Really too risk averse and too impatient to escape poverty? Insights from a field experiment in West Africa

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Abstract:

In this paper, we analyze risk and time preferences as factors related to technology adoption. In the context of West African small-scale cattle farm households, we examine why the adoption of prophylactic drugs as an ex-ante risk management strategy to protect cattle from tsetse-transmitted African Animal Trypanosomosis (AAT) despite experts' recommendation is low. To do so, we conducted two types of economic field experiments: (i) to elicit farmers' risk and time preferences, considering additional behavioral information beyond standard economic theory and (ii) to observe farmers' adoption decision of alternative drug treatments to manage the risk of AAT. Results show that loss aversion and high discount rates are associated with low prophylaxis take-up. More specifically, farmers value losses of animals that are infected with AAT larger than gains from healthy animals and short-term benefits from therapeutic treatment over long-term benefits from prophylactic treatment. As a consequence, a loss averse and impatient farmer that is less likely to apply AAT prophylaxis forgives chances of higher and sustainable returns, thereby deteriorates risk management abilities and likely perpetuates poverty. We suggest that the consideration of farmers' risk and time preferences can help improving the effectiveness of livestock extension and veterinary services in West Africa.

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Abstract

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Keywords

Adoption, cattle farmers, risk and time preferences, trypanosomosis, West Africa

1 Introduction

The decision to adopt a new technology is a major strategy to manage adverse risks that involves investments with uncertain outcomes over time. Economic literature suggests that poorer people, who are more exposed to adverse risks and unprotected by dysfunctional market and government institutions, are more risk averse and more likely to discount the future than wealthier people (Haushofer and Fehr 2014). In turn, poor individuals who are risk averse and impatient are less likely to adopt new technologies, since they involve uncertain and longsighted returns. As a consequence, poor people's chances of higher and sustainable returns are forgone and abilities to manage risks further deteriorate, increasing the likelihood that the individual will remain below the poverty line. The link between risk aversion, impatience and the technology adoption decision can, hence, perpetuate a poverty trap (Rosenzweig and Binswanger 1993; Mosley and Verschoor 2005; Dercon and Christiaensen 2011; Naschold 2012; Brick and Visser 2015).

Empirical studies that investigate the link between risk aversion, impatience and technology adoption are, however rare. Among the few extant studies is the study by Liu (2013) who measured risk preferences of Chinese cotton farmers following Kahneman and Tversky's (1979; 1992) prospect theory and finds that risk aversion and loss aversion are associated with low adoption rates of genetically modified cotton seeds. Tarozzi and Mahajan (2011) measured time preferences of Indian farmers in accordance to hyperbolic discounting (Laibson 1997) and show that low adoption of re-treating bed-nets with insecticides to prevent malaria infection is related to present bias.

In this paper, we combine the approaches of Liu (2013) and Tarozzi and Mahajan (2011) and simultaneously consider risk and time preferences beyond standard expected utility models as factors related to technology adoption. We use individual parameter estimates of West African cattle farmers' risk and time preference elicited in an earlier paper (Liebenehm and Waibel 2014). In particular, we estimated a discounted utility model, where we specified the utility function in accordance to prospect theory and the discounting function in accordance to quasi-hyperbolic discounting. This model allows explaining farmers' dynamic decision making behavior in managing adverse risks, taking into account additional behavioral information such as non-linear probability weighting, loss aversion or inconsistent discount rates.

One of the predominant risks cattle farmers in West Africa are exposed to is African animal trypanosomosis (AAT) - a vector-borne livestock disease transmitted by the tsetse fly. The tsetse fly is unique to Africa and infests 39 sub-Sahara African countries (SSA). Alsan (2015) recently identified the tsetse fly as a historical constraint to economic development in SSA.

The application of trypanocidal drugs is cattle farmers' major strategy to manage the risk of AAT. Trypanocidal drugs can be either applied as prophylactic treatment *ex-ante* AAT infection or as therapeutic treatments *ex-post* AAT infection (McDermott and Coleman 2001). Veterinarian experts recommend the use of prophylactic drugs *ex-ante* AAT infection applied as block treatments which provide protection against AAT of up to three months (Geerts and Holmes 1998). Against experts' recommendation most farmers apply curative drugs *ex-post* AAT infection on animals they believe are sick with AAT, which leads to frequent cases of misuse (Grace et al. 2009). Such a misuse of drugs has led to the widespread resistance of AAT pathogens to drugs (Clausen et al. 2010). A drug-resistant AAT infection can be treated by a sanative pair that involves one of the drug pairs in which resistance has not developed (Whiteside 1962; Geerts and Holmes 1998; Chitanga et al. 2011). Farmers however, rarely apply sanative pairs (Grace et al. 2009).

In this paper, we seek to examine why farmers' take-up of prophylactic drugs as an *ex-ante* risk management strategy to protect animals from falling sick with AAT against experts' recommendation is low. We hypothesize that risk and time preferences, especially the role of behavioral information beyond standard economic theory such as non-linear probability weighting, loss aversion or present bias, are important factors affecting farmers' AAT management decisions. Investigating farmers' actual AAT management decisions might hinge on individual circumstances such as exposure to AAT and resistance, wealth in terms of income or assets, in particular cattle herd size, or farming experience – factors that make it difficult to assess farmers' AAT management choices. We therefore, develop a dynamic field experiment where we are able to observe farmers' AAT management choices under controlled conditions. Across three hypothetical cattle farming seasons, farmers are exposed to the same level of risk of AAT and resistance, they dispose of the same budget constraint available exclusively for curative, prophylactic or sanative drug treatments and they are exposed to the same basis risk that every treatment applied can also fail.

Our main findings are that, on average, West African cattle farmers value therapeutic treatments *ex-post* sensitive and resistant AAT infections over prophylactic treatments *ex-ante* AAT infections. Results suggest that the low take-up of prophylactic treatments is related to loss aversion and impatience. Farmers that place a higher value on losses, i.e., on AAT infected animals, than on gains, i.e., healthy animals, are more likely to apply *ex-post* curative or sanative treatments in order to recover the sick animal. Also, farmers with higher discount rates prefer short-term benefits from *ex-post* therapeutic treatments over long-term benefits from *ex-ante* prophylactic treatments. As a consequence, loss averse and impatient farmers' chances of higher and sustainable returns are forgone and increase the risk of perpetual poverty. The results confirm the findings from the few other experimental studies from China (Liu 2013) and India (Tarozzi and Mahajan 2011), where loss aversion and present biasedness were associated with low adoption rates of a new technology, respectively.

In the next section, we describe the data and experimental design, which is followed by a discussion of the main findings. Finally, in section four, we draw conclusions and policy recommendations.

2 Data

The data used in our study come from two waves of socio-economic household surveys conducted in 2007 and 2011 and economic field experiments conducted in 2011. The first household survey was conducted in 2007 as part of a multi-disciplinary research project led by the International Livestock Research Institute (ILRI) to ensure the future efficacy of trypanocidal drugs as one component of integrated AAT control. The study villages had been selected during previous research activities (Affognon 2007). In the selected villages, we sampled our target population, i.e., cattle farmers, by including all households that possessed at least one bovine animal. The sample included 508 heads of small-scale cattle farm households. The household heads reported demographic information and detailed economic data on cattle herd production to improve our understanding how they manage AAT and drug resistance (Liebenehm, Affognon and Waibel 2011a; 2011b). Simultaneously, epidemiologists assessed the prevalence of AAT and identified specific "hot spots" of drug resistance (Clausen et al. 2010).

In 2011, we re-visited the study site and conducted a socio-economic survey of a random sub-sample of 211 farmers out of 508 farmers originally sampled. We collected the same socio-economic information as in 2007 and conducted economic field experiments to improve our understanding of farmers' decision-making behaviors. Before describing the economic field experiments, we present summary statistics of our sample in what follows.

2.1 Descriptive statistics

The socio-economic characteristics presented in Table 1show that the sample is fairly distributed across the two countries of Mali and Burkina Faso; 107 households were from the circle around Sikasso in southeastern Mali and 104 households were from the province of Kénédougou in southwestern Burkina Faso. The average household head was approximately 56 years old and had spent as much time in a formal school as in a Koranic school, i.e. one year. The household sizes were generally large, because of polygamy and multiple generations living together. On average 24 members belonged to one household, where the ratio of dependent to non-dependent members was almost fair. Common to the context of West Africa, smallholder pastoralist households cannot afford to send all children to school. However, on average 6 out of 11 children were enrolled. Each household possessed approximately eight means of transports such as carts, bicycles or motorbikes.

With respect to the characteristics of cattle production, we can see that approximately 5% of households had no more cattle in 2011. However, those farmers who bred cattle in 2011 kept on average 21 animals, approximately one animal more than one year before. Experience in cattle keeping was reported to be high, on average 22 years. Approximately, 37% of households employed an external herdsman that was not considered a household member. The average annual income from selling bovine produce was US$3771 ($PPP).

Following subjective probability judgments on AAT shows that farmers assumed that the probability that their animals would be infected with AAT was approximately 30%; the joint probability of a sensitive infection was 16.87%, and the joint probability of a resistant infection was 12.51%[1].

From the socio-economic survey in 2007, we know that 55% of farmers perceived AAT as the major disease in their cattle herds. Approximately 72% reported at least one AAT case. On average, 5 animals per herd were infected with AAT, however, case fatality was low. In addition, every second farmer treated his animals without veterinary support. 74% of farmers administered curative drugs ex-post AAT infection upon the emergence of disease symptoms as the major treatment strategy, whereas approximately 10% applied prophylactic drugs ex-ante AAT infection. Although prophylactic treatment is relatively low, the reported treatment failure rate is almost 10% higher than the curative treatment failure rate. One explanation for this result might be that prophylactic treatment strategies involve frequent drug application at fixed intervals, which increases the potential for misuse. Furthermore, 45% of farmers kept trypanotolerant cattle breeds, such as N'Dama or Baoulé, that possess a significant degree of natural resistance to AAT. Approximately, half of the sample participated in a veterinarian extension program. However, farmers' average performance in a knowledge, attitude and practice (KAP) survey towards AAT was low.

With respect to village level characteristics, 64% of the farmers resided in villages in which AAT is prevalent and 74% resided in villages where resistance to drug treatment was evident.

[1] Subjective probability judgments on AAT had been inferred using the visual impact method (Hardaker et al. 2004; Witt, Pemsl and Waibel 2010), which is one approach to obtain joint probability distributions by asking the farmer about his probability judgment of uncertain events, taking into account stochastic dependencies. To visualize subjective probability judgements, farmers were asked to allocate counters to different uncertain events that were illustrated on picture cards, e.g., the probability that cattle are infected with trypanosomosis.

Table 1 Descriptive statistics of sampled households

Variable	Description	Mean	SD	Source
Socio-economic characteristics				
Burkinabé	Dummy = 1 if Burkinabe, 0 otherwise	0.493	0.501	
Age	Age in years	55.725	14.172	
Education	Years of formal schooling completed	1.095	2.473	
Religion	Years of Koranic school completed	1.052	2.807	
Household size	Number of household members	24.033	16.77	
Dependency ratio	Ratio of dependent household members (below 15 and over 60) to non-dependent household members	0.468	0.393	
Children in school	Number of children in school	5.972	4.971	
Means of transport	Number of transports owned	7.763	5.398	
Characteristics of cattle production				Socio-economic survey 2011
Cattle keeper	Dummy = 1 if breeding cattle, 0 otherwise	0.957	0.203	
Experience in cattle keeping	Years of breeding cattle	21.593	17.656	
Herd size	Number of cattle owned	20.673	36.027	
L1 Herd size	Number of cattle 12 months before	19.239	33.82	
External herdsman	Dummy = 1 if herdsman is no household member, 0 otherwise	0.374	0.485	
Income	Income derived from the sale of animal byproducts such as milk, manure, and traction, in $PPP	3771.001	782.812	
Subjective probabilities of AAT				
Subjective probability of AAT infection	Stated probability that animals would be infected with ATT	29.23	10.827	
Subjective probability of AAT sensitive infection	Stated probability that animals would be infected with drug-sensitive trypanosomes	16.865	7.945	
Subjective probability of AAT resistant infection	Stated probability that animals would be infected with drug-resistant trypanosomes	12.505	6.192	

Variable	Description	Mean	SD	Source
Characteristics of AAT and its management				
AAT perception	Dummy = 1 if AAT is perceived as major cattle disease	0.545	0.499	
AAT report	Dummy = 1 if AAT is reported	0.716	0.452	
AAT infected cattle	Number of cattle infected with AAT	4.733	5.714	
AAT case fatality	Number of cattle died from AAT	0.76	1.816	
Self-administration of drugs	Dummy = 1 if drugs are administered by farmers themselves	0.521	0.502	Socio-economic survey 2007
Administration of curative drugs	Dummy = 1 if curative drugs are administered *ex post* AAT infection as major treatment strategy	0.735	0.443	
Administration of prophylactic drugs	Dummy = 1 if prophylactic drugs is administered *ex ante* AAT infection as major treatment strategy	0.104	0.306	
Curative treatment failure	Dummy = 1 if failure after curative treatment *ex post* AAT infection	0.181	0.386	
Prophylactic treatment failure	Dummy = 1 if failure after prophylactic treatment *ex ante* AAT infection	0.265	0.444	
Trypanotolerant	Dummy = 1 if breeding indigenous cattle that tolerate AAT	0.45	0.499	
Extension	Dummy = 1 if participated in veterinarian extension program	0.512	0.501	
Performance	Percentage points achieved in knowledge, attitude, practices (KAP) survey	0.197	0.058	
Village characteristics				
Disease prevalence	Dummy = 1 if AAT is prevalent in the village (i.e., if 10% of the randomly sampled cattle in the village were sick with AAT), 0 otherwise	0.641	0.481	Epidemiological survey 2002 - 2007
Resistance	Dummy = 1 if drug resistant is prevalent in the village (i.e., if drug treatment failure rate is above 25%), 0 otherwise	0.737	0.442	
N		211		

2.2 Economic field experiments

We conducted two kinds of economic field experiments: (i) to elicit farmers' risk and time preferences and (ii) to assess farmers' adoption of alternative AAT drug treatments. All experiments were played with real money to assure that participants show their true preferences (Andersen et al. 2006). The design of the experiments and the experimental procedures are described in the following subsections.

2.2.1 Risk and time preference experiment

The design of the risk and time experiments followed Tanaka et al. (2010), calibrated to the local conditions in Mali and Burkina Faso. In an earlier paper, we have estimated five risk and time preference parameters using a discounted utility model (Liebenehm and Waibel 2014). Table 2 presents the average parameter estimates of the underlying sample. We found that the average farmer was likely to be inaccurate in the assessment of probability information and tended to overweight unlikely but desirable events and to underweight likely but undesirable events ($\alpha < 1$). Furthermore, the results suggested that the average farmer was risk averse towards gains ($\sigma <$ 1) and towards losses ($\lambda > 1$) and was patient as indicated by a low discount rate (δ) and a small present bias ($\beta < 1$). These five parameter estimates will serve as the main covariates that are expected to help us to explain farmers' adoption of alternative AAT drug treatments.

Table 2: Overview of estimated risk and time preference parameters

Preference parameters	**Description**	**Mean**	**SD**
Probability weighting (α)	Degree of departure from linear assessment of probabilities	0.133	0.022
Risk aversion (σ)	Degree of concavity of the value function for gains and losses	0.112	0.006
Loss aversion (λ)	Degree of perception of losses as compared to gains	1.351	0.262
Discount rate (δ)	Degree of future discrimination	0.001	0.0001
Present bias (β)	Degree of preference for the present	0.942	0.028
N		211	

Source: Liebenehm and Waibel (2014).

2.2.2 AAT treatment adoption experiment

The treatment adoption experiment was designed as a decision problem of AAT management and aimed to assess farmers' adoption of alternative drug regimes against AAT. The farmer was asked to manage a hypothetical cattle herd at risk of AAT and drug resistance across three farming seasons. The hypothetical herd was determined by a random draw of ten animals, each could be in one of the three following health states: (i) 50% chance that an animal will be healthy and able to produce a value of FCFA1000, (ii) 35% chance that an animal will be infected with a sensitive AAT infection and able to produce FCFA500, and (iii) 15% chance that an animal will be infected with a resistant infection and able to produce FCFA250.

After the random draw of the hypothetical cattle herd and the determination of its total production value, 10% of the production value could be invested in AAT management[2]. The farmer had four treatment options to manage AAT: (a) simply doing nothing, (b) apply curative treatment to drug-sensitive infected animals, (c) apply prophylactic treatment to healthy animals or (d) apply a sanative pair to drug-resistant infected animals. The farmer was asked to choose which animals in his hypothetical cattle herd he likes to treat with which treatment option. We used the Becker-DeGroot-Marschak mechanism (BDM) for eliciting farmers' willingness to pay (WTP) for a chosen strategy (Becker, DeGroot and Marschak 1964). Following the BDM, a farmer reported a bid for a chosen treatment option; the price of the treatment was then randomly drawn from a uniform distribution of prices. If farmer's bid was above the price, the farmer applied the treatment to an animal in his hypothetical cattle herd and paid the drawn price. If the bid was below the price, no treatment was applied and the farmer paid nothing[3]. This mechanism induces a farmer to state his "true" willingness-to-pay (Horowitz 2006). Given the budget constraint, the farmer could choose different options for several animals.

After the identification of treatment application, every treatment outcome was associated with a good, a medium or a bad outcome at probability of 50%, 35% and 15%, respectively. Plotting the cumulative distribution functions of the four alternative treatment options in Figure 1 shows that sanative treatment against drug-resistant AAT infections is the dominant strategy, followed by

[2] It was explained that 90% of the production value need to be spent for other necessary expenses for the family, like food, transport to school, etc.

[3] The randomly drawn price was determined by a roll of a 10-sided-dice, whereby 1 indicates a price of FCFA100 and 10 indicates a price of FCFA1,000.

prophylactic treatment *ex-ante* AAT infection, curative treatment against drug-sensitive AAT infections and finally, no treatment[4]. At the end of each round, all farmers received an additional healthy animal that was added to the hypothetical herd to account for natural reproduction.

The experiment was developed in cooperation with veterinary epidemiologists, technicians and agro-economists. We are therefore confident that the experiment represents a valid instrument to observe and assess farmers' adoption decision of alternative drug treatments against AAT in a controlled environment.

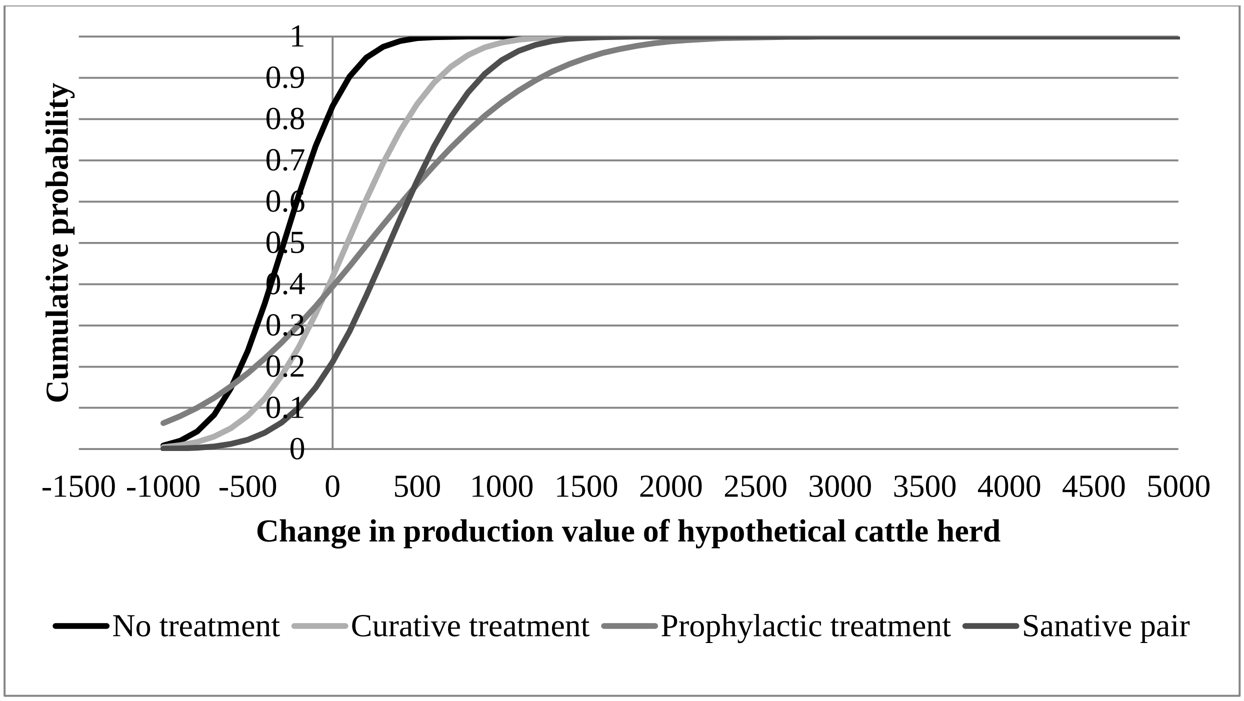

Figure 1: Cumulative distribution functions of AAT treatment options

Source: Own illustration.

2.2.3 Experimental procedures

According to our survey plan, we conducted interviews and experiments with cattle farmers in one village per day. Usually in the evenings we visited the village scheduled for the next day to

[4] The first-order (FOSD) and second-order (SOSD) stochastic dominance properties of the treatment options are: Sanative pair $>_{FOSD}$ curative treatment $>_{FOSD}$ no treatment; and sanative pair $>_{SOSD}$ prophylactic treatment $>_{SOSD}$ curative treatment $>_{SOSD}$ no treatment.

meet the village head and to explain our activities. The village head then announced the household heads on our randomly drawn list of cattle-dependent small-scale farm households to be present for interview in the following day. Experienced enumerators that were working as veterinarian assistants in the region and participated in previous research activities led by ILRI were well respected and trusted by farmers. Every farmer was told that he will earn FCFA1,000 for participating in a survey and that he could add or lose money in experiments. The maximum amount that could have been lost was FCFA1,000.

In terms of sequential setup, farmers first completed the socio-economic survey, then a series of risk games, followed by the AAT treatment adoption experiment and finally, participated in a series of time games. Each game represented a new game, because payoffs were determined and paid or deducted before continuing with the next game (except for the time game, where a trusted agent kept the money until delivery). Although farmers' performance in one game might be affected by payments from previous games, which we control for in the analyses, we argue that farmers perceive payments as earned income, rather than easily-gotten house money (Cardenas et al. 2014).

Against the background of farmers' low levels of education (Table 1), probabilities associated in the risk experiment and in the adoption experiment were visualized with picture cards.
On average, farmers earned FCFA3,045 (excluding money earned from the time game) during one day, which corresponds approximately to three to four days of income for a pastoralist household in the study area.

3 Results

We use farmers' AAT management choices observed across three hypothetical farming seasons as our dependent variable. In particular, the BDM-mechanism that induces farmers to state their "true" WTP enables us to observe farmers' actual treatment applications. Based on Figure 1, we could specify a farmer's AAT treatment application as a categorical variable that is ordered by means of first- and second-order stochastic dominance properties as 1 = application of no treatment, 2 = application of curative treatment, 3 = application of prophylactic treatment and 4 = application of sanative pair. We however, find that the parallel regression assumption is violated and therefore, specify farmers' choice as a nominal outcome variable estimated by a multinomial logistic regression model (Long and Freese 2014). The multinomial logistic regression model can simultaneously estimate binary logits for all comparisons among the alternative outcomes.

Table 3 shows only the odds ratios for comparisons among all pairs of outcomes for the most interesting explanatory variables, namely the five estimated behavioral parameters of risk and time. We find significant odds ratios on the probability weighting parameter (α), on the risk aversion parameter (σ), on the loss aversion parameter (λ) and on the discount rate (δ).

The larger the parameter α is, the better the assessment of probability information. For a unit increase in α, the odds of applying no treatment relative to curative treatment and no treatment relative to sanative treatment are 1.7 and 1.5 times higher, respectively.

The degree of risk aversion is decreasing with an increase in the parameter σ. Therefore, the odds ratios of 9.3 and 8.8 indicate that decreasing risk aversion is associated with an increasing likelihood of applying curative treatment relative to prophylactic treatment and relative to sanative treatment, respectively.

The degree of loss aversion is increasing with an increase in the parameter λ. Increasing loss aversion is, hence, correlated with a higher probability of curative treatment relative to no treatment and sanative treatment relative to no treatment.

A larger δ indicates larger discount rates and hence larger impatience. The significant odds ratios of δ suggest that increasing impatience is associated with an increasing likelihood of applying no treatment, curative treatment or sanative treatment relative to prophylactic treatment.

The results imply that a farmer, who performs better in the assessment of probability information, prefers to do nothing than to invest in curative or sanative treatment, probably in order to save money for the next round. Furthermore, a less risk averse farmer is more likely to apply curative treatment relative to prophylactic and sanative treatment. Following from the investigation of first and second order stochastic dominance (Figure 1), a less risk averse farmer is more likely to apply a more risky treatment, i.e., curative treatment, with larger standard variation. This result is in accordance to the findings from experimental studies that show correlation between risk taking behavior and adoption of risky (new) agricultural technologies (Simtowe et al. 2006; Liu 2013; Brick and Visser 2015).

Table 3: Multinomial logistic regression model of AAT treatment application

Odds ratios for					
Comparison	Probability weighting (α)	Risk aversion (σ)	Loss aversion (λ)	Discount rate (δ)	Present bias (β)
No treatment vs. Curative	1.731***	0.374	0.025***	1.027	0.816
No treatment vs. Prophylactic	1.134	3.470	0.205	1.579***	0.668
No treatment vs. Sanative	1.448*	3.322	0.06**	0.943	1.604
Curative vs. Prophylactic	0.655	9.267*	8.126	1.538**	0.819
Curative vs. Sanative	0.836	8.872**	2.377	0.918	1.966
Prophylactic vs. Sanative	1.277	0.957	0.293	0.597**	2.4
N	462				
n	154				
Pseudo R^2	0.1619				
Wald Chi^2	260.21***				

Notes: The dependent variable is a categorical variable, where 1 = No treatment, 2 = Curative treatment, 3 = Prophylactic treatment and 4 = Sanative pair. The model also includes game effects and socio-economic variables. The full model can be found in the Appendix Table A1. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Own survey.

Also, the larger the loss aversion of a farmer, the larger is the likelihood that he applies curative or sanative treatment relative to no treatment. That means a farmer who is more loss averse more likely invests in *ex-post* treatments of animals with both drug-sensitive and drug-resistant infections in order to take the chance to avert the loss of the sick animal compared to a less loss averse farmer. This finding is consistent with the finding of Liu (2013), who shows that loss aversion is correlated with low adoption rates of a new technology.

Similarly, the significant odds ratios for the discount rate on prophylactic treatment versus all other treatment options imply that a more patient farmer is more likely to apply treatment *ex-ante* AAT infection than *ex-post* AAT infection. That means a more patient farmer values long-term benefits of AAT prevention higher than an impatient farmer. Comparing this result with Tarozzi and Mahajan (2011) shows a similarity: As Indian farmers with larger present bias are less likely to adopt a prophylactic strategy to prevent malaria, our West African farmers with larger discount rates are less likely to adopt prophylaxis against AAT.

The results on the loss aversion parameter and the discount rate imply that loss aversion and impatience are associated with a willingness to invest in sick animals with curative and sanative treatments.

As a first kind of robustness check, we investigate if the results hold, when we exclude the no treatment option. Only three farmers chose the option not to treat. That means the application of the no treatment option was not planned by 98.6% of farmers, but resulted in application whenever farmers' WTP was lower than the random price. The exclusion of no treatment application reduces the sample to 117 observations. The dependent variable in Table 4 is therefore, a categorical variable, where 1 = application of curative treatment, 2 = application of prophylactic treatment and 3 = application of sanative pair.

Table 4: Multinomial logistic regression model of AAT treatment application excluding no treatment option

Odds ratios for					
Comparison	Probability weighting (α)	Risk aversion (σ)	Loss aversion (λ)	Discount rate (δ)	Present bias (β)
Curative vs. Prophylactic	0.346**	9.876	147.602**	1.928***	0.296
Curative vs. Sanative	0.885	12.793*	1.668	1.018	1.401
Prophylactic vs. Sanative	2.555	1.295	0.011**	0.528**	4.74
N	351				
n	117				
Pseudo R^2	0.2533				
Wald Chi^2	101.33***				

Notes: The dependent variable is a categorical variable, where 1 = Curative treatment, 2 = Prophylactic treatment and 3 = Sanative pair. The model controls for the same covariates as the model in Table 3. The full model can be found in the Appendix Table A2. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Own survey.

Comparing the results from Table 4 with the previous model in Table 3, we find similarities that support the implications from the previous model. For example, Table 4 shows the same significant relations on the risk aversion parameter (σ) and on the discount rate (δ) as in the previous model. Smaller risk aversion is associated with a larger probability of applying the more risky option of curative treatment than the less risky option of sanative treatment. Smaller discount rates are related to a larger probability of applying prophylactic treatment *ex-ante* AAT infection than curative or sanative treatment *ex-post* AAT infection.

Furthermore, the larger the loss aversion (λ) of a farmer, the larger is the likelihood that he applies curative or sanative treatment *ex-post* AAT infection relative to prophylactic treatment *ex-ante* AAT infection. While in the previous model (Table 3), larger loss aversion was associated with the likelihood of applying both *ex-post* treatments instead of no treatment, the exclusion of the no treatment option in Table 4 leads to the preference of *ex-post* over *ex-ante* treatment. That means that a farmer in a loss situation prefers to invest in a sick animal in order to take the chance to cure the infection and avert the loss of an important asset than to invest in a healthy animal, whereby an infection and hence, a loss of asset could have been prevented.

Hence, the findings on the two behavioral parameters, i.e., the loss aversion parameter and the discount rate, support the implication drawn from the previous model: a cattle farmer, who is loss averse and impatient is more willing to invest in sick animals *ex-post* AAT infection than in healthy animals *ex-ante* AAT infection. One possible explanation for this result is farmers' tendency to smooth major assets at risk of loss. It has been often observed that in the advent of a negative shock, such as AAT infection in cattle, valuable assets are not sold, but consumption is sacrificed to smooth assets (Fafchamps, Udry and Czukas 1998; Hoogeveen 2002; Kazianga and Udry 2006). In particular, our result corresponds to the study by Lybbert and McPeak (2012) who find that risk aversion and impatience of Kenyan pastoralists are related to asset smoothing.

Finally, we investigate the robustness of this result when reducing the outcome variable to a binary comparison between *ex-post* versus *ex-ante* treatment application. Therefore, we regress a binary outcome variable that equals one if *ex-post* AAT treatment was applied (i.e., either curative or sanative treatment), 0 if *ex-ante* prophylactic AAT treatment was applied, on the same set of covariates as in the previous models.

Table 5: Logistic regression model of ex-post versus ex-ante AAT treatment application

Ex-post versus ex-ante AAT treatment application		
	Odds ratio	**Robust standard error**
Preference parameters		
Probability weighting (α)	0.453*	0.216
Risk aversion (σ)	17.637*	16.321
Loss aversion (λ)	118.509**	151.193
Discount rate (δ)	1.825**	0.363
Present bias (β)	0.118	0.188
N	351	
n	117	
Pseudo R²	0.2931	
Wald Chi²	44.6***	

Notes: Dependent variable is a binary variable, where 1 = Curative or Sanative treatment, 0 = Prophylactic treatment The model controls for the same covariates as the models in Table 3 and in Table 4. The full model can be found in the Appendix Table A3. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Own survey.

Table 5 shows significant odds ratios on the loss aversion parameter (λ) and the discount rate (δ) at the 5% and 1% level, respectively. For a unit increase in loss aversion, the odds of applying *ex-post* treatment relative to *ex-ante* treatment increases by a factor of 119, holding all other covariates constant. Similarly, but alleviated, the factor change in odds of applying *ex-post* treatment for a unit increase in the discount rate is 1.8. Hence, in accordance to the two models before, a cattle farmer's willingness to invest in sick animals *ex-post* AAT infection is consistent with high levels of loss aversion and impatience. In other words, the take-up of prophylactic treatment *ex-ante* AAT infection is low because farmers value losses (of sick animals) larger than gains (healthy animals) and short-term benefits of *ex-post* treatment over long-term benefits of *ex-ante* treatment.

4 Summary and conclusion

The objective of this paper has been to improve our understanding why farmers' take-up of prophylactic drugs as an *ex-ante* risk management strategy to protect animals from falling sick with AAT as recommended practice is low. We focused on the role of intrinsic behavioral characteristics such as risk and time preferences as likely explanations. We therefore, developed a dynamic field experiment in cooperation with veterinary epidemiologists, technicians and agro-economists where we were able to observe farmers' AAT management choices over time in a controlled environment.

The analysis showed that farmers generally value *ex post* treatment strategies such as curative treatments and sanative pairs over recommended *ex ante* prophylactic treatments, whereby a higher expected value is forgone for the sake of a lower variance. This result suggests that farmers distinguish between the shock of AAT, i.e., cattle are already infected with AAT, and the risk of AAT, i.e. cattle are not yet infected with AAT but might get infected.

Investigating correlations between farmers' AAT management choices and intrinsic behavioral characteristics across different model specifications revealed two important preference parameters, namely loss aversion and impatience as likely drivers of farmers' preference for *ex-post* AAT treatment. Hence, adoption of AAT prophylaxis despite veterinarian experts' recommendation is low because farmers value losses of animals that are infected with AAT larger than gains from healthy animals and short-term benefits over long-term benefits. This finding confirms results from experimental studies conducted in China (Liu 2013) and India (Tarozzi and Mahajan 2011), where low adoption rates of new technologies were related to loss aversion and present biasedness, respectively.

Our result that loss aversion and high discount rates are associated to low adoption rates of AAT prophylaxis is also related to the literature on asset smoothing (Fafchamps et al. 1998; Hoogeveen 2002; Kazianga and Udry 2006). In the advent of a negative event, such as cattle contract AAT, a loss averse and impatient farmer is more likely to sacrifice consumption needs and invest in the treatment of his sick animal in order to save the valuable asset from loss. In that way, our result is also in line with the finding of Lybbert and McPeak (2012) that risk averse and impatient Kenyan livestock keepers are more willing to smooth assets.

Consequently, a loss averse and impatient farmer that practices *ex-post* AAT treatments, probably in order to smooth assets, forgives chances of higher and sustainable returns, further deteriorates his options and finally, increases the likelihood of being trapped in poverty.

Our results have implications for the operation of extension and veterinary services that can set incentives to optimize current treatment against AAT and drug resistance. If farmers choose curative treatments in order to safe infected animals from death, but neglect the benefit of prophylactic treatments in the long-run, then distribution and marketing of veterinarian treatments need to consider farmers' valuation of risks and time. In addition, extension services such as livestock farmer field schools can use the valuation information to convey the message that prophylactic measures can reduce the risk of AAT infection in the first place, and in less likely cases were prophylactic measures are not effective, curative treatments can be applied as a follow-up measure.

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Appendix

Table A1. Multinomial logistic regression model of AAT treatment application

	AAT treatment application		
	Curative treatment	**Prophylactic treatment**	**Sanative pair**
Preference parameters			
Probability weighting (α)	-0.549***	-0.126	-0.37*
Risk aversion (σ)	0.982	-1.244	-1.2
Loss aversion (λ)	3.682***	1.587	2.816**
Discount rate (δ)	-0.026	-0.457***	0.059
Present bias (β)	0.203	0.403	-0.473
Game effects			
Round			
Second round	-1.07*	-0.065	0.554
Third round	-2.322**	0.753	1.9**
Production risk	-0.001***	-0.0006	-0.0002
Basis risk	0.73***	1.34***	-0.698*
Budget	0.002**	0.0001	-0.001**
Payoff	0.006***	0.01***	0.005***
Socio-economic characteristics			
Experience in cattle keeping	-0.003	0.011	0.01
Performance	6.471**	-7.333*	11.535***
Subjective probability of AAT infection	0.007	0.004	0.018
Self-administration of drugs	-0.581**	-0.446	-0.773**
Curative drug expenditures / prophylactic drug expenditures	0.045**	-0.408*	0.037*
Average village income	-0.002	-0.005	0.0007
Rewards from previous games			
Risk game I	-0.00003	0.0004	0.00003
Risk game II	-0.00007	-0.0001	0.0001
Constant	-11.964*	7.886	-9.784
N	462	n	154
Wald Chi²	260.21***	Pseudo R²	0.1619

Notes: The dependent variable is a categorical variable, where 1 = No treatment (base outcome), 2 = Curative treatment, 3 = Prophylactic treatment and 4 = Sanative pair. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Own survey.

Table A2. Multinomial logistic regression model of AAT treatment application excluding no treatment option

	AAT treatment application	
	Prophylactic treatment	**Sanative pair**
Preference parameters		
Probability weighting (α)	1.061**	0.123
Risk aversion (σ)	-2.29	-2.549*
Loss aversion (λ)	-4.995**	-0.511
Discount rate (δ)	-0.657***	-0.018
Present bias (β)	1.219	-0.337
Game effects		
Round		
Second round	2.141**	1.87**
Third round	4.633***	4.549***
Production risk	0.0004	0.0005*
Basis risk	1.043*	-1.507***
Budget	-0.003***	-0.003***
Payoff	0.005***	-0.001
Socio-economic characteristics		
Experience in cattle keeping	0.006	0.005
Performance	-22.523***	5.082
Subjective probability of AAT infection	0.021	0.021
Self-administration of drugs	0.526	-0.148
Curative drug expenditures / prophylactic drug expenditures	-0.564	-0.026
Average village income	-0.011***	-0.001
Rewards from previous games		
Risk game I	0.0004	0.0001
Risk game II	0.0000009	0.0001
Constant	31.891**	1.277
N 351	n 117	
Wald Chi² 101.33***	Pseudo R^2 0.2533	

Notes: The dependent variable is a categorical variable, where 1 = Curative treatment (base outcome), 2 = Prophylactic treatment and 3 = Sanative pair. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Own survey.

Table A3. Logistic regression model of *ex-post* versus *ex-ante* AAT treatment application

	Ex-post versus ex-ante AAT treatment application
Preference parameters	
Probability weighting (α)	-0.791*
Risk aversion (σ)	2.87*
Loss aversion (λ)	4.775**
Discount rate (δ)	0.601***
Present bias (β)	-2.138
Game effects	
Round	
Second round	-1.309
Third round	-2.514**
Production risk	-0.0003
Basis risk	-1.687***
Budget	0.001
Payoff	-0.005***
Socio-economic characteristics	
Experience in cattle keeping	-0.007
Performance	21.16***
Subjective probability of AAT infection	0.009
Self-administration of drugs	-0.539
Curative drug expenditures / prophylactic drug expenditures	0.442
Average village income	0.007**
Rewards from previous games	
Risk game I	-0.0003
Risk game II	0. 00002
Constant	-18.645*
N 351	n 117
Wald Chi² 44.6***	Pseudo R^2 0.2931

Notes: Dependent variable is a binary variable, where 1 = Curative or Sanative treatment, 0 = Prophylactic treatment. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Own survey.