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Risk Preferences and the Poverty Trap

A Look at Farm Technology Uptake amongst Smallholder Farmers in the Matzikama Municipality

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Hafsah Jumare, Martine Visser, and Kerri Brick

Abstract

This study looks at the determinants of farm technology uptake, with attention to farmers' risk preference and income. We use a field experiment to elicit measures of risk aversion, loss aversion, and non-linear weights of probability. We then relate these measures to the uptake of drought-resistant and improved seeds. In light of the poverty trap theory, we also consider the role that income plays in risk preference. Our findings suggest that farm risk management policies need to take into account the role of risk and loss preferences in uptake decisions. We find that farmers do not effectively weight probabilities and that the weighting of probabilities in turn affects the uptake of adaptive mechanisms. Improved access to extension services can help farmers understand weather and climate risk, probabilities of loss, and technologies and other adaptive strategies. We also find that low incomes discourage the uptake of resilient crop types, both in the form of naturally drought-resistant crops and technologically modified improved seeds. This signals the need for proactive measures to guarantee access to a minimum package of assets to poor farmers.

Key Words: risk, poverty, technology, seeds, South Africa

JEL Codes: Q16, Q18

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Risk Preferences and the Poverty Trap: A Look at Farm Technology Uptake amongst Smallholder Farmers in the Matzikama Municipality

Hafsah Jumare, Martine Visser, and Kerri Brick*

1. Introduction

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 2015), despite the benefits of recent innovations in technology. These include new, extensive ranges of crops that are more nutrient-rich and at the same time more resistant than traditional varieties to insects, disease and drought (Liu and Huang 2010). These poor technology diffusion rates have been cited as one of the reasons for the persistence of poverty in developing countries. Behavioral economic studies on farmers' decisions to take up technology have identified risk preference and financial constraints as factors that are crucial to the technology adoption process.

In this chapter, we look at the determinants of farm technology uptake in the form of drought-resistant and improved seeds, paying special attention to farmers' risk preference and income. We use a field experiment to elicit measures of risk aversion, loss aversion, and non-linear weights of probability. We then relate these three elicited measures to respondents' reported uptake of drought-resistant and improved seeds. In light of the poverty trap theory, which suggests that low-income people make choices that keep them in poverty, we also consider the role that income plays in risk preference.

Technology uptake has been found to depend not only on financial constraints but also on behavioral traits such as risk preference that arise as a result of these constraints. A standard feature of poverty trap models is that they recognize a divergence of behavior

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between low-income and higher-income groups, where pathways out of persistent poverty are obstructed for low-income groups (Carter and Barrett 2006, 2007). As a result, the persistence of poverty hinges on the degree to which households are restricted in intertemporal exchange and the extent to which poverty affects farmers' investments in technology, by means of both tangible constraints and behavioral traits, such as risk preferences (Carter and Barret 2006).

Many studies have looked at the role of risk preferences in technology uptake. If we assume the expected utility model generally adopted in studies on farmers' choices, farmers will, given their level of risk preference, 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). One downside of the expected utility model is that it considers risk aversion only as a risk preference. Risk aversion describes observed behavior that demonstrates a fear of variance in outcomes (Kahneman and Tversky 1979; Binswanger and Sillers 1983; Hill 2005; Yesuf and Bluffstone 2009; Tanaka et al. 2010; Brick and Visser 2010, 2015; Di Falco 2014).

Measures of risk aversion in expected utility models assume that farmers perceive the impact of losses and gains to be the same in absolute terms and can effectively perceive the probability of outcomes. However, empirical evidence from behavioral literature has established that this is not the case. Individuals do not accurately perceive probabilities, in that they overestimate the probabilities of unlikely events and underestimate the probabilities of likely events. This phenomenon, called nonlinear probability weighting, is another key violation of expected utility (Tversky and Kahneman 1992; Humphrey and Verschoor 2004; Ranjan and Shogren 2006; Brick and Visser 2010; Tanaka et al. 2010). They also display a greater sensitivity to losses compared to gains, which is described as loss aversion (Tversky and Kahneman 1991, 1992; Thaler et al. 1997; Brick and Visser 2010; Tanaka et al. 2010; Ward and Singh 2013; Liu 2013). Even though loss aversion has been under-represented in the literature, there is now a growing list of studies exploring the role it plays in decision making. We therefore consider probability weighting, along with risk and loss aversion.

We use the method described in Tanaka, Camerer and Nguyen (2010) (TCN) to measure the three parameters, i.e., risk aversion, loss aversion, and nonlinear weighting of probabilities, under the assumption of prospect theory. Few studies have considered the role of these three risk preference parameters, collectively, on technology uptake. Amongst these studies is Liu (2013), who uses the TCN method and a Weibull hazard model to test the effects of risk preferences on the timing of Bt Cotton uptake by smallholder farmers in China. Liu (2013) finds that risk aversion and loss aversion are correlated with later adoption of Bt cotton, while farmers who overweight small probabilities are found to adopt Bt cotton earlier. Other studies consider at most two of the parameters. These include Hill (2005), who finds that risk aversion is correlated with replanting of coffee trees, and Ward and Singh (2013), who find loss aversion to be correlated with a switch from traditional rice seeds to a new variety.

Besides the prospect theory parameters, numerous studies have identified drivers of uptake. Some of these studies find household size to be positively related to farm technology uptake, which is attributed to the increased labor available to engage in physically challenging strategies, as well as the ability to spread risk and pool financial resources (Croppenstedt et al. 2003; Nhemachena and Hassan 2007; Deressa et al. 2009). While some studies have found female-headed households to be more likely to adopt a farm strategy or technology (Nhemachena and Hassan 2007; Deressa et al. 2009), the majority of studies have found opposite gender effects, indicating that females are less likely to take up farm technologies or strategies. This is attributed to constraints that are usually related to differences in land access, assets, education, health care, markets, extension services, and social/cultural exclusion, which typically pose obstacles for female farmers (Quisumbing 1995; Doss and Morris 2001; World Bank 2001; Githinji et al. 2011; Odame et al. 2002; Meinzen-Dick et al. 2010; Quisumbing and Pandolfelli 2010; Croppenstedt et al. 2013 in Ndiritu et al. 2014).

Looking at studies that consider crop type, Panda et al. (2013) find total income and total farming income to be linked to a change of crop variety. Etwire et al. (2016) find that uptake of improved seeds, for a sample of smallholder farmers in Northern Ghana, depends on the seed delivery system. Monela (2014) finds that uptake of improved seeds, amongst a sample of smallholder farmers in Tanzania, depends on land ownership and awareness of improved seeds. So, despite the assumptions that we make about income and risk preferences, we consider a range of other factors, e.g., land and gender.

We consider the use of both genetically improved seeds and drought-resistant crops as alternative technologies available to farmers. Drought-resistant crops are natural substitutes to improved seeds. We use experimental and survey data obtained from 125 small-scale farmers from farming communities in the Matzikama Municipality of Western Cape, South Africa.

This chapter proceeds as follows. The next section shows the summary statistics of the farmers' characteristics. The following section describes the experiment design and methodology for eliciting the prospect theory parameters. The fourth section explains the results for the determinants of risk preferences. The fifth section presents the results of the logit regressions on uptake of improved seeds, and draws a comparison with the choice of naturally occurring drought-resistant crops. The concluding section includes policy recommendations.

2. Background and Summary Statistics

The data used for the analysis in this study was obtained via survey collection and risk experiments carried out with small-scale farmers in the Matzikama Municipality of the Western Cape, South Africa.[1] Agriculture in Matzikama is supported by the Clanwilliam Dam and Olifants River. The area is dominated by viniculture, vegetables, citrus fruits and livestock production, and is characterized by arid terrain 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. The average age of farmers in the sample is 43 years, with approximately 44% of the farmers female and 56% male. Average monthly household income is R2365,[2] with about 60% of the sample below the average relative household income level. Only 30% of the farmers have an alternative source of employment outside of farming.

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 2. Just under 9% said they use drought-resistant crops (i.e., naturally occurring crops that are more resilient to poor rainfall), while 8.8% use improved seeds, showing a significantly low rate of uptake of more resilient crops (either natural or genetically modified) amongst farmers in the sample.

[1] See Appendix 1 for sample questionnaire.

[2] In August 2017, 1 South African Rand = USD .077.

3. Risk Preference Elicitation and Estimation

This section illustrates the risk preference elicitation and estimation methodology.

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 a safe option (similar to Holt and Laury, 2002). They assumed the following utility function:

$$U(x,p;y,q) = \begin{cases} v(y) + \pi(p)\big(v(x) - v(y)\big) & x > y > 0; x < y < 0 \\ \pi(p)v(x) + \pi(q)v(y) & x < 0 < y \end{cases} \quad (1)$$

$U(x, p; y, q)$ 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 preference and $\sigma < 1$ implies risk-averse preference. For λ, $\lambda > 1$ ($\lambda < 1$) implies greater sensitivity 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 $\lambda = 1$, 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 overweighted and large probabilities are underweighted. The function is S shaped if $\alpha > 1$, indicating that small probabilities are underweighted while large probabilities are overweighted.

3.2. Elicitation

Similarly to TCN, the Matzikama farmers were given three sets of multiple price lists (MPLs) with pair-wise lottery sheets.[3] The first two lists (i.e., Series 1 and 2) had a series of 14 decision rows each, both of which were gain-only lotteries. The third sheet (Series 3) had both gain and loss lotteries, with seven decision rows. Subjects had 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 Lottery B representing the outcome if farmers chose to use

[3] A sample of the multiple price lists is presented in Appendix 2.

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.

Subjects were asked to select the row where 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% chance of receiving a high payoff and a 70% chance of receiving a low payoff. The first row of lottery B offered a 10% chance of receiving a higher payoff than the high payoff in Lottery A and a 90% chance of receiving a lower payoff than the low payoff in Lottery B. In Series 2, the first row of Lottery A offered a 90% chance of receiving a high payoff and a 10% chance of receiving a low payoff. The first row of Lottery B offered a 70% chance of receiving a higher payoff than the high payoff in Lottery A and a 30% chance of receiving a lower payoff than the low payoff in Lottery B.

In Series 1, the outcome in Lottery A was 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 farther down the row they switch to Lottery B. In Series 3, the subjects had a 50% probability of a positive payoff (gain) and a 50% 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 farther 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 which decision row was to be played for money. Rainfall probabilities were also denoted by 10 numbered balls. For example, for traditional seeds in Series 1, three balls represented good rainfall levels, while seven balls represented poor rainfall levels. The rainfall level is determined by one of the subjects selecting a ball from the bag.

The MPL lotteries in TCN were structured so that the switching points of the three 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 rationalize 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 rationalize the switch are (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 rationalize 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 value of sigma 0.8 and the subject switching in the 6th Row of Series 3, this implies the following inequalities:

$$(-\lambda)(-(-2^{0.8}))(0.5) + (12.5^{0.8})(0.5) > (-\lambda)(-(-10.5^{0.8}))(0.5) + (15^{0.8})(0.5),$$

$$(-\lambda)(-(-2^{0.8}))(0.5) + (2^{0.8})(0.5) > (-\lambda)(-(10.5^{0.8}))(0.5) + (15^{0.8})(0.5),$$

$$(-\lambda)(-(-2^{0.8}))(0.5) + (0.5^{0.8})(0.5) > (-\lambda)(-(-10.5^{0.8}))(0.5) + (15^{0.8})(0.5),$$

$$(-\lambda)(-(-2^{0.8}))(0.5) + (0.5^{0.8})(0.5) > (-\lambda)(-(-8^{0.8}))(0.5) + (15^{0.8})(0.5),$$

$$(-\lambda)(-(-4^{0.8}))(0.5) + (0.5^{0.8})(0.5) > (-\lambda)(-(-8^{0.8}))(0.5) + (15^{0.8})(0.5),$$

$$(-\lambda)(-(-4^{0.8}))(0.5) + (0.5^{0.8})(0.5) < (-\lambda)(-(-7^{0.8}))(0.5) + (15^{0.8})(0.5),$$

$$(-\lambda)(-(-4^{0.8}))(0.5) + (0.5^{0.8})(0.5) < (-\lambda)(-(-5.5^{0.8}))(0.5) + (15^{0.8})(0.5)$$

The implied interval of lambda is $3.62896 < \lambda < 4.76259$. Note that, if subjects switch in Row 1 or never switch, the intervals are censored. The summary of the payoffs implied by the switching points are presented in Appendix 3.

Figure 1. Sample Lottery Task

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

4. Determinants of Risk Preferences

In this section, we assess the determinants of risk aversion, non-linear probability weighting and loss aversion. The results presented in Table 3 are, *ceteris paribus*, outcomes of the Ordinary Least Square regressions on normalized σ (risk aversion) (Column 1) and α (probability weighting) (Column 2), respectively, and interval regression on λ loss aversion) (Column 3). We reframe the parameters so that positive values on σ and interval λ regressions denote an increase in risk aversion and loss aversion, respectively, while positive values on α indicate greater weighting of low-probability events. Thus, for ease of interpretation, we use $\sigma = - \sigma$ and $\alpha = - \alpha$ in order to present a measure that shows a higher σ and α, denoting greater risk aversion and increase in the overweighting of small probabilities. Brick and Visser (2015), using the same method and data, look at the determinants of risk and loss aversion; however, unlike Brick and Visser (2015), our analysis considers the determinants of probability weighting. In addition, we also control for additional variables, namely farm experience and type of land farmed, i.e., ownership status.

The explanatory variables are the farmer's age, gender (dummy variable equals 1 if the farmer is female and 0 if the farmer is male), log of education level of farmer, a dummy variable equal to 1 if the farmer is the primary bread winner of the household and 0 if not, normalized monthly household income, and a dummy variable for land type (1 if the farmer farms on commercial land through an equity share or as an employee and 0 if the farmer owns the land or uses communal land, state land as part of a land reform initiative, or land in proximity to the farmer's residence). The premise is that farmers are more likely to receive greater support in terms of technology, resources or training if they work on commercial land with an external and centralized decision maker. Only three farmers in the sample own the land they farm, so using farmer ownership as the major indicator of land type would not provide meaningful information. The other variables include household size and log of farmer's farm experience in years. We use the log form of education level and farm experience because their distributions are positively skewed.

As can be seen Table 3, higher age and education levels are related to lower loss aversion [Table 3, Column 3, P-value = 0.045; P-value= 0.009]. We find that primary bread winners are less risk averse and loss averse [Table 3, Column 1, P-value= 0.031]. 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). They may be willing to take more risk to bring in income. This is also reflected in their loss aversion because it indicates that they have a preference for upside risk, which shows a greater willingness to take on potential losses as long as potential gains exist.

Lastly we find that greater household monthly income is related to lower loss aversion [Table 3, Column 3, P-value = 0.028]. This negative relationship is expected, given that the disutility from loss of income decreases as income increases. It is necessary to mention that, unlike this study, Brick and Visser (2015) find no statistically significant coefficients on any of the variables regressed on the loss aversion parameter.

Similarly to Brick and Visser (2015), we find household size to be related to less risk aversion; we find similar results for loss aversion [Table 3, Columns 1 & 3; P-value = 0.005, P-value = 0.068]. Wik et al. (2004) found similar results and suggest that household size represents a wealth factor. Bigger households imply a larger household labor force or wealth-generating capacity. Furthermore, household size may be correlated with lower risk aversion because of the greater opportunities for risk sharing/pooling, i.e., an implicit form of insurance for members of the household (Barr 2003; Wik et al. 2004).

5. Determinants of Technology Uptake: Drought-resistant Crops and Improved Seeds

In this section, we consider the uptake of two farm adaptive mechanisms: drought-resistant crops and improved seeds. The determinants of uptake are obtained using logit regressions and the results are presented in Table 4. The coefficients are the expected changes in the probability of taking up an option due to a unit change in the explanatory variable.

The farmers in our sample gave responses about a range of agricultural strategies they recently adopted.[4] We select two strategies that represent the cropping choices of these farmers. These choices tell us whether or not farmers are likely to abandon certain

[4] See Table 2 for the summary statistics of all the uptake options in the survey.

crops for others or to take up an improved version of the crops they already farm. The first strategy we consider is a switch to drought-resistant crops. These are traditional means of mitigating risk. They are not technological innovations, in that they exist naturally. The second is improved seeds, which are considered new technology. They are more costly for farmers but have higher expected yields. They also have a high variance, i.e., the risk is higher because improved seeds are more expensive; therefore, in the event of a failed harvest, a farmer will face a greater loss compared to the case when he/she uses traditional seeds. Using these two alternatives to crops that the farmers already cultivate, we explore how risk preference and income affect the uptake of technology in the form of improved seeds and compare these effects with the effects on uptake of drought-resistant crop types.

Looking at the risk preference parameters in Table 4, we find no evidence to suggest that risk or loss aversion influences the uptake of either option. However, we find that an increased weighting of small probability events increases the likelihood of uptake of drought-resistant crop varieties [Table 4, Columns 1, 2 & 3; P-values =0.066; 0.031; 0.042]. This result is explained if fear of a drought causes farmers to overestimate its likelihood and thus switch to more drought-resistant crops.

When we consider the other explanatory variables, we find that females are less likely to take up either drought-resistant crop varieties or improved seeds [Table 4, Columns 1, 2 & 3; P-values = 0.001; 0.001; 0.001 and Columns 4, 5 & 6; P-values= 0.002; 0.004; 0.044]. This gender effect is consistent with the most common findings in the existing literature (Ndiritu et al. 2014). A higher education level is found to increase the likelihood of improved seeds uptake [Table 4, Columns 4, 5 & 6; P-values=0.056; 0.078; 0.055]. This in line with the common assumption that the education level of farmers has a positive effect on technology uptake because of the connection between education and knowledge of technology (Knowler and Bradshaw 2007).

We find that household income increases the likelihood of both drought-resistant seeds and improved seeds uptake [Table 4, Columns 1, 2 & 3; P-values= 0.008; 0.001; 0.002 and Columns 4, 5 & 6; P-values =0.008; 0.001; 0.001]. One would expect that lower-income farmers would opt for drought-resistant crops, while higher-income farmers would opt for improved seeds; nonetheless, we see that poorer farmers are sticking to non-resilient crops. This to some degree supports the poverty trap hypothesis in so far as households that are poor at the outset do not improve their farm prospects by taking on more resilient crops, while those that are initially more affluent can progress to higher levels of wealth (Adato et al. 2006; Barrett and Carter 2013). The relatively wealthy farmers take on more advanced crops, both in the form of naturally drought-resistant crops and improved seeds

We also find that primary breadwinners are more likely to take up drought-resistant crop varieties [Table 4, Columns 2 & 3; P-values = 0.014; 0.016]. Those who farm on commercial land through equity sharing or as an employee are more likely to use both drought-resistant crop varieties and improved seeds [Table 4, Columns 1, 2 & 3; P-values = 0.002; 0.001; 0.001 and Columns 4, 5 & 6; P-values = 0.001; 0.001; 0.033]. This again points to the possible influences of commercialization through a centralized body, which are likely to improve the delivery mechanism of improved seeds and improve the knowledge of both improved seeds and drought-resistant crops.

6. Conclusion

Advancements in farm technology have provided farmers with the means to improve yields while safeguarding farm productivity against harsh climatic and weather events. Nonetheless, the diffusion of these technologies has been slow in developing countries. Evidence from economic and behavioral literature suggests that there are tangible and behavioral attributes of farmers that contribute to the slow uptake of farm technology. The tangible factors include factors such as income, which may determine the willingness and ability to invest in new technology, while behavioral factors such as risk preference may play a further role in determining investments in such technology.

In this study, we carry out an analysis to determine the extent to which these income and risk preferences contribute to the farm technology uptake process. Our findings suggest that farm risk management policies need to take into account the role of risk and loss preferences in uptake decisions. We find that farmers do not effectively weigh probabilities and that the weighting of probabilities in turn affects the uptake of adaptive mechanisms. Therefore, farmers should be involved in understanding weather and climate risk and probabilities of loss, so that they can participate in developing responsive, adaptive or mitigation strategies (Patt and Schröter 2008). An institutional factor that should be considered is access to extension services, which provide information on climate and on the nature of technologies and other adaptive strategies. Farmers can only construct viable and efficient farm strategies if they have comprehensive and accurate information on impending occurrences or outcomes (Smit and Skinner, 2002).

Our findings on the effect of income are to some degree consistent with the poverty trap hypothesis. We find that low incomes have dampening effects on the uptake of resilient crop types, both in the form of naturally drought-resistant crops and technologically modified improved seeds. This signals the need for proactive measures to guarantee access to a minimum package of assets to poor farmers which, as explained by Carter and Barret (2006), is required for their successful rise out of poverty through investment in strategies such as the uptake of more advanced crops.

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Tables

Table 1. Summary Statistics

Variable	Mean	Standard Deviation
Age	42.951	16.337
Female	44%	50%
Male	56%	50%
Primary Bread Winner	55%	50%
No Schooling	3%	18%
Some Primary School	34%	48%
Complete Primary School	16%	37%
Some Secondary School	36%	48%
Matric Certificate	9%	28.1%
Higher Education	2%	13%
Household Size	4.699	1.916
Farm Experience in Years	6.512	7.023
Commercial Farm Land	4.8%	21.46%
Employed	30%	46%

Sample Size: 125

Table 2. Farm Uptake

Variable	Obs.	Mean	Std. Dev.
Drought Resistant Crops	125	8.8%	28.4
Improved Seeds(excl. drought-resistant seeds)	125	8.8%	28.4
Intercropping	125	14.4%	35.3
Mulching	125	10.4%	30.6
Fertilizer	125	9.6%	29.6
Organic Manure	125	20.8%	40.8
Changing Planting Date	125	4.8%	21.5
Wind Breaks	125	10.4%	30.6
Irrigation	125	19.2%	39.5

Sample Size:125

Table 3. Determinants of Risk Preferences

	Risk Aversion	Prob. Weighting	Loss Aversion
Age	-0.003	0.001	-0.055
	(0.004)	*(0.003)*	*(0.028)***
Female	0.063	0.050	0.561
	(0.084)	*(0.065)*	*(0.901)*
Log Education Level	-0.063	0.048	-3.996
	(0.103)	*(0.111)*	*(1.526)****
Primary Bread Winner	-0.165	-0.070	-1.982
	*(0.097)**	*(0.079)*	*(0.921)***
Normalized HH income	0.078	-0.074	-3.383
	(0.159)	*(0.142)*	*(1.543)***
Land Type	-0.074	0.141	0.039
	(0.095)	*(0.102)*	*(1.499)*
Log Farm Experience in Yrs.	0.011	0.009	0.425
	(0.044)	*(0.033)*	*(0.439)*
Household Size	-0.053	0.004	-0.371
	*(0.018)****	*(0.016)*	*(0.204)**
Constant	0.072	-0.930	16.380
	(0.354)	*(0.364)***	*(4.884)****
lnsigna_cons	_	_	1.189
			*(0.150)****
R2	0.20	0.05	_
Prob > f	0.0252	0.7384	_
Prob >chi2	_	_	0.0797
N	71	71	71

* p<0.1; ** p<0.05; *** p<0.01.

Table 4. Determinants of Uptake

	Drought Resistant Crop			Improved Seeds		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Risk Aversion	-1.139 *(0.99)*	-0.957 *(0.67)*	-0.858 *(0.55)*	0.520 *(0.53)*	0.590 *(0.65)*	2.784 *(1.34)*
Probability Weighting	3.207 *(1.84)**	4.237 *(2.15)***	4.172 *(2.04)***	2.799 *(1.08)*	2.962 *(1.18)*	2.574 *(1.10)*
Loss Aversion	-0.080 *(0.67)*	-0.010 *(0.07)*	0.005 *(0.04)*	0.050 *(0.49)*	0.067 *(0.77)*	0.253 *(1.54)*
Age	-0.077 *(1.38)*	-0.104 *(1.48)*	-0.102 *(1.45)*	0.014 *(0.27)*	0.008 *(0.13)*	0.041 *(0.98)*
Female	-3.258 *(3.48)****	-2.855 *(3.36)****	-2.911 *(3.48)****	-4.122 *(3.10)****	-4.010 *(2.90)****	-6.707 *(2.01)***
Log Education Level	-0.329 *(0.22)*	-0.126 *(0.07)*	0.028 *(0.01)*	3.759 *(1.91)**	3.647 *(1.76)**	6.487 *(1.92)**
Primary Bread Winner	_	2.782 *(2.47)***	2.786 *(2.42)***	_	0.532 *(0.44)*	1.027 *(0.68)*
Normalized Hh income	4.309 *(2.67)****	7.310 *(3.29)****	7.212 *(3.15)****	8.164 *(2.64)****	8.611 *(3.33)****	7.969 *(3.27)****
Land Type	4.033 *(3.15)****	4.563 *(3.25)****	4.606 *(3.27)****	4.794 *(3.32)****	4.770 *(3.41)****	7.375 *(2.13)***
Log Farm Experience in Yrs.	0.265 *(0.65)*	0.157 *(0.34)*	0.150 *(0.32)*	-0.207 *(0.86)*	-0.235 *(0.88)*	-0.649 *(1.32)*
Household Size	_	_	0.052 *(0.25)*	_	_	0.749 *(1.40)*
Constant	3.073 (0.61)	2.122 (0.38)	1.448 (0.24)	-9.907 (1.96)*	-9.609 (1.83)*	-20.983 (2.14)**
Prob > Chi2	0.0066	0.0026	0.0009	0.0339	0.0076	0.1074
Df	9	10	11	9	10	11
N	71	71	71	71	71	71

* p<0.1; ** p<0.05; *** p<0.01.

Table A1. Summary of Payoffs

		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**
	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
	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
	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
	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
	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
	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
	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
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-

Brick and Visser 2010

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 certificate)
☐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 own household's financial situation, would you describe yourself as:
☐Poor
☐Lower income
☐Middle income
☐Upper income
☐Rich

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

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? ____

What is your monthly income from this job? R____________________________

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
	💧💧	R20 if ❶❷❸	R34 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R37.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R41.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R46.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R53 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R62.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R75 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R92.5 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R110 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R150 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R200 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R300 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	R20 if ❶❷❸	R500 if ❶
	💧	R5 if ❹❺❻❼❽❾❿	R2.5 if ❷❸❹❺❻❼❽❾❿
	💧💧	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.

Series 2

		Traditional Seeds	Improved Seeds
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R27 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R28 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R29 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R30 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R31 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R32.5 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R34 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R36 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R38.5 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R41.5 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R45 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R50 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	R20 if ❶❷❸❹❺❻❼❽❾	R55 if ❶❷❸❹❺❻❼
	💧	R15 if ❿	R2.5 if ❽❾❿
	💧💧	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
	💧💧	R12.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R10 if ❻❼❽❾❿
	💧💧	R2 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R10 if ❻❼❽❾❿
	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R10 if ❻❼❽❾❿
	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R2 if ❻❼❽❾❿	-R8 if ❻❼❽❾❿
	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R4 if ❻❼❽❾❿	-R8 if ❻❼❽❾❿
	💧💧	R0.5 if ❶❷❸❹❺	R15 if ❶❷❸❹❺
	💧	-R4 if ❻❼❽❾❿	-R7 if ❻❼❽❾❿
	💧💧	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.

Table 4. Summary of Payoffs

	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**
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
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
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
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
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
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
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
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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-
	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	-	-	-	-

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