RISK AND TIME PREFERENCES OF WEST AFRICAN CATTLE FARMERS

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Abstract

This study investigates risk and time preferences of small-scale cattle farmers in West Africa and examines how demographic and socio-economic characteristics are related to these preferences. Using a maximum likelihood approach we jointly estimate risk and time preferences. Our findings show that, overall the West African cattle farmer shows poor performance in using probability information and is generally risk averse. The average cattle farmers' time preferences indicate a higher degree of patience than expected. We also find that income, education, and religion are highly correlated with risk and time preferences.

Keywords

Experiments, prospect theory, risk preference, time preference, West Africa

1 Introduction

Risk and time preference are important factors in understanding investment decisions of poor households. Literature suggests that poor households in developing countries are reluctant to make investments in new technologies because of risk aversion and high levels of impatience (YESUF AND BLUFFSTONE 2009; TANAKA, CAMERER, AND NGUYEN 2010). To date however only limited field research was carried out that accurately measures both time and risk preference simultaneously. Our work builds on the laboratory and field experiments that help measure risk and time preferences which had mostly been conducted in Asia. The contribution of this article is to extend existing field research to Africa by investigating one of the most vulnerable groups of African rural population, namely cattle farmer in West Africa.

West African cattle farmers are exposed to a myriad of adverse events, such as the risk of drought due to the proximity of the Sahara desert, the risk of flood from the Niger river, or the risk of pests and diseases such as African animal trypanosomosis (AAT). In addition, they live in countries where markets and government policies largely fail to protect farmers from such risks.

The objectives of this article are to simultaneously assess risk and time preference of small-scale cattle farmers in West Africa and to examine how demographic and socio-economic characteristics are related to these preferences. Additionally, given the dearth of literature on time and risk preferences in developing countries, we compare our findings to one of the few comparable studies based in Asia such as TANAKA, CAMERER AND NGUYEN (2010) and NGUYEN (2011).
Our data set is a combination of economic field experiments conducted in 2011 along with a household panel survey from 2007 and 2011. The experiments yield information on cattle farmers' risk and time preference whilst the panel data allows us to analyze the correlation between these preferences and demographic and socio-economic characteristics.

To identify the preferences of cattle farmers we apply a discounted utility model. Such model allows us to explain the dynamic decision making behavior of cattle farmers under uncertainty. A farmer's utility function is derived using prospect theory (KAHNEMAN AND TVERSKY 1979; TVERSKY AND KAHNEMAN 1992) in order to capture risk in gain and loss situations, and the respondents' weighting of probabilities. We then use a quasi-hyperbolic discounting function to estimate the present value of future utility streams. We simultaneously estimate the parameters of the discounted utility model using the maximum likelihood technique as suggested by NGUYEN (2011).

Our main findings are that: (1) the average farmer shows poor performance in using probability information and is generally risk averse; (2) the average cattle farmer is more patient and less present-biased than previous research would suggest. Time and risk preferences are mainly influenced by the following variables: (i) cattle farmers with higher income and (ii) more children in school are more willing to take risks and are more patient; (iii) we also find a link between religious behavior and risk aversion, i.e. spending more time in a Koran school increases the tendency to overweigh small probabilities, to lower risk aversion in gains and losses and to a higher level of patience.
Comparing our results with the studies in Asia (e.g. TANAKA, CAMERER, AND NGUYEN 2010; LIU FORTHCOMING) we find similarities and differences. Corresponding with the results in Asia is that wealthier farmers are less averse to losses and are more patient. Also the finding that religious belief seems to absorb the "angst" associated with risk is in accordance with the findings among cotton farmers in China. On the other hand, it seems that education in West Africa makes people to be more open towards taking up risky opportunities, while in Asia education may have the effect that people become more considerate in their choices.

In the next section we describe the conceptual framework and section three presents the methodology. Data collection and the design of the field experiments are outlined in section four and the main findings are discussed in section five. Finally, in section six we draw our conclusions including some suggestions for rural development policy.

2 Conceptual framework

In this study we follow the approach first introduced by ANDERSEN ET AL. (2008) to incorporate risk and time preferences into a single framework. Several studies (NGUYEN 2011; HARRISON, LAU, AND RUTSTRÖM 2011; COLLER, HARRISON, AND RUTSTRÖM 2012) have applied and further advanced this idea.

Our study applies a discounted utility model to estimate the present value of utility streams. Following NGUYEN (2011), we modify the utility function using prospect theory and adjust the discounting function using quasi-hyperbolic discounting defined by LAIBSON (1997) and O'DONOGHUE AND RABIN (1999). We assume that our agents (i.e. cattle farmers in West Africa) behave in accordance with the assumptions underlying cumulative prospect theory (TVERSKY AND KAHNEMAN 1992).

Farmer's utility under cumulative prospect theory is then defined as:

$$V(x,p;y,1-p)=\begin{cases} v(y)+w(p)((v(x)-v(y)), & x>y>0 \quad or\, x<y<0 \\ w(p)v(x)+w(1-p)(v(y), & x<0<y \end{cases} \tag{1}$$

where: *V(x,p;y,1-p)* is the expected value over binary prospects (*x;y*) with corresponding probabilities (*p;1-p*).
Further, a two-part power function assigns a value for gains (*x>0*) and losses (*x<0*) separately:

$$v(x)=\begin{cases} x^{\sigma}, & if \quad x\geq 0 \\ -\lambda(-x)^{\sigma}, & if \quad x<0 \end{cases}. \tag{2}$$

The parameter σ determines the concavity of the value function for gains and losses and can be interpreted as a proxy for risk aversion[1]. The parameter λ reflects the degree of loss aversion. It is hypothesized that *v(x)* is s-shaped, i.e. concave above the reference point, convex below the reference point, and also steeper for losses than for gains (TVERSKY AND KAHNEMAN 1992).

The probability weighting function is:

$$w(p)=\frac{1}{\exp(\ln(1/p))^{\alpha}} \quad , \tag{3}$$

where α presents a proxy for probability weighting (PRELEC 1998). It is hypothesized that *w(p)* is an inverted s-shaped, i.e. a subject will overweight small probabilities and underweight large probabilities. The above specification of a utility model under prospect theory nests the expected utility model. That is, the standard expected utility specification is obtained if $\alpha=1$ and $\lambda=1$.

Following LAIBSON (1997) and O'DONOGHUE AND RABIN (1999), we apply the quasi-hyperbolic specification, where the future reward is associated with a cost that is proportional to the amount of that reward. This specification expands exponential discounting in a way that it is adequate to reproduce the reversal of preferences (BENHABIB, BISIN, AND SCHOTTER 2010). Then, the discount factor is defined for the present ($t=0$) and for the delayed rewards ($t>0$) as:

$$D(\beta,\delta,t)=\begin{cases} 1, & if\ t=0 \\ \beta\exp(-\delta t), & if\ t>0 \end{cases}, \tag{4}$$

where β is the parameter reflecting present biasedness and δ represents the parameter for time preference. The quasi-hyperbolic specification reduces to the exponential specification whenever $\beta=1$. Based on the findings of many other studies (FISHER 1930; PENDER 1996; NIELSEN 2001; HARRISON, LAU, AND WILLIAMS 2002; ANDERSON ET AL. 2004) it can be hypothesized that subjects living in a poor environment, as is the case for West African small-holder pastoralists, are generally impatient.

Finally, we complete our discounted utility model by incorporating the utility function under prospect theory and the quasi-hyperbolic discounting function into an additive utility function where the preferences over the temporal prospects (x_i, t_i) are inter-temporal separable (LOEWENSTEIN AND PRELEC 1992):

$$U(x_1,t_1;\ldots;x_n,t_n)=\sum_{i=1}^{n}V(x_i)D(t_i), \tag{5}$$

In total, there are five parameters in our discounted utility model that need to be jointly estimated, i.e.: (i) σ, which describes the concavity of the value function and is the measure of

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[1] Although the risk aversion index of the Constant Relative Risk Aversion (CRRA) family cannot be equated with utility curvature under prospect theory (WAKKER 2008), the terminology of "concavity" and "risk aversion" is used interchangeably in this article.

risk aversion; (ii) λ, which represents the degree of loss aversion, (iii) α, which presents a proxy for probability weighting, (iv) β, which denotes the present biasedness parameter, and (v) δ, which signifies the subjective discount rate.

Our hypotheses can be summarized as follows:

1. $\sigma < 1$ and $\lambda > 1$, resulting in a s-shaped value function.
2. $\alpha < 1$ resulting in an inverted s-shaped probability weighting function
3. δ is not significantly different from 0.078 and that $\beta < 1$[2].

The first three parameters are estimated by means of the observations in the risk experiment, while the last two parameters are estimated by means of the time experiment. The design of the experiments is explained in the next section.

3 Data

The data used in our study stems from two sources: (i) household panel survey conducted over two waves in 2007 and 2011 and (ii) economic field experiments conducted in 2011.

In the first household survey in 2007 we sampled 508 small-scale cattle farmers living in Mali and Burkina Faso, representative for the West African cotton belt. Detailed economic data on cattle herd production, such as input costs, output quantities and selling prices were collected. In the second household survey in 2011, we randomly drew a sub-sample of 211 cattle farmers out of the 508 cattle farmers originally sampled. We then collected the same quantitative data on cattle production and also conducted risk and time experiments. In total there were 211 observations obtained over two time periods from the same smallholder cattle farmers; 107 farmers from the circle around Sikasso in south-eastern Mali and 104 farmers from the province of Kénédougou in south-western Burkina Faso.

Table 1 shows descriptive statistics of our sample, some of them will be later used as covariates in the analysis.

[2] As there is no accepted delta that indicates patience or impatience, our hypothesis is that the delta would not be dissimilar to comparable studies such as TANAKA, CAMERER AND NGUYEN (2010).

Table 1: Descriptive Statistics of Households over Time

Variable	Mean	
	2007	**2011**
Individual characteristics		
Burkinabe (%)	49.289	49.289
Age of HH Head (years)	54.614	55.725
Formal education of HH Head (years)	0.924	1.095
Religious education of HH Head (years)	1.69	1.052
Cattle herd production		
Keeping cattle (%)	100	95.735
Number of cattle	12.17	20.673
Number of cattle sick with AAT	4.733	4.355
Number of cattle died from AAT	0.76	0.384
Keeping trypanotolerant cattle (%)	42.18	45.024
Experience of HH Head in cattle keeping (years)	na	21.593
Participation in extension service (%)	51.185	na
Expenditures for curative drug treatment ($ PPP)	53.558	61.923
Expenditures for preventive drug treatment ($ PPP)	33.142	48.863
Expenditures for other veterinary inputs ($ PPP)	65.946	88.448
Expenditures for feeding ($ PPP)	49.479	48.043
Income from herd production ($ PPP)	2741.425	3771.001
Total expenditures - income ratio (%)	5.363	4.245
Household characteristics		
Household size	18.046	24.033
Dependency ratio	0.459	0.468
Number of active household members	13.92	17.038
Percentage of children at school	43.527	67.25
Number of motorbikes owned	1.327	1.773
Village characteristics		
Disease prevalence (%)	66.351	na
Resistance prevalence (%)	70.142	na
N	211	211

Source: Own survey

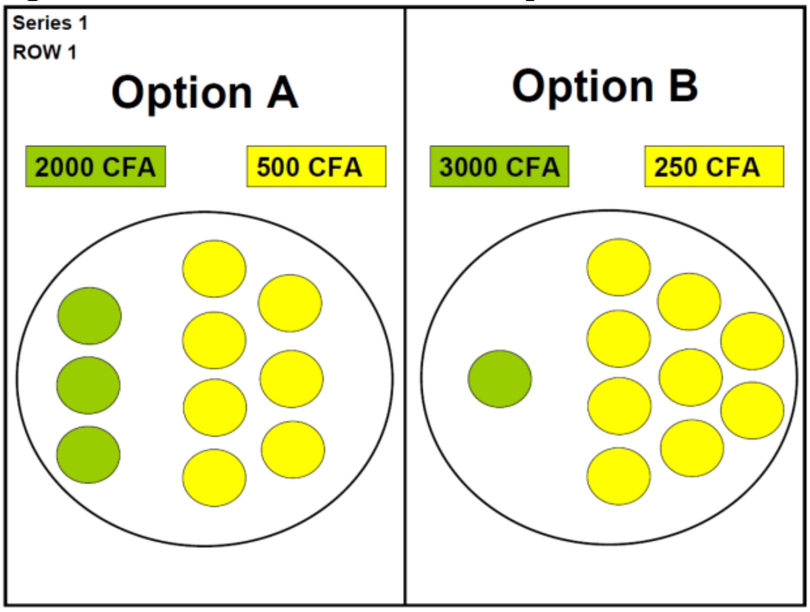
The average household head was about 55 years old and spent only one year at formal school. All respondents were Muslims and attended a Koran school. Around 5% of farmers had no more animals in 2011 than they did in 2007 largely due to death from livestock disease. However, overall, the average herd size increased from 12 animals in 2007 to 20 animals in 2011, which remains below the sub-Saharan average of 38 head (OTTE AND CHILONDA 2002). About half of the sample participated in an extension program. On average there were about 4.5 animals sick with AAT per household, however the case fatality rate decreased from 2007 to 2011. Farmers spent more money in 2011 than in 2007 for curative and preventive drug treatment as well as for other veterinary inputs like antibiotics, vaccines and vermicides. Also, in 2011 farmers managed to increase their income from bovine production, largely due to an increase in output, as prices remained steady[3]. Individual household sizes were generally large due to the practice of polygamy and multigenerational households. 2011 also saw an increase in the number of children attending school per household[4]. 66% of farmers lived in villages where AAT is prevalent and 70% of farmers lived in an area where resistance to drug treatment is also prevalent (AFFOGNON, RANDOLPH, AND WAIBEL 2010).

The field experiments on risk and time preferences were designed in the form of a 'switching Multiple Price List' (sMPL) design (ANDERSEN ET AL. 2006; TANAKA, CAMERER, AND NGUYEN 2010; NGUYEN 2011). The sMPL was calibrated to the local conditions of West African cattle farmers. In the experiment, respondents (the household head) were confronted with an array of paired lotteries, A and B, of which one option has to be chosen, thus at the same time rejecting the other option. The sMPL design is a variant of the MPL standard approach and forces monotonic switching, i.e. respondents were not allowed to switch back and forth within one series. In the end one row was randomly selected to be played with real money that encourages participants to reveal their true preferences (ANDERSEN ET AL. 2006). In the following, the two experiments are explained in more detail.

Experiment on risk preferences

The risk game was comprised of three series of paired lotteries. In each series, the respondent had the choice between two options (A and B), whereby each option was a lottery, where the probabilities were explained using 10 colored chips, with different rewards for each option. The respondent made his choice based on single picture cards illustrating each lottery pair (Figure 1).

Figure 1: Picture Card in Risk Experiment



Source: Own survey

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[3] We calculated income derived from the sale of animal byproducts such as milk, manure and traction.

[4] It is common in the context of West African small-holder pastoralists that not all children of the household are sent to school.

Using this illustration procedure we took utmost care to circumvent the weakness of MPL, whereby the frame encourages respondents to choose the middle row of tables (HARRISON AND RUTSTRÖM 2008). In total there were 35 choices to make; they are partially illustrated in Table 2.

Table 2: Design of Risk Experiment

Series	Rows	Option A		Option B	
		Probability		**Probability**	
		30%	**70%**	**10%**	**90%**
	1	2000 FCFA	500 FCFA	3000 FCFA	250 FCFA
	2	2000 FCFA	500 FCFA	3300 FCFA	250 FCFA
	3	2000 FCFA	500 FCFA	3700 FCFA	250 FCFA
	4	2000 FCFA	500 FCFA	4200 FCFA	250 FCFA
	5	2000 FCFA	500 FCFA	4800 FCFA	250 FCFA
	6	2000 FCFA	500 FCFA	5800 FCFA	250 FCFA
1	7	2000 FCFA	500 FCFA	7000 FCFA	250 FCFA
	8	2000 FCFA	500 FCFA	9000 FCFA	250 FCFA
	9	2000 FCFA	500 FCFA	11000 FCFA	250 FCFA
	10	2000 FCFA	500 FCFA	14000 FCFA	250 FCFA
	11	2000 FCFA	500 FCFA	18000 FCFA	250 FCFA
	12	2000 FCFA	500 FCFA	25000 FCFA	250 FCFA
	13	2000 FCFA	500 FCFA	35000 FCFA	250 FCFA
	14	2000 FCFA	500 FCFA	50000 FCFA	250 FCFA

Source: Own survey

The average reward is equal to around seven days income for a cattle dependent household in the study area (6065 FCFA or about US$12), The maximum amount that could have been lost by the respondent was 1000 FCFA (about 2 US$), which was the amount the respondent had been paid when he agreed to participate in the survey.

Experiment on time preferences

The time preference experiment was constructed as 15 series of five choices between two options, i.e. a smaller reward delivered immediately (option A) and a larger reward delivered at a later specified time (option B). The experiment is illustrated in Table 3. The table shows only the first three series, where the same range of five immediate rewards (option A) was contrasted with a constant delayed reward at three different points of time in the future (option B). Every fourth series the amount of the five immediate rewards (x_t) and the delayed reward ($x_{t+\tau}$) changed, but the ratio between the two options remained the same, i.e. $x_t = \frac{x_{t+\tau} * v}{6}$, where $v=1,...,5$ is the row number within each series. The future reward varied between 1500 FCFA (about 3 US$) and 15000 FCFA (about 30 US$) and the delay varied between three days and three months. The maximum delay of three months corresponds to treatment decisions in managing AAT. Within each series the respondent had to decide row by row which option he preferred. Again monotonic switching was enforced.

Table 3: Design of Time Experiment

Series	Rows	Option A	Option B
	1	250 FCFA today	1500 FCFA in 1 week
	2	500 FCFA today	1500 FCFA in 1 week
1	3	750 FCFA today	1500 FCFA in 1 week
	4	1000 FCFA today	1500 FCFA in 1 week
	5	1250 FCFA today	1500 FCFA in 1 week
	16	250 FCFA today	1500 FCFA in 1 month
	17	500 FCFA today	1500 FCFA in 1 month
2	18	750 FCFA today	1500 FCFA in 1 month
	19	1000 FCFA today	1500 FCFA in 1 month
	20	1250 FCFA today	1500 FCFA in 1 month
	31	250 FCFA today	1500 FCFA in 3 months
	32	500 FCFA today	1500 FCFA in 3 months
3	33	750 FCFA today	1500 FCFA in 3 months
	34	1000 FCFA today	1500 FCFA in 3 months
	35	1250 FCFA today	1500 FCFA in 3 months

Source: Own survey

After the completion of all 75 choices, the respondent was asked to blindly draw one card out of 75 numbered cards in a bag. The card drawn determined the row and the participant gained the reward at the respective time according to his choices made. As suggested by CARDENAS AND CARPENTER (2008), a trusted agent, well-known and commonly accepted for this duty, had been assigned to keep the money until delivery.

In total, across both experiments, the respondent has to complete 110 decision tasks, 35 in the risk experiment and 75 in the time experiment. The data is incorporated into the structural estimation approach that is introduced in the next section.

4 Methodology

The approach of HARRISON AND RUTSTRÖM (2008) and ANDERSEN ET AL. (2008) has been widely used to estimate parameters within a utility model. NGUYEN (2011) built on this approach by integrating the discounting function into the utility function to simultaneously estimating the risk and time preference parameters which we also apply in this article.

Following utility theory a decision participant of the risk and of the time experiment can be hypothesized to switch from option A to option B whenever utility of option B exceeds utility of option A. Let $U_i^j\left(X_i;Z^j\right)$ be the utility of respondent *i* from any option A or B in the decision task *j* from the risk experiment and the time experiment. While the utility value is only known by the respondent the researcher can observe the respondent's characteristics X_i and knows all information on decision task *j*, denoted by Z^j, including rewards, probabilities and the time of payment. Under prospect theory, a respondent's utility from option A can therefore be defined as:

$$U_i^{A;j} = PT_i^{A;j}(X_i;Z^j) + \varepsilon_i^{A;j}, \tag{6}$$

where $PT_i^{A;j}$ describes the utility under prospect theory and $\varepsilon_i^{A;j}$ is the error term, normally, independent and identically distributed. A respondent's utility for option B can also be defined in the same way as in equation (6). Since option B in the time experiment involves monetary rewards obtained in the future, the discounting function D_i needs to be incorporated, which is a function of *t* (the delay in days) and individual characteristics X_i:

$$U_i^{B;j} = D_i(t;X_i)PT_i^{B;j}(X_i;Z^j) + \varepsilon_i^{B;j}. \tag{7}$$

Hence, the present value of utility streams under both options A and B can be obtained by the means of $U_i^{A;j}$ and $U_i^{B;j}$, respectively. The utility for each lottery pair in scenario *j* can be expressed by the latent index ∇U_i^j:

$$\nabla U_i^j = U_i^{B;j} - U_i^{A;j}, \tag{8}$$

The latent index ∇U_i^j is then linked to the observed binary choices made by the respondent in the experiments using a standard cumulative distribution function $\Phi(\nabla U_i^j)$. A respondent's conditional log likelihood of choosing option B can be expressed as:

$$\ln L_i(\alpha,\sigma,\lambda;\beta,\delta;X_i;Z^j;y_i^j) = \sum_{j=1}^{110}\left\{ \left[\ln\Phi(\nabla U_i^j) \mid y_i^j = 1\right] + \left[\ln\Phi(\nabla U_i^j) \mid y_i^j = 0\right] \right\}, \tag{9}$$

and depends on the utility function parameters under prospect theory (α, σ and λ), the discount function parameters (β and δ) and 110 observed binary choices in the risk experiment and time experiment[5]. These choices are captured by y_i^j, which equals one if individual *i* chooses option B in decision task *j* and zero otherwise.

The corresponding procedure is written in Stata 11 to estimate the parameters and their correlation with socio-economic characteristics X_i using the cluster option that takes into account arbitrary intra-farmer correlation (HARRISON AND RUTSTRÖM 2008). The vector X_i contains data on farmers' socio-economic characteristics collected during the two household surveys in 2007 and 2011 as presented in Table 1. We investigate how the socio-economic

[5] We argue that there is no ordered list effect in the 110 risk and time choices, because respondents were asked to complete all 35 choices in the risk experiment and all 75 choices in the time experiment based on picture cards that illustrated each choice separately. In the end they were paid a reward in each experiment that was determined by a random draw. Therefore, we argue that in every decision tasks respondents made their choice independently from any other decision task.

characteristics are correlated with pastoralists' risk and time preferences. The results are presented in the next section.

5 Results

We present the results in two parts. In the first part we present results of a model, where respondents are treated as homogenous in their preferences and exclude individual covariates (Table 4), thus obtaining an overall first glance of their time and risk preferences. In the second part, we include individual covariates in the model in order to analyze the relationship between elicited preferences and socio-economic characteristics (Table 6 and Table 7). In both analyses, each farmer represents a cluster, in which all 110 binary choices from both experiments are observed. In the maximum likelihood estimation 23210 observations are obtained, which corresponds to 211 distinct units of observations.

5.1 Homogenous model

Table 4 presents the maximum likelihood estimates of the five parameters in our discounting utility model, excluding individual covariates.

Table 4: Model Estimates of Parameters without Individual Characteristics

Parameter	Estimate	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Probability weight (α)	0.133***	0.022	0.089	0.177
Risk aversion (σ)	0.112***	0.006	0.101	0.123
Loss aversion (λ)	1.351***	0.262	0.837	1.865
Time preference (δ)	0.001***	0.0001	0.0004	0.0008
Present bias (β)	0.942***	0.028	0.888	0.997
Test	p-value			
H0: α=1	0.000			
H0: λ=1	0.1804			
H0: δ=0.078	0.000			
H0: β=1	0.0375			
N = 23210 (Number of clusters = 211)				

Note: Single, double, and triple asterisks (*,**,***) denote $p < 0.10$, 0.05, and 0.01, respectively
Source: Own survey

The estimate of the probability weighting parameter (α) is 0.133. From this estimate it can be concluded that the probability weighting function is an inverted s-shaped and respondents seem to overweight small probabilities and underweight large probabilities, as is associated with prospect theory. With respect to risk aversion, the estimated exponent of the value function (σ) is 0.112, which indicates that cattle farmers are risk averse. The estimated coefficient of the loss aversion parameter (λ) is 1.351 indicating risk aversion in the loss

domain. However, the one-sided test shows that the coefficient is not significantly different from 1, indicating that there is little evidence that respondents are, on average, averse to losses.
The estimate of the time preference parameter (*δ*), 0.0006, and the estimate of the present biasedness (*β*), 0.942, suggest that respondents are on average rather patient and associate a relatively low cost to utility streams obtained in the future. It should also be noted that in the one-sided test, *β* is significantly different from 1, which indicates the presence of quasi-hyperbolic discounting.

In contributing to the understanding of the way the poor make decisions under uncertainty, we compare our results to one of the few applicable studies found in developing countries (Table 5)[6].

Table 5: Comparison with Findings from Asian studies

	Study				
	Own study	**Liu (Forthcoming)**	**Tanaka, Camerer and Nguyen (2010)**	**Nguyen and Leung (2010)**	**Nguyen (2011)**
Country	Mali and Burkina Faso	China	Vietnam	Vietnam	Vietnam
Group of respondents	Cattle farmer	Cotton farmer	Rural villagers	Livestock farmer	Fishermen
Parameter					
Probability weight (α)	0.133	0.69	0.74	0.75	0.96
Risk aversion (σ)	0.112	0.48	0.59	0.62	1.012
Loss aversion (λ)	1.351	3.47	2.63	2.05	3.255
Time preference (δ)	0.001	-	0.078	-	0.28
Present bias (β)	0.942	-	0.82	-	0.72
N	211	320	181	103	181

The parameter for the probability weighting function ($\alpha = 0.133$) is much lower than estimates from these Asian studies. This lower value constrains future investment by overweighting unlikely risks, such as the risk of shocks or other negative events that may impact investment in the future (DERCON 2008). Then, in turn, it is likely to impede development where reasonable investments may improve a household's livelihood.

[6] TANAKA, CAMERER AND NGUYEN (2010) , LIU (Forthcoming), LIU AND HUANG (2013) and NGUYEN AND LEUNG (2010) apply the same experimental design. NGUYEN (2011) applies the same experimental design as in TANAKA, CAMERER AND NGUYEN (2010) but a different estimation approach.

The estimate of the utility curvature parameter ($\sigma = 0.112$) is smaller than results found in the Asian studies cited above, which suggests that on average the West African cattle farmer is more risk averse in the gain domain than the average Asian farmer. These low values may reinforce the notion of a poverty trap because the poor are reluctant to take engage in high return albeit risky investments.

Based on the estimate of the parameter of loss aversion (i.e. $\lambda = 1.351$), the small-holder cattle farmer in West Africa appears less loss averse than compared to her Asian counterpart. This lower aversion to loss can contribute to potentially fatal investment decisions, particularly when combined with underweighting of high probabilities ($\alpha<1$). For example, in a severe drought situation, a farmer can choose to sell his cow, or keep it, in the hope that the cow would survive the drought. A farmer with a high aversion to loss would sell the cow, whereas a farmer with lower loss aversion would keep the cow and accept the risk of losing it.

The results for time preference show a lower estimate for the subjective discount rate ($\delta = 0.0006$) while the estimate for present biasedness ($\beta = 0.942$) is larger than the estimates of the quasi-hyperbolic specification in the study of TANAKA, CAMERER, AND NGUYEN (2010). That implies that the average West African pastoralist is more patient and less biased towards the present than the average Vietnamese farmer.

These results are contrary to our expectations. We hypothesized that poor farmers would have higher levels of impatience due to the immediate survival needs. However, in conjunction with the risk aversion parameter, these results make sense. West African livestock farmers prefer investments with a certain return and a long payback period, over a potentially risky project, with a higher return and a shorter payback period.

5.2 Heterogenous model

The homogenous model enabled a comparison of time and risk preferences between a "typical" West African and Asian farmer. In the second model we explore the relationship between the West African cattle farmers' risk and time preferences and their socio-economic characteristics. With survey data from two time periods and experimental data for one point in time we cannot solve the endogeneity problem. Therefore, we apply lagged variables to reduce the potential endogeneity problem (DUNCAN, MAGNUSON, AND LUDWIG 2004). We use lagged variables (L1) for all time-variant observations. Whenever the variable is constant over time, such as the number of years the household head spent at school or country of origin we apply the observation from the most recent survey. We assume that variables observed in 2007 are potentially less endogenous and therefore more useful to explain estimated preferences elicited in 2011[7]. The joint model estimates of risk and time preferences are presented in Table 6 and 7, Table 6 shows the correlation between risk preferences and respondent characteristics, while Table 7 shows the same for time preferences[8]. In the following we will discuss the most important variables and compare them with findings from the Asian studies.

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[7] Additionally, income variables had been controlled for endogeneity following TERZA, BASU AND RATHOUZ (2008) who tested endogeneity in non-linear models. Also, the model had been controlled for heteroskedasticity and autocorrelation.

[8] Note that the number of distinct units of observations is reduced to 202 due to missing values in socio-economic variables.

Table 6: Model Estimates of Risk Preference Parameters with Individual Characteristics

	Probability weight (α)	Risk aversion (σ)	Loss aversion (λ)
Variable	Estimate	Estimate	Estimate
Burkinabé	0.598	0.016	28.909
L1 Age of HH Head (years)	0.062	-0.005***	-0.184
Formal education of HH Head (years)	-0.051	0.03***	-0.319
Religious education of HH Head (years)	-0.067*	0.038***	-1.161*
L1 Household size	0.010	-0.023	-0.054
L1 Percentage of children at school	-0.492	0.259***	17.309
L1 Number of motorbikes owned	0.063	0.03	-0.593
L1 Number of cattle	0.021***	0.009	0.245***
L1 Keeping trypanotolerant cattle	-0.299*	0.076	0.225
Participation in extension service	0.303	0.041	4.828*
L1 Expenditures for curative treatment ($ PPP)	-0.002*	0.0005**	-0.064
L1 Expenditures for preventive treatment ($ PPP)	-0.005	0.0005	-0.094**
Interaction term of curative and preventive treatment	0.00001**	-0.0000001	0.0004***
L1 Income from herd production ($ PPP)	0.85**	-0.039	-8.684
L1 First income quintile	0.121	-0.088	-2.221
L1 Third income quintile	-0.781**	0.229**	-20.214*
L1 Fifth income quintile	-1.449***	0.234**	5.826
Disease prevalence	-2.079***	-0.057	-15.617
N = 22210 (Number of clusters = 202)		Pseudo-Log Likelihood = -11431.71	

Note: Single, double, and triple asterisks (*,**,***) denote p < 0.10, 0.05, and 0.01, respectively
Source: Own survey

Probability weighting

Focusing first on the coefficient estimates of the probability weighting function (α) in Table 6, we find a negative correlation between probability weighting and years spent at a Koran school, which suggests a stronger religious orientation in decision-making lessens their reliance on objective probability information.

Income from cattle and herdsize is positively correlated with probability weighting. Hence, richer farmers generally become more efficient in the use and interpretation of information. This finding confirms the behavior observed among Asian farmers with regards to probability weighting (NGUYEN AND LEUNG 2010). However, considering income quintiles the correlation switches above the first quintile, i.e. richer respondents tend to inflected probability weighting, and, possibly, stronger orientation on investment outcomes.

Expenditures for disease control, like curative drugs, are negatively correlated with probability weighting. This indicates that farmers who wait for disease symptoms to be observed before spending money on curative drugs tend to have an inflected probability weighting function. They underweight the likelihood of an infection and overweight the probability of convalescence. This conclusion is supported by the negative correlation with the disease prevalence coefficient, which suggests that farmers living in high disease prevalence villages tend to underweight the risk of disease outbreaks.

Risk aversion

Next, we examine the correlation between the proxy for risk aversion[9] (σ) and the socio-economic characteristics of respondents. It can be shown that there is a positive correlation between age and risk aversion, i.e. the elderly are seemingly more risk averse, which confirms findings in the Vietnamese studies (NGUYEN AND LEUNG 2010; TANAKA, CAMERER, AND NGUYEN 2010).

On the other hand we find different results for the correlation between education and risk aversion. While in Asia educations seems to make people more risk averse, the effect of schooling in rural Africa appears to be opposite. Both educational variables, namely (i) respondents' formal education and (ii) the percentage of children at school are negatively correlated with risk aversion. It seems that the rather rudimentary education, which is characteristic for rural Africa, makes people to be more open towards taking up risky opportunities. This may be different in Asia where more years of education may have the effect that people become more considerate (TANAKA, CAMERER, AND NGUYEN 2010; NGUYEN 2011). This may help better target extension services, particularly when it involves the adoption of new technologies, which have an inherent associated risk.

For the income variable we obtain similar findings. Generally, richer farmers are less risk averse. We observe a switch point above the first income quintile, where the negative correlation becomes signifcant. Hence, very poor farmers are more risk averse which may contribute them to be trapped in poverty - consistent with findings in many other literatures (LIU FORTHCOMING; TANAKA, CAMERER, AND NGUYEN 2010).

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[9] With respect to the interpretation of the coefficients on risk aversion, it has to be considered that a negative value of the coefficient implies that the variable has a positive impact on risk aversion and we call it a positive correlation with risk aversion.

We also find a negative correlation between religion and risk aversion that indicates that religious belief absorbs the angst associated with risk. This corresponds with findings among cotton farmers in China (LIU FORTHCOMING).

Likewise risk aversion is negatively correlated with curative drug expenditures which confirms results from the probability weighting parameter. Hence, it seems that farmers who rely on the use of curative drugs underweight disease infection events and are more willing to take the risk of cattle disease.

Loss aversion

The third parameter of interest is loss aversion (λ) and its relationship with individual and household characteristics.

First, we find a negative correlation between religious education and loss aversion suggesting that persons who spent more years at a Koran school are less loss averse similarly to risk aversion. Once again faith reduces fears.

Second, we find that farmers with more cattle are more averse to loss. It seems plausible that for farmers where cattle are a dominant source of income they tend to attach a higher value to loss as compared to an equivalent value in a gain situation.

Third, there is a negative correlation between loss aversion and expenditures for preventive drug treatments. Similarly as was found in the case of pesticide use (LIU AND HUANG 2013) loss aversion could stimulate the preventive use of animal drugs.

Time preference

In Table 7 we show results for the correlation between time preference (δ) and socio-economic characteristics.

First a significant country-specific difference, between Burkina Faso and Mali can be observed. Since there are no ethnic nor climatic differences this could be due to differences in the political and institutional conditions. At the time when the study was conducted Mali was en route towards democratization and market liberalization while in Burkina Faso the authoritarian regime exerted more market restrictions. That could mean for example that Burkinabées are used to longer time horizons in terms of development and change and therefore may be more patient.

Second, there is a positive correlation between education variables and patience. Respondents, with more years of formal schooling tend to be more patient as shown in their lower discount rate, which is consistent with findings from Vietnam (TANAKA, CAMERER, AND NGUYEN 2010). In Africa, the correlation between religious education and patience is also positive. Likewise, the correlation between household heads with more children at school and their time preference is negative, suggesting that they put higher value on future benefits.

Third we observe a positive correlation between patience and income from livestock products. As for the previous parameters we find a switching point above the first income quintile.

Table 7. Model Estimates of Time Preference Parameters with Individual Characteristics

	Discount rate (δ)	Present biasedness (β)
Variable	Estimate	Estimate
Burkinabé	-0.514**	2.165
L1 Age of HH Head (years)	0.02**	0.023**
Formal education of HH Head (years)	-0.102**	-0.054
Religious education of HH Head (years)	-0.114*	-0.084
L1 Household size	0.042**	-0.069
L1 Percentage of children at school	-0.809**	-2.239*
L1 Number of motorbikes owned	-0.231**	0.281
L1 Number of cattle	-0.011***	0.056**
L1 Keeping trypano-tolerant cattle	-0.188**	-0.589
Participation in extension service	0.42*	-0.818
L1 Expenditures for curative treatment ($ PPP)	-0.004*	-0.002
L1 Expenditures for preventive treatment ($ PPP)	0.004***	-0.032*
Interaction term of curative and preventive treatment	0.000001	0.00004**
L1 Income from herd production ($ PPP)	0.15***	-0.182
L1 First income quintile	0.091	0.451
L1 Third income quintile	-0.397*	-0.075
L1 Fifth income quintile	-0.616**	0.312
Disease prevalence	-1.442**	0.797
N = 22210 (Number of clusters = 202)	Pseudo-Log Likelihood = -11431.71	

Note: Single, double, and triple asterisks (*,**,***) denote p < 0.10, 0.05, and 0.01, respectively
Source: Own survey

Hence very poor people are less patient, which corresponds to results of those Asian studies that included the discounting function (TANAKA, CAMERER, AND NGUYEN 2010; NGUYEN 2011).

Fourth, the same relationship holds for farmers who keep cattle breeds tolerant to AAT and other diseases (indigenous cattle races). Farmer who adopted non-tolerant but higher productive Zebus cattle were found to be less patient.

Characteristics that show a negative correlation with patience are (i) respondents' age and (ii) household size. Here we obtain differences from the results of the Asian studies. In Asia patience seems to be going up with age (TANAKA, CAMERER, AND NGUYEN 2010; NGUYEN 2011). In rural Africa there is practically no formal social protection for the elderly. Therefore investments with returns in the far future are less attractive for the older African farmer.

Present biasedness

With respect to present biasedness (β), we find a negative correlation with age, i.e. elder people decrease their discount factor at a higher rate than younger people.

We also find a negative correlation between present biasedness and cattle stocks. Respondents with more cattle decrease their discount factor stronger than respondents with fewer animals. Both coefficients are in line with results found in Asia.

6 Summary and conclusions

The objectives of this article were to increase our understanding of investment decisions of West African cattle farmers living in high risk environments. The simultaneous assessment of both risk and time preferences of small-scale cattle farmers in West Africa and the examination of the role of demographic and socio-economic characteristics in shaping those preferences facilitates the formulation of more effective intervention strategies. Additionally, given the dearth of literature on time and risk preferences in developing countries, we can draw interesting lessons by comparing Africa with Asia.

To achieve our objective we applied a discounted utility model, where we define a prospect theory-based utility function and use a quasi-hyperbolic discounting function in order to estimate the present value of future utility streams. We estimated two models that capture the dynamic decision making behavior of cattle farmers. The first model simultaneously provided parameters of risk and time preference and the second model explained these parameters against the background of socio-economic characteristics of West African cattle farmers.

From both models we can derive similarities as well as interesting differences between Africa and Asia.

In the first model we can derive a number of behavioral characteristics of the average West African farmer and can compare them to findings from similar studies in Asia.
We found that (i) the average West African farmer is less responsive to actual probability information than for example the Vietnamese (NGUYEN AND LEUNG 2010) or Chinese farmer (LIU FORTHCOMING), (ii) is more risk averse in the gain domain and (iii) less loss averse. Also

the average West African cattle farmer seems to be (iv) more patient and (v) less present-biased than the average Asian (Vietnam) farmer (TANAKA, CAMERER, AND NGUYEN 2010).

With the second model we tried to identify variables that can explain differences in those behavioral parameters. Three variables are highly correlated with risk and time preference for the West African farmer, namely (i) income, (ii) education and (iii) religion. Farmers with higher income tend to perform better in using probability information, are more willing to take risks and are more patient. Farmers with more children in school are more willing to take risk and tend to be more patient. Cattle farmers in West Africa, who spent more time in a Koran school, show lower performance in using probability information, are less risk averse in gains and losses and are more patient. Comparing results with Asia we observe a similar result for income and religion but differences for schooling. Contrary to farmers in West Africa, a higher number of children at school seem to make Asian farmers more risk averse.

The findings have implications for development interventions and projects. For example, extension services often assume rational assessment of information by farmers and tend to overload farmers with technical details. In the light of our findings however it could be damaging to educate farmers for example about the existence and control of a large number cattle diseases, as they may theoretically exist in West Africa, because this could lead to unjustified fear and overweighting of the probability of disease events.

Development projects also need to be aware of the time horizon that poor people have. African farmers were found to be patient; development projects however are of a short term nature and are designed to produce quick results. As a consequence, development agencies place much hope on the transfer of successful Asian development models to Africa such as green revolution technologies. Our results suggest that there may be scope for a stronger role of augmenting indigenous African development paths, taking into account cultural and socioeconomic characteristics of rural Africa.

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