Attitudes towards risk and time among small-scale farmers in West Africa

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Abstract

This study presents an advanced methodology of jointly eliciting attitudes towards risk and time and the subjective perception of uncertainty among 212 smallholder cattle farmers in the cotton belt of West Africa. The sample had been randomly selected from a panel of previous socio-economic survey samples in 2003/2004 and 2007 in the study area. All respondent farmers face the same problem, i.e. managing African animal trypanosomosis (AAT) a major livestock disease in cattle and its widespread resistance to commonly available drugs. Because of the dynamic nature of the disease and its strong interdependency with farmer's behavior and perception of uncertain events it is useful to expand the measurement of risk attitudes and simultaneously elicit farmers' time preferences and subjective probabilities of cattle's health states.

In total, five economic field experiments had been conducted during January and February 2011 in the study area common to southeastern Mali and southwestern Burkina Faso that are introduced in this paper. First preliminary results show that the general perception of the threat of cattle diseases is serious and AAT is among the most important one. Furthermore, respondents seem to be rather risk-seeking. The time preference experiment showed that 40% of respondents are rather patient and wait for a higher future reward.

Key words: experiments, risk and time preferences, dynamics, West Africa

1 Background

African animal trypanosomosis (AAT) in cattle and the threat of widespread drug resistance are important production risks to resource-poor cattle farmers in smallholder crop-livestock production systems in the cotton belt of West Africa (Clausen et al., 2010). Recent studies in that region underline the urgency to improve the understanding of drug resistance development and to find ways of its sustainable containment and prevention (Affognon et al., 2005, Grace et al., 2009). The development of resistance in pathogens to tryopanocidal compounds is influenced not only by the interactions of factors related to respective characteristics of pathogen, vector and host involved, but also by human interference (Geerts & Holmes, 1998). Since early studies, the exposure of trypanosomes to sub-therapeutic drug doses has been considered as a key factor for the development of resistance (Boyt, 1986, Whiteside, 1960, 1962). Hence, one can argue that farmers' decision making is the 'lynchpin' for introducing better disease and resistance management options. Decision outcomes are uncertain and are of a long-term nature, because the success of the treatment is influenced by random events and consequences are delayed. In this context the decision making behavior of farmers with regard to three factors, namely (i) the perception of uncertain events, (ii) attitudes towards risk and (iii) time preferences are crucial parameters. Therefore, the overall aim of this study is to generate a better understanding of farmers' behavior by means of economic field experiments.

Economic field experiments in developing countries eliciting people's risk preferences have a long tradition. For example, Binswanger (1980, 1981) conducted a 'choose lottery' with rural farmers in India, Harrison et al. (2005) in Ethiopia and Uganda and Yesuf and Bluffstone (2009) in Ethiopia. In contrast to those choose lotteries, which contain alternative choices, Holt and Laury (2002) developed 'accept/reject lotteries, where participants are confronted with a pair-wise lottery choice in two columns. All these studies had been limited to risk preferences.
More recent studies conducting economic field experiments aimed to jointly elicit risk and time preferences. Most of these studies took place in the developed world (e.g. Andersen et al. (2008) in Denmark or Ida & Goto (2009) in Japan). With respect to experimental work in developing countries, Tanaka et al. (2010) conducted experiments with rural villagers in Vietnam. They expanded the measurement of risk attitudes beyond the only parameter of concavity underlying expected utility theory to test Tversky and Kahnemann (1992)'s prospect theory. By means of prospect theory more insights into economic behavior can be obtained, including subject's loss aversion as compared to gains and the weighting of probabilities (Humphrey & Verschoor, 2004). Moreover, Tanaka et al. (2010)'s time preference experiment had been designed in a way to test several forms of discounting, i.e. exponential, hyperbolic and quasi-hyperbolic discounting, as recommended by Benhabib et al. (2010).
Dynamic economic experiments in which subjects are confronted with a decision problem across repeated rounds can be mainly found in the field of microfinance (e.g. Abbink et al., 2006, Giné et al., 2010). In the field of agricultural economics, the work of Lybbert (2006) is one of the first that assessed farmer's risky decision making across repeated rounds of hypothetical farming seasons using the case of new crop varieties.

The objective of the paper is (i) to describe the implementation of economic field experiments to jointly elicit perceptions, risk attitudes and time preferences of African cattle farmers in the cotton belt of Mali and Burkina Faso and (ii) to present preliminary results to allow first assessment of the validity of these experiments.

In the next section the procedures of data collection are presented, followed by the methodology of jointly eliciting perceptions and preferences in section three and preliminary results in section four. Finally, section five concludes.

2 Data

The empirical bases for conducting economic field experiments in West Africa were prior studies of the first author and other researchers of the International Livestock Research Institute (ILRI). In the study area of Mali and Burkina Faso two socio-economic surveys had been already conducted in 2003/2004 (Affognon et al., 2010) and in 2007 (Liebenehm et al., 2011). From January to February 2011 the study area had been visited again, to elicit farmers' perception of uncertainty and risk and time preferences. Table 1 presents the number of households in previous and present surveys.

Table 1 here

In the baseline sample of 2003/2004 detailed information about cattle production had been obtained from 206 households (Affognon et al., 2010). In 2007 it was aimed to measure the impact of ILRI's project intervention. Here, 117 households could be matched to the former baseline sample and 306 were used as controls (Liebenehm et al., 2011)[1]. In 2011 it was aimed to randomly select 100 observations from those households that already participated in the previous two surveys and another 100 households that already participated in the 2007 survey. In the end the experiments had been conducted with 98 households, where production information from two points in time is available and 114 households, where production data from 2007 is available.

The first part of the questionnaire focused on household demographics and cattle herd production in accordance to previous surveys. In the second part farmers were asked to participate in five experiments. Detailed guidelines of each experiment had been prepared in cooperation with other economists and veterinary experts. All materials had been explained to experienced enumerators, who already took part in the former surveys and were familiar with the topic of AAT and the study area. Role games between enumerators helped to establish a common interviewer standard and to minimize enumerators' bias. Finally, the questionnaire had been pre-tested in one village. The survey team visited each village in advance to introduce the venture and provide the lists of names in order to ensure that the randomly drawn respondents were present.

3 Experimental design

In this study five economic field experiments had been conducted (Table 2). Subjective (joint) probability judgments were inferred by the visual impact method (Hardaker et al., 2004). There were three different types of risk experiments. The first one had been designed as a binary choice between a lottery and safe amount to calculate the indifference point (or certainty equivalent) for a risky option (Hardeweg et al., 2011, Henrich & McElreath, 2002). The second risk experiment was designed as 'accept/reject lotteries' in order to elicit the three parameters of prospect theory, i.e. (i) concavity of the utility function, (ii) non-linear probability weight and (iii) degree of loss aversion in relation to gains (Tanaka et al., 2010). The third risk game was rather a strategic game suited to the decision problem in managing the disease. Finally, in the time experiment participants basically had the choice between an immediate and a delayed reward (Tanaka et al., 2010).

Table 2 here

3.1 Experiment on risk perception

Subjective (joint) probability judgments had been inferred by the visual impact method (VIM). VIM is a tabular approach to obtain probability distributions by asking the participant about

[1] In the research output from 2007 the information of respondents' self-report of participation has been used to distinguish between participants and non-participants (Liebenehm et al. 2011).

their probability judgment of uncertain events using counters that represent relative probabilities. Mostly, sources of uncertainty are interdependent and VIM makes it possible to account for stochastic dependency by eliciting joint probabilities (Hardaker et al., 2004).

In a first step, the respondent had been asked how often in the next 12 months he expects his cattle to be healthy, infected with AAT or infected with another disease. With the help of counters (cotton swabs) the respondent was asked to allocate the 12 counters in the way he thinks how often the respective proposition will occur in the next 12 months. In case the respondent assigned at least one counter to AAT, he was asked to continue with the next question, i.e. 'In case you believe your cattle will be infected with AAT, how often you think they will be infected with resistant or sensitive strains?' Again the respondent had been asked to re-allocate the number of counters assigned to AAT in the first question over the two possible types of AAT infection. The number of counters assigned in the first step was multiplied by two to ensure the number of counters is sufficient for reallocation. In the third step, given the particular joint probability of AAT and the respective type of infection, the respondent was asked to judge about the percentage of cattle dying and output loss with and without medical treatment, each on a 5-scale interval from 0% to 100%. In order to facilitate reallocation of counters the number of counters in the second step was multiplied by five. Respective tables were provided as picture cards to facilitate the arrangement of counters. After each question the respondent was asked to thoroughly check all values in the tables again to make sure that the allocation of counters corresponds to personal beliefs.

3.2 Experiments on risk preferences

In the following three risk experiments are described to some detail.

3.2.1 Risk game I

Respondent were asked to choose among 20 decision problems between an identical lottery (Option A) and increasing safe pay-off (Option B). In the lottery a blind draw of one red or one yellow chip out of a bag decided about a payoff of zero or 1500 CFA (about 2 €). The certain amount started with 0 CFA and increases by 50 CFA row by row up to 950 CFA in the last row. Hence, the preference of a safe amount below 750 CFA implies that respondents are risk-averse. The preference of a safe amount above 750 CFA implies risk-seeking behavior (Table 3).

Table 3 here

The respondent was asked to select the row, where he would switch from Option A to Option B. The respondent could switch in the first row, and he did not have to switch at all. In total, there were 20 choices to make and the row number had been noted down in the questionnaire.
After the completion of all 20 choices, the respondent was asked to draw one card out of a bag with 20 numbered cards. If this number on the card drawn is lower than the row number that indicates the switching point from Option A to B, the respondent had to play the lottery. If the number on the card drawn is higher than the row number, the respondent receives the safe amount of the row indicated by the randomly drawn number.

3.2.2 Risk game II

Three series of paired lotteries had been conceptualized in order to expand the measurement of farmers' risk preferences beyond the concavity of the utility function, taking into account the influence of non-linear weighting of probabilities and the aversion of losses as compared to gains.

In each series, the respondent had the choice between two options, i.e. Option A and Option B, whereby each option is a lottery out of 10 colored chips with different rewards to be obtained (Table 4). The difference in expected pay-offs of Option A relative to Option B is shown in the right column. In series 1, probabilities are fixed in all 14 rows and only the high pay-off in Option B increases in every row. Hence, Option A dominates Option B in the first seven rows in terms of expected pay-off. From row eight to 14 Option B starts to dominate Option A. Series 2 shows the same pattern like Series 1, but different pay-offs and probabilities. Here, Option B immediately starts to dominate Option A in terms of expected pay-off from the first row. Those who are risk-averse will choose Option A longer than those who are rather risk-taking. The third series involves both gains and losses. Probabilities are fixed at 50:50 for all rows. In Option A the positive pay-off decreases, while the negative pay-off increases from row to row. In Option B the positive pay-off is constantly high, and the negative pay-off decreases row by row.

Table 4 here

In each series, the participant was asked, which option he would accept, at the same time rejecting the other one. Basically, the respondent could choose Option B in the first row and he did not have to switch to Option B at all. In total, there were 35 choices to make. After the completion of all 35 choices, the respondent was asked to blindly draw one card out of 35 numbered cards in a bag. The card drawn determined the row of choice and the respective ten colored chip lottery had been played for real money.
The largest reward of 50000 CFA (about 76 €) is equivalent to 15% of the average annual income of a cattle dependent household in the study area. The maximum amount that could have been lost by the respondent was 1000 CFA (about 1.5 €), which equalled the amount the respondent had been paid when he agreed to participate in the survey at the very beginning. As visual aid picture cards were used in order to account for the low educational background of respondents in the study area (Liebenehm et al 2011). The picture cards illustrated each lottery in each series with rewards or losses and respective probabilities as indicated by differently colored chips.

3.2.3 Risk game III

The dynamic risk game aimed to better understand farmers' valuation of AAT treatment options by evaluating pay-off distributions that depend on the chosen input. The respondent was asked to play three series of hypothetical farming seasons to allow for learning across repeated rounds. At the beginning of each season the respondent was confronted with the yield distribution of his hypothetical cattle herd. Therefore, he was asked to blindly draw ten chips out of a bag with 20 chips in three different colors (10 white chips, 7 green chips and 3 blue chips). The three different colors represent the three different health states of cattle, namely healthy (white), sensitive infection with AAT (green) and resistant infection with AAT (blue). That means the risk of infection with AAT is 50%, whereby 15% of those infected animals will be infected with resistant strains. The ten blindly drawn chips were put on the soil in front of the respondent. Now the respondent knew the health state of his hypothetical cattle herd and the potential yield that can be produced in this first season could be calculated (1 white chip=1000 CFA, 1 green chip=500 CFA, 1 blue chip=250 CFA). Only 10% of this income generated by the hypothetical cattle herd could be exclusively used by the respondent to invest in health of his cattle herd, whereby 90% of this money was said to be spent for supporting the family, etc[2]. Thereafter, the respondent was shown four different treatment options and corresponding physical outcomes and monetary consequences (Table 5).

[2] Following Shaw et al. (2006) the relation between average live weight price of Zebus and trypanocide cost are 100 to 1. In this game, the value of cattle and treatment costs are adjusted to 100 to 10 to reflect the difficult situation of making a treatment decision under strong monetary constraints.

Table 5 here

Each treatment strategy can result into different outcomes that indicate possible reactions with respect to cattle's health state. In turn, each outcome comes with a certain probability. There are 4x20 chips representing the four treatment options, whereby number and color of the chips follow the probabilities of respective outcomes. The respondent could choose several options, each for one animal. The only constraint had been the budget available for treatment. After the respondent made his choice he was asked to state his willingness to pay (WTP) for the chosen strategies following a mechanism suggested by Becker, DeGroot and Marschak (1964). In case respondent's WTP was higher than a random draw of input price from a uniform distribution of prices of the respective strategy, the chosen strategy would be applied. In case his WTP was lower than the random draw of input price, no treatment would be applied. The random draw of input price had been determined by a roll of a ten-sided-die, whereby 1 indicates a price of 100 CFA and 10 indicates a price of 1000 CFA. In correspondence to the resulting strategy applied, the respondent was given the respective bag and was asked to blindly draw one chip out of the bag. The cattle health state of the hypothetical herd, represented by the ten chips on the soil, was adjusted according to the respective consequences resulting from the blindly drawn chip. Finally, the profit in the end of the first season could be determined. In order to account for natural reproduction, one white chip (1000 CFA) was added to the hypothetical herd. In the next round the respondent could choose among the four treatment options again, using 10% of the production value obtained in the previous round. In total three rounds were played. At the end, the respondent obtained 10% of the final production value in cash. Picture cards had been used to illustrate the course of the game and to make it easier for the respondent to remember each strategy with corresponding outcomes.

3.3 Experiment on time preferences

The time preference experiment aimed to test several functional forms of discounting consists of 75 choices in total between two options, i.e. a larger reward delivered at a specified time in the future (Option A) and a smaller reward delivered immediately (Option B). The future reward varies between 1500 CFA (about 2.3 €) and 15000 CFA (about 23 €). There are 15 combinations of future rewards and time delays, i.e. 1500 CFA, 6000 CFA and 15000 CFA with delays of one week, one month and three months, respectively and 3000 CFA and 12000 CFA with delays of three days, two weeks and two months. The maximum delay of three months corresponds to treatment decisions in managing the disease. Each of those 15 combinations of rewards and delays is opposed to five different rewards that can be obtained immediately. The respondent had to decide row by row which option he prefers.
After the completion of all 75 choices, the respondent was asked to blindly draw one ball out of 75 numbered bingo balls in a box. The ball drawn will determine the row and the participant gain the reward at the respective time according to his choice made. A trusted agent, well-known and commonly accepted for this duty, had been assigned to keep the money until delivery.

4 Descriptive results

4.1 Risk perception

The joint probabilities elicited by means of the visual impact method (VIM) are presented in Figure 1.

Figure 1 here

The average subjective probability that cattle will stay healthy in the next twelve months is 44.51%, followed by trypanosomosis with 29.21% and other cattle diseases with 26.28%. Therefore, the general perception of cattle diseases among respondents is that they are a serious problem and AAT is among the most important one. Given the incidence of AAT in the next twelve months the joint probability that cattle will be infected with sensitive strains is higher than an infection with drug-resistant strains. Further along the probability tree, the outcomes of each type of AAT infection on the percentage of herd mortality and output loss in monetary terms are different. The average subjective probability of higher monetary losses is higher than in terms of mortality in case of a sensitive infection with AAT and vice versa in case of a resistant infection. This observation is plausible, because a resistant infection is less likely to be successfully cured. The comparisons of outcomes with and without trypanocidal control are similar among the two types of AAT infection. In both cases the percentage of loss is perceived to be smaller with control than without any means of AAT control both in terms of monetary loss and herd mortality.

4.2 Risk preferences

4.2.1 Risk game I

The cumulative distribution of switching points from a lottery (1500CFA or 0CFA) to an increasing safe amount is presented in Figure 2.

Figure 2 here

Almost 70% out of 212 participating cattle farmers never switched to the safe amount. Instead, they always preferred to play the lottery. In contrast, the remaining 30% of the respondents switched rather sooner than later along the rows. They prefer obtaining a small safe reward than to play the lottery. Hence, the majority of risk-taking cattle farmers of 70% are opposed to 30% of risk-averse farmers.

4.2.2 Risk game II

Table 6 displays the number of respondents by switching points in series one, two and three.

Table 6 here

There are respondents at any given switching point from A to B, including the option to never switch, which shows that the experimental instructions had been understood. Focusing on the switching points in series one and two, the majority of respondents are rather earlier switching to Option B than later down the rows, trying to obtain a higher reward at higher risk. In contrast, 35 of 212 respondents never switched to Option B, to back up at least 500 CFA at lower risk. Hence, in correspondence to risk game I, the majority of respondents shows risk-seeking behavior.

In series three the distribution of respondents by switching point is similar. Around 60% of respondents are rather likely to switch in the beginning, taking into account to loose a high amount of money. Approximately, 30% of respondents never switched to Option B, being rather loss-averse.

4.2.3 Risk game III

In dependence of randomly drawn health state chips, the respondents started with a hypothetical cattle herd that could produce on average a value of 7100 CFA, which corresponds to the expected value when drawing 10 out of 20 chips from the starter-bag. While after the first round the mean value of herd production decreases slightly, the value of production is increasing by 1000 CFA after Round 2 and Round 3 (Figure 3). In consideration of the fact that this increase in value of production excludes the natural reproduction in terms of additional 1000 CFA after each round, it shows that respondents were on average able to improve the health states of their cattle.

Figure 3 here

Figure 4 presents the four strategies chosen and actually applied, i.e. no treatment (A), curative (B), preventive (C) and sanative (D) strategies in each round. Around 60% of respondents chose the curative treatment strategy, followed by sanative pair and preventive treatment across all rounds. However, in most cases no treatment is applied in the end. The order of all other strategies applied following behind corresponds to the chosen ones.

Figure 4 here

Figure 5 shows the mean willingness to pay by strategy and the average randomly drawn prices determined by a ten-sided die. On average random prices are higher than respondents' WTP, which explains that mostly no treatment strategy (A) is applied in the end of each round.

Figure 5 here

Noticeable, is also the fact that respondents increase their WTPs for all strategies B, C and D across the three rounds and the percentage of those strategies actually applied is increasing, too (Figure 4).
Moreover, it can be observed that in the first round respondents were willing to spend only half of the budget available for treatment. After each following round they are increasing their WTP steadily in accordance to an increased production value and resulting budget. Respondents were willing to spent most of the budget for sanative pair (D), followed by curative treatment (B) and preventive treatment (C) in Round 1 and Round 2. In the third round, the WTP for preventive treatment is on average higher than for curative treatment. The highest WTP for strategy D (sanative pair) corresponds to the highest expected value that could have been obtained by this choice, which shows that respondents understood the game quite well and are acting economically. The higher mean WTP for curative treatment relative to preventive treatment in the first two rounds shows that respondents prefer to cure their animals when they are sick with AAT in the first place, since it is only possible to choose one strategy per round. The change in WTP for preventive treatment over curative treatment in the last round shows that respondents were also willing to provide protection for healthy animals as well. Hence, a learning curve across the rounds becomes visible, which makes respondents' behavior perfectly comprehensible.

4.3 Time preferences

Figure 6a and 6b plot the distributions of preferences for the immediate pay-off per future reward in different reward-time combinations. In Figure 6a the future rewards vary between 1500 CFA, 6000 CFA and 15000 CFA, each in one week, one month and three months. The immediate pay-off starts at 1/6th of the future reward and increases by the same relation over five rows. In Figure 6b the future rewards vary between 3000 CFA and 12000 CFA, each in three days, two weeks and two months. The immediate pay-off is in the same relation as before.

At a first glance across all plots, it can be observed that approximately 40% of the respondents always chose the future reward and never switched to the immediate reward, as indicated by 'Never today'. Those rather patient 40% are opposed to another fraction of about 40% of respondents, who were switching already in the first row to the immediate reward. This fraction of respondents did not like to wait for a higher reward delivered in the future, but preferred to obtain any smaller reward immediately.

The comparison of distributions across increasing pay-off levels shows that respondents were more likely to prefer the immediate reward. For example, the fraction of respondents preferring 250 CFA today to 1500 CFA in the future is smaller than the fraction of respondents favoring 2500 CFA today to 15000 CFA in the future.

Figure 6a and 6b here

Secondly, it can be observed that the fraction of respondents switching at the smallest immediate reward is increasing with the time span. That means the longer the respondent has to wait for the future reward, the more likely he prefers a smaller amount today. For example, the larger the time-span of receiving 1500 CFA, the higher the fraction of respondents preferring 250 CFA today (Figure 6a).

Hence, respondents' behavior is also comprehensible in this time experiment.

5 Summary and conclusions

The conduct of a survey with five economic field experiments varying in their degree of complexity and abstraction requires thorough preparation. In particular, the dynamic risk game had been discussed with economists and veterinary experts and was tested in advance. Detailed descriptions with step-wise instructions of each experiment were elaborated for the enumerators. Moreover, picture cards had been designed in order to take into account the low level of formal education of respondents. It was observed however that respondents easily understood the most complex experiment, i.e. the dynamic risk game, because the experimental task of the game is close to their farming reality. Experienced enumerators familiar with the topic of AAT and commonly-known in the villages of the study area had been chosen. Intensive enumerator training, including role games helped to establish a common interviewer standard in accordance to guidelines and to minimize enumerator bias. Finally, the questionnaire had been pre-tested in one village.

The economic field experiments allow some preliminary conclusions based on a first glance of the results. The general perception of cattle diseases among respondents is that they are a serious problem and AAT is among the most important one. Monetary losses are perceived to be higher in case of a sensitive infection and mortality is perceived to be more frequent in case of a resistant infection.
The first risk game showed that 70% of respondents prefer to play the lottery than to obtain a safe amount. The second risk game showed a similar picture. The majority of respondents preferred to play the more risky lottery to obtain a higher pay-off. Moreover, the incorporation of losses reveals that 60% of respondents are willing to take the relatively high loss of 1000 CFA. This suggests that the majority of respondents tend to be risk-seeking and is rather not averse to losses.
In the dynamic risk game it could have been observed that respondents adjust their behavior when being confronted with the same decision problem across repeated rounds. In accordance to their budget limitations they were adjusting their willingness to pay in order to be able to apply their chosen strategy. Hence, it was possible to identify a learning curve.
Finally, the time preference experiment showed that 40% of respondents are rather patient to wait for the higher future reward. Along the line of past findings, it could be observed that firstly, the higher the pay-off levels, the more likely the immediate pay-off had been favored. Secondly, the fraction of respondents switching at the smallest immediate reward is increasing with the time span. Hence, it can be argued that respondents' behavior is comprehensible in all economic field experiments and data are sufficiently valid to be used in planned analyses.

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Tables and figures

Table 1 Number of households per survey

Year	Number of households	
2003/2004	206	-
2007	117	306
2011	98	114

Source: Affognon et al. (2010);
Liebenehm et al. (2011)

Table 2 Overview of five economic field experiments

Objective	Decision task	Procedure	Main reference
Risk preception	Visual impact method	Allocation of counters to interdependent uncertain events	Hardaker et al 2004
Risk preferences	Certainty equivalent	Series of binary choices involving safe amount and fixed lottery	Henrich & McElreath 2002
	Accept/reject lottery	Series of pair-wise lottery choices, accepting one lottery per line and reject the other	Tanaka et al. 2010
	Dynamic risk game	Choice among four treatment strategies varying in expected pay-off across three repeated rounds	Lybbert 2006
Time preferences	Accept/reject delay	Series of binary choices between lower reward today and higher reward in the future	Tanaka et al. 2010

Source: Own illustration

Table 3 Risk game I

Switching point to Option B	Option A Lottery (CFA)		Option B Safe amount (CFA)	Risk premium (CFA)	Risk classification
	Yellow chip	Red chip			
1	1500	0	0	750	Averse
2	1500	0	50	700	
3	1500	0	100	650	
4	1500	0	150	600	
5	1500	0	200	550	
6	1500	0	250	500	
7	1500	0	300	450	
8	1500	0	350	400	
9	1500	0	400	350	
10	1500	0	450	300	
11	1500	0	500	250	
12	1500	0	55	695	
13	1500	0	600	150	
14	1500	0	650	100	
15	1500	0	700	50	
16	1500	0	750	0	Neutral
17	1500	0	800	-50	Seeking
18	1500	0	850	-100	
19	1500	0	900	-150	
20	1500	0	950	-200	

Source: Own survey based on Hardeweg et al. (2011)

Table 4 Risk game II (pay-offs in CFA)

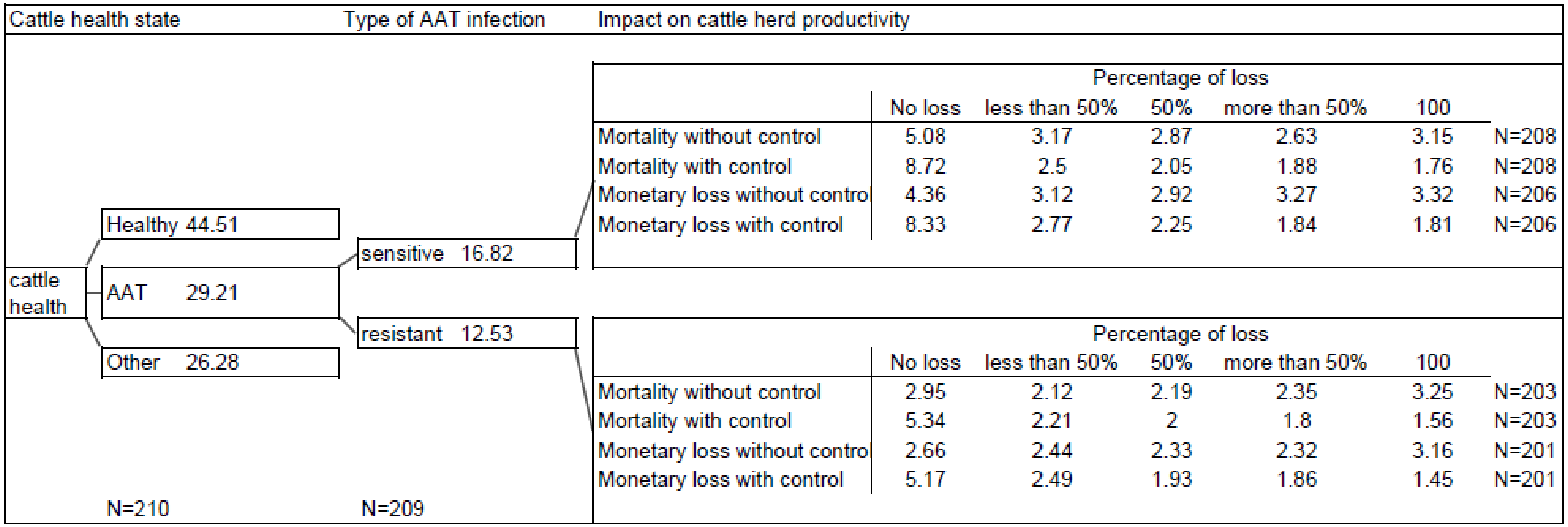
		Option A		**Option B**		**Difference in expected pay-off (A-B)**
	Row	**3 green balls**	**7 yellow balls**	**1 green ball**	**9 yellow balls**	
Series 1	1	2000	500	3000	250	425
	2	2000	500	3300	250	395
	3	2000	500	3700	250	355
	4	2000	500	4200	250	305
	5	2000	500	4800	250	245
	6	2000	500	5800	250	145
	7	2000	500	7000	250	25
	8	2000	500	9000	250	-175
	9	2000	500	11000	250	-375
	10	2000	500	14000	250	-675
	11	2000	500	18000	250	-1075
	12	2000	500	25000	250	-1775
	13	2000	500	35000	250	-2775
	14	2000	500	50000	250	-4275
		9 green balls	**1 yellow ball**	**7 green balls**	**3 yellow balls**	
Series 2	15	2000	1500	2500	250	-100
	16	2000	1500	2600	250	-180
	17	2000	1500	2700	250	-260
	18	2000	1500	2800	250	-340
	19	2000	1500	2900	250	-420
	20	2000	1500	3100	250	-580
	21	2000	1500	3200	250	-660
	22	2000	1500	3400	250	-820
	23	2000	1500	3600	250	-980
	24	2000	1500	3900	250	-1220
	25	2000	1500	4300	250	-1540
	26	2000	1500	4800	250	-1940
	27	2000	1500	5200	250	-2260
	28	2000	1500	6500	250	-3300
		5 green balls	**5 yellow balls**	**5 green balls**	**5 yellow balls**	
Series 3	29	1200	-200	1500	-1000	250
	30	200	-200	1500	-1000	-250
	31	50	-200	1500	-1000	-325
	32	50	-200	1500	-800	-425
	33	50	-400	1500	-800	-525
	34	50	-400	1500	-700	-575
	35	50	-400	1500	-500	-675

Source: Own survey based on Tanaka et al. (2010)

Table 5 Treatment options in dynamic risk game (Risk game III)

Treatment option	Outcome on cattle health	Monetary consequences (CFA)	Expected pay-off of treatment option (CFA)
No treatment	No infection (50%)	0	-287.5
	Sensitive infection (35%)	- 500	
	Resistant infection (15%)	- 750	
Curative treatment	Healthy (50%)	+ 500	87.5
	Resistant infection (35%)	- 250	
	Dying (15%)	- 500	
Preventive treatment	No infection (50%)	+ 1000	212.5
	Sensitive infection (35%)	- 500	
	Resistant infection (15%)	- 750	
Combination of curative and preventive treatment (sanative pair)	Healthy (50%)	+ 750	337.5
	Resistant infection (35%)	0	
	Dying (15%)	- 250	

Source: Own survey



Sensitive (16.82)

	Percentage of loss					
	No loss	less than 50%	50%	more than 50%	100	
Mortality without control	5.08	3.17	2.87	2.63	3.15	N=208
Mortality with control	8.72	2.5	2.05	1.88	1.76	N=208
Monetary loss without control	4.36	3.12	2.92	3.27	3.32	N=206
Monetary loss with control	8.33	2.77	2.25	1.84	1.81	N=206

Resistant (12.53)

	Percentage of loss					
	No loss	less than 50%	50%	more than 50%	100	
Mortality without control	2.95	2.12	2.19	2.35	3.25	N=203
Mortality with control	5.34	2.21	2	1.8	1.56	N=203
Monetary loss without control	2.66	2.44	2.33	2.32	3.16	N=201
Monetary loss with control	5.17	2.49	1.93	1.86	1.45	N=201

Figure 1 Mean joint probabilities on cattle health states and respective outcomes
Source: Own survey

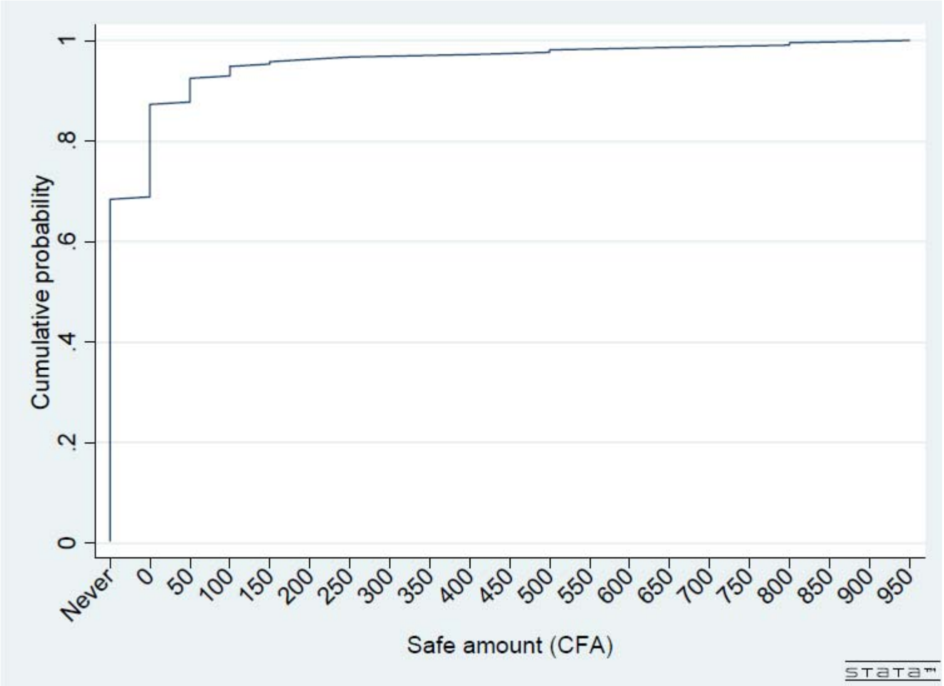


Figure 2 Cumulative distribution of choosing safe amount in risk experiment 1
Source: Own survey

Table 6 Number of respondents by switching point in risk experiment 2

Switchingpoint in Series 2	**Switchingpoint in Series 1** Never	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Never	35	11	0	0	1	2	0	0	0	0	0	0	0	1	1	51
1	16	49	8	7	7	2	1	0	0	0	0	2	0	0	3	95
2	0	11	9	4	3	0	1	1	1	0	0	0	0	0	1	31
3	0	3	1	1	1	0	0	1	0	1	0	0	0	0	0	8
4	0	0	3	0	0	0	0	0	0	0	1	1	0	0	0	5
5	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4
6	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	3
7	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2
9	2	1	1	0	0	0	1	0	0	0	0	0	1	0	0	6
10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2
11	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
13	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	57	80	24	12	12	5	4	3	2	1	1	3	1	1	6	212

Switchingpoint in Series 3								
Never	1	2	3	4	5	6	7	Total
59	63	37	26	17	4	3	3	212

Source: Own survey

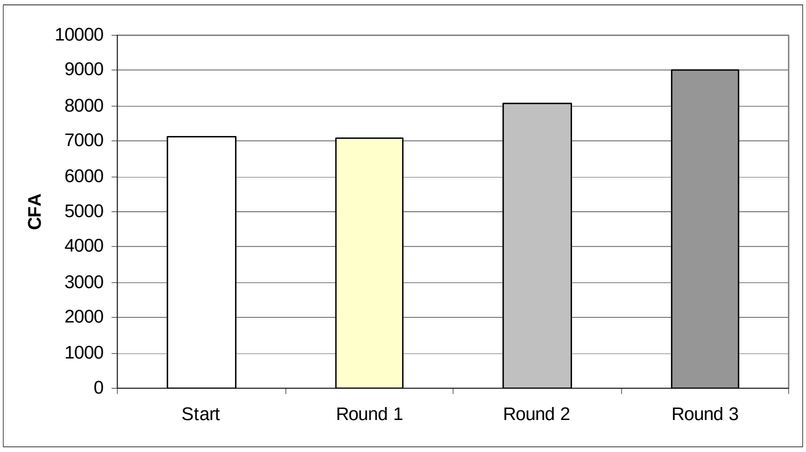


Figure 3 Mean value of herd production across three rounds in risk experiment 3
Source: Own survey

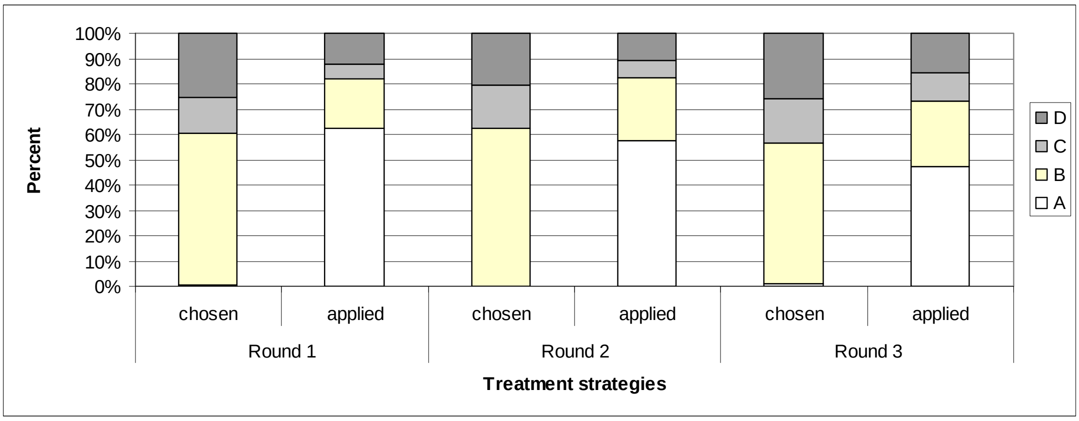


Figure 4 Mean chosen and applied treatment strategies across three rounds in risk experiment 3
Source: Own survey

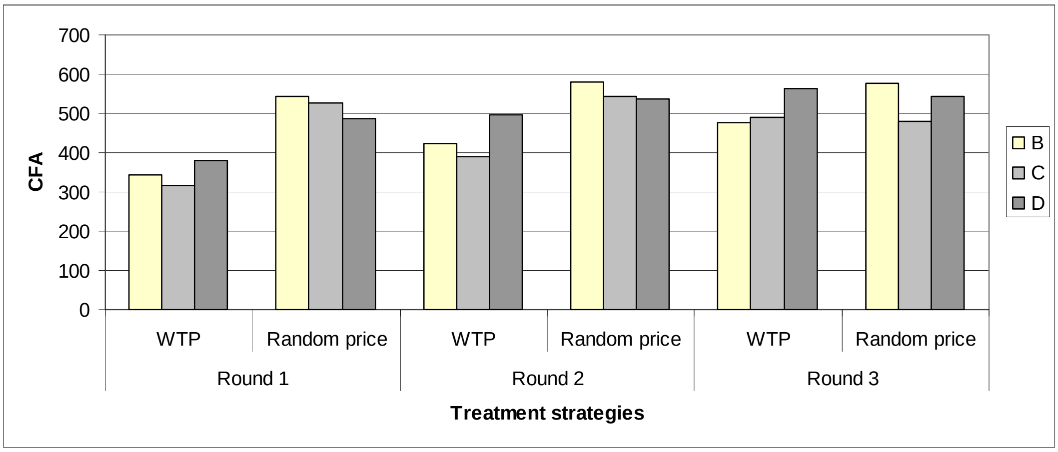


Figure 5 Mean WTP and random price of treatment strategies across three rounds in risk experiment 3
Source: Own survey

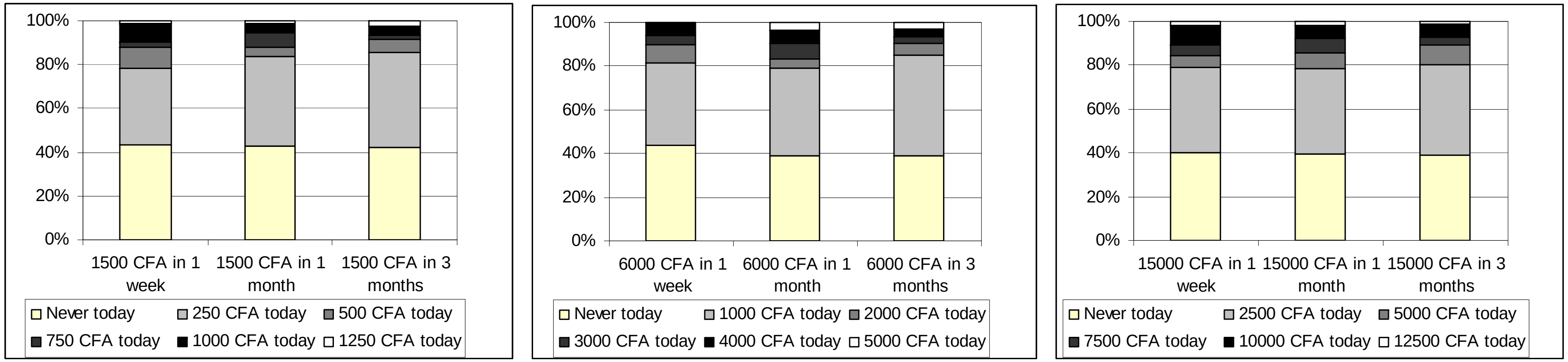


Figure 6a Distribution of choices in time experiment (row 1 – row 45)
Source: Own survey

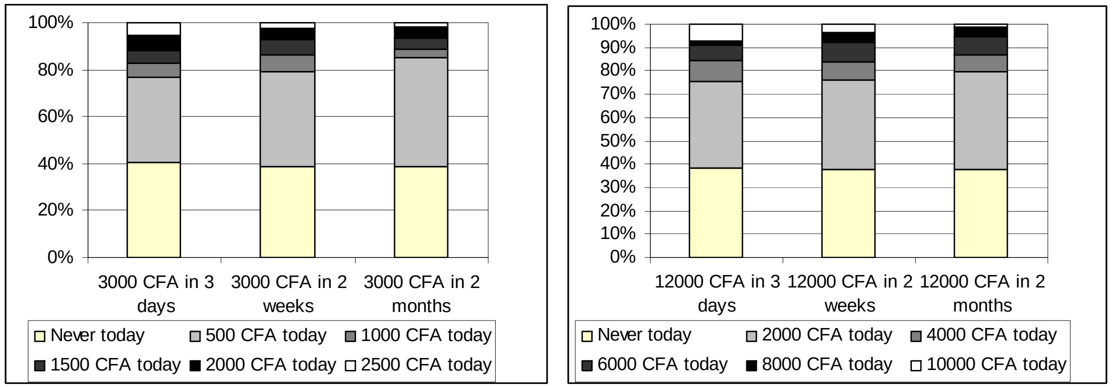


Figure 6b Distribution of choices in time experiment (row 46 – row 75)
Source: Own survey