Do farmers prefer to insure their production against rare or frequent droughts ?

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Abstract

This paper analyzes the role of drought frequency in farmers demand for index insurance in developing countries. In a model derived from Doherty and Schlesinger (1990), we show that the demand for insurance is an inverted U curve function of drought frequency. We further show that both loading factor and basis risk hinder insurance demand for high drought frequency. To assess the empirical relevance of such effects, we led an insurance field experiment in Burkina Faso with 205 farmers. Analysis of revealed insurance demand for different frequencies of insured drought, different levels of basis risks and different loading factors through incentivized loteries choices confirms that insurance demand decreases with basis risk and the loading factor. More importantly we empirically establish that increasing drought frequency hinders insurance demand. Finally, we validate the theoretical result that such negative impact of drought frequency on demand increases with the loading factor and show that is also strongly depend on the zone (latitude/rainfall, household characteristics?).

Keywords: Index insurance, Extreme events, Basis risk

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Contents

1 Introduction

In developing countries, index insurance projects are developing rapidly. Yet, and despite recent evidence of the role of uninsured risk in input use (Donovan, 2014; Emerick, de Janvry, Sadoulet, and Dar, 2016) and despite the growing interest of donors, insurers and banks, there is a low take up rate of index insurance products among farmers

(Cole, Giné, Tobacman, Topalova, Townsend, and Vickery, 2013; Giné and Yang, 2009). Substantive progress has been made in the economic literature to understand the factors that may prevent farmers from purchasing index insurance in developing countries (De Bock and Gelade, 2012).

A first set of factors are related to the lack of interest or capacity of farmers to buy index insurance products. Farmers may be liquidity constrained, especially in the absence of credit markets, and unable to afford insurance premiums (Cole, Giné, Tobacman, Topalova, Townsend, and Vickery, 2013; Carter, Cheng, and Sarris, 2016). Because of low financial literacy (Cai, De Janvry, and Sadoulet, 2015), farmers may find index insurance too complex to understand (Gaurav, Cole, and Tobacman, 2011). They may not trust the insurance seller to provide the promised pay-outs (Patt, Suarez, and Hess, 2010; Cai, Chen, Fang, and Zhou, 2009; Dercon, Gunning, and Zeitlin, 2015). They also may be already insured through informal networks, through non agricultural activities or through limited liability credit contracts, which in turn limits their demand for a formal insurance product (Mobarak and Rosenzweig, 2013).

A second set of factors are related to the limitations of index insurance products, that may be too expensive or present tecnical deficiencies. Recent experiments made with different subsidization levels argue in favor of a high elasticity of insurance demand to insurance price (Mobarak and Rosenzweig, 2012; Karlan, Osei, Osei-Akoto, and Udry, 2014). Yet, a strong empirical body of evidence shows low average take up of formal insurance products, even when subsidized, suggesting that farmers may have other reasons for not buying those products (Cole, Giné, Tobacman, Topalova, Townsend, and Vickery, 2013; Tadesse, Shiferaw, and Erenstein, 2015; Jensen, Mude, and Barrett, 2014). Contract nonperformance is another potential source of insurance product rejection by farmers (Doherty and Schlesinger, 1990). Although this is of general concern in insurance, it is particularly striking for index insurance contracts which are nonperforming contracts by nature because of the existence of an imperfect correlation between the index and farmers yields. This discrepancy between insurance payouts and agricultural output has been coined as basis risk and may deter farmers demand for index insurance (Giné, Townsend, and Vickery, 2008; Giné and Yang, 2009; Cole, Giné, Tobacman, Topalova, Townsend, and Vickery, 2013; Clarke, 2016). This is especially the case for so called type II basis risk, that corresponds to a yield shock situation with no payout triggered by the index. Thus, situations may occur where the farmer doesn't receive any payout despite the fact is yield is devastated, i.e. the farmer finds himself in a worse situation with insurance after paying a premium than without insurance. Type II basis risk exactly corresponds to insurer's default risk in the model of Doherty and Schlesinger (1990).

Basis risk is widely acknowledged as a major determinant of low index insurance take up (Tadesse, Shiferaw, and Erenstein, 2015; Dercon, Hill, Clarke, Outes-Leon, and Taffesse, 2014; Clarke, 2016), but few papers have dealt with the empirical measurement of the effect of basis risk on insurance demand (Jensen, Barrett, and Mude, 2015). In India, where index insurance is the most developed market, Mobarak and Rosenzweig (2012) used the perceived distance to the station used to insure Indian farmers as a proxy for basis risk and established that basis risk impact on demand is high. Further analysis on basis risk is needed, in particular to correctly capture empirically basis risk.

In this paper we look at another explanation of low demand for index insurance in Africa, namely the frequency of insured events. In countries like Burkina Faso where rainfall season quality is critical for agriculture, the definition of a climate shock is critical for farmers' interest into insurance. The insurer can choose the degree of drought to build an insurance product, typically a threshold (strike) for index insurance, and doing so he also sets a drought frequency for a given location, i.e. with a given distribution of historical events. The impact of this parameter on insurance demand by farmers has not been analyzed in the literature. Intuitively, yet it is reasonable to expect that insurance against very frequent drought is of little interest for farmers because the risk vanishes as the variance of drought decreases; and one can also expect that insurance against very rare drought is of little interest for farmers because the average expected gain is weak.

We study how the frequency of insured events may hinder the demand for insurance, depending on the level of basis risk. We build a discrete choice model of insurance derived from the conceptual model of Doherty and Schlesinger (1990) to analyze the effect of events frequency on insurance demand. We establish that (1) the demand for insurance is an inverted U curve function of events frequency indicating that there is an optimal frequency for farmers to get insurance, (2) that for high frequency events it is non profitable to get insured, meaning that there is a range of insurable risks, and that (3) and that both optimal frequency and the range of uninsurable risks are influenced by basis risk (increasing optimal frequency and maximum frequency) and loading factor levels (deacreasing both of them).

To assess the empirical relevance of those effects, we led an insurance field experiment in Burkina Faso to analyze 205 farmers' demand for drought insurance with different drought frequencies, different levels of basis risks and different loading factors. Farmers were asked to choose between insurance and no insurance, in 9 lottery choices representing different insurance policies.

- Three frequencies of shocks were tested in the insurance experiment: rare shocks that occur on average once over a 20 years period; moderate shocks that occur on average twice over a 20 years period; and frequent shocks that statistically occur seven times over a 20 years period.

- Three basis risk levels were tested: no basis risk indicating that there is no discrepancy between the index and the yield (the insurance is perfect); a moderate basis risk, discrepancy between the index and the yield occurring in one case over 5, conditional of the occurrence of a yield shock; and an important basis risk, discrepancy between the index and the yield occurring in 2 cases over 5, conditional of the occurrence of a yield shock.

The 9 choices are being repeated twice, in a game with a loading factor equal one (actuary fair price insurance) and in a subsequent game with an higher loading factor. We find that an increase in basis risk or loading factor also leads to lower demand, and, more originally, that an increase in drought frequency significantly hinders insurance demand. Those experimental results, robusts to different specifications, validates the theoretical model.

The paper is organized as follows. In section 2, we build upon a conceptual model to accounts for the effect of shock frequency on insurance demand. In section 3, we present the field experiment that we implemented in Burkina Faso. In section 4, we deliver our empirical results.

2 Model

We build upon Doherty and Schlesinger conceptual framework to analyze the effect of events frequency on insurance demand, in the presence of basis risk. Different basis risks can occur. Type I basis risk is the probability for a farmer to get an indemnification while his production has not been impacted by random shock. Type II basis risk is the probability for a farmer to get no indemnification while his production has been impacted by a random shock that is theoretically included in the contract. These two risks potentially have contradictory effects on insurance subscription. To keep the analysis simple, we will only consider type II basis risk. This basis risk is very close to what Doherty and Schlesinger (1990) call non performing contract, be it an imperfection in the insurance scheme or a default from the insurer.

2.1 Index insurance framework probability set up

We adapt the formal framework by Doherty and Schlesinger (1990) to a binary decision to get full insurance or no insurance. We note p the frequency of drought and r the probability for a farmer who has contracted an insurance to get no indemnity conditional on the drought occurrence. The type II basis risk is then simply the probability, for a farmer who has contracted an insurance, to endure a drought without being paid any indemnity (i.e. $r.p$).

Let L denote the loss in case of a drought. If y is the farmer's income in a normal year, $y - L$ is the income in case of a dry year. In case of drought, the insurer pays an indemnity L with probability $1 - r$. Let P denote the yearly premium, and $m \geq 1$ the loading factor applied by the insurer. The premium is then the average loss $p.L$ multiplied by the probability of indemnification $1 - r$ multiplied by the loading factor, $P = m.p(1 - r).L$.

The insurance framework probability set up is summarized in table 1.

Table 1: Insurance framework probability set-up

	Payout (1-r)	No payout (r)
No yield shock (1-p)	0	$1-p$
Yield shock (p)	$(1-r).p$	$r.p$

The farmer's expected utility gain from getting the insurance is the difference between his expected utility with insurance and the expected utility without insurance. This supposes that the decision to get insurance is a binary decision, which is a simplification with regard to Doherty and Schlesinger (1990) where the decision is about choosing an insurance rate between 0 and 1. This simplification is consistent with our field experimental framework, that we wanted to keep as simple as possible, and in which farmers were asked wether they wanted or not to get the insurance for 18 insurance policies.

$$\begin{aligned} \Delta EU = (1-p).u(y-P) + (1-r).p.u(y-P) + r.p.u(y-P-L) \\ - [(1-p).u(y) + p.u(y-L)] \end{aligned} \tag{1}$$

We need to identify the effect of drought frequency on the sign and magnitude of the above expression. We replace P by $m.p(1-r).L$, and derivate with regard to p to understand how propension to get insured varies with drought frequency.

$$\begin{aligned} &\tfrac{\partial \Delta EU}{\partial p} = -r.u(y-m.p.(1-r).L) - (1-p.r)m.(1-r)L.u'(y-m.p.(1-r).L) \\ &+r.u(y-m.p.(1-r).L-L) - p.r.m.(1-r)L.u'(y-m.p.(1-r).L-L) \\ &+u(y) - u(y-L) \end{aligned} \tag{2}$$

The sign and variation of above expression are not constant on $[0,1]$ and notably depend on loading factor. In the following paragraphs, we analyze the effect of drought frequency on insurance demand in cases of moderate and heavy loading factors. We show that a moderate loading factor is compatible with insurance subscription while an heavy loading factor discourage farmers to insure their production against drought.

2.2 Drought frequency and insurance demand: case of a moderate loading factor

We establish in this section that a moderate loading factor, compatible with insurance subscription, is $m < \frac{u(y)-u(y-L)}{L.u'(y)}$. Under this case, we show that insurance is profitable for a range of drought frequencies.

2.2.1 Optimal drought frequency

Low drought frequency : expected utility fonction is upward sloping. Indeed, for $p = 0, \Delta EU = 0$ and $\frac{\partial \Delta EU(p=0)}{\partial p} = (1-r)\left[u(y) - u(y-L) - m.L.u'(y)\right]$, which is positive if and only if $m < \frac{u(y)-u(y-L)}{L.u'(y)}$.

Moderate drought frequency : expected utility function is concave. Furthermore, $\forall\, p \in [0;1]$ $\frac{\partial^2 \Delta EU}{\partial p^2} < 0$. This proves that $m < \frac{u(y)-u(y-L)}{L.u'(y)}$ is a necessary condition for $\delta EU > 0$.

High drought frequency : expected utility function is downward sloping. For $p = 1$, $\frac{\partial \Delta EU(p=1)}{\partial p} < 0$ (see proof in annex).

These elements alltogether guarantee that if $m < \frac{u(y)-u(y-L)}{L.u'(y)}$, expected gain ΔEU is positive and increasing with p in zero, reaches a maximum at $p^* \in]0;1[$ and decreases until $p = 1$. There exists a critical value of drought frequency for which the incentive to take insurance is maximal. This is true for all values of basis risk $r \in [0,1[$ ($\Delta EU = 0$ if $r = 1$).

Proposition 1. *If* $m < \frac{u(y)-u(y-L)}{L.u'(y)}$*, there exists a unique* $p^* \in\ ]0;1[$ *such that* $p^* = argmax(\Delta EU)$.

The incentive to get insurance is first increasing and then decreasing with p. In other words, if droughts are too rare, gains from insurance are low and if droughts are too frequent, gains are low. Paragraph below provides some intuition of this result. Starting from a virtual climate where drought is very rare, the premium is cheap, but the indemnity is rare, so that only the most risk adverse farmers want to get insurance. When p increases, the premium and indemnity increase in a fixed proportion, but the gain of insurance increases simply because the ponderation of the worst case $u(y-L)$ increases. But when p gets higher and the premium gets higher, the second worst case $u(y-m.p.L)$ gets closer to the worst case $u(y-L)$. The role of risk aversion on insurance tends to disapear as the insured payoff gets closer to the non-insured payoff. The bad situation without insurance is not bad enough any more in comparison with the case with insurance.

2.2.2 Maximum drought frequency

The questions we want to adress here is whether it exists a drought frequency p^{**} beyond wich is is not profitable to get insurance and in case it exists, what is the maximal insurable drought frequency?
In the particular well known case with actuarialy fair rate $m = 1$ and no basis risk $r = 0$, ΔEU remains positive for all values of $p \in]0;1[$ ($\Delta EU = 0$ for $p = 0$ or $p = 1$).
In the case with $m > 1$ or $r > 0$, the existence of p^{**} is certain if $\Delta EU(p = 1) < 0$, because u is concave on p on $[0;1]$, increasing in p for $p = 0$ and decreasing in p for $p = 1$. Since $\Delta EU(p = 1) < 0$ is equivalent to $r > \frac{u(y-m.(1-r)L-u(y-L)}{u(y-m.(1-r).L-u(y-m.(1-r).L-L}$, and since this fraction is negative, the existence of p^{**} is certain.

The variation of p^{**} with r however is non trivial. For our empirical purpose, we can approximate our problem with a Taylor development series, noting that in our experimental framework, as well as in reality in Burkina, the insurance premium is much lower than the income in case of good weather ($P << y$). In reality indeed, the average premium in Burkina Faso is around 10 000FCFA per hectare for an insurance on maize and the average income from maize production in the area where insurance exists is around 300 000FCFA per hectare. The average ratio P/y is around one one thirty, which allows the following approximation : $u(y-P) = u(y) - Pu'(y)$. The aim is to provide a handable expression of p^{**}, for ordinary values of P.

Under these conditions, we can rewrite ΔEU as

$$\Delta EU \approx p.(1-r).u(y) - P.(1-r.p).u'(y) - p.(1-r)u(y-L) - P.r.p.u'(y-L) \quad (3)$$

Which we can use to solve $\Delta EU = 0$ in terms of p, after replacing P by $mpL(1-r)$. This defines the maximal value $p^{**} \in]0;1[$ such that if $p \geq p^{**}$ then $\Delta EU \leq 0$. Everybody subscripts to insurance for $p \in]0;p^{**}[$ and nobody gets insurance for $p \geq p^{**}$

$$p^{**} \approx \frac{u(y) - u(y-L) - m.L.u'(y)}{m.L.r\left[u'(y-L) - u'(y)\right]} \quad (4)$$

It is clear from this expression that $0 < p^{**} < 1$ and that $\frac{\partial p^{**}}{\partial r} < 0$. This means that the maximal insurable drought frequency decreases as basis risk increases. In other words, when basis risk increases, insurance adoption decreases. Also note that r and p are substitute in expression (6) and a maximal admissible basis risk can be defined for each drought frequency for insurance to be interesting. In practical terms, farmers get insurance if the loading factor is not too great and if the drought frequency is not too great.

Proposition 2. *If* $m < \frac{u(y)-u(y-L)}{L.u'(y)}$, *there exists a unique* $p^{**} \in]0;1[$ *such that* $\forall p \in]0;p^{**}[\quad \Delta EU > 0$ *and* $\forall p \in [p^{**};1] \quad \Delta EU \leq\leq 0$

2.2.3 Expected impacts

The decision to take an insurance or not is a binary decision that directly derives from the continuous variable ΔEU. But because there is some unobserved heterogeneity among farmers we define a decision variable $x = 1$, iff $\Delta EU > 0$ and $x = 0$, iff $\Delta EU \leq 0$. Including inobservable heterogeneity among agents, we create an individual adoption variable $\tilde{x_i} = x + \epsilon_i$, and get the following expected effects:

Proposition 3. *If* $m < \frac{u(y)-u(y-L)}{L.u'(y)}$ *and if* $P << y$,

$\frac{\partial prob(\tilde{x_i}=1)}{\partial m} < 0$
Insurance demand is a decreasing function of the loading factor.

$\frac{\partial prob(\tilde{x_i}=1)}{\partial r} < 0$

Insurance demand is a decreasing function of basis risk.

$\frac{\partial prob(\tilde{x_i}=1)}{\partial p} < 0 \quad iff \quad p > p^*$
Insurance demand is a decreasing function of drought frequency (p) for sufficiently high frequencies.

$\frac{\partial^2 prob(\tilde{x_i}=1)}{\partial rp} < 0$
The higher the basis risk, the lower is the (positive or negative) impact of p on insurance demand.
$\frac{\partial^2 prob(\tilde{x_i}=1)}{\partial mp} < 0$
The negative effect of drought frequency on insurance demand is greater for higher values of loading factor.
$\frac{\partial^2 prob(\tilde{x_i}=1)}{\partial rm} < 0$

Figure 1 shows the expected effect of an increase of basis risk (r) on expected utility.

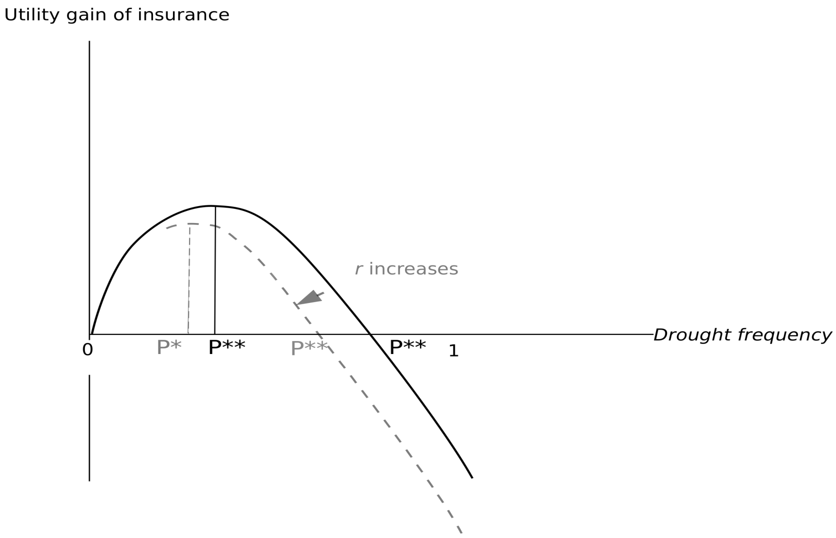

Figure 1: Expected effect of an increase of basis risk (r) on index insurance demand)

2.3 Drought frequency and insurance demand: case of a heavy loading factor

If the insurance company imposes a heavy loading factor $m \geq \frac{u(y)-u(y-l)}{lu'(y)}$, gains from insurance are always negative and farmers never get insurance, whatever basis risk and whatever drought frequency. To see this, we first note that in $p = 0$, $\Delta EU = 0$ and expression (2) is negative if and only if $m \geq \frac{u(y)-u(y-l)}{lu'(y)}$. Furthermore, we can show that ΔEU is concave in p on $[0; 1]$:

$$\begin{aligned}
\frac{\partial^2 \Delta EU}{\partial p^2} &= rm(1-r)Lu'(y-mp(1-r)L)+ \\
& rm(1-r)Lu'(y-mp(1-r)L)+(1-rp)m^2(1-r)^2L^2u''(y-mp(1-r)L) \\
& -m(1-r)Lru'(y-mp(1-r)l-l)-rm(1-r)Lu'(y-mp(1-r)l-l) \\
& +rpm^2(1-r)^2l^2u''(y-mp(1-r)l-l)
\end{aligned} \tag{5}$$

Or after rearranging,

$$\begin{aligned}
\frac{\partial^2 \Delta EU}{\partial p^2} &= 2rm(1-r)L\left[u'(y-mp(1-r)L)-u'(y-mp(1-r)l-l)\right]+ \\
& +(1-rp)m^2(1-r)^2L^2u''(y-mp(1-r)L) \\
& +rpm^2(1-r)^2l^2u''(y-mp(1-r)l-l)
\end{aligned} \tag{6}$$

Concavity of u ensures that $u'(y-mp(1-r)L) < u'(y-mp(1-r)l-l)$ and that $u'' < 0$. We thus have $\frac{\partial^2 \Delta EU}{\partial p^2} < 0$. Since $\Delta EU = 0$ when $p = 0$, ΔEU is decreasing in p for $p = 0$ and $\frac{\partial^2 \Delta EU}{\partial p^2} < 0$, this proves that $\forall p \in [0;1], \Delta EU \leq 0$, and nobody gets insurance, no matter the drougth frequency or the basis risk.

3 Experimental design and estimation

Agriculture in Burkina Faso is dominated by grain and cotton production. Grain production tends to be oriented towards self consumption strategies, especially millet and sorghum. Maize is partly sold in the domestic markets. Millet, sorghum and maize are rain fed crops : yields are highly depending on the occurence of drought. In november 2015, we led a field experiment with 205 farmers in Burkina Faso to simulate the influence of different insurance policies on insurance demand.

3.1 Sample description

9 villages were randomly selected in two different departments of Burkina. We led field experiment sesions in each village, with 20 or 25 farmers. A total number of 205 producers were surveyed into those 9 villages and participated to the insurance field experiment.

3.2 The insurance field experiment

We went trough two main sessions to lead the field experiment. As an introduction, we briefly described drought index insurance to the farmers: its principle, the frequency of the insured droughts, the existence of basis risk, the premiums farmers have to pay in case they want to contract an insurance policy and the payouts they received from the insurer in case of a drought occurs and is effectively being paid. Then, in a first session, we run an hypothetical training session of contextualized games of insurance contracts

Table 2: Households characteristics

Variable	Obs.	Mean	Std. Dev.	Min	Max
sex	205	1.3	0.5	1	2
age	204	40	12	17	72
alphabetization	204	0.5	0.5	0	1
number of household members	204	9	5	1	30
total acreage (ha)	198	3.2	2.3	0.25	15
sorghum acreage (ha)	205	1.6	1.6	0	10
maize acreage (ha)	205	0.5	0.8	0	5
millet acreage (ha)	205	0.7	0.8	0	4
cattle	202	1	3.3	0	40

where farmers had to choose to take up the insurance or not, on the basis of 18 examples of insurance contracts. In the first session, none of farmers choices were paid. In a second sesion, we then run a incentivized session of the same contextualized games where farmers were presented 18 insurance contracts that were similar to the training session contracts. In this second session, 2 of 18 choices were paid to the farmers, with a x100 down scaling factor, at the end of the session.
Contracts presented were calibrated with existing insurance contracts in Burkina Faso. Contracts proposed were all based on the following characteristics : a fixed surface of 0.5 ha of maize, and an outcome based on maize production of 800 kg in a normal year, yielding an income of 80 000 Fcfa, and zero production in a dry year, yielding a nil income. For each of the 18 examples, we offer the farmer a contract defined by the drought probability, the basis risk, the premium, and the payoffs. The insurance premium differs for each one of the 18 questions, with a minimum of 2 000 Fcfa (rare drought, high basis risk, no loading factor) and a maximum of 56 000 Fcfa (frequent drought, no basis risk and high loading factor). Table 8 in appendix 6.2.3 summarizes these 18 products. Insurance premium mechanically increases with the loading factor, the frequency of the insured drought and the lowering of the basis risk. For each one of the 18 questions, once farmers have chosen to subscribe or not to the insurance, we run the lotteries. The climate random selection is made by a child with banded eyes who picks one ball in the drought lottery, and in case he picks a drought ball, the basis risk lottery is then played.

Drought lottery
The drought occurence is the result of a lottery, materialized by a transparent bowl with table tennis balls of white and orange colors. The proportion of balls of each color reflects the drought frequency. The drought frequency varies from 1/20 to 7/20, and the number of "drought-balls" (orange ones) in the bowl varies from 1 to 7 and the number of "rain-balls" varies from 19 to 13 (white ones).

Basis risk lottery
The second lottery represents basis risk, and is played for contracts with basis risk (12

of 18 choices) and only if a drought occurred in the first lottery. The second lottery is materialized by a different transparent bowl with table tennis balls of black and red colors. The proportion of balls of each color reflects the basis risk. Basis risk varies from 0 to 2/5 and the number of risky balls (black ones) in the bowl varies from 0 to 2 while the number of non risky balls varies from 5 to 3 (red ones).

3.2.1 Training session

The training session is made of 18 examples. The nine first examples correspond to actuary fair rate insurance policies (m=1), the nine subsequent ones correspond to insurances with insurer profit (m=1.5). For each subset of those nine examples, the examples with no basis risk are played first, and correspond to examples 1 to 3 and 9 to 11. Examples with basis risk correspond to examples 4 to 8 and 12 to 18.
Examples without basis risk
In examples without basis risk, the decision scheme is straightforward as we don't have to go though the second lotetry that is conditional on the occurence of a drought in the first lottery. Once the contract is defined, each farmer decides if he subscribes to the insurance, if so he notes down if he pays the premium, then the lottery is played. If a drought-ball is picked, insured farmers receive an indemnification of 80 000FCFA to compensate for their outcome loss and are told their net income (80 000FCFA minus the premium); while non insured farmers receive nothing. If a rain-ball is selected, insured and non insured farmers receive 80 000FCFA for their outcome, but insured farmers have a lower net income (80 000FCFA minus the premium).
Examples with basis risk
In examples with basis risk, two sequential lotteries are used. The first lottery is the climate lottery, as described above. If the result is "rain", no other lottery is used and payments are validated. If the result is "drought", a second lottery is used, the basis risk lottery, which decides whether the insured farmers actually get indemnified or not. The probability of getting indemnified, conditional on a drought, is $(1-r)$. The number of black balls among this second lottery indicates the level of basis risk (0, 1 or 2 black balls). If a black ball is picked, the insured farmers actually loose money, as they are not compensated for their outcome loss and they had to pay a premium.

3.2.2 Incentivized session

The inventivized session is the same one as the training session, except that the farmers are told that 2 of their 18 choices will be paid. They have to decide whether they want to subsribe to an insurance policy for 18 situations that exactly correspond to the ones presented during the training session, and 2 choices will be randomly selected. Farmers will be given the money fixed by the contract they get or not, depending on the drought lottery and the basis risk lottery. A first payment is registered at the end of the first nine choices on the actuary fair rate experiment, and a second payment is registered at the end of the other nine choices on the high loading factor experiment. Paiements are made at the end of the incentivized session, with a x100 down scaling factor. The

average gains were around 700 Fcfa for the first set of nine questions and around 600 Fcfa for the second set of nine questions. The overall average gains was thus 1300 Fcfa (about 2.2 usd), corresponding to about 1 working days wage in BF.
Because of the existence of basis risks, some farmers may loose money. Those situations could only occur under four conditions: (1) the farmer decided to subscribe to insurance to question 3 or to question 12, (2) the randomly paid choices correspond to question 3 or to question 12, (3) a drought ball is picked in the first lottery and (4) a black ball is picked in the basis risk lottery. The maximum losses are of 280 FCFA for question 3 and of 560 FCFA for question 12. We attributed a fixed amount of 840 FCFA to each participant before beginning, so that liquidity is not a constraint to participation and no farmer can loose money during the experiment. For practical reasons, no cash was manipulated during the experiment, the paiement was made at the end of the experiment. Table 3 details paiments of the incentivized session, to be multiplied by 100 to obtain contextualized outcomes (cf. table 8).

Table 3: Insurance contracts characteristics and lotteries expected gains

choice	load.	basis	drought	premium	outcome (Fcfa)					expec. gains (Fcfa)	
(#)	fact.	risk	freq.	(Fcfa)	not insured		insured			not	insured
	m	r	p	P	rain	drought	rain	drought		insured	
								indemn.	No indemn.		
					$(1-p)$	p	$(1-p)$	$(1-r).p$	$r.p$		
1	1	0	1/20	40	800	0	760	760	-40	760	760
2	1	0	2/20	80	800	0	720	720	-80	720	720
3	1	0	7/20	280	800	0	520	520	-280	520	520
4	1	1/5	1/20	30	800	0	770	770	-30	760	760
5	1	1/5	2/20	60	800	0	740	740	-60	720	720
6	1	1/5	7/20	220	800	0	580	580	-220	520	520
7	1	2/5	1/20	20	800	0	780	780	-20	760	760
8	1	2/5	2/20	50	800	0	750	750	-50	720	720
9	1	2/5	7/20	170	800	0	630	630	-170	520	520
10	1.5	0	1/20	80	800	0	720	720	-80	760	720
11	1.5	0	2/20	160	800	0	640	640	-160	720	640
12	1.5	0	7/20	560	800	0	240	240	-560	520	240
13	1.5	1/5	1/20	60	800	0	740	740	-60	760	730
14	1.5	1/5	2/20	130	800	0	670	670	-120	720	650
15	1.5	1/5	7/20	450	800	0	350	350	-450	520	290
16	1.5	2/5	1/20	50	800	0	750	750	-40	760	730
17	1.5	2/5	2/20	100	800	0	700	700	-100	720	670
18	1.5	2/5	7/20	340	800	0	460	460	-340	520	350

Table 4 describe the samples of both insurance games.

Table 4: Contract choices offered by villages

Lotteries	choices	Nb villages	Nb prod	Nb obs.
Actuarially fair (m=1)	1 to 9	10	205	1,841
Loading factor (m=1.5)	10 to 18	6	130	1,168

Note: insurance with m=1.5 could not be played in 4 out of 10 villages

3.3 Estimation strategy

To identify the specific effect of insured droughts frequency on farmers insurance demand, we ran panel analysis. The general specification of our empirical model is as follows:

$$Adoption_{it} = a_0 p + a_1 m + a_2 r + \beta X_{it} + b_0 + b_1 \eta_t + \epsilon_i t \quad (7)$$

where $Adoption_{it}$ is a dummy variable taking 1 if the choice it is to get insurance, i is an individual index and t is an index for the choice identification. Vector X_{it} is a vector of control variables used in the random effects estimations only (table **??**) and η_t are individual effects (random or fixed). Our data set has a panel structure with 205 cross sections (individuals) and 18 times series (choices offered). The use of a probit fixed effects panel regression would be helpful to handle unobserved heterogeneity between observations, but would potentially be biased because the decision variable is a dummy variable. Thus, building upon Greene's suggestion (Greene, 2003), in a first step we estimate a probit random effects panel regression, with bootstrapped standard errors. The Maximum Likelihood Estimator of this model is the efficient-unbiased estimation method in case of no correlation between error terms and random effects. However, Hausman's test (Ho rejected significantly with Prob chi2 = 0.0000 and robust to specification changes) indicates that there exists unobserved fixed individual effects, thus arguing in favor of the use of a fixed effect model.

To handle for these unobserved individual fixed effects, in a second step, we estimate a logit fixed effects panel regression. Indeed, Greene (2003) recommends to use the Chamberlain's (Chamberlain, 1984) conditional maximum likelihood estimator to estimate a fixed effects logit panel (alternatively called conditional logit) which is unbiased if the individual effects are constant indeed. Given Hausman test ran after logit estimations we have an unbiased estimator.

4 Results

4.1 Overall insurance demand

Table 5 shows the summary statistics of the insurance games.

Table 5: Descriptive statistics of the insurance games

	Obs	Mean	Std. Dev.	Min	Max
take up if m=1	1841	0.81	0.39	0	1
take up if m=1.5	1168	0.67	0.47	0	1

Overall, we obtain high insurance take up rates, on average 80% for actuary fair rate and 67% with a loading factor $m = 1.5$ (table 5), comparable to other similar real earning games of contextualized agricultural insurance among farmers (Petraud, Boucher, Carter, et al., 2014).

Contrarily to other empirical experiments[1], uptake rates are very high in our experiment. We clearly have a bias towards insurance taking, but we argue that explaining variations of take-up in our experiment may however be informative for increasing uptake in real life index-insurances. Our experiment tries to reconcile a huge gap between theoretical models that would predict every risk averse farmer should buy an actuarially fair rate insurance and empirical studies showing the very low interest for such products.

We are confident that m=1.5 is inferior to the limit for which insurance is no more interesting to farmers ($m \geq \frac{u(y)-u(y-l)}{lu'(y)}$, cf. section 2.3) for two reasons: first uptake rates are still very high with m=1.5 and computations (available on request) with a CRRA function and for acceptable values of risk aversion and initital (certain) income showed that the bound values is under 1.5.

4.2 Explaining individual insurance demand

We hereby present our results following two main econometric models : a probit random effects panel model (table 6) and a logit fixed effects panel model (table 7). In table 6, the different specifications correspond to the inclusion of village fixed effects (see specifications corresponding to columns 2 and 4), and of interaction variables (columns 3 and 4). Fixed effects couln't be included in the logit fixed effect model (table 7), the specifications correspond to the variables of interests included, namely p, m and r (column 1), and the interaction variable (columns 2).

After having estimated the specifications of our logit model, we ran Hausman tests to test the similarity of coeficients between logit and probit models. Those tests confirm that we have an unbiased fixed effect estimator and thus that our logit results are valid.

Moreover, basic farmers individual characteristics, were found to be unsignificant (cf. table 10 in the Appendix, section 6.3). Clustered simple probit (without considering panel structure of the data) regressions are provided as a robustness check in the Appendix (cf. table 11).

Probit and logit panel models regressions validate that increasing the loading factor and the basis risk reduces insurance adoption. The demand for insurance decreases with the loading factor, which is in accordance with previous results in the literature (Mobarak and Rosenzweig, 2012; Karlan, Osei, Osei-Akoto, and Udry, 2014). It also

[1]Cf. section 1

Table 6: Drivers of insurance hypothetical adoption, xtprobit (RE), games 3 (fair rate) & 4 (heavy loading)

	(1) adoption	(2) adoption	(3) adoption	(4) adoption
m	-1.152^{***}	-1.130^{***}	-0.336	-0.318
	(0.285)	(0.265)	(0.265)	(0.329)
p	-1.417^{***}	-1.417^{***}	2.936^{***}	2.938^{***}
	(0.326)	(0.359)	(0.779)	(0.829)
r	-0.506^{**}	-0.505^{*}	-0.505^{**}	-0.504^{**}
	(0.233)	(0.297)	(0.250)	(0.207)
$p \times m$			-3.040^{***}	-3.046^{***}
			(0.508)	(0.565)
Constant	3.237^{***}	2.751^{***}	2.273^{***}	1.801^{***}
	(0.450)	(0.623)	(0.437)	(0.660)
lnsig2u	1.088^{***}	0.942^{***}	1.147^{***}	0.997^{***}
	(0.161)	(0.194)	(0.184)	(0.195)
Observations	3009	3009	3009	3009
Village fixed effects	No	Yes	No	Yes

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 7: Drivers of insurance hypothetical adoption, xtlogit FE, games 3 (fair rate) & 4 (heavy loading)

	(1) adoption	(2) adoption
m	-1.919^{***}	-0.498
	(0.225)	(0.312)
p	-2.402^{***}	5.320^{***}
	(0.445)	(1.283)
r	-0.886^{**}	-0.883^{**}
	(0.357)	(0.363)
$p \times m$		-5.480^{***}
		(0.864)
Observations	1596	1596
Prob > chi2	0.0000	0.0000

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

decreases with basis risk, which is also consistent with previous empirical results (Giné, Townsend, and Vickery, 2008; Giné and Yang, 2009; Cole, Giné, Tobacman, Topalova, Townsend, and Vickery, 2013). Those results are consistent with theoretical predictions (Clarke, 2016) and with expected effects identified in *Proposition 3* of our conceptual model for moderate loading factors situations.
Probit and logit panel models regressions validate that the demand for insurance decreases with drought probability. This result is robust to all the specifications presented here. It tends to indicate that in the trade-off between smoothing income and maintaining a higher income average, the second effects tend to dominate the first effect as the drought frequency increases. It is consistent with our conceptual model, if we consider the range of frequencies beyond the optimal frequency (see *Proposition 3*), in the case of an insurance policy with a moderate loading factor. Now, if we look at the effect of frequency combined with loading factor, we observe that the higher the loading factor, the higher is the negative effect of the probability of insured shock (table 6, columns 3 and 4 and table 7, column 2). This implies that, as showed in the theoretical model, the optimal level of shock insured depends on the insurer loading.

We thus validated our model predictions, regarding the expected effects of the type II basis risk (r) and the loading factor (m). The probability of the shock (p) negatively affects adoption and the concavity of such impact cannot be validated with the 3 values of p tested (squared value of p is found unsignificant in all specifications, regressions available on request).

The role of the loading factor (m) on the effect of drought frequency (p) on insurance uptake is found coherent with the model predictions (a higher loading factor will enhance the negative role of p on the demand).

5 Conclusion

While insurers and reinsureres are reluctant to supply insurance products against frequent damages, it seems that, in the context of index-based insurances and developing countries, a trade-off between basis risk level and indemnification rate exists for a given level of losses.

Index-based insurance products, by offering a choice in the trigger (strike) setting, allows to consider optimal hedging level and this should be considered in the contract policy design.

We find that high frequency droughts get out of the range of insurable droughts, especially with positive loading and basis risk. In order to increase uptake of such products, the pooling institution (either the state of a private agent depending on p) should take great care of the insurance strike (level of the index triggering payouts) setting, especially regarding long run historical series of yields and index and the underlying type II basis risk.

We thus deepen Clarke (2016) reasoning and show the major role of the probability of the covered shock and show that index insurance adoption depends also on the probability of the event insured and that optimal probability of shock to be insured depends on the loading factor and the basis risk.

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6 Appendix

6.1 Model proofs

6.1.1 proof ΔEU decreasing in p at $p = 1$

If $p = 1$,

$$\begin{aligned}&\tfrac{\partial \Delta EU}{\partial p} = -ru(y - m(1-r)L) - m(1-r)^2 LU'(y - m(1-r)L)\\&+ru(y - m(1-r)l - l) - rm(1-r)LU'(y - m(1-r)l - l)\\&+u(y) - u(y - l)\end{aligned} \tag{8}$$

Noting that

$$m(1-r)Lu'(y - m(1-r)L) \geq (1-r)[u(y) - u(y - m(1-r)L)] \tag{9}$$

and

$$mr(1-r)Lu'(y - m(1-r)L - l) \geq r[u(y - m(1-r)L - l) - u(y - l)] \tag{10}$$

we can write

$$\begin{aligned}&\tfrac{\partial \Delta EU}{\partial p} \leq -ru(y - m(1-r)L) - (1-r)[u(y) - u(y - m(1-r)L)\\&+ru(y - m(1-r)l - l) - r[u(y - l) - u(y - m(1-r)L - l)]\\&+u(y) - u(y - l)\end{aligned} \tag{11}$$

This expression can be reorganised in the following way

$$\begin{aligned}&\tfrac{\partial \Delta EU}{\partial p} \leq -[u(y - l) - u(y - m(1-r)L)]\\&-r\left[2[u(y - m(1-r)L) - u(y - m(1-r)l - l)] - [u(y) - u(y - l)]\right]\end{aligned} \tag{12}$$

Two cases should be distinguished.

If $m \geq \frac{1}{1-r}$, $u(y - m(1-r)L) - u(y - l) \leq 0$. Furthermore, concavity of u implies that $u(y) - u(y - l) < u(y - m(1-r)L) - u(y - m(1-r)l - l)$, thus $u(y) - u(y - l) < 2[y(y - m(1-r)L) - u(y - m(1-r)l - l)]$. Theen, $\frac{\partial \Delta EU}{\partial p} \leq 0$.

If $m \leq \frac{1}{1-r}$ the same expression can be reorganised in

$$\begin{aligned}&\tfrac{\partial \Delta EU}{\partial p} \leq -r\left[u(y - l) - u(y - m(1-r)L - l)]\right]\\&-[[u(y - l) - u(y - m(1-r)L - l)] - r[u(y) - u(y - m(1-r)L)]]\end{aligned} \tag{13}$$

where both brackets are negative since u is concave.
$\forall p \in [0; 1] \qquad \frac{\partial \Delta EU}{\partial p} \leq 0$

6.1.2 proof $\Delta EU(p = 1) < 0$

$$\begin{aligned}\Delta EU(p = 1) = &-[u(y - l) - u(y - m(1-r)L)]\\&-r[u(y - m(1-r)L) - u(y - m(1-r)L - l)]\end{aligned} \tag{14}$$

where both brackets are positive if $m \geq \frac{1}{1-r}$

If $m < 1/(1-r)$ and $r < \frac{u(y-l) - u(y - m(1-r)L}{u(y - m(1-r)L - u(y - m(1-r)L - l}$, $\Delta EU > 0$.

6.2 Experimental protocol

6.2.1 Introductory comments

You have the possibility to participate to a field experiment about drought insurance. Drought insurance is an agreement between a farmer and an insurer such that the farmer pays a premium in May and in case of drought, he receives an indemnity in November. We will describe 18 types of insurance, and for each one, you have to decide if you want to get the insurance and pay the premium. A the end of the experiment, you will get the amount of money that is defined in these contracts, depending on the choices you made in these games, and on the occurrence of drought or not. Out of the 18 choices, two will be randomly selected, and these two choices will determine how much money you will win. The amount you will win depends on your choices, but also on random since the occurrence of drought or rain is random. This money will be yours.

If you have questions during the games, raise your hand and we will answer to you. It is important that you do not talk with one another once the game has started. There is no false or true answer. It is important that you do not try to look at your neighbour's sheet.

This game will last 2 hours. If you think you cannot stay for 2 hours, please tell it now.

6.2.2 Instructions given to farmers. Training examples

Before starting with the experiment, we give two examples.
In this game, we consider that you produce maize and you have the choice to get an insurance against drought on your maize production.

In the example, you cultivate half an ha of maize and your yield is 8 bags of 100kg if the rain is good and 0 bag if there is a drought. Each bag you produce is sold 10 000Fcfa. If the rain is good, you earn 80 000Fcfa and if there is a drought you earn zero.

In the first example, drought is rare. There is a drought once every 20 years. In May, you decide to subscribe the insurance, then you pay a premium of 4 000Fcfa or not to subscribe to the insurance, and not to pay the premium. Then we must know if there is rain or drought. To do so, we put one orange ball in the bowl and 19 white balls in the bowl. A child with banded eyes picks one ball .
If he picks a white ball, the season is rainy and the harvest is good. If you have paid the insurance premium (4000F)the harvest value is 80000 Fcfa so that your income is 76000 Fcfa. If you did not pay the insurance, your income is 80000 Fcfa.
If the child picks the orange ball, the season is dry and the harvest is nil. If you had paid the premium (4000F) you get an indemnity to compensate for your loss (80 000Fcfa), so that your income is 76 000Fcfa. If you did not pay the premium, you get zero.
The choice you have to make is: "do you want to subscribe to this insurance ?"

In the second example, the drought is still rare, but there is a small risk that the insurer makes a mistake and does not pay the indemnity. There is one drought every 20 years and the insurer can make a mistake twice over ten times. This means that if there is a drought and if you have paid the premium, there is 2 chances over 10 that the insurer does not pay the premium. This is because, for example, the insurer thinks that there has been rain but in reality, the rain has not fallen on your field or not during the useful period. The insurance premium is then cheaper (3 200Fcfa) because the insurer knows that he can make mistake. First you decide to pay the insurance premium or not, and then the child picks a ball in the bowl to check if the weather is rainy or dry.
If he picks a white ball, there is rain. Every body harvest 80 000Fcfa. the income of those who have paid the premium is 76 800 Fcfa, and those who have not paid the premium get 80 000Fcfa.
If the child picks an orange ball, there is a drought. The harvest is zero. Those who did not take the insurance get zero. The income of those who took the insurance depends on the issue in the bucket. In the bucket, there is two red balls and 8 orange balls. If the child picks a red ball, those who have paid the insurance get zero from the insurer, so that they have lost 3 200 Fcfa. If the child picks an orange ball, the income of those who have paid the insurance is 76 800 Fcfa.
The choice you have to make is: “do you want to subscribe to this insurance ?” Do you have questions ? has every one understood everything ?

6.2.3 Instructions given to farmers. Incentivised experiment

Now, the game is for real money. For each type of insurance, we will tell you the amount of the premium, the frequency of drought, and the risk that the insurer makes a mistake. For each type of insurance, you decide if you want to pay the premium or not. If you want to pay the premium, you make a cross in the blue column. If you do not want to pay the insurance, you make a cross in the yellow column. There are 18 choices in this game, for 18 types of insurance. At the end of the game, a child will pick two of the 18 balls with a number in this cage. The number on these two balls indicate the number of the choice for which you will receive money. Then , the child will pick one ball in the bowl to know if the rain was good, and one ball in bucket to know if you get the indemnity from the insurer. You will then receive the amount of money corresponding to your decision to get insurance or not. In the previous examples, the price of a bag is 10 000Fcfa. In the experiment, it is 100Fcfa. In the first example above, this means that the harvest is 800Fcfa instead of 80 000Fcfa if there is rain, and the premium is 40Fcfa instead of 4000Fcfa.

Do you have questions ? has every one understood everything ?

- Insurance 1. Drought occurs once every twenty years, and the insurer makes no mistake. The premium is 40Fcfa. There are 19 white balls and 1 orange ball in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 760, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who take the insurance get 760, those who do not take the insurance get zero. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 2. Drought occurs twice every twenty years, and the insurer makes no mistake. The premium is 80Fcfa. There are 18 white balls and 2 orange balls in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 720, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who take the insurance get 720, those who do not take the insurance get zero. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 3. Drought occurs seven times every twenty years, and the insurer makes no mistake. The premium is 280Fcfa. There are 13 white balls and 7 orange balls in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 520, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who take the insurance get 520, those who do not take the insurance get zero. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 4. Drought occurs once every twenty years, and the insurer makes 2 mistakes over 10 cases. The premium is 30Fcfa. There are 19 white balls and 1 orange ball in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 770, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who do not take the insurance get zero and the income of those who take the insurance depends on the bucket issue. If the child picks a red ball in the bucket, they lose their 30 F and if the child picks an orange ball, they get 770Fcfa. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 5. Drought occurs twice every twenty years, and the insurer makes 2 mistakes over 10 cases. The premium is 60Fcfa. There are 18 white balls and 2 orange balls in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 740, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who do not take the insurance get zero and the income of those who take the insurance depends on the bucket issue. If the child picks a red ball in the bucket, they lose their 60Fcfa and if the child picks an orange ball, they get 740Fcfa. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 6. Drought occurs seven times over twenty years, and the insurer makes 2 mistakes over 10 cases. The premium is 220Fcfa. There are 13 white balls and 7 orange balls in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 580, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who do not take the insurance get zero and the income of those who take the insurance depends on the bucket issue. If the child picks a red ball in the bucket, they lose their 220Fcfa and if the child picks an orange ball, they get 580Fcfa. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 7. Drought occurs once every twenty years, and the insurer makes 4 mistakes over 10 cases. The premium is 20Fcfa. There are 19 white balls and 1 orange ball in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 780, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who do not take the insurance get zero and the income of those who take the insurance depends on the bucket issue. If the child picks a red ball in the bucket, they lose their 20Fcfa and if the child picks an orange ball, they get 780Fcfa. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 8. Drought occurs twice every twenty years, and the insurer makes 4 mistakes over 10 cases. The premium is 50Fcfa. There are 18 white balls and 2 orange balls in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 750, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who do not take the insurance get zero and the income of those who take the insurance depends on the bucket issue. If the child picks a red ball in the bucket, they lose their 50Fcfa and if the child picks an orange ball, they get 750Fcfa. Do you want to pay the premium and subscribe to the insurance ?

- Insurance 9. Drought occurs seven times every twenty years, and the insurer makes 4 mistakes over 10 cases. The premium is 170Fcfa. There are 13 white balls and 7 orange balls in the bowl. If the child picks a white ball, there is rain, and those who take insurance win 630, and those who do not take insurance win 800Fcfa. If the child picks an orange ball, harvest is nil, those who do not take the insurance get zero and the income of those who take the insurance depends on the bucket issue. If the child picks a red ball in the bucket, they lose their 170Fcfa and if the child picks an orange ball, they get 630Fcfa. Do you want to pay the premium and subscribe to the insurance ?

Nine similar choices are made in the case where the insurer makes profit (loading factor $m = 1.5$). The 18 insurance products are summarized below.

Table 8: Hypothetical premiums and loading factors, basis risks and drought frequencies

choice number	Loading factor	Basis risk	Drought frequency	Premium (Fcfa)	Outcome					Δ Expected gain
					not insured		insured			
	m	r	p	P	Rain	drought	rain	Drought		
								indemnity	No indemnity	
1	1	0	1/20	4000	80000	0	76000	76000	-4000	0
2	1	0	2/20	8000	80000	0	72000	72000	-8000	0
3	1	0	7/20	28000	80000	0	52000	52000	-28000	0
4	1	1/5	1/20	3000	80000	0	77000	77000	-3000	0
5	1	1/5	2/20	6000	80000	0	74000	74000	-6000	0
6	1	1/5	7/20	22000	80000	0	58000	58000	-22000	0
7	1	2/5	1/20	2000	80000	0	78000	78000	-2000	0
8	1	2/5	2/20	5000	80000	0	75000	75000	-5000	0
9	1	2/5	7/20	17000	80000	0	63000	63000	-17000	0
10	2	0	1/20	8000	80000	0	72000	72000	-8000	-4000
11	2	0	2/20	16000	80000	0	64000	64000	-16000	-8000
12	2	0	7/20	56000	80000	0	24000	24000	-56000	-28000
13	2	1/5	1/20	6000	80000	0	74000	74000	-6000	-3000
14	2	1/5	2/20	13000	80000	0	67000	67000	-13000	-6000
15	2	1/5	7/20	45000	80000	0	35000	35000	-45000	-28000
16	2	2/5	1/20	5000	80000	0	75000	75000	-5000	-2000
17	2	2/5	2/20	10000	80000	0	70000	70000	-10000	-5000
18	2	2/5	7/20	34000	80000	0	46000	46000	-34000	-17000

Table 9: Matrice des paiements avec risque de base de type 2 en cas de scheresse ralise

		Producteur assure			Producteur non assure	
		Secheresse		Non secheresse	Secheresse	Non secheresse
P	Prime	Pas fiable	Fiable			
0,07	36	-36	464	464	0	500
0,08	42	-42	458	458	0	500
0,10	50	-50	450	450	0	500
0,13	63	-63	438	438	0	500
0,17	83	-83	417	417	0	500
0,25	125	-125	375	375	0	500
0,50	250	-250	250	250	0	500

6.3 Robustness checks

The results of probit panel specifications show no stable impact of household characteristics on adoption rates (table 10). We control for households characteristics and for productive assets, and notably for age and education (alphabetisation and secondary scholl attendance), number of members of the household, total acreage and cattle size.

As a second robustness check we show the results of a specification that doesn't take

Table 10: Drivers of insurance hypothetical adoption, xtprobit (RE), games 3 (fair rate) & 4 (heavy loading)

	(1) adoption	(2) adoption	(3) adoption	(4) adoption
m	−1.160***	−1.141***	−0.368	−0.352
	(0.286)	(0.277)	(0.247)	(0.316)
p	−1.425***	−1.425***	2.806***	2.805***
	(0.325)	(0.316)	(0.687)	(0.934)
r	−0.500**	−0.499**	−0.498*	−0.498**
	(0.205)	(0.224)	(0.259)	(0.251)
$p \times m$			−2.951***	−2.954***
			(0.491)	(0.616)
sex	0.401	0.449	0.416	0.462
	(0.332)	(0.356)	(0.404)	(0.323)
age	0.0255*	0.0184	0.0263*	0.0189
	(0.0145)	(0.0123)	(0.0137)	(0.0144)
alphabetisation	−0.166	−0.197	−0.170	−0.202
	(0.271)	(0.305)	(0.276)	(0.314)
secondary sch. att.	−0.554	−0.553	−0.565	−0.570
	(0.482)	(0.497)	(0.440)	(0.495)
# HH members	0.0144	0.0255	0.0153	0.0257
	(0.0308)	(0.0280)	(0.0350)	(0.0308)
cultivated area	−0.0731	−0.0990*	−0.0740	−0.100
	(0.0467)	(0.0582)	(0.0518)	(0.0668)
# cattle	0.0496	0.0374	0.0510	0.0382
	(0.0819)	(0.0850)	(0.0935)	(0.0941)
Constant	1.855*	1.561	0.859	0.608
	(1.012)	(0.986)	(1.069)	(0.958)
lnsig2u	1.014***	0.875***	1.070***	0.928***
	(0.162)	(0.206)	(0.210)	(0.234)
Observations	2928	2928	2928	2928
Village fixed effects	*No*	*Yes*	*No*	*Yes*

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

panel dimension of the data, a probit estimation robust to individual clustering (table 11).

Table 11: Drivers of insurance hypothetical adoption, robust to individual correlation, games 3 (fair rate) & 4 (heavy loading)

	(1) adoption	(2) adoption	(3) adoption	(4) adoption
m	-0.719^{***}	-0.671^{***}	-0.261	-0.205
	(0.152)	(0.162)	(0.161)	(0.161)
p	-0.740^{***}	-0.782^{***}	1.603^{***}	1.639^{***}
	(0.177)	(0.184)	(0.418)	(0.446)
r	-0.293^{**}	-0.310^{**}	-0.285^{**}	-0.302^{**}
	(0.140)	(0.143)	(0.141)	(0.145)
$p \times m$			-1.637^{***}	-1.695^{***}
			(0.278)	(0.304)
Constant	1.743^{***}	1.452^{***}	1.182^{***}	0.885^{***}
	(0.217)	(0.303)	(0.221)	(0.292)
Observations	3009	3009	3009	3009
Village fixed effects	*No*	*Yes*	*No*	*Yes*

Standard errors in parentheses, robust to individual clustering

* $p < .1$, ** $p < .05$, *** $p < .01$