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Methodological and Ideological Options

Investment, insurance and weather shocks: Evidence from Cambodia

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A B S T R A C T

The livelihoods of poor people in developing countries are increasingly dependent on weather shocks whose effects are exacerbated by the lack of access to adequate insurance markets allowing risk hedging. Index-based insurance underwrites a weather risk as a proxy for economic loss: when the index falls below a certain level, farmers automatically get a payment. The aim of this paper is to study the impact of an Index-based insurance on investment decisions in profitable but risky inputs in presence of weather shocks by means of an incentivized lab-in-the-field experiment conducted in Cambodia. The protocol is designed so as to study the extent to which investment decisions change under risk or ambiguity, for different levels of initial wealth, under contract nonperformance (i.e., when claims are not repaid by the insurer) and when the insurance is fully subsidized. The findings indicate that, while the mere presence of a market for insurance increases investment, the strength of the effect crucially depends upon the level of initial wealth and upon the subjects' ability to correctly assess the probability of a shock.

1. Introduction

The share of the world population living in extreme poverty fell sharply during the years of the Green Revolution (Mehta, 2018) as a result of the combination of investments that increased production, reduced risk and enhanced market access (Hansen et al., 2019). This reduction was, however, unequally distributed as rural poverty reduction was less evident in marginal production environments (Pingali, 2012). That is why, today, scholars and development practitioners are increasingly calling for a second Green Revolution, which could go beyond increased agricultural production per se, and mitigate the risks posed by increasingly extreme weather shocks (Hansen et al., 2019).

The effects of these shocks are often exacerbated by the lack of access to adequate insurance markets allowing risk hedging. The combination of vulnerability to shocks, lack of assets to fall back on and of risk management strategies can perpetuate poverty traps by preventing poor people from taking the risks involved in pursuing new opportunities and from using improved technologies (e.g., Carter and Barrett, 2006; Rosenzweig and Binswanger, 1993; Dercon and Christiaensen, 2011). Although this is common to all poor households, regardless of their income level, rural households living in rain-fed areas in dry sub-humid to arid agro-ecological zones (Zimmerman and Carter, 2003) tend to be particularly vulnerable since their survival strictly depends on fragile ecosystems and on rain-fed agriculture (Chen et al., 2016).

Formal insurance is deemed as a way to transfer risk from the insured to the insurer and to improve investment and use of risky but more remunerative tools (Hill and Viceisza, 2012). When insured households are hit by shocks, they receive or anticipate indemnity payments reducing their reliance on detrimental coping strategies such as distress sales of livestock, cut back on meals and pulling children from school to work (Janzen and Carter, 2019; ILO, 2016). At the same time, insurance alters farmers risk-taking behavior. In India, for instance, insured farmers shifted investments towards cash crops. Such crops are more sensitive to rainfall shocks but are expected to lead to higher returns (Cole et al., 2017). Furthermore, insurance might also catalyze opportunities. Lenders might be more willing to extend credit to insured farmers, allowing them to invest in more lucrative and productivity-enhancing assets. All these aspects mitigate the deleterious consequences of climate change in terms of food security and, ultimately, constitute a vehicle to poverty reduction.

Recently, practitioners and researchers have seen in Index-based insurance a way to reduce the high costs of information along with

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the problems of moral hazard and adverse selection associated with conventional loss-indemnifying insurance. This relatively new and innovative instrument underwrites a weather risk, typically highly correlated with yields in the region where the farmer lives, as a proxy for economic loss. When the index falls below a certain level, farmers automatically get a payment, without requiring the traditional services of insurance claims assessors. Although excitement for this instrument has grown rapidly over the past decade (Jensen et al., 2015), uptake has typically been quite low (Cole et al., 2013). The literature put forward many reasons to explain the observed low uptake of weather index insurance and, among those, farmers' subjective belief about the probability of a shock, their ability to understand the insurance product, their liquidity constraints and their level of trust (Giné et al., 2008).

The aim of this paper is to study the impact of an Index-based insurance on investment decisions in profitable but risky inputs in the presence of weather shocks by means of an incentivized lab-in-the-field experiment conducted in Cambodia. More specifically, we focus on how investment decisions in profitable but risky inputs change when the probability of a shock is known and when it is ambiguous – i.e., when events do not have a unanimously agreeable probability assignment (Ghirardato, 2004), both in presence and in absence of an Index-based insurance and of a subsidy to purchase it. Given the fact that the impact of insurance on risky inputs is ambiguous under financial constraints, we randomize subjects' initial endowments (i.e., we vary credit constraints).[1] Our design accounts also for the probability that insurance contracts may be nonperforming – i.e., valid insurance claims are not repaid by the insurer (Doherty and Schlesinger, 1991; Biener et al., 2019)–, a very common case in developing countries.

Our results suggest that although the mere presence of a market for insurance increases, overall, investment in profitable but risky inputs, this positive effect is significantly smaller for poor farmers under risk. Under ambiguity, poor farmers choose more frequently to invest only in risky inputs without buying an insurance with respect to rich farmers. When a subsidy is available, insured farmers invest significantly less than their uninsured counterparts. This extremely counterintuitive result could be interpreted as evidence that the provision of an insurance grant in a complete market discourages investment. However, it could hardly be extended to different contexts. Furthermore, it could be driven by the choice, which we recognize to be extreme, of fully subsidizing the insurance. In the conclusions we extensively discuss these possibilities. As far as the determinants of insurance purchase are concerned, our results confirm previous literature by showing that under ambiguity individuals form beliefs about expected return and risk using heuristic tools, such as past experiences (Tversky and Kahneman, 1971, 1974; Gallagher, 2014; Conrads et al., 2016). The quality of these experiences shapes, therefore, their choices.

Cambodia is an interesting case study with respect to insurance and exposure to weather shocks. With its tropical weather characterized by a monsoon and a dry season, it is one of the most disaster-prone country in Southeast Asia and, in 2013, it was one of the top three countries most affected by weather–related loss events (Kreft et al., 2014). Moreover, being dependent on agriculture, Cambodia is among the most vulnerable countries in Southeast Asia to climate change and this is basically due to major limitations in the capability of rural people to adapt to climatic stimuli, to cope with their impacts and effects, due to poverty, farming techniques and inadequate investments. During the past 50 years, steady climate shifts have been occurring throughout the country, such as rising in average temperature, shift in rainfall pattern and increase in flooding severity and frequency. Nevertheless, the current trend will continue and estimations of future climate change based on specific models suggest an increase in rainfall, flood and droughts, less predictable rainfall, longer dry season and shorter wet season with higher rainfall. Moreover, since the vast majority of people in poor areas rely on farm profits rather than wage income, and most farming in Cambodia is rain fed, those climate changes have affected, and are supposed to keep affecting, households' farm production, thus leading to agriculture failure and food insecurity (Bylander, 2015; Nguyen et al., 2015). Over the past two decades, Cambodia has also experienced a credit boom driven by the rapid expansion of the microcredit sector (Bylander et al., 2019). This growth has not always been coupled by a growth in income per capita, generating concerns about over–indebtedness (Seng, 2018). Cambodia offers an interesting case study also for another, more painful, motivation. The country experienced a bloody genocide which began with the capture of the capital, Phnom Penh, by Khmer Rouge forces in April 1975 and was followed by a civil war. During the period 1975–1979, urban areas were closed down by the regime, and urban residents were forcibly resettled in rural spaces (Rice and Tyner, 2017).

The remainder of the paper is organized as follows: Section 2 presents the research background, Section 3 presents the experimental design, Section 4 the results, while Section 5 discusses some policy implications and concludes.

2. Research background

This paper deep delve into the question of substitution, i.e., why subjects reduce the use of inputs when they are offered insurance, a question analyzed, among others, in Karlan et al. (2014) where the authors show that, *if credit constraints bind*, then insurance will reduce investment in a profitable technology. More specifically, this paper focuses on this issue in the context of Index-based insurances.

The literature on the relationship between investment decisions and Index-based insurance is growing. Carriquiry and Osgood (2012) theoretically show that farmers increase the level of inputs used when insured. The results are corroborated by Cai (2016), who uses a natural experiment and finds that farmers invest more and increase their first period consumption when insured, and by De Nicola (2015) who theoretically argues that weather insurance enhances the adoption of risky but more productive seeds. Cole et al. (2013) highlights that a risk averse farmer invests more in risky production when provided with insurance against production risk. In a field experiment Karlan et al. (2014) show that farm investments are lower if both credit and insurance markets are missing, that relaxing liquidity constraints enhances farm investment while provision of insurance grant discourage investment but only when markets are complete.[2] This evidence is corroborated by field studies involving randomized control trials and lab-in-the field experiments.

In a framed field experiment conducted with farmers in Ethiopia, Hill and Viceisza (2012) find a positive effect of insurance on technology adoption and, more specifically, on the purchase of fertilizers. In a Randomized control trial, Giné and Yang (2009) show that farmers are less likely to demand insured loans for purchasing high-yielding seeds compared to uninsured loan for the same product. In Janzen and Carter (2019), insured households in Kenya are less likely to sell their livestock following weather shock. Using the same methodology, Cole et al. (2013) find an increase in both investment in inputs for high yielding cash crops and land allocated for these crops. Recently, Cole et al. (2017) make use of a randomized controlled trial involving Indian farmers to show that insurance provision induces farmers to invest more in higher-return but rainfall-sensitive cash crops. This effect is found to be greater for more educated farmers.

In contrast with the above described literature, in this paper we make

[1] In fact, if insurance can promote investment in high-risk and high-return options, it can have an opposite effect when, by requiring payments in advance, it affects farmers' financial resources. As a result, farmers reduce investment in order to buy insurance.

[2] A market is complete when: 1) transaction costs are negligible and 2) there is a price for every asset in every possible state of the world (there is perfect information).

use of a laboratory experiment to study the differential effects of insurance on investment both in presence of risk and of ambiguity.

According to Ghirardato (2004), ambiguity refers to situations in which some events do not have a unanimously agreeable, probability assignment. This is exactly what farmers in developing countries experience when making decisions about the uptake of new crops or investment in new technologies under unknown risks (Engle-Warnick et al., 2007; Alpizar et al., 2011; Akay et al., 2012). Indeed, climate change and weather shocks are complex phenomena that can be considered as ambiguous since the risks associated with them are still un-measurable.

The role of ambiguity in insurance decisions (in some cases compared to risk-reduction investment decisions) has been analyzed both theoretically and through lab and field experiments. To date, a substantial body of literature shows that, faced with offering a contract under ambiguity, insurers increase their premiums, limit coverage, or are unwilling to provide insurance at all (Walker and Dietz, 2012; Kunreuther et al., 1995; Koufopoulos and Kozhan, 2014). At the same time, several experimental studies have shown that economic agents are, in general, ambiguity averse, i.e. they prefer to know the probability of an event rather than being uncertain about it (Attanasi et al., 2014). Alary et al. (2013) show that under risk aversion, more ambiguity-averse agents tend to have a lower willingness to pay for marginal investment in self-protection, but a higher willingness to pay for insurance and self-insurance. Bryan (2010) formalizes a model of ambiguity aversion where sufficiently ambiguity averse households will not value any actuarially fair insurance contract and they will have a lower willingness to pay for any specific contract. He tests the hypotheses of the model by using data gathered from Giné and Yang (2009) and Ashraf et al. (2009). Barham et al. (2014) find that ambiguity aversion has a differential effect in terms of adoption of improved seeds according to the typology of the technology proposed. Elabed and Carter (2015) offer theoretical and experimental evidence of the fact that index insurance contracts appears to the farmer as a compound lottery in which uncertainty arises both from individual production outcomes, as well as from the validity of the index itself in correctly assessing individual losses. This compound lottery structure dampens the demand for index insurance. As a result, designing contracts with minimal basis risk is crucial to increase insurance uptake.

Our paper innovates with respect to the existing literature along three main lines. First, the design of our experiment is such that we account for heterogeneous effects across wealth status. This is particularly relevant since the impact of insurance on risky inputs is ambiguous under financial constraints and structuring instruments that reach the poorest is often challenging (Poulton et al., 2006). Second, we account for the probability that insurance contracts may be nonperforming. This additional feature is particularly common in developing countries (Harrison and Ng, 2016) and can constraint the demand for insurance (Dercon et al., 2014; Banerjee et al., 2014; Jensen et al., 2018) while having also effects in terms of investment. Third, we consider both decisions taken under risk and ambiguity. Climate-related disasters, in fact, often have large impacts on the economy. However, they occur rarely and take place abruptly (Olijslagers and van Wijnbergen, 2019). Moreover, despite the remarkable accomplishments achieved by climate scientists and experts, the currently available information about future climate risks is still not perfectly specified by stochastic setups (Etner et al., 2020).

3. The experiment

3.1. Design

We study the impact of insurance on investment in the presence of risk and ambiguity by developing a game protocol in which subjects are asked to make decisions about the purchase of inputs. We refer to this baseline treatment as the *Input Treatment* ($T1_{r,\ a}$). To address the question of how insurance affects ex-ante risk taking behavior, we also consider three different treatments in which we manipulate the presence of the insurance, the presence of contract nonperformance and the presence of a subsidy to purchase the insurance. In the first treatment, the *Input Insurance Treatment* ($T2_{r,\ a}$), we introduce the possibility to buy an insurance against shocks. In the second treatment, the *Input Insurance Contract Nonperformance Treatment* ($T3_{r,\ a}$), we introduce the possibility to buy an insurance against shocks while we allow also for the presence of contract nonperformance (with a probability equal to either 1% or to 10%). In the third treatment, we offer to a small randomly drawn set of "poor" subjects a subsidy (equal to the cost of the insurance) to purchase the insurance. We refer to this treatment as the *Input Insurance Subsidy Treatment* ($T5_{r,\ a}$). As a further control, in the *Input Insurance Past Treatment* ($T4_{r,\ a}$), we give subjects a knowledge about the frequency with which shocks have occurred in the last 5 years, i.e., they know the frequency of previous events while they do not know the probability of occurrence of a shock.[3]

Before the start of the game, subjects were randomly assigned either to the status of poor or rich farmers, with a different initial endowment, and either to the risk or to the ambiguity group, in a between subject design as illustrated in Table 1. While in the risk variant of the game subjects know the probability of a shock, in the ambiguity variant of the game, subjects have no knowledge about the probability distribution. More specifically, under ambiguity, the subjects know only that, at the end of the game, a shock could occur but do not know the probability distribution of the event. On the contrary, under risk, the subjects know that, at the end of the game, a shock could occur with a probability equal to 20%. In order to make the treatment manipulation more understandable and more salient, the instructions (which are reported in the Appendix), included clarifying drawings. We furthermore adopted a physical implementation: at the end of the game an extraction actually happened from an urn containing colored balls. In the risk treatment, the participants in the game saw how many yellow balls (representing a shock) and how many white balls (representing the absence of a shock) were placed in the urn. In the case of ambiguity, no.

The protocol resulted therefore in 4 treatments (played one-shot) in a within-subjects design each one played in a rich/poor and in a risk/ambiguity variant in a between-subjects design. In order to minimize the consequences of possible order effects, in each session, we reversed the order of the treatments resulting in a total of 11 possible orders. The

Table 1
Treatments: number of observations.

		Between subjects				Total
		Poor		Rich		
		Risk	Ambiguity	Risk	Ambiguity	
Within subjects	T1	64	60	43	48	215
	T2	64	60	43	48	215
	T3, 1%	40	36	19	27	122
	T3, 10%	24	24	24	21	93
	T4	40	36	43	48	167
	T5	24	24			48

Notes: Subjects have undergone either T3,1% or T3,10%. T5 has been conducted on a randomly drawn set of subjects who have not undergone treatment T4. Recall: T1 = *Input Treatment*, T2 = *Input Insurance Treatment*, T3 = *Input Insurance Contract Nonperformance Treatment* (with a probability equal to either 1% or to 10%), T4 = *Input Insurance Past Treatment*, T5 = *Input Insurance Subsidy Treatment*.

[3] Notice that the results concerning this control treatment are available upon request since there is no significant difference with respect to the treatment under ambiguity.

results show no order effect.

3.2. The game

At the beginning of the game each player is endowed with $y_i^{r,p}$.[4] The player has to decide how many inputs to purchase using this initial endowment. Every input costs i ECU,[5] the experimental currency. To keep the initial capital operative, the player pays a sunk cost (k) regardless of the fact that he buys or not inputs.[6] Every input is productive and produces (r), where r represents the return to inputs, if a shock does not occur. As in Hill and Viceisza (2012), the return from inputs (r) depends on the probability of shock occurrence (p) at the end of the experiment. The initial endowment produces a fixed amount (f) if a shock does not occur, 0 if a shock occurs. Every input is non-productive and it produces 0 if a shock occurs. The player's income is therefore given by the following equation, with n being the number of inputs purchased:

$$y_f^{r,p} = y_i^{r,p} - k - ni + p(0) + (1-p)[(1+r)ni + f] \quad (1)$$

Payoff and the maximum amount of inputs that can be bought are set in order to insure that $y_i^{r,p} > k + ni$. Based on available World Bank's Cambodian data of climate change at the time the experiment was fielded,[7] the probability of a shock is set equal to 20% in the risk version of the game and is kept constant in the ambiguity version of the game and in the *Input Insurance Past Treatment* ($T4_{r,a}$).

In $T2$ the player has the possibility to purchase insurance at unit cost $m > 0$ (out-of-pocket). The insurance in case of a shock repays the investment made in inputs.

Purchase decisions for inputs and insurance are made simultaneously.

The game allows us to formulate some general hypotheses.

First, we expect a risk averse farmer to increase his inputs' choice when an insurance is available holding wealth and expectation of the weather constant. In fact, holding the number of inputs constant, the insurance reduces the spread between incomes when a shock occurs and when it does not occur, therefore reducing the variance. However, we expect this to hold only under risk and not under ambiguity. Under ambiguity, in fact, individuals form beliefs about expected return and risk using heuristic tools, such as past experiences (Kahneman and Tversky, 1979) and often place a greater weight on the worst signal (Li et al., 2017). It is plausible to expect, therefore, that insurance has no or a negligible effect on investment under ambiguity. Accordingly, wealth and the presence of a subsidy affects the budget constraint, therefore affecting inputs' choice. More specifically, we expect poor farmers to invest less both in the presence of risk and ambiguity. We also expect to witness an increase in investment when the insurance is subsidized.

3.3. Procedures

Our experiment took place in Saint Paul Institute (Takeo, Cambodia) in February 2016. The Saint Paul Institute is a Catholic Higher Education Institution in Cambodia. Established in 2009, it hosts more than 350 students, across a diverse range of undergraduate programs: Agronomy, Information Technology, Tourism Management, English Literature, and Social Work. Subjects were students from the undergraduate population of the Institute recruited by public announcement. Although the participants in the experiment are students, they constantly take part in the farming activities of their families and of the institute, which is located in the countryside, in the Angkorki Village, in Takeo Province.[8] In Section 3.4, we offer further descriptive statistics of the subject pool that will help us in better understanding why this population is well-suited for the purposes of the present research.

We run 11 sessions, with, on average, 19 subjects participating in each session, for a total of 216 subjects. Subjects were randomly assigned to a position upon arrival and were seated at spaced intervals. In order to maintain a high degree of experimental control, since only two of the experimenters spoke the subjects' national language, Khmer, all sessions were conducted by the same experimenter assisted by three research assistants who were trained on the protocols prior to the first session. This afforded the authors full control over both the explanation of the game protocol and of the questions arising from the participants. A picture of one session is reported in Fig. 1.

To ensure public knowledge, instructions were distributed and read aloud in Khmer. Instructions used loaded terms and probabilities were framed (physical implementation) by means of an urn containing white and yellow balls with a yellow ball indicating the realization of a shock. Given our subject pool, we tried to keep the game as simple and as close as possible to the Cambodian day-to-day decision making environment. To check comprehension, some control questions (the same for all participants) were administered after the instructions.

At the end of the experiment, one treatment was selected for payment by randomly extracting from an urn containing 4 numbers, only one number. Next, a ball was extracted from a dark urn containing yellow and white balls indicating the presence or absence of a shock, respectively. Subjects were then asked to answer to a questionnaire about socio-demographic background containing also questions about exposure to shocks, risk, time and discount preferences and household's composition.

Subjects earned, on average, 2 dollars for a session lasting on average 90 min, including the completion of a questionnaire regarding individuals and household characteristics. This payment compares to approximately one day of casual farm labor wage in this area. The experimental was conducted *paper and pencil*. The response tables and the experimental instructions are reported in English in the Appendix. Any

Fig. 1. Session example.

[4] With $y_i^r = 1000$ ECU and $y_i^p = 650$ ECU.

[5] With $i = 120$ ECU.

[6] This is equivalent to the consumption fee in Hill and Viceisza (2012).

[7] Source data: World Bank Group, Cambodia dashboard, http://sdwebx.worldbank.org/climateportalb/home.cfm?page=countryprofile&CCode=KHM.

[8] Moreover, although the median age of the sample appears to be low, it is only slightly lower with respect to the median age of the Cambodian population, which, in 2019, was of 26.4 years. In fact, although the age distribution of the population is becoming more balanced as the country recovers from its losses occurred during the Khmer Rouge genocide, children under age 15 still constitute the largest group of the population, amounting to 1/3 of the total population.

additional information regarding the protocol, the instructions, or the procedures is available upon request.

3.4. Sample description

Table 2 contains some selected summary statistics and the set of controls included in the econometric specification. 95% of the subjects come from rural areas, mainly from the provinces of Takeo (66.33%), Kampot (12.56%) and Kampong Cham (7.54%). The remaining 13.57% comes from Kampong Speu, Kandal, Kampong Chhnang, Battambang, Preah Sihanouk, Kampong Thom, Mondulkiri, Pailin, Prey Veng and Siem Reap. They are aged, on average, 22 years old.

Considering the type of occupation, 81.48% declare to be farmers as first or second occupation, and there is no statistically significant difference between gender. Students' main source of income are related to agriculture (for 9.26% is subsistence farming while for 37.04% is livestock sales) or to informal business related to agriculture (9.72%). Focusing on subjects' access to credit and participation in risk-sharing networks, 45% of the sample have borrowed some money in the past 6 months (35% in cash, 3.24% in kind and 7.41% both in kind and in cash) while 34% participated in some Community Based Organizations (hereafter, CBO). Shocks are not unknown to our subject pool. In fact 60% of the subjects declared to have experienced at least one negative shock, as detailed in Table 2, during the last 12 months.

As far as risk and time preferences are concerned, 62% are impatient, so as they prefer 20.000 Riel (about 5,00 USD) tomorrow instead of 25.000 Riel (about 6,00 USD) after one month and 20,000 Riel tomorrow instead of 30.000 Riel (about 7,00 USD) after one month. The amount desired to wait is, on average, 7 times greater, which corresponds to almost 45,00 USD.[9] On a scale from 0 to 10, subjects are, on average, 7 points risk averse.[10] Almost 40% of the students have been obliged to skip at least once a meal in the last 12 months because of food shortage. The main coping strategies used to overcome food shortage are primarily selling livestock, piecework, and reducing the number of meals.

Table 2
Selected summary statistics.

Variables	Mean	Std. Dev.	Min.	Max.	N.
Age	21.62	2.91	18	35	215
Male	0.53	0.50	0	1	216
Farmer	0.81	0.38	0	1	216
Borrow money	0.45	0.49	0	1	216
Risk aversion	6.91	1.91	1	10	210
Impatient	0.62	0.48	0	1	215
School Grade	76.43	6.94	56.66	94	216
CBO	0.343	0.475	0	1	216
Negative shocks					
Shock	0.60	0.49	0	1	216
Drought	0.43	0.49	0	1	216
Flood	0.06	0.24	0	1	216
Rain	0.03	0.18	0	1	216
Crop	0.31	0.46	0	1	216
Coping strategies					
Government support	0.02	0.16	0	1	216
Reducing the number of meals	0.10	0.30	0	1	216
Selling household assets	0.09	0.29	0	1	216
Selling livestock	0.35	0.47	0	1	216
Piecework	0.12	0.32	0	1	216
Appeal for help to relatives	0.04	0.20	0	1	216

Table 3 reports the means of the covariates used in the empirical analysis for each pool of subjects playing the two variant of the game (Rich vs Poor and Ambiguity vs Risk). Overall, the set of covariates includes standard individual characteristics (i.e., age, gender = 1 if male), a dummy for wealth status (=1 if the subject has been randomly assigned to the poor group), a set of behavioral characteristics such as time and risk preferences, the final grade (the mean of all final grades obtained by each student in all the courses the student did during the academic year) as a proxy for individual ability, a set of dummies assuming value 1 when the subject has experienced a shock, a dummy equal to 1 when the respondent participates in CBOs, and a dummy equal to 1 when the respondent has borrowed some money in the past.

Table 4 presents basic summary statistics on insurance take up and investment decisions by treatment.[11]

4. Results

This section presents the results of the empirical analysis. We start by presenting some descriptive evidence on the relationship between investment and insurance. In the subsection “ Main results”, we (i) analyze the effect of the mere presence of a market for insurance on investment decision under risk and ambiguity and (ii) we focus on the effect of the presence of an insurance on the purchase of inputs. Last, we study the effect of a subsidy on (iii) insurance purchase and investment in inputs. Subsection “ Determinants of insurance purchase” presents the results on how additional factors – such as having experienced shocks in the past – influence the decision to purchase insurance.

4.1. Descriptive evidence

Let us first look at the overall share of farmers who decide to purchase both, inputs and insurance, and those who decide to purchase only inputs in treatment T2. On average, 73% of the subjects purchase at least one input *and* insurance while 25% purchase only inputs. These figures hide, however, some significant differences across wealth status. In fact, considering the whole, sample 29% of the poor choose to invest only in risky inputs with respect to 18% of the rich. This unexpected difference is significant only under ambiguity, suggesting that liquidity constraints matter to a greater extent under ambiguity and that, under ambiguity, the poor experience a slight substitution effect between investment and insurance.

4.2. Main results

4.2.1. Effects of insurance on investment

In what follows, we study the relationship between investment and insurance more thoroughly through a parametric approach. The aim of this first exploration is to answer the question: What happens to investment choices when a market for instance is available?

First, we focus on the mere effect of the presence of a market for insurance on investment by accounting for wealth status (i.e., poor vs rich). We therefore confront the baseline treatment (*T*1) with the treatments with insurance. Table 5 reports estimations under risk (column 1–5) or under ambiguity (column 6–10). Column 1 and 6 present estimations considering the overall sample. Column 2 and 7 make use of observations gathered from the baseline treatment (*T*1) and Input Insurance Treatment (*T*2). Columns 3 and 8 present estimation considering the baseline treatment (*T*1) together with the Input Insurance

[9] Notice that this measure was not incentivized.

[10] Risk aversion is measured as a self-reported risk attitude in general human domains measured on a ten items scale. This approach differs from incentivized measures of risk aversion since subjects are not provided with financial incentives. Although this choice presents clear limitations, recent research shows the ability of the general risk measure to predict real-stakes incentivized lottery choices (Dohmen et al., 2011).

[11] Note that randomization was done on administrative data before starting the sessions. These administrative documents are often of poor quality, which is why some features (especially gender and age) result slightly unbalanced.

Table 3
Selected T-test.

	Full sample	Rich	Poor	Ambiguity	Risk	T-test (poor)	T-test (risk)
Age	21.6	21.2	21.9	21.5	21.7	−0.72***	−0.18
Male	0.54	0.48	0.58	0.52	0.56	−0.09***	−0.04
Borrow money	0.46	0.45	0.46	0.44	0.47	−0.013	−0.02
Risk aversion	6.91	6.84	6.96	6.71	7.12	−0.12	−0.41***
Impatient	0.62	0.60	0.64	0.66	0.59	−0.03	0.07*
School Grade	76.4	75.2	77.4	76.0	76.9	−2.18***	−0.85*
CBO	0.34	0.29	0.38	0.31	0.38	−0.10***	−0.07**
Drought	0.44	0.42	0.45	0.43	0.44	−0.03	−0.02
Flood	0.06	0.04	0.08	0.05	0.08	−0.04**	−0.04**
Rain	0.04	0.03	0.04	0.04	0.04	−0.01	0
Crop	0.31	0.30	0.32	0.31	0.31	−0.02	−0.01

Notes: Observations: 216.
* $p<0.10$,
** $p<0.05$,
*** $p<0.01$.

Table 4
Investment in inputs and insurance purchase by treatment.

Variable	Mean	Std. Dev.
Investment in Input, T1	3.563	2.103
Investment in Input, T2	4.188	1.887
Investment in Input, T3, 1%	4.259	2.28
Investment in Input, T3, 10%	3.714	1.419
Investment in Insurance, T2	0.813	0.394
Investment in Insurance, T3, 1%	0.815	0.396
Investment in Insurance, T3, 10%	0.619	0.498

Notes: T1 = *Input Treatment*, T2 = *Input Insurance Treatment*, T3 = *Input Insurance Contract Nonperformance Treatment* (with a probability equal to either 1% or to 10%), T4 = *Input Insurance Past Treatment*, T5 = *Input Insurance Subsidy Treatment.*

Contract Nonperformance Treatment (*T*3) while columns 4–5 and 9–10 split the sample according to the probability of contract nonperformance (1% and 10%, respectively). Summary statistics for the covariates are reported in Table 3. The model includes also the interaction between a dummy taking value 1 if a market for insurance exists and wealth status. The OLS results cluster standard errors at the individual level and include order fixed effects. In order to take into account the ordinal nature of the dependent variable, we have estimated also Ordered Logit models with qualitatively unchanged results. Estimates are available upon request.

Table 5 suggests that liquidity constraints matter in investment decisions with the poor investing systematically less than the rich. Overall (see column 1 and 6) and consistent with previous studies (Hill et al., 2013), the mere presence of a market for insurance increases investment in inputs both in the presence of risk and ambiguity. Under risk, the effect of the presence of a market for insurance is positive and significant only when contract nonperformance is low and becomes small and not significant (column 5) when contract nonperformance is higher. Under ambiguity, the intrinsic characteristics of the insurance contract (i.e., contract nonperformance) matter more than under risk, consistent with Elabed and Carter (2015). In fact, both in case of low and high contract nonperformance (Columns 8, 9, and 10) the coefficients (although positive) are not significant. Given the within-subjects nature of some of the collected decisions, we can perform within-subjects comparisons. Table A1 in the Appendix depicts the results of this exercise. As expected, the size of the coefficients is lower, but the results are largely consistent with those presented above.

We now focus on the effect of insurance *purchase* on investment, i.e., we condition on having purchased an insurance. Table 6 reports the results. The main result of a positive effect of insurance on investment is confirmed under risk: this effect turns out to be positive and significant (column 1). However, it turns out to be negative, although not significant, under ambiguity (column 6). While the wealth effect is strongly significant overall and across treatments in the case of ambiguity (column 6–10), it turns out to be significant under risk only in the presence of contract nonperformance (column 3 and column 5). To put it differently, liquidity constraints play a role in investment decision only when farmers cannot correctly assess the probability of a shock (i.e., under ambiguity), or when a feature of the insurance contract introduces further variability with respect to the expected returns of the investment. Overall, the results depicted in Table 5 and in Table 6 seem to suggest that ambiguity plays a key role in shaping farmers' investment decisions. Accordingly, they suggest that liquidity constraints matter only under certain circumstances. In the next subsection we therefore relax liquidity constraints for the poor by introducing a subsidy to purchase the insurance.[12]

4.2.2. Subsidy

We first look at descriptive statistics. Under ambiguity, the share of poor subjects who opt-in for an insurance,[13] when subsidized, is significantly greater than in *T*2 (83% and 70%, respectively). However, conditional on having bought a subsidized insurance, the average number of inputs purchased significantly decreases with respect to *T*2 both under risk and under ambiguity (See Fig. 2). This result is in line with the findings presented in Karlan et al. (2014) where the provision of an insurance grant discourages investment when markets are complete. Furthermore, the share of poor subjects purchasing both investment and insurance, is significantly greater with respect to *T*2 (6% in *T*5 and 11% in *T*2). On the opposite, the share of subjects choosing to invest only in inputs is, overall, smaller (14% in *T*5 and 29% in *T*2) and, significantly smaller, under ambiguity.

When using a parametric approach (See Table 7), results are unchanged. The mere presence of a subsidy (column 1) significantly reduces the number of inputs purchased with respect to the case of a market for non-subsidized insurance. Overall, descriptive statistics and parametric models suggest that insurance has a greater effect in terms of investment when individuals purchase it with their own money (Hill

[12] Notice that we decided to fully subsidize our experimental insurance. This extreme decision was made with the declared aim to create an extreme-case scenario. Obviously, this choice has limitations which are discussed in the conclusions.

[13] In this treatment, with the insurance being fully subsidized, the subjects did not have to buy it but simply decide whether they wanted it or not.

Table 5
Effects of a market for insurance on inputs' purchase.

	Risk					Ambiguity				
	Overall	T1&T2	T1&T3	T1&T3, 1%	T1&T3, 10%	Overall	T1&T2	T1&T3	T1&T3, 1%	T1&T3, 10%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Insurance mkt. = 1	0.77*** (0.24)	0.98*** (0.29)	0.61** (0.26)	1.22*** (0.33)	0.41 (0.32)	0.55* (0.30)	0.61* (0.34)	0.45 (0.34)	0.42 (0.47)	0.50 (0.36)
Poor	−1.13*** (0.29)	−1.04*** (0.39)	−1.15*** (0.30)	−0.41 (0.37)	−1.42*** (0.32)	−1.69*** (0.36)	−2.55*** (0.52)	−1.76*** (0.39)	−1.84*** (0.44)	−2.02*** (0.43)
Insurance mkt. = 1 X Poor	−0.70** (0.27)	−0.63* (0.34)	−0.74** (0.31)	−1.23*** (0.41)	−0.87** (0.41)	−0.09 (0.38)	−0.17 (0.40)	−0.07 (0.43)	0.11 (0.58)	−0.32 (0.47)
Drought	−0.14 (0.15)	−0.33 (0.21)	−0.19 (0.17)	−0.30 (0.20)	−0.20 (0.20)	−0.04 (0.15)	0.24 (0.23)	0.02 (0.18)	0.01 (0.23)	0.14 (0.23)
Flood	0.04 (0.23)	0.07 (0.30)	−0.08 (0.26)	−0.44 (0.27)	0.20 (0.29)	0.24 (0.22)	0.27 (0.36)	0.23 (0.24)	−0.19 (0.27)	0.92** (0.36)
Rain	−0.42** (0.19)	0.68 (0.42)	−0.34 (0.31)	−0.24 (0.30)	0.57 (0.81)	−0.59** (0.27)	−0.17 (0.94)	−0.65* (0.35)	−0.63 (0.42)	−0.07 (0.66)
Crop	0.13 (0.19)	0.32 (0.27)	−0.00 (0.22)	0.19 (0.26)	−0.11 (0.26)	0.07 (0.18)	0.14 (0.27)	−0.11 (0.20)	0.03 (0.25)	−0.22 (0.27)
Age	−0.01 (0.03)	−0.03 (0.04)	−0.00 (0.03)	−0.03 (0.03)	0.01 (0.03)	−0.00 (0.03)	0.00 (0.04)	0.00 (0.03)	−0.02 (0.03)	0.05 (0.04)
Male	0.29* (0.16)	0.81*** (0.25)	0.32* (0.18)	0.39* (0.21)	0.54** (0.23)	0.09 (0.18)	−0.28 (0.34)	0.02 (0.21)	−0.06 (0.27)	−0.06 (0.26)
Risk aversion	−0.01 (0.04)	0.06 (0.05)	−0.02 (0.05)	0.02 (0.05)	−0.03 (0.07)	−0.02 (0.04)	−0.00 (0.07)	−0.03 (0.04)	0.01 (0.05)	−0.05 (0.06)
Borrow money	−0.08 (0.16)	−0.03 (0.23)	−0.07 (0.18)	0.04 (0.21)	−0.07 (0.21)	−0.07 (0.17)	0.26 (0.31)	−0.08 (0.19)	0.02 (0.24)	−0.04 (0.25)
Impatient	−0.18 (0.16)	−0.44* (0.23)	−0.12 (0.18)	−0.33 (0.21)	−0.09 (0.21)	−0.02 (0.16)	−0.06 (0.27)	0.16 (0.18)	0.09 (0.25)	0.33 (0.22)
CBO	0.10 (0.17)	0.27 (0.23)	0.27 (0.18)	0.27 (0.22)	0.21 (0.20)	0.01 (0.18)	−0.38 (0.31)	0.13 (0.20)	0.03 (0.28)	−0.04 (0.25)
Grade	0.02* (0.01)	0.02 (0.02)	0.02 (0.01)	−0.00 (0.02)	0.02 (0.02)	0.02 (0.01)	0.02 (0.02)	0.02 (0.01)	−0.01 (0.02)	0.03* (0.02)
Order dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N.	519	206	311	219	195	521	210	313	221	197

Notes: OLS estimations. Standard errors clustered at the individual level. Covariates as described in Table 3. Order fixed effects.
Recall: T1 = *Input Treatment*, T2 = *Input Insurance Treatment*, T3 = *Input Insurance Contract Nonperformance Treatment* (with a probability equal to either 1% or to 10%), T4 = *Input Insurance Past Treatment*, T5 = *Input Insurance Subsidy Treatment*.
* $p<0.10$,
** $p<0.05$,
*** $p<0.01$.

et al., 2013; Karlan et al., 2014).[14] These counterintuitive results are discussed in the conclusions.

4.3. Determinants of insurance purchase

We now explore the determinants of insurance purchase. The results of this exercise are reported in Table 8. According to previous literature, under ambiguity, having experienced a flood or rain shock is positively related to the decision to buy insurance (column 1). Column 4 shows that the more risk averse the individual is, the lower the probability that he buys an insurance in presence of contract nonperformance. Moreover, absent contract nonperformance, if the individual is poor, there exist a negative relationship with the decision to buy an insurance under ambiguity, and a positive one in case of risk, mirroring the results obtained for investment.

5. Discussion and conclusions

This paper presented the results of a lab-in-the-field experiment conducted in Cambodia in which subjects were asked to choose whether or not to buy an insurance and whether or not to invest in risky inputs, both in presence of risk and of ambiguity.

Our findings indicate that the mere presence of a market for insurance increases, overall, investment in profitable but risky inputs. However, this positive result is heterogeneous across wealth status and vary when the probability of a shock is known (under risk) or unknown (ambiguity). More specifically, we found this positive effect to be significantly smaller for the poor but only under risk. Our experimental results also suggest that the availability of a subsidy seems not to increase the average number of inputs purchased suggesting that insurance has a greater effect in terms of investment when individuals purchase it with their own money (Hill et al., 2013; Karlan et al., 2014). Analyzing the determinants of insurance purchase, our results confirm previous literature by showing that under ambiguity individuals form beliefs about expected return and risk using heuristic tools, such as past experiences (Tversky and Kahneman, 1971, 1974; Gallagher, 2014; Conrads et al., 2016). The quality of these experiences shapes, therefore, their choices.

The most important finding of this paper is that ambiguity plays a crucial role in shaping farmers' decisions. In fact, the positive effect of insurance on investment in risky but profitable inputs is found to be significant only when farmers can assess the probability of a shock. This is not, however, the standard case in agricultural decisions, especially in developing countries. The inability to correctly assess the probability of a shock leads farmers to be more conservative in their investment

[14] Notice that, when interacting the presence of a subsidy with impatience we find that impatient farmers are less likely to invest in inputs (consistent with evidence from the labor market (Cadena and Keys, 2015)) and that the subsidy might benefit more impatient farmers than patient ones consistent with evidence from Ngoma et al. (2018). We thank an anonymous referee for having suggested this further exploration.

Table 6
Effects of insurance purchase on inputs' purchase.

	Risk					Ambiguity				
	Overall	T2	T3	T3, 1%	T3, 10%	Overall	T2	T3	T3, 1%	T3, 10%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Insurance = 1	2.16*** (0.65)					−1.02 (0.82)				
Poor	0.30 (0.86)	0.30 (0.86)	−1.18** (0.59)	0.21 (1.35)	−2.76*** (1.01)	−3.15*** (0.88)	−3.15*** (0.88)	−3.20*** (0.72)	−3.83** (1.47)	−3.02*** (0.76)
Insurance = 1 X Poor	−2.88*** (0.73)					0.98 (0.90)				
Insurance, T2 = 1		2.16*** (0.65)					−1.02 (0.82)			
Insurance, T2 = 1 X Poor		−2.88*** (0.73)					0.98 (0.90)			
Insurance, T3 = 1			0.39 (0.54)					−0.49 (0.58)		
Insurance, T3 = 1 X Poor			−0.83 (0.65)					1.16* (0.70)		
Insurance, T3, 1% = 1				1.12 (1.31)					−1.21 (1.36)	
Insurance, T3, 1% = 1 X Poor				−1.83 (1.48)					1.13 (1.54)	
Insurance, T3, 10% = 1					0.54 (0.80)					−0.79 (0.68)
Insurance, T3, 10% = 1 X Poor					0.35 (1.03)					2.00** (0.81)
Drought	−0.34 (0.25)	−0.34 (0.25)	−0.05 (0.22)	−0.27 (0.40)	−0.41 (0.40)	0.12 (0.24)	0.12 (0.24)	−0.14 (0.24)	−0.06 (0.41)	−0.01 (0.39)
Flood	0.21 (0.47)	0.21 (0.47)	0.21 (0.32)	−0.39 (0.51)	1.28 (0.92)	−0.16 (0.38)	−0.16 (0.38)	0.71 (0.61)	−2.79*** (0.92)	0.58 (0.69)
Rain	−0.33 (0.35)	−0.33 (0.35)	−1.56*** (0.35)	−1.96*** (0.53)	0.00 (.)	−0.46 (1.00)	−0.46 (1.00)	−0.71 (0.87)	−0.78 (0.92)	−2.50*** (0.76)
Crop	0.52 (0.32)	0.52 (0.32)	−0.17 (0.29)	0.45 (0.66)	−1.01* (0.53)	0.19 (0.30)	0.19 (0.30)	−0.37 (0.29)	−0.21 (0.44)	0.12 (0.52)
Age	0.01 (0.04)	0.01 (0.04)	0.00 (0.03)	−0.03 (0.04)	0.16 (0.13)	−0.04 (0.04)	−0.04 (0.04)	0.01 (0.04)	−0.15** (0.07)	0.13 (0.11)
Male	0.39 (0.29)	0.39 (0.29)	0.19 (0.23)	0.00 (0.37)	−0.20 (0.43)	−0.22 (0.36)	−0.22 (0.36)	−0.03 (0.25)	−0.15 (0.44)	−0.18 (0.54)
Risk aversion	0.06 (0.06)	0.06 (0.06)	−0.04 (0.05)	0.02 (0.09)	−0.12 (0.18)	−0.03 (0.07)	−0.03 (0.07)	−0.10 (0.07)	0.02 (0.11)	−0.16 (0.11)
Borrow money	−0.04 (0.26)	−0.04 (0.26)	−0.17 (0.20)	−0.10 (0.33)	−0.60 (0.47)	0.28 (0.33)	0.28 (0.33)	−0.15 (0.24)	0.31 (0.49)	0.51 (0.38)
Impatient	−0.38 (0.26)	−0.38 (0.26)	0.01 (0.22)	−0.57* (0.32)	0.52 (0.47)	−0.31 (0.30)	−0.31 (0.30)	0.27 (0.26)	0.28 (0.57)	0.13 (0.47)
CBO	−0.13 (0.24)	−0.13 (0.24)	0.51*** (0.19)	0.70** (0.31)	−0.50 (0.42)	−0.46 (0.38)	−0.46 (0.38)	−0.04 (0.27)	−0.98 (0.62)	0.67** (0.27)
School Grade	0.01 (0.02)	0.01 (0.02)	0.04** (0.02)	0.01 (0.03)	0.00 (0.02)	0.02 (0.02)	0.02 (0.02)	0.03** (0.02)	0.01 (0.04)	0.09*** (0.03)
N.	103	103	147	55	48	105	105	153	61	44

Notes: OLS estimations. Standard errors clustered at the individual level. Covariates as described in Table 3. Order fixed effects.
Recall: T1 = *Input Treatment*, T2 = *Input Insurance Treatment*, T3 = *Input Insurance Contract Nonperformance Treatment* (with a probability equal to either 1% or to 10%), T4 = *Input Insurance Past Treatment*, T5 = *Input Insurance Subsidy Treatment*.
* $p<0.10$,
** $p<0.05$,
*** $p<0.01$.

choices even when they have the possibility to insure themselves against shocks. One possible interpretation of this result is that, consistently with Epstein and Schneider (2008) and Li et al. (2017), ambiguity leads farmers to place a greater weight on the worst outcome. As a result, investment decreases. An alternative explanation for this result lies in the structure of Index-based insurance itself. Index-based insurance, in fact, does not reduce downside risks. However, it reduces income variability with respect to weather, which is a part of a farmer's objective function. As a result, farmers reduce investment in newly and more profitable inputs.

This finding has important policy implications. Since poor people are usually exposed to negative shocks, formal insurance in general and weather insurance in particular, might offer a way to improve the use of risky but more profitable inputs (Hill and Viceisza, 2012). As a result, any policy promoting access and purchase of insurance could potentially be seen as a winning poverty-reduction strategy. The results of our paper suggest that this is true only under specific conditions. More specifically, we find that some of the policies specifically aimed at promoting weather insurance as a potential coping strategy in the face of climate shocks, or at least those designed as the one experimented in this paper, would terribly be debased if they do not take into account the fact that farmers' ability to assess the probability of a shock affects their investment choices. As a result, tackling the issue of liquidity constraints by subsidizing insurance purchase might not be enough, and it can even have detrimental effects in terms of investment response. This result could at least partially explain why uptake of Index-insurance products is still low especially in countries, such as Cambodia, characterized by a growing impact of climate change and its associated risks in terms of

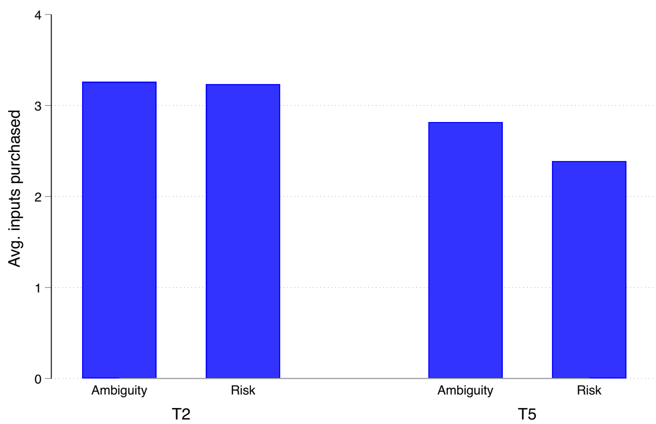

Fig. 2. Investment in risky inputs. Only poor. Notes: T2 = *Input Insurance Treatment*, T5 = *Input Insurance Subsidy Treatment*.

Table 7
Effects of a subsidy on investment.*

	(1)	(2)
	T2–T5	T5
Subsidy = 1	−0.58** (0.29)	
Risk	−0.17 (0.32)	2.79*** (0.75)
Subsidy = 1 X Risk	0.09 (0.39)	
Insurance, T5 = 1		2.36*** (0.50)
Insurance, T5 = 1 X Risk		−3.08*** (0.84)
Drought	−0.16 (0.19)	−0.10 (0.27)
Flood	−0.15 (0.40)	0.27 (0.45)
Rain	−0.65 (0.50)	
Crop	0.29 (0.22)	0.13 (0.26)
Age	−0.06 (0.05)	−0.00 (0.05)
Male	0.08 (0.24)	−0.14 (0.34)
Risk aversion	−0.00 (0.05)	−0.02 (0.07)
Borrow money	−0.09 (0.21)	−0.15 (0.29)
Impatient	−0.18 (0.22)	0.53 (0.34)
CBO	−0.30 (0.21)	−0.45 (0.29)
School Grade	−0.00 (0.02)	0.00 (0.02)
Order dummies	Yes	Yes
N.	247	47

Notes: OLS estimations. Covariates as described in Table 3. Standard errors clustered at the individual level. Order fixed effects.
Recall: T1 = *Input Treatment*, T2 = *Input Insurance Treatment*, T3 = *Input Insurance Contract Nonperformance Treatment* (1% or to 10% prob.), T4 = *Input Insurance Past Treatment*, T5 = *Input Insurance Subsidy Treatment*.
* $p<0.10$,
** $p<0.05$,
*** $p<0.01$.

Table 8
Determinants of insurance purchase.

	Ambiguity		Risk	
	Insurance, T2	Insurance, T3	Insurance, T2	Insurance, T3
	(1)	(2)	(3)	(4)
Drought	0.108 (0.095)	0.054 (0.052)	−0.071 (0.106)	0.037 (0.054)
Flood	0.392** (0.165)	−0.005 (0.090)	0.070 (0.149)	0.083 (0.117)
Rain	0.235* (0.120)	−0.003 (0.139)	−0.079 (0.254)	−0.142 (0.144)
Crop	−0.073 (0.110)	0.025 (0.061)	0.097 (0.111)	−0.033 (0.060)
Age	0.013 (0.014)	0.014 (0.008)	−0.016 (0.015)	−0.001 (0.010)
Gender	0.072 (0.104)	−0.054 (0.053)	0.012 (0.101)	−0.049 (0.056)
Risk aversion	−0.011 (0.027)	−0.013 (0.014)	0.030 (0.029)	−0.026* (0.014)
Borrow money	0.077 (0.109)	0.052 (0.053)	−0.019 (0.100)	−0.019 (0.055)
Impatient	0.106 (0.101)	−0.062 (0.052)	−0.092 (0.101)	−0.049 (0.056)
CBO	−0.001 (0.106)	0.037 (0.055)	0.061 (0.094)	0.008 (0.057)
School Grade	0.006 (0.009)	0.002 (0.004)	0.000 (0.007)	0.001 (0.004)
Poor	−0.152 (0.191)	−0.105* (0.054)	−0.044 (0.210)	0.158*** (0.059)
Order dummies	Yes	Yes	Yes	Yes
N.	105	314	103	313

Notes: OLS estimations, Standard errors in parentheses. Order fixed effects.
Recall: T1 = *Input Treatment*, T2 = *Input Insurance Treatment*, T3 = *Input Insurance Contract Nonperformance Treatment* (1% or to 10% prob.)
* $p<0.10$,
** $p<0.05$,
*** $p<0.01$.

poverty and food insecurity.

Of course, as recent literature shows (Carter and Janzen, 2018), this might be due to a specific feature of our design, i.e., the fact that the insurance was fully subsidized and that no other transaction costs were included in our design. In developing countries, however, insurance markets are often incomplete or virtually non-existent. Therefore, even if the insurance were fully subsidized, there would be transaction costs which are not considered in our experiment and that would greatly affect both insurance uptake and investment. Furthermore, insurance markets in developing countries often lack institutional stability and trust, which might also affect farmers' perceptions and decisions in our experiment. As a matter of fact, governments usually offer only temporary subsidies that might help the farmers, which are initially uncertain about a new type of insurance product, to familiarize themselves with it and assess its real risks and benefits. Our experiment does not take this aspect into account. A subsidized insurance mechanism in which the cost of the insurance is shared between the public sector and the beneficiary of the funds or in which the government offers a subsidy during an initial learning phase might be better suited.

It is plausible to assume that in an extremely poor context such as the one in which we conducted the experiment, there may be mechanisms at work that undermine the replicability of our results. One of them is the one indicated by Jakiela and Ozier (2016). Jakiela and Ozier (2016) show that during a lab experiment, subjects – and especially women having their relatives attending the experiment – tend to reduce their income in order to keep it hidden. In fact, individuals living in poor and remote communities are often forced (or feel the pressure) to transfer their wealth to relatives and neighbours, especially when economic conditions are particularly bad. Even in our context, therefore, it would be rational not to get insured, or even not to increase the investments in inputs, in order to reduce wealth and, therefore, the need to redistribute it to relatives and friends. This hypothesis, however, can be excluded for at least two reasons. First, in our experiment, there is no observability of decisions or outcomes. Second, even if observability was present, the outcomes would be observed only by peers on campus. In fact, during the day, the students have no contacts with their families. Even assuming these peers put pressure to share money, the only place near the campus to spend it is a refectory that offers few and relatively cheap refreshments. We are relatively safe in concluding that there is only a mild pressure for sharing in case of unfavorable outcomes, which, therefore, cannot be the only driver of the subjects' behavior during the experiment.

The methodology adopted in this paper represents, at the same time, its main strength and weakness. Laboratory experiments, especially in developing countries, are often difficult to implement. Farmers in developing countries are, in fact, faced with complicated situations and barriers such as as volatile crop prices, limited information and local culture. By promoting a controlled environment in which incentives are kept constant, lab experiments allow the researcher to reduce several problems usually present in empirical works but could neglect some important aspects. Furthermore, while lab experiments are helpful in addressing the problem of endogeneity, they lack external validity (Deaton, 2010). While we are aware of these limitations, we think that experiments can still play an important role in complementing empirical results and in unpacking the black box of theory (Viceisza, 2016).

In our design take-up of insurance and subsidy remain a matter of subjects' choice. As a result, the estimated effects of insurance purchase on investment and that of subsidy on investment might be affected by selection bias. Nevertheless, the paper opens up fruitful avenues for future research.

First, future research could assess whether these findings, based on individual-level data for Cambodia, generalize to other countries within and outside Asia. Second, further research might focus on studying policies targeted to attenuate the deleterious effect of ambiguity on insurance and investment decision. One possibility could be to study the best way to communicate to farmers the predicted probability of a bad event. If ambiguity has detrimental effects in terms of investment and risk-reducing strategies, governments could be pushed to provide reliable information (which is often costly) on climate change. Accordingly, communication and coordination can play a crucial role. Policies targeted to community-based organizations and farming cooperatives could be useful in improving information about climatic projections and weather forecasts which could potentially improve farmers ability in making investment decisions. Further research could explore these interesting and rather neglected aspects.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1
Effects of a market for insurance on inputs' purchase: Within-subjects model.*

	Risk				Ambiguity			
	Overall	T1&T2	T1&T3,1%	T1&T3,10%	Overall	T1&T2	T1&T3,1%	T1&T3,10%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Inputs purchased	Inputs purchased	Inputs purchased	Inputs purchased	Inputs purchased	Inputs purchased	Inputs purchased	Inputs purchased
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Insurance mkt	0.58*** (0.15)	0.37** (0.14)	0.69*** (0.18)	0.10 (0.23)	0.53*** (0.18)	0.41*** (0.15)	0.27 (0.30)	0.24 (0.28)

Note: Fixed effect model. Standard errors clustered at the individual level. Covariates as described in Table 2. Order fixed effects.
* $p<0.10$,
** $p<0.05$,
*** $p<0.01$.

A.1. Instructions

Note: These instructions refer to the poor group and to the first task. Instructions for the rich group report an initial endowment of 1000 ECU. Tables are modified accordingly. The text reported in brackets and in italics refers to the risk variant of the game.

A.2. General rules

Welcome!

Welcome and thank you for participating in this experimental session. By following these instructions you will earn an amount in ECU (1000 ECU = 1 dollar) that will be paid in cash at the end of the session.

Your earnings will be based entirely on your decisions: decisions of other participants will not affect your earnings.

Decisions and earnings of each participant will remain anonymous throughout the experiment. This means that no one will receive information on other participants' choices and earnings.

Please turn off your cell phones and do not talk or in any way communicate with other participants.

If you have any question or problem at any point in this experiment, please raise your hand and one of the assistants will answer you.

The following rules are the same for all participants.

- In this experiment you will participate in 4 different tasks.
- Only one of these 4 tasks will be used to determine your final earnings.
- More specifically, at the end of the experiment we will randomly select the task to be paid to all participants by randomly draw, with equal probability, a ball from an urn containing 4 balls marked with 4 numbers, from 1 to 4.
- The drawn number indicates the task that will be effectively paid in cash at the end of the experiment.
- This means that you will receive an amount of dollars equal to the earnings that you have realized in that specific task.
- On the top of your earnings, you will receive an additional dollar for the compilation of a questionnaire.
- The instructions for each task will be given to you at the end of the previous task.

A.3. Task 1

You have 650 ECU. You can choose to buy some INPUTS. Every INPUT costs 120 ECU. To keep your initial capital operative, you pay a sunk cost equal to 150 ECU regardless of the fact that you buy or not INPUTS. A shock can occur at the end of the experiment.

(The probability that a shock occurs is 20% that is to say that the shock occurs 1 over 5 times).

Your initial endowment produces 250 ECU if a shock does not occur, 0 if a shock occurs. Every INPUT is productive and it produces 25% of your investment if a shock does not occur. Every INPUT is non-productive and it produces 0 if a shock occurs.

For example:

- You have 650 ECU.
- You decide to buy 3 INPUTS.
- You pay 360 ECU and you are left with: $650 - 360 = 290 ECU$.
- You pay 150 ECU as a sunk cost and you are left with: $290 - 150 = 140 ECU$
- At the end of the experiment, if a shock does NOT occur, you earn: $650 - 3x120 - 150 + 3x120 + 0.25x3x120 + 250 = 840 ECU$
- At the end of the experiment, if a shock occurs, you earn: $650 - 3x120 - 150 = 140 ECU$

The table below shows all your possible choices with their relative payoffs:

					If a shock does NOT occur		If a shock occurs	
You have	You buy	You spend	You pay a sunk cost	You are left with	Your investment produces	At the end of the session you earn	The investment produces	At the end of the session you earn
650	0 INPUT	0	150	500	250	750	0	500
650	1 INPUT	120	150	380	400	780	0	380
650	2 INPUTS	240	150	260	550	810	0	260
650	3 INPUTS	360	150	140	700	840	0	140
650	4 INPUTS	480	150	20	850	870	0	20

At the end of the experiment, if this task will be randomly chosen for payment, one of the participants will draw from an urn containing some orange ball and some white balls, one ball.

(one of the participants will draw from an urn containing 1 orange ball and 4 white balls, one ball):

- If an orange ball is drawn, a shock will occur
- If a white ball is drawn, a shock will NOT occur

(The figure below shows the composition of the urn:)

You will now receive a table. You have to choose how many INPUTS you want to buy, by putting a cross next to the number of INPUTS you would like to buy.

Pay attention: you can indicate ONLY one cross next to the INPUTS.

Id.n°	Put a cross next to the number of INPUTS that you want to buy
0 INPUT	
1 INPUT	
2 INPUT	
3 INPUT	
4 INPUT	

A.4. Task 2

You have 650 ECU. You can choose to buy some INPUTS. Every INPUT costs 120 ECU. To keep your initial capital operative, you pay a sunk cost equal to 150 ECU regardless of the fact that you buy or not INPUTS. A shock can occur at the end of the experiment. Your initial endowment produces 250 ECU if a shock does not occur, 0 if a shock occurs. Every INPUT is productive and it produces 25Every INPUT is non-productive and it produces 0 if a shock occurs. You can buy an insurance. The insurance costs 110 ECU. If a shock occurs, the insurance will give you back the amount that you have spent to buy INPUTS.

(The probability that a shock occurs is 20% that is to say that the shock occurs 1 over 5 times).

For example:

- You have 650 ECU.
- You decide to buy 3 INPUTS.
- You pay 360 ECU and you are left with: 650-360 = 290 ECU.
- You pay 150 ECU as a sunk cost and you are left with: 290-150 = 140 ECU
- If you buy the insurance:
- At the end of the experiment, if a shock does NOT occur, you earn: 650-3 × 120–150-110 + 3 × 120 + 0.25 × 3 × 120 + 250 = 730 ECU
- At the end of the experiment, if a shock occurs, you earn: 650-150-110 = 390 ECU
- If you DON'T buy the insurance:
  - At the end of the experiment, if a shock does NOT occur, you earn: 650-3 × 120–150 + 3 × 120 + 0.25×3 × 120 + 250 = 840 ECU
  - At the end of the experiment, if a shock occurs, you earn: 650-3×120–150 = 140 ECU

If you buy the insurance for 110 ECU										
						If a shock does NOT occur		If a shock occurs		
You have	You buy	You spend	You pay a sunk cost	Insurance cost	You are left with	The investment produces	At the end of the session you earn	The investment produces	At the end of the session you earn
650	0 INPUT	0	150	110	390	250	640	0	390
650	1 INPUT	120	150	110	270	400	670	0	390
650	2 INPUTS	240	150	110	150	550	700	0	390
650	3 INPUTS	360	150	110	30	700	730	0	390
650	4 INPUTS	480	150	110	-90	850	760	0	390

If you DON'T buy the insurance									
						If a shock does NOT occur		If a shock occurs	
You have	You buy	You spend	You pay a sunk cost	Insurance cost	You are left with	The investment produces	At the end of the session you earn	The investment produces	At the end of the session you earn
650	0 INPUT	0	150	0	500	250	750	0	500
650	1 INPUT	120	150	0	380	400	780	0	380
650	2 INPUTS	240	150	0	260	550	810	0	260
650	3 INPUTS	360	150	0	140	700	840	0	140
650	4 INPUTS	480	150	0	20	850	870	0	20

At the end of the experiment…

You will now receive a table.

You have to choose how many INPUTS do you want to buy, by putting a cross next to the number of INPUTS you would like to buy. You have to choose if you would like to buy an insurance, by putting a cross next to YES (if you want to buy) or NO (if you don't want to buy).

Pay attention: you can indicate ONLY one cross next to the INPUTS and one cross next to the insurance.

Id.n°	Put a cross next to the number of INPUTS that you want to buy	
0 INPUT		
1 INPUT		
2 INPUTS		
3 INPUTS		
4 INPUTS		If you buy 4 INPUTS, you cannot buy the insurance

I want to buy an insurance	YES	NO

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