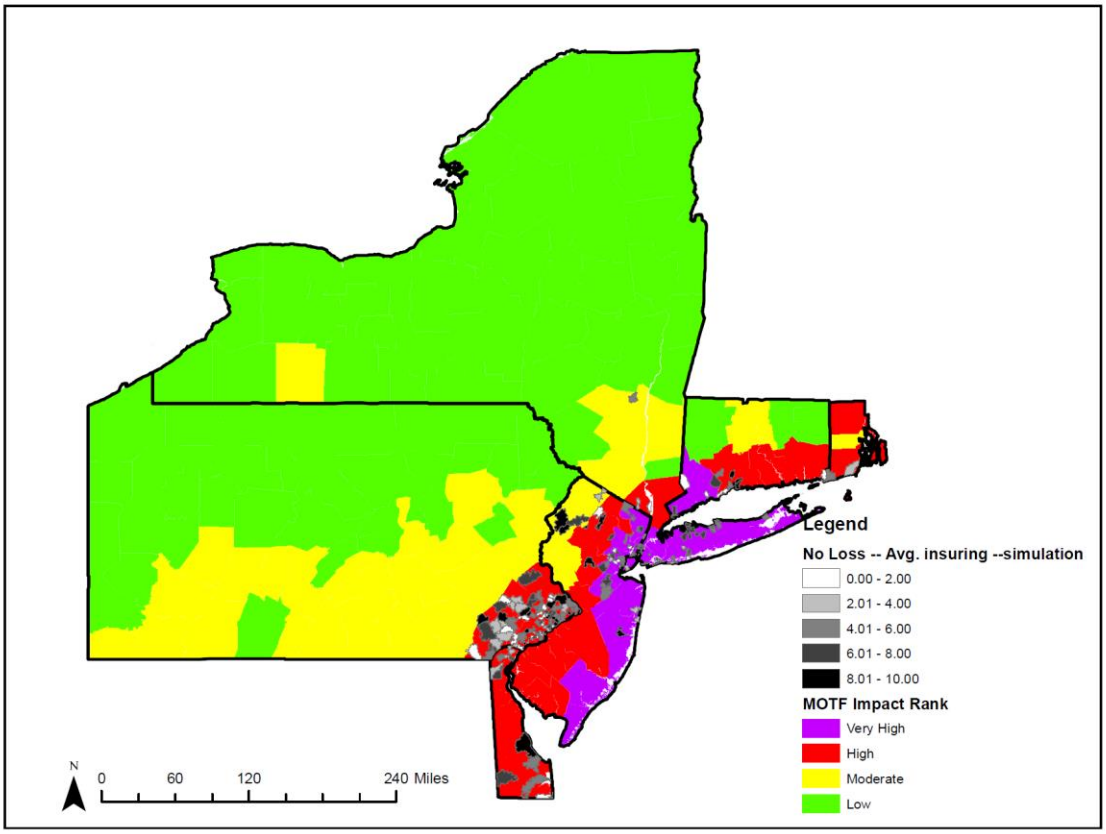

Figure 9.2 Simulation insuring behaviour for households with no loss from Hurricane Sandy[342]

In this section data specific to insuring behaviour in the simulation and the gamble are noted.

The self-reported risk of home flooding from extreme weather is skewed left in absolute terms for the cohort that experienced a financial loss from Hurricane Sandy; see Table 9.1. This distribution is expected and provides some evidence that Sandy flooding is still salient, as those with a financial loss experienced flooding only six months ahead of when the data was gathered and were in the process of making claims.

Table 9.2 provides the distribution of respondents' self-reported financial risk-taking behaviour. There is no significant pre-existing difference in financial habits or risk-taking between the cohorts. This pattern is also followed when we look at the distribution of insurance purchases in the flood simulation activity.

[342] *Map created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved.*

Table 9.1 Self-reported flood risk to home relative to surrounding properties

	All		NO LOSS		LOSS	
	Freq.	%	Freq.	%	Freq.	%
(0) Lower than avg.	382	47.81	201	67.00	181	36.27
(1) Average	301	37.67	86	28.67	215	43.09
(2) Higher than avg.	116	14.52	13	4.33	103	20.64

Table 9.2 Self-reported financial risk-taking

	TOTAL		NO LOSS		LOSS	
	Freq.	%	Freq.	%	Freq.	%
(0) Not at all similar	31	3.88	11	3.67	20	4.02
(1) Not similar	76	9.52	29	9.67	47	9.44
(2) Slightly similar	215	26.94	84	28.00	131	26.31
(3) Similar	233	29.20	87	29.00	146	29.32
(4) Very similar	184	23.06	71	23.67	113	22.69
(5) Extremely similar	59	7.39	18	6.00	41	8.23

Note that 0 accords to be least risk averse; 5 is associated with the most risk averse.

We ask respondents about experience with home flooding aside from Hurricane Sandy. There is no statistically significant difference between households with and without losses from Sandy. Across the sample roughly 50% of households have not previously experienced home flooding. Of other flood events, approximately 25% arose from household-specific issues, such as broken drains or water heaters. There is no significant correlation between the types of flood and flood insurance held. As noted previously, relative to the number of households with flood insurance, those holding other insurance is quite high. There is no significant difference between reported financial risk-taking or perceived household risks related to types of insurance held by the household.

9.4.1 Flood simulation data

Respondents display largely heterogeneous insuring behaviour between scenarios in the flood simulation. Disregarding the risk and loss magnitude of the various scenarios, 9.2% of the total sample never insured and 15.7% of the total sample insured in all ten presented scenarios.[343] This behaviour does not demonstrate a significant departure from expectations under EU Theory; however, it is likely that the decision process was not one that was premised on EU Theory maximisation. For example, affect[344] could apply to those insuring in all scenarios as a way to maintain peace of mind and reduce potential regret in the case of flooding without

[343] It is reassuring that the average time for respondents who opt for the same level of insurance in all scenarios does not deviate from the average time spent on the online tool across all respondents (i.e., approximately 28 minutes).
[344] For example, what we term feeling of insurance in the Basic dice game results.

insurance cover. Alternatively, those who choose to never insure may have a likelihood of occurrence was below their personal threshold of concern.

The percent breakdown of the sample that insures (does not) in each scenario is provided in Tables 9.3-9.4. It appears that respondents may be sensitive to the probability of flood occurrence more so than to the potential loss magnitude (in Lab$).[345] As discussed previously, the flood scenarios are paired such that the same expected loss is achieved by a varying combination of risk and loss magnitude. In four of the five pairs there is a statistically significant ($p<0.05$) reduction in the number of respondents insuring when they see a lower probability of flood (higher magnitude of loss) for a given expected loss.

Table 9.3 Distribution of aggregate number of scenario insurance purchases across simulation

Number of scenarios in which insurance was 'purchased' by respondent	Total Sample		Table Treatment		No Table Treatment	
	Freq.	%	Freq.	%	Freq.	%
0	73	9.2	40	10.08	33	8.35
1	36	4.5	16	4.03	20	5.06
2	35	4.4	19	4.79	16	4.05
3	68	8.6	34	8.56	34	8.61
4	84	10.6	33	8.31	51	12.91
5	85	10.7	41	10.33	44	11.14
6	101	12.8	50	12.59	51	12.91
7	63	8.0	39	9.82	24	6.08
8	66	8.3	37	9.32	29	7.34
9	57	7.2	32	8.06	25	6.33
10	124	15.7	56	14.11	68	17.22

Table 9.4 Number of respondents insuring in each flood simulation scenario

Scenario	Respondents' Insurance		Probability of flood	Loss from flood	Expected Value from
	Uninsured	Insured			
1	311 (39.0)	487 (61.0)	0.30	7,000	27,585
2	406 (50.8)	393 (49.2)	0.14	15,000	27,585
3	340 (42.7)	457 (57.3)	0.10	7,000	29,195
4	382 (47.8)	417 (52.2)	0.14	5,000	29,195
5	303 (37.9)	496 (62.0)	0.50	7,000	25,975
6	406 (50.9)	392 (49.1)	0.14	25,000	25,975
7	350 (43.8)	449 (56.2)	0.20	7,000	28,390
8	396 (49.6)	403 (50.4)	0.14	10,000	28,930
9	268 (33.5)	531 (66.4)	0.40	7,000	26,500
10	311 (39.0)	487 (61.0)	0.14	20,000	26,500

Each respondent was exposed to the same ten scenarios, in the same order. Each scenario's outcome was a random draw from the underlying simulation programme, which followed the percent chance of flood occurrence ascribed to that specific scenario. The flood outcomes in

[345] This is investigated further in our modelling of insuring in Section 5. See Sjöberg (1999) for further discussion of response to the probability or risk versus severity of potential consequences when expected losses are held constant.

one period may influence the respondent's intention to insure in the next period. Table 9.5 indicates how the flood outcomes were distributed across simulations across all respondents.[346]

Table 9.5 Flood outcomes by scenario

Simulation	Flood outcome		Total
	No Flood (0)	Flood (1)	
1	567	233	800
2	673	127	800
3	722	78	800
4	692	108	800
5	383	417	800
6	343	457	800
7	640	160	800
8	686	114	800
9	506	294	800
10	670	130	800
Total	5,882	2,118	8,000

It is not clear why some individuals insure regardless of variation in the specification of flood conditions (e.g., expected loss), but there are at least two possible explanations which accord with our data. It is likely that these individuals are: 1. highly risk averse and/or 2. obtain utility from the *feeling of insurance*; these possibilities are not mutually exclusive and we find evidence in our data to support both.[347] Firstly, regarding risk aversion, there is a significant positive correlation ($p<0.05$) between propensity to insure in all rounds and self-described financial risk.

This type of correlation does not appear to hold when we view subjective risk aversion through self-reported risk of home flooding (from extreme weather). In accordance with the second explanation, we find that insuring in all ten scenarios is correlated with expressed desire to insure in real life ($p<0.01$). Furthermore, though stated (subjective) flood risk is no greater in real life for this group, there is a significant and relatively strong correlation between the response pattern in the simulation for those who opt to always insure and their choice to purchase household flood insurance in real life in the past (corr=0.47; $p<0.01$). The correlation with purchase of other types of insurance coverage (e.g., life) is significant and positive (corr=0.36; $p<0.01$). Again, it is reassuring that the relative strength of correlation is greater in the realm of home flood coverage (since that is the context of the scenario) than is the case for other types of insurance coverage in real life. There is no statistically significant difference between the sample affected by Sandy and the unaffected cohort with respect to the frequency of insurance purchases in the 10 scenarios (at the aggregate level).

9.5 Regression model specification–insuring behaviour

9.5.1 Variable specifications

Table 9.6 provides variable types and definitions for the regression analysis for the mixed model for simulation insuring behaviour. Table 9.7 gives the summary statistics for the respondent-

[346] This data for 'flood outcome' is applied to the variable outcome in the regression analysis.

[347] In Chapter 5 we provide a longer discussion of the concept of the 'feeling of insurance' (via our Basic Dice Game), which likely accounts of some of the rationale for those respondents who always insure in the simulation.

level time-invariant variables of the mixed model. The bivariate correlations between regressors are given in Appendix G2.

The rationale for inclusion of specific variables in the model for insuring behaviour in the flood simulation is discussed below. As described in Chapter 3, we employ a mixed logit model regression structure. To the extent possible we follow from the conceptual framework for insurance demand indicated in Chapter 2.[348]

Table 9.6 Variable definitions (time-invariant and time-variant)

Variable name	*Related Factors (conceptual framework)*	*Type*	*Meaning/definition*
Time invariant variables			
age	Personal and demographic	continuous	Age of respondent in years
gender	Personal and demographic	binary	Gender of respondent. male=0; female=1
income	Economic	ordinal	Estimated gross household yearly income
education	Personal and demographic	ordinal	Highest level of education achieved
kids	Personal and demographic	continuous	Number of children in household
damage_perc	Economic & structural factors – risk exposure	continuous	Value of home's structural damage from Superstorm Sandy (as percent of house value). Those in the cohort of "no damage from Hurricane Sandy" have damage_perc=0
home_ins	Structural / social and cultural	binary	Home insurance not held ex-ante Superstorm Sandy=0; Home insurance not held ex-ante Superstorm Sandy=1
risk_fin	Social and cultural	ordinal	Self-identified financial risk-taking of respondent
worry_index	Social and cultural	ordinal	Average score of risk concern over a series of realms (i.e., terrorist attack, burglary, house fire, car fire, house flood, traffic accident)

[348] Given the stark differences between the Ugandan microinsurance case study and the Hurricane Sandy study it is not possible to use the same variable specifications in both studies of insurance demand. Furthermore, the application of the conceptual framework for insurance demand is adjusted appropriately.

tables	Experimental treatment	binary	Table treatment: respondent not exposed to table presentation of data=0; respondent not exposed to table presentation of data=1
ImpactRnk	Structural – risk exposure	ordinal	Impact rank category in which household is situated according to the FEMA MOTF data: green (low)=0; yellow (moderate)=1; red (high)=2; purple (very high)=3
Time-variant variables (scenario-specific)			
Prob	n/a	ordinal	Probability of flood occurrence
Mag	n/a	ordinal	Damage from flood if flood occurs; otherwise damage is 0.
ExLoss	n/a	ordinal	Expected loss for given scenario
InCost	n/a	ordinal	Cost of flood insurance coverage
Scenario	n/a	ordinal	Accounts for time-variant
OutcomeLag	n/a	binary	Accounts for outcome in previous scenario

Age is often positively associated with risk aversion; thus, the continuous variable *age* is included in the modelling of insurance choice. Specifically, positive association between age and risk perception is noted in a number of studies of natural disaster risk perceptions (e.g., Lazo et al., 2000; Armaş, 2006). Burningham et al. (2008) and Knocke & Kolivras (2007) note that there is a point in older age (unique across individuals) at which the impact of age on risk perception decreases sharply. Atreya et al. (2015) note that after age 45 there is a significant positive relationship between age and flood insurance purchase. Though, studies that look at the relationship between risk perception and probability judgement specifically have found no significant age effects (e.g., Lindell & Hwang, 2008). The variable *age* reflects respondents' age in years.

As is the case with age, there is little on the direct effect between gender and insurance uptake, but rather the relationship between gender and risk perception which may mediate the demand for insurance. Thus, the binary variable *gender* is included in the modelling. The empirical findings relating gender and risk perception in a developed world context are mixed. Many studies find a positive relationship between being female and risk perception (e.g., Armaş, 2006; Plattner et al., 2006; Lindell & Hwang, 2008), while some observe a negative relationship (e.g., Lazo et al., 2000). Furthermore, some studies report (e.g., Schubert et al., 1999; Knocke & Kolivras, 2007; Burningham et al., 2008) no difference in risk-taking behaviour between the genders when they control for other demographic variables, such as education and income.

Income is an ordinal variable which accounts for the household's combined net-income. It is divided in intervals of 10,000 USD, from 0-10,000 to 190,000-200,000 USD. As noted in the Uganda research, household wealth does not always indicate a strong relationship with insurance demanded. In some studies of home flood insurance there is a positive correlation between household income and flood insurance coverage (Landry & Jahan-Parvar, 2011). Yet, this may be in part due to the correlation in some areas between property price and flood risk (e.g., Kriesel & Landry, 2004).

Ludy & Kondolf (2012) demonstrate that even homeowners with high educational achievement have trouble understanding the risk of home flooding. Inclusion of the ordinal variable, *education* helps to control for the possible effect of education. Atreya et al. (2015) find that educated individuals are more likely to purchase flood insurance. Related to education is financial literacy; there is extensive literature on the relationship between financial literacy and use of financial services in the developed country context; however, the relationship to insurance demand is somewhat less studied (e.g., Tennyson, 2011). Studies demonstrate a positive association between financial literacy and insurance demand (e.g., Masci et al., 2007; Cappellettia et al., 2013). Education is an ordinal variable with seven categories: no formal education, elementary education, some high school, high school completion, bachelor's degree, master's degree, doctorate/medical degree.

Kids is a continuous variable incorporated to control for potential effects of the number of members in a household. Baumann & Sims (1978) and Thieken et al. (2007) note a positive association between extent and type of private precautions taken (including insurance). As would be expected, there is a significant positive association between marital status and *kids* for our sample; thus to avoid introducing issues of multicollinearity into the model we do not include marital status as a variable.

Variables related to households' previous insuring behaviour are included in the model. *Damage_perc* accounts for the percent of the home's value lost to damage sustained from Sandy. The binary variable *home_ins* indicates whether or not home flood insurance was held by the household ex-ante Sandy.[349]

Variables are introduced in order to access the extent to which self-perceived risk-taking accords with the choice to insure. *Risk_fin* is an ordinal variable that places respondents within a category of risk aversion relative to their neighbours based on financial decision-making. A greater value for *risk_fin* indicates higher risk aversion.

The *worry_index* is an ordinal value that situates a respondent based on her average score of concern over a series of categories and is predicated on the finite-pool-of-worry hypothesis (e.g., Linville & Fischer, 1991) which relates to emotional responses as well as personality factors that relate to intolerance of uncertainty (e.g., Freeston et al., 1994). A greater value of *worry_index* indicates a greater level of worry.

The binary variable *tables* control for whether a respondent is exposed to the table treatment in order to access the effect of visualisation of flood scenario details.

[349] Alternative model specifications included the binary variable *want_ins*, which indicates whether the household expresses interest in affordable insurance coverage in real life following Sandy. There was no significant effect associated with this variable.

The ordinal variable *impactRnk* controls for the impact rank in which households are situated according to the FEMA MOTF data. Atreya et al. (2015) explain that recent flood events temporarily increase insurance purchases;[350] this effect fades after three years.

Table 9.7 Summary statistics of respondent level data – fixed time-invariant variables

Variable	*Min.*	*Max.*	*mode*	*median*	*mean*	*s.d.*	*value*	*Frequency (%)*
age	17	92	27	42	43	16		
gender	0	1	1	1	1	0	0	358 (45)
							1	442 (55)
income	1	21	1	8	10	6		
education	1	7	5	5	4	2		
kids	1	7	1	1	2	1		
damage_perc	0	100	0	0	9	20		
home_ins	0	1	1	1	1	0	0	300 (38)
							1	500 (63)
risk_fin	1	6	4	4	4	1		
worry_index	0	100	30	26	30	21		
tables	0	1	0	1	1	1	0	400 (50)
							1	400 (50)
ImpactRnk	0	1	1	1	1	0	0	10 (1)
							1	19 (2)
							2	387 (48)
							3	384 (48)

Two mixed logit models are developed for the choice to insure in the flood simulation, with the binary response variable *insure*. Model(1) is a general model which combines the constituent elements of each scenario (i.e., time invariant variables) into the variable *scenario*. Model(2) breaks down the constituent elements of *Simulation* in order to access the extent to which respondents respond to probability of potential loss versus the magnitude (i.e., financial impact) of a potential loss. The time variant variables, which accord to the scenario conditions and the choice to insure. The regression form of the mixed model was given in Chapter 3.

To structure the model, let Y_{it} be the insurance decision of the ith respondent ($i = 1, \dots, 800$) at the tth simulation ($t = 1, .., 10$). Respondents' (time-invariant) characteristics are fixed across simulations for each respondent, *i*; they represent the fixed part of the model denoted by Matrix $[X_i]$.

Each given simulation *t* has the following fixed characteristics (i.e., constant) across respondents for each individual scenario; these values are noted in the right side of Table 9.4. These characteristics are fixed within the system, there is no variation across respondents. The dummy variable s*imulation* is modelled as part of the random part of the model denoted by Matrix $[Z_{it}]$.[351]

Each given scenario has a binary *insure* response (i.e., decision to insure or not) and a binary *outcome* (flood or no flood occurs), associated with each respondent. Therefore, *outcome* and

[350] This effect does not appear significantly different between households with ex-ante flood insurance versus those without it.

[351] This is the matrix Z in the mixed model of the form:

$$Y_{it} = \beta X_i + \gamma Z_{it} + \epsilon_i + \eta_t$$

insure vary across respondents and scenarios. By definition *insure* is the "decision to insure or not" and *outcome* is defined as the "flood outcome" (i.e., if a flood took place or not). These two make up the random part of the model. The model response variable is *insure* while *outcome* is a time varying covariate. Since knowledge of the flood outcome follows the decision to insure for a given scenario, it is modelled as a lagged variable between periods (i.e., scenarios).

Diagnostics were run to examine the feasibility of assumptions of the mixed logit model in fitting the data set including checks for potential collinearity between independent variables. A summary of the diagnostics is provided in Appendix I.

The number of variables in the fixed part of the model was reduced by applying the stepwise logistic regression technique (Harrell, 2001); each scenario in the simulation was modelled with the potential independent variables from which the subset of variables for the forecasting model was selected. At each step, for all variables in the model individually, the t-statistic for its estimated coefficient is transformed (i.e., squared) to form an '*F-to-remove*' statistic.

Given the survey data with potential noise in each round that is uncorrelated, it is of interest to assess the contribution of individual predictors for a given model (for a given scenario) and to furthermore assess the number of individual scenario choices a given predictor contributes. In this case for each scenario, the predictors were entered hierarchically, comparing each new model to the previous to determine the contribution of each predictor in a given scenario.

9.5.2 Mixed model definition

In Table 9.8, variables denoted by X represent the fixed part of the model signified by $\mathrm{X_i}$ with column elements $X_{i1} \ldots., X_{i11}$ for each ith respondent. The random part of the model is represented by a matrix $\mathrm{Z_{it}}$ a matrix of the simulation variant variable outcome lagged at the previous period (i.e., *OutcomeLag*) and the simulation conditions that are a list of dummy variables that we have denoted as Z_{2it} a matrix of all the simulation condition dummy variables.

We include *scale* as the estimator of a scale parameter, which determines the scale of the distribution function–this is always in the underlying data. Typically, it is assumed that preference heterogeneity is the main driver behind individuals making different choices. Yet some research indicates that much of preference heterogeneity may be described as *scale heterogeneity* (e.g., Louviere et al., 1999), meaning that the idiosyncratic error term is greater for some would-be consumers than for others. Since the scale of the error term is inversely-related to error variance, the argument implies that choice behaviour is more random for some consumers. We explicitly include *scale* in the specification and model reporting in order to gauge if this effect is significant in our case study.

Table 9.8 Full model list of variables

Variable	Denoted by
age	X_{i1}
education	X_{i2}
damage_perc	X_{i3}
impactRnk	X_{i4}
income	X_{i5}
kids	X_{i6}
worry_index	X_{i7}
risk_fin	X_{i8}
scale	X_{i9}
gender	X_{i10}
tables	X_{i11}
outcomeLag	Z_{1it}
scenario	Z_{2it}

The resulting model is a model of the form:

$$E(Y_{it}) = \frac{\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_1 Z_{1it}+\gamma_2 Z_{2i1}+\cdots+\gamma_{11} Z_{2i10})}{1+\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_2 Z_{2i1}+\cdots+\gamma_{11} Z_{2i10})} \tag{9.1}$$

Where Z_{2i1} =1 , if 1st Simulation and Z_{2i1} =0 otherwise ……

……. Z_{2i10} =1 , if 10th Simulation and Z_{2i10} =0 otherwise

$$Var(Y_{it}) = E(Y_{it})[1 - E(Y_{it})] \tag{9.2}$$

The probability of choosing to insure given X and Z is P(Y_it ∣ X_i,Z_it) is given by:

$$(X_i, Z_{it}) = \frac{\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_1 Z_{1it}+\gamma_2 Z_{2i1}+\cdots+\gamma_{11} Z_{2i10})}{1+\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_1 Z_{1it}+\gamma_2 Z_{2i1}+\cdots+\gamma_{11} Z_{2i10})} \tag{9.3}$$

which implies that the log odds:

$$\log\left(\frac{E(Y_{it})}{1-E(Y_{it})}\right) = \beta_0 + \beta_1 X_{i1} + \ldots + \beta_9 X_{i11} + \gamma_1 Z_{1it} + \gamma_2 Z_{2i1} + \cdots + \gamma_{11} Z_{2i10} \tag{9.4}$$

It is assumed that there is variation among respondents; therefore, decisions to insure or not across scenarios for a given respondent are 'more alike' than those from different respondents. Likewise, decisions will also vary within respondents. To this point, three different error correlation structures were explored, as listed below.[352]

1. Unstructured correlation, that puts no restriction on the association between observations taken from the same respondent at different time points.
2. AR(1) correlation, that allows for the correlation observations taken from the same respondent to increase auto regressively, such that $\varepsilon_t = \rho\varepsilon_{t-1} + u$.
3. One dependent correlation, that allows observations adjacent to one another to be correlated.

When the full model was fit with all three structures, results were not qualitatively different (i.e., significant variables are the same using all three structures), so we adopted the AR(1)

[352] Results from the full model fit using all three correlation structures are given in Table I.5.

correlation structure. This autoregressive structure allows the respondent's previous insurance choice to be correlated with the insuring choice in the current period (Hill et al., 2012),[353] allowing this relationship to decay as we move from one scenario to another, mirroring real-life insurance practices.

9.5.3 Model Regression Results

Results from the full model assuming an AR(1) correlation structure are given in Table 9.9. Seven variables seem to be significant in the model. They include: *age, education, kids, worry_index, risk_fin, tables* and *scenario*. A reduced model is fit that only includes these variables; see Table 9.10. Both models demonstrate a relatively good fit with pseudo R-squared values ~0.25 (e.g., Hosmer & Lemeshow, 2000).[354]

Table 9.9 Model(1)–full model estimation

Parameter	*Ψ*	*Estimate*	*SE*	
Intercept		-0.05	0.35	
age		-0.01	0.00	***
education		-0.07	0.02	***
damage_perc		0.08	0.07	
ImpactRnk	1	-0.10	0.30	
ImpactRnk	2	-0.17	0.30	
ImpactRnk	3	-0.23	0.36	
income		0.00	0.01	
kids		-0.10	0.03	***
worry_index		0.00	0.00	***
risk_fin		0.18	0.03	***
home_ins	1	0.06	0.08	
gender	1	0.01	0.00	
tables	1	0.70	0.06	***
outcomeLag	1	0.02	0.06	
scenario	2	-0.51	0.09	***
scenario	3	-0.17	0.10	
scenario	4	-0.38	0.10	***
scenario	5	0.04	0.11	
scenario	6	-0.52	0.11	***
scenario	7	-0.22	0.11	**
scenario	8	-0.46	0.10	***
scenario	9	0.24	0.11	**
scenario	10	-0.49	0.11	***
scale[1]		1.00	.	
AIC=10473 SC=10634		*-2LogL=10427*	*Pseudo R-Square = 0.251*	
Test	*Chi-sq.*	*DF*	*Pr>Chi-sq.*	
Likelihood Ratio	*516.7179*	*22*	*<.0001*	
Score	*503.9357*	*22*	*<.0001*	
Wald	*476.6087*	*22*	*<.0001*	

Ψ category at which estimation is made relative to the reference category for a given variable.

[353] We would expect that someone's decision to insure in the current simulation is affected by their decision in the previous round; however, we do not estimate this as a direct effect, so we do not have an estimate for it.

[354] This is a relatively reasonable pseudo R-squared value given the type of model and the fact that it is based on empirical data from human behaviour (e.g., DeMaris, 2002).

The results from the reduced model are given in Table 9.10. The reference category for the simulation conditions is based on the specifications for scenario 1. Compared to scenario 1, scenarios 3 and 5 are not significant predictors of probability of insure. It is also particularly interesting that the simulation conditions at round 9 have a positive effect while the rest have a negative effect.

Table 9.10 Results Model(1)–reduced model estimation

Parameter		***Estimate***	***SE***	***95% confidence***		
Intercept		0.230	0.162	-0.087	0.547	
age		-0.007	0.002	-0.010	-0.003	**
education		-0.060	0.018	-0.096	-0.024	**
Kids		-0.097	0.028	-0.152	-0.042	**
worry_index		0.005	0.002	0.002	0.008	**
risk_fin		0.187	0.025	0.137	0.236	**
tables	1	0.340	0.031	0.401	0.279	**
scenario	2	-0.507	0.089	-0.683	-0.332	**
scenario	3	-0.164	0.101	-0.362	0.033	
scenario	4	-0.378	0.103	-0.580	-0.176	**
scenario	5	0.047	0.105	-0.159	0.254	
scenario	6	-0.506	0.104	-0.710	-0.302	**
scenario	7	-0.210	0.104	-0.414	-0.005	**
scenario	8	-0.454	0.104	-0.658	-0.250	**
scenario	9	0.247	0.107	0.037	0.456	**
scenario	10	-0.475	0.104	-0.679	-0.271	**
scale		1.000	.	.	.	

AIC=10499 SC=10611 -2LogL=10467 Pseudo R-Square = 0.250

Test	*Chi-sq.*	*DF*	*Pr>Chi-sq.*
Likelihood Ratio	*509*	*15*	*<.0001*
Score	*497*	*15*	*<.0001*
Wald	*470*	*15*	*<.0001*

Somewhat surprisingly *age* is significantly negatively associated with *insure*. This is also the case for the association between *education* and *insure*, as well as *kids* and *insure*. Additionally, *income* and *gender* were not significant.

Worry_index is significantly and positively associated with *insure*; the greater level of worry the greater the likelihood of insuring in a given scenario. *Risk_fin* is also significantly positively associated with *insure*; respondents self-identifying as more risk averse financially are more likely to insure in a given scenario. The effect of demographic factors on insuring may be partially mediated through their effects on individuals' risk aversion and/or perceived risk (e.g., Asgary & Willis, 1997; Botzen et al., 2009);. It may be the case that for our data, relevant effects related to income and gender, as well as other demographics are captured in part by our measures related to risk.

We see no significant effect on *insure* based on household losses (*damage_perc*) from Sandy. Additionally, there is no significant effect from the MOTF *impactRnk* designation for the location of the household. Though somewhat surprising these findings agree with past research indicating that homeowners in areas with relatively high chance of flooding do not necessarily hold (e.g., Kunreuther & Michel-Kerjan, 2009) or renew (e.g., Kunreuther & Pauly, 2004) flood insurance. Since the MOTF designations are based on Sandy's impacts in areas, some of which were not covered by complete FEMA floodplain maps pre-Sandy, some households were likely not aware of the details of possible flooding; there is no significant correlation between ex-ante flood insurance in real life and *ImpactRnk* for our sample.

The table treatment has a positive significant association with *insure*; indicating that individuals exposed to the treatment are more likely to insure.

OutcomeLag is not significant to *insure*. This gives an indication that respondents consider each scenario independently. We see that the parameters of a given scenario affect the likelihood of insuring. This is to be expected, as in repeated-measures data, the respondent is one source of variation – in addition to the usual measurement error, a given respondent's choices will vary between scenarios. Yet, in some cases the magnitude of effect for the scenario factors is rather high, making further exploration of the relative effects of given aspects of the scenarios of interest.

Odds ratio estimates for the model are given in Table 9.11; in our model the odds ratio is specified as P(insuring)/P(not insuring) for a unit (or category) increase in a given explanatory variable, all other variables held constant.[355] The model covariance matrix is given in Appendix I. The estimated change in the odds of insuring for a one year increase in age is 0.99 with confidence interval (0.99, 1.00). The odds of insuring for respondents that are exposed to the table treatment is estimated to be 1.4 times the odds of insuring for respondents who are not exposed to the table treatment with confidence interval (1.28, 1.54).

There appears to be a difference between the odds of insuring based on the parameters of a given scenario. The odds of insuring if a respondent is given conditions in simulation 2 are 1.41 times the odds of insuring if given the conditions in simulation 1 with confidence interval (1.19, 1.67). In order to further investigate the relative significance of different aspects of an insurance scenario in the decision to insure, we develop a model that disaggregates the factors in each scenario.[356]

[355] We present the odds ratio values opposed to log odds (or odds) for simplicity of interpretation with regards to potential insuring behaviour (e.g., Agresti, 2002; Fleiss et al., 2003).

[356] In model(1) we capture that differences through an index for each scenario time-invariant factors presented to all respondents using dummy variables.

Table 9.11 Odds ratio estimates with confidence intervals, based on the reduced form of model(1)

Variable	*Ψ*	*Estimate*	*SE*	*95% confidence interval*	
Age		0.99	0.00	0.99	1.00
education		0.94	0.03	0.89	1.00
Kids		0.91	0.04	0.84	0.98
worry_index		1.00	0.00	1.00	1.01
risk_fin		1.21	0.05	1.11	1.30
tables	*0*	0.71	0.03	0.65	0.78
tables	*1*	1.40	0.07	1.28	1.54
scenario	*(2 vs. 1)*	1.41	0.12	1.19	1.67
scenario	*(3 vs. 1)*	1.14	0.10	0.96	1.35
scenario	*(4 vs. 1)*	1.74	0.17	1.43	2.11
scenario	*(5 vs. 1)*	1.00	0.07	0.87	1.16
scenario	*(6 vs. 1)*	1.35	0.12	1.14	1.59
scenario	*(7 vs. 1)*	1.05	0.08	0.91	1.22
scenario	*(8 vs. 1)*	2.13	0.20	1.76	2.56
scenario	*(9 vs. 1)*	1.03	0.08	0.89	1.19
scenario	*(10 vs. 1)*	1.66	0.15	1.39	1.99

Ψ category at which estimation is made relative to the reference category for a given variable.

The model fit statistics indicate that the model (compared to the full model and an intercept only model) provides a good fit. The global test for the null hypothesis that all the Betas and Gammas are zero also shows that the model fits well.

An alternative model specification treats scenario conditions as individual effects. Each scenario had a combination of different levels of probability (i.e., *prob*) (with six levels i.e., 0.1, 0.14, 0.2, 0.3, 0.4, 0.5), magnitude (i.e., mag) (with six levels i.e., 5000, 7000, 10000, 15000, 20000, 25000), *ExLoss* – the interaction between Magnitude and probability (with five levels i.e., 700, 1400, 2100, 2800, 3500). These factors were noted in Chapter 3 in the description of the model; they are reprinted in Table I.X. The fixed part of the model formulation stays unchanged from that in model(1).

In fitting this formulation of the model, Matrix Z_{it} above now consists of a column for *prob*, *mag*, and ex*Loss* denoted as Z_{2it}, Z_{3it} and Z_{4it} respectively. Model(2) can then be expressed as:

$$E(Y_{it}) = \frac{\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_1 Z_{1it}+\gamma_2 Z_{2it}+\gamma_3 Z_{3it}+\gamma_4 Z_{4it})}{1+\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_1 Z_{1it}+\gamma_2 Z_{2it}+\gamma_3 Z_{3it}+\gamma_4 Z_{4it})} \tag{9.5}$$

$$Var(Y_{it}) = E(Y_{it})[1 - E(Y_{it})] \tag{9.6}$$

The probability of choosing to insure given X and Z is $P(Y_{it}|X_i, Z_{it})$ is given by:

$$\pi(X_i, Z_{it}) = \frac{\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_1 Z_{1it}+\gamma_2 Z_{2it}+\gamma_3 Z_{3it}+\gamma_4 Z_{4it})}{1+\exp(\beta_0+\beta_1 X_{i1}+\ldots+\beta_9 X_{i11}+\gamma_1 Z_{1it}+\gamma_2 Z_{2it}+\gamma_3 Z_{3it}+\gamma_4 Z_{4it})} \tag{9.7}$$

Which implies that the log odds is given as:

$$\log\left(\frac{E(Y_{it})}{1-E(Y_{it})}\right) = \beta_0 + \beta_1 X_{i1} + \ldots + \beta_9 X_{i11} + \gamma_1 Z_{1it} + \gamma_2 Z_{2it} + \gamma_3 Z_{3it} + \gamma_4 Z_{4it} \tag{9.8}$$

Table 9.12 provides results for Model(2); expected results are similar to Model(1). This formulation of the model indicates that probability levels are the most important predictors of households' probability to insure; the other simulation conditions (*mag* and *exLoss*) have non-significant effects on respondents' choice to insure. Values of *prob* are estimated relative to *prob*=0.1. Note that *mag, prob,* and *exLoss* do not vary per respondent and they are not observed, but are fixed conditions to which respondents react. As such, they do not vary much and the effect of *exLoss* cannot be estimated. We further refine the set of variables; the reduced model estimates are given in Table 9.13.

Table 9.12 Model(2)–full model estimation

Parameter		*Estimate*	*SE*	
Intercept		-0.22	0.35	
age		-0.01	0.00	***
education		-0.07	0.02	***
damage_perc		0.08	0.07	
ImpactRnk	*1*	-0.23	0.36	
ImpactRnk	*2*	-0.17	0.30	
ImpactRnk	*3*	-0.10	0.30	
income		0.00	0.01	
kids		-0.10	0.03	***
worry_index		0.01	0.00	***
risk_fin		0.18	0.03	***
house_in	*1*	0.06	0.08	
tables	*1*	0.70	0.06	***
outcomeLag	*1*	0.02	0.06	
prob	*0.14*	0.21	0.09	**
prob	*0.2*	0.06	0.11	
prob	*0.3*	0.17	0.10	
prob	*0.4*	0.41	0.11	***
prob	*0.5*	0.21	0.10	**

Parameter		*Estimate*	*SE*
mag	*7000*	-0.02	0.10
mag	10000	-0.08	0.10
mag	15000	-0.13	0.10
mag	20000	-0.11	0.10
mag	25000	-0.14	0.10
ExLoss	1400	0.00	0.00
ExLoss	2100	0.00	0.00
ExLoss	2800	0.00	0.00
ExLoss	3500	0.00	0.00
Scale		1	.
AIC=10530	*SC=10690*	*-2LogL=10484*	*Pseudo R-Square = 0.247*
Test	*Chi-sq.*	*DF*	*Pr>Chi-sq.*
Likelihood Ratio	517	22	<.0001
Score	504	22	<.0001
Wald	477	22	<.0001

Table 9.13 Model(2)–reduced model estimation

Parameter		Estimate	SE	95% confidence		Z	Pr > |Z|	
Intercept		-0.29	0.16	-0.60	0.03	-1.79	0.07	
age		-0.01	0.00	-0.01	0.00	-3.66	0.00	***
education		-0.06	0.02	-0.10	-0.02	-3.25	0.00	***
kids		-0.10	0.03	-0.15	-0.04	-3.47	0.00	***
worry_index		0.01	0.00	0.00	0.03	3.09	0.00	***
risk_fin		0.19	0.03	0.14	0.24	7.44	<.0001	***
tables	1	0.68	0.06	0.56	0.80	10.90	<.0001	***
probability	0.14	0.29	0.07	-0.43	-0.15	-4.10	<.0001	***
probability	0.2	0.03	0.10	-0.22	0.16	-0.28	0.78	
probability	0.3	0.19	0.10	-0.01	0.38	1.87	0.06	
probability	0.4	0.42	0.10	0.23	0.62	4.25	<.0001	***
probability	0.5	0.21	0.10	0.02	0.40	2.16	0.03	**
Scale		1	.	.	.	.	.	

AIC = 10493 SC=10577	-2LogL =10469	Pseudo R-Square = 0.245	
Test	Chi-sq.	DF	Pr>Chi-sq.
Likelihood Ratio	507	11	<.0001
Score	495	11	<.0001
Wald	468	11	<.0001

Note that the reference category for Probability is probability = 0.1

Odds ratio estimates for the reduced model(2) are given in Table 9.14. The estimates for the fixed variables are the same as the ones in model(1). The reference used is probability 0.1, such that the odds of insuring when the probability of flood is 0.14 is estimated to be 1.3 times the odds of if the probability is 0.10. Somewhat surprisingly the odds ratio does not continue to increase with the increase in *perc*, but rather increases until a maximum at *perc*=0.30 and decreases with almost symmetrical odd ratios around the maximum point.[357] There is not a straightforward interpretation as to why this is the case; though in all cases the odd ratios are greater than 1, which makes the findings believable. It is possible that there is a level of risk at which individuals may become less sensitive to the relative risk. Also, in order to make the simulation accessible and avoid confounding through numeracy, we used relatively large probabilities in comparison to real-life chance of extreme floods, which may cause some unintended bias.

[357] In other words, the odds ratio at *prob*=0.14 is very close to that at *prob*=0.5 likewise the odds ratio at *prob*=0.20 is very close to that at *prob*=0.4.

Table 9.14 Odds ratio estimates for Model(2)–reduced form

Parameter		*Estimate*	*SE*	
Intercept		-0.22	0.35	
age		-0.01	0.00	***
education		-0.07	0.02	***
damage_perc		0.08	0.07	
ImpactRnk	*1*	-0.23	0.36	
ImpactRnk	*2*	-0.17	0.30	
ImpactRnk	*3*	-0.10	0.30	
income		0.00	0.01	
kids		-0.10	0.03	***
worry_index		0.01	0.00	***
risk_fin		0.18	0.03	***
house_in	*1*	0.06	0.08	
tables	*1*	0.70	0.06	***
outcomeLag	*1*	0.02	0.06	
prob	*0.14*	0.21	0.09	**
prob	*0.2*	0.06	0.11	
prob	*0.3*	0.17	0.10	
prob	*0.4*	0.41	0.11	***
prob	*0.5*	0.21	0.10	**

Parameter		*Estimate*	*SE*
mag	*7000*	-0.02	0.10
mag	10000	-0.08	0.10
mag	15000	-0.13	0.10
mag	20000	-0.11	0.10
mag	25000	-0.14	0.10
ExLoss	1400	0.00	0.00
ExLoss	2100	0.00	0.00
ExLoss	2800	0.00	0.00
ExLoss	3500	0.00	0.00
Scale		1	.
AIC=10530	*SC=10690*	*-2LogL=10484*	*Pseudo R-Square = 0.247*
Test	*Chi-sq.*	*DF*	*Pr>Chi-sq.*
Likelihood Ratio	517	22	<.0001
Score	504	22	<.0001
Wald	477	22	<.0001

The model fit statistics show that the model (compared to the reduced model above and an intercept only model) is a good fit. The global test for the null hypothesis that all the Betas and Gammas are zero also shows that the model fits well. The covariance matrix for model(2) is given in Appendix I.

Both specifications of the mixed model show good explanatory power from the Wald test (Fox, 2002), suggesting that the variables are aggregately reasonable predictors of the dependent variable, *insure*. The benefit of model(2) is that it allows us to look at respondents reactions to specific elements of the scenarios. The two fit models are comparable since the difference in AIC and SC values are negligible. Using the AIC criteria, Model(1) is a better model than Model(2), while using the SC criteria, Model(2) is better.

Discussion of the error rates, accuracy, specificity, and sensitivity for the two models is presented using three different cut-off points in Table I.10.

9.6 Gambling behaviour–data, model, and results

In this section we review the data distribution associated with respondents' choices in the gambling exercise. We compare it to observed propensity to insure in the scenarios. Finally, we develop an ordered logit model for gambling behaviour using the (time-invariant) variables applied to the choice to insure.

9.6.1 Data–gambling behaviour

The gambling exercise is the final section of the online exercise, in which we ask respondents to choose a gamble, the outcome of which decides their final payout (USD) for participation. The frequency distribution of respondents' gambling choices are given in Table 9.15. Almost 75% of the total sample elected the option of receiving the value of the chosen scenario outcome (in USD) with certainty. 19.3% of the total sample took the option of 50% chance of doubling outcome and 5.6% chose the 10% chance of obtaining ten times the outcome.

Table 9.15 Frequency distribution of gambling choices

Gambling Option (*Gambling* value)		Total Sample *Frequency (Percent)*	Unaffected by Sandy *Frequency (Percent)*	Affected by Sandy *Frequency (Percent)*
100 % certainty	(1)	597 (74.6)	112 (78.32)	485 (74.27)
50 % chance of doubling scenario outcome	(2)	154 (19.3)	24 (16.78)	130 (19.91)
10 % chance of ten times scenario outcome	(3)	45 (5.6)	7 (4.90)	38 (5.82)

We included the gambling exercise in order to compare preferences for a question framed as a gamble to those of questions specifically expressed as a choice to insure. In short, we find that on the aggregate level, that risk aversion in one instance does not adequately reflect it in the other. When we correlate respondents' gambling choice with the total number of insurance purchases in the simulation the result is 0.025 ($p<0.01$). In order to ensure that it is indeed the case that gambling choices do not relate to insurance choices, we examined the correlations for within respondents for all scenarios in the flood simulation. The correlation between the chosen gambling option and in the first scenario of the simulation is 0.022 (p<0.01) and in the final (10th) scenario of the simulation it is 0.013 (p<0.01). We also look at the binary decision to take a gamble opposed to a sure pay-out versus the choice to insure in each scenario across respondents, which yields no significant effect; see Table I.11. Furthermore, there is no significant correlation between gambling and: 1. the total number of times one insures (corr=0.023, p=0.57); 2. total number of floods experienced in the simulation (corr=0.083, p=0.36); and 3. propensity to insure in the period following uninsured scenario outcomes (corr=0.045, p=0.57).

9.6.2 Regression–gambling behaviour

As discussed previously, some studies extrapolate expected insuring behaviour from stated preference responses to questions structured as a gamble (e.g., Page et al., 2014). In our study we apply the time-invariant variables from our insure model to a multinomial logit model for gambling. This allows us to obtain a better understand as to whether gambling decisions and decisions to insure have common significant factor motivations.

In this model, we use *gambling* as the response variable. We treat the categories for gambling (0-2) as nominal.[358] A complication to the gambling exercise is that the respondent must choose the type of gamble without knowing to which flood scenario outcome it will apply. Given that the spread of scenario outcomes is highly heterogeneous between respondents,[359] which may disrupt the ordinal nature of the choice to gamble, we employ a logistic regression structure that treats the three possible gambling choice categories as nominal.

This model assumes the response variable has three categories, such that the probability of being in category 1 given a set of predictors $X_1,\ldots X_k$ is given by $\pi_1(X_i) = P(Y = 1)$. Likewise the probability of being in category 2 given a set of predictors $X_1,\ldots X_k$ is given by $\pi_2(X_i) = P(Y = 2)$ and $\pi_3(X_i) = P(Y = 3)$ and $\pi_1 + \pi_2 + \pi_3 = 1$.

Using category 1 as a reference cell, the model form is given as:

$$\log\left(\frac{\pi_2(X_i)}{\pi_1(X_i)}\right) = \alpha_1 + \beta_1 X_i \text{ and } \log\left(\frac{\pi_3(X_i)}{\pi_1(X_i)}\right) = \alpha_2 + \beta_2 X_i\ . \quad (9.9)$$

The estimated probabilities of being in a given gambling category are given by the following:

$$\pi_2 = \frac{\exp(\alpha_1+\beta_1 X)}{1+\exp(\alpha_1+\beta_1 X)} \quad (9.10)$$

$$\pi_3 = \frac{\exp(\alpha_2+\beta_2 X)}{1+\exp(\alpha_2+\beta_2 X)} \quad (9.11)$$

$$\pi_1 = 1 - \pi_2 - \pi_3 \quad (9.12)$$

The estimated coefficients with their corresponding standard errors for the full model are given in Table 9.16. A reduced model specification is given in Table 9.17.

[358] Treating them as nominal made no significant difference in the model outcomes.

[359] In some cases, the compound risk of obtaining a zero payout caused by a relatively high number of scenario outcomes with zero Lab$ made choosing a high-risk gamble relatively more rational.

Table 9.16 Parameter estimates for gambling behaviour (full model)

Gambling	Parameter	Level	Estimate	SE	Chi	P-Value
1 vs. 2	Intercept		-1.03	1.21	0.72	0.396
	age		-0.20	0.19	1.06	0.302
	education		0.10	0.06	3.06	0.080
	damage_perc		-0.02	0.01	8.11	0.004
	impactRnk	1	0.34	1.11	0.09	0.762
	impactRnk	2	0.03	1.12	0.00	0.976
	impactRnk	3	0.30	1.22	0.06	0.807
	income		0.00	0.02	0.03	0.866
	kids		0.04	0.09	0.24	0.625
	worry_index		0.01	0.00	2.05	0.153
	risk_fin		-0.13	0.08	2.78	0.096
	tables	1	0.14	0.25	0.30	0.584
1 vs. 3	Intercept		-0.27	1.36	0.04	0.842
	age		-0.29	0.32	0.81	0.370
	education		-0.02	0.10	0.04	0.843
	damage_perc		-0.02	0.01	3.91	0.050
	impactRnk	1	-0.93	1.13	0.68	0.410
	impactRnk	2	-1.24	1.13	1.19	0.275
	impactRnk	3	-1.36	1.51	0.81	0.369
	income		-0.02	0.03	0.36	0.547
	kids		0.05	0.15	0.13	0.714
	worry_index		0.00	0.01	0.00	0.953
	risk_fin		-0.04	0.13	0.09	0.759
	tables	1	0.10	0.41	0.06	0.801
Model fit statistics						
AIC= 1127.32	*SC=1239.63*	*-2LogL =1079.32*	*Pseudo R-Square 0.0354*	*N=800*		

Table 9.17 Odds ratio estimated and confidence intervals for gambling behaviour (reduced model)

Gambling	*Odds Ratio Estimates*	*Estimate*	*95%*	*95%*
1 Vs 2	damage_perc	0.98	0.97	0.99
	education	1.12	1.00	1.26
	kids	1.05	0.89	1.25
	worry_index	1.01	1.00	1.02
	risk_fin	0.88	0.76	1.02
1 Vs 3	damage_perc	0.98	0.96	1.00
	education	0.97	0.80	1.17
	kids	1.06	0.79	1.40
	worry_index	1.00	0.99	1.02
	risk_fin	0.95	0.74	1.23

Estimated probabilities for each level of gambling using the average and median characteristics for relevant variables across sample respondents are given in Appendix I.

The main motivation for developing the regressions related to gambling choice was to compare relative motivations to gamble to those identified as significant for insuring. The fit of these models is rather poor; for example, the indicated McFadden's (1974) pseudo R-squared values indicate that the models explain very little variation in the data. We do find that damage to the house from Sandy appears to have a significant weak negative relationship to the choice to engage in a relatively more risky gamble. *Damage_perc* is a significant factor in insuring; in the same direction – an increase in age indicates lower likelihood of insuring. However, aside from education being positively associated with a change from taking no gamble to the moderate gamble, there are no other significant factors indicated. Somewhat surprisingly, we find that variables related to risk aversion (e.g., *worry_index* and *risk_fin*) and demographic factors are largely not significant to the gambling choice, as gambling is explicitly a risky prospect.

These findings suggest that linking insuring behaviour by proxy from gambling behaviour (i.e., choice over risky prospects) needs to be re-considered and further tested.

9.7 Discussion

We return to the four research questions introduced in Section 3 to frame this discussion. By aiming our online task at respondents affected by Sandy in addition to a control group, we are able to contribute to the developing literature on experiments ex-post a flood disaster and subsequent risk perception and insurance behaviour. We discuss each in turn.

9.7.1 Research Question 1[360]

Self-reported probability of experiencing 'disaster events,' such as terrorism or a car accident as captured by *worry_index* significantly increases ($p<0.001$) the odds ratio of an individual purchasing insurance in a given insurance scenario. There is not a significant correlation between any metric of risk perception and numeracy or education in our sample. Additionally, there is a significant, but weak negative effect of -0.120 ($p<0.01$) of *worry_index* on the desire to adopt affordable flood insurance in real life in the future. This indicates that the effect of risk perception and the desire for insurance likely arise from different impetuses, which is in agreement with arguments that risk perception can be high without adoption of accompanying mitigating methods, such as insurance (e.g., Beck, 1992).

Those identifying as more 'careful with finances' are more likely to adopt insurance in a given scenario, *ceteris paribus*. There is no significant correlation between financial responsibility and risk perception; those who are more financially responsible do not tend to rate risk probabilities higher than less financially responsible parties. To this point, the effect of *risk_fin* on the probability to *insure* in a given scenario is distinct from perception of risk. For those who are more financially conservative, it may be that they are more strongly influenced by budgeting heuristics than are others. They may also experience a stronger feeling from the loss of money (or foregone gains) than those who are less used to financial planning and are willing to buy insurance to avoid losses if there is any financial loss at stake. In this case, they could be affected by temporal planning bias with regards to trying to save as much from being lost as possible through investing in insurance in the present period.

The desire to adopt affordable home flood insurance for their household had a notably high impact on the probability that one would adopt insurance in a given scenario.

[360] How is the purchase of flood insurance affected by an individual's attitudes regarding insurance and risk, controlling for socio-economic and demographic factors?

Previously holding flood insurance (ex-ante Sandy) in real life somewhat surprisingly did not have a significant effect on *insure*. However, this may indicate that respondents consider each scenario based upon the given parameters. Furthermore, in many cases holding flood insurance may be related to risk perception of home flooding and personal risk aversion based on the reality of not only losing money, but also experiencing the loss of personal valuables and the effort of clean-up in real life.

It is possible that not requiring a deductible in the simulation, led respondents (who did not calculate the 15% loading) to think that the insurance offers were affordable (e.g., actuarially fair). As noted previously, the desire for affordable flood insurance actually had a weak negative correlation with those affected by Sandy (-0.178, p<0.01). Thus, it seems that those expressing a desire for such insurance may like the 'feeling of insurance' or genuinely feel that flood insurance coverage is currently unaffordable for them. Related to Kunreuther's (2009) finding that positive experiences of state support ex-post a flood event may entice individuals away from adopting flood insurance, it is possible that those who have benefited from the state after Sandy may genuinely be less inclined towards insurance, regardless of affordability.[361]

Throughout the simulation it appears that expressed attitudes and perceptions have an influence on the decision to insure in each scenario, while it seems that actual reported financial losses from Hurricane Sandy are somewhat of a moot point regarding respondents' insurance decisions in the simulation. It could be argued that Hurricane Sandy was temporally distant when the simulation activity took place; however, the majority of respondents affected were still dealing with insurance claims from Hurricane Sandy at the time they took part in the simulation and we asked respondents to recall Hurricane Sandy and think about flooding throughout the task.

Overall, we find that expressed desires for future behaviours and related attitudes are significant factors in the Insure model. In contrast there is a notable lack of significance from variables related to past actual (i.e., real life) behaviours. This difference in influence is likely related to the fact that expressed preferences often do not carry forward to actualised behaviours. Furthermore, in many models of behaviour (e.g., Triandis, 1979), it is actually expressed preferences as opposed to actualised behaviour that is measured.

We claim that expressed attitudes and perceptions appear to have a significant influence on insuring behaviour, while past experiences (e.g., flooding from Sandy) appear to make no significant impact. We note that, theoretically, it is unclear whether past experiences could in fact affect insurance choices via the attitudes that they shape. We do our best to control for this fact through inclusion of a number of socio-economic and demographic variables in the regression model. Furthermore, we ran a series of correlations between variables that account for attitudinal/perceptual factors and socio-economic/demographic variables. In the majority of cases, there is no significant relationship; in the cases where there is a significant relationship, it is rather weak–though there may be some relationship, it does not appear that past experiences directly shape attitudes. For example, we find only a very weak, significant

[361] At the time this research was carried out we asked respondents to indicate if they had received support from FEMA; as it was relatively soon after the event the number that has received such support was less than 10% and there was no statistically significant difference between those households and others in the sample regarding simulation play or expressed desire for insurance. It would be of interest to follow-up with households at a later stage to see which have obtained further support from FEMA as additional supports were rolled out in the two years following Sandy.

(corr=0.120; p<0.05) relationship between experiencing loss in Hurricane Sandy and a positive attitude towards flood insurance/expressed desire for insurance. Furthermore, there is a negative relationship between one's subjective (estimated) probability of flood for house and home insurance holdings (corr=-0.168; p<0.05).

Though we are primarily interested in the effects of attitudes on insurance purchases, it is worth noting the relevant impact of demographic indicators as well. Of the demographic factors considered in our Insure model, age and education had a significant impact in the insurance behaviour observed in the simulation.

We note that there is a weak correlation between age and risk perception for flood, 0.115 (p<0.01) and furthermore, the correlation between age and numeracy is 0.090 (p<0.01). This follows typical findings in the literature (Lazo et al., 2000). This finding may be an artefact of the fact that those who are older have lived in the same area for longer and also have memories of whether a flood has taken place; the availability of personal experience with flooding is greater.[362]

Our findings fall within the group of studies that report ambiguous findings related to gender and its influence on insurance (e.g., Schubert et al. 1999); we find no significant correlation between gender and perceived flood risk. This may be related to the fact that the purchase of flood insurance is a household decision and about 62% of our total sample lives in a household with at least one other individual. Thus, regardless of gender, respondents appear to consider the experimental task on the household level. There has been much written on the impact of age and gender on risk perception, but not necessarily specific to the uptake of flood insurance.

The positive relationship found between the number of children (household size) and insuring is potentially related to budgeting heuristics. The variation probably comes from the need to spend money on other aspects in daily life when family size is larger. When we look at the relationship between household size (i.e., *kids*) and insurance uptake in real life, there is no significant correlation. Furthermore, household size shows no correlation with risk perception for probability of home flood; however, the correlation between our index of risk perception and number of children is 0.115 (p<0.01).[363]

9.7.2 Research Question 2[364]

There are studies that suggest that in the period immediately following a flood event there is a temporary increase in insurance purchases (e.g., Bin & Polasky, 2004; Kunreuther & Pauly, 2004). Our finding is such that the outcome of the previous flood scenario is not enough to significantly influence the probability that insurance will be purchased in the current scenario. We structured the model to follow findings that insurance demand tends to drop back to past levels over time (e.g., Gallagher, 2014b). In the experimental realm, our finding is consistent

[362] This argument is supported by the fact that the correlation between respondent age and years residing in one's current dwelling is 0.333 (p<0.01).

[363] This may be connected to the finite pool of risk theory in the sense that once one has children, one shifts concern towards risks that relate directly to human well-being in their mind, such as terrorism or traffic accidents.

[364] How is the purchase of insurance affected by the occurrence of an extreme weather (i.e., flood) event in the previous period?

with Meyer's (2012) finding of self-extinguishing mitigation investments–the more time that elapses without experiencing the harm against which the investment protects, the more difficult it becomes for the individual to observe its benefits.

Though our flood simulation offers a good approximation of a real life flood insurance market, we must remember that it takes place in a matter of minutes, whereas real-life flood insurance purchases (and renewals) occur (bi-)annually. At the extremes, approximately 15% of respondents adopt insurance in every scenario and about 9% adopt it in no scenario. We account for the cumulative number of times a respondent opts for flood insurance coverage in our model of insurance behaviour, which is not significant. Holding constant other factors, the positive relationship found between expected loss in a scenario and probability of insurance purchase suggests that respondents are paying attention to the context within which they decide to insure against flood. This finding supports past suggestions that individuals may insure less against lower-probability events (e.g., Slovic et al., 1977). We do note that the probabilities presented in the simulation are much greater than those faced in actuality for home flooding by the average respondent. Furthermore, there is an inherent limitation in the fact that we provide exact measures of probability and impact magnitudes to respondents, which is generally not the case in real life flood insurance markets. Yet, in studies where probabilities are not given, but rather learned (e.g., Zahn & Neuß, 2012), there has not been the scope to obtain the attitudinal and demographic data we collect because of the large amount of time needed for the number of scenarios required.

Since there is not an accumulated bankroll throughout our flood simulation (i.e., the respondent starts each scenario with a new and equal endowment), we do not need to control for a possible substitution effect (e.g., no insurance purchase) after a tail event due to a perceived financial burden. Taken in isolation, there is not a strong correlation between the number of floods encountered by an individual and the number of times that individual purchases insurance; it is 0.0063 ($p<0.05$). Thus, individuals seem to be highly heterogeneous in their motivations for insurance coverage, both in the simulation and real life. For example, there is no significant correlation between those affected by Hurricane Sandy and the total number of scenarios within which the respondent purchases insurance in the simulation.

9.7.3 Research Question 3[365]

When we look at the behavioural patterns of the sample cohort assigned to the treatment group exposed to the table presentation there is a significant difference. There is a rich literature on the effects of data presentation, but little has been directly applied to studies of insurance uptake, especially with regards to flood insurance uptake. Some interactive experimental studies (e.g., Meyer, 2012) use graphical interfaces in order to simulate storm-like conditions or to provide simulated radar, as to give an impression of storm severity. In the case of the Meyer (2012) simulation there was no control group that did not experience the simulation; thus, the effect is unclear. We opted for a basic quadrant-based table presentation of expected loss related to potential combinations of insurance adoption and flood occurrence. We used this design in order to make the presentation as understandable and straightforward as possible to those in the treatment group. This design follows from similar numeric descriptions in past

[365] How does the presentation of data related to a potential extreme weather event affect the purchase of insurance?

studies of effects of graphical displays on risky decisions (e.g., Hertwig et al., 2004) and was aimed at insuring. We did not confound the treatment by using a complex presentation that may have encompassed unexpected underlying factors.

The direct effect of visualisation (via the table treatment) is significant and positive in our model for *insure*; those in the treatment group are more likely to take up insurance in a given scenario, *ceteris paribus*. This finding is in agreement with studies which note that detailed numerical descriptions of potential outcomes yield less risk-seeking behaviour (e.g., Hertwig et al., 2004). In our case less risk-seeking behaviour involves purchasing insurance, which has a greater outcome in all scenarios in comparison to the most risky outcome, flood occurrence without insurance cover.

It is worth noting that the probabilities we chose for the simulation were much higher than current expected flood probabilities facing the majority of homes in reality. Yet, this should have no effect on the findings related to the table treatment. Rather, it would be expected that given humans' bounded ability to interpret and act upon low magnitude probabilities, the results of our table treatment would be more pronounced if applied to lower probabilities.

We also ensured that the treatment and control group cohort of respondents came from the same population via the Rank Sum test and the Krusal Wallis test; in both tests the null hypothesis was rejected (p<0.01). In addition, we tested the interaction between education and use of tables to determine whether the effect was more pronounced depending on educational background, but found that the effect of the table presentation was uniform across educational attainment levels.

9.7.4 Research Question 4[366]

In our dataset, choices in the gambling exercise do not accord well with insurance decisions throughout the flood simulation. This finding calls into question past research which draw parallels between gambling choices and potential future insurance behaviour. The most straightforward manner by which to explore this claim is through exploratory correlations between insurance purchase behaviour in the simulation and respondents' choice of a final gamble. The correlation between *gamble* and the total number of insurance purchases in the simulation is found to be 0.025 (p<0.01). The correlation between *gamble* and insurance behaviour in the first scenario of the simulation is 0.022 (p<0.01). The correlation between *gamble* and insurance purchase in the final (10th) scenario of the simulation is 0.013 (p<0.01). When we look at insuring in each scenario in relationship to gamble as a binary choice between *gambling* at all or taking the sure-thing pay-out, we see no significant correlations.

Furthermore, there is relatively little overlap in significant explanatory variables in the model developed for *gamble* that uses the time-invariant variables from *insure*. Neither response variable is highly correlated with individuals' self-described financial risk taking or individual risk perception for various potential hazards (e.g., car accident). Though it is of low magnitude, we do observe a significant negative relationship between the monetary value of damage to one's

[366] Do individuals' choices in questions framed as a gamble provide an appropriate proxy for individuals' insurance purchase behaviour?

home and the likelihood of taking a gamble with higher stakes, which is in agreement with findings of Cassar et al. (2011) and Cameron & Shah (2015), but in opposition to the findings of Page et al. (2014) and Eckel et al. (2009).

Both Page et al. (2014) and Eckel et al. (2009) report that direct experience with flooding decreases risk aversion in comparison with a control group comprised of less affected and unaffected households (i.e., individuals are more likely to take a risky gamble if they have experienced losses from flooding recently). These studies were both conducted in-person within a few weeks of a major flood and are relatively small-n studies in comparison to our study. Studies that have claimed to use the setting of a natural experiment after a major flood (e.g., Eckel et al., 2009; Page et al., 2014) have done so based on questioning the viability of using measurements of risk attitudes on small stakes to credibly predict risky behaviour for large stakes.

Our findings agree more with those of Cameron & Shah (2015), such that there is a negative effect between the percent of damage to one's home from Hurricane Sandy flooding and gambling. It is possible that there is some background risk related to experiencing greater levels of damage from Sandy. In some cases, background risk has been demonstrated to induce greater risk aversion (e.g., Gollier & Pratt, 1996; Guiso & Paiella, 2008).

Though the outcome of the simulation scenarios in our study are related to the final payout, the gamble is clearly directly related to a bonus pay-out on top of the participation stipend; it is a tangible payout. The gamble is relatively high stakes, making it comparable to the approach taken by Page et al. (2014). Yet, we note that Page et al. (2014) do not take account of information such as risk estimations in realms other than flood or pre-existent insurance holdings.

Our gamble is between a certain option and two uncertain ones, in the sense that it introduces ambiguity since the respondent does not know which scenario outcome will be chosen ahead of indicating the gambling choice. Ambiguity aversion differs between the positive and negative realms (Einhorn & Hogarth, 1986). Individuals are ambiguity averse in gains and ambiguity seeking in losses (Wakker, 2010), which agrees with our findings.

There are also potential framing effects, which support our findings around this hypothesis. In our insurance simulation, respondents were likely guarding against hypothetical reductions (i.e., loss) in their endowment in each scenario. Yet, in the gambling exercise, the potential reward was a real payout and framed as a gain. When gambles are framed as losses, individuals appear to be risk loving, while when gambles are framed as gains, individuals behave as if risk averse. The phenomenon of being risk loving over losses and risk averse over gains is pervasive (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992; Currim & Sarin, 1989).

9.8 Summary and Conclusions

Notably, there is little difference in insurance demand in the flood simulation between cohorts that are affected and unaffected by Hurricane Sandy. Furthermore, controlling for losses from Hurricane Sandy, we see that it is not insurance holdings in real life, but rather attitudes towards risk and flood insurance that are significant to the decision to insure throughout the simulation. These findings hint that individuals have underlying predispositions to insurance and risks, across various contexts (including flooding), which ultimately trump other factors in the decision to purchase flood insurance.

In order to encourage purchase of (appropriate levels) of flood insurance for households most sensitive to flooding, attention may be best aimed towards motivating change in these predispositions in attitudes. To some extent our table treatment, wherein we provide a cohort of our sample with more details about the flood scenarios, is an example of such an effort. There is a notable positive effect on insurance purchases associated with viewing risks and expected loss in the form of a table. In future research it would be ideal to conduct a within-subject experiment which gauges if an individual's perception of expected loss and insurance purchases change when presented with a table specification versus not. Furthermore, piloting insurance policy materials that express risk and uncertainty in a graphic and explicit format would be relatively inexpensive and largely informative.

In some instances, it is important that those most exposed to flooding are insured, especially as the effects of such events are predicted to be more costly and intense in the future. Notably, almost 10% of respondents in our sample, across cohorts of those affected and unaffected by Sandy were predisposed to never insure throughout the flood simulation.

Some may contend that preferences are indeed preferences, regardless of the risk faced; however, when private homeowners fail to insure against flood, it is the state that generally shoulders this burden after the fact (Botzen, 2012; FEMA & RAMPP, 2013). We also noted previously that throughout a number of developed countries, in Europe in particular, flood insurance is mandatory (e.g., Bouwer et al., 2007; Klein & Wang, 2009). Immediately following such an event, the affected community and the constituent individuals must cope in the immediate term. In the developed world insurance is one of the main means of coping and rebuilding in particular. Yet, coping capacity can only be maintained over time and through a series of extreme weather events if those most affected by these events (presumably the most statistically at risk) are largely insured.

More research is required to understand the factors leading to bounded rationality that culminates in one choosing to never insure; the literature shows limited understanding of this attitude towards flood insurance. This may be related to the same reason some individuals enjoy the *feeling of insurance*, thus over-insuring in some cases. Overconfidence and optimism bias is an example of one potential contributor (Weinstein & Klein, 1996; Shepperd et al., 2002).[367] There are a significant number of those affected by Hurricane Sandy who chose to never insure in the simulation. People are known to have trouble treating outcomes of disparate events as such, though some studies (e.g., Kunreuther & Michel-Kerjan, 2009) indicate that those affected by flooding sometimes imagine that their recent experience with flooding actually reduces their chances for flooding in a disparate period in the future.

In such circumstances, especially when one lives in an area prone to flooding, there may be a case for stronger legal requirements for flood insurance adoption from government and a re-working of how federal food insurance cover is determined and executed. Requirement that individuals who opt to not insure against flooding, but live in a high-risk area would

[367] We do include two standard metrics associated with optimism bias in our survey tool with regards to house flooding, namely individuals' self-perceived absolute risk (e.g., Gouveia & Clarke 2001) and comparative risk (e.g., Helweg-Larsen & Shepperd, 2001)

simultaneously address issues of: 1. irrational underinsuring, 2. ease the burden of private insurers in the face of potential more frequent and intense flooding from extreme weather, and 3. save the large-scale emergency spending to help those who are not insured after flooding from extreme weather.

Critics note that the NFIP may not execute its mandate effectively or to all parties' best interests (e.g., Best, 2005). For example, the NFIP faced a major financial crisis following the storm surge and flooding from Hurricane Katrina in 2005, needing to borrow over $20 billion from the USA Treasury. Although the NFIP is required to analyse and map the level of flood risk in different areas, including designating 100-year floodplains or zones, the evidence indicates that they inaccurately mapped some flood areas, which subsequently may contribute to consumers' decision to under insure.[368] Furthermore, this poor information makes it difficult for individual communities to adopt (and enforce) a floodplain management ordinance to reduce future flood in Special Flood Hazard Areas (SFHA), which is required for households to obtain the federally-offered flood insurance available within the community.

One caveat in our research is that the sample was relatively well-to-do, measured by household income. In reality, 43% of the 518,000 households in New York and New Jersey asking for federal aid (i.e., FEMA claims) after Hurricane Sandy reported annual (gross) incomes of less than 30,000 USD (ECP, 2013). As many of these households are still waiting for claims to be approved, it is likely that they have less ability to be reached online; therefore, they were underrepresented in the group from which our sample was drawn. Yet, it follows that a relatively similar percent of those in a lower income bracket would opt to not insure (as this percent was relatively consistent between all cohorts of our sample). Furthermore, we expect that budget constraints and learned dependence on federal aid would yield an even greater relative percent opting to never insure.

Many well-known models of behaviour (e.g., Fishbein et al., 2001) do not trace actualised behaviour, but, rather, stop at the intention phase. In our study we are able to trace behaviour throughout the simulation, but with regards to real-life flood insurance behaviour, it would be ideal to see if our sample engages with flood insurance for their home in the period following Hurricane Sandy. Furthermore, it would be ideal to have better objective flood risk measures for our sample with which to compare self-reported/perceived absolute and comparative flood risks.

Additionally, our flood simulation, though reflective of the market, is nonetheless conceptualised as a simulation by our sample. In particular, we do not deal with deductibles in the scenarios. Furthermore, the probabilities of potential flood damage are relatively high compared to the flood plains on which respondents live in real life; however, they are comparable to those used in studies on home flood preparedness (e.g., Meyer, 2012).[369] Subsequently, some behaviour over the series of scenarios may be reflective of game play, as

[368] The *Biggert-Waters Flood Insurance Reform Act of 2012* called for FEMA to make changes to the NFIP in response to such criticisms. A key provision is the requirement that NFIP rates must reflect true flood risk and improve floodplain maps. Over time there are plans to increase the mean premium rate for most policyholders, but this has not started as of November 2015.

[369] For example, in the Meyer (2012, 34) lab simulation "the 10 to 14 storms witnessed by participants, slightly more than half (52%) came close enough to threaten damage sufficient to make investments in mitigation worthwhile."

opposed to what would occur in the actual insurance market and with real life stimuli associated with experiencing home flooding.

In future research it would be ideal to address household decisions regarding not only insurance, but additional combinations of insurance and alternative risk reduction (e.g., retrofit of homes) options. Ideally, such a study would be repeated and extended in future work, specifically with regards to obtaining more detailed qualitative data on individuals' underlying thought processes and potential use of heuristics. For example, there is the scope to extend this online structure to ask participants about their emotions[370] throughout the simulations and to determine the extent to which changes between holding insurance and not in subsequent scenarios is associated with emotions,[371] controlling for real-life flood risk.

As weather-related covariate risks, namely in the form of home flooding, increase in the future, households need insurance that conforms to individuals' preferences and also helps in the formation of perceived risks that better match objective flood risks. Our online tool does offer an improvement and extension of studies that address insurance decisions of a sample recently affected by extreme flooding. Furthermore, we address a relatively representative large-N sample and highlight the importance of considering attitudinal factors in addition to demographics. Though it was not our main motivation, we do find evidence that assessment of potential insurance behaviour through extrapolation from gamble choices may not be appropriate.

[370] For example, in line with affect related to insuring as noted in the concept of feeling of insurance discussed in the Ugandan Basic dice game work.

[371] Kunreuther & Pauly (2015) look at a simulation over ten flood scenarios with attention to their adherence to expected utility maximization as well as potential impact of emotions, as reported by respondents following the outcome of each scenario. This type of research and my own work on this topic was discussed with Prof. Howard Kunreuther in June 2014 and April 2015.

10 Findings and conclusions

10.1 Introduction

As weather-related covariate risks intensify in the future, households need coping mechanisms that are viable at the nexus of coverage, cost[372], and affordability. These mechanisms should also address other factors/preferences that make them desirable tools to sub-sets of households that may benefit the most from their use. Additionally, it is important to understand how these coping mechanisms serve as complements or substitutes. In this thesis we focus on the demand for household-level (micro)insurance in both the developing and developed country context through the use of two case studies. The first is a study of weather index-based microinsurance in two rural Ugandan districts, Oyam and Kapchorwa. The second is an online survey tool employed in the wake of Hurricane Sandy to compare risk aversion between those affected and those not affected by the event in the Northeast USA.

The case studies are differentiated by context and underlying policy environments; however, the same general conceptual framework is applicable, which is focused on four factor-classes that affect demand for insurance against extreme weather: 1. economic, 2. social and cultural, 3. structural, and 4. personal and demographic factors. Within the application of this framework we address factors related to intended behaviour to insure (e.g., System I and System II thinking).

In this chapter we summarise case study findings and compare and contrast the two cases. Methodological and new knowledge contributions are noted, as well as potential policy implications of the research. In Section 2 we review findings related to the large-N Ugandan survey tool. In Section 3 we review findings from the *Complex Dice* game, which looks at responses to basis risk in potential index-based insurance adoption. Findings from the large-N Hurricane Sandy online tool are reviewed in Section 4. Section 5 summarises cross-case-study findings. Section 6 concludes by noting limitations to this research and potential extensions in the future.

10.2 Developing country study findings (Large-N Ugandan survey)

In our Ugandan case study, we combine a large-N survey administered by a mobile phone application with field games to obtain data on the relative demand for microinsurance in view of the debate as to whether there is poor demand for microinsurance tools in real life. We use the results to better understand demand for agricultural microinsurance, how it relates to preferences over traditional coping mechanisms, and how it relates to risk attitudes within a rich set of household characteristics. Additionally, we conduct a detailed field game that gauges reactions to basis risk in a hypothetical index-based agricultural microinsurance tool.

10.2.1 Demand for microinsurance and loans compared to other coping strategies

In the Ugandan case, WTJ the agricultural microinsurance scheme is over 95% and the average WTP is moderate relative to household wealth with a spread across all intervals, with maximums

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[372] Cost here is considered the direct and indirect costs to the providing entity or institution; for example: net-providers of remittances, insurance companies, and banks providing loans.

at 500-1,000UGX for Oyam and 1,000-5,000UGX for Kapchorwa. We find similar demand schedules for WTP for a loan covering the same loss, indicating that the two are implicitly perfect substitutes in respondent utility for our sample.

Our survey results suggest that selling livestock is by far the most frequently chosen traditional coping strategy; this runs counter to some previous studies that indicate that the sale of livestock plays a minor role in coping with extreme weather (e.g., Fafchamps & Gavian, 1996; Kazianga & Urdy, 2006). We find that strategies involving reducing current consumption or augmenting it by borrowing/begging[373] would be used fairly infrequently. Our results support the argument that livestock are held as a form of liquid savings (e.g., Dercon, 1998). This finding demonstrates that assessment of the backdrop of coping strategies available and preferred by a community is important in the planning for the introduction of new (formal) coping strategies, e.g. microinsurance.

The WTP distributions for microinsurance and loans are relatively similar and follow the same pattern relative to the traditional coping strategies employed by a household in both regions. Uniformly we see slightly lower WTP for a loan than WTP for microinsurance across households employing each of the available coping strategies. This may be explained by the fact that taking loans[374] is often regarded as a relatively negative experience by our sample, making it less appealing to engage, especially in the event that microinsurance may be available in the market.

Net-providers of remittances have a statistically significant higher WTP for microinsurance opposed to net-receivers. This is also the case for WTP for loans. Greater knowledge of the interaction of the relative trade-offs between the use of microinsurance- and loan-related tools may demonstrate the usefulness of marketing to net-providers.

As expected, the number of loans taken in the prior year for farming is positive and significant to WTP for loans, whereas the demand for microinsurance is only significant and positively associated with those taking one loan in the past year. We take this to indicate that those who have taken a loan demonstrate the need for formal financial assistance following extreme weather, but would be open to the use of microinsurance instead. On the other hand, those taking multiple loans per year may have a preference for loans over microinsurance if given the choice.[375]

Microinsurance and loans may act as substitutes; however, analysis of the motivating factors for WTP for the use of each tool (separately) to cover the same loss indicates that the underlying motivation is quite different.

10.2.2 Determinants of WTP for microinsurance and loans

Using the large-N survey tool we were able to obtain information in a single study over a number of factors that have been shown to affect demand for microinsurance in previous synthesis studies of the literature (Cole et al., 2012; Eling et al., 2014).[376] In assessing demand for

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[373] Some literature differentiates between borrowing (from neighbours) and begging (WHO, 1999).

[374]This appears to be especially true in the case of taking loans from local moneylenders and banks.

[375] Here we refer to the fact that microinsurance requires payment and planning ahead of a potential extreme weather event, while the use of loans can be organized entirely ex-post extreme weather (assuming that the household is eligible).

[376] To clarify, in the studies reviewed in the syntheses look at individual WTP and demand studies that each review only a handful of factors noted in our conceptual framework.

microinsurance we see that in relative terms social/cultural and structural factors tend to be more significant in the model than are economic or personal/demographic factors to WTP levels.[377] We review some key findings here that may be especially relevant to the application of index-based microinsurance in Uganda, but more generally provides information about factors to be considered in scoping projects in markets new to microinsurance.

Some demographic factors are significant to WTP for microinsurance. As is the case in other models, both age and education have a positive significant relationship to WTP.

At greater levels of risk aversion, WTP for microinsurance is likely to be higher; however, it is worth noting that the magnitude of effect peaks at a CRRA 0.1-1.3. This may indicate that microinsurance is of greatest interest for households at a certain level of risk aversion, but for the most risk averse, preference is for tried and true coping strategies due to some level of risk being associated with the use of microinsurance. This is in general agreement with the probit model specific to selling livestock—the likelihood of selling livestock is significantly positively associated with risk aversion—and for our sample this is a frequently chosen coping strategy.

The manner in which respondents store and sell their crops on the market has an effect on the WTP for microinsurance. Those in the categories that saved and received the same market price or lost money on the market are more likely to have a higher WTP value—the magnitude is similar for the two cases. This makes sense and is important in view of the fact that a number of crops grown in the two regions pose major storage issues.[378] In the formulation of microinsurance tools this finding should be noted such that those crops that are most difficult to store and sell later be addressed first in such tools.

Knowledge of insurance ahead of the survey makes a difference. Somewhat surprisingly, those with no personal knowledge/experience with insurance, but with friends with knowledge/experience, were more likely to have higher WTP compared with the case in which one had personal knowledge, but no friends with knowledge. We also see a rather high propensity for respondents to change their minds about farming decisions after discussing with others. Thus, in the development and marketing of microinsurance it is important to consider social networks of knowledge-sharing. Yet, though respondents may take peers' decisions into account, it is important to acknowledge that the sample is largely in favour of individual-level microinsurance, opposed to group policies.

We find that relative to trust in businessmen, those indicating greater trust in (government) bureaucrats are significantly less likely to invest in microinsurance. This finding is in agreement with studies that highlight the importance of trust in willingness to engage in microinsurance. Specifically, this finding is rational within the knowledge we have of trust issues within farming decisions in the context of this case study–it makes sense that those trusting businessmen would be willing to engage in microinsurance as a *business transaction*. In the development of microinsurance tools, especially subsidised by the government, it is important to consider not

[377] This is a generalisation and in the model for WTP for microinsurance elements in all four factor classes are found to be significant. Those in the factor classes of social and cultural and structural were more frequently found to be significant.

[378] For example, groundnuts and grains tend to last longer than fruits; thus, making fruits perhaps a good crop group to focus microinsurance tools around initially. Responses about storage and selling maps almost directly to the type of crops grown by respondents.

only that trust in the product is important, but that pre-existing trust in the provider may have an effect.

It is especially important to note some of the factors that were not found to be significant in the model of WTP for microinsurance. In particular, the household's percent of income from farming is not significant, which is surprising as those with a higher percentage (i.e. less income diversification) would be more vulnerable to extreme weather. Our baseline level of concern (i.e. worry) is also not significant in the model. Yet, affect associated with the feeling of being insured is positively and significantly associated with WTP for microinsurance. Thus again, in creating microinsurance tools, it is important to consider the role of affect.

Unlike WTP for microinsurance, the percent of household income associated with farming is positive and significant for 25-50% and 50-75% of income. Similar to the model for WTP microinsurance and regressions for coping strategies, education is significant and positively associated with WTP loan. In both cases we find that type of weather hazard and actual weather do not have a significant effect on WTP.

In this research the conceptual framework used was aimed towards demand for (micro)insurance. In future work development of a framework specific to the demand for loans and hybrid microinsurance and loan tools would be advantageous in allowing better targeting of sub-groups for the use of microinsurance versus loans.

10.2.3 Ugandan research methodology and field game findings

The large-N Ugandan survey offers a structure by which to obtain a range of indicators related to the WTP for microinsurance as well as other relevant aspects associated with alternative forms of coping. We are able to cover a wide range of factor areas and incorporate some aspects that have not been covered previously to the best of our knowledge. There are limits to the extent to which we can incorporate considerations around bounded rationality and tracing other information because of the cross-sectional structure nature of the study. We do use field games as a part of the large-N study which allows us to cross-references findings from the games and direct questioning in other sections of the tool.

For example, the *Coin* game allows us to gauge respondents risk aversion in a manner that we cross-reference with stated farming decisions. There is evidence that there is a close and representative relationship between our estimated risk aversion parameters and real-life farming choices—riskiness in real-life seed choice is reflected in farmers' choices in the *Coin* game.

In the *Basic Dice* game we find that the feeling of being insured is important to many farmers in our dataset, and the relative affect obtained from this *feeling* is related to higher levels of WTP for microinsurance. In future research it would be useful to include an indicator of affect for the feeling of insurance in a context where the realisation of basis risk is tractable (e.g., the *Complex Dice* game).

We demonstrate the usefulness of quick and familiar games that can provide information about preferences that are relevant to households' intended demand for microinsurance, specifically risk aversion and affect towards insurance. Of course there are limitations and biases to the use of field games, as noted previously. Yet, they can be useful short-cuts for demand-side assessment circumventing long questionnaires while encompassing some aspect of relevant psychological factors. In many cases this type of "snapshot" is an improvement on situations when respondents may otherwise be ignored due to the time and effort to ask and analyse longer questionnaires.

10.3 Attitudes toward basis risk—findings from the Complex Dice game

The *Complex Dice* game is played with a group of 128 CKWs in the two Ugandan study regions. The approach of the game provides a manner by which to trace reactions to the realisation of basis risk over iterative insuring periods. To the best of our knowledge the empirical study of reaction to basis risk in the positive direction (from the perspective of the respondent) is a novel methodological advancement of this game. Furthermore, playing with a partner in order to assess the relative effect of observation of insuring behaviour and realisation of basis risk for another (e.g., neighbour) is to the best of our knowledge a new approach. There is precedence for looking at this effect given that there is precedence in the large-N survey tool—such that friends' knowledge of insurance is important to the WTP of the respondent, even more so than his own knowledge.

Significant effects are found in the model for all independent variables associated with basis risk and insurance behaviour observed from the experience of one's "playing partner" in a previous round. Notably, holding all else constant and regardless of the outcome of the previous round, respondents were affected by partners' insurance decisions in a significant positive manner. Alternatively, if a respondent observes realisation of basis risk for his partner, in either the positive or negative direction, there is a significant negative effect on insuring in the next period. As to be expected, experiencing extreme weather in a given period is significantly positively related to greater levels of insurance in the next period.

Notably, we find that the experience of basis risk in either direction—in the farmer's favour or to his detriment–is significantly negatively-related to level of insuring in the next round. It is notable that the negative effect of basis risk realised in a given period on microinsurance purchase in the next period is relatively greater for basis risk realised in the positive direction.[379] It is of specific interest that *good* basis has a negative effect on insuring in the next period to a greater extent than *bad* basis risk. This makes sense from the standpoint of incongruence with expectations – respondents may be disappointed when bad basis risk is realised, but it is expected, while *good* basis risk is not expected given the goals of the insurance product and thus shakes overall consumer confidence. To the best of our knowledge this is a new empirical finding and should be expanded upon in future research.

We find significant effects associated with some of the socio-demographic and attitudinal variables in the iterative decision to insure in the *Complex Dice* game. Again, we see somewhat less effect from the wealth – there is no significant effect related to ownership of productive assets. Age has a positive and significant effect on microinsurance purchase. The share of household income from farming is important to the WTP of the respondent—those with less income diversification would be relatively more willing to insure. Numeracy has a significant positive effect on insuring. Finally, trust has the same effect as seen in the large-N survey—trust

[379] Note that we also developed a model in which we tabulated the number of times the respondent experienced basis risk in the positive (and negative) direction. This did not have a significant effect on the player's responses.

in a businessman compared to trust in a (government) bureaucrat has a positive significant effect on insuring.

10.4 Developed country study findings (Online simulation post-Hurricane Sandy)

Our developed country case study was in the Northeast USA and compared the propensity to purchase flood insurance between those affected and unaffected by Hurricane Sandy in an online simulation and related survey tool. There are few studies to date that address a relatively large sample of individuals who recently experienced an extreme weather event, especially in a manner by which both a rich set of potential demographic and attitudinal determinants are obtained as well as indications of respondents' future and past insuring behaviour.

Notably, there is no significant difference in insurance demanded between groups affected and unaffected by Hurricane Sandy. Furthermore, controlling for losses from Hurricane Sandy, we see that it is not insurance holdings in real life, but rather attitudes towards risk and other expressed preferences that significantly affect insuring. These findings highlight that individuals have underlying predispositions towards insurance and risks, related to flood and in other realms.

We note that the provision of information about the probability and magnitude of a potential flood event is significant to the choice to insure and it appears that respondents are more sensitive to percent chance than magnitude. We see that almost 10% of respondents, across groups of those affected and unaffected by Hurricane Sandy, were predisposed to never insure throughout the flood simulation. Additionally, about 15% of the total sample insure in all simulation scenarios, regardless of details about the potential flood event. We find evidence in the data that these individuals are relatively highly risk-averse; it is also plausible that the feeling of insurance (as noted in the *Basic Dice* game) is applicable in this case—some respondents obtain utility simply from feeling insured. Though, it should be noted that holding alternative types of insurance (e.g., automobile or health) is not directly related to either insuring in the simulation or holding flood insurance ex-ante Sandy.

Self-reported probability of experiencing "disaster events," such as terrorism or a car accident is significantly positively related to insuring. Furthermore, those identifying as "careful with finances" (i.e., more risk averse) are more likely to adopt insurance in a given scenario.

Though we are primarily interested in the effects of perceptions on insuring, it is worth noting the relevant impact of demographic indicators. Of those considered in the model, we find age and education to have a significant impact in the insurance behaviour observed in the simulation. Furthermore, there is a significant positive relationship found between the number of children in the household and insuring.

An important finding from the simulation is that those exposed to the table presentation of relevant insuring and expected values are more likely to insure in a given scenario. This finding is in agreement with studies that note detailed numerical descriptions of potential outcomes yield less risk-seeking behaviour (e.g., Hertwig et al., 2004); in our case less risk-seeking behaviour is the purchase of insurance, which has a greater outcome in all scenarios in comparison to the most risky outcome, flood occurrence without insurance cover. This presentation of insuring information could translate into the presentation of flood-likelihood data offered to homeowners and home-dwellers in the USA This is especially salient because we find that there is no significant relationship between insuring in the simulation or in real life related to the MOTF-defined flood-impact categories. Thus, it does appear that households are unaware of flood risk[380] and presentation in a table that is easily read and interpreted may help better inform them and subsequently encourage purchase of flood insurance where appropriate.

Findings related to our gambling exercise bring into question two issues: 1. reliability of standard gambles as measures of WTJ/WTP for insurance and 2. impacts on preferences having suffered a real-life flood. Choices in our gambling exercise do not accord well with insurance decisions throughout the flood simulation. There is not a strong correlation between the two measures and which pre-empts the viability of risk aversion measured through a standard gamble indicating likelihood to insure. Furthermore, there is relatively little overlap in significant explanatory variables in the model developed for gambling that uses the time-invariant variables and the modelling for insuring in the simulation as based on the conceptual framework for insuring.

The presumption in past work (e.g., Eckel et al., 2009; Page et al., 2014) was that direct experience with flooding decreases risk aversion in comparison with a control group of less affected and unaffected households (i.e., individuals are more likely to take a risky gamble if they have experienced losses from flooding recently).

In our study we relate the gamble to the same realm in which losses were experienced in real life (e.g., outcome of flood insuring), which should make it more likely that gambling and insuring are related—but this is not the case. Though an individual experiences loss in one realm it does not indicate that she will be risk-loving in that realm or in general (when faced with a gamble). Our findings are more closely associated with those of Cameron & Shah (2011), such that there is a negative effect between the percent damage to one's home from Hurricane Sandy flooding and gambling[381]—but not necessarily intended insuring behaviour. It is possible that there is some background risk related to experiencing greater levels of damage from Sandy; background risk in some cases has been demonstrated to induce greater risk aversion (e.g., Gollier & Pratt, 1996; Guiso & Paiella, 2008).

10.5 Synthesis of cross-case findings

These two case studies address demand for insurance against extreme weather. Yet, in the context of the conceptual framework from which we work to model (micro)insurance demand they are relatively well differentiated from one another. In particular, there is a stark difference in the underlying social policies and legal frameworks that govern the availability of coping strategies outside of the use of insurance tools. In general we take the stance that in the Ugandan example to date there is less availability of ex-post government intervention, while in the USA Federal disaster assistance is one of the few facets households depend on following floods (e.g., through FEMA assistance) outside of formal methods such as insurance and loans. In terms of the insurance tools themselves, the two case studies are differentiated based on the

[380] They may be under-informed because of miscommunication of flood risk, inexact mappings of flood risk ex-ante Hurricane Sandy, or disinterest in knowing the flood risks, which is especially relevant to those in the least affected areas.
[381] We do find weak significant correlations between gambling and insuring in various scenarios.

type of inuring tool most prevalent; in Uganda this is rainfall-indexed microinsurance and in the USA it is indemnity-based. Though there are major differences in the case studies, some of the findings are applicable across both.

Rejda (1995, pp. 23-24) indicates idealised conditions for insurable risks, a number of which are challenged by insuring covariate weather risks.[382] Skees and Barnett (1999) use the term *in-between* risks to note those natural hazards that violate some of Rejda's (1995) criteria and ultimately reduce market supply of insurance to cover such risks and cause incomplete markets. Arrangements have been made to address this issue over time; for example, elements of microinsurance have been structured to this end and FEMA administers subsidised flood insurance. Yet, there are some factors that remain challenging. In this thesis we look at the demand-side dynamics; however, supply-side dynamics are one element that directly effects the demand options facing those deciding whether to insure. It is the case that in the developed country context example respondents are working under a schematic of highly-subsidised government funded programmes.

Skees and Barnett (1999) note that it is bounded rationality[383] that often reduces demand for risk transfer for these "in-between risks." As reviewed previously, this is the case—households may not know or grasp the probability and magnitude of potential extreme weather (e.g., Kunreuther & Michel-kerjan, 2013). We see evidence of this in both case studies—it is not the risk associated with the real life occurrence of extreme weather[384] that affects the level of insurance demanded in the hypothetical studies, but rather perceived risk.

We need to take care when comparing the two case studies, but it is notable that WTJ for insurance in both cases implicates the importance of subjective probability estimates on the part of the respondent. Those respondents who just experienced rather severe flooding from Hurricane Sandy seem not to make major changes to their preferences to insure in the simulation (regardless of whether they held insurance before Sandy), even when we control for their background level of worry and self-reported risk aversion. But those who perceive a relatively high likelihood of flooding and other risks (even without real life experience) are more likely to insure, *ceteris paribus*.

There is a group of respondents (defined by heterogeneous factors) who either always or never insure with consistency, across all scenarios in both the Hurricane Sandy simulation, the *Basic Dice* game, and the *Complex Dice* game. The direct motivations for these extreme approaches, which in some cases deviate from expected utility, appear to relate to affect and what we term the *feeling of insurance*. Addressing these groups and the underlying effects would help reduce over-insuring and motivate under-insurers if done within the context of other available coping strategies.

In the Ugandan research we find that there is stated sensitivity to both the consequences of extreme weather and the cost of insurance relative to home income when deciding to insure; those conceptualising the decision to insure in this manner have a higher WTP than others. Yet, the metric for worry across a number of different realms is not significant to the choice to insure.

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382 These idealised conditions include the following: large number of independent heterogeneous exposure units, no catastrophic loss, calculable chance of loss, economically-feasible premium.

383 Skees & Barnett (1999) refer to what we term bounded rationality as "cognitive failure."

384 In the Hurricane Sandy case this accords to the MOTF data. For the large-N Ugandan survey it relates to rainfall data calculated from TAMSAT data.

Similar to the Ugandan results, Sjöberg (1999, p. 129) found that "the level of perceived risk was…related mostly to the probability of harm…but demand for risk reduction [through insurance] was related mostly to the expected severity of consequences" for general hazard events as well as home insurance for a sample of home insurance costumers that assess every-day risks.[385]

In the Hurricane Sandy simulation we find evidence that individuals respond more to the probability, opposed to the magnitude of consequences. Furthermore, those with higher perceived risk of negative events in situations outside of home flooding, indicating overall worry were more likely to insure. This is consistent with findings specific to home flood insurance suggesting probability dominates the choice to (not) insure for flood (e.g., Kunreuther, 1976; Kunreuther et al., 1977).[386]

Though assessed differently, in both case studies findings relate expected consequences (i.e., magnitude), perceived risk, and probability of harm. We have findings that support both assertions: 1.people demand insurance based on consequences of harm, not necessarily risk or probability of harm (e.g., Sjöberg, 1999)—Ugandan study versus 2.people dismiss small risks and insure on the basis of probability (e.g., (Slovic et al., 1977)—Hurricane Sandy study. Though the two are not directly comparable this seeming disagreement highlights the claim made by Sjöberg (1999, p. 138) that home flood insurance is likely a "deviating and very special case…because it was believed that the government would intervene" regardless and in other realms individuals likely assess magnitude of consequences in the decision to insure. To this point we find evidence that home flood insurance is unique in people's minds—in our Sandy sample that holding other forms of insurance has little effect on holding flood insurance in real-life or insuring in the simulation. Yet, in the Ugandan sample knowledge of insurance against unrelated issues (especially via a friend) did have a significant effect on intention to insure.

There is one differentiating factor between the two case studies that highlights variation in response to *in-between* risks due to experience. In the literature it is clear that individuals underinsure against low-probability, high-magnitude events (e.g., Kunreuther & Pauly, 2005; Kunreuther et al., 2012). Yet, if we look at the real-life probability distribution of the events that we ask about insuring in our two case studies, there is an important difference. The incidence of flood or drought that causes the loss of a crop is rather frequent for our rural Ugandan sample—they have experienced such losses and subsequent coping multiple times. Thus, it follows that they identify the incidence of loss correctly (i.e., in a manner that roughly agrees with weather data). And there is a type of cogent learning effect through repeated (real-life) experience that is not seen in the Hurricane Sandy study. Whereas, those who experienced Hurricane Sandy may perceive themselves as a one-off experience and though losses may have been great, the relative learning effect is likely not the same—this is even seen in some choices throughout the iterative simulation. This contextual variation accounts for at least some of the difference in the rates of insurance adoption and expressed desire for insurance we note in the two case studies. It would be ideal to assess the threshold of repeated experience at which individuals become relatively more aware of the probability of occurrence.

[385] In Sjöberg, (1999) study home insurance is not specific to flood insurance, but rather coverage of home contents and structure in the case of events such as burglary or fire.

[386] These studies find that households ignore the risk of flooding and were unwilling to buy subsidized flood insurance—they were sensitive to low probabilities opposed to high magnitude of consequence.

In both case studies, demographic factors have some impact, but attitudinal and perceptual factors appear to be relatively more significant to the choice to insure. Notably in both cases it is surprising that income and other factors related to household wealth are not significant to insuring. This finding indicates that income elasticity of demand in both our case studies is relatively low. Some previous studies note positive price sensitivities (e.g., Browne & Hoyt, 2000; Kriesel & Landry, 2004). Our finding highlights the fact that wealth effects may often be over-weighted in studies of households' intended insurance uptake and that when more considerations are made in modeling intended insuring, insurance is relatively income elastic.

Budget constraints play a role in the extent to which households can cope, but perhaps have less to do with preferences for coping once a threshold level of ability is surpassed. To date it is likely that ability-to-pay for home flood insurance in the USA due to subsidies and ex-post government support is not as pertinent to the decision to insure as attitudes. Furthermore, aside from the most vulnerable, to date it is likely that in the developing context, wealth effects have been over-weighted as a reason for uptake of microinsurance and attitudes and perceptual factors should be generally used as indicators of potential WTJ and WTP, especially as policies that combine work-for-pay programmes become increasingly popular.

Variation in cultural context, the nature of extreme weather faced, and the type of insurance to be employed makes comparing our two case studies complex, but there are some important findings that link the two, as noted above. There are a number of findings in that inform the manner by which insurance may be developed and marketed in each case. In this research we have obtained greater understanding of expressed preferences for insuring. In turn, policies can use this information to communicate insurance options and target specific sub-groups best suited for insuring relative to the social optimum. Nudge-like options to get the right people to insure… more research has to go into it and the right incentives need to be applied.

10.6 Research limitations and future research

The research presented in this thesis strove to extend the knowledge-base and methodology employed in understanding motivations to insure against extreme weather in different contexts. There are some limitations to approaches followed and caveats related to data obtained; we touch upon these in the discussion below. Furthermore, we highlight potential extensions to the research in each context.

Throughout the thesis we highlighted potential hypothetical biases associated with the field games, CV questions, and simulation. To the extent possible we provide financial incentives to induce well-considered responses. In some cases, we were able to cross-reference game responses with other data obtained from respondents, e.g., the *Coin* game and farming choices. Furthermore, high-levels of WTJ and WTP for microinsurance may be related to hypothetical biases; however, we saw similar patterns for loans which are a tool with which respondents are already acquainted in the market. Given that agricultural microinsurance was not previously available in the research areas hypothetical questioning was necessary. Synthesis reviews of microinsurance demand studies (e.g., Eling et al., 2014) indicate that the majority of microinsurance demand studies have a hypothetical aspect; further (Cole et al., 2012) detail potential threats to study validity for thirteen microinsurance studies often cited within the relevant literature.

We are able to assess representativeness of our samples; however, given limited accessibility to data by which to assess revealed preferences concerning insuring and savings behaviours in the past, we are constrained in our ability to effectively assess external validity for self-reported responses for these issues.

Overall, we find that expressed desires for future behaviours and related attitudes are significant factors in insuring. In contrast there is a notable lack of significance from variables related to past actual (i.e., real life) behaviours. This difference in influence is likely related to the fact that expressed preferences often do not always carry forward to actualised behaviours. In many models of behaviour (e.g., Triandis, 1979), it is actually expressed preferences as opposed to actualised behaviour that is measured.

Well-structured games can predict relationships between factors and intended behaviour if not actualised behaviour. For example, in the simulation (game) for Hurricane Sandy there is significant correlation between those claiming to want insurance in real-life ex-post Sandy and insuring behaviour in the simulation, though there is not significant relationships between insure and holding flood insurance ex-ante Sandy. The purpose of such games and simulations can be to trace ideal behaviour on the part of respondents when they are in a situation that they are focused on the issue being studied and in our case have (near) full information. From these intended behaviours it is the case that insurance tools and related policies may be tailored to bring actualised behaviours closer to those intended and further match socially-optimal standards.

In our regression analyses we strive to avoid endogeneity; however, this is a difficult aspect because the literature hints at a number of interdependencies between elements of the four factor classes used in the conceptual framework for (micro)insurance demanded, as noted in Chapter 2. For example, a number of demographic factors have been identified as associated with risk aversion; however, these demographic factors as well as risk aversion are related to the choice to insure.

The field games and simulation were structured such that they were simplistic and relatively easily explained while addressing the most pertinent aspects of the study issues. In future research it would be useful to try to incorporate basis risk into the *Basic Dice* game if possible. A description of deductibles would make the Sandy simulation more realistic. Furthermore, providing a simulation structure closer to that of the *Complex Dice* game would provide insight into the relative trade-off between insuring and alternative mitigation strategies. Additionally, in the future CV questions should be asked using various formats to better gauge the validity of the price ladder approach.

We structured our research such that we could obtain data allowing for consideration of individuals' preferences that may be informed by bounded rationality to be included in a demand-side analysis of (micro)insurance in large-N relatively quick assessments. In doing so we were about to include factors (especially in the microinsurance study) that covered all factor classes in our conceptual framework; allowing us to compare factors within a single study. Yet, there are distinct limitations to the extent to which we were able to draw conclusions related specifically to System I and II thinking and bounded rationality due to the mode of research for this relatively complicated topic of insurance.

In future research it would be useful to combine our methods with a framework that allows in-depth iterative qualitative data about individuals' preferences. In the developing country context, it would be ideal to have a research framework that combines the type of stated preference study we conduct with more qualitative research that allows respondents to provide detailed qualitative responses over a longer period in the style of an economic ethnographical study (e.g., Collins et al., 2009) in order to explain their choices to cope and insure iteratively in real life. To this point, we were constrained by time and resources such that a multi-year qualitative study was not feasible at this point. We did conduct focus groups in order to gain some qualitative understanding of these factors.

In the developed country study it would be ideal to extend research on the effect of various presentations of data on potential losses; such a presentation may have a practical role in motivating individuals to insure. For example, we may conduct a within-subject experiment which gauges if an individual's perception of expected loss and insurance purchases change when presented with a table specification versus not. Furthermore, piloting insurance policy materials that express risk and uncertainty in a graphic and explicit format would be relatively inexpensive and largely informative.

In order to better control for environmental background factors in both case studies it would be ideal to employ similar studies to those reported in this thesis in the alternative context. Arguably analysis of agricultural insurance in a developed country context would more readily provide direct comparisons to the Ugandan study. Furthermore, a study of indemnity-based insurance structured in the developing country context may yield more comparable findings to those of our Hurricane Sandy work.

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