Risk Preferences and the Poverty Trap: A Look at Technology Uptake amongst Small-Scale Farmers in the Western Cape

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COMPULSORY DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

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Abstract

The poverty trap hypothesis postulates that very low income individuals may be trapped in poverty because severe constraints give rise to behaviour that limits their ability to take up and benefit from new investments. Furthermore, the theory suggests that insurance and credit can serve as effective tools in counteracting the mechanisms that create this type of persistent poverty. In this study, using data obtained from two separate samples of farmers in the Western Cape, we explore the validity of this hypothesis in a South African context. One sample consists of organic farmers from Cape Town whilst the other comprises of conventional farmers from the Matzikama Municipality. We elicit behavioural traits; more specifically risk preferences, using lottery type experiments with real money at stake. Using a series of logit regressions we look at the relationship between these preferences i.e. risk aversion, loss aversion and nonlinear probability weighting and actual uptake of farm technology in both samples. Using the Matzikama sample, we then apply the estimates to uptake in an experimental setting where insurance and credit are provided. The experimental study allows us to test for both absolute and path dependent effects by examining both the levels, using a multinomial logit model, and the timing, using a cox proportional hazard model, of uptake. The results from the real life data show that the effects of the risk preferences tend to differ depending on the type of technology, and this is true for both samples. One consistent finding from both the real life and experimental uptake data is that the farmers who live in households that have below average relative income levels are less likely to take up technology; even with insurance and loans being made available in the experiment. This finding is unexpected given that all the farmers face the same objective risk levels and do not have their real life income at stake in the experiment. Our results show that the availability of insurance improves uptake in the overall sample and can serve as effective tools in reducing poverty. However, contrary to the poverty trap hypotheses, little evidence is found to suggest that the insurance contract in the study sufficiently serves as a device to counteract the risk preferences that are linked to low technology uptake. This finding is evident when considering both absolute uptake and the timing of uptake. Therefore, the results on the effects of insurance and credit on technology uptake, given risk preference and relative income position, may imply that low income farmers in South Africa are not only constrained by behaviour that is prompted by monetary or risk factors but also other behavioural or psychological components e.g. the feeling of hopelessness that stems from persisting conditions of poverty; however, this requires further investigation.

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Introduction

There is a growing urgency in the need to intensify food production. The world's population is projected to increase to approximately 9 billion people by 2050 (UNPD, 2006) and even the most optimistic projections of future food demand call for growth in food production by nearly 50 percent (Ray et al., 2013). In developing countries, small scale farming is currently being seen as a means to meet these food production targets and also as a device for achieving significant reduction in poverty. Small-scale farmers are one of the most underprivileged and vulnerable people in developing countries. In addition, most of the people existing in absolute poverty in these countries live on small farms. Growth analyses have revealed that, for developing countries, the agricultural sector has to a certain degree a strong positive effect on growth in non-agricultural sectors and a comparatively bigger impact on poverty than its evident portion of the economy (Timmer, 2002; World Bank, 2001; Nagayets, 2005; Bezemer, 2008). Hence, the growth of small-scale farming amongst low income groups can be a viable solution to the development, food security and poverty challenge in developing countries.

A number of key features of agricultural led growth since the green revolution of the 1960's have been identified in the literature (Hazel and Diao, 2005). In this paper, we focus on one of these key features, namely technological innovation. Agricultural growth needs to be technologically driven so that output prices can fall while farm incomes increase (Hazel and Diao, 2005). That is to say that wide-ranging diffusion of new and innovative technology is a precondition for growth in small-scale agriculture. Diffusion itself is an outcome of a sequence of individual decisions to initiate the use of new technology. These decisions are based on comparisons of the uncertain costs and benefits of adopting new inventions (Uaiene, 2009). Since technological diffusion is a crucial means of development for poor countries, a poor or slow-growing economy would indicate incomplete technology uptake or the underutilization of inputs that are linked to technology (Foster and Rosenzweig, 2010). An examination of the factors that influence technology uptake choices is thus necessary for policy makers in developing countries to make effective contributions to food security, economic growth and poverty reduction.

There is evidence to suggest that incomplete technology uptake can be linked to the inability of the poor to enjoy the benefits of growth. This occurs because the ability to benefit from growth is linked to the countries initial conditions e.g. initial levels of income inequality

(Ravallion, 2001). Growth in agriculture necessitates a broad based and equitable mechanism in order for it to be economically efficient and by which purchasing power can be increased amongst the rural masses; as opposed to a privileged few. This mechanism would require equitable access to land, modern farm inputs, credit, and markets in the economy (Hazel and Diao, 2005). If we consider a polarised country such as South Africa, looking at technological growth alone while ignoring equity issues may hide a great deal of structural immobility or hopelessness which can be masked by the increased success of farmers that already own assets and benefit from returns (Carter and Berrett, 2006).

There are a number of theoretical hypotheses that suggest that South Africa suffers from a legacy of blocked pathways and structural immobility, thus leaving a large numbers of people in a poverty trap (Adato et al., 2006). In the country, equity lines are more pronounced because rising income gaps bear a distinctive racial footprint (Leibbrandt et al., 2011). Poor small-holder farmers in developing countries such as South Africa, where income inequalities are high, usually have no or limited access to land, modern farm inputs, credit, and markets. These constraints on access to or ownership of assets may account for the slow diffusion of agricultural technology and low agricultural growth in South African smallholder farming. Even though the post-apartheid South African government has delivered considerable pro poor support through broad social grants and capital structures, it is evident that further efforts need to be carried out to lessen the growing intra race inequality and reduce the constraints that poor farmers face (Finn et al., 2014).

If we consider a more basic poverty trap process, poor South African farmers will be caught in a poverty trap when they have limited access to financial services such as credit and insurance and marginal returns to investment increase with increase in wealth. This circumstance gives rise to a situation where low income farmers have limited assets and are also unable accumulate assets, e.g. farm technology, in order to advance themselves. This is because, in condition like these, distribution of incomes will be a divergent process. Groups or individuals that are poor at the outset will be trapped in poverty, whereas those that are initially more affluent can progress to higher levels of wealth (Barrett and Carter, 2013; Adato et al., 2006). Given the unchangeable features of the poor and the conditions of production and exchange technologies, a poor equilibrium outcome is the only situation that exists for initially poor farmers (Barrett and Carter, 2013). Nonetheless, when the poor can secure loans based on future incomes; with the aim of taking on investments, or acquire insurance; in order mitigate the effects of future losses, a convergence in the distribution of incomes possible i.e. the wealth levels of the initially poor farmers can grow towards that of their wealthier counterparts (Adato et al., 2006).

There are numerous processes that cause poverty traps to exist and this paper we identify four; from current literature, which appear to be relevant to the South African case. These are: **Inadequate asset poverty traps**: This is based solely on initial asset holdings and increasing marginal returns to investment as wealth rises; **Dynamic and inter-generational poverty traps:** These poverty traps are grounded in the household characteristics that are correlated with poverty, e.g. residing in unsafe or decrepit housing locations or the absence of capable male role models in a household. These are factors that can create a sub-culture of poverty, pervade family values or entrap the current and future generation of the household in the same detrimental behaviour or system of living. **Social and economic exclusion poverty traps:** These traps are a result of prejudices that are linked to features such as caste and race. **Spatial development traps:** These types of poverty traps are location dependent and occur when a disproportionately high population of poor people are situated in locations that place them at a productive disadvantage or high risk, as in the case of the urban informal settlements in and around Cape Town and other major South Africa cities. The disadvantage can be associated with factors such as great levels of community-based vulnerability e.g. long distance to markets, lack of arable land, droughts or floods. (Duclos and O'Connell, 2009; Thorbecke, 2013).

Poor households can face a number of these poverty traps concurrently (Thorbecke, 2013). When a combination of poverty trap processes are working together simultaneously, a multiple equilibria poverty trap can exist. Multiple equilibrium poverty traps have numerous stable states, with no less than one equilibrium linked to a state of poverty. At the boundaries between these multiple stable states, multiple equilibrium suggests the presence of a critical threshold i.e. 'an unstable dynamic equilibrium'. Above this threshold, the system is characterized by a building up of assets while below this threshold a diminishing of assets dominates. The existence of this threshold, due to multiple equilibrium, complicates risk management because, in this instance, shocks can only exogenously shift the underlying forces of asset accumulation in the presence of multiple equilibria (Barnet et al., 2008; Barret and Carter, 2013). Therefore, the collective consequence of mutually reinforcing poverty traps is to heighten the scale of poverty (Mwabu and Thorbecke, 2004; Thorbecke, 2013).

Poverty traps may further be deepened by behavioural anomalies that occur in conditions of multiple equilibrium. Crucial material determinants of persevering poverty, e.g. low asset holdings, can lead to endogenous changes in risk preferences in such a way that results in behaviour based path dependent poverty. In addition, amongst individuals facing multiple equilibrium poverty traps, observed behaviour is driven not only by fixed risk preferences but also ex ante risk management practice that are determined by expected future asset levels (Lybbert and Barrett, 2011; Barret and Carter, 2013). Ex ante actions to decrease vulnerability to risk can inhibit accumulation of assets and in so doing produce a low-level equilibrium. Also, the ex post results of a shock can cause a relapse into poverty trap. However, the deterrent effects of risk can be limited if financial market failures are addressed such that financial institutions are available and can enable poor individuals to adopt insurance, ex ante, in order to mitigate shocks, or acquire loans which can serve as quasi-insurance due to the ex post nature of loan repayments (Carter and Barrett, 2006; Barnett et al., 2008)

If we consider the farming scenario, there are two reasons farmers will be motivated to obtain insurance. First, farmers have usually been found to be risk averse which indicates that the costs of occasionally large losses are considered to be more severe by farmers than the cost of relatively minor annual insurance premiums. Second, insurance can enable loan uptake since it can serve as a qualification for taking on credit by shielding creditors from the consequences of farmers' misfortunes (Patt et al., 2010). Therefore, government support of greater access and availability of loans can be useful to agricultural modernization policy, especially if insurance, which serves as risk-transfer device, is made available (Mahul and Stutley, 2010).

A number of countries have supported agricultural insurance schemes. For example, India and Mexico have developed extensive and massive weather based crop insurance schemes to safeguard farmers against harsh weather variation. China saw a substantial growth in the agriculture insurance market through government backing and premium subsidies. In 2008, its market became the world's second largest; surpassed only by the United States. China's subsidies on agricultural insurance premiums have been successful in boosting their agricultural insurance markets. Nonetheless, these subsidies need careful consideration since they can alter price signals and offer inappropriate incentives that lead to the finance of unreasonable farm activities or induce a certain degree of moral hazard (Mahul and Stutley, 2010). Subsidised insurance premiums are often required when cost on premiums are so high that low income farmers cannot afford them. Costs of premiums tend to be high when they are accompanied by high administrative cost, as a result, the creditors' burden of assessing losses at each farm level. A significant reduction of administrative costs can be achieved by tying insurance to a simple and broad indicator of losses such poor rainfall. Pay-outs from such insurance contracts, instead of being linked to real substantiated losses, will be linked to broad occurrences or events that creates losses. However even though this type of insurance scheme is more economical to administer, it has a shortcoming in that it cannot completely cover risk. Farmers may still face basis risk i.e. the possibility of a failed harvest that is not reflected in the indicators of loss used by the creditors (Patt et al., 2010).

Another financial market imperfection that can influence poverty traps, such as in the case of ineffective insurance markets, is the cognitive or practical limitation of predicting or measuring outcomes. A good quantification of outcomes is a precondition for evaluating to what degree agents will be receptive to variation in earnings that are linked to the use of inputs or technologies. However, these sorts of measurements are often not straightforward (Foster and Rosenzweig, 2010). The extent to which agricultural producers have cognitive shortcomings in measuring outcomes such as gains and losses or costs of insurance and loans will have behavioural consequences on risk management decisions, including the actual demand for the agricultural technology or insurance (Mahul and Stutley, 2010). For example, studies have found that majority of people tend to poorly evaluate the probability of a loss which hinders their capability to assess whether or not a certain insurance contract is fair (Johnson et al., 1993 in Patt et al., 2010). Unfortunately, many studies that have looked at behavioural anomalies and their influences on farm risk management decisions have failed to consider cognitive failures in processing probability. One reason is that earlier behavioural economic studies have generally assumed that individual behaviour is consistent with expected utility.

Expected utility assumes a linear processing of probabilities and that farmers will, given their level of risk aversion, select the technology that offers the maximum expected utility (Feder et al., 1985; Sunding and Zilberman, 2001; Isik and Khanna, 2003; Marra et al., 2003; Foster and Rosenzweig, 2010, Barham et al. 2014). However, more recent research identify several systematic violations of the expected utility model (Starmer, 2000, Hershey and Schoemaker 1985; Bleichrodt et al. 2001; Abdellaoui et al. 2007; Einhorn and Hogarth, 1981). One theory namely, prospect theory, delivers empirical proof from numerous sets of choice problems where preferences fail to conform to expect utility theory axioms (Kahneman and

Tversky, 1979; Sebora and Cornwall, 1995). The theory suggests three consistent violations of expected utility which occur in a two-staged process. The first and second violations occur in the first stage. The first violation is reference dependence which is that agents view choices as changes to their current wealth relative to a subjective reference point. From this reference point, agents have a tendency to be risk averse towards changes perceived as gains and risk seeking towards changes perceived as losses (Einhorn and Hogarth, 1981; Sebora and Cornwall, 1995), with individuals being more sensitive to losses compared to gains; this is the second violation, which is often referred to as loss aversion. It is in fact expected that farmers will have a subjective reference points for evaluating outcomes e.g. subsistence incomes in the context of farm production decisions. The second stage; and third violation, is the nonlinear weighting of probabilities. A growing number of empirical evidence exists to support the notion that farmers depend on subjective probabilities as opposed to real or objective probabilities (Bocqueho et al., 2013).

In this study, we explore how these behavioural anomalies (i.e. risk aversion, loss aversion and nonlinear probability weighting) and proxies for asset holdings (relative household income position and household monthly income) are linked with decisions to invest in farm technology. We, therefore, determine whether or not these factors are determinants of poverty traps by way of their effects on investment carried out by smallholder farmers. Since we do not have data on asset holdings of the farmers, we adopt a rudimentary approach by assuming relative income as a proxy for asset holdings. Individuals with below average relative household income are considered to be the poor farmers. We do not explicitly explore for the present of a threshold but if there is a significant enough divergence at the threshold, as in the case of multiple equilibria poverty traps, we will see a substantial difference between the poorest and the richest group. We estimate the parameters of behavioural traits under the assumption of prospect theory.

The analysis is conduct using data from two samples of small scale farmers, one comprising of organic farmers in Cape Town and the other of conventional farmers from the Matsikama Municipality of Western Cape, South Africa. In chapter one, we consider the conventional farming context while in chapter two we look at the organic farmers. Since organic farming defers from conventional farming, by its dependence on natural ecological systems alone, it may present with different risks and risk management methods. (Hanson et al., 2004). In chapter 3, we explore the uptake of technology in an experimental setting. In the experimental setting, we test for the effects of loan and insurance availability on technology uptake. Decisions are carried out in a series of time frames, thus we are able to consider the time dependent dynamics of uptake.

Chapter 1 - Risk Preferences and Poverty Traps: A Look at Technology Uptake amongst Smallholder Farmers in the Matzikama Municipality.

1.1 Introduction

Behavioural economic studies on farmers' decision to take up technology have commonly recognized an aversion risk as, inter alia, being crucial to farm technology adoption decisions. More recent studies are beginning to realise the role of loss aversion, which is sensitivity to losses relative to gains, and the way in which individuals assess probabilities in technology uptake decisions. In this chapter, we study the effects of risk and loss aversion and probability weighting on technology uptake, using a sample of small-scale farmers in the Western Cape Province of South Africa. In addition, and owing to the poverty trap hypothesis, we consider the role of relative income constraints on technology uptake and how that leads to poverty traps for small-scale farmers.

Numerous studies have found that the diffusion of new farm technology has been slow in developing countries (Feder et al., 1985; Engle-Warnick et al., 2007; Duflo et al., 2011; Simtowe, 2006, Fernandez-Cornejo et al., 2002; Brick and Visser, 2014). This is occurring despite the benefits of recent modern innovations in technology. For example, there now exists an extensive range of genetically modified crops that boast being more nutrient-rich while at the same time having more insect, disease and drought resistance than traditional varieties (Liu and Huang, 2010). The slow diffusion rates have been attributed to a number of limitations that farmers in developing countries face, some of which are economic situations, poor access to social capital, credit and insurance markets. These limitations place important restrictions on households' ability to prepare for and respond to shocks. Besides the effects of these constraints on the physical ability to take up technology, they have also been found to prompt risk and loss averse behaviour toward new farm technology. These fears of risk and loss have been suspected (and in some cases proven) to contribute to the poverty trap in which farmers in developing countries find themselves (Yesuf and Bluffstone, 2009 and Liu, 2013). In South Africa the incidence of these constraints is uniquely polarised, a consequence of racially entrenched poverty and inequality, raising questions about the capacity of the poor to use social instruments to construct passages out of poverty (Adato et al.; 2006).

A standard feature of poverty trap models is that they recognize a critical asset threshold about where there is a divergence of behaviour. Pathways out of persistent poverty are obstructed beneath this threshold, whereas above this threshold there are opportunities to advance productively and accumulate assets (Carter and Barrett, 2006; 2007). The presence of this threshold hinges on the degree to which households are restricted in intertemporal exchange by the use of formal and informal credit, insurance or savings (Carter and Barret, 2006). Hence, there is a need for studies on the behavior of poor farmers in South Africa, which is a society characterized by polarized income and asset levels, to consider this physically limiting threshold as a potentially critical factor that interacts with fear of risk and loss in the technology diffusion process.

Risk aversion describes the observed behaviour that individuals are reluctant to accept a situation when there is a variance in outcome. Loss aversion in turn describes the observed behaviour that individuals are more sensitive to losses relative to commensurate gains (Köbberling and Wakker, 2005). This implies that individuals are more concerned with the downside risk of investment, as opposed to upside risk. Numerous studies have been carried out on the role of risk aversion on farm technology uptake whereas the influence of loss aversion is not often explored. Another under-represented factor that may potentially play a key role in determining whether or not technology is taken up is the cognitive processing of probabilities. Evidence has shown that individuals do not always accurately process probabilities; they have a tendency to overweight the probability of unlikely events and underweight the probability of likely events. By way of example, let's consider a natural-hazard such as a flood: the perceived probability is linked to an individual's expectation of being affected by a flood and its severity (Grothman and Patt, 2005). An underweighting of the probability of a flood or its severity will result in a lower likelihood of using technology such as a buffer to mitigate the impact of a flood.

We, therefore, consider probability weighting, along with risk and loss aversion, to be psychological factors that determine farm technology uptake. These factors are regarded in behavioral economics as risk preferences. We use the prospect theory method in Tanaka et al. (2010) (TCN) to measure the three parameters, i.e. risk aversion, loss aversion, and nonlinear weighting of probabilities, under the assumption of prospect theory. TCN, under the assumption cumulative prospect theory, conducted experiments with villagers in North and South Vietnam. They presented three different multiple price lists with paired lottery choices. The experiment was framed in such a way that the switching point in each list could be used to evaluate the three prospect theory parameters based on a 'parsimonious three parameter cumulative prospect value function' (Hurley, 2010). They find that, on average, individuals were risk averse and overweighed small probabilities whilst underweighting high probabilities. They find a high degree of loss aversion with approximately 90 percent of their sample exhibiting loss aversion.

Not enough literature has looked at loss aversion and nonlinear probability weighting when considering farmer characteristics. We, however, provide a minor account of what some research has delivered so far. In contrast, a substantial amount of literature on risk aversion has been carried out. Previous empirical and experimental evidence suggests that most individuals are risk averse. Binswanger (1980) conducted gains frame lottery type experiments using a constant partial risk aversion utility function. The study finds that most individuals are risk averse with high payoffs being linked to intermediate and moderate levels of risk aversion. Barr (2003) conducted a similar experiment in Zimbabwe but included opportunities for individuals to pool risk. The study shows that most of the sample is risk averse with risk aversion decreasing when individuals could pool risk by being part of a group.

Miyata (2003), Wike et al. (2004), Yesuf and Bluffstone (2009) also use a method similar to Binswanger. Miyata (2003) in examining risk attitudes of individuals in village households in Indonesia finds three quarters of the sample to be in the range of severely to moderately risk averse. Miyata's ordered probit regressions shows that the more educated or wealthy an individual is the less he/she exhibits risk aversion. People who live in household with larger household sizes are also found to be less risk averse. Wik et al. (2004) in experiments with Zambian villagers find a relationship between lottery payoffs and risk aversion. Their results show that risk aversion ranges from severe risk aversion to risk neutrality when relatively low payoffs are involved but with high payoffs, severe risk aversion to moderate risk aversion is observed. They find women to be more risk averse than men and risk aversion to be increasing with land size. According to their results, household size, income and education are all negatively correlated with risk aversion. Yesuf and Bluffstone (2009), using a gains frame lottery, find risk to be the dominant behaviour pattern – with more than 79 percent of their sample displaying risk aversion irrespective of payoffs. Nonetheless, unlike Binswager, Yesuf and Bluffstone (2009) also consider lotteries presented in a combination of both gain and loss prospects. Risk aversion still dominates with 66 percent of the sample exhibiting risk aversion which is robust to payoff changes. They find that wealth and farm size are negatively correlated with risk aversion, while age of household head and percentage of children in the household are positively correlated with risk aversion.

The effects of individual and household characteristics on risk aversion are contentious due to the inconsistency of results found in various studies. The studies we have presented so far suggest that being male, higher incomes and greater wealth are all negatively related to risk aversion, but this may not always be the case. Mosley and Verschoor (2005), in looking at risk attitudes of semi-subsistence farmers, use an experiment that consists of seven different lottery pairs with only one choice being played for money. They find no evidence to suggest that gender, income and wealth are consistent determinants of risk aversion.

Using a mixture model approach, Harrison et al. (2010) assume both expected utility and prospect theory. However, because all their lottery type experiments are gain framed, their prospect theory model does not account for loss aversion. They find that most of the individuals in their sample are risk averse under the expected utility assumption, with women and age being linked to less risk aversion. Using prospect theory, they also find similar results. Most of the individuals in the sample are found to underweight low probability events and overweight high probability events with the effect being more prominent the greater the household size. Half their samples are seen to behave in terms of prospect theory while just under half the sample conforms to expected utility. Their study is unique in that it separates individuals by those who conform to expected utility and those that behave in terms of prospect theory, whereas most studies have estimated parameters by either only assuming expected utility or prospect theory. Ward and Singh (2013) in a series of field experiments conducted in rural India find that women are more risk and loss averse than men, although, as they explain, this may be caused by a higher proportion of risk averse women in the sample.

In the context of technology adoption, fewer studies have considered risk preferences in the prospect theory context. Amongst the studies that assume this theory, Hill (2005) finds, using a sample of Ugandan farmers, that risk aversion is correlated with replanting of coffee trees. Ward and Singh (2013) find that loss aversion is more correlated with a switch from traditional rice seeds to the new variety they explored. Liu (2013) using the methodology of TCN and a Weibull hazard model finds that risk aversion and loss aversion amongst farmers in China is correlated with later adoption of Bt cotton, while farmers who overweight small probabilities are found to adopt Bt cotton earlier.

Besides the prospect theory parameters, numerous studies have recognised certain important drivers of uptake. Nhemachena and Hassan (2007) and Deressa et al. (2009) find household size to be positively related to farm technology uptake. This may be because larger household size assists in the realisation of numerous agricultural practices since households with more members will not have the labour constraint that households with fewer members suffer (Croppenstedt et al., 2003; Nhemachena and Hassan, 2007). Nhemachena and Hassan (2007) and Deressa et al. (2009) also find that female headed households were more likely to adopt a farm strategy or technology. Panda et al. (2013) find that total income and total farming income are linked to a change of crop variety. Their results show that farm experience, land area irrigated, and access to credit to be correlated with two of the uptake options they explored. Shiferaw and Holden's (1998) findings suggest that age and adoption of soil conservation techniques are negatively correlated, implying that older farmers are more reluctant to modify farm practices.

Conceivably, one other important factor in the decision to take up technology is expectations related to climate and weather events or conditions. As climate changes worsen, causing occurrences like droughts and floods, short-run fluctuations in food production in semi-arid will become more pronounced (Schmidhuber and Tubiello, 2007). In order to mitigate the effects of adverse climate on agricultural efficiency, farmers are likely to adopt agricultural practices that make them more immune to the risk of 'bad weather' (Belliveau et al., 2006).

For the purpose of this analysis, we consider 7 farm technologies and practices, namely drought resistant crops, improved seeds, intercropping, fertilizer, organic manure, wind breaks and irrigation. We use experimental and survey data obtained from 125 farmers from farming communities in the Matzikama Municipality of Western Cape, South Africa. The study looks at the determinants of farm technology uptake – paying special attention to farmers' risk preferences and relative income position (which acts as a proxy for accumulated assets).

The paper is broken down into the following: Section 1.1 presents an introduction and review of current literature. Section 1.2 shows the summary statistics of the farmers' characteristics. Section 1.3 describes the experiment design and methodology for eliciting the prospect theory parameters. Section 1.4 explains the results for the determinants of risk aversion, loss aversion and non-linear probability weighting. Section 1.5 presents the results of the logit regressions on technology uptake decisions. Sections 1.6 provides a conclusion along with policy recommendations.

1.2 Background and Summary Statistics

The data used in this analysis was obtained by Martine Visser, Kerri Brick and Feri Gwata of the Environmental Research Policy Unit EPRU, University of Cape Town, via survey collection and risk experiments carried out with small-scale farmers in the Matzikama Municipality of the Western Cape, South Africa, between July and August of 2010[1]. Agriculture in Matzikama is supported by the Clanwilliam Dam and Olifants River. The area which is mostly dominated by viniculture, vegetables, citrus fruits and livestock production is characterised by arid terrains and cool temperatures (Matzikama IDP, 2009-2010).

The sample consists of 125 farmers from the towns of Vanrhynsdorp, Lutzville, Klawer, Clanwilliam and Wupperthal who were recruited through the Matzikama Emerging Farmers Forum. Table 1 presents the summary statistics of farmer characteristics. Average approximate age of farmers in the sample is about 43 yrs., with approximately 44 percent of the farmers being female and 55.6 percent being male. Average monthly household income is R2365 with about 60 percent of the sample being below the average relative household income level. Only 30 percent of the farmers have an alternative source of employment outside of farming. The respondents were asked yes or no questions about their own belief about their behaviour in the context of risk. When asked about how frequently they take risks, 20 percent of the respondents indicated that they “often” take risks, 54 percent said they ‘“sometimes” take risks and 26 percent indicated that they “never” take risks.

[1] See Appendix 1 for sampe quetionnare.

The farmers were also asked whether or not they noticed any changes in Rainfall (frequency and timing), Rainfall (Level and intensity), temperature and pests. The summary statistics are presented in Table 2. Altogether, 62 percent of the respondents stated that they noticed changes in the state of rainfall frequency and timing, 70 percent stated that they had noticed a change in rainfall level and intensity and 59 percent stated that they had perceived temperature changes. Since climate is essentially a local phenomenon (IPCC, 2001) it is difficult to say how these perceived changes will affect technology uptake in this context.

Table 2: Climate change perceptions

Variable	Mean	Std. Dev.
Rainfall (Frequency and Timing)	62%	49%
Rainfall(Level and Intensity)	70%	46%
Temperature Changes	59%	49%
Changes in Pest Levels	64%	48%

Sample Size:125

In the survey, respondents were asked to indicate whether they had started using any new farming practices. The summary statistics for these farming practices are presented in Table 3. Just less than 9 percent said they use more drought resistant crops (i.e. crops that are more resilient to poor rainfall), 8.8 percent use improved seeds (i.e. seeds of the hybrid pollinated variety), 12.4 percent use intercropping, 9.6 percent use fertilizer, 20.8 percent use organic manure, wind breaks usage is at 10.4 percent and irrigation use is at 19.2 percent .

Table 3: Farm Uptake

Variables	**Mean**	**Standard Deviation**
Drought Resistant Crops	8.80%	28.40%
Improved Seeds	8.80%	28.40%
Intercropping	14.40%	35.30%
Fertilizer	9.60%	29.60%
Organic Manure	20.80%	40.80%
Wind Breaks	10.40%	30.60%
Irrigation	19.20%	39.50%

Sample Size:125

1.3 Risk Preference Elicitation and Estimation

1.3.1 Methodology

The experiments in this study were modelled after the design of Tanaka, Camerer and Nguyen (2010) (TCN) who assume cumulative prospect theory. TCN use a series of gain-only and gain-and-loss pair-wise lotteries with both a risky and safe option (similar to Holt and Laury (2002)). They assumed the following utility function:

$$U(x,p;y,q) = \begin{cases} v(y) + \pi(p)\big(v(x) - v(y)\big) & x > y > 0; x < y < 0 \\ \pi(p)v(x) + \pi(q)v(y) & x < 0 < y \end{cases} \qquad \textit{Equation 1.1}$$

$U(x, p; y, q)$ denotes the expected value linked to prospects$(x, p; y, q)$, p and q are the probabilities of receiving outcomes x and y, respectively. The power function $v(x) = x^{\sigma}$ for gains $(x > 0)$ and $v(x) = -\lambda(-x^{\sigma})$ for losses $(x < 0)$ is assumed with σ being the risk aversion parameter (i.e. measure of the concavity of the value function) and λ the parameter for loss aversion. The risk aversion parameter (σ) is presumed to be identical in both gains and losses; the inequality $\sigma > 1$ implies risk seeking preferences and σ <1 implies risk averse behaviour. For λ, λ>1(λ<1) implies greater sensitive to losses (gains) compared to gains (losses).

TCN use the nonlinear probability weighting function of Prelec (1998) where $\pi(p) = \exp[-(-\ln p)^{\alpha}]$ with the function being linear if $\alpha = 1$. If $\alpha = 1$ and $\lambda = 1$; in this case the model reduces to expected utility. If $\alpha < 1$ the function is an inverted S-shape. The inverted S-shape indicates that small probabilities are overweighed and large probabilities are underweighted. The function is S shaped if $\alpha > 1$, indicating that small probabilities are underweighted and large probabilities are overweighed.

1.3.2 Elicitation

Similar to TCN, the Matzikama farmers were given three sets of multiple price lists (MPLs) with pair wise lotteries sheets[2]. The first two lists (i.e. Series 1 and 2) had a series of 14 decision rows each, with both being gain only lotteries. The third sheet (Series 3) had both gain and loss lotteries with 7 decision rows[3]. Subjects have a choice between lottery A or lottery B in each row. The lotteries were framed to represent farming seasons with lottery A representing the outcome if farmers chose to use traditional seeds and lotteries B representing the outcome if farmers chose to use improved seeds. The payoffs are dependent on whether or not there is sufficient rainfall for yields to be good. The premise of this framing is that improved seeds require more rain relative to traditional seeds. The probabilities in the lotteries represented the probabilities of good rainfall for the high payoffs and probabilities of bad rain for the low payoffs. The payoffs represent the yields in a farming season.

[2] A sample of the multiple price lists are presented in appendix 2

[3] Sample of the list are presented in Appendix 2

Subjects were asked to select the row they wanted to switch from lottery A (traditional seeds) to lottery B (Improved seeds) (participants could only select one option (A or B) in each decision row). The probabilities of outcomes in the first two series were fixed all through the row. The first row of series 1 had lottery A offering a 30 percent chance of receiving a high payoff and a 70 percent chance of receiving a low payoff. The first row of lottery B offers a 10 percent chance of receiving a higher payoff than the high payoff in lottery A and a 90 percent chance of receiving a lower payoff than the low payoff in lottery B. In series 2, the first row of lottery A offers a 90 percent chance of receiving a high payoff and a 10 percent chance of receiving a low payoff. The first row of lottery B offers a 70 percent chance of receiving a higher payoff than the high payoff in lottery A and a 30 percent chance of receiving a lower payoff than the low payoff in lottery B.

In Series 1, the outcome in lottery A is also fixed but in lottery B the payoffs change as one goes down the rows until the expected payoff of lottery B ultimately surpasses that of lottery A. In both Series 1 and 2, the more risk averse a participant is the further down the row they switch to lottery B. In Series 3, the subjects had a 50 percent probability of a positive payoff (loss) and a 50 percent probability of a negative payoff (loss) in both lotteries. The expected value of lottery A decreases and lottery B increases as we move down the rows. The more risk-averse a participant is the further down the row they switch to Lottery B. Subsequent to the completion of each MPL, a subject would draw a numbered ball from numbered balls that were placed in a bag. The balls were numbered 1 to 14 for Series 1 and Series 2 and 1 to 7 for Series 3.The chosen ball then determined what decision row was to be played for money[4]. Rainfall probabilities were also denoted by 10 numbered balls. For example, for traditional seeds in series 1, 3 balls represented good rain fall levels while 7 balls represented poor rainfall levels. The rainfall level is determined by one of the subject selecting a ball from the bag.

The MPL lotteries in TCN were structured so that the switching points of the 3 series produce a permutation of the prospect theory parameters risk aversion, non-liner probability weighting and loss aversion. Series 1 and 2 estimate the parameters sigma (the measure of risk aversion) and alpha (the measure for probability weighting). In Series 1, a set of sigma and alpha (σ, α) combinations that rationalise the switching points are estimated. Another combination of sets that justifies the switching point is found for series 2. For example, if a subject switched in row 6 of series 1, the values of sigma and alpha that can rationalise the

[4] Summary of Payoffs is presented in table 4.

switch is (0.5, 0.4) (0.6, 0.5), (0.7, 0.6), (0.8, 0.7), (0.9, 0.8), (1.0, 0.9). This implies the following inequalities:

$$5^{\sigma} + \exp[-(-ln0.3)^{\alpha}]\,(20^{\sigma} - 5^{\sigma}) < 2.5^{\sigma} + \exp[-(-ln0.1)^{\alpha}](55^{\sigma} - 2.5^{\sigma})$$

$$5^{\sigma} + \exp[-(-ln0.3)^{\alpha}]\,(20^{\sigma} - 5^{\sigma}) > 2.5^{\sigma} + \exp[-(-ln0.1)^{\alpha}](62.5^{\sigma} - 2.5^{\sigma})$$

If a subject switched in row 6 in series 2 this implies the following inequalities:

$$15^{\sigma} + \exp[-(-ln0.9)^{\alpha}]\,(20^{\sigma} - 15^{\sigma}) < 2.5^{\sigma} + \exp[-(-ln0.7)^{\alpha}](31^{\sigma} - 2.5^{\sigma})$$

$$15^{\sigma} + \exp[-(-ln0.9)^{\alpha}]\,(20^{\sigma} - 15^{\sigma}) > 2.5^{\sigma} + \exp[-(-ln0.7)^{\alpha}](32.5^{\sigma} - 2.5^{\sigma})$$

The combination of sigma and alpha that can rationalise the switch is (0.5, 1), (0.6, 0.9), (0.7, 0.8), (0.8, 0.7), (0.9, 0.6), (1, 0, and 0.5). The crossing point is thus (0.8, 0.7).

In TCN, the coefficient of loss aversion (λ) is derived from Series 3: conditional on the value of sigma derived from Series 1 and Series 2, the switching point in Series 3 implies a range of values for λ. The TCN method produces interval values for the loss aversion parameter. For the values of sigma 0.8 and the subject switched in the 6th row of series 3, this implies the following inequalities:

(-λ)(-(-2^0.8))(0.5) + (12.5^0.8) (0.5)> (-λ) (-(-10.5^0.8)) (0.5) + (15^0.8) (0.5),

(-λ)(-(-2^0.8))(0.5) + (2^0.8) (0.5)> (-λ) (-(10.5^0.8)) (0.5) + (15^0.8) (0.5),

(-λ)(-(-2^0.8))(0.5) + (0.5^0.8) (0.5)> (-λ) (-(-10.5^0.8)) (0.5) + (15^0.8) (0.5),

(-λ)(-(-2^0.8))(0.5) + (0.5^0.8) (0.5)> (-λ) (-(-8^0.8)) (0.5) + (15^0.8) (0.5),

(-λ)(-(-4^0.8))(0.5) + (0.5^0.8) (0.5)> (-λ) (-(-8^0.8)) (0.5) + (15^0.8) (0.5),

(-λ)(-(-4^0.8))(0.5) + (0.5^0.8) (0.5) < (-λ) (-(-7^0.8)) (0.5) + (15^0.8) (0.5),

(-λ)(-(-4^0.8))(0.5)+ (0.5^0.8) (0.5) < (-λ) (-(-5.5^0.8)) (0.5) + (15^0.8) (0.5)

The implied interval of Lambda is: 3.62896< λ <4.76259. Note that if subjects switch in row 1 or never switch, the intervals are censored.

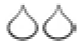
	Rainfall	Traditional Seeds	Improved Seeds
1		R20 if ❶	R38.5 if ❶
		R16 if ❷❸❹❺❻❼❽❾❿	R1 if ❷❸❹❺❻❼❽❾❿

Figure 1: Sample Lottery Task

Table 4: Summary of Payoffs

Switching Rows		Series 1				Series 2				Series 3			
	Rainfall Level	**Traditional Seed**	**Probability**	**Improved Seed**	**Probability**	**Traditional Seeds**	**Probability**	**Improved Seeds**	**Probability**	**Traditional Seeds**	**Probability**	**Improved Seeds**	**Probability**
1	*Good*	R 20.00	0.3	R 34.00	0.1	R 20.00	0.9	R 27.00	0.7	R 12.50	0.5	R 15.00	0.5
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-R 2.00	0.5	-R 10.00	0.5
2	*Good*	R 20.00	0.3	R 37.50	0.1	R 20.00	0.9	R 28.00	0.7	R 2.00	0.5	R 15.00	0.5
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-R 2.00	0.5	-R 10.00	0.5
3	*Good*	R 20.00	0.3	R 41.50	0.1	R 20.00	0.9	R 29.00	0.7	R 0.50	0.5	R 15.00	0.5
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-R 2.00	0.5	-R 10.00	0.5
4	*Good*	R 20.00	0.3	R 46.50	0.1	R 20.00	0.9	R 30.00	0.7	R 0.50	0.5	R 15.00	0.5
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-R 2.00	0.5	-R 8.00	0.5
5	*Good*	R 20.00	0.3	R 53.00	0.1	R 20.00	0.9	R 31.00	0.7	R 0.50	0.5	R 15.00	0.5
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-R 4.00	0.5	-R 8.00	0.5
6	*Good*	R 20.00	0.3	R 62.50	0.1	R 20.00	0.9	R 32.50	0.7	R 0.50	0.5	R 15.00	0.5
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-R 4.00	0.5	-R 7.00	0.5
7	*Good*	R 20.00	0.3	R 75.00	0.1	R 20.00	0.9	R 34.00	0.7	R 0.50	0.5	R 15.00	0.5
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-R 4.00	0.5	-R 5.50	0.5
8	*Good*	R 20.00	0.3	R 92.50	0.1	R 20.00	0.9	R 36.00	0.7	-	-	-	-
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-	-	-	-
9	*Good*	R 20.00	0.3	R 110.00	0.1	R 20.00	0.9	R 38.00	0.7	-	-	-	-
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-	-	-	-
10	*Good*	R 20.00	0.3	R 150.00	0.1	R 20.00	0.9	R 41.00	0.7	-	-	-	-
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-	-	-	-
11	*Good*	R 20.00	0.3	R 200.00	0.1	R 20.00	0.9	R 45.00	0.7	-	-	-	-
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-	-	-	-
12	*Good*	R 20.00	0.3	R 300.00	0.1	R 20.00	0.9	R 50.00	0.7	-	-	-	-
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-	-	-	-
13	*Good*	R 20.00	0.3	R 500.00	0.1	R 20.00	0.9	R 55.00	0.7	-	-	-	-
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-	-	-	-
14	*Good*	R 20.00	0.3	R 850.00	0.1	R 20.00	0.9	R 60.00	0.7	-	-	-	-
	Bad	R 5.00	0.7	R 2.50	0.9	R 15.00	0.1	R 2.50	0.3	-	-	-	-

1.4 Determinants of Risk Aversion, Non-Linear Probability Weighting and Loss Aversion

In this section, we assess the determinants of risk aversion, non-linear probability weighting and loss aversion. The results presented in Table 5 are, ceteris paribus, outcomes of the Ordinary Least Square regressions on normalised sigma (Risk aversion)(1) and alpha (Nonlinear probability weighting)(2), respectively, and interval regression on lambda (Loss Aversion)(3). Positive values on sigma and interval lambda regressions denote an increase in risk aversion and loss aversion respectively while positive values on alpha indicate an increase in the weighting of small probabilities relative to large probabilities. In this paper, we replace $\sigma = - \sigma$ and $\alpha = - \alpha$ in order to have a measure that shows a higher σ and α denoting greater risk aversion and increase in the overweighting of small probabilities, respectively.

The explanatory variables are the farmer's age, gender (dummy variable = 1 if the farmer is female), education level of farmer, if the farmer is the primary bread winner of the household, monthly household income, if the farmer has an alternative source of paid employment besides farming, the farmers farm experience in years, household size, if the household income is below the average relative household income in their community; relative income here is the ratio of the individuals household income and mean income in the community.

In Table 5(1), our findings show that household size (p-values =0.004; 0.011) is negatively correlated with risk aversion. This is similar to the finding of Wik et al. (2004). Household size can represent a wealth factor. Bigger households imply a larger household labour force or wealth generating capacity. Furthermore household size may be correlated with lower risk aversion because of the greater opportunities for risk sharing i.e. an implicit form of insurance for members of the household (Wik et al., 2004). This is consistent with Barr (2003) who find that risk aversion decreases when individuals can pool risk. We find that primary bread winners are less loss averse than non-primary bread winners (p-value = 0.093). There were no statistical significant effects on the coefficient from the regressions on nonlinear probability weighting in 5(2). In 5(3), we find that primary bread winners (p-value = 0.020; 022) are significantly less loss averse than non-primary bread winners. Primary bread winners have greater command over the resources of their households and a greater burden in terms of bringing in income to satisfy household consumption (Rouse and Kitching, 2006, Jayawarna et al., 2013) which may create a bias for upside risk (variability in financial gains) compared to downside risk (variability in financial losses). We further find that farm experience (p-values = 0.064; 0.034) is related to loss aversion indicating a greater concern for downside risk. Greater household monthly income is related to lower loss aversion, but its effect is minor. The negative sign is nonetheless expected given that the disutility from loss of income decreases as income increases.

Table 5: Determinants of Risk Preferences

	Sigma(RA)		Alpha (PW)		Lambda(LA)	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Age	-0.003	-0.003	0.000	0.000	-0.037	-0.038
	(0.002)	*(0.002)*	*(0.002)*	*(0.002)*	*(0.027)*	*(0.031)*
Female	0.046	0.037	0.052	0.056	0.653	0.480
	(0.057)	*(0.059)*	*(0.042)*	*(0.046)*	*(0.852)*	*(0.917)*
Education Level	-0.007	-0.009	-0.007	-0.008	-0.205	-0.289
	(0.011)	*(0.013)*	*(0.008)*	*(0.009)*	*(0.176)*	*(0.196)*
Primary Bread Winner	-0.091	-0.114	-0.014	-0.059	-1.896	-2.037
	(0.064)	*(0.067)**	*(0.054)*	*(0.056)*	*(0.817)***	*(0.892)***
Employed	-0.014	-0.013	0.025	0.048	-0.729	-0.770
	(0.052)	*(0.059)*	*(0.053)*	*(0.064)*	*(0.752)*	*(0.855)*
Farm Experience in Yrs.	0.004	0.004	0.002	0.002	0.125	0.141
	(0.003)	*(0.003)*	*(0.002)*	*(0.002)*	*(0.067)**	*(0.067)***
Household Size	-0.036	-0.035	-0.008	-0.004	-0.225	-0.280
	*(0.012)****	*(0.013)***	*(0.010)*	*(0.010)*	*(0.199)*	*(0.197)*
Below Avg. Rel. Inc.	-0.010	-	-0.054	-	0.777	-
	(0.053)	-	*(0.050)*	-	*(0.720)*	-
Household Income	-	0.000	-	-0.000	-	-0.000
	-	*(0.000)*	-	*(0.000)*	-	*(0.000)**
lnsigma_cons	0.078	0.085	-0.415	-0.436	7.145	9.108
	(0.192)	*(0.223)*	*(0.167)***	*(0.184)***	*(3.128)***	*(3.548)***
Constant	-	-	-	-	1.185	1.190
	-	-	-	-	*(0.133)****	*(0.145)****
Observations	84	74	84	74	84	74

Robust standard errors in parentheses

+ significant at 10%; * significant at 5%; ** significant at 1%

1.5 Determinants of Technology Uptake

In this section, we consider seven farm technologies and practices, namely, drought resistant crops, improved seeds, intercropping, fertilizer, organic manure, wind breaks and irrigation. The explanatory variables are the same as in section 1.4. Additional explanatory variables are the dummy variables Rain (Frequency and Timing) = 1 if the farmer has perceived any changes in rainfall frequency and timing and '0' if not, Rainfall (level and Intensity) = 1 if the farmer has perceived any changes in rainfall level and intensity and '0' if not, and Temperature = 1 if the farmer has perceived any changes in temperature levels and '0' if not. The determinants of uptake are obtained using logit regressions and the results are presented in Table 6 below. The coefficients are the expected changes in the probability of taking up an option due to a unit change in the explanatory variable. Two regressions are carried out for each uptake option[5]. Our results indicate that risk aversion (Sigma) increases the likelihood of fertilizer uptake (p-value = 0.008, 0.035). We find that the more an individual weights small probabilities relative to large probabilities (Alpha) the more likely they are to take up improved seeds (p-value = 0.056, 0.036).[6] This result is expected if there is less uncertainty attached to improved seeds.

We find that females are less likely to take up drought resistant crops (p-values = 0.080; 0.095), fertilizer (p-values = 0.047; 0.037) and manure (p-value = 0.069). Education level is seen to be negatively related to uptake of intercropping (p-value = 0.062). This contradicts the common assumption that the education level of farmers has a positive effect on uptake because of the connection between education and knowledge on farm technology (Knowler et al., 2007). Nonetheless, more educated individuals are more likely to have better non farming jobs and may, therefore, be less driven to invest more time in intercropping which requires a more disciplined farming structure.

Greater household size is related to greater likelihood of fertilizer uptake (p-values = 0.019; 0.059), this may be linked to the greater labour power or pooled resources that accompany increased household size. Employment is seen to be related to lower likelihood of uptake of manure (p-values = 0.001; 0.000). This can be expected since having an alternative income source means another method of satisfying consumption. Alternative employment can reduce the importance of farming in a household and in so doing diminish the importance of improving farm practices (Knowler et al., 2007) or engaging in practices that involve high effort levels.

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5 The second set of regressions include all variables while the first set of regressions exclude the dummy variables for below average relative income and climate change perceptions. A third set of regressions which include household monthly income is in Appendix 3.

6 It is important to note that there are several categories of improved seeds. Improved seeds can be seeds that are genetically modified to contain more nutrients, generate greater yields or are drought- or disease resistant etc. or a combination of these categories. The characteristic of the type of improved seeds are not explicitly stated in the survey

With the exception of drought resistant crops, having below average relative income decrease the likelihood of uptake of all the options namely, improved seeds (p-values = 0.039; 0.045), intercropping (p-value = 0.066), fertilizer (p-values = 0.015; 0.050), manure (p-values = 0.005; 0.007), windbreaks (p-values = 0.015; 0.019) and irrigation(p-values = 0.094,0.012). Having below average relative income has a greater effect than household income[7]. This suggests that relative income limits uptake if it is below a certain threshold which is consistent with the asset based approach to poverty traps. Of all the variables explored, the relative income position has the most dominant effects, suggesting that poverty trap is the most important feature of slow technology diffusion. Nonetheless, this effect may be specific to South Africa due to its unique legacy of racially polarised income levels. The limitation to self-advancement are not only characterised by asset constraints but also distinctive structural exclusion which deepens the magnitude of the poverty trap.

Our results indicate that a perceived change in rainfall frequency and timing increases the likelihood of fertiliser uptake (p-value = 0.037). This is expected given that fertilisers can be used to supplement the nutrients for plants in the event of inadequate rainfall. In contrast, a perceived change in rainfall levels and intensity decreases the likelihood of fertilizer usage (p-value = 0.093). We find that perceived temperature changes increase the likelihood of uptake of intercropping (p-value = 0.000) and also fertilizer (p-value = 0.092). These results indicated that there is a significant relation between perceived changes in climate and the uptake of new technologies and therefore also the importance to educate farmers via training programs, making information more accessible via early warning systems and other information campaigns.

[7] See Appendix 3.

Table 6: Determinants of Uptake

	Drought Resistant Crops		Improved Seeds		Intercropping		Fertilizer		Manure		Windbreaks		Irrigation	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Sigma	0.268	0.354	0.437	0.390	0.851	1.286	6.116	7.267	0.848	0.387	0.742	0.608	1.171	0.785
	(1.482)	*(1.362)*	*(1.854)*	*(1.892)*	*(1.391)*	*(1.661)*	*(2.290)****	*(3.445)***	*(1.546)*	*(1.641)*	*(1.172)*	*(1.298)*	*(1.407)*	*(1.671)*
Alpha	3.688	3.404	4.429	4.394	-1.177	-1.728	0.957	1.408	-1.767	-2.081	-0.980	-0.834	-0.481	-0.502
	(2.266)	*(2.254)*	*(2.313)**	*(2.094)***	*(1.308)*	*(1.565)*	*(1.754)*	*(2.525)*	*(1.542)*	*(1.801)*	*(1.388)*	*(1.610)*	*(1.231)*	*(1.242)*
Lambda	-1.931	-2.037	-0.177	-0.063	-0.533	-0.948	0.318	0.745	-0.647	-0.797	1.324	1.528	1.129	1.579
	(3.173)	*(2.948)*	*(2.023)*	*(2.009)*	*(1.040)*	*(1.242)*	*(1.256)*	*(1.923)*	*(1.142)*	*(1.355)*	*(1.296)*	*(1.453)*	*(1.022)*	*(1.071)*
Age	-0.018	-0.009	0.043	0.039	0.009	-0.002	0.069	0.076	0.023	0.013	0.019	0.009	0.029	0.017
	(0.025)	*(0.025)*	*(0.031)*	*(0.030)*	*(0.021)*	*(0.025)*	*(0.043)*	*(0.067)*	*(0.021)*	*(0.021)*	*(0.023)*	*(0.024)*	*(0.021)*	*(0.022)*
Female	-1.882	-1.868	-0.941	-0.937	0.283	0.390	-2.312	-3.605	-1.462	-1.189	-0.796	-0.833	-0.911	-0.660
	*(1.074)**	*(1.119)**	*(0.914)*	*(0.891)*	*(0.681)*	*(0.792)*	*(1.167)***	*(1.727)***	*(0.805)**	*(0.817)*	*(0.786)*	*(0.707)*	*(0.802)*	*(0.826)*
Farm Experience in yrs.	0.016	0.019	-0.028	-0.035	-0.041	-0.018	-0.081	-0.101	0.007	0.012	-0.053	-0.045	-0.021	-0.030
	(0.067)	*(0.061)*	*(0.066)*	*(0.068)*	*(0.067)*	*(0.069)*	*(0.134)*	*(0.190)*	*(0.050)*	*(0.053)*	*(0.088)*	*(0.086)*	*(0.041)*	*(0.042)*
Education Level	-0.179	-0.120	-0.102	-0.130	-0.155	-0.240	0.022	-0.049	0.016	-0.061	-0.038	-0.091	0.069	-0.016
	(0.159)	*(0.140)*	*(0.175)*	*(0.173)*	*(0.109)*	*(0.129)**	*(0.141)*	*(0.194)*	*(0.101)*	*(0.118)*	*(0.107)*	*(0.126)*	*(0.087)*	*(0.112)*
Household Size	-0.076	-0.059	0.010	-0.011	0.168	0.223	0.807	1.098	0.187	0.141	0.209	0.198	0.267	0.236
	(0.350)	*(0.337)*	*(0.256)*	*(0.270)*	*(0.145)*	*(0.153)*	*(0.345)***	*(0.582)**	*(0.159)*	*(0.158)*	*(0.227)*	*(0.220)*	*(0.174)*	*(0.182)*
Employed	1.306	1.256	1.170	1.148	-0.796	-0.843	-0.506	0.020	-3.470	-3.588	0.256	0.312	-0.725	-0.747
	(1.122)	*(1.114)*	*(1.041)*	*(1.078)*	*(0.704)*	*(0.822)*	*(0.883)*	*(0.921)*	*(1.039)****	*(0.895)****	*(0.896)*	*(0.879)*	*(0.671)*	*(0.643)*
Below Avg. Rel. Inc.	-0.586	-0.582	-1.675	-1.618	-1.238	-1.150	-2.570	-3.245	-1.919	-1.919	-2.071	-2.135	-1.658	-1.740
	(0.797)	*(0.797)*	*(0.813)***	*(0.807)***	*(0.673)**	*(0.753)*	*(1.062)***	*(1.653)***	*(0.690)****	*(0.716)****	*(0.852)***	*(0.914)***	*(0.639)****	*(0.691)***
Perceived Changes in Climate														
Rainfall Frequency and Timing	-	-0.580	-	0.382	-	-0.098	-	2.446	-	-0.198	-	0.019	-	0.831
	-	*(0.979)*	-	*(1.226)*	-	*(0.824)*	-	*(1.171)***	-	*(0.954)*	-	*(1.018)*	-	*(0.830)*
Rainfall Level and Intensity	-	0.111	-	0.429	-	-1.244	-	-2.627	-	0.303	-	0.096	-	1.569
	-	*(1.179)*	-	*(1.307)*	-	*(0.942)*	-	*(1.564)**	-	*(1.095)*	-	*(1.540)*	-	*(1.291)*
Temperature	-	-0.388	-	-0.400	-	3.649	-	1.818	-	1.516	-	1.730	-	0.466
	-	*(0.769)*	-	*(0.830)*	-	*(1.002)****	-	*(1.081)**	-	*(1.191)*	-	*(1.436)*	-	*(0.852)*
Constant	3.128	2.567	-0.038	0.113	-0.600	-1.786	-4.925	-6.495	-1.459	-1.660	-2.647	-3.175	-3.019	-4.113
	(3.409)	*(3.124)*	*(2.966)*	*(2.909)*	*(1.988)*	*(2.712)*	*(3.027)*	*(5.048)*	*(1.926)*	*(1.753)*	*(2.142)*	*(2.827)*	*(1.802)**	*(2.074)***
Observations	85	85	85	85	85	85	85	85	85	85	85	85	85	85

Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%

1.6 Conclusion (Chapter 1)

Advancements in farm technology and practices have provided farmers with the means to improve yields while safeguarding farm productivity against harsh climatic and weather events. Nonetheless, there is evidence to suggest that the diffusion of these farm practices and technology has been slow. Evidence from economic and behavioural literature suggests that there are certain real and psychological attributes of farmers that contribute to the slow uptake of farm technology. The real attributes include factors such as relative income, wealth, education and the actual risk associated with technology adoption while the psychological attributes include factors such as farmers' perceptions, preferences and emotions.

In this paper, we carry out an analysis to determine to what extent these real and psychological attributes contribute to the farm technology uptake process. Based on our finding on the effects of psychological constructs such as individual risk preferences and perceptions, we recommend that climate risk management policies need to include a significant amount of participatory risk evaluation and strategies. Farmers should be involved in the understanding of the risks, be it weather or climate risk, the probabilities they face and in the construction of responsive or adaptive strategies (Patt and Schroter, 2008). An institutional factor that should be considered is access to extension services, which provide information on climate and technology. Farmers can only construct viable and efficient farm strategies with comprehensive and accurate information on impending occurrences such as climate conditions (Smit and Skinner, 2002).

Our finding on the effect of relative household income positon is consistent with the poverty trap hypothesis which suggests the existence of an asset threshold with people below that threshold being reluctant to take on investment. We find that being below the average relative income has a negative effect on all but one of the uptake options we explored. This confirms that for low income farm households, there may be a minimum combination of assets or economic circumstances necessary to eventually formulate pathways out of poverty (Carter and Barret; 2006). It is unclear as to whether this is as a result of physical or psychological constructs or a combination of both. It nonetheless has the most consistent effect on uptake, out of all the determinants we explored, suggesting that it is an extremely crucial factor to the technology uptake process. This finding signals the need for stronger proactive actions to guarantee access to a minimum package of assets for poor South African farmers, this is required for their successful advancement (Adato et al., 2006). An example would be a formal credit system linked to harvest levels in order to reduce the downside risk associated with crop production and aid in the overcoming of the asset threshold levels. It is important to mention that the impact of relative income position could also be an emotional construct where people compare their activities with those of others in their income group and develop subjective norms from their observations regarding the correct strategy or solution (Festinger, 1954; Gifford, 2011). Therefore, mechanisms that support of greater market participation, discourse between income groups as well as social capital should be explored.

Chapter 2 –Risk Preferences and Poverty Traps: A Look at Urban Smallholder Organic Farmers in Cape Town.

2.1 Introduction

Agricultural production is an inherently risky enterprise. Some of the main issues regarding risks in agriculture revolve around the level of yields and more recently the degradation of the environment as a result of unsustainable agricultural practices. In recent years, substantial technological progress has provided farmers with the means and capacity to improve farms yields and efficiency while limiting the effects of occurrences, such as weather variations, on farm productivity. However, these technologies are not always innocuous to the environment. There are concerns about the detrimental impact of current agricultural methods on the environment, the growing dependence of agriculture on non-renewable natural capital, and the long-run efficiency of agricultural systems that rely on high external-input. And these concerns have led to the promotion of sustainable agricultural practices by governmental and non-governmental bodies (De sauza et al., 1999). One practice that has been widely promoted is organic farming. This method of farming is viewed by some as one that offers answers to problems linked to conventional farming such as biodiversity loss, pollution and animal wellbeing (Häring et al., 2004; Lampkin, 1994; Lynggaard, 2006; Rigby et al., 2001 and Van Mansvelt and Mulder, 1993; Lapple et al., 2011).

Organic farming has been widely supported as an opportunity for small-scale farmers in Africa to meet consumption needs and also for commercialization (Green Clippings, 2003 in Thamaga-Chitja and Hendriks, 2008). Growing consumer support for more health and environmental consciousness in developed countries has resulted in a corresponding upsurge in the demand for produce from sustainable production methods (Niemeyer and Lombard, 2003). South Africa, unlike other Sub-Saharan countries, has also seen a considerable growth in the domestic market for organic products (Groslink, 2002). As a result, there is a potential for local consumer driven organic farming in South Africa that is not dependent solely on the export markets from Europe and the USA (Niemeyer and Lombard, 2003). With the right incentivising environment, organic agriculture could offer economic development for small scale farmers in South Africa (Thamaga-Chitja and Hendriks; 2008). If the adoption of organic agricultural practices is seen as an essential characteristic of a mobilization towards more sustainable agriculture [and the economic progress of smallholder farmers] then an understanding of the determinants of uptake of sustainable technology should be a crucial element of policy design (Burton et al.; 1999)

One challenge facing the development community is that the diffusion of agricultural technology has been slow in developing countries (Feder et al., 1985; Engle-Warnick et al., 2007; Duflo et al., 2011; Simtowe, 2006, Fernandez-Cornejo et al., 2002; Brick and Visser, 2014). It has been observed that poor farmers that have difficulty guarding against consumption risk respond by selecting low return - low risk agricultural practices (Brick and Visser, 2014). This is possibly because uptake of technology does not occur independently from other risk related activities (Smit and Skinner, 2002). Studies have also shown that organic farming may be suffering an even greater hindrance from this proclivity for low-risk-low return agricultural practices. Organic farming differs from conventional farming in that it depends natural processes of the environment and, as a result, entails specific risk and risk management methods. Organic farming practices exclude the effective management devices that have been established and used in conventional farming, e.g. synthetic chemicals and antibiotics (Hanson et al., 2004) which decrease output variability by increasing agricultural production in adverse states of nature (Horowitz and Lichtenberg, 1994). Serra and Zilberman (2008) found evidence that the ability to control production risk do differ between organic and conventional farms a consequence of which is organic farms suffering a higher burden of risk. They thus deduce that, to the extent that average profit and variances vary between organic and conventional farming, farmers' risk preferences may contribute to explaining economic behaviour in framework of farm technology uptake.

Current available literature has documented several important factors that influence adoption behaviour (Serra and Zilberman; 2008) and technology uptake. These are economic factors like financial resources (Maddison, 2007; Nhemachena and Hassan, 2007) and observable non-economic factors like personal characteristics (organic farmers have been typically found to be better educated and younger relative to conventional growers) (Serra and Zilberman; 2008) and, since adoption is still subject to the deliberate decision-making of the farmers (Smit and Skinner, 2002), also immaterial personal characteristics like fears.

Ziervogel et al. (2006) proposes that wealthy farmers are more able to pursue market priorities (e.g. planting crops that are more income generating), instead of adaptation priorities (e.g. planting crops that are more drought resistance) because they possess resources that make them more able to substitute their incomes in the event of loss. Poorer farmers, because of lesser access to inputs, will be more inclined to improve their resilience by expanding their strategies to counter shocks rather than focus on market priorities. Panda et.al (2013) find evidence to suggest that total income and total farming income were correlated with changing crop variety (i.e. changing from rice to cotton and the use of early maturing crop variety). Their findings show that farm experience, land area irrigated, and access to credit are positively related to two farm technology uptake options while crop insurance and water resource are each positively linked to the uptake three farm uptake options. Shiferaw and Holden (1998) find that the age of the farmer and adoption of soil conservation techniques are negatively correlated, suggesting that older farmers are more resistant to reforming or adopting new farm practices. Niemeyer and Lombard (2003) in looking at the difference between organic and conventional farmers find that younger farmers and farmers with higher education levels tended practice organic farming more than conventional farmers. They establish that their findings abide by innovation theory, which states that innovators are younger and more educated.

Studies on farmers' decision making and behaviour in developing countries have paid close attention to the role of risk preferences (Feder, 1980; Just and Zilberman, 1983, Liu and Huang, 2010). One concern has been risk averting behaviour prompted by low income smallholder farmers' incapacity to transfer risks to third parties which is exacerbated by constraint such as inadequate or absent insurance, credit, and labour markets. This risk averting behaviour is alleged to be responsible for the risk-induced poverty trap (Yesuf and Bluffstone, 2009) in which farmers in developing countries find themselves.

The constraints and factors we have mentioned affect technology uptake directly but in this study we are particularly interested in looking as their effects on uptake through their effects on risk aversion. It is important to mention that there are two component of risk aversion, namely, pure risk-aversion and market risk-aversion (Binswanger and Sillers, 1983; Eswaran and Kotwal, 1990 in Knight et al., (2003) Pure risk-aversion is a manifestation of inherent preference (a psychological trait) and is defined scientifically by the concavity of an individual's utility function. Market risk-aversion, on the other hand, results from the interaction of pure risk-preference with constraints and risk mitigating opportunities (i.e. it is partially determined by one's ability to shoulder risk). With the same risk-preferences, i.e. pure risk-aversion, farmers may exhibit dissimilar behaviour in reaction to risk if they have differing levels of access to capital, credit or differ in their aptitude for mitigating risk (Masson, 1972 in Knight et al., 2003) through for example accumulated human capital such as education. Education, by improving farmers' aptitude for receiving and decoding information, may directly reduce market risk-aversion. It may also decrease market risk-aversion indirectly through its influence on wealth and access to credit (Knight et al. 2003).

Another preference that has been identified in literature as being important to the technology adoption process is preference for gains over losses. One key empirical observation with regards gains and losses is that individuals tend to exhibit more sensitivity to losses compared to proportionate gains (Sebora and Cornwall, 1995). A consequence of this is that the utility function for losses is steeper than that of gains (Köbberling and Wakker, 2005). This phenomenon is known as 'Loss aversion' and is scientifically denoted by the kink in the utility function below the horizontal axis. There are several scenarios in which a farmer may be loss averse. The first is that the farmer perceives the level of risks and [absolute] payoffs to be similar between gains and losses but likes risk in one of the domains compared to the other. On the other hand, risk aversion can differ between the gain and loss domains because the farmer perceives the risk and absolute payoff levels to differ between gains and losses but likes the risk associated with both domains equally (Weber et al., 2002).

Empirical evidence has in fact established that loss aversion exists and is also influenced by similar factors and constraints as risk aversion and, similar to risk aversion, it may also have an effect on technology uptake. A number of studies have explored the relation between risk or loss aversion and farm technology uptake. Liu (2013) finds that Chinese farmers that exhibit greater loss aversion adopt Bt cotton later. Ward and Singh (2013), in their sample of study, determine that loss aversion is correlated with a switch from traditional rice seeds to a new variety. Hill (2005) using a sample of Ugandan farmers, finds that risk aversion is correlated with replanting of coffee trees. Serra and Zilberman (2008) find risk aversion to decreases the uptake of organic farming processes. Burton et al. (1999) in looking at the contributing factor to uptake decision of organic production processes found that attitudinal factors are linked to adoption. This suggests that any study of the determinants of the adoption of organic techniques which is limited to farm-level financial factors may be omitting important features of the decision making process (Burton et al.; 1999). As previously mentioned, we include two attitudinal variable namely risk and loss aversion in our study and our focus is on the urban organic smallholder agriculture in the city of Cape Town South Africa.

Urban agriculture is roughly defined as 'the cultivation, processing, marketing and distribution of food crops and products in an urban environment and for the benefit of urban residents' (City of Cape Town, 2007:3). This form of agriculture is particularly important because of its ability to support cities' poverty alleviation strategies by giving marginalised urban residents sources of income and employment that are related to small scale agricultural production (Hovorka et al., 2009). Urban agriculture has a great potential in a South African where continuing poverty and social marginalization are strongly related (Adato et al., 2006). Urban agriculture combined with organic practices can make a useful contribution to the sustainable development process in South Africa.

In this chapter, the sample of study consists of 82 small scale and subsistence farmers, in the urban informal settlements of Cape Town, who are members of Abalimi Bezekhaya's Harvest of Hope Scheme. Abalimi Bezekhaya is an urban agriculture (UA) and environmental action (EA) non-government organization (NGO) functioning in some of the urban informal settlement in around Cape Town South Africa. Harvest of Hope is an organic vegetable box project which originated from a partnership between the South African Institute for Entrepreneurship, the Ackerman Pick 'n Pay Foundation and Abalimi Bezekhaya (De Satge and William, 2008). The Harvest of Hope Scheme offers a means of marketing excess produce on behalf of farmers. The farmers that partake in the project cultivate organic produce in vegetable gardens in Cape Town. Information on farmer characteristics are obtained from survey data whilst risk preferences are obtained using a series of lottery type experiments conducted with the farmers, which are then used to estimate risk and loss aversion parameters. The chapter is presented in 6 sections. In the introduction, section 2.1, we give an overview of current theory and literature regarding the study. Section 2.2 describes the survey data and sample statistics. Section 2.3 presents an outline of the methodology and elicitation method used to estimate risk and loss aversion. Section 2.4 presents the regression results for the determinants of risk preferences and loss aversion. Section 2.5 shows the regression results for determinants of organic farm technology uptake. Section 2.6 is the conclusion.

2.2 Sample

This study uses a sample of 82 small scale and subsistence farmers, in the urban informal settlements of Cape Town South Africa, who participate in the Harvest of Hope scheme of Abalimi Bezekhaya[8]. The data was obtained by Martine Visser and Kerri Brick of the Environmental Research Policy Unit EPRU, University of Cape Town. The sample

[8] The questionnaire can be found in Appendix 4.

summary statistics are presented in Tables 1. In Table 1, the average age of farmers in the Sample is 54 years. Most of the farmers are female, making up approximately 62 percent of the sample. Approximately 19 percent of the farmers have another source of employment besides farming. Average education level in the sample is low with the average attainment being primary school education. 24 percent of the farmers stated that they had not completed primary school and only 18 have a matric certificate. The average monthly household income is also low with the average being approximately R696. Only 30 percent of the farmers had some form of insurance at the time of the survey. 66.7 percent of the sample had previously applied for a loan while 29.3 percent have had some form of formal insurance.

Summary statistics for self-reported indicators of risk preference are also included. The respondents were asked to indicate what type of person they were in terms of risk attitude, the respondents had the option of choosing between 'Often takes risks', 'Sometimes takes risks' or 'Never takes risks'. 45.2 percent of the sample indicated that they never take risks, 34.4 percent indicated that they sometime take risks and 16.4 percent stated that they often takes risks. This subjective measures of risk preference, despite its biases, is consistent with results from empirical studies that found most farmers to be risk averse (Escalante et al. 2001).

Table 1: Basic Summary Statistics

	Mean	Standard Deviation
Age	53.852	14.365
Male	38.00%	48.80%
Female	62.00%	48.80%
No Schooling	13.40%	34.30%
Education Level	8.61	4.27
Incomplete Primary Schooling	24.40%	43.20%
Complete Primary Schooling	12.20%	32.90%
Some Secondary Schooling	31.70%	46.80%
Grade 12	7.30%	26.20%
Matric Certificate	18.30%	38.90%
Higher Education	9.80%	29.90%
Employed	19.10%	39.60%
Monthly HH Income	696.863	597.837
Below Avg. Rel. HH Income	52.941%	50.664%
Farm Experience in yrs.	4.375	3.939

Loan	66.70%	47.80%
Insurance	29.30%	45.80%
Often takes risks	16.40%	37.30%
Sometime takes risks	38.40%	49.00%
Never takes risks	45.20%	50.10%

Sample size:82

In the survey, farmers were asked if they used a number of farming technology and practices. In this study, we explore 6 of the option, namely, Intercropping, Organic Manure, Mulching, Improved Seeds and Windbreaks. The summary statistics for the uptake of these options are presented in Table 2 below. 52.4 percent of the farmers stated that they used Intercropping, 71.95 percent stated that they used organic manure, 71.17 percent of the farmer stated that they used mulching, 48.78 percent stated that they used improved seeds and 50 percent stated that they used wind breaks.

Deressa et al. (2009) using a sample from the Nile Basin of Ethiopia found an adoption rate of 58 percent. Hassan and Nhemachena (2008) analysed the contributing factors to farm climate adaptation measures in Africa, they uses a cross-sectional survey of more than 8000 farms across 11 countries in African. They found that 63 percent of their sample had adopted at least 1 farm strategy. One possible explanation for the high uptake rate found in our sample is the effect of NGO and government support provided to the farmers.

The Harvest of Hope scheme entails that Abalimi provides the farmers with inputs, infrastructure, technical advice, institutional support and organised production and marketing practice. Intermediaries are removed in the distribution system thus permitting farmers to improve profits (Jarosz 2008; Kirkland, 2008). The farmers pay for seedlings, seed and electricity while Abalimi or other agencies like the Department of Agriculture, the Department of Social Services and the City of Cape Town cover the expenses of organic fertiliser, manure, transport, mulch, fencing, irrigation infrastructure, transport and marketing (De Satgé and Williams, 2008).

Table 2: Technology Uptake

Variable	Mean	Standard Deviation
Intercropping	52.44%	50.25%
Organic manure	71.95%	45.20%
Mulching	73.17%	44.58%
Improved Seeds	48.78%	50.29%
Wind breaks	50.00%	50.31%

Sample Size: 82

2.3 Estimating the Risk and Loss Aversion Parameters

2.3.1 Methodology

Owing to the assumption that risk preferences have sign dependence, we assume a loss aversion index (λ). We then consider a Certainty Equivalent CE gamble where the respondents are asked to equate a sure outcome y to a gamble (q, M, m). M and m being the absolute value maximum and minimum outcomes, respectively. Outcome y is varied in order to get to the indifference point. Two outcomes are then considered under the assumption of expected utility: $y \sim (q, M, m)$ and $U(y) = qU(M) + (1 - q)U(m) = q$. We normalise the CE by assuming that $U(M) = 1$ and $U(m) = 0$. Therefore, for outcomes perceived as losses we assume $U(y)_{\text{loss frame}} = \lambda U(y)$. The CE is thus; $|\text{CE}| = \frac{|y| - |m|}{|M| - |m|}$. The higher the CE in the gains frame the greater amount an individual will need in order to make the riskier option equivalent to the certain option. This implies that the less risk averse and individual will be in the gains frame. The higher the |CE| in the loss frame the greater the absolute value of the amount an individual will need in order to make the riskier option equivalent to the certain option. This implies that the less risk averse and individual will be in the loss frame.

We estimate the risk aversion parameters using the CE directly. We do not assume any specific parametric functions. While there are benefits to parametric studies, outcomes may be subject to the specific parametric function selected. Non-parametric estimation, on the other hand, permits reliable tests of crucial characteristics concerning the shapes of the utility function (Abdellaoui, 2000).

Loss aversion is modelled using a basic utility function u and a loss aversion index. The Utility U is the utility that is observable and it constitutes the loss aversion index $\lambda > 0$ and the basic utility u. The parameter λ represents the rate at which losses are evaluated compared to gains (Kobberling and Wakker, 2005). The equation is formally written as:

$$U(x) = \begin{cases} u(x)\ if\ x \geq 0 \\ \lambda u(x) if\ x \leq 0 \end{cases} \qquad \text{Equation 2.1}$$

Kahneman and Tversky (1979) definition of loss aversion considers $-U\ (-x) > U(x)$ for all $x > 0$. The loss aversion parameter is then evaluated at the mean or median of $-U(-x)/U(x)$ over related x. We use Tversky and Kahneman (1992) where loss aversion is $-U(-\$1)/U(\$1)$. This is the limiting case of Kahneman and Tversky (1979).

2.3.2 Elicitation and Estimation

Brick and Visser (2014) elicited preference by use of multiple price lists (MPL). A MPL is a fairly simple method for eliciting values. With the aim of estimating a willingness to pay for goods, the subject are presented with a range of ordered prices in a tabular form, one per row, the respondents can indicate whether or not they accept each price (Andersen et al., 2006). In order words, it elicits the prices that are equivalent to the value of a good for each individual. Similarly Brick and Visser (2014) we use a multiple price list to obtain the certainty equivalent value of a gamble for each respondent. In the experiments, the test subjects were offered three gambles. In each gamble, they were asked to make a series of choices between a risky prospect and a sure payoff that was increasing in absolute value[9].

Brick and Visser (2014) following Moore and Eckel (2003), presented an increasing/decreasing certain payoff in Option 1 which ranges from R3 to R26, in absolute value. The payoff increases (decreases), in R1 increments, for the gains (loss) frame decision sheets. This incremental increase or decrease is the same in all the decision sheets. In option 2, the payoff is the same all through the decision rows. Subjects could either earn or lose R50 for the gain and loss frame sheet, respectively, or nothing. A significantly risk averse participant would select option 1 in row 1 of the decision sheet, and a very risk-loving participant would select option 2 in the final row of the decision sheet. The row at which a subject moves from

[9] A sample of the framing for the decision sheet is presented in Appendix 5

option 2 to option 1, for gains the frame, or option 1 to option 2, for loss frame, is used to approximate the individuals' certainty equivalent.

The instructions were cautiously formulated to make the logical inconsistency of multiple switching clear to the subjects. After participants had gone through the instructions, a practice round was carried out, were the participants were asked to identify the row in which they opted to switch from option 2 to option 1 in the gain frame and option 1 to option two in the loss frame. Two of the participants demonstrated multiple switching and were thus omitted from the sample. Note that several examples were given to the subjects, including: choosing only option 1, choosing only option 2 and switching from option 2 to option 1 (for gains) and option 1 to option 2 (for losses) at various rows. Consequently, participants did not perceive having a switching point at a particular point to be required.

Following the collection of the decision sheets for each gamble, each subject drew a ball from a bag in order to determine the row in the decision sheet that was to be played for money. Due to the prevalence of low education and numeracy levels in the sample, the probabilities linked with each gamble were represented on a spinning wheel. The wheel had two sections, one black and one white, which were equivalent to the probabilities in the relevant gamble. Ensuing the spinning of the wheel, if a participant chose option 2 in the relevant row being played and the arrow points to the black section, then participant would gain or lose R50; similarly, if the arrow points to white, the participant will gain or lose nothing. Information was symmetric between the experimenter and the subjects. Both knew the row to be played for money and the outcome that would result from spinning the wheel.

The summary statistics and graphs for the distribution of risk aversion and loss aversion obtain in the lottery type experiment are presented in the Figures 1 and 2 below. The risk aversion parameters are normalized so that the midpoint, 0.5, signifies risk neutrality. Risk aversion measures below 0.5 indicate risk-averse preferences whilst risk aversion measures above 0.5 indicate risk-seeking. Individuals that exhibit extreme risk aversion will have a risk aversion measures close to zero, whilst individuals that exhibit extreme risk seeking will have risk aversion measures close to 1. The average risk aversion measures are 0.175, 0.225 and 0.326 for the 30, 50 and 70 percent probabilities in the gains frame. This indicates that most of the respondents are risk averse in the gains frame with risk aversion decreasing as the probability of gains increases.

In the loss frame, the average risk aversion measures was much higher than that of gains, The measure indicates that, on average, the farmers exhibit risk seeking behaviour in this frame. The risk preference measures in the loss frame are 0.514, 0.510, and 0.581 at the 30, 50 and 70 percent probability, respectively. Consistent with Tversky and Kahneman (1992) and most literature, this implies greater sensitivity to losses compared to gains because the certainty equivalents of losses are higher. It can also be seen that, on average, risk aversion in the loss frame decreases with the increase in the probability of loss. If we relax the assumption of strict risk neutrality, the average risk preference over losses could at the margin be classified as risk neutrality since all the risk preference measures in the loss frame are close to 0.5. The loss aversion indexes are 2.97, 2.62 and 1.13 at the 30, 50 and 70 percent probabilities, respectively. We find that the loss aversion index decreases as the probability of gain/losses increases.

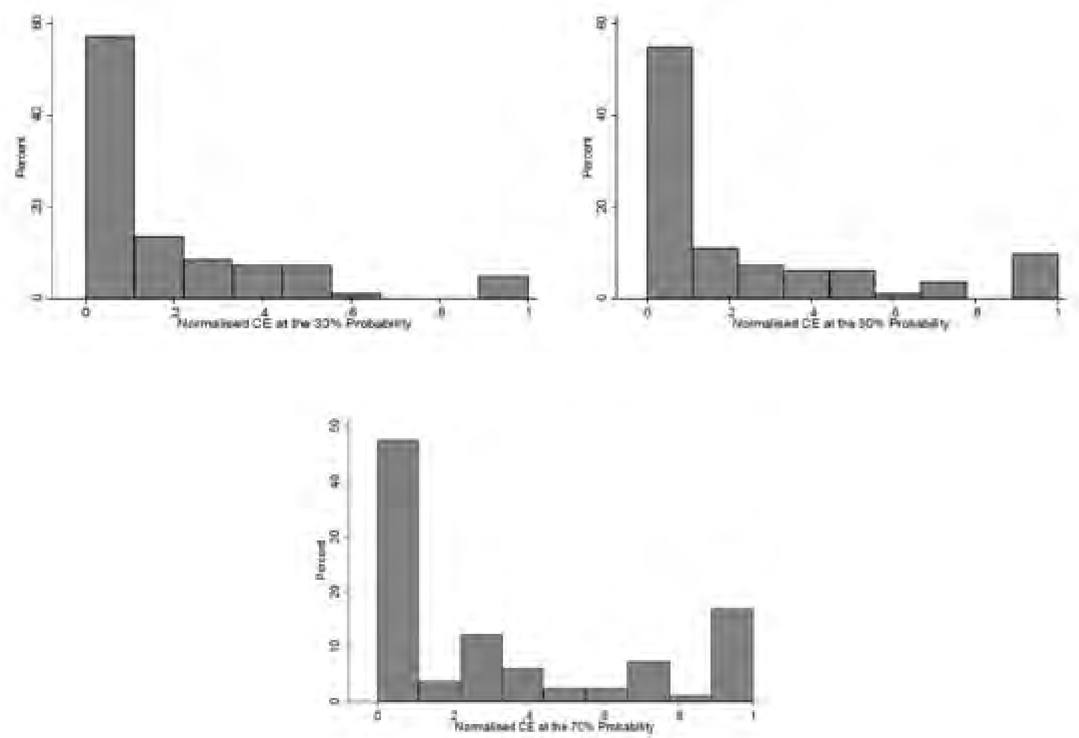


Figure 1: Distribution of Risk Aversion(Gains Frame)

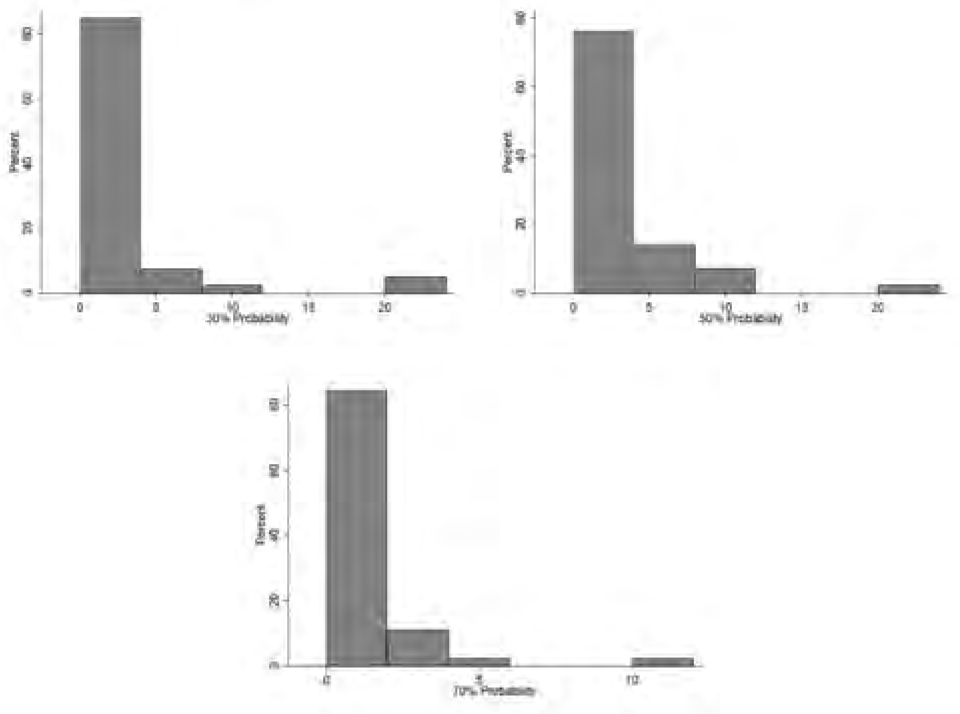


Figure 2: Distribution of Loss Aversion

2.4 Determinants of Risk Aversion and Loss Aversion

We carry out regressions to determine the human capital and socio-economic characteristics that affect risk and loss aversion. Table 3 shows the result of the Panel Data Tobit regressions with random effects. The regressions describe the relationship between a non-negative dependent variable and an independent variable. Coefficients are ceteris paribus marginal effects for an average individual. We multiply the preference parameters by -1 so that a positive coefficient indicates an increase in risk or loss aversion.

The independent variables are; dummy variables session 1,2 and 3; these indicate the experiment session in which the farmers participated in, dummy variables for the 30 percent and 70 percent probability of Gain/losses; this is represented by a variable = 1 if the lottery type experiment had a 30 percent or 70 percent probability of loss or gains and 0 otherwise, the farmer's age, dummy variable = 1 if the farmer is female, education level of the farmer, monthly household income, dummy variable = 1 if the farmer has an alternative source of paid employment besides farming, the farmers farm experience in years, household size, dummy variable = 1 if the household has below the average relative household income; relative income here is the ratio of the individuals household income and mean income in the sample.

Our findings indicate that age (p-value = 0.031; 0.042) is related to increased risk aversion. Education is correlated to lower risk (p-value = 0.013; 0.016) and loss aversion (p-value = 0.028; 0.010). Employed individuals are less risk averse (p-value = 0.000; 0.000) than individuals that are unemployed. Farm experience (p-value = 0.049; 0.017) and household income (p-value = 0.004) are related to less loss aversion. These effects are expected since education, farm experience and employment are all factors that are linked to greater earning capacity and greater earnings imply lower relative income risk and loss. Furthermore, education increases the ability to process outcomes thus decreasing uncertainty and resulting in lower level of risk and loss aversion.

Table 3: Determinant of Risk and Loss Aversion

	Risk Aversion		**Loss Aversion**	
	(1)	**(2)**	**(1)**	**(2)**
Session 2	0.071 *(0.099)*	0.097 *(0.098)*	-6.724 *(2.422)***	-3.890 *(2.304)+*
Session 3	0.158 *(0.128)*	0.187 *(0.125)*	-8.515 *(2.641)***	-5.115 *(2.387)**
30% Prob. Gains/Losses	0.037 *(0.064)*	0.037 *(0.064)*	1.532 *(1.320)*	1.760 *(1.401)*
70% Prob. Gains/Losses	-0.043 *(0.064)*	-0.043 *(0.064)*	-0.836 *(1.365)*	-0.736 *(1.452)*
Age	0.007 *(0.003)**	0.006 *(0.003)**	-0.071 *(0.048)*	-0.074 *(0.051)*
Female	0.054 *(0.072)*	0.057 *(0.073)*	-0.127 *(1.515)*	-0.586 *(1.607)*
Education Level	-0.024 *(0.010)**	-0.024 *(0.010)**	-0.437 *(0.199)**	-0.532 *(0.208)**
Employment	-0.418 *(0.097)***	-0.430 *(0.098)***	-0.199 *(1.710)*	-0.489 *(1.815)*
Farm Experience in Yrs.	0.006 *(0.009)*	0.005 *(0.009)*	-0.412 *(0.209)**	-0.521 *(0.218)**
Household Size	0.006 *(0.017)*	0.007 *(0.017)*	-0.292 *(0.279)*	-0.265 *(0.299)*
Households Income	-0.000 *(0.000)*	_	-0.004 *(0.001)***	_
Below Avg. Relative HH Inc.	_	0.093 *(0.070)*	_	1.896 *(1.346)*

Constant	0.553 *(0.243)**	0.423 *(0.233)+*	22.721 *(4.620)***	18.008 *(4.618)***
Wald Chi Squared	46.39	44.68	39.76	29.86
Prob > Chi Squared	0.0000	0.0000	0.0000	0.0017
DF	11	11	11	11

Standard errors in parentheses + significant at 10%; * significant at 5%; ** significant at 1%

2.5 Technology Uptake: Survey

We consider the socio economic and human capital factors that influence uptake and whether or not they impact uptake through risk and loss aversion. We look at 6 organic farming options, namely, Intercropping, Organic Manure, Mulching, Improved Seeds and Windbreaks.

Windbreaks are generally trees or shrubs planted in an order that provides shielding to protect soil from erosion by wind. Wind breaks which are the core pest control for the Abalimi organic gardens are supplied to the farmers at no cost. Mulching is also used by the farmers to prevent from wind erosion. It is a process of using a layer of a protective material (e.g. grass clippings, straw and stones) to cover the top of the soil. Abalimi supplies mulching material from their gardens to the farmers. The main issue identified with using mulch in the gardens is that it attracts snails however this occurs when the mulch is not used properly. Increased snails means increased labour burden to the farmers. The improved seed used by Abalimi farmers are not of the genetically modified variety as these go against the rules of production in the gardens. The improved seeds are thus seeds and seedlings of the hybrid variety. Abalimi provides seeds to farmers at a cost while the department of agriculture sometimes gives free seeds to farmers and this is mostly linked to start ups and training. The alternative to hybrid seeds is traditional seeds which are seeds of the open pollinated variety. Abalimi encourages the farmers to use the open pollinated variety as the seeds can be collected and used in the next planting season however Abalimi reported that the farmers prefer to use the hybrid seeds. Two reasons that they provided was that first, the outcomes of the open pollinated variety are more uncertain and there is less public information on the open pollinated variety thus making them the more risky option, and second, **t**here has been a move toward hybridization and experts often recommend the hybrids and even though hybrid seeds are costly, on the micro farm small scale, the costs are not substantial.

Organic manure is also used by the farmers in the gardens. Organic manures are fertilizers sourced from animal or vegetable matter. Abalimi supplies free cow manure and compost to the farmers. The government also often supplies provides organic manure to the farmers. Abalimi stated that the main problem with manure usage was shortages. When there is a shortage the farmers themselves have to buy organic manure. The application of organic manure in the gardens is not labour intensive or time consuming. Furthermore, its use has a high payoff in the long run and in the short run it has a high payoff when used in abundance. However because of past experience with shortages, some of the farmers tend to under fertilize and get poor results. Intercropping is a technique that is highly recommended to the farmers. It involves the cultivation of two or more crops in proximity. The aim of the use of intercropping is to generate greater yields on a piece of land by using resources that would otherwise not be used by a single crop both spatially and over time. Abalimi encourages the use of intercropping. Intercropping does not take up labour or time and has a high payoff if properly manage however it requires a more disciplined fertilizing regime.

Table 4 presents the results of the logit regressions of adoption of organic farm technology[10]. The dependent variable is a dummy variable with 1 indicating that the individual adopted a specific option and 0 indicating that the respondent did not. The coefficients obtained in the logit regressions are, ceteris paribus, marginal effects. They are the expected changes in the probability of adopting an option due to a unit change in the explanatory variable. We find that increased loss aversion is related to greater likelihood of uptake of organic manure (p-value = 0.055). Older individuals are less likely to use organic manure (p-value = 0.013; 0.004), mulch (p-value =.043; 0.058) and are more likely to take up improved seeds (p-value = 0.007; 0.005). Primary bread winners (p-value = 0.000; 0.000) are more likely to take up mulching. Farm experience increases the likelihood of intercropping uptake (p-value = 0.096) and windbreaks (p-value = 0.038; 0.033) uptake. Education increases the likelihood of intercropping (p-value = 0.091; 0.050), improved seeds (p-value = 0.046; 0.022) and windbreaks (p-value = 0.002; 0.004) uptake. Household size increases the likelihood of mulching (p-value = 0.048; 0.047) and improved seeds (p-value = 0.000; 0.000) uptake and decreased the likelihood of manure (p-value = 0.023; 0.036) uptake. We find that employed individuals are more likely to take up mulching (p-value = 0.012; 0.009) and windbreaks (p-

[10] Results with Houshold income are presented in Appendix 6

value = 0.061; 0.092). Individuals with below average relative household income are less likely mulching (p-value = 0.019; 0.023) and improved seeds (p-value = 0.000; 0.000).

Our findings show that the human capital and socio-economic factors namely, farm experience, education and employment that are linked to risk aversion, loss aversion and greater earning capacity generally influence technology uptake. However, risk and loss aversion are not found to decrease the likelihood of any of the uptake option. Thus, one can purport that the human capital and socioeconomic factors are not increasing uptake through their effects on risk and loss aversion. Our evidence on relative income position shows that it represents significant financial constraints, but it could also be an indication that farmers develop subjective norms from their observations regarding the correct strategy or solution from other members of their social group (Gifford, 2011).

Table 4: Determinants of Uptake

	Intercropping		Manure		Mulching		Improved Seeds		Windbreaks	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Risk Aversion(Gains Frame)	-0.574	–	-0.801	–	0.881		1.439	–	1.274	–
	(0.780)		*(0.701)*		*(1.026)*		*(1.266)*		*(0.977)*	
Loss Aversion	–	0.025	–	0.265	–	0.047	–	0.105	–	0.062
		(0.069)		*(0.138)*+		*(0.062)*		*(0.075)*		*(0.065)*
30% Prob. Gains/Losses	0.023	-0.024	0.005	-0.087	-0.023	-0.052	-0.063	-0.199	0.017	-0.019
	(0.569)	*(0.563)*	*(0.646)*	*(0.658)*	*(0.632)*	*(0.655)*	*(0.712)*	*(0.718)*	*(0.582)*	*(0.585)*
70% Prob. Gains/Losses	-0.034	0.021	-0.056	0.102	0.104	0.050	0.079	0.070	0.136	0.068
	(0.564)	*(0.568)*	*(0.650)*	*(0.688)*	*(0.634)*	*(0.640)*	*(0.710)*	*(0.708)*	*(0.592)*	*(0.593)*
Age	0.018	0.015	-0.065	-0.075	-0.046	-0.044	0.076	0.079	0.027	0.034
	(0.025)	*(0.024)*	*(0.026)**	*(0.026)***	*(0.023)**	*(0.023)*+	*(0.028)***	*(0.028)***	*(0.023)*	*(0.021)*
Female	-0.488	-0.530	0.627	0.425	-0.690	-0.615	-0.153	0.118	-0.281	-0.192
	(0.525)	*(0.529)*	*(0.657)*	*(0.666)*	*(0.781)*	*(0.750)*	*(0.657)*	*(0.680)*	*(0.538)*	*(0.539)*
Primary Bread Winner	0.326	0.327	-0.202	-0.080	2.629	2.794	-0.928	-0.623	0.913	1.047
	(0.533)	*(0.506)*	*(0.834)*	*(0.838)*	*(0.591)***	*(0.628)***	*(0.718)*	*(0.682)*	*(0.662)*	*(0.688)*
Farm Experience in Yrs.	0.096	0.100	0.130	0.140	0.114	0.117	-0.061	-0.049	0.121	0.121
	(0.059)+	*(0.060)*+	*(0.092)*	*(0.087)*	*(0.102)*	*(0.101)*	*(0.067)*	*(0.065)*	*(0.059)**	*(0.057)**
Education Level	0.132	0.151	-0.074	0.000	-0.077	-0.076	0.146	0.160	0.201	0.200
	(0.078)+	*(0.077)*+	*(0.068)*	*(0.087)*	*(0.071)*	*(0.072)*	*(0.073)**	*(0.070)**	*(0.065)***	*(0.069)***
Household Size	0.222	0.225	-0.292	-0.296	0.306	0.300	0.855	0.823	0.010	-0.003
	(0.145)	*(0.145)*	*(0.129)**	*(0.141)**	*(0.154)**	*(0.152)**	*(0.172)***	*(0.165)***	*(0.123)*	*(0.118)*
Employment	0.657	0.958	-0.469	0.726	3.132	3.000	-0.158	-0.265	1.678	1.407
	(0.739)	*(0.756)*	*(0.893)*	*(1.035)*	*(1.243)**	*(1.143)***	*(1.198)*	*(1.066)*	*(0.897)*+	*(0.835)*+
Below Avg. Relative Inc.	-0.771	-0.844	-0.452	-0.703	-1.297	-1.244	-3.315	-3.177	-0.394	-0.289
	(0.503)	*(0.503)*+	*(0.549)*	*(0.613)*	*(0.551)**	*(0.549)**	*(0.691)***	*(0.726)***	*(0.529)*	*(0.526)*
Constant	-3.101	-3.636	7.019	5.343	-0.092	0.118	-8.626	-8.487	-5.644	-5.373
	(1.921)	*(1.943)*+	*(1.648)***	*(1.599)***	*(2.164)*	*(2.071)*	*(2.287)***	*(2.073)***	*(1.711)***	*(1.731)***
Observations	90	90	90	90	90	90	90	90	90	90
Wald Chi Squared	12.97	12.80	19.44	19.04	29.73	28.96	51.56	50.20	22.92	19.99
Prob > Chi Squared	0.2954	0.3066	0.0537	0.0604	0.0017	0.0023	0.0000	0.0000	0.0181	0.0455
DF	11	11	11	11	11	11	11	11	11	11

Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%

2.6 Conclusion (Chapter 2)

Many urban small-scale farmers function in greatly constrained settings which are characterised by a deficiency in human capital, poor access to land, technology, credit and infrastructure for production, technical and institutional backing, market linkages and aptitude for farm management. Abalimi Bezekhaya is geared toward providing an extensively subsidised production structure and support scheme which systematically removes or alleviated these constraints (De Satge and William, 2008). Such incentives where the risk of organic farm technology uptake is shared between the farmers and another party are effective methods of overcoming farmers' adverse sensitivities. Nonetheless, these types of packages are expensive and direct financial support systems cannot guarantee the economic practicality of organic farm production in the long term **(**Genius et al., 2006)

In order to identify alternative means of supporting farmers in the uptake of organic farming technology, it is important to look at the characteristics that motivate adoption amongst the farmers. Our study finds that even with subsidies in place, low human capital and financial obstacles are still major impediments to organic farm technology uptake. This suggests that there is a need for the establishment and strengthening of institutional platforms that are geared towards greater access to knowledge sharing, information services and training provision for organic farmers.

Our study also show that even though the Harvest of Hope farmers faced minimized income risks due to substantial infrastructure and input support, financial constraints still exist. This point toward the potential of financial incentives, such as credit schemes targeted at low income farmers and linked to organic farm technology, to improve small-scale organic farming. Although some level of infrastructure support is needed in order support the entry of farmers into the organic farming enterprise, loans as opposed to subsidies are more likely to give more market and profit driven incentives to the farmers. The evidence that income groups, as opposed to income itself, has a greater effect on uptake suggests a need for greater development of social capital and social networks that involve greater information sharing and performance linkages between farmers.

Chapter 3 - The Link between Insurance and Farm Technology Uptake amongst Small Holder Farmers in the Matzikama Municipality: Risk Preferences, Poverty Traps and Timing

3.1 Introduction

Poor farmers in developing countries face a number constraints that have been found to inspire behavioural or cognitive traits that inhibit farm technology uptake. In economic literature, one of most explored of these traits is risk aversion. Evidence from majority of the studies on agricultural risk management indicate that most farmers are risk averse. This is expected given that small scale farmers in developing countries face a number of risks that are inherent to environment which they operate in. Some of the risks are explicit via changes in the agro-ecological environment while others are implicit via effects on growth and income distribution (IPCC, 2007). The problem facing development stakeholder, in the food growth challenge, is thus two-fold. The first is to guarantee that the agricultural system is able to comply with food demand which, amongst others, is contingent on the agro-ecological requisites of crop production. The second is to ensure that farmers are insulated from short term or long term loss of access to resources that are linked to the sufficient consumption of necessities like food (Tubiello et al., 2007). The problems are not independent. For instance, farmers that rely wholly on income from agricultural sources are more vulnerable to agricultural shocks and, as a result, would have a higher risk of losing access to resources that makes consumption possible (Schmidhuber and Tubiello, 2007). Similarly, in order to limit consumption risk, farmers may refrain from investing time or resources in agricultural production and pursue other more predictable non-farming activities so as to substitute farm income in the event of an unsuccessful harvest (Ellis, 2000). That is to say that farmers who are unable to adequately protect their households from consumption risk choose to avert this risk by opting for low risk agricultural production which entails lower returns (Dercon and Christiaensen, 2011; Mosley and Verschoor, 2005; Brick and Visser, 2014)

Two other behavioural and cognitive traits that have been identified in the literature are loss aversion and nonlinear probability weighting. Loss aversion is an observed phenomena where individuals weight the downside risk associated with an investment more heavily than upside risk. Loss averse behaviour can thus result in farmers avoiding the out of pocket costs associated with technology uptake even when potential benefits i.e. upside risks are high. Nonlinear probability weighting, on the other hand, refers to the observation that individuals have a tendency to overweight small probability events and underweight large probability events. Farmers may display "cognitive failure" in that they underweight the possibility or severity of disastrous events. For example, stakeholder consultations in India and Mongolia show that farmers in recollecting past events tend to underestimate the levels of the negative impacts of those past events (Mahul and Stutley, 2010). This propensity to underweight the severity and likelihood of catastrophic events can result in farmers not taking up the technology associated with mitigation of the impacts of those events.

The notion that low income individuals fail to invest in technology as a result of behavioural or cognitive inclinations prompted by a set of constraints has been extensively considered in literature. One of the most notable theories that have come from this concept is the asset based approach to poverty traps. This approach identifies an asset threshold in which behaviour toward investment diverges. Individuals below that threshold behave in such a way that limits their ability to advance themselves through investment or the accumulation of assets (Carter and Barrett, 2006; 2007). This approach is closely linked to one of the key features of agricultural growth, namely, equitability. High inequality would point toward the bifurcation of behaviour around this threshold being more distinct because of the greater amount of restrictions that poor groups face. Access to credit would be extremely limited for a significant portion of the low income population. This would be primarily because the seasonality of farming and its vulnerability to natural and unpredictable calamities raise the likelihood of default risk of poor farmers and expose the creditors or financial intuitions to covariant price and yield risks (Mahul and Stutley; 2010). One factor that reinforces this credit market imperfection and is often a characteristic of credit markets in developing countries is absent or limited insurance markets. Since agricultural insurance reduces both downside risk and variance in outcomes by transferring excess risk to a third party, insured farmers may be more inclined to take-up loans to invest in more lucrative but sometime riskier activities (Patt et al., 2010). A lack or insurance can also discourage low income farmers from taking on credit due to the risk of high default costs e.g. repossession of property (Gine and Yang, 2009).

There are a number of studies that have been undertaken to determine whether the availability of insurance inspires its uptake as well as the uptake of technology or credit amongst low income farmers. Carter et al. (2008) developed and implemented insurance games with cotton farmers in Peru and herders in Kenya. Using real money at stake, they simulated a series of years and rainfall index and basis risk through the use of coloured chips. They observe, in both countries, that majority of the farmers opt to buy some degree of insurance. Likewise, Dinku et al. (2009) and Peterson and Mullally (2009) conducted insurance games with farmers in Ethiopia as part of a selection of communication instruments to assist in explaining index insurance to farmers.[11] They find that the majority of the farmers were inclined to purchase insurance in the course of the game. Gine and Yang (2009) carried out randomized field experiments using small scale farmers in Malawi to determine whether or not the availability of insurance against a main source of production risk encourages farmers to acquire loans in order to obtain new crop technology. They find loan uptake to be 13 percentage points lower amongst farmers offered an insurance-and-loan bundle compared to farmers who were only offered a loan thus lending little evidence to suggest that insurance is an effective tool in motivating credit uptake. Similar to Gine and Yang (2009, we found that insurance was not an effective to tool in reducing the effects of risk aversion associated with technology uptake. However, because we considered both absolute uptake and timing of uptake, the time factor reveals information that shows that relationship between the insurance component and risk aversion is not as simple as when considered in stasis.

In this chapter, we look at the link between risk aversion, loss aversion and probability weighting and the adoption tradition and new farm technology, namely traditional seeds and improved seeds (with an uninsured loan and insured loan, respectively). In order to test for absolute and path dependent effects, both the levels and timing of adoption are considered. Most studies only considered farm technology uptake at an instantaneous point in time but, in reality, technology uptake decisions are likely to be made in a series of time frames. For example, Liu (2013) carried out an analysis of the role of timing of uptake of bt cotton by farmers in China and found that increased risk and loss aversion were correlated with later technology adoption. Liu (2013) suggests that as time goes by, farmers have a chance to update the information they have regarding the risk of technology which will affect their decisions to take up technology. Studies like these, that consider the timing of uptake, can shine further light on the factors that determine path dependent or structural immobility as suggested by the poverty trap hypothesis.

We use experimental and survey data obtained from 125 farmers from farming communities in the Matzikama Municipality of Western Cape, South Africa. We estimate risk

11 Index insurance is a type of insurance scheme where pays outs are based on a predetermined index, usually a weather index (e.g. rainfall level).

aversion, loss aversion and probability weighting parameters using the TCN (Tanaka et al. (2010)) method. Choices of technology uptake are elicited using a series of insurance games with real money at stake. Tanaka et al. (2010) under the assumption of cumulative prospect theory conducted experiments with villagers in North and South Vietnam. They presented three different multiple price lists with paired lottery choices. The experiment was framed in such a way that the switching point in each list could be used to evaluate the three prospect theory parameters based on a "parsimonious three parameter cumulative prospect value function" (Hurley, 2010). Tanaka et al. (2010) find that on average individuals were risks averse, loss averse and overweighed small probabilities.

This chapter is broken down into 6 sections. Section 3.1 is the introduction. Section 3.2 provides back ground information on the sample of study. Section 3.3 describes the risk preference estimation method. Section 3.4 shows the experiment design for the insurance simulation games. Section 3.5 presents the results for determinants of farm technology uptake. Section 6 presents the results for the cox proportional hazard model of timing of uptake. Section 7 is the conclusion.

3.2 Sample and Background

The data used in this study was obtained by way of survey and experiments undertaken with small-holder farmers in the Matzikama Municipality of the Western Cape, South Africa, between July and August of 2010[12]. The area which is mostly dominated by viniculture, vegetables, citrus fruits and livestock production is characterised by arid terrains and cool temperatures (Matzikama IDP, 2009-2010). Agriculture in Municipality is sustained by the Clanwilliam Dam and Olifants River. Our sample consists of 125 farmers from the towns of Vanrhynsdorp, Lutzville, Klawer, Clanwilliam and Wupperthal solicited through the Matzikama Emerging Farmers Forum.

[12] Sample questionaire is presented in Appendix 1

3.3 Methodology and Experimental Design

Similar to TCN, the Matzikama farmers were given three sets of multiple price lists (MPLs) with pair wise lotteries sheets. The first two lists (i.e. Series 1 and 2) had a series of 14 decision rows each, with both being gain only lotteries. The third sheet (Series 3) had both gain and loss lotteries with 7 decision rows[13.] Subjects have a choice between lottery A or lottery B in each row. The lotteries were framed to represent farming seasons with lottery A representing the outcome if farmers chose to use traditional seeds and lotteries B representing the outcome if farmers chose to use improved seeds. The payoffs are dependent on whether or not there is sufficient rainfall for yields to be good. The premise of this framing is that improved seeds require more rain relative to traditional seeds. The probabilities in the lotteries represented the probabilities of good rainfall for the high payoffs and probabilities of bad rain for the low payoffs. The payoffs represent the yields in a farming season. The MPL lotteries in TCN were structured so that the switching points of the 3 series produce a permutation of the prospect theory parameters risk aversion, non-liner probability weighting and loss aversion. Rainfall probabilities were also denoted by 10 numbered balls. For example, for traditional seeds in series 1, 3 balls represented good rain fall levels while 7 balls represented poor rainfall levels. The rainfall level is determined by one of the subject selecting a ball from the bag.

The MPL lotteries in TCN were structured so that the switching points of the 3 series produce a permutation of the prospect theory parameters risk aversion, non-liner probability weighting and loss aversion. Series 1 and 2 estimate the parameters sigma (the measure of risk aversion) and alpha (the measure for probability weighting). In Series 1, a set of sigma and alpha (σ, α) combinations that rationalise the switching points are estimated[14]. Another combination of sets that justifies the switching point is found for series 2. For example, if a subject switched in row 6 of series 1, the values of sigma and alpha that can rationalise the switch is (0.5, 0.4) (0.6, 0.5), (0.7, 0.6), (0.8, 0.7), (0.9, 0.8), (1.0, 0.9). If a subject switched in row 6 in series 2, the combination of sigma and alpha that can rationalise the switch is (0.5, 1), (0.6, 0.9), (0.7, 0.8), (0.8, 0.7), (0.9, 0.6), (1, 0, and 0.5). The crossing point is thus (0.8, 0.7). In TCN, the coefficient of loss aversion (λ) is derived from Series 3: conditional on the value

13 Sample of the MPL's are presented in Appendix 2.

14 See section 1.3 for the inequlities implied by the switching points

of sigma derived from Series 1 and Series 2, the switching point in Series 3 implies a range of values for λ. The TCN method produces interval values for the loss aversion parameter.

3.4 Risk Preference Estimation

The experiments in this study were modelled after the design of Tanaka, Camerer and Nguyen (2010) (TCN) who assume cumulative prospect theory. TCN use a series of gain-only and gain-and-loss pair-wise lotteries with both a risky and safe option (similar to Holt and Laury (2002)). They assumed the following utility function:

$$U(x,p;y,q) = \begin{cases} v(y) + \pi(p)\big(v(x) - v(y)\big) & x > y > 0; x < y < 0 \\ \pi(p)v(x) + \pi(q)v(y) & x < 0 < y \end{cases} \qquad \text{Equation 3.1}$$

$U(x, p; y, q)$ denotes the expected value linked to prospects$(x, p; y, p)$, p and q are the probabilities of receiving outcomes x and y, respectively. The power function $v(x) = x^{\sigma}$ for gains $(x > 0)$ and $v(x) = -\lambda(-x^{\sigma})$ for losses $(x < 0)$ is assumed with σ being the risk aversion parameter (i.e. measure of the concavity of the value function) and λ the parameter for loss aversion. The risk aversion parameter (σ) is presumed to be identical in both gains and losses; the inequality $\sigma > 1$ implies risk seeking preferences and σ <1 implies risk averse behaviour. For λ, λ>1(λ<1) implies greater sensitive to losses (gains) compared to gains (losses).

TCN use the nonlinear probability weighting function of Prelec (1998) where $\pi(p) = \exp[-(-\ln p)^{\alpha}]$ with the function being linear if $\alpha = 1$. If $\alpha = 1$ and $\lambda = 1$; in this case the model reduces to expected utility. If $\alpha < 1$ the function is an inverted S-shape. The inverted S-shape indicates that small probabilities are overweighed and large probabilities are underweighted. The function is S shaped if $\alpha > 1$, indicating that small probabilities are underweighted and large probabilities are overweighed.

3.5 Timing of Uptake

3.5.1 The Cox Proportional Hazard

In order to determine how farmer characteristics and the prospect theory parameters affects the timing of uptake, we choose the most widely used model of survival analysis namely, the cox proportional hazard model[15]. The model estimates the relationship between covariates and the timing of uptake. In a proportional hazard model, the unique effect of a unit increase in a covariate is multiplicative with respect to the hazard rate, which is defined as the uptake rate at time t conditional on no uptake until time t or later. To denote the model in mathematical terms, let us assume T to be a non-negative random variable denoting time to uptake of an option which is the survival time. Rather than referring to T's probability density function f(t) – or its cumulative distribution function F(t) = Pr(T<t) survival analysis instead talk about T's survivor function S(t) or its hazard function h(t). The reverse cumulative distribution function of T is the survival function:

$$S(t) = 1 - F(t) = Pr(T > t) \quad \text{Equation 3.2}$$

The survivor function denotes the probability of survival beyond time t. It is the probability that there is no uptake prior to time t. The function is equals to 1 at time 0. The function is a non-decreasing function of time. The density function can be obtained from S (t) or F (t):

$$f(x) = \frac{dF(t)}{dt} = 1 - \frac{d}{dt}\{1 - S(t)\} = -S'(t) \quad \text{Equation 3.3}$$

The hazard function h (t) is used to denote the instantaneous rate of uptake. It is the (limiting) probability that the uptake event occurs in a given time interval, condition that the subject is still participating at the beginning of the interval, divided by the width of the interval.

$$H(t) = \lim_{\Delta t \to 0} \frac{Pr(t+\Delta t > T > t \mid t)}{\Delta t} = \frac{f(t)}{S(t)} \quad \text{Equation 3.4}$$

The general form of the proportional hazard function is;

$$h_i(t) = h_o(t)\, exp(\beta_1 x_{i1} + \beta_2 x_{i2} \dots . \beta_k x_{ik}) \quad \text{Equation 3.5}$$

[15] See Therneau, and Grambsch, 2000; Lunn and McNeil, 1995; Box-Steffensmeier and Zorn, 2001, Prentice et al., 1997 and Liu, 2013.

$h_o(t)$ is the baseline hazard. In the cox proportional hazard model, the baseline hazard function $\alpha(t) = \log h_0(t)$ is unspecified. This model is semi-parametric because, while the baseline hazard can take any form, the covariates enter the model linearly. The model is proportional in that the 'hazard' a subject faces is multiplicatively proportional to the baseline hazard. $h_o(t)$ and cancels from the calculation when binary-outcome analyses is undertaken at individual failure times. For example, if we compare subject i to subject m, the model thus states that;

$$\frac{h(t|x_i)}{h(t|x_m)} = \frac{exp(x_i\beta_x)}{exp(x_m\beta_x)}$$ Equation 3.6

3.5.2 Multiple Competing Events

The cox model described in section 3.5.1 only takes into the occurrence of one event. However, in the insurance simulation games used in this analysis, there is a chance of 4 different events occurring, namely; bankruptcy, uptake of Traditional Seed, High yielding seeds with uninsured loan and high yielding seeds with insured loan. Furthermore for each individual, only one event occurs at any given time. Therefore, in order to investigate the timing factor of the covariates, we need a modified version of the cox model which takes into account multiple competing events[16].

In order to take into account multiple competing events, we use the latent survivor time approach were we assume that observation 'i' is at risk of k different kinds of events. In this paper, we have four event types namely, traditional seeds, high yielding seeds with uninsured loan, high yielding seeds with insured loan and bankruptcy. There is a different time corresponding to each event type and is denoted by $T_{1i}T_{2i}T_{3i} \dots \dots .. T_{ki}$ with each event also having a hazard function $h_{ki}(t)$ and a survival functions $S_{ki}(t)$.

Only the shortest duration of time T_{ki} to each event is observed and is in effect the latent failure time. An assumption is made which undertakes that the observed time to event (i.e. failure time) exists and is observed if a long enough time went by without failure from any other event occurring. A measure of which event is experienced is denoted by $R_i = k$ if $T_i = T_{ki}$. The interval for each different event occurring is assumed to not be exactly the same. This

[16] See Therneau, and Grambsch, 2000; Lunn and McNeil, 1995; Box-Steffensmeier and Zorn, 2001, Prentice et al., 1997 and Liu, 2013.

simply says that more than one different type of event cannot occur at exactly the same time. Each uncensored observation thus contributes equation 3.7 to the likelihood.

$$\mathcal{L} = f_k(t_i, X_{ki}, \beta_k) \prod_{k/r} S_r(t_i | X_{ki} \beta_r) \qquad \text{Equation 3.7}$$

k represents the k^{th} event and r in the product term indicates that the product in all states, with the exception of k, is the takeover survivor time The subscript k on β implies that for each failure, there are different coefficient sets. Therefore, the heterogeneity across different event types in terms of the explanatory variables is capture. The full sample likelihood is represented by equation 3.8. Nonetheless because for each unit only a single failure within the k possible events is observed, the entire likelihood can be separated using the amount of units failing by each of the k events and written as equation 3.9.

$$\mathcal{L} = \prod_{i=1}^{N} f_k(t_i, X_{ki}, \beta_k) \prod_{k=1}^{r} S_k(t_i, X_{ki} \beta_k) \qquad \text{Equation 3.8}$$

$$\mathcal{L} = \prod_{k=1}^{r} \prod_{i=1}^{N_k} f_k(t_i, X_{ki}, \beta_k) S_k(t_i, X_{ki}, \beta_j) \beta \qquad \text{Equation 3.9}$$

3.6 Technology, Loan and Insurance Uptake

A series of insurance simulation games were conducted to assess whether or not the availability of insurance has an impact on the willingness of farmers to take up loan in order to invest in technology i.e. high yielding seed. The farmers in the experiment are provided with three choices namely traditional seeds, high yielding seeds which require securing a loan and improved seed with an insured loan option[17]. The experiment is carried out over 8 rounds with each round representing a farming season. The participants are told that their income in each round is dependent on the type of seed they choose and amount of rainfall. At the start of the games, the participants were informed that the experiments will be carried out in 8 round with each representing a farming season. They were also told that they were 3 rainfall levels which had equal 0.33 probabilities of occurring. Rainfall levels were represented by 3 balls placed in a bag; a blue ball, a yellow ball and a red ball signifying good rainfall levels, low rainfall levels and very poor rainfall levels. The farmers were deprived of an initial endowment in the first round. However, the respondents were told they would be given R15 at the end of the rounds

17 A sample of the decision sheet is presented in Appendix 2.

so as to avoid using their own money to cover losses. The R15 does not count as their endowment in the experiments. A bankruptcy rule is included in the experiment which mandates that a participant can only move on to the next round if the cumulative income from previous rounds can cover the losses at the end of the current round.

Once the participant had indicated that they understood the games and after several examples, the experiment commenced. One of the farmers was randomly chosen to a pick a random ball from the bag on behalf of the participants. The colour of the selected ball was entered into a spread sheet and the participant were able to view the returned earning for a particular round, after each round. A participants who did not secure enough earning to move on to the next round were disqualified from the games[18]. The payoff from each option are as follows.

Traditional seeds: These are considered to be seeds that farmers save from their previous harvests and thus cost nothing. The payoff from these seeds after each season is R10 and this outcome does not vary. The earning for traditional seeds is R10 regardless of rain fall level. The traditional seeds option is a riskless option with expected earnings or certainty value in each round being R10. If they favourite the traditional seeds they would get a comparatively low payoff of R10 if the rainfall level was good, R10 if the rainfall level was low and R10 if the it very low. We assume that farmers suffer no cost in adopting traditional seeds.

High yielding seeds: These are assumed to be drought resistant seeds with a farming season payoff of R40 when rainfall is good. With low rain, the payoff is R30 which is more than the R10 the participants receive if they choose traditional seeds but when rainfall is very low, however, the payoff from these seeds is R0.

- *Loan:* If the participant chooses to buy high yielding seeds, they have to take out a R10 loan from the bank to purchase these seeds each season. This loan is to be paid back at the end of each season with a R1 interest. So in total the improved seed cost R11. The expected earnings for high yielding seeds with a loan are R29, R19 and –R11 for good rainfall, low rainfall and very low rainfall respectively. Thus, total expected earnings are R12.33 for uptake of high yielding seeds with loan.

18 see Appendix 7 for detailed experiment instructions

- Insurance: With the exception of round 1, an option of buying rainfall insurance at R2 at the start of each round is given to the subjects. The subjects had no initial endowment in the first round so they could not purchase insurance. This insurance pays respondent R4 when rainfall is low and R8 when rainfall is very low. However, no payoff is given when rainfall level is good. The expected earnings for improved seed with loan and insurance is R27, R21 and -R5 for good rain, low rain and very low rain, respectively. Thus total expected earning is R14.33 for uptake high yielding seeds loan and insurance. A breakdown of the payoff in each round is presented in Table 1 below

Table 1: Payoff in Each Round

	OPTION	**Earnings if blue ball is drawn**	**Earnings if yellow ball is drawn**	**Earnings if red ball is drawn**
1	**Traditional seeds:**	R 10	R 10	R 10
	Income for this round:	R 10	R 10	R 10
2	**High yielding seeds with Uninsured Loan**	R 40	R 30	R 0
	Minus cost of loan (R10) plus interest (R1) = R11	R -11	R -11	R -11
	Income for this round:	R 29	R 19	R -11
3	**High yielding seeds with Insured Loan**	R 40	R 30	R 0
	Minus cost of loan (R10) plus interest (R1) = R11	R -11	R -11	R -11
	Minus cost of insurance	R -2	R -2	R -2
	Plus what you get back from insurance	R 0	R 4	R 8
	Income for this round:	R 27	R 21	R -5

3.6 Results

3.6.1 Break Down of Uptake in Rounds

Table 1 presents the percentage uptake in each round with bankruptcy[19]. From this point onwards we consider **traditional seeds = TS, high yielding seeds with uninsured loan = HYL and high yielding seeds with insured loan = HYLI**. In the first panel, uptake is aggregated across all subjects per round. In round 1, when the purchase of the insured loan option is not possible, 69.60 percent of the farmers take up TS while 30.40 percent of the farmers take up HYL. In figure 1 we see a dramatic decline of uptake of TS and a slight decline in the uptake of the uninsured loan option, however, we see a steady increase in the uptake of the insured loan option over the rounds. In round seven, with insurance available, 33.60 percent of the farmers are taking up TS whilst 46.40 percent of the farmers are taking up (HYL and HYLI) and 22.40 percent of the farmers have gone bankrupt. This suggests that the availability of insurance does served to improve technology uptake and the effect grows stronger with time. We now consider through which mechanism access to insurance serves to improve uptake.

In Panels 2-5, the percentage uptake is further broken down into 4 categories. The first category shows uptake in rounds for individuals that exhibit risk averse behaviour (i.e. $\sigma < 1$) and risk seeking behaviour (i.e. $\sigma > 1$). Figure 1 presents a graphical representation of uptake in category 1. We do not consider the first round because the purchase of insurance is not possible in this round owing to the participant lack or initial endowment. We also do not take the final round into consideration in order to discount behaviour associated with terminal conditions. Farming, in actual fact, does not have a terminal season thus this round will be less representative of real live scenarios.

If we ignore the initial and final round, we see that the risk averse group start out by taking on less TS than the group that exhibits risk seeking behaviour. The risk averse group start out by taking on more HYLI than the risk seeking group. However in round 7, the risk averse group are taking on more TS and less HYL and HYLI than the risk seeking group. For TS, we see a steady decline of uptake from round 3 and, for HYLI, we see a steady rise in uptake from round 3. There is also an unsystematic decline in uptake of HYL amongst both groups, however, the risk averse group end up with more HYL in round 7 than the risk seeking

[19] See breakdown of uptake in rounds without bankrupcy in appendix 8

group. The risk averse group are also the only group that goes bankrupt. This demonstrates that despite the overall improvement in uptake due to the availability of insurance, as the farmers gain more experience in the games, the insurance contract is becoming less and less attractive to risk averse group, relative to the risk seeking group. This theory is further reinforced by the evidence that the risk averse group end up taking on more(less) of the HYL option in round 7(3) relative to the risk seeking group.

The second category shows uptake in rounds for individuals that overweight small probabilities (i.e. $\alpha < 1$) and individual that that under weigh large probabilities (i.e. $\alpha > 1$). We find that the group that overweight's small probability events start out by taking up more TS than the group that underweights small probabilities. They start out by taking on less HYL. Even though the probabilities of all-weather events are the same throughout the game, at the start of the game, with no accumulated income, the probable relative severity (i.e. potential relative losses) associated with TS is less than that associated with HYL.

The third category shows the uptake per round for individuals that are loss avers (i.e. $\lambda > 1$) and individuals that are loss seeking (i.e. $\lambda < 1$). The results show that the loss averse group is more likely to go bankrupt than the loss seeking group.

The forth category shows uptake per round for individuals that have below average relative household income and individuals that have above average in the sample. Relative income is measured by the difference between the lowest household income in each community and household income divided by the difference between the lowest and largest household income in each community. The below average relative income group consistently take up more TS than the individuals in the above average relative income group. They also generally take up less HYLI compared to their upper income counterparts. This is somewhat consistent with the poverty trap hypothesis that suggests behaviour diverges at a certain threshold. Given that real life relative income levels affect uptake in the experimental setting, where basis risk is absent and all individuals face the same risk and expected outcomes, the outcomes on the graph could indicate hopelessness amongst the low income group as explained by Carter and Berrett (2006).

Table 2: Percentage Uptake and Bankruptcy in Rounds (Sample Size - 125)									
Round		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Perc.	Perc.	Perc.	Perc.	Perc.	Perc.	Perc.	Perc.
TS		69.6	44.8	49.6	38.4	42.4	34.4	33.6	31.2
HYL		30.4	31.2	16	20	12.8	22.4	24	23.2
HYLI		0	12.8	12.8	19.2	22.4	20.8	20	23.2
Bankrupt		0	11.2	21.6	22.4	21.6	22.4	22.4	22.4
Category 1: Level or Risk Aversion. (Sample Size: Risk Averse - 119 , Risk Seeking - 6)									
TS	Risk Averse	69.75	43.7	48.74	38.66	43.7	34.45	34.45	31.93
	Risk Seeking	66.67	66.67	66.67	33.33	16.67	33.33	16.67	16.67
HYL	Risk Averse	30.25	31.09	15.97	20.17	11.76	22.69	24.37	21.85
	Risk Seeking	33.33	33.33	16.67	16.67	33.33	16.67	16.67	50
HYLI	Risk Averse	0	13.45	12.61	17.65	21.01	19.33	17.65	22.69
	Risk Seeking	0	0	16.67	50	50	50	66.67	33.33
Bankrupt	Risk Averse	0	11.76	22.69	23.53	22.69	23.53	23.53	23.53
	Risk Seeking	0	0	0	0	0	0	0	0
Category 2: Probability Weighting (Sample Size: Overweigh -107, Under weigh -18)									
TS	Over weigh	71.96	45.79	50.47	41.12	43.93	35.51	34.58	29.91
	under weigh	55.56	38.89	44.44	22.22	33.33	27.78	27.78	38.89
HYL	Over weigh	28.04	31.78	16.82	19.63	11.21	22.43	22.43	23.36
	Under weigh	44.44	27.78	11.11	22.22	22.22	22.22	33.33	22.22
HYLI	Over weigh	0	12.15	11.21	16.82	22.43	19.63	20.56	24.3
	Under weigh	0	16.67	22.22	33.33	22.22	27.78	16.67	16.67
Bankrupt	Over weigh	0	10.28	21.5	22.43	21.5	22.43	22.43	22.43
	Under weigh	0	16.67	22.22	22.22	22.22	22.22	22.22	22.22
Category 3: Level of Loss Aversion(Sample Size: Loss Averse - 50 , Loss Seeking - 75)									
TS	Loss Averse	69.33	40	45.33	30.67	40	33.33	30.67	26.67
	Loss Seeking	70	52	56	50	46	36	38	38
HYL	Loss Averse	30.67	30.67	12	21.33	8	18.67	16	20
	Loss Seeking	30	32	22	18	20	28	36	28
HYLI	Loss Averse	0	13.33	12	17.33	21.33	17.33	22.67	22.67
	Loss Seeking	0	12	14	22	24	26	16	24
Bankrupt	Loss Averse	0	16	30.67	30.67	29.33	30.67	30.67	30.67
	Loss Seeking	0	4	8	10	10	10	10	10
Category 4: Average Relative Income Position(Sample Size: Below Average - 75, Above Average - 50)									
TS	Below Avg.	74.65	50.7	50.7	42.25	47.89	38.03	38.03	36.62
	Above Avg.	62.96	37.04	48.15	33.33	35.19	29.63	27.78	24.07
HYL	Below Avg.	25.35	36.62	14.08	16.9	14.08	22.54	23.94	29.58
	Above Avg.	37.04	24.07	18.52	24.07	11.11	22.22	24.07	14.81
HYLI	Below Avg.	0	9.86	12.68	18.31	15.49	16.9	15.49	11.27
	Above Avg.	0	16.67	12.96	20.37	31.48	25.93	25.93	38.89

Bankrupt	**Below Avg.**	0	2.82	22.54	22.54	21.13	22.54	22.54	22.54
	Above Avg.	0	22.22	20.37	22.22	22.22	22.22	22.22	22.22

3.6.1.1 Graphical Representation of Uptake in Rounds

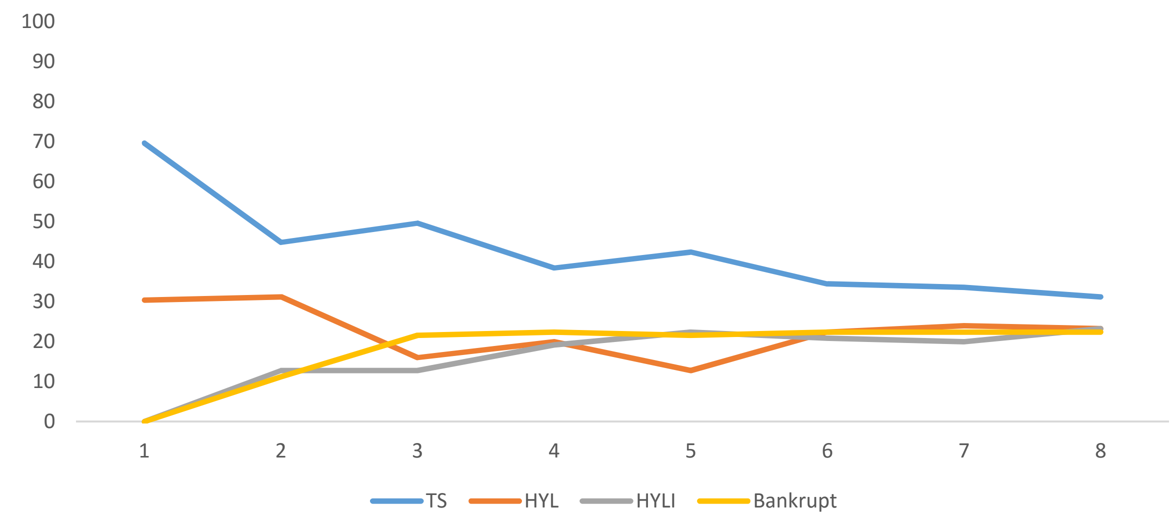


Figure 1: Percentage Uptake in Round by Uptake and Bankruptcy

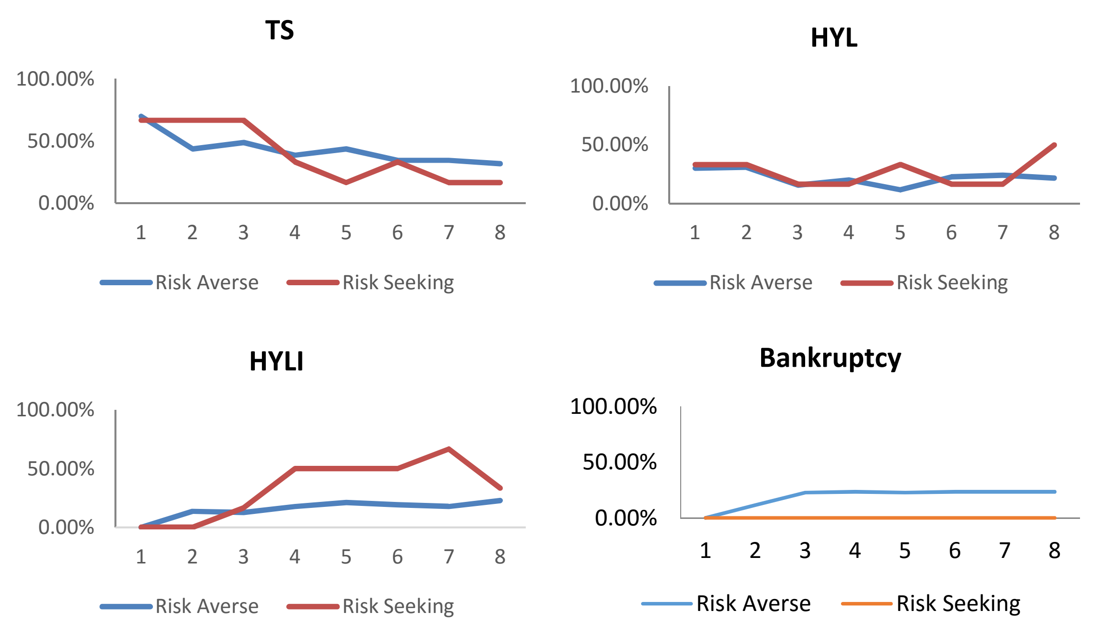


Figure 2: Uptake in Round by Risk Aversion Levels

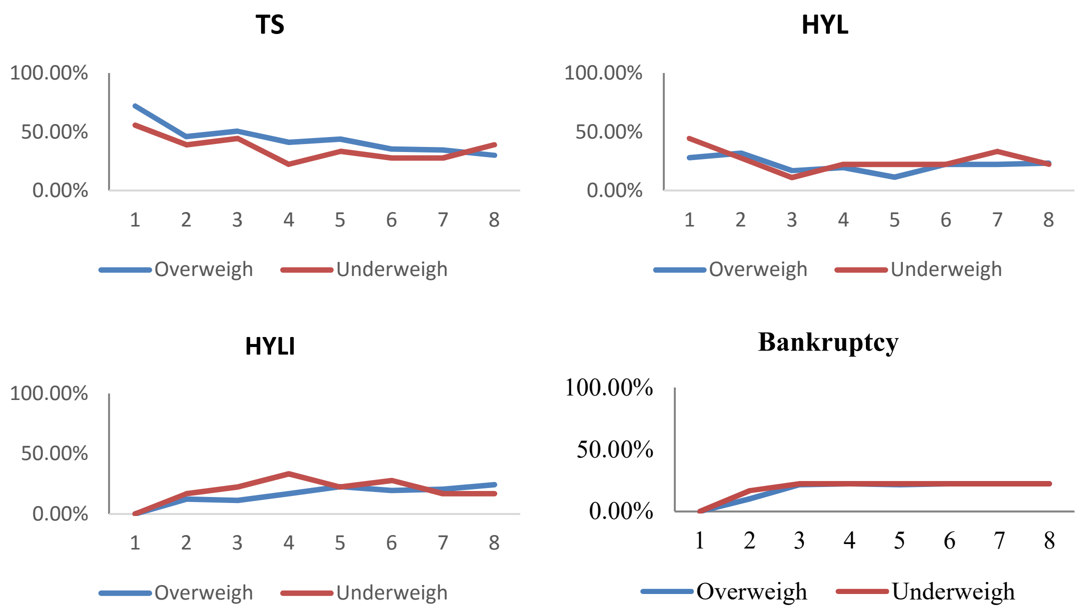


Figure 3: Uptake in Rounds by Probability Weighting Levels

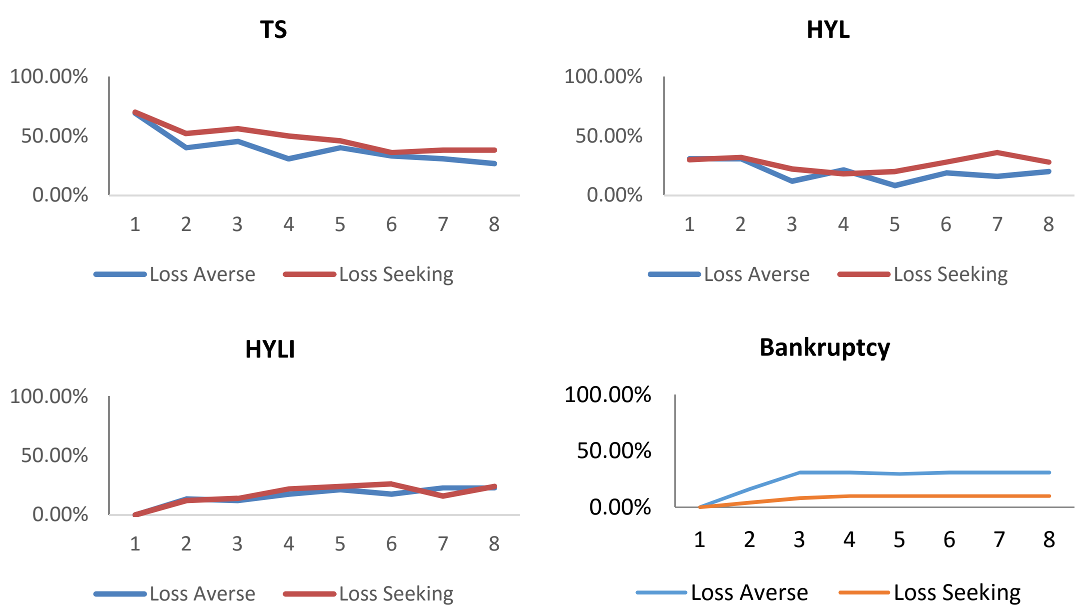


Figure 4: Uptake in Rounds by Loss Aversion Levels

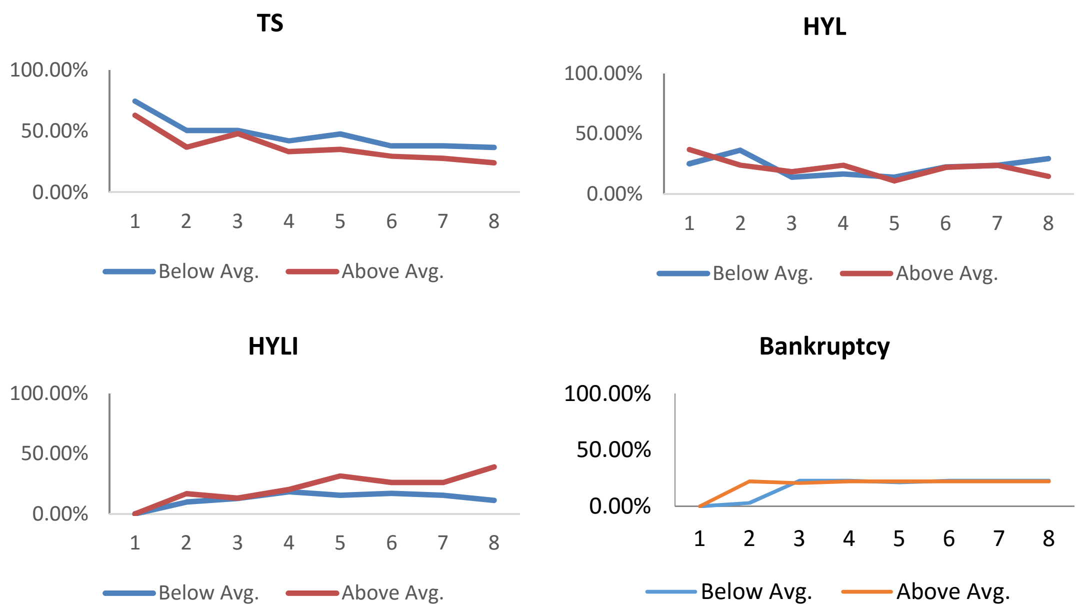


Figure 5: Uptake in Rounds by Relative Income Level

3.6.2 Determinants of Technology Uptake

The determinants of uptake are obtained using Multinomial Logit regressions. Random effects are accounted for using generalised multilevel structural equation modelling. The dependent variables are dummy variables for bankruptcy (with bankruptcy = '1' if the individual went bankrupt and Bankruptcy = '0' if the individual did not), TS (TS = '1' for uptake and TS= '0' for no uptake), high yielding seeds with loan (HYL = '1' for uptake and HYL= '0' for no uptake) and high yielding seeds with loan and insurance (HYLI = '1' for uptake and HYLI= '0' for no uptake). The base case is TS. The independent variables are Sigma (which signifies increasing risk aversion), alpha (which denotes increase in the weighting of small probabilities relative to large probabilities), Lambda (which indicates increasing loss aversion), Round of the experiment, Age, Dummy variable for Female, Education Level, Farm experience in years, Cumulative income in the experiment, Dummy variable = '1' if individual has a shock (i.e.) loss in previous rounds '0' if they have not, household monthly income, dummy variable = '1' for if the individual has below average monthly household relative income and '0' if it is above average. Once again we discount the initial and final rounds. The coefficients on the multinomial logit regressions are the expected changes in the probability of taking up an option due to a unit change in the explanatory variable. The results are presented in Table 3.

Our findings indicate that females are more likely to go bankrupt (p-value = 0.017; 0.008; 0.003) as well as people who have experienced a shock in previous (p-value = 0.037; 0.119; 0.055). Interestingly, those who experienced a shock in earlier rounds were more likely to switch from other options to HYL relative to TS (p-value =0.003; 0.003; 0.002). It is not evident whether they are moving from TS to HYL or from HYLI to HYL. A move from HYLI to HYL will suggest that those who experience a shock did not find the insurance cover in the experiment to be sufficient.

Risk aversion is found to be related to lower uptake of both HYL and HYLI (p-value =0.018; 0.014; 0.018, p-value = 0.067; 0.045; 0.064). In contrast, our results shows that the effect of loss aversion on uptake goes in the opposite direction, specifically we see that loss aversion is related to greater likelihood of uptake of HYL(p-value = 0.001; 0.006; 0.001).

Leading out previous discussions about poverty traps, we see here that an increase in cumulative income (earned over rounds of the experiment) increases the likelihood of taking up HYL, as well as, HYLI (p-value =0.093; 0.918; 0.143, p-value =0.000; 0.000; 0.000). This finding falls in line with the asset based approach to poverty traps which suggest that people with more accumulated assets are more likely to invest in and benefit from technology uptake.

Finally, with regards to the role of income on uptake, we find no evidence to suggest that real life household income affects uptake, it, however, decreases the likelihood of bankruptcy (p-value = 0.046). Our results also show that individuals with below-average relative income in real life are more likely to go bankrupt (p-value = 0.025). Equally those with below-average relative income (in real life) are less likely to take-up both HYL and HYLI (p-value = 0.040, p-value =0.085). This result confirms the poverty trap hypothesis which says behaviour towards investment bifurcates at a certain threshold (in this case: average relative income) (Carter and Barrett, 2006). The behaviour of the poorest in the sample indicates less inclination to invest in new technology. They thus prolong their destitute conditions for the reason that they cannot realise productivity gains associated with improved investment.

Table 3: Determinants of Uptake (Multinomial Logit with Base Case = TS)

	Bankruptcy			HYL			HYLI		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Sigma	-1.665	-0.150	-2.504	-1.118*	-1.133*	-1.247*	-1.032+	-1.051+	-1.205*
	(1.719)	*(1.919)*	*(2.133)*	*(0.474)*	*(0.477)*	*(0.507)*	*(0.562)*	*(0.567)*	*(0.601)*
Alpha	-1.748	-0.954	-2.122	0.759	0.650	0.135	0.662	0.486	0.498
	(1.358)	*(1.345)*	*(1.426)*	*(0.583)*	*(0.587)*	*(0.640)*	*(0.718)*	*(0.728)*	*(0.784)*
Lambda	-0.0884	-0.772	0.175	1.229**	1.316**	1.161**	-0.206	-0.165	0.463
	(1.007)	*(1.060)*	*(1.258)*	*(0.381)*	*(0.386)*	*(0.425)*	*(0.552)*	*(0.559)*	*(0.574)*
Round	1.122**	1.138**	1.082**	-0.0331	-0.0156	0.0885	-0.203*	-0.181+	-0.204+
	(0.187)	*(0.196)*	*(0.188)*	*(0.0787)*	*(0.0791)*	*(0.0841)*	*(0.0993)*	*(0.100)*	*(0.110)*
Age	0.00240	-0.0238	-0.00586	0.00105	0.00132	-0.0193+	0.00624	0.00532	0.0101
	(0.0295)	*(0.0326)*	*(0.0310)*	*(0.00827)*	*(0.00831)*	*(0.00997)*	*(0.00964)*	*(0.00972)*	*(0.0121)*
Female	1.423*	2.161**	2.045**	-0.214	-0.212	-0.432+	-0.213	-0.200	0.0350
	(0.598)	*(0.727)*	*(0.768)*	*(0.224)*	*(0.225)*	*(0.252)*	*(0.270)*	*(0.271)*	*(0.291)*
Education Level	-0.0100	-0.107	-0.0804	-0.0371	-0.0512	-0.135**	0.0721	0.0526	0.113+
	(0.100)	*(0.108)*	*(0.133)*	*(0.0411)*	*(0.0417)*	*(0.0470)*	*(0.0512)*	*(0.0531)*	*(0.0578)*
Farm Experience in years	0.0540	0.0237	-0.0407	-0.0196	-0.0167	-0.00960	-0.0306	-0.0277	-0.0503*
	(0.0812)	*(0.0882)*	*(0.112)*	*(0.0137)*	*(0.0137)*	*(0.0141)*	*(0.0214)*	*(0.0215)*	*(0.0252)*
Cumulative Income	-0.260**	-0.301**	-0.267**	0.00893+	0.00782	-0.000613	0.0389**	0.0373**	0.0418**
	(0.0477)	*(0.0575)*	*(0.0519)*	*(0.00532)*	*(0.00533)*	*(0.00595)*	*(0.00638)*	*(0.00646)*	*(0.00734)*
Shock in previous round	1.174*	1.118+	0.919	0.780**	0.788**	0.814**	0.523	0.531	0.457
	(0.563)	*(0.583)*	*(0.589)*	*(0.258)*	*(0.259)*	*(0.278)*	*(0.368)*	*(0.369)*	*(0.407)*
Household Income			- 0.000647*			3.93e-05			-1.57e-05
			(0.000324)			*(2.68e-05)*			*(4.20e-05)*
Below Avg. Rel. Income.		1.778*			-0.471*			-0.469+	
		(0.796)			*(0.229)*			*(0.273)*	
Constant	-6.458**	-4.944*	-4.580+	-0.877	-0.582	0.254	-3.191**	-2.814**	-4.213**
	(2.281)	*(2.296)*	*(2.625)*	*(0.789)*	*(0.799)*	*(0.899)*	*(1.003)*	*(1.033)*	*(1.173)*
Observations	678	678	598	678	678	598	678	678	598

3.6.3 Determinants of Timing of Uptake

The results of the cox proportional hazard model regressions on the experimental uptake options are presented in the Table 4 below. The coefficients are the hazard rates. A **negative coefficient implie**s a decrease in the hazard rate which means an increase in the time to uptake (**later uptake**). A **positive coefficient** implies an increase in the hazard rate, which indicates a decrease in the time to uptake (**earlier uptake**).

Our result indicate that the greater the level of risk aversion, the later uptake of TS and the earlier the uptake of HYLI (HYLI) (p-value = 0.007; 0.024; 0.073, p-value = 0.001; 0.001; 0.032). Despite controlling for other factors, this result supports the evidence in table 2 where the risk averse farmers take up more TS in round 7 and take up more for the HYLI option in round 2 relative to the risk seeking group. In view of that, more risk averse individuals are first-movers to take up insurance as a way to mitigate risk. On the other hand in section 3.2.6 we find that more risk averse individuals are overall less likely to take up HYLI. They also take up less of the insurance option relative to TS. Hence more risk averse individuals, as they gain more experience in the games, may find the cover provided by the insurance to be insufficient.

We find that individuals who overweight small probability events take up HYL option later (p-value = 0.015; 0.006; 0.067). We also find that more loss averse individuals take up TS earlier (p-value = 0.055; 0.079). Greater loss aversion therefore only raises worries about downside risk in earlier stages. This is evident given that, in the section 3.6.2, the likelihood of aggregate uptake of HYL compared to TS is higher for loss averse individuals.

Our findings also show that older individuals take up HYLI earlier, females take up TS earlier and increases in education levels are linked to earlier uptake of HYLI; this may suggest that more educated individuals have a greater aptitude for understanding the insurance contract(p-value =0.000; 0.012, 0.025, p-value =0.094, p-value =0.001; 0.007; 0.035). Farm experience is found to be related to earlier uptake of TS and later uptake of HYL (p-value =0.098, p-value = 0.007; 0.008; 0.036). We also find that household income is related to earlier uptake of HYL option, but the effect is marginal (p-value =0.019).

Greater cumulative experimental income is found to be related to later uptake of HYL and HYLI (p-value =0.027; 0.027; 0.056, p-value = 0.001; 0.000; 0.012). This is not surprising considering that higher cumulative income indicates a greater capacity to bear the default cost of an uninsured loan and, all things equal, will be higher at later stages of the game. However at the earlier stages of the experiment when cumulative incomes are lows, TS is the safer option because of the low relative costs associated with its uptake. We also see that individuals with below average relative income take up the HYL option earlier (p-value =0.054) and, given the lower likelihood of uptake of this option in section 3.6.3, this points toward divestment by lower income groups as time goes by which is consistent with the 'de-cumulation' of assets stated in the poverty trap theory.

Table 4 : Determinants of Timing of Uptake(Cox Proportional Hazard Model)

	TS			HYL			HYLI		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Sigma	-3.003**	-3.028*	-2.438+	-0.450	-0.557	-0.802	4.223**	4.337**	6.822*
	(1.114)	*(1.340)*	*(1.362)*	*(0.434)*	*(0.395)*	*(0.525)*	*(1.224)*	*(1.329)*	*(3.177)*
Alpha	-0.120	-0.108	0.164	-1.498*	-1.663**	-1.497+	0.904	1.270	2.773
	(1.594)	*(1.635)*	*(1.504)*	*(0.615)*	*(0.602)*	*(0.817)*	*(1.463)*	*(1.406)*	*(5.082)*
Lambda	1.966+	1.989+	1.422	-0.196	-0.154	-0.203	0.865	0.666	1.047
	(1.025)	*(1.134)*	*(1.467)*	*(0.241)*	*(0.236)*	*(0.331)*	*(0.624)*	*(0.725)*	*(1.361)*
Age	-0.00849	-0.00887	0.00892	0.000997	0.00125	-0.00804	0.0754**	0.0857*	0.151*
	(0.0179)	*(0.0231)*	*(0.0293)*	*(0.00953)*	*(0.00850)*	*(0.0125)*	*(0.0204)*	*(0.0342)*	*(0.0670)*
Female	0.689+	0.693	0.608	0.174	0.0149	0.0330	-0.102	-0.405	0.00603
	(0.412)	*(0.431)*	*(0.512)*	*(0.217)*	*(0.250)*	*(0.308)*	*(0.763)*	*(1.038)*	*(1.244)*
Education	0.143	0.143	0.232	-0.0387	-0.0503	-0.0772	0.521**	0.599**	0.900*
	(0.0914)	*(0.0897)*	*(0.156)*	*(0.0363)*	*(0.0335)*	*(0.0587)*	*(0.151)*	*(0.222)*	*(0.427)*
Farm Experience in yrs.	-0.0263	-0.0264+	-0.0248	-0.0532**	-0.0480**	-0.0525*	0.0842	0.118	0.147
	(0.0162)	*(0.0159)*	*(0.0187)*	*(0.0198)*	*(0.0180)*	*(0.0250)*	*(0.0659)*	*(0.0982)*	*(0.384)*
Below Avg. Rel. Inc.	-	-0.0235	-	-	-0.428+	-	-	0.598	-
	-	*(0.515)*	-	-	*(0.222)*	-	-	*(1.089)*	-
Household Income	-	-	-0.000206	-	-	3.54e-05*	-	-	0.000197
	-	-	*(0.000178)*	-	-	*(1.51e-05)*	-	-	*(0.000144)*
Cumulative Income	0.0247	0.0243	0.0447	-0.0374*	-0.0395*	-0.0488+	0.106**	0.103**	0.141*
	(0.0218)	*(0.0250)*	*(0.0377)*	*(0.0169)*	*(0.0178)*	*(0.0255)*	*(0.0244)*	*(0.0192)*	*(0.0558)*
Observations	29	29	27	41	41	35	16	16	12

Robust standard errors in parentheses ** p<0.01, * p<0.05, + p<0.1

3.7 Conclusion (Chapter 3)

In developing countries, small scale farming has been explored and promoted as a tool to sustain growing food demand and reduce poverty. However, low income small-scale farmers in developing countries often face constraints such as limited access to credit and insurance markets which prevent them from investing in new agricultural technology that could boost productivity. According to the poverty trap hypothesis groups that are below a certain asset threshold face severe constraints such that their behaviour limits their ability to use traditional mechanisms (e.g. technology) to further themselves. These groups are therefore stuck in a poverty trap. People below this threshold would be unable or reluctant to access credit that enables them to take up technology. Furthermore, lenders will be disinclined to provide loans to this group due to high default risks and potential borrower in this group will be reluctant to take up loans due to preferences associated with the downside risk of borrowing. Consequently, many countries have explored the role of agricultural insurance as a tool to motivate farmers to purchase new technology using devices such as credit. The premise is that agricultural insurance serves to lessen risk by transferring surplus risk to third parties and would thus motivate farmers to acquire more rewarding but sometime riskier investments.

To test the hypothesis that access to insurance stimulates technology uptake, we conducted an analysis to determine the effects of insurance on farmers risk preferences (i.e. risk aversion, loss aversion and probability weighting) that are linked to farm technology uptake. In a series of insurance simulation games, we assume that in order to purchase new farm technology (i.e. high yielding seeds) farmers must take up a loan. An option to take the loan bundled with an insurance package is given to the farmers. The options the farmers have are traditional seeds, high yielding seeds (with uninsured loan) and high yielding seeds (insured loan). Farmers can also go bankrupt if they face a loss greater than their cumulative income in the games. Owing to the hypothesis that behaviour diverges at a certain income threshold, we consider the farmers relative income position in our study. We test for both absolute and path dependent effects by examining both the levels and timing of uptake.

Our results show that even with the insurance package, risk aversion is found to be related to lower uptake of improved seed. Uptake with the insured loan option is even lower than with the uninsured loan. Even though risk aversion is related to lower overall uptake of high yielding seeds, we consistently find that greater risk aversion results in later uptake of TS and earlier uptake of HYLI. It is, therefore, possible that as the farmers gain more experience in the games, more risk averse individuals find the cover provided by the insurance as insufficient. This may explain the later shift to TS.

Our results also show that loss aversion is related to greater uptake of technology for both the insured and uninsured loan option. We consistently find that more loss averse individuals take up TS earlier. This points towards loss averse individuals being more concerned with downside risk at earlier stages as opposed to in the overall game. As a result, they avoid downside risk by opting for the safer traditional option at the start of the game. We also find that loss averse individual take up HYL early but not as early as TS. The overall likelihood of uptake of this option compared to TS is higher for loss averse individuals. This again confirms that downside risk is only a concern at the very early in the game. With more experience in the game more loss averse individuals shift to the improved seed with loan option. This may indicate that experience reduces the fear of down side risk. We, however, find no evidence to suggest the insurance option is attractive to loss averse individuals.

Individual below average relative income threshold are found to be more likely to and both HYL and insured loan option, with the likelihood of uptake being lower for the insured loan option. They are also found to be more likely to go bankrupt. The effect on real life relative income is surprising, given that the farmers do not have their own money at stake in the experiments. This would suggest that the effect is purely an outcome of behaviour associated with the lower relative income group. This result further validates the poverty trap hypothesis. We also see that individuals with below average relative income take up TS later suggesting that as time goes by more individual with below average relative income shift from other options to TS. That is to say that there is not only stasis amongst the low income group but a reversion by those already investing which further supports the poverty trap hypothesis.

In this chapter, we found little evidence to suggest that insurance serves as an effective tool to counteract the risk preferences and behaviour that are linked to low technology uptake amongst low income farmers. It may be the case that the cost of the insurance premium in the experiment is considered too high by the farmers. One solution would be for policy makers to offer premium subsidies under programs that target smallholder poor farmers.

It is important to point out that our study only accounts for the behaviour of potential borrowers. In the real world, agricultural insurance may still be essential because it can encourage lending owing to the positive effect is has on the creditworthiness of farmers and other agricultural sector participants. Insofar as this type of insurance improves the general financial stability of agribusiness, unforeseen benefits though credit accessibility can occur at other points of the agricultural market chain. (Mahul and Stutley, 2010)

Conclusion

The theory on poverty traps suggests that poor smallholder farmers in developing countries stay in conditions of persistent poverty because certain behavioural anomalies that are associated with the constraints they face result in a disinclination to take up new investment. In addition, the theory proposes that providing poor farmers with access to insurance and credit will counterweight the dampening effects of these behavioural anomalies on investment in farm technology. In this study, we investigate the validity of this hypothesis using both real life and experimental data. In Chapter 1, using a sample of small-scale conventional farmers, we determine whether or not farm technology uptake is limited by certain behavioural anomalies, i.e. risk preferences, and low relative income levels. We find that, for the farmers, being below the average relative income threshold has a negative impact on the uptake of all but one of the uptake options we explored, this result therefore supports the poverty trap hypothesis. In Chapter 2, we use a sample of organic farmers to conduct an analysis similar to chapter 1 and we again find that having below the average relative household income has the most consistent effect, it is linked to lower uptake of almost all the technology types we explored. In chapter 1 and 2, risk preferences do not seem to have a consistent or across the board effect on technology uptake. In Chapter 3, using experimentally obtained data from the conventional farmers, we determine whether or not risk preferences are mechanisms via which insurance motivates uptake. We test for both absolute and path dependent effects by examining both the levels and timing of uptake. Risk aversion is found be responsible for lower technology uptake in the experimental study.

In Chapter 1 and 2, we find no strong relationship between the risk preference parameters and behaviour. Given that in real life farming scenarios, the accurate probability of outcomes are hardly know, one could infer that measures of ambiguity preferences may have a stronger impacts than measures of risk preferences. It is thus important to evaluate both risk and ambiguity preferences and consider them both when examining the impact of uncertainty related preferences on technology uptake. Another reason for the weak relationship between risk preference and behavior in chapter 1 and 2 is possibly that the risk level of choices are unknown in the analysis, we only infer. Furthermore, the options we explored may have substitutes or compliments with unknown risk and cost factors.

In all 3 analyses, one consistent finding is that having below average relative income position is linked to lower uptake. In Chapter 3, our results show that access to insurance improves uptake in the overall sample. However, contrary to the poverty trap hypothesis, we found little evidence to suggest that the insurance contract in our study serves as an effective tool to counteract the risk preferences that are linked to low technology uptake. This finding is evident when considering both absolute uptake and the timing of uptake. The finding that farmers with below average relative income are less likely to take up technology in the experiment is unexpected. This is because all farmers in the study face the same object risk, given that they do not have their real life incomes in at stake. In addition, we find that the availability of insurance does not improve the likelihood of uptake amongst the low relative income farmers. This may suggest that constraints faced by lower income groups result in some form of behavioural anomaly or psychological response that is not accounted for by risk preference. One example could be a feeling of hopelessness or pessimisms as a result of persistent poverty which gives rise to underinvestment in technology.

One interesting finding in Chapter 2, where we explored organic farmers, is that despite institution support the dampening effect of low relative income still persists. This signals the need for greater studies into the types of institutional support that are relevant to organic farming which is relatively more risky and uncertain than traditional farming. Based on our experimental results, we suggest that greater provision of insurance should be explored as one of the devices in both organic and convention agricultural modernisation policy, but careful consideration should be given to the type of insurance contract and whether or not the insurance contract provides sufficient cover. Our results also infer that equity issue should be examined more comprehensively, this includes not only the monetary issues but also the psychological components such as those linked to social exclusion.

References

Adato, M., Carter, M. R., & May, J. (2006). Exploring poverty traps and social exclusion in South Africa using qualitative and quantitative data. The Journal of Development Studies, 42(2), 226-247.

Abdellaoui, M., Bleichrodt, H., & Paraschiv, C. (2007). Loss aversion under prospect theory: A parameter-free measurement. Management Science, 53(10), 1659-1674

Andersen, S., Harrison, G. W., Lau, M. I., & Rutström, E. E. (2006). Elicitation using multiple price list formats. Experimental Economics, 9(4), 383-405.

Barham, B. L., Chavas, J., Fitz, D., Salas, V. R., & Schechter, L. (2014). The roles of risk and ambiguity in technology adoption. Journal of Economic Behaviour & Organization, 97, 204-218.

Barnett, B.J.., Barret, C.B. & Skees, J.R. (2008). Poverty Traps and Index-Based Risk Transfer Products. World Development, 36(10), 1788-1785

Barr, A. (2003). Risk Pooling, Commitment, and Information: An experimental test of two fundamental assumptions. Centre for the Study of African Economies, University of Oxford.

Barrett, C.B. & Carter, M.R. (2013). The Economics of Poverty Traps and Persistent Poverty: Empirical and Policy Implications. The Journal of Development Studies, 49(7), 976-990.

Belliveau, S., Bradshaw, B., Smit, B., Reid, S., Ramsey, D., Tarleton, M., et al. (2006). Farm level adaptation to multiple risks: Climate change and other concerns. Occasional Paper, (27)

Bezemer, D. (2008). Agriculture, Development, and Urban Bias. World Development, 36(8), 1342-1364

Binswanger, H. P. (1980). Attitudes towards Risk: Experimental Measurement Evidence in Rural India.î, Amer. J. Agric. Econ., 62(3):395ñ407.

Binswanger, H. P., & Sillers, D. A. (1983). Risk aversion and credit constraints in farmers' decision-making: A reinterpretation. The Journal of Development Studies, 20(1), 5-21.

Bleichrodt, H., Pinto, J. L., & Wakker, P. P. (2001). Making descriptive use of prospect theory to improve the prescriptive use of expected utility. Management Science, 47(11), 1498-1514.

Bocqueho, G., Jacquet, F. & Reynaud, A. (2013). Assessing farmers' risk behaviour from field-experiment data.

Box-Steffensmeier, J. M., & Zorn, C. J. (2001). Duration models and proportional hazards in political science. American Journal of Political Science, 972-988.

Brick, K., & Visser, M. (2014). Risk preferences, technology adoption and insurance uptake: A framed experiment. Environment for development. Discussion paper series 14.

Burton, M., Rigby, D., & Young, T. (1999). Analysis of the determinants of adoption of organic horticultural techniques in the UK. Journal of Agricultural Economics, 50(1), 47-63.

Carter, M. R., and Barrett, C.B. (2006). The economics of poverty traps and persistent poverty: An asset-based approach. The Journal of Development Studies 42(2), 178-199.

Carter, M. R., & Barrett, C. B. (2007). Asset Thresholds and Social Protection: A 'Think-Piece'. IDS Bulletin, 38(3), 34-38.

Carter, M., Barret, C. B., Bouche, S., Chantarat, S., Galarza, F., Mcpeek, J. & Trivelli, C.(2008). Insuring the Never Before Insured: Explaining Index Insurance through Financial Education Games. Basis Brief, 7, 1-8

City of Cape Town. (2007). Urban Agriculture Policy for the City of Cape Town.

Croppenstedt, A., Demeke, M., & Meschi, M. M. (2003). Technology adoption in the presence of constraints: The case of fertilizer demand in Ethiopia. Review of Development Economics, 7(1), 58-70.

Dercon, S., & Christiaensen, L. (2011). Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. Journal of Development Economics, 96(2), 159-173.

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile basin of Ethiopia. Global Environmental Change, 19(2), 248-255.

De Satge, R., & William, B. (2008). Pushing and pulling: Attempts to stimulate smallholder agriculture in metropolitan Cape Town. Phuhlisani Solutions–September.

Dinku, T., Giannini, A., Hansen, J., Holthaus, E., Ines, A., Kaheil, Y., … Vicarelli, M. (2009). Designing Index-based Weather Insurance for Farmers in Adi Ha, Ethiopia. International Research Institute for Climate and Society, New York

Duclos, J. Y., & O'Connell, S. A. (2009). Is Poverty a Binding Constraint on Growth in Sub-Saharan Africa?.

Duflo, E., Kremer, M., & Robinson, J. (2011). Nudging farmers to use fertilizer: Theory and experimental evidence from Kenya. American Economic Review, 101(6), 2350-2390.

Einhorn, H. J., & Hogarth, R. M. (1981). Behavioural decision theory: Processes of judgment and choice. Journal of Accounting Research, 1-31.

Ellis, F. (2000). Rural livelihoods and diversity in developing countries Oxford University Press.

Engle Warnick, J. C., Escobal, J., & Laszlo, S. C. (2011). Ambiguity aversion and portfolio choice in small-scale Peruvian farming. The BE Journal of Economic Analysis & Policy, 11(1)

Engle-Warnick, J., Escobal, J., & Laszlo, S. (2007). Ambiguity Aversion as a Predictor of Technology Choice: Experimental Evidence from Peru. CIRANO- Scientific Publications.

Escalante, C. L., & Barry, P. J. (2001). Risk balancing in an integrated farm risk management plan. Journal of Agricultural and Applied Economics, 33(3), 413-430.

Eswaran, M., & Kotwal, A. (1990). Implications of credit constraints for risk behaviour in less developed economies. Oxford Economic Papers, 473-482.

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. Economic Development and Cultural Change, 255-298.

Fernandez-Cornejo, J., Daberkow, S., & McBride, W. D. (2002). Decomposing the size effect on the adoption of innovations.Agbioforum, 4(2), 2.

Festinger, L. (1954). A theory of social comparison processes. Human relations, 7(2), 117-140.

Foster, A. D., & Rosenzweig, M. R. (2010). Microeconomics of technology adoption. Annual Review of Economics, 2(1), 395-424.

Finn, A., Leibbrandt, M., & Woolard, I. (2014). The middle class and inequality in South Africa. SALDRU Research Brief.

Giné, X., & Yang, D. (2009). Insurance, credit, and technology adoption: Field experimental evidence from Malawi. Journal of Development Economics, 89(1), 1-11.

Genius, M., Pantzios, C. J., & Tzouvelekas, V. (2006). Information acquisition and adoption of organic farming practices. Journal of Agricultural and Resource economics, 93-113.

Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. American Psychologist, 66(4), 290

Green Clippings. (2003). Can organic agriculture contribute to economic development in South Africa? 23: 1–2.

Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: the process of individual adaptation to climate change. Global Environmental Change, 15(3), 199-213.

Harrison, G.W., Humphrey S.J. & Verschoor, A. (2010). Choice under Uncertainty: Evidence from Ethiopia, India and Uganda. Economic Journal 120:80-104.

Hassan, R., & Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. African Journal of Agricultural and Resource Economics, 2(1), 83-104.

Hanson, J., Dismukes, R., Chambers, W., Greene, C., & Kremen, A. (2004). Risk and risk management in organic agriculture: views of organic farmers. Renewable agriculture and food systems, 19(04), 218-227.

Hazell, P., & Diao, X. (2005). The role of agriculture and small farms in economic development. *The future of small farms*, 23.

Hershey, J. C., & Schoemaker, P. J. (1985). Probability versus certainty equivalence methods in utility measurement: Are they equivalent? Management Science, 31(10), 1213-1231.

Hill, R. E. (2005). Risk, production and poverty: a study of coffee in Uganda (Doctoral dissertation, University of Oxford).

Hovorka, A., De Zeeuw, H., & Njenga, M. (2009). Gender in urban agriculture: an introduction. In Women Feeding Cities. Same authors (Eds.) Totton: Hobbs the Printers Ltd.

Hurley, T. M. (2010). A review of agricultural production risk in the developing world. St. Paul, MN: University of Minnesota, Harvest Choice.

Horowitz, J.K., and E. Lichtenberg. (1994). "Risk-Reducing and Risk-Increasing Effects of Pesticides." Journal of Agricultural Economics 45:82-89.

IPCC .(2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK. pp. 996.

Isik, M., & Khanna, M. (2003). Stochastic technology, risk preferences, and adoption of site-specific technologies. American Journal of Agricultural Economics, 85(2), 305-317.

Jayawarna, D., Rouse, J., & Kitching, J. (2013). Entrepreneur motivations and life course. International Small Business Journal, 31(1), 34-56.

Johnson, E.J., Hershey, J., Meszaros, J., Kunreuther, H. (1993). Framing, probability distortions, and insurance decisions. Journal of Risk and Uncertainty 7 (1), 35– 51.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. Econometrica: Journal of the Econometric Society, 263-291.

Knight, J., Weir, S., & Woldehanna, T. (2003). The role of education in facilitating risk-taking and innovation in agriculture. The Journal of Development Studies, 39(6), 1-22.

Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food policy, 32(1), 25-48

Kobberling, V. and Wakker, P. (2005). An index of Loss Aversion. Journal of Economic Theory 122, 119-131

Läpple, D., & Van Rensburg, T. (2011). Adoption of organic farming: Are there differences between early and late adoption? Ecological economics, 70(7), 1406-1414.

Leibbrandt, M., Wegner, E., & Finn, A. (2011). The policies for reducing income inequality and poverty in South Africa. SALDRU

Liu, E. & Huang, J. (2010). Risk preferences and pesticide use by cotton farmers in china. Journal of Development Economics 103 (2013) 202 -215

Liu, E. M. (2013). Time to change what to sow: Risk preferences and technology adoption decisions of cotton farmers in china. Review of Economics and Statistics, 95(4), 1386-1403.

Lunn, M., & McNeil, D. (1995). Applying Cox regression to competing risks.*Biometrics*, 524-532.

Lybbert, T. J., & Barrett, C. B. (2011). Risk-taking behaviour in the presence of nonconvex asset dynamics. Economic Inquiry, 49, 982–988.

Lynggaard, K. (2006). The common agricultural policy and organic farming. CAB International, Cambridge

Maddison, D. (2007). The perception of and adaptation to climate change in Africa. World Bank Policy Research Working Paper, (4308).

Mahul, O., & Stutley, C. J. (2010). Government support to agricultural insurance: challenges and options for developing countries. World Bank Publications.

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

Masson, R.T. (1972). The Creation of Risk Aversion by Imperfect Capital Markets. American Economic Review, 62(1/2), 77–86.

Miyata, S. (2003). Household's risk attitudes in Indonesian villages. Applied Economics 35, 573– 583.

Moore, E., & Eckel, C. (2003). Measuring ambiguity aversion. *Unpublished manuscript, Department of Economics, Virginia Tech*.

Mosley, P. & Verschoor, A. (2005). Risk Attitudes and the Vicious Circle of Poverty. The European Journal of Development Research, 17(1):59 – 88

Mwabu, G. & Thorbecke, E. (2004) 'Rural Development, Growth and Poverty in Africa', Journal of African Economies, 13 (Supplement 1): 116– 65.

Nagayets, O. (2005). Small farms: current status and key trends. The future of small farms, 355.

Niemeyer, K., & Lombard, J. (2003). Identifying problems and potential of the conversion to organic farming in South Africa. In Meeting of the Agricultural Economic Association of South Africa (AEASA), Pretoria, South Africa.

Nhemachena, C., & Hassan, R. (2007). Micro-level analysis of farmer's adaption to climate change in Southern Africa Intl Food Policy Res Inst.

Panda, A., Sharma, U., Ninan, K. N., & Patt, A. (2013). Adaptive capacity contributing to improved agricultural productivity at the household level: Empirical findings highlighting the importance of crop insurance. Global Environmental Change.

Patt, A. G., & Schröter, D. (2008). Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. Global Environmental Change, 18(3), 458-467.

Patt, A., Suarez, P., & Hess, U. (2010). How do small-holder farmers understand insurance, and how much do they want it? Evidence from Africa. Global Environmental Change, 20(1), 153-161.

Peterson, N., Mullally, C. (2009). Index Insurance Games in Adi Ha Tabia, Tigray Regional State, Ethiopia. Oxfam America, Boston.

Prelec, D. (1998). The probability weighting function. Econometrica 66 (3), 497{527}

Ravallion, M. (2001). Growth, Inequality, and Poverty: Looking beyond Averages. World Development 29 (11): 1803–15.

Prentice, R. L., Kalbfleisch, J. D., Peterson Jr, A. V., Flournoy, N., Farewell, V. T., & Breslow, N. E. (1978). The analysis of failure times in the presence of competing risks. *Biometrics*, 541-554.

Ray, D. K., Mueller, N. D., West, P. C., & Foley, J. A. (2013). Yield trends are insufficient to double global crop production by 2050. PLoS ONE, 8(6)

Rigby, D., Woodhouse, P., Young, T., Burton, M. (2001). Constructing a farm level indicator of sustainable agricultural practice. Ecol. Econ. 39, 463–478.

Rouse, J., & Kitching, J. (2006). Do enterprise support programmes leave women holding the baby?. Environment and Planning C, 24(1), 5.

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. Proceedings of the National Academy of Sciences, 104(50), 19703-19708.

Sebora, T. C., & Cornwall, J. R. (1995). Expected utility theory vs. prospect theory: Implications for strategic decision makers. Journal of Managerial Issues, 41-61.

Serra, T., Zilberman, D., & Gil, J. M. (2008). Differential uncertainties and risk attitudes between conventional and organic producers: the case of Spanish arable crop farmers. Agricultural Economics, 39(2), 219-229.

Shiferaw, B., & Holden, S. T. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: A Case Study in Andit Tid, North Shewa. Agricultural Economics, 18(3), 233-247.

Simtowe, F. (2006). Can risk-aversion towards fertilizer explain part of the non-adoption puzzle for hybrid maize? Empirical evidence from Malawi. Journal of Applied Sciences, 6(7), 1490-1498.

Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: A typology. Mitigation and Adaptation Strategies for Global Change, 7(1), 85-114.

Starmer, C. (2000). Developments in non-expected utility theory: The hunt for a descriptive theory of choice under risk. Journal of Economic Literature, 332-382.

Sunding, D., & Zilberman, D. (2001).The agricultural innovation process: Research and technology adoption in a changing agricultural sector. In: Evenson, R.,pingali, P. (eds.), in: Handbook of Agricultural Economics, 1, 207-261

Tanaka, T., Camerer, C., Nguyen, Q. (2010). Risk and Time Preferences: Linking Experimental and Household Survey Data from Vietnam. American Economic Review, 100(1):557 – 571.

Thamaga-Chitja, J., & Hendriks, S. L. (2008). Emerging issues in smallholder organic production and marketing in South Africa. Development Southern Africa, 25(3), 317-326.

Thorbecke, E. (2013). The Interrelationship Linking Growth, Inequality and Poverty in Sub-Saharan Africa. Journal of African Economies, 22(Supplement 1), . I15–i48

Therneau, T. M., & Grambsch, P. M. (2000). Modeling survival data: extending the Cox model. Springer Science & Business Media.

Timmer, P. (2002). Agriculture and Economic Development. In Handbook of Agricultural Economics, vol. 2A, edited by B.L. Gardner and G.C. Rausser. Amsterdam: North-Holland.

Tubiello, F. N., Soussana, J., & Howden, S. M. (2007). Crop and pasture response to climate change. Proceedings of the National Academy of Sciences, 104(50), 19686-19690

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. Journal of Risk and uncertainty, 5(4), 297-323.

Uaiene, R. N., Arndt, C., & Masters, W. A. (2009). Determinants of agricultural technology adoption in Mozambique. Discussion papers, (67E), 1-29.

UNPD. (2006) World population projections, the 2006 revision. New York, NY: United Nations Population Division.

Ward, P. S., & Singh, V. (2013). Risk and ambiguity preferences and the adoption of new agricultural technologies: Evidence from field experiments in rural India. In Paper selected for presentation at the Agricultural and Applied Economics Association 2013 AAEA & CAES Joint Annual Meeting, Washington, DC.

Wik, M., T.A. Kebede, O. Bergland and S.T. Holden. (2004). On the measurement of risk aversion from experimental data. Applied Economics 36, 2443-2451

World Bank. (2001). Poverty and Income Distribution in a High-Growth Economy: The Case of Chile, 1987–1998. Report No. 22037-CH.

Van Mansvelt, J.D., Mulder, J. (1993). European features for sustainable development: a contribution to the dialogue. Landscape Urban Plan, 27, 67–90.

Yesuf, M., and Bluffstone, A. (2009). Poverty, Risk aversion and path dependence in low-income countries: Experimental Evidence from Ethiopia. American Journal of Agricultural Economics. 91(4): 1022-1037

Ziervogel, G., Bharwani, S., & Downing, T. E. (2006). Adapting to climate variability: pumpkins, people and policy. In Natural resources forum, 30(4), 294-305. Blackwell Publishing Ltd.

Appendices

Appendix 1

Questionnaire

Experiment number: _____________

BACKGROUND INFORMATION

1. Age: _________________________

2. Gender: [put a tick in the relevant box]

☐ Male

☐ Female

EDUCATION

3. How well can you read in your home language?

☐ I cannot read

☐ Not well

☐ Fair

☐ Very well

☐ Prefer not to answer

4. How well can you write in your home language?

☐ I cannot write

☐ Not well

☐ Fair

☐ Very well

☐ Prefer not to answer

5. What is the highest level of education that you have completed?

☐ No schooling

☐ Sub A

☐ Sub B

☐ Standard 1

☐ Standard 2

☐ Standard 3

☐ Standard 4

☐ Standard 5

☐ Standard 6

☐ Standard 7

☐ Standard 8

☐ Standard 9

☐ Diploma/certificate with less than a Standard 10/Matric certificate

☐ Standard 10/ Matric

☐ Diploma or certificate (with a Standard 10/Matric certidicate)

☐ Degree

☐ Postgraduate degree or diploma

INCOME

6. How many people (including you) live in your household? ______________________ (here, you should include all those people who sleep in the same household as you on a regular basis)

7. How many people aged less than 18 live in your household? ______________________ (here, you should include all those people who sleep in the same household as you on a regular basis)

8. Are you the main breadwinner in your household?

☐ Yes

☐ No

9. Thinking about your <u>own household's financial situation</u>, would you describe yourself as:

☐ Poor

☐ Lower income

☐ Middle income

☐ Upper income

☐ Rich

10. What is your household's monthly income? R________________________

11. Do you have a sufficient amount of food in your household?

☐ We always have enough food in our household

☐ Most of the time we enough food in our household

☐ We often do not have enough food in our household

☐ We never have enough food in our household

EMPLOYMENT

12. Besides your own farming activities, do you have a job?

☐ Yes

☐ No

13. If yes, what job do you do? ____

14. What is your monthly income from this job? R____________________________

15. Is the job full-time or part-time?

☐ Full-time

☐ Part-time

☐ I do not have a job

16. If you are not working, do you have any other form of income?

☐ Pension: if so, how much do you receive each month? R_______________

☐ Child Care Grant: if so, how much do you receive each month? R_____________

☐ Disability Grant: if so, how much do you receive each month? R_____________

☐ Remittances: if so, how much do you receive each month? R_____________

17. In addition to your farming activities and any job that you have already told us about, do you have a part-time job or do you do any activity to earn money for yourself?

☐ Yes: if so, tell us what you do: ____

☐ No

18. How much do you earn each month from this job or activity? R__________________

FARMING ACTIVITIES

19. How many years have you been involved in farming? ____________________

20. What kind of crops do you grow? ______________________________________

21. How much do you earn during a farming season from farming activities? R_________

22. On what type of land do you grow crops or rear animals on?

☐ Land which you or a household member owns

☐ Land which you or a household member has access to as an employee on a commercial farm

☐ A land reform project on state land

☐ An equity share scheme on a commercial farm

☐ Communal land

☐ Land in/near an informal or urban settlement in which the household lives

23. How many hectares is the land that you farm? ________________________________

CLIMATE CHANGE

24. Have you noticed any of the following changes?

Changes in the frequency and timing of rainfall? ☐ Yes ☐ No

Changes in the rainfall level? ☐ Yes ☐ No

Changes in the rainfall intensity? ☐ Yes ☐ No

An increase in temperature? ☐ Yes ☐ No

An increase in the number of pests? ☐ Yes ☐ No

25. Which of the changes have affected your crop yield?

☐ these changes have not affected my crop yield

☐ Changes in the frequency and timing of rainfall

☐ Changes in the level of rainfall

☐ Changes in the rainfall intensity

☐ An increase in the temperature

☐ An increase in the number of pests

26. How has your crop yield been affected?

☐ My yield has increased

☐ My yield has decreased

☐ My yield has been affected

NEW FARMING PRACTICES

27. Please indicate whether you have adopted any of the farming strategies listed below:

[Please tick all the options that apply to you]

☐ I have not adopted any new farming practices

☐ Growing more drought resistant crops → when: Year: __________ Month: __________

☐ Using improved seeds → when: Year: __________ Month: __________

☐ Intercropping → when: Year: __________ Month: __________

☐ Mulching → when: Year: __________ Month: __________

☐ Applying fertilizer → when: Year: __________ Month: __________

☐ Applying organic manure → when: Year: __________ Month: __________

☐ Changing planting dates → when: Year: __________ Month: __________

☐ Planting wind breaks → when: Year: __________ Month: __________

☐ Using irrigation → when: Year: __________ Month: __________

☐ Other: ______________________ → when: Year: __________ Month: __________

28. If you have adopted new farming practices, how have they affected your yield?

☐ My yield has increased

☐ My yield has decreased

☐ My yield has stayed the same

29. If you have not adopted new farming practices, why have you not?

☐ I do not know what measures to take (or what methods to use)

☐ I do not have the money to adopt these measures

☐ The risk of crop failure is too great

☐ Other: ____

CREDIT AND INSURANCE

30. Are you a member of a savings group?

☐ Yes

☐ No

☐ I used to

31. If YES, have you contributed this year?

☐ Yes; if so: how much did you contribute this year? R____________________

☐ I have not yet contributed

☐ Will not contribute this year

☐ I prefer not to answer

32. If you want to invest in farming equipment or other farming inputs, where do you obtain the money for this?

☐ From my savings

☐ I borrow money from my savings group

☐ I request a loan from the bank

☐ I request a loan from a financial institution

☐ I borrow money from friends and/or relatives

☐ Other; please specify: ____

33. Have you ever applied for a loan from a bank or other formal institution for farming activities?

☐ Yes

☐ No

34. Did you take any bank loans for farming this year?

☐ Yes; if so: how much was requested: R____________________
; if so: was the loan granted? ☐ Yes ☐ No

☐ No

35. If you have never attempted to borrow money, why have you not?

☐ There are no formal lending institutions

☐ I did not need credit

☐ I dislike any borrowing

☐ The loans are too expensive

☐ I would have like to apply for a loan but did not apply because I felt that the loan would not be granted

☐ Other; if so, please specify: ____

36. Have you heard of insurance?

☐ Yes

☐ No

37. Would you consider purchasing insurance?

☐ Yes

☐ No

SOCIAL

38. Which of the following statements describes you the best?

☐ I often take risks

☐ I sometimes take risks

☐ I never take risks

Appendix 2

Series 1

Once again please assume that it is planting season. You must decide whether you would like to plant traditional seeds or improved seeds.

This game consists of 14 rows. For **each** row, you must decide between planting traditional seeds or improved seeds.

Let's do an example [*turn to the poster*]. Look at row 1:

Let's start with traditional seeds. The level of rainfall will be enough for a high yield if you draw ball number 1, 2 or 3 out of this bag. If you draw ball number 4, 5, 6, 7, 8, 9 or 10 out of the bag, there is drought. If you planted traditional seeds and there is enough rain for a high yield, your harvest will be worth R20. If you planted traditional seeds and there is a drought, your harvest will be worth R5.

With improved seeds: there will be enough rain for a good harvest if you draw ball number 1 out of this bag. If you draw ball number 2, 3, 4, 5, 6, 7, 8, 9 or 10 out of the bag, there is a drought. If you had planted improved seeds and there is enough rain for a good harvest, your harvest will be worth R34. If you had planted improved seeds and there is a drought, your harvest will be worth R2.50.

Now let's move to row 2:

Let's start with traditional seeds. There will be enough rain for a good harvest if you draw ball number 1, 2 or 3 out of this bag. If you draw ball number 4, 5, 6, 7, 8, 9 or 10 out of the bag, there is a drought. If you planted traditional seeds and there is enough rain for a good harvest, your harvest will be worth R20. If you planted traditional seeds and there is a drought, your harvest will be worth R5.

With improved seeds: there will be enough rain for a good harvest if you draw ball number 1 out of this bag. If you draw ball number 2, 3, 4, 5, 6, 7, 8, 9 or 10 out of the bag, there is a drought. If you had planted improved seeds and there is enough rain for a good harvest, your harvest will be worth R34. If you had planted improved seeds and there is a drought, your harvest will be worth R2.50.

Notice that the balls showing whether there is enough rain for a good harvest or whether there is drought stay the same throughout the game. The value of the harvest for planting traditional seeds also stays the same throughout the game. **The only thing that changes** is the value of the harvest for planting improved seeds **when there is enough rain for a good harvest**.

In the first row, if you plant improved seeds and there is enough rain for a good harvest, your harvest is worth R34. In the very last row, if you plant improved seeds and there is enough rain for a good harvest, you harvest is worth R850.

Remember, because the payoffs are so high for this game, if this game is chosen to be played for real money, two of you will randomly be chosen to play the game for money. We don't know who those 2 of you will be, so it is important to play this game as if you are playing for real money.

Just like before, we won't play all the rows for money. Once you have made your decisions, one of you will draw a ball from this bag which has 14 balls inside it. This will tell us which row you are playing for money. If ball number 1 is drawn from the bag, you will play row 1 for money. If ball number 2 is drawn from the bag, you will play row 2 for money. If ball number 14 is drawn from the bag, you will play row 14 for money.

Does anyone have any questions before we start?

Let's start. Please write the number we gave you at the start of the experiment on the top left hand side of the sheet where it says experiment number *[gesture to where they must put their number]*.

For each row in the sheet in front of you, indicate whether you would like to plant traditional seeds or improved seeds.

		Traditional Seeds	Improved Seeds
1	💧💧	R20 if ❶❷❸	R34 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
2	💧💧	R20 if ❶❷❸	R37.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
3	💧💧	R20 if ❶❷❸	R41.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
4	💧💧	R20 if ❶❷❸	R46.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
5	💧💧	R20 if ❶❷❸	R53 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
6	💧💧	R20 if ❶❷❸	R62.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
7	💧💧	R20 if ❶❷❸	R75 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
8	💧💧	R20 if ❶❷❸	R92.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
9	💧💧	R20 if ❶❷❸	R110 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
10	💧💧	R20 if ❶❷❸	R150 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
11	💧💧	R20 if ❶❷❸	R200 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
12	💧💧	R20 if ❶❷❸	R300 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
13	💧💧	R20 if ❶❷❸	R500 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
14	💧💧	R20 if ❶❷❸	R850 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿

Answer:

I choose Traditional Seeds for rows 1 - [ ]

I choose Improved Seeds for rows [ ] - 14

Series 2

This game works exactly the same as the previous game. Once again please assume that it is planting season. You must decide whether you would like to plant traditional seeds or improved seeds. This game also consists of 14 rows. For **each** row, you must decide between planting traditional seeds or improved seeds.

Let's do an example [*turn to the poster*]. Look at row 1:

Let's start with traditional seeds. There will be enough rain for a good yield if you draw ball number 1, 2, 3, 4, 5, 6, 7, 8 or 9 out of this bag. If you draw ball number 10 out of the bag, there is a drought. If you planted traditional seeds and there is enough rain for a good yield, your harvest will be worth R20. If you planted traditional seeds and there is a drought, your harvest will be worth R15.

With improved seeds: there will be enough rain for a good yield if you draw ball number 1, 2, 3, 4, 5, 6, or 7 out of this bag. If you draw ball number 8, 9 or 10 out of the bag, there will be a drought. If you had planted improved seeds and there is enough rain for a good yield, your harvest will be worth R27. If you had planted improved seeds and there is a drought, your harvest will be worth R2.50.

Now let's move to row 2:

Let's start with traditional seeds. There will be enough rain for a good yield if you draw ball number 1, 2, 3, 4, 5, 6, 7, 8 or 9 out of this bag. If you draw ball number 10 out of the bag, there is a drought. If you planted traditional seeds and there is enough rain for a good yield, your harvest will be worth R20. If you planted traditional seeds and there is a drought, your harvest will be worth R15.

With improved seeds: there will be enough rain for a good yield if you draw ball number 1, 2, 3, 4, 5, 6, or 7 out of this bag. If you draw ball number 8, 9 or 10 out of the bag, there is a drought. If you had planted improved seeds and there is enough rain for a good yield, your harvest will be worth R28. If you had planted improved seeds and there is a drought, your harvest will be worth R2.50.

Notice that the balls showing whether there is enough rain for a good harvest or whether there is drought stay the same throughout the game. The value of the harvest for planting traditional seeds also stays the same throughout the game. **The only thing that changes** is the value of the harvest for planting improved seeds **when there is enough rain for a good yield**.

In the first row, if you plant improved seeds and there is enough rain for a high yield, your harvest is worth R27. In the very last row, if you plant improved seeds and there is enough rain for a high yield, you harvest is worth R65.

Just like before, we won't play all the rows for money. Once you have made your decisions, one of you will draw a ball from this bag which has 14 balls inside it. This will tell us which row you are playing for money. If ball number 1 is drawn from the bag, you will play row 1 for money. If ball number 2 is drawn from the bag, you will play row 2 for money. If ball number 14 is drawn from the bag, you will play row 14 for money.

Does anyone have any questions before we start?

Let's start. Please write the number we gave you at the start of the experiment on the top left hand side of the sheet where it says experiment number *[gesture to where they must put their number]*.

For each row in the sheet in front of you, indicate whether you would like to plant traditional seeds or improved seeds.

		Traditional Seeds	Improved Seeds
1	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R27 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
2	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R28 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
3	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R29 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
4	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R30 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
5	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R31 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
6	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R32.5 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
7	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R34 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
8	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R36 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
9	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R38.5 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
10	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R41.5 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
11	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R45 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
12	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R50 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
13	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R55 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
14	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R65 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿

Answer:

I choose Traditional Seeds for rows 1 - [ ]

I choose Improved Seeds for rows [ ] - 14

Series 3

This game works exactly the same as the previous game.

Once again please assume that it is planting season. You must decide whether you would like to plant traditional seeds or improved seeds.

This game consists of 7 rows. For **each** row, you must decide between planting traditional seeds or improved seeds.

The difference in this game is that, now, you can **lose money**. Any money you lose will be taken from your earnings for this session.

Let's do an example [*turn to the poster*]. Look at row 1:

Let's start with traditional seeds. There is enough rain for a good yield if you draw ball number 1, 2, 3, 4 or 5 out of this bag. If you draw ball number 6, 7, 8, 9 or 10 out of the bag, there is a drought. If you planted traditional seeds and there is enough rain for a good yield, your harvest will be worth R12.50. If you planted traditional seeds and there is a drought, you will lose R2.

With improved seeds: there is enough rain for a good yield if you draw ball number 1, 2, 3, 4 or 5 out of this bag. If you draw ball number 6, 7, 8, 9 or 10 out of the bag, there is a drought. If you planted improved seeds and there is enough rain for a good yield, your harvest will be worth R15. If you planted improved seeds and there is a drought, you will lose R10.50.

Now let's move to row 2:

Let's start with traditional seeds. There is enough rain for a good yield if you draw ball number 1, 2, 3, 4 or 5 out of this bag. If you draw ball number 6, 7, 8, 9 or 10 out of the bag, there is a drought. If you planted traditional seeds and there is enough rain for a good yield, your harvest will be worth R12.50. If you planted traditional seeds and there is a drought, you will lose R2.

With improved seeds: There is enough rain for a good yield if you draw ball number 1, 2, 3, 4 or 5 out of this bag. If you draw ball number 6, 7, 8, 9 or 10 out of the bag, there is a drought. If you planted improved seeds and there is enough rain for a good yield, your harvest will be worth R15. If you planted improved seeds and there is a drought, you will lose R10.50.

Just like before, we won't play all the rows for money. Once you have made your decisions, one of you will draw a ball from this bag which has 7 balls inside it. This will tell us which row you are playing for money. If ball number 1 is drawn from the bag, you will play row 1 for money. If ball number 2 is drawn from the bag, you will play row 2 for money. If ball number 7 is drawn from the bag, you will play row 7 for money.

Does anyone have any questions before we start?

Let's start. Please write the number we gave you at the start of the experiment on the top left hand side of the sheet where it says experiment number *[gesture to where they must put their number]*.

For each row in the sheet in front of you, indicate whether you would like to plant traditional seeds or improved seeds.

	Rainfall	**Traditional Seeds**	**Improved Seeds**
1	💧💧	R12.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R10 if ❻❼❽❾❿
2	💧💧	R2 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R10 if ❻❼❽❾❿
3	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R10 if ❻❼❽❾❿
4	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R8 if ❻❼❽❾❿
5	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R4 if ❻❼❽❾❿	-R8 if ❻❼❽❾❿
6	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R4 if ❻❼❽❾❿	-R7 if ❻❼❽❾❿
7	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R4 if ❻❼❽❾❿	-R5.5 if ❻❼❽❾❿

Answer:

I choose Traditional Seeds for rows 1 - [ ]

I choose Improved Seeds for rows [ ] - 7

Appendix 3

Determinants of Uptake

	Drought Resistant Crops		Improved Seeds		Intercropping		Fertilizer		Manure		Windbreaks		Irrigation	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Sigma	0.012	0.309	0.606	0.849	1.048	1.776	4.419	5.464	0.279	0.657	0.607	0.794	1.274	1.077
	(1.545)	*(1.324)*	*(1.904)*	*(1.738)*	*(1.218)*	*(1.784)*	*(2.051)***	*(2.391)***	*(1.354)*	*(1.581)*	*(0.942)*	*(1.352)*	*(1.170)*	*(1.452)*
Alpha	3.953	3.803	3.807	3.825	0.520	0.229	0.437	0.926	0.025	-0.367	0.917	1.031	0.526	0.211
	*(2.337)**	*(2.300)**	*(2.284)**	*(2.140)**	*(1.474)*	*(1.950)*	*(1.476)*	*(1.983)*	*(1.826)*	*(2.700)*	*(1.708)*	*(2.068)*	*(1.359)*	*(1.486)*
Lambda	-1.760	-1.713	-0.270	-0.056	-1.551	-2.040	-0.189	-0.360	-0.795	-0.882	0.090	0.330	0.542	1.030
	(2.730)	*(2.483)*	*(1.696)*	*(1.823)*	*(1.217)*	*(1.576)*	*(1.119)*	*(1.562)*	*(1.095)*	*(1.230)*	*(1.318)*	*(1.467)*	*(1.075)*	*(1.205)*
Age	-0.057	-0.041	-0.005	-0.008	0.010	-0.010	0.021	0.007	0.018	0.002	0.008	-0.010	0.022	0.004
	(0.035)	*(0.035)*	*(0.036)*	*(0.040)*	*(0.024)*	*(0.035)*	*(0.034)*	*(0.044)*	*(0.026)*	*(0.038)*	*(0.028)*	*(0.033)*	*(0.023)*	*(0.028)*
Female	-1.805	-1.798	-0.900	-0.951	0.081	0.051	-1.094	-1.971	-1.118	-1.345	-0.587	-0.680	-0.483	-0.285
	(1.124)	*(1.362)*	*(0.939)*	*(1.014)*	*(0.682)*	*(0.811)*	*(0.858)*	*(0.987)***	*(0.722)*	*(0.907)*	*(0.797)*	*(0.836)*	*(0.689)*	*(0.785)*
Farm Experience in yrs.	0.036	0.036	-0.012	-0.018	-0.014	0.013	-0.023	0.004	0.010	0.043	-0.041	-0.041	-0.019	-0.023
	(0.069)	*(0.064)*	*(0.059)*	*(0.062)*	*(0.052)*	*(0.049)*	*(0.089)*	*(0.093)*	*(0.056)*	*(0.065)*	*(0.074)*	*(0.069)*	*(0.045)*	*(0.046)*
Education Level	-0.272	-0.182	-0.181	-0.195	-0.141	-0.226	-0.075	-0.131	0.062	0.051	-0.015	-0.111	0.067	-0.055
	*(0.163)**	*(0.130)*	*(0.176)*	*(0.162)*	*(0.112)*	*(0.175)*	*(0.121)*	*(0.173)*	*(0.119)*	*(0.162)*	*(0.119)*	*(0.156)*	*(0.098)*	*(0.130)*
Household Size	-0.084	-0.038	-0.072	-0.095	0.101	0.158	0.551	0.771	0.180	0.249	0.070	0.017	0.190	0.147
	(0.394)	*(0.370)*	*(0.280)*	*(0.327)*	*(0.139)*	*(0.158)*	*(0.217)***	*(0.230)****	*(0.164)*	*(0.180)*	*(0.192)*	*(0.258)*	*(0.151)*	*(0.204)*
Employed	0.749	0.774	0.528	0.621	-1.971	-1.793	-1.180	-1.409	-5.617	-5.733	-0.338	-0.204	-1.301	-1.277
	(1.401)	*(1.567)*	*(1.259)*	*(1.432)*	*(1.099)**	*(1.064)**	*(1.171)*	*(1.843)*	*(1.236)****	*(1.379)****	*(1.030)*	*(1.054)*	*(0.947)*	*(1.098)*
Household Income	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	*(0.000)**	*(0.000)**	*(0.000)*	*(0.000)**	*(0.000)*	*(0.000)***	*(0.000)***	*(0.000)*	*(0.000)****	*(0.000)****	*(0.000)***	*(0.000)***	*(0.000)**	*(0.000)**
							Perceived Changes in Climate							
Rainfall Frequency and Timing		-0.117		1.382		4.937		6.164		1.897		1.233		2.056
		(1.083)		*(1.914)*		*(2.295)***		*(2.284)****		*(1.278)*		*(1.707)*		*(1.691)*
Rainfall Level and		-0.386		-0.627		-4.981		-4.460		-2.169		-0.325		0.652
Intensity		(1.138)		(1.412)		(2.350)**		(1.736)**		(1.696)		(1.994)		(1.495)
		-0.657		*-0.373*		*2.617*		*-0.193*		*1.375*		*1.154*		*0.433*
Temperature		(0.941)		(1.261)		(0.785)***		(1.491)		(2.032)		(1.403)		(1.128)
	5.160	*4.244*	*1.654*	*1.806*	*-0.688*	*-1.131*	*-4.021*	*-4.686*	*-2.778*	*-3.287*	*-1.773*	*-1.455*	*-3.410*	*-4.225*
Constant	(3.806)	(3.224)	(3.482)	(3.548)	(2.281)	(3.330)	(2.482)	(2.850)	(2.312)	(2.595)	(2.665)	(3.598)	(2.075)	(2.364)*
Observations	*75*	*75*	*75*	*75*	*75*	*75*	*75*	*75*	*75*	*75*	*75*	*75*	*75*	*75*

Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%

Appendix 4

Questionnaire

Experiment number: _____________

Please note that you are free to leave out any questions that you prefer not to answer.

BACKGROUND INFORMATION

1. Age: ___________________________

2. Date of Birth: _____________________

3. Gender:

[Tick one box only]

☐ Male

☐ Female

EDUCATION

4. How well can you read in your home language:

[Tick one box only]

☐ I cannot read

☐ Not well

☐ Fair

☐ Very well

☐ Prefer not to answer

5. What is the highest level of education that you have <u>completed</u>:

[Tick one box only]

☐ No schooling

☐ Sub A

☐ Sub B

☐ Standard 1

☐ Standard 2

☐ Standard 3

☐ Standard 4

☐ Standard 5

☐ Standard 6

☐ Standard 7

☐ Standard 8

☐ Standard 9

☐ Diploma/certificate with less than a Standard 10 (Matric certificate)

☐ Standard 10 (Matric certificate)

☐ Diploma or certificate (with a Standard 10/Matric certificate)

☐ Degree

☐ Postgraduate degree or diploma

☐ Other: please explain: ____

YOUR HOUSEHOLD

Here, you should include all those people who sleep in the same household as you on a regular basis and share from the food in the home with other household members)

6. How many people (including you) live in the household? ______________________

7. How many people aged less than 18 live in the household? ____________________

8. How many people living in your household have regular employment? __________

INCOME AND EMPLOYMENT

9. What is your monthly income from your farming activities?

☐ R________________

☐ Prefer not to answer

10. In ADDITION to your farming activities, are you being paid a wage or salary by an employer for regular full-time or part-time work?

☐ Yes

☐ No

11. If you answered yes, what is your monthly salary or wage from this job?

☐ R________________

☐ Prefer not to answer

12. In ADDITION to your farming activities, are you self-employed? This means that your work for yourself on a full-time or part-time basis and not for an employer.

☐ Yes

☐ No

13. If you answered yes, what is your monthly salary from your self-employment activities?

☐ R____________

☐ Prefer not to answer

14. In ADDITION to your farming activities AND any job that you have ALREADY told us about, do you do any other job or activity to earn money for yourself?

☐ Yes

☐ No

15. If you answered yes, what is your monthly salary from this job or activity?

☐ R____________

☐ Prefer not to answer

16. What is your monthly income FROM ALL YOUR JOBS?

☐ R____________

☐ Prefer not to answer

17. **Please show which bracket your monthly income falls into:**

☐ R0-R250

☐ R251-R500

☐ R501-R1000

☐ R1001-R2000

☐ R2001-R3000

☐ R3001-R4000

☐ R4001-R5000

☐ R5001-R6000

☐ R6001-R7000

☐ R7001-R8000

☐ R8001-R9000

☐ R9001-R10000

☐ More than R10000 per month

18. **Are you the main breadwinner in your household?**

☐ Yes

☐ No

GOVERNMENT GRANTS

19. **Do you or any of your household members receive any money from the Government?**

☐ Yes

☐ No

20. **If yes, what do you receive this money for, and how much do you receive?**

☐ Pension: if so, how much do you receive each month? R_______________

☐ Child Care Grant: if so, how much do you receive each month? R_____________

☐ Disability Grant: if so, how much do you receive each month? R_____________

☐ Prefer not to answer

HOUSEHOLD INCOME

21. Please show which bracket your monthly household income falls into:

☐ R0-R250

☐ R251-R500

☐ R501-R1000

☐ R1001-R2000

☐ R2001-R3000

☐ R3001-R4000

☐ R4001-R5000

☐ R5001-R6000

☐ R6001-R7000

☐ R7001-R8000

☐ R8001-R9000

☐ R9001-R10000

☐ More than R10000 per month

22. Thinking about your own household's financial situation, would you describe yourself as:

☐ Poor

☐ Lower income

☐ Middle income

☐ Upper income

☐ Rich

HOUSEHOLD EXPENDITURE

23. Please show which expenditure bracket your average monthly household expenditure falls into:

☐ R0-R250

☐ R251-R500

☐ R501-R1000

☐ R1001-R2000

☐ R2001-R3000

☐ R4001-R5000

☐ R5001-R6000

☐ R6001-R7000

☐ R7001-R8000

☐ R8001-R9000

☐ R9001-R10000

☐ More than R10000 per month

FARMING ACTIVITIES

24. Which farming area are you from?

☐ Khayelitsha

☐ Nyanga

☐ Other: please specify: ________________________________

25. How many years have you been involved in farming? ______________________

26. With regard to the plot of land that you farm on, do you farm on a community plot of land or an individual plot of land?

☐ Community/group plot

☐ Individual plot

27. If you do farm on a community plot, how many people (including yourself) farm on the same plot of land? ___________________

28. If you farm on a community plot, do you have an individual plot of land on the community plot that you are responsible for, or do you all share the plot?

☐ Yes, I have an individual plot of land in the community plot

☐ No, we all share the plot

29. If you farm on a community plot, are you all equally involved in the decision-making?

☐ Yes, we all make decisions together

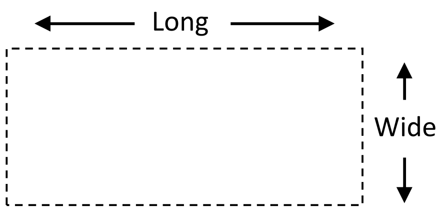
☐ No, one person makes decisions on behalf of the rest of us

☐ Other: ____

____

____

30. How many metres long and wide is the land that you farm:



Metres long: _____________________

Metres wide: ____________________

31. What kind of crops do you grow?

☐ Sweet potatoes

☐ Lettuce

☐ Spinach

☐ Cauliflower

☐ Broccoli

☐ Carrots

☐ Beetroot

☐ Turnips

☐ Cabbage

☐ Fennel

☐ Tomatoes

☐ Other: ____

NEW FARMING PRACTICES

32. Please indicate whether you have started using any NEW farming practices:

[Please tick all the options that apply to you]

☐ I have not started using any new farming practices

☐ Mulching (covering the soil to keep in moisture)

Year: __________

Month: __________

Why did you start doing this? ____

☐ Using seeds that grow better in dry weather conditions

Year: __________

Month: __________

Why did you start doing this? ____

☐ Intercropping (growing two crops on the same land)

Year: __________

Month: __________

Why did you start doing this? ____

☐ Using fertilizer

Year: __________

Month: __________

Why did you start doing this? ____

☐ Using organic manure

Year: __________

Month: __________

Why did you start doing this? ____

☐ Changing planting dates

Year: __________

Month: __________

Why did you start doing this? ____

☐ Planting wind breaks

Year: __________

Month: __________

Why did you start doing this? ____

☐ Using irrigation (water from a tap)

Year: __________

Month: __________

Why did you start doing this? ____

☐ Other: ____

Year: __________

Month: __________

Why did you start doing this? ____

CREDIT

33. Have you ever applied for a loan from a bank or any other financial institution?

☐ Yes

☐ No

34. If yes, you have applied for a loan, did the bank give you the loan?

☐ Yes

☐ No

35. If you have never applied for a loan from a bank or financial institution, why have you not?

[Tick as many options as you like]

☐ I do not like to borrow money from anyone

☐ I prefer to borrow money from family and friends

☐ I did not know how to apply for a loan

☐ A loan is too expensive and difficult to pay back

☐ I did not think I would be given a loan so I never applied for one

☐ I have not needed to take out a loan

☐ Other: if so, please specify: ____

____

____

36. Do you personally have any of the loans mentioned below

[Please tick all the options that apply to you]

☐ Home loan

☐ Personal loan

☐ Study loan

☐ Vehicle finance

☐ Credit card

☐ Store card (for example: Edgars, Clicks, Foschini)

☐ Loan from a friend or family member

37. If you want to buy new farming equipment or new farming inputs (like seeds), where do you get the money for this?

☐ From my personal savings

☐ I borrow money from my savings group

☐ I get a loan from the bank

☐ I borrow money from friends and/or relatives

☐ Other; please specify: ____

____

____

INSURANCE

38. Have you heard about buying insurance products to protect yourself against risk or negative events (for example a fire)?

☐ Yes

☐ No

39. Have you ever experienced a negative event and wished that you had been insured?

☐ Yes

☐ No

40. **Do you think buying insurance is a useful way to protect yourself against risk and negative events?**

☐ Insurance is very useful

☐ Insurance is sometimes useful

☐ Insurance is not very useful

☐ I don't know

41. **Have you ever had an insurance policy?**

☐ Yes

☐ No

42. **If yes, you have had an insurance policy, what type of insurance policy was/is it?**

☐ Crop insurance

☐ Life insurance

☐ Funeral policy

☐ Medical insurance

☐ Disability insurance

☐ Homeowners insurance

☐ Vehicle insurance

☐ Other; if so, please specify: ____

43. **Do you still have this/these insurance policy/policies?**

Please select the policy/policies you still have:

☐ Crop insurance

☐ Life insurance

☐ Funeral policy

☐ Medical insurance

☐ Disability insurance

☐ Homeowners insurance

☐ Vehicle insurance

☐ Other; if so, please specify: ____

44. **If you have never bought insurance: what is the reason for this?**

☐ I have never thought of buying insurance

☐ I don't really understand how buying insurance will benefit me

☐ I have thought about buying insurance, but don't know how to buy it

☐ I have thought about buying insurance, but find that buying insurance is too complicated and difficult

☐ I have thought about buying insurance, but it is too expensive

☐ I do not want to buy insurance

ATTITUDES TO RISK

45. What type of person are you?

[Tick one box only]

☐ A person who **often** takes risks

☐ A person who **sometimes** takes risks

☐ A person who **never** takes risks

46. Do you every buy lottery tickets (lotto and powerball for example)?

☐ Yes

☐ No

47. If yes, how often do you buy lottery tickets?

☐ Every day

☐ Once a week

☐ Twice a month

☐ Once a month

☐ Every two months

☐ Four times a year

☐ Twice a year

☐ Once a year

48. How much do you usually spend on lotto tickets when you buy them?

☐ R______________________

☐ Prefer not to answer

49. Do you ever play Fafi (iChina)?

☐ Yes

☐ No

50. If yes, how often do you play Fafi?

☐ Every day

☐ Once a week

☐ Twice a month

☐ Once a month

☐ Every two months

☐ Four times a year

☐ Twice a year

☐ Once a year

51. How much do you usually spend when you play Fafi?

☐ R______________________

☐ Prefer not to answer

52. Do you ever play card/dice games for money?

☐ Yes

☐ No

53. If yes, how often do you play card/dice games for money?

☐ Every day

☐ Once a week

☐ Twice a month

☐ Once a month

☐ Every two months

☐ Four times a year

☐ Twice a year

☐ Once a year

54. How much do you usually spend when you play card/dice games for money?

☐ R______________________

☐ Prefer not to answer

55. Do you ever bet on animals (for example horse racing, dog racing etc)?

☐ Yes

☐ No

56. If yes, how often do you bet on animals?

☐ Every day

☐ Once a week

☐ Twice a month

☐ Once a month

☐ Every two months

☐ Four times a year

☐ Twice a year

☐ Once a year

57. How much do you usually spend when you bet on animals?

☐ R______________________

☐ Prefer not to answer

58. Do you ever go to the casino (for example play the slot machines)?

☐ Yes

☐ No

59. If yes, how often do you go to the casino?

☐ Every day

☐ Once a week

☐ Twice a month

☐ Once a month

☐ Every two months

☐ Four times a year

☐ Twice a year

☐ Once a year

60. **How much do you usually spend at the casino when you go?**

☐ **R______________________**

☐ Prefer not to answer

Appendix 5

Framing: Table a represents the gains prospect while table 1b represents the losses prospect, with probability levels of the first, second and third gamble being 30 percent, 50 percent and 70 percent, respectively.

Table a: 30 percent, 50 percent and 70 percent gains gambles (in Rand)

Gamble	Option 1		Option 2		
	Min.	Max.	Prob.	Prize	EV
1	R3	R26	30 percent	R50	R15
2	R13	R36	50 percent	R50	R25
3	R23	R46	70 percent	R50	R35

Table b: 30 percent, 50 percent and 70 percent losses gambles (in Rand)

Gamble	Option 1		Option 2		
	Min.	Max.	Prob.	Prize	EV
1	-R3	-R26	30 percent	-R50	-R15
2	-R13	-R36	50 percent	-R50	-R25
3	-R23	-R46	70 percent	-R50	-R35

Sample Decision Sheets

30% Probability of Gains

	Option 1	✓		Option 2	✓
[1]	R3 for sure		**OR**	Spin the wheel: ○0 / ●50	
[2]	R4 for sure		**OR**	Spin the wheel: ○0 / ●50	
[3]	R5 for sure		**OR**	Spin the wheel: ○0 / ●50	
[4]	R6 for sure		**OR**	Spin the wheel: ○0 / ●50	
[5]	R7 for sure		**OR**	Spin the wheel: ○0 / ●50	
[6]	R8 for sure		**OR**	Spin the wheel: ○0 / ●50	
[7]	R9 for sure		**OR**	Spin the wheel: ○0 / ●50	
[8]	R10 for sure		**OR**	Spin the wheel: ○0 / ●50	
[9]	R11 for sure		**OR**	Spin the wheel: ○0 / ●50	
[10]	R12 for sure		**OR**	Spin the wheel: ○0 / ●50	
[11]	R13 for sure		**OR**	Spin the wheel: ○0 / ●50	
[12]	R14 for sure		**OR**	Spin the wheel: ○0 / ●50	
[13]	R15 for sure		**OR**	Spin the wheel: ○0 / ●50	
[14]	R16 for sure		**OR**	Spin the wheel: ○0 / ●50	
[15]	R17 for sure		**OR**	Spin the wheel: ○0 / ●50	
[16]	R18 for sure		**OR**	Spin the wheel: ○0 / ●50	
[17]	R19 for sure		**OR**	Spin the wheel: ○0 / ●50	
[18]	R20 for sure		**OR**	Spin the wheel: ○0 / ●50	
[19]	R21 for sure		**OR**	Spin the wheel: ○0 / ●50	
[20]	R22 for sure		**OR**	Spin the wheel: ○0 / ●50	

[21]	R23 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[22]	R24 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[23]	R25 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[24]	R26 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐

50% Probability of Gains

	Option 1	✓		Option 2	✓
[1]	R13 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[2]	R14 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[3]	R15 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[4]	R16 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[5]	R17 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[6]	R18 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[7]	R19 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[8]	R20 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[9]	R21 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[10]	R22 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[11]	R23 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[12]	R24 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[13]	R25 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[14]	R26 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[15]	R27 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[16]	R28 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[17]	R29 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐

[18]	R30 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[19]	R31 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[20]	R32 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[21]	R33 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[22]	R34 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[23]	R35 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[24]	R36 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐

70% probability of gains

	Option 1	✓		**Option 2**	✓
[1]	R23 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[2]	R24 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[3]	R25 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[4]	R26 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[5]	R27 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[6]	R28 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[7]	R29 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[8]	R30 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[9]	R31 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[10]	R32 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[11]	R33 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[12]	R34 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[13]	R35 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[14]	R36 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[15]	R37 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐
[16]	R38 for sure	☐	**OR**	Spin the wheel: ◯0 / ●50	☐

[17]	R39 for sure		**OR**	Spin the wheel: ○0 / ●50	
[18]	R40 for sure		**OR**	Spin the wheel: ○0 / ●50	
[19]	R41 for sure		**OR**	Spin the wheel: ○0 / ●50	
[20]	R42 for sure		**OR**	Spin the wheel: ○0 / ●50	
[21]	R43 for sure		**OR**	Spin the wheel: ○0 / ●50	
[22]	R44 for sure		**OR**	Spin the wheel: ○0 / ●50	
[23]	R45 for sure		**OR**	Spin the wheel: ○0 / ●50	
[24]	R46 for sure		**OR**	Spin the wheel: ○0 / ●50	

30% Probability of Losses

	Option 1	✓		**Option 2**	✓
[1]	LOSE R3 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[2]	LOSE R4 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[3]	LOSE R5 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[4]	LOSE R6 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[5]	LOSE R7 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[6]	LOSE R8 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[7]	LOSE R9 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[8]	LOSE R10 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[9]	LOSE R11 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[10]	LOSE R12 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[11]	LOSE R13 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[12]	LOSE R14 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[13]	LOSE R15 for sure		**OR**	Spin the wheel: ○R0 / ●R50	

[14]	LOSE R16 for sure		OR	Spin the wheel: ○R0 / ●R50	
[15]	LOSE R17 for sure		OR	Spin the wheel: ○R0 / ●R50	
[16]	LOSE R18 for sure		OR	Spin the wheel: ○R0 / ●R50	
[17]	LOSE R19 for sure		OR	Spin the wheel: ○R0 / ●R50	
[18]	LOSE R20 for sure		OR	Spin the wheel: ○R0 / ●R50	
[19]	LOSE R21 for sure		OR	Spin the wheel: ○R0 / ●R50	
[20]	LOSE R22 for sure		OR	Spin the wheel: ○R0 / ●R50	
[21]	LOSE R23 for sure		OR	Spin the wheel: ○R0 / ●R50	
[22]	LOSE R24 for sure		OR	Spin the wheel: ○R0 / ●R50	
[23]	LOSE R25 for sure		OR	Spin the wheel: ○R0 / ●R50	
[24]	LOSE R26 for sure		OR	Spin the wheel: ○R0 / ●R50	

<u>50% probability of Losses</u>

	Option 1	✓		**Option 2**	✓
[1]	LOSE R13 for sure		OR	Spin the wheel: ○R0 / ●R50	
[2]	LOSE R14 for sure		OR	Spin the wheel: ○R0 / ●R50	
[3]	LOSE R15 for sure		OR	Spin the wheel: ○R0 / ●R50	
[4]	LOSE R16 for sure		OR	Spin the wheel: ○R0 / ●R50	
[5]	LOSE R17 for sure		OR	Spin the wheel: ○R0 / ●R50	
[6]	LOSE R18 for sure		OR	Spin the wheel: ○R0 / ●R50	
[7]	LOSE R19 for sure		OR	Spin the wheel: ○R0 / ●R50	
[8]	LOSE R20 for sure		OR	Spin the wheel: ○R0 / ●R50	
[9]	LOSE R21 for sure		OR	Spin the wheel: ○R0 / ●R50	

[10]	LOSE R22 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[11]	LOSE R23 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[12]	LOSE R24 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[13]	LOSE R25 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[14]	LOSE R26 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[15]	LOSE R27 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[16]	LOSE R28 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[17]	LOSE R29 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[18]	LOSE R30 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[19]	LOSE R31 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[20]	LOSE R32 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[21]	LOSE R33 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[22]	LOSE R34 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[23]	LOSE R35 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[24]	LOSE R36 for sure		**OR**	Spin the wheel: ○R0 / ●R50	

70% Probability of Losses

	Option 1	✓		**Option 2**	✓
[1]	LOSE R23 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[2]	LOSE R24 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[3]	LOSE R25 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[4]	LOSE R26 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[5]	LOSE R27 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[6]	LOSE R28 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[7]	LOSE R29 for sure		**OR**	Spin the wheel: ○R0 / ●R50	
[8]	LOSE R30 for sure		**OR**	Spin the wheel: ○R0 / ●R50	

[9]	LOSE R31 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[10]	LOSE R32 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[11]	LOSE R33 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[12]	LOSE R34 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[13]	LOSE R35 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[14]	LOSE R36 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[15]	LOSE R37 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[16]	LOSE R38 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[17]	LOSE R39 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[18]	LOSE R40 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[19]	LOSE R41 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[20]	LOSE R42 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[21]	LOSE R43 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[22]	LOSE R44 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[23]	LOSE R45 for sure		**OR**	Spin the wheel:	○R0 /	●R50	
[24]	LOSE R46 for sure		**OR**	Spin the wheel:	○R0 /	●R50	

Appendix 6

Determinants of Uptake

	Intercropping		Manure		Mulching		Improved Seeds		Windbreaks	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Risk Aversion(Gains Frame)	-0.686	–	-0.882	–	0.786	–	4.040	–	1.189	–
	(0.766)		*(0.711)*		*(0.969)*		*(1.369)***		*(0.975)*	
Loss Aversion	–	0.023	–	0.274	–	0.049	–	0.152	–	0.061
		(0.069)		*(0.144)+*		*(0.063)*		*(0.095)*		*(0.065)*
30% Prob. Gains/Losses	0.027	-0.020	0.000	-0.075	-0.030	-0.061	-0.016	-0.173	0.012	-0.018
	(0.562)	*(0.554)*	*(0.644)*	*(0.660)*	*(0.620)*	*(0.643)*	*(0.885)*	*(0.806)*	*(0.582)*	*(0.585)*
70% Prob. Gains/Losses	-0.041	0.019	-0.066	0.119	0.084	0.050	0.406	0.164	0.125	0.066
	(0.558)	*(0.559)*	*(0.649)*	*(0.688)*	*(0.621)*	*(0.627)*	*(0.832)*	*(0.783)*	*(0.590)*	*(0.593)*
Age	0.020	0.015	-0.065	-0.077	-0.044	-0.042	0.106	0.088	0.027	0.034
	(0.025)	*(0.023)*	*(0.027)**	*(0.026)***	*(0.021)**	*(0.021)**	*(0.035)***	*(0.033)***	*(0.023)*	*(0.021)*
Female	-0.464	-0.501	0.655	0.459	-0.632	-0.577	2.046	2.257	-0.241	-0.164
	(0.521)	*(0.523)*	*(0.660)*	*(0.677)*	*(0.732)*	*(0.710)*	*(1.519)*	*(1.406)*	*(0.539)*	*(0.538)*
Primary Bread Winner	*0.367*	*0.356*	*-0.193*	*-0.030*	*2.563*	*2.731*	*-4.657*	*-2.753*	*0.929*	*1.058*
	(0.523)	*(0.495)*	*(0.813)*	*(0.788)*	*(0.624)***	*(0.674)***	*(1.420)***	*(1.179)**	*(0.659)*	*(0.691)*
Farm Experience in Yrs.	0.081	0.084	0.123	0.130	0.091	0.094	-0.192	-0.138	0.115	0.117
	(0.060)	*(0.062)*	*(0.092)*	*(0.086)*	*(0.106)*	*(0.105)*	*(0.081)**	*(0.070)**	*(0.059)+*	*(0.057)**
Education Level	0.133	0.154	-0.073	0.010	-0.062	-0.059	0.533	0.411	0.203	0.202
	(0.080)+	*(0.078)**	*(0.067)*	*(0.084)*	*(0.077)*	*(0.078)*	*(0.170)***	*(0.131)***	*(0.068)***	*(0.071)***
Household Size	0.182	0.187	-0.312	-0.318	0.274	0.268	3.546	2.571	-0.010	-0.018
	(0.139)	*(0.140)*	*(0.131)**	*(0.141)**	*(0.155)+*	*(0.152)+*	*(1.109)***	*(0.930)***	*(0.122)*	*(0.116)*
Employment	0.673	0.998	-0.514	0.736	3.037	2.955	-0.928	-1.387	1.648	1.408
	(0.699)	*(0.719)*	*(0.893)*	*(1.044)*	*(1.141)***	*(1.070)***	*(1.757)*	*(1.391)*	*(0.890)+*	*(0.830)+*
Household Income	0.000	0.000	0.000	0.001	0.001	0.001	0.013	0.010	0.000	0.000
	(0.000)	*(0.000)*	*(0.000)*	*(0.001)*	*(0.000)+*	*(0.000)+*	*(0.004)***	*(0.004)***	*(0.000)*	*(0.000)*
Constant	-3.462	-4.127	6.791	4.619	-1.212	-1.068	-39.922	-28.914	-5.810	-5.498
	(2.067)+	*(2.059)**	*(1.723)***	*(1.678)***	*(2.189)*	*(2.064)*	*(11.249)***	*(9.612)***	*(1.793)***	*(1.821)***
Observations	90	90	90	90	90	90	90	90	90	90
Wald Chi Squared	10.65	10.14	19.09	17.80	23.93	22.61	23.93	16.09	22.42	20.33
Prob > Chi Squared	0.4732	0.5178	0.0595	0.0864	0.0130	0.0201	0.0130	0.1378	0.0213	0.0411
DF	11	11	11	11	11	11	11	11	11	11

*Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%*

Appendix 7

Insurance Games Experiment Instructions

We will be completing 1 activity. This activity is played over eight rounds.

Let's begin. We will do **eight rounds** of this activity and **each round will represent a farming season.** In this exercise we are going to imagine that you are at the start of a farming season. You have to make a decision about the type of seeds you are going to use for this season. Your income will depend on what type of seed you plant and the amount of rainfall the district receives.

RAINFALL

To see how much rainfall there is for the round we will draw a ball from this bag. If we draw a blue ball that means the rainfall is good. If a yellow ball is drawn that means the rainfall is low and if a red ball is drawn the rainfall is very low. There are three blue balls in the bag, three yellow balls and three red balls. [SHOW THEM ALL THE BALLS THAT WILL GO INTO THE BAG]

Alright let me ask you a question. If I pull out a ball from the bag, is it more likely that it will be a blue ball, a yellow ball or a red ball?

[WAIT FOR RESPONSE]

[IF THEY GET IT RIGHT] That's right. There is an equal chance of drawing out a blue ball, a yellow ball or a red ball. Why? Because there are three balls of each colour.

[IF THEY GET IT WRONG] Actually, there is an equal chance of drawing out either a blue ball, a yellow ball or a red ball because there are exactly the same number of balls of each colour.

Let's do an example. Would anyone like to pull a ball out of the bag?

[PICK A VOLUNTEER]

You sir? You are going to draw a ball out of the bag. [HAVE HIM OR HER PULL OUT A BALL FROM THE BAG]. A [COLOUR OF BALL] ball. So is the rain collected by the rainfall meter good, low or very low? [WAIT FOR RESPONSE; HELP THEM IF THEY HAVE TROUBLE]. Yes, it will be [RAINFALL TYPE].

TRADITIONAL SEEDS:

You have always used a certain type of seed every year which we shall call traditional seeds. Compared with other types of seeds these traditional seeds give you a lower yield. However they always give you the same yield whether the rains are good, low or very low. In other words, you always know what to expect. If you decide to plant these seeds, come harvest time, you will receive R10 for your yield for this farming season if the rains are good, low or very low.

If you would like to stick with the traditional seeds there is no cost in using these seeds. We will assume that you have been storing some of these seeds after every farming season over the years. So you can go ahead and start planting.

NEW IMPROVED SEEDS:

On the other hand, you have heard that new types of seeds have been introduced in Matzikama and that only a few farmers have started using them. You have not yet used these seeds but you have heard great things about them and you are wondering if you should try them. The few farmers who have started using these new seeds have told you that the seeds are drought resistant and can increase the yield on your piece of land substantially.

If you choose to use these new seeds and if the rains are good you earn R40 in one farming season. If the rains are low you earn R30 which is more than the R10 you get from the traditional seeds. But, you are told that there is a disadvantage to using the new seeds. If the rains are very low you will not get any yield from your land. You have a decision to make. Do you want to plant traditional seeds which always give you the same yield when rains are good and even when they are bad? Or do you want to try the new seeds which give you a higher yield when the rains are good or low, but which give you a zero yield when the rains are very low?

LOAN FOR BUYING NEW IMPROVED SEEDS:

However, if you decide to grow the new seeds you will have to borrow money from the bank to buy these seeds. They are expensive because they give you higher yields than the traditional seeds in most cases. You are required to take out a R10 loan in order to buy these new seeds. At the end of the season you are required to pay back the R10 plus an additional R1, which is interest on the loan. So, in total, if you would like to purchase the new seeds, the loan will cost you R11.

Are there any questions?

[PAUSE TO ANSWER QUESTIONS]

LOAN AND INSURANCE

In addition to the loan, you can also buy insurance that will protect you from losing income if rainfall is low or very low. We will call this insurance "rainfall insurance."

We will first explain about the insurance. Insurance is a way to protect against losses. You pay a little bit before the season begins to protect against losses. In the case of rainfall insurance if the rains are low or very low in a particular farming season the insurance company will give you some money to make up for the losses due to not having enough rain. But if the rains are good you do not receive any money from insurance. Why? Because your crops received enough rainfall. Losses that you experience on your farm as a result of other things such as pests or crop disease are not covered by this type of insurance. Also, whether the rainfall is low or not you must always pay for the insurance before the round begins if you want this protection against losses.

The money that is paid out by the insurance to you is meant to protect against losses suffered due to the rains being below what you would normally expect. How does the insurance company decide if the rains are low or not? A container which measures rainfall is placed in a central location in each town and village in Matzikama. This container acts as a rainfall meter. It records how much rain you receive in the area during the rainy season. If the rains are good (a blue ball is drawn from the bag), the container will have a lot of water in it when the insurance company goes to check it.

If you decide to buy insurance, you will receive money from the insurance company only if [STRESS THIS POINT] the rain collected by the rainfall meter is low or very low; that is, if a yellow or red ball are pulled out from the bag in each round.

What the insurance company does not know is the actual crop yield you get on your farm. To do this they would have to go from farm to farm, asking everyone with insurance whether they had a large, average or small harvest. This would cost too much money and make the insurance very expensive. Therefore we will only use the amount of rainfall recorded at the rainfall meter to determine the amount you will receive from insurance.

So how does this really work? This figure [POINT TO FIGURE IN FRONT OF THE ROOM] explains how rainfall amounts are tied to insurance payments. Remember that if you want insurance payouts you must first pay for insurance at the beginning of the round. Insurance costs R2. Remember this is just an exercise, so the cost of insurance is very low here. It would be much more expensive if you were actually buying for your farm. Your payments from the insurance company would also be much larger.

Table 2: Insurance

	If a blue ball is drawn from the bag GOOD RAINFALL	If a yellow ball is drawn from the bag LOW RAINFALL	If a red ball is drawn from the bag VERY LOW RAINFALL
Cost of insurance:	**R2**	**R2**	**R2**
If you have bought insurance you receive:	**R0**	**R4**	**R8**

As I said earlier you only receive money from the insurance if rain collected by the rainfall meter is low or very low, or when a yellow or red ball is pulled from the bag.

As you can see from the chart you receive a big payment from insurance of R8 when a red ball is pulled out meaning rain is very low in the rainfall meter. You receive the smaller payment of R4 when a yellow ball is drawn out meaning rain is low in the rainfall meter. You will not receive anything from the insurance if a blue ball is drawn because this means that the rains were good. Remember that if you are interested in buying insurance, you always pay R2 for insurance at the beginning of the round.

BANKRUPTCY RULE:

At the end of every round we will give you information about what your earnings for that round was and also what your TOTAL EARNINGS for Activity 2 are so far. If at the end of any round in this activity, if you have made a loss you can still continue to the next round if your TOTAL INCOME for Activity 2 so far (which includes your income from previous rounds) can cover your losses. If not, you will be disqualified from the ACITIVTY 2, which means you will not be able to continue to the next round. **You will however each receive R15 at the end of this activity to cover you for such losses so that you will not lose any of your own money or money that you earned in ACTIVITY 1.**

EXAMPLE OF ACTIVITY 2:

So now that I have explained everything to you, lets do an example.

In this activity you have to decide if you want to use **traditional seeds** or **new seeds**. If you want to use the traditional seeds you do not have to worry about borrowing money or buying insurance.

If however you decide to use the new seeds you **will have to** [STRESS THIS POINT] borrow R10 from the bank to pay for the seeds. Remember that you will have to pay this back with **R1** interest at the end of the round. In total you will have to pay back R11.

If you want to use the new seeds you could in addition to taking out a loan, also buy insurance for R2 which will pay out R4 if the rainfall is low and R8 if the rain is very low.

The figure on this board (or wall) shows you exactly how this all works.Let's go over the figures in this table: [SHOW THEM THE TABLES]

INCOME IF YOU USE TRADITIONAL SEED:

If you decide to use traditional seeds you will receive R10 in the first round if the rains are good. If the rains are low, you will also receive R10 and when the rains are very low you will still receive R10. Are there any questions?

[PAUSE TO ANSWER QUESTIONS]

	OPTION	Earnings if blue ball is drawn	Earnings if yellow ball is drawn	Earnings if red ball is drawn
1.	If you choose to use traditional seeds you receive (for your harvest):	**R10**	**R10**	**R10**
	Income for this round:	**R10**	**R10**	**R10**
	Total Income for all previous rounds:	**…..**	**…..**	**…..**

2.	If you choose to take out a loan to buy improved seeds, you receive (for your harvest):	**R40**	**R30**	**R0**
	Minus cost of loan (R10) plus interest (R1) = R11	**-R11**	**-R11**	**-R11**
	Income for this round:	**R29**	**R19**	**-R11**
	Total Income for all previous rounds:	**…..**	**…..**	**…..**
3.	If you choose to take out a loan and to also buy insurance, you receive (for your harvest):	**R40**	**R30**	**R0**

	Minus cost of loan (R10) plus interest (R1) = R11	**-R11**	**-R11**	**-R11**
	Minus cost of insurance	**-R2**	**-R2**	**-R2**
	Plus what you get back from insurance	**+R0**	**+R4**	**+R8**
	Income for this round:	**R27**	**R21**	**-R5**
	Total income for all previous rounds:	…..	…..	…..

INCOME IF YOU TAKE OUT A LOAN TO BUY NEW SEEDS

If you decide to use new seeds you have to borrow R10 from the bank so that you can buy the new seeds. If the rains are good, that is, if a blue ball is drawn from the bag, you will receive R40. **However, from that R40 you will have to pay back the bank the R10 you borrowed at the start of the round plus an additional interest of R1. So in total you will owe the bank R11. You will be left with R29 after paying back the loan. This is your TOTAL INCOME for Activity 2 so far.**

If the rains are low, that is, if a yellow ball is pulled out, you will receive R30 at the end of the round. **Again you will have to pay back the R11 to the bank, leaving you with R19. This is your TOTAL INCOME for Activity 2 so far.**

If the rains are very low, that is, if a red ball is drawn out, you will not receive any income for your harvest. This is because your seeds failed to germinate. However, you still need to pay back the money you borrowed from the bank. So although you did not make any money, you still owe the bank the R10 you borrowed at the beginning of the round plus the R1 interest. **This leaves you with a LOSS (or negative income) of –R11 for this round.**

This is where the bankruptcy rule comes in. If you make a loss we will have to check if you have enough TOTAL INCOME (from previous rounds) to cover your losses and to continue. If you don't, you will not be able to continue to the next round, and you will be disqualified from the activity. [EXPLAIN TO THEM THAT IN THE FIRST ROUND THEY WILL NOT HAVE FUNDS FROM PREVIOUS ROUNDS TO COVER SUCH LOSSES]

As we explained before, even though you have made a loss – you will receive R15 at the end of Activity 2 to cover any such losses.

Are there any questions?

[PAUSE TO ANSWER QUESTIONS]

LOAN AND INSURANCE

If you decide to use new seeds and in addition to the loan you also want to buy insurance this will cost you an additional R2. In the first round none of you will be able to afford insurance, since you have not received any income for your harvest yet. Remember what we said about the insurance. You have to pay for it before the round begins if you are interested in insurance and this will cost you R2 at the beginning of the round. [SHOW THEM THE DISTRIBUTION CHART AGAIN]

So, if we draw out a blue ball this means that the rains are good and you receive R40 and the insurance pays out nothing. But remember that we will subtract the R11 you owe for taking out a loan, and that you already paid R2 for insurance coverage, so you income for this round is R27.

If the rains are low, that is, if we draw out a yellow ball, you will receive R30 and the insurance will pay out another R4.. **Again you will owe the bank R11, and remember that you paid R2 for insurance, so you income for this round will be R21.** [SHOW THEM THE DISTRIBUTION CHART AGAIN]

If we draw out a red ball, we assume that your crops failed and so you do not earn any money from your farm. Your seeds were unsuccessful and you did not make any money, but the insurance pays out R8. **Once again you owe the bank R11, and remember that you paid R2 for insurance coverage, so you make a loss (negative income) of –R5 for this round. [SHOW THEM THE DISTRIBUTION CHART AGAIN].**

Once again this is where the bankruptcy rule comes in. If you make a loss we will have to check if you have enough TOTAL INCOME (from previous rounds) to cover your losses and to continue. If you don't, you will not be able to continue to the next round, and you will be disqualified from the activity. [EXPLAIN TO THEM THAT IN THE FIRST ROUND THEY WILL NOT HAVE FUNDS FROM PREVIOUS ROUNDS TO COVER SUCH LOSSES]

As we explained before, even though you have made a loss – you will receive R15 at the end of Activity 2 to cover any such losses.

We have given you a lot of information today and I am sure there are some questions. If anything is unclear please feel free to ask before we begin the activity. Remember you are playing for real money so make sure you understand all this before you start playing.

[PAUSE TO ANSWER QUESTIONS]

The assistants will hand out new pieces of paper which you will use to indicate the option you want i.e. 1, 2 or 3 [ASSITANTS: HAND OUT SHEETS. POINT OUT DIFFERENT PARTS OF THE WORKSHEET AS EMCEE EXPLAINS THEM]. **At the end of each round, you will be asked to indicate your choice on this sheet of paper as you did in the first activity. After you've circled the option you want our assistants will come round to you and collect your answer sheets. We will work out how much each person gets. Before we move on to the next round we will give each person receipt feedback sheet which tells you how much money you earned in this round and what you TOTAL INCOME is for Activity 2 so far.**

Before we begin, let's do an example.

[EMCEE: PICK ANOTHER VOLUNTEER]. You sir. Please choose one of the three options. Now pick someone else to draw a ball from the bag. [PARTICIPANT DRAWS BALL]. You drew a [COLOUR OF BALL] ball from the bag. This means the rainfall for this round is [RAINFALL TYPE]. How much would he have earned if we were playing an actual round?

We need to explain here that in this activity only one person will draw out a ball for the entire group in each round. Why do you think this is the case? The reason is that if there is high rainfall in your town, you are all likely to receive the same amount or very similar amounts of rainfall on your farm. If there is low rainfall in the rainfall meter it is likely that you all received low rains on your farms, so we only need one person to draw out a ball for us.

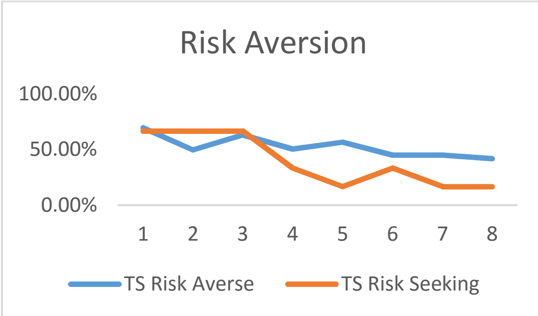
Does anyone have any questions? Ok, we are ready to start this exercise. [ASSISTANTS SHOW YOUR GROUP MEMBERS HOW TO MAKE THEIR CHOICES]. After they have finished making their choices find a volunteer to draw out a ball for the group. Record earnings for the round.

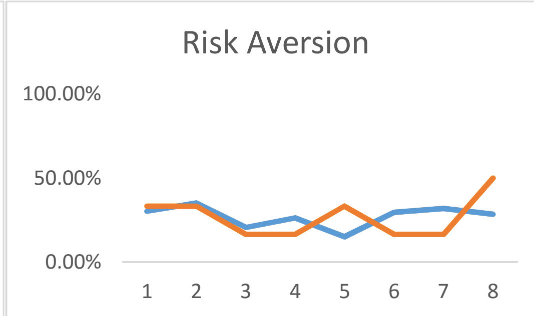
[REPEAT AS IN ROUND 1 FOR ROUNDS 2-8]

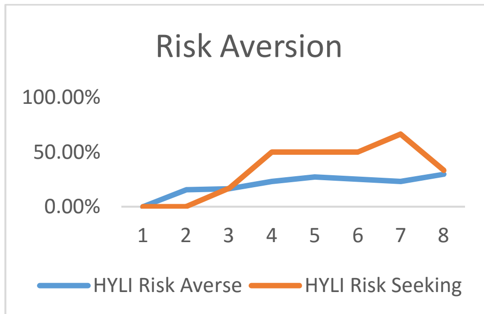
Appendix 8

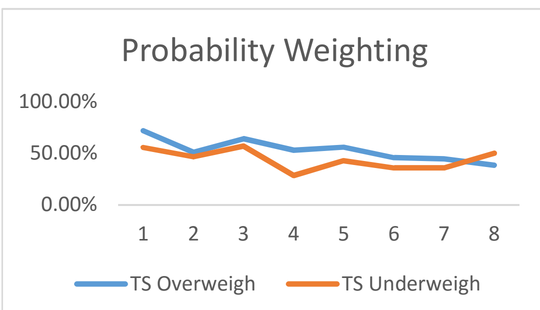
Percentage Uptake in Rounds(without bankrupt individuals)									
Round		**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**
TS		69.60%	50.45%	63.27%	49.48%	54.08%	44.33%	43.30%	40.21%
HYL		30.40%	35.14%	20.41%	25.77%	16.33%	28.87%	30.93%	29.90%
HYLI		0.00%	14.41%	16.33%	24.74%	28.57%	26.80%	25.77%	29.90%
Level or Risk Aversion									
TS	***Risk Averse***	69.75%	49.52%	63.04%	50.55%	56.52%	45.05%	45.05%	41.76%
	Risk Seeking	66.67%	66.67%	66.67%	33.33%	16.67%	33.33%	16.67%	16.67%
HYL	***Risk Averse***	30.25%	35.24%	20.65%	26.37%	15.22%	29.67%	31.87%	28.57%
	Risk Seeking	33.33%	33.33%	16.67%	16.67%	33.33%	16.67%	16.67%	50.00%
HYLI	***Risk Averse***	0.00%	15.24%	16.30%	23.08%	27.17%	25.27%	23.08%	29.67%
	Risk Seeking	0.00%	0.00%	16.67%	50.00%	50.00%	50.00%	66.67%	33.33%
Probability Weighting									
TS	***Overweigh***	71.96%	51.04%	64.29%	53.01%	55.95%	45.78%	44.58%	38.55%
	Underweigh	55.56%	46.67%	57.14%	28.57%	42.86%	35.71%	35.71%	50.00%
HYL	***Overweigh***	28.04%	35.42%	21.43%	25.30%	14.29%	28.92%	28.92%	30.12%
	Underweigh	44.44%	33.33%	14.29%	28.57%	28.57%	28.57%	42.86%	28.57%
HYLI	***Overweigh***	0.00%	13.54%	14.29%	21.69%	28.57%	25.30%	26.51%	31.33%
	Underweigh	0.00%	20.00%	28.57%	42.86%	28.57%	35.71%	21.43%	21.43%
Level of Loss Aversion									
TS	***Loss Averse***	69.33%	47.62%	65.38%	44.23%	56.60%	48.08%	44.23%	38.46%
	Loss Seeking	70.00%	54.17%	60.87%	55.56%	51.11%	40.00%	42.22%	42.22%
HYL	***Loss Averse***	30.67%	36.51%	17.31%	30.77%	11.32%	26.92%	23.08%	28.85%
	Loss Seeking	30.00%	33.33%	23.91%	20.00%	22.22%	31.11%	40.00%	31.11%
HYLI	***Loss Averse***	0.00%	15.87%	17.31%	25.00%	30.19%	25.00%	32.69%	32.69%
	Loss Seeking	0.00%	12.50%	15.22%	24.44%	26.67%	28.89%	17.78%	26.67%
Relative Income									
TS	***Below Avg.***	74.65%	52.17%	65.45%	54.55%	60.71%	49.09%	49.09%	47.27%
	Above Avg.	62.96%	47.62%	60.47%	42.86%	45.24%	38.10%	35.71%	30.95%
HYL	***Below Avg.***	25.35%	37.68%	18.18%	21.82%	17.86%	29.09%	30.91%	38.18%
	Above Avg.	37.04%	30.95%	23.26%	30.95%	14.29%	28.57%	30.95%	19.05%
HYLI	***Below Avg.***	0.00%	10.14%	16.36%	23.64%	19.64%	21.82%	20.00%	14.55%
	Above Avg.	0.00%	21.43%	16.28%	26.19%	40.48%	33.33%	33.33%	50.00%

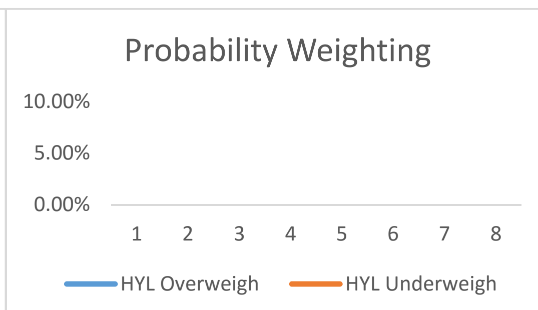
Graphical Representation of uptake in rounds

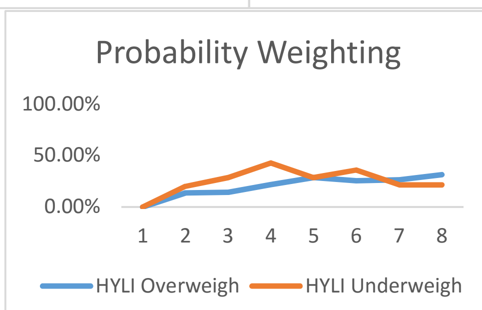


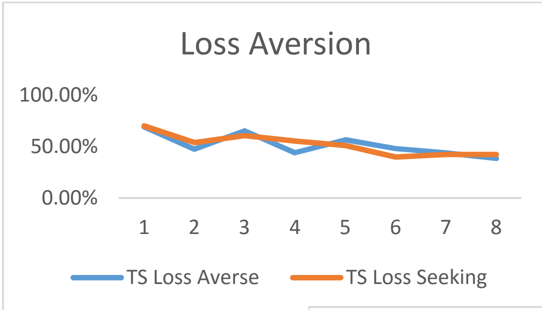


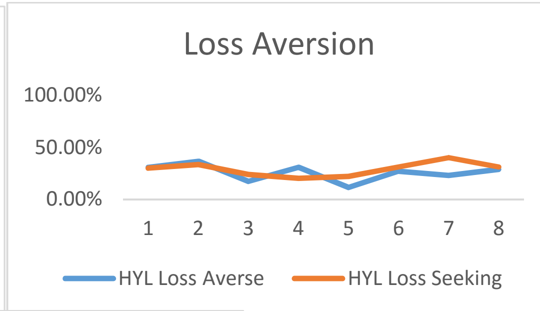


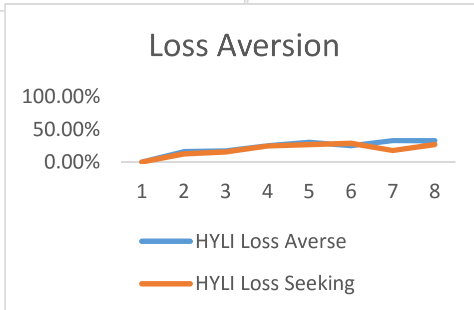


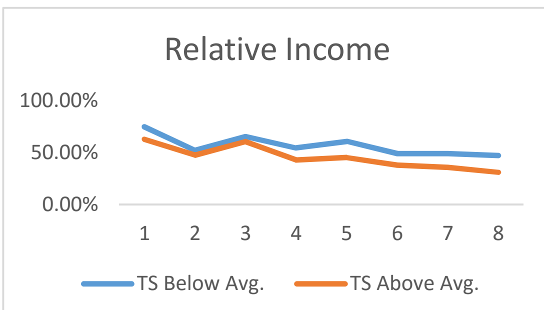


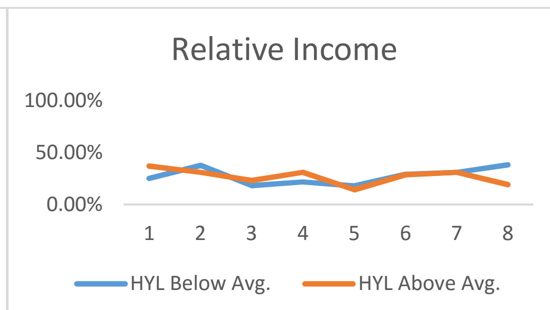


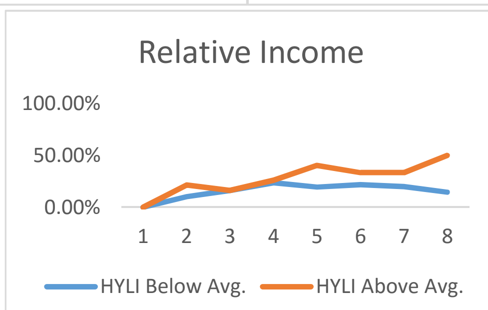

Loss Aversion
100.00%
50.00%
0.00%
1 2 3 4 5 6 7 8
TS Loss Averse
TS Loss Seeking


Loss Aversion
100.00%
50.00%
0.00%
1 2 3 4 5 6 7 8
HYL Loss Averse
HYL Loss Seeking


Loss Aversion
100.00%
50.00%
0.00%
1 2 3 4 5 6 7 8
HYLI Loss Averse
HYLI Loss Seeking


Relative Income
100.00%
50.00%
0.00%
1 2 3 4 5 6 7 8
TS Below Avg.
TS Above Avg.


Relative Income
100.00%
50.00%
0.00%
1 2 3 4 5 6 7 8
HYL Below Avg.
HYL Above Avg.


Relative Income
100.00%
50.00%
0.00%
1 2 3 4 5 6 7 8
HYLI Below Avg.
HYLI Above Avg.