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Consistency of Risk Preference Measures and the Role of Ambiguity:

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Abstract

A variety of measures have been developed to elicit individual risk preferences. How these measures perform in the field, in particular in developing countries with non-student subjects, is still an open question. We implement an artefactual field experiment using a large sample of Chinese farmers to investigate (i) whether subjects behave in a consistent manner across incentivized experimental risk measures, (ii) whether non-incentivized survey measures can elicit actual risk preferences, and (iii) possible explanations for risk preference inconsistency across measures. We find that inconsistent risk preferences across survey and experimental measures may be explained by ambiguity preferences. In the survey, subjects seem to mix risk and ambiguity preferences.

Keywords: risk preferences, ambiguity preferences, field experiments, socio-economic survey, China.

JEL Codes: C93, D81, O1

1. Introduction

Risk preferences play an important role in individual decisions and behaviors such as investments, production decisions, and technology adoption.[1] Various measures have been developed to elicit individual risk preferences (Charness et al., 2013). Some measures rely on simple survey questions on willingness to take risks in general or in specific domains, or questions on hypothetical gambles, lotteries, and investments to elicit subjects' risk attitudes.[2] Other measures are based on complex experimental designs with real monetary incentives, often developed and tested in the laboratory with educated students.[3] Compared to experimental measures, survey measures are simpler and less costly. Survey measures, however, are not incentivized, which raises the concern on whether they can reveal true and accurate risk preferences (Charness et al., 2013).

In this study, we investigate in a developing country context with non-student subjects first, whether subjects behave in a consistent manner across different incentivized experimental risk measures; second, whether non-incentivized survey measures can elicit actual risk preferences and predict subjects' behaviors in incentivized experiments; and third, possible explanations for risk preference inconsistency across survey and experimental measures. Most previous studies focus on only one risk measure. Recently, some studies have compared different elicitation measures (see appendix A for a review). However, the wide majority of studies are based on experiments conducted in the laboratory in developed countries with students. A common criticism of such experiments is that students are not representative of non-student populations, and therefore laboratory experimental findings may be invalid in the field (Falk and Heckman, 2009). This concern is particularly valid for developing country contexts with less-educated subjects. Whether elicited preferences are consistent across measures in such a setting, is still an open question.

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[1] See for instance, studies by Cardenas and Carpenter (2008), Hill (2009), Tanaka et al. (2010), Dohmen et al. (2011), Liu (2013), Liu and Huang (2013), Ward and Singh (2015).

[2] See for instance, studies by Blais and Weber (2006), Hill (2009), Dohmen et al. (2011), or Vieider et al. (2015) for measures relying on simple survey questions; and Anderson and Mellor (2009), Ding et al. (2010), Dohmen et al. (2011), or Vieider et al. (2015) for measures relying on hypothetical gambles, lotteries, and investments.

[3] See for instance, studies by Gneezy and Potters (1997), Eckel and Grossman (2002), Holt and Laury (2002), Lejuez et al. (2002), Deck et al. (2008a), or Crosetto and Filippin (2013a) for measures based on experiments.

In addition, the overall evidence on whether a simple survey question of risk preferences performs as well as the experimental measures is mixed. Dohmen et al. (2011), Hardeweg et al. (2013), and Vieider et al. (2014) find that the survey measure can significantly predict experimental results. However, other studies show low or no correlations between risk preferences elicited via the survey measure and the experimental measure (Pennings and Smidts, 2000; Ding et al., 2010; Lönnqvist et al., 2011; Charness and Viceisza, 2012). Only two studies focus on non-student subjects in developing countries, and find contradictory results. Charness and Viceisza (2012) use a between-subject comparison with a small sample size (91 farmers in Senegal) and find that subjects behave differently in two experimental measures and that the survey measure is unlikely to reveal accurate risk attitudes. Hardeweg et al. (2013) conduct a within-subject comparison with a large sample size (934 farmers in Thailand) and find that the survey measure can predict subjects' choices in the experiment.

We contribute to the literature by implementing an artefactual field experiment on risk preferences with a large sample of non-student subjects (farmers) in a developing country context (rural China). We adopt a within-subject comparison of a risk measure based on a survey question on willingness to take risks in general (Dohmen et al., 2011), and two incentivized experimental measures based on the Holt and Laury (2002) (henceforth HL) experiment, and the Andreoni and Harbaugh (2010) (henceforth AH) experiment.

We first compare elicited risk preferences at the aggregate level. Results from all the elicitation measures indicate that subjects are on average risk averse. Following a within-subject comparison, however, we find a large level of inconsistency between the two experimental measures, and between the survey and the experimental measures. We test some possible explanations of the inconsistency. Dave et al. (2010) suggest that the inconsistency may be related to the difference of cognitive difficulties across elicitation measures. Our empirical results do not support this explanation in line with findings by Reynaud and Couture (2012). We also examine another possible and previously unexplored explanation for the inconsistency, that is the role played by ambiguity preferences in the survey question. We find that the inconsistency between the survey and experimental measures seems to be related to the fact that the survey measure may reveal a mix of risk and ambiguity preferences instead of pure risk preferences.

This paper contributes to the literature also by providing further empirical evidence on the determinants of individual differences in risk preferences from rural China. We investigate the effects of individual and household characteristics such as age, gender, and also personality traits. Previous studies provide mixed evidence (Dohmen et al., 2010; He et al., 2012; Liu, 2013; Vieider et al., 2015). Our results show that the effects of these factors depend on the risk measure adopted.

The paper is organized as follows. Section 2 describes the experimental design and the measures used to elicit risk and ambiguity preferences. Section 3 presents and discusses the results. Section 4 concludes.

2. Experimental Design

In this section, we first describe the sampling and procedures of the experiments, and then, the experimental measures used to elicit risk and ambiguity preferences.

2.1 Sampling and Procedures

Our study was conducted in the Hubei Province of China in March and April of 2012 using a sample of farmers as part of a project on the adoption of biogas technology. We conducted two pre-tests on 20 farmers to test for the comprehension of the survey and the experimental instructions.[4] We then randomly selected 685 households in 12 villages, excluding the villages where we conducted the pre-tests to avoid contamination. Village leaders helped us inform the decision-maker of each household and persuade him/her to participate in the study. A show-up fee of 5 CNY was used to incentivize participation.[5] 597 farmers participated in the study, generating a response rate of 87%. One subject did not complete the experimental tasks, and was excluded from the analysis.

[4] After receiving positive feedback, we started the final experiments four days after the second pre-test.
[5] $1 ≈ CNY 6.

In the end, our final sample includes 596 farmers. Table 1 presents the descriptive statistics. The average farmer is 48 years old and has a middle school degree (nine years). The majority of farmers are male decision-makers (74%). About half of the respondents have worked off-farm in the last year. The average household consists of four members, owns 0.70 hectares of land, and has an annual income of CNY 25,000.

[TABLE 1 HERE]

Each subject was assigned an identification number to guarantee the anonymity, and faced first an experimental session and then, a survey section. At the beginning of the experimental session, each subject received a brief introduction of the tasks, and information for example, on the expected duration of the study, and how the earnings were delivered. After the introduction, subjects were allowed to decide whether to participate or leave.[6] The experimental session included three tasks eliciting subjects' risk and ambiguity preferences through the Holt and Laury (2002) experiment, the Andreoni and Harbaugh (2010) experiment, and an ambiguity experiment based on Ellsberg's two-color problem (Ellsberg, 1961). We used a within-subject design, which implies that the same subjects participated in all the three tasks. To control for order effects, the two risk preference tasks were conducted before the ambiguity preference task in half of the villages and the order was switched in the other half. The Holt and Laury experiment (HL) was conducted before the Andreoni and Harbaugh experiment (AH) in half of the villages and the order was switched in the other half.

At the beginning of each task, subjects were explained the experiment. The experimental instructions are presented in the online appendix. Subjects were told that one decision in each task would be randomly selected to decide their earnings. This random selection was implemented at the end of each task so that subjects should treat each decision equally. In addition, tests were

[6] In total, 34 subjects did not participate in the study.

conducted to ensure the comprehension of the tasks. For example, in the HL experiment, subjects were asked how much they could earn if their choice in the first paired lottery was Option 1 and the randomly drawn number was three out of 1-10. If participants gave a wrong answer, the experimenters explained the experiment and tested them again. After all subjects finished one task, the next task began.

At the end of the experimental session, all subjects had to complete a survey that included questions on individual and household characteristics such as age, education and household income, and a risk elicitation question described in the next sub-section. We also elicited two indicators of personality traits. The first one is the Big Five capturing the five basic dimensions of personality: neuroticism, extraversion, openness, agreeableness, and conscientiousness (Costa and McCrae, 1992; McCrae and John, 1992). The second one is the locus of control capturing how people interpret the results of events they experience (Rotter, 1966). After completing the survey, one subject at the time was invited to another room to receive the total earnings of all the experimental tasks. The highest total possible earning of the three tasks was CNY 50, which is equivalent to the daily wage of a farmer working at a factory. The total duration of the study including the distribution of the payoffs was between 2.5 and 3 hours.

2.2 Survey Question on Willingness to Take Risks

The survey measure of risk preferences is a typical risk preference elicitation question measured on a 5-point Likert scale: "In general, how would you rate your willingness to take risks? (1 = very unwilling; 2 = unwilling; 3 = neutral; 4 = willing; 5 = very willing)" (see for example, Charness et al., 2013). We use this question to elicit subjects' self-reported willingness to take risks in general. Subjects choosing the Likert scale 1 (very unwilling to take risk) or 2 (unwilling to take risk) are classified as risk averse, subjects choosing the Likert scale 3 (neutral) are classified as risk neutral, and subjects choosing the Likert scale 4 (willing to take risk) or 5 (very willing to take risk) are classified as risk loving. This survey question is not incentivized, and it is included in the postexperiment survey. In order to mediate the potential effects of previous experiments, we place this survey question at the end of the questionnaire.

2.3 The Holt and Laury (2002) (HL) Task

The Holt and Laury (2002) (HL) method elicits risk preferences by asking subjects to make choices in 10 binary lotteries as shown in Table 2. In each binary lottery there are two options, Option 1 and Option 2, and subjects need to choose one of them. Each option has two outcomes, a higher outcome $x1$ and a lower outcome $x2$.[7] Outcomes in Option 1 have lower variations with respect to outcomes in Option 2. This implies that Option 1 is less risky than Option 2. The probabilities of receiving the higher outcomes in the two options are the same, and increase from 1/10 in the first lottery to 10/10 in the last lottery. At the beginning, subjects may choose the less risky option. As the probabilities of receiving the higher outcomes increase, subjects may switch to the more risky option in a certain lottery. This switching point reveals subjects' risk preferences. Risk neutral subjects would switch to the more risky option in the fifth lottery, risk loving subjects before the fifth lottery, whereas risk averse subjects after the fifth lottery. Based on the switching point, an interval of utility parameters r with a constant relative risk aversion (CRRA) utility function $u(x) = x^{1-r}/(1 - r)$ can be obtained (Holt and Laury, 2002), which indicates the risk preferences of subjects ($r < 0$: risk loving; $r = 0$: risk neutral; $r > 0$: risk aversion).

After subjects complete all choices, one lottery is randomly selected to decide subjects' earnings.[8] Since each lottery has the same chance of being chosen, subjects should reveal their true risk preferences in each lottery. After the lottery is selected, one number between 1 and 10 is randomly picked. Subjects' earning is the corresponding outcome in the preferred option. For

[7] In this study, we scale up the values of the outcomes in the original Holt and Laury (2002) study to make the maximal outcome equal to that in the Andreoni and Harbaugh (2010) experiment, so that the two experiments are comparable. All scaled-up values of outcomes are adjusted to the nearest multiples of 0.5 for the purpose of easing the implementation.

[8] A parallel gains/loss HL task is conducted but the task over losses is not in the scope of this study and is not reported. Therefore, each lottery over gains has a 1/20 chance of being selected.

instance, assume the selected lottery is lottery 3 and subjects choose Option 2, and the randomly drawn number is 6, then subjects obtain a payoff corresponding to CNY 0.5.

[TABLE 2 HERE]

2.4 The Andreoni and Harbaugh (2010) (AH) Task

In each choice set of the Andreoni and Harbaugh (2010) (AH) task, subjects face a number of combinations of an outcome x and a probability p of receiving x under a budget constraint:

$$r_1 p + r_2 x = m \tag{1}$$

where r_1 is the price of the probability p, r_2 is the price of the outcome x, and m is the experimental budget. Subjects need to choose one favorite combination in each choice set.

In the original laboratory experiment (Andreoni and Harbaugh, 2010), r_2 is set equal to 1 in all choice sets. The value of p ranges from 0 to m/r_1, with a unit of increase $\Delta p = 1/100$. This implies that (p, x) combinations range from (0, m) to (m/r_1, 0), generating $100*m/r_1 + 1$ combinations. When subjects change the probability p on a computer screen, they can immediately see the corresponding change of the outcome x. In a field experiment without computers, some adjustments have to be made. We simplify the AH method following the procedure by Andreoni et al. (2013). In each choice set, we decrease the number of combinations to seven. The (p, x) combinations are: (0, m), ($m/6r_1$, $5m/6$), ($2m/6r_1$, $4m/6$), ($3m/6r_1$, $3m/6$), ($4m/6r_1$, $2m/6$), ($5m/6r_1$, m/6), (m/r_1, 0). Since the first and the last combinations mean that subjects definitely obtain zero payoffs, we only present the remaining five combinations in the task table (see Table B1 of the appendix). Table 3 presents an example of choice set. For instance, assume the subject chooses Option 4 in this choice set, then she/he has a 64/100 chance of receiving CNY 8. If this choice set is selected to decide the experimental payoffs, then one number between 1 and 100 is drawn. If this number is not higher than 64, then the subject obtains CNY 8; otherwise the subject obtains nothing.

[TABLE 3 HERE]

In this study, the AH task contains nine choice sets in total. Following Andreoni and Harbaugh (2010), r_2 is equal to one in all choice sets, but m and r_1 are different in each choice set as shown in Table 4. At the end of the task, one choice set is randomly chosen to determine subjects' earnings.

[TABLE 4 HERE]

Using laboratory data from 88 subjects, Andreoni and Harbaugh (2010) show that the independence axiom is more supported than probability weighting, and the assumption of a CRRA utility is reasonable. We confirm their findings with our field experimental data. Therefore, in this study we calculate subjects' CRRA coefficients to present their risk preferences elicited in the AH experiment. Since the HL experiment also reveals subjects' CRRA coefficients, results of the two experiments are comparable.

As shown in Andreoni and Harbaugh (2010), subjects choose the combination that maximizes the utility:

$$U(p, x) = px^{\alpha} \tag{2}$$

where α is the utility parameter indicating risk preferences ($\alpha < 1$: risk aversion; $\alpha = 1$: risk neutral; $\alpha > 1$: risk loving). Solving the problem of maximizing (2) subject to (1), we can obtain

$$x = \alpha \times \frac{r_1 p}{r_2} \tag{3}$$

For the purpose of comparing the AH task to the HL task, in this study we report and use the CRRA coefficient $r = 1 - \alpha$. The parameters α can be obtained by estimating (3) using ordinary least squares (OLS).

2.5 The Ambiguity Preferences Task

Most measures of ambiguity preferences are developed based on Ellsberg's two-color problem (Ellsberg, 1961). In these measures, subjects are asked to make choices between a risky option and an ambiguity option. In the experiment proposed by Lauriola and Levin (2001), subjects are presented with 41 choice questions. Both risk and ambiguity options have two outcomes: receiving a payment or nothing. Subjects know the probabilities of the outcomes in the risky options, but do not know the probabilities in the ambiguity options. The probabilities of receiving outcomes in the risky options change in steps ($\Delta p = 0.025$). In our field experiment, we set the probability change of the risky option as $\Delta p = 0.1$ to make a shorter list feasible for the implementation in the field.

Table 5 shows the 11 pairs of risky and ambiguity options. The possible payoffs in the risky option and the ambiguity option are the same. The probability of receiving the payoff in the risky option increases from 0/10 in the first row to 10/10 in the last row. The probability of receiving the payoff in the ambiguity option, however, is unknown (marked as "?") and will be randomly determined at the end of the task by drawing one number out of 0-10. This implies that the probability in the ambiguity option has a uniform distribution with an expected center of 5/10 (Lauriola and Levin, 2001). In the first row, subjects may choose the ambiguity option. As the probability in the risky option increases, subjects may switch to the risky option at a certain row. This switching point shows subjects' ambiguity preferences. Ambiguity averse subjects switch before the seventh row, whereas ambiguity loving subjects switch at the seventh row or after. One shortage of this method is that it cannot distinguish ambiguity neutrality from small levels of ambiguity loving and ambiguity aversion. Therefore, we follow the standard method (see for example, Kahn and Sarin, 1988; Lauriola and Levin, 2001) and classify subjects into ambiguity averse and ambiguity loving subjects ignoring ambiguity neutral subjects.

[TABLE 5 HERE]

3. Results

In this section, we first report results from aggregate data collected using different risk elicitation measures (section 3.1). Second, we conduct a within-subject comparison of different risk elicitation measures (section 3.2). Third, we investigate the determinants of risk preferences (section 3.3) elicited via different risk measures. Forth, we examine some possible reasons for inconsistency across survey and experimental measures (section 3.4).

3.1 Risk Preferences Elicited via Different Measures at the Aggregate Level

Figure 1 displays the distribution of subjects' willingness to take risks in general, which is elicited via the survey question described in section 2.2 on a Likert scale ranging from 1 to 5. About 27% of subjects report the midpoint of the scale, and about 8% of subjects choose the two extreme points.[9] The shares of risk averse, risk neutral, and risk loving subjects are 40%, 27%, and 33%, respectively.

[FIGURE 1 HERE]

In the HL experiment, 552 subjects (92%) report a unique switching point that allows us to generate an interval of constant relative risk aversion (CRRA) coefficient *r*. Figure 2 shows the distribution of CRRA coefficient *r*. The distribution follows a pattern similar to that presented in the original Holt and Laury (2002) study. The majority (68%) of subjects appear to be risk averse, about 18% risk neutral, and the remaining 14% risk loving.

[FIGURE 2 HERE]

[9] Hardeweg et al. (2013) find that about 40% of subjects choose the midpoint and 25% of subjects choose the two extreme points. Charness and Viceisza (2012) find a high proportion (27%) at one extreme point.

Figure 3 presents the distribution of CRRA coefficient *r* estimated in the AH experiment. The figure shows a considerable variation of the values of *r*. Most of the values are in the range (-1, 1), however, some extreme values can be observed suggesting that those subjects are highly risk loving. A relatively large proportion (55%) of subjects are risk averse in the experiment while the percentages of risk neutral and risk loving subjects are smaller, 7% and 38%, respectively.

[FIGURE 3 HERE]

Table 6 summarizes the percentages of risk averse, risk neutral, and risk loving subjects elicited via the survey question, the HL experiment, and the AH experiment at the aggregate level. All three measures reveal that risk averse subjects are the majority, which is consistent with results from other studies (Holt and Laury, 2002 in U.S. with students; Akay et al., 2012 in rural Ethiopia; Liu, 2013, and Carlsson et al., 2013 in rural China). The percentages of risk averse subjects elicited via the survey question and the AH experiment are smaller than those elicited in the HL experiment. In particular, 40% of subjects report that they are risk averse in the survey compared to 68% in the HL experiment and 55% in the AH experiment. In addition, the survey and AH measures reveal larger fractions of risk loving subjects (33% and 38%) compared to the HL measure (15%).

[TABLE 6 HERE]

3.2 Within-Subject Comparison of Risk Preferences across Measures

We first perform a within-subject comparison of the two incentivized experimental measures (HL and AH experiments). Then, we investigate how many subjects have CRRA coefficient *r* in the same range in the two experiments.[10] Figure 4 presents the number of subjects in each combination of CRRA coefficient intervals in the HL and AH experiments. The size of the point indicates the

[10] The CRRA coefficient *r* estimated in the AH experiment is allocated into intervals of CRRA coefficient *r* shown in Table 2 for the purpose of comparing the AH experiment and the HL experiment.

number of subjects. The shape of the point indicates different types of risk preference consistency. The triangle indicates that CRRA coefficients are in the same interval. Only 18% of subjects are in this group. The square presents subjects without the same CRRA coefficient interval but with the same classified risk attitudes (risk aversion, risk neutrality, risk loving). This group contains 21% of subjects. A large proportion (61%) of subjects (indicated by the solid circle) shows different risk attitudes in the two experiments. The ranked correlation between CRRA coefficients estimated in the HL and AH experiment is $\rho = 0.049$. The correlation is low and insignificant. In summary, subjects' estimated risk preferences are not stable across experiments. This result is in line with the majority of previous studies comparing different incentivized experimental measures (Isaac and James, 2000; Berg et al., 2005; Dulleck et al., 2013).

[FIGURE 4 HERE]

We then compare the non-incentivized survey measure with the incentivized experimental measures. Table 7 shows the percentage of subjects in each combination of classified risk preferences between the survey and the HL experiment, and between the survey and the AH experiment. Only 34% of subjects are in the same risk preference category across the survey and the HL experiment. Similarly, only 35% of subjects can be grouped into the same risk preference category across the survey and the AH experiment. The ranked correlation between risk preferences elicited via the survey and the HL experiment is weakly significant (at the 10% statistical level), and the correlation is low and negative ($\rho = -0.072$). The ranked correlation between risk preferences elicited via the survey and the AH experiment is also negative ($\rho = -0.044$) and insignificant.

[TABLE 7 HERE]

3.3 The Determinants of Risk Preferences Elicited via Different Measures

In this section, we investigate the determinants of risk preferences elicited using the survey and experimental measures. We examine the effects of individual and household characteristics such as age, gender, education, income, and household size as well as the Big Five personality traits and the locus of control, controlling for village fixed effects and tasks' order effects. Standard errors are clustered at the village level. Some characteristics such as age and gender are exogenous, however, characteristics like income and education may be endogenous (Hardeweg et al., 2013). Therefore, the results on the endogenous variables should be interpreted as correlations. In addition, the self-reported willingness to take risks is used to predict the experimental results to investigate whether the non-incentivized survey question is a good predictor for the incentivized experimental measures, as reported in Dohmen et al. (2011).

Results are presented in Table 8. In column 1, the dependent variable is the willingness to take risks in general measured on a 5-point scale. In columns 2 and 3, the dependent variable is the midpoint of interval of CRRA coefficient estimated in the HL experiment while in columns 4 and 5, the dependent variable is the CRRA coefficient estimated in the AH experiment. In columns 3 and 5, we further include the willingness to take risks to predict the CRRA coefficients. We find a gender effect only in the specification where risk preferences are elicited via the survey measure (column 1). Male subjects are more willing to take risks, which is consistent with most studies (Croson and Gneezy, 2009; Dohmen et al., 2011; He et al., 2012; Liu, 2013; Vieider et al., 2015). Similarly to the studies by Dohmen et al. (2011) and Hardeweg et al. (2013), we find that younger people are more risk loving when we use both the survey measure and AH experimental measure. Dohmen et al. (2011) find a significant correlation between education and survey-based willingness to take risks, whereas Hardeweg et al. (2013) find an insignificant correlation. Our results are consistent with Dohmen et al. (2011): a higher education level is correlated with more risk loving preferences when risk preferences are elicited via the survey measure. Working off-farm is correlated with survey-based risk aversion. In addition, we find that some personality traits such as extraversion, openness, and locus of control have some effects that, however, depend on the measure used.[11] Importantly, the coefficient of self-reported willingness to take risks in columns 3 and 5 are both insignificant which implies that the survey measure does not predict the experimental outcomes.

[TABLE 8 HERE]

3.4 Possible Explanations for Risk Preference Inconsistency across Survey and Experimental Measures

We have shown that the survey risk measure and the experimental measures yield to different categorization of risk preferences. Few studies investigate why survey and experimental measures reveal inconsistent risk preferences. One potential reason could be that elicitation measures differ in cognitive difficulty, and subjects have different levels of cognitive skills (Anderson and Mellor, 2009; Dave et al., 2010; Reynaud and Couture, 2012). We test this explanation following Reynaud and Couture (2012) and using education years as a proxy for cognitive skills to predict the consistency of risk preferences across measures. We control for some other individual characteristics such as age, gender, household income, household size, and land area.[12] We include village fixed effects and cluster the standard errors at the village level. Table 9 displays the marginal effects of a probit model where the dependent variable is a dummy variable equal to 1 if subjects have same classified risk preferences (risk aversion, risk neutrality, and risk loving) across measures, 0 otherwise. We find that education has an insignificant effect on the consistency between survey and experimental risk measures. This result is in contrast with findings by Dave et al. (2010) from Canada while it confirms previous findings by Reynaud and Couture (2012) from

[11] In column 1, the personality traits are jointly significant at the 1% statistical level; in columns 2 and 3 they are insignificant; in column 4, they are jointly significant at the 5% statistical level; while in column 5, they are jointly significant at the 1% statistical level. Dohmen et al. (2010) show that personality traits have insignificant effects on risk preferences.

[12] Except for land size, the coefficients of these control variables are not significant at conventional statistical levels.

rural France, which suggests that risk preference inconsistency may not be explained simply by differences in cognitive difficulties across measures.

[TABLE 9 HERE]

In our study, we examine another possible and previously unexplored reason for the inconsistency between the survey and experimental measures: the survey question might elicit a mix of risk and ambiguity preferences. The probability of outcomes in risky tasks is known, while the probability of outcomes in ambiguity tasks is unknown. Experimental designs allow distinguishing between risk and ambiguity preferences. In a survey question, instead, where subjects give a self-assessment of their willingness to take risks in general, it is difficult to distinguish between risk and ambiguity. When subjects' risk and ambiguity preferences differ, it may happen that self-reported willingness to take risks is different from risk preferences elicited via the experimental measures. The shift of risk preferences from the experimental measure to the survey measure can be categorized into two opposite directions. Direction 1 is towards risk loving, which includes risk aversion to risk loving, risk aversion to risk neutrality, and risk neutrality to risk loving. If our hypothesis of subjects mixing risk and ambiguity preferences in the survey holds, we would expect to observe such shifts more often when subjects are ambiguity loving. Direction 2 is towards risk aversion, which includes risk loving to risk aversion, risk loving to risk neutrality, and risk neutrality to risk aversion. Such shifts are expected to be more common among subjects that are ambiguity averse.

We use the ambiguity experiment described in section 2 to elicit subjects' ambiguity preferences. We find that 538 subjects (90%) have a unique switching point so that we are able to classify their ambiguity attitudes into ambiguity aversion and ambiguity loving. Figure 5 shows the distribution of switching row in the ambiguity experiment. We first examine the 343 subjects with inconsistent classified risk preferences across the HL experiment and the survey. Among these subjects, 195 are ambiguity averse (about 57%) and 148 (about 43%) are ambiguity loving. In addition, 95 subjects (about 28%) shift towards risk aversion in the survey and 248 (about 72%) towards risk loving. As expected, the proportion of ambiguity averse (loving) subjects shifting towards risk aversion (loving) in the survey is significantly larger (at the 5% statistical level) than the proportion of ambiguity loving (averse) subjects shifting towards risk aversion (loving): about 31% vs 23% in the case of the shift towards risk aversion, and 77% vs 69% in the case of the shift towards risk loving. This result is also confirmed by the comparison between the risk preferences elicited in the AH experiment and the survey where 353 subjects exhibit inconsistent classified risk preferences. Among these subjects, 204 are ambiguity averse (about 58%) and 149 are ambiguity loving (about 42%). The proportion of ambiguity averse (loving) subjects shifting towards risk aversion (loving) in the survey is about 49% (60%) while the proportion of ambiguity loving (averse) subjects shifting towards risk aversion (loving) is about 40% (51%). These proportions are significantly different at the 5% statistical level in line with our expectations that subjects may mix ambiguity and risk preferences in the survey question.

In addition, we formally test for the effect of ambiguity preferences on risk preference inconsistency by estimating a probit model on inconsistent subjects where the dependent variable is a dummy variable equal to one if subjects shift towards risk aversion (direction 2), and zero if subjects shift towards risk loving (direction 1); and where the independent variable is the ambiguity aversion measure.[13] Table 10 shows that compared to ambiguity loving subjects, ambiguity averse subjects are significantly more likely to make the shift towards risk aversion in both HL and AH experiments. This suggests that inconsistent risk preferences across the survey measure and experimental measures may be explained by ambiguity preferences, and that subjects seem to mix risk preferences and ambiguity preferences in the survey.

[13] We also control for individual socio-demographic characteristics (age, gender, education, working off-farm, household size, income, and land size), village fixed effects, and cluster the standard errors at the village level. The effects of gender and household size are significant at the 5% statistical level in both models. The effects of age and education are weakly significant (at the 10% statistical level), while the coefficients of the other variables are not significant.

[TABLE 10 HERE]

4. Conclusions

This paper contributes to the ongoing discussion on the consistency of risk preference elicitation measures by comparing three different elicitation measures on a large sample of non-student subjects (Chinese farmers) in a developing country using a within-subject design. Due to the lack of field evidence, especially from developing countries with non-student subjects, our study contributes to the literature by expanding laboratory findings on this topic to a broader population. The measures used to elicit risk preferences in this study include one non-incentivized survey question and two incentivized experimental measures proposed by Holt and Laury (2002) and Andreoni and Harbaugh (2010).

We examine both the consistency between the two experimental measures and the consistency between the survey and experimental measures. At the aggregate level, all elicitation measures show that the largest proportion of subjects are risk averse, although the percentages of risk averse subjects differ depending on the risk measure. Substantial within-subject inconsistencies of elicited risk preferences are observed between the two experiments. This result is in line with most previous studies (see appendix A) finding that subjects' risk preference classification often varies across experiments.

In addition, the within-subject comparison between the survey and experimental measures does not support the validity of the survey measure in terms of predicting experimental outcomes, as found by Charness and Viceisza (2012) with farmers in Senegal and in contrast to the finding by Hardeweg et al. (2013) from rural Thailand. Unlike Dave et al. (2010) but similarly to Reynaud and Couture (2012), we do not find that different cognitive difficulties of elicitation measures can explain the inconsistency across measures. We propose and test a previously unexplored explanation of the inconsistency between the survey and experimental measures: subjects may not distinguish between risk and ambiguity when they give a self-assessment of their willingness to take risks in the survey. Our findings support this explanation: the survey question seems to elicit a mix of risk and ambiguity preferences.

Given our findings on the inconsistency of risk preference elicitation measures, further research is needed to investigate the underlying reasons of this inconsistency in order to develop more reliable measures of risk preferences.

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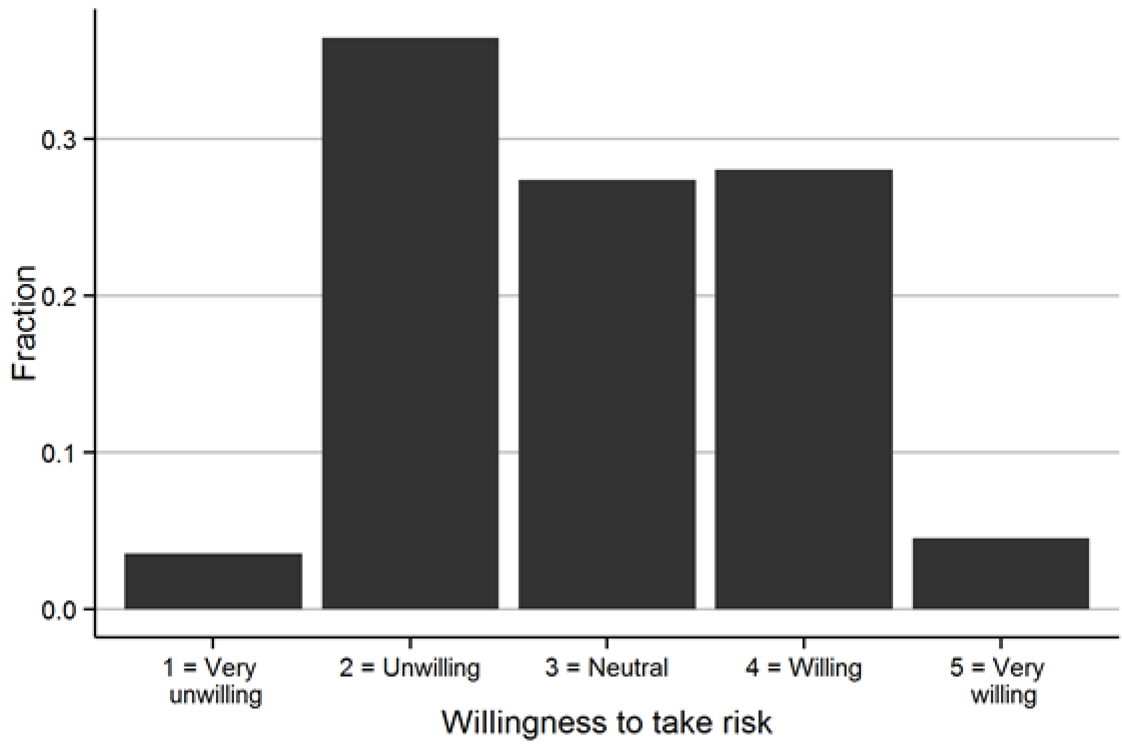

Figure 1. Histogram of Self-reported Willingness to Take Risks

Notes: The self-reported willingness to take risks is elicited by a risk preference question measured on a 5-point scale: "In general, how would you rate your willingness to take risks? (1 = very unwilling; 2 = unwilling; 3 = neutral; 4 = willing; 5 = very willing)."

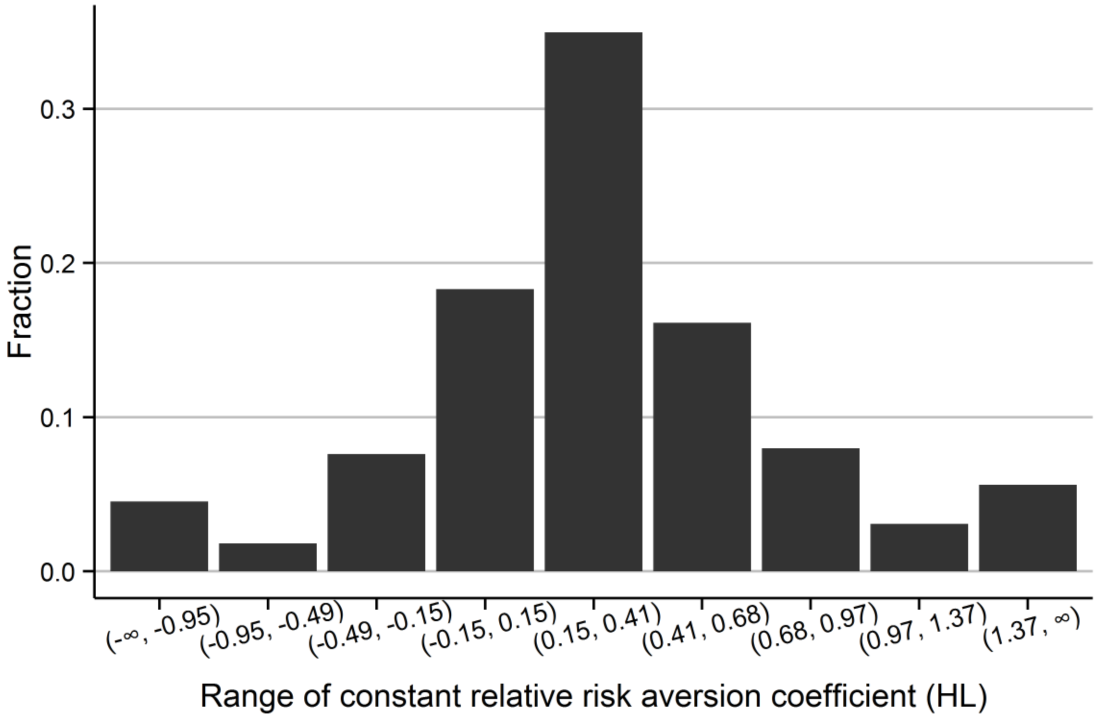

Figure 2. Histogram of CRRA Coefficient *r* in the Holt and Laury (HL) Experiment

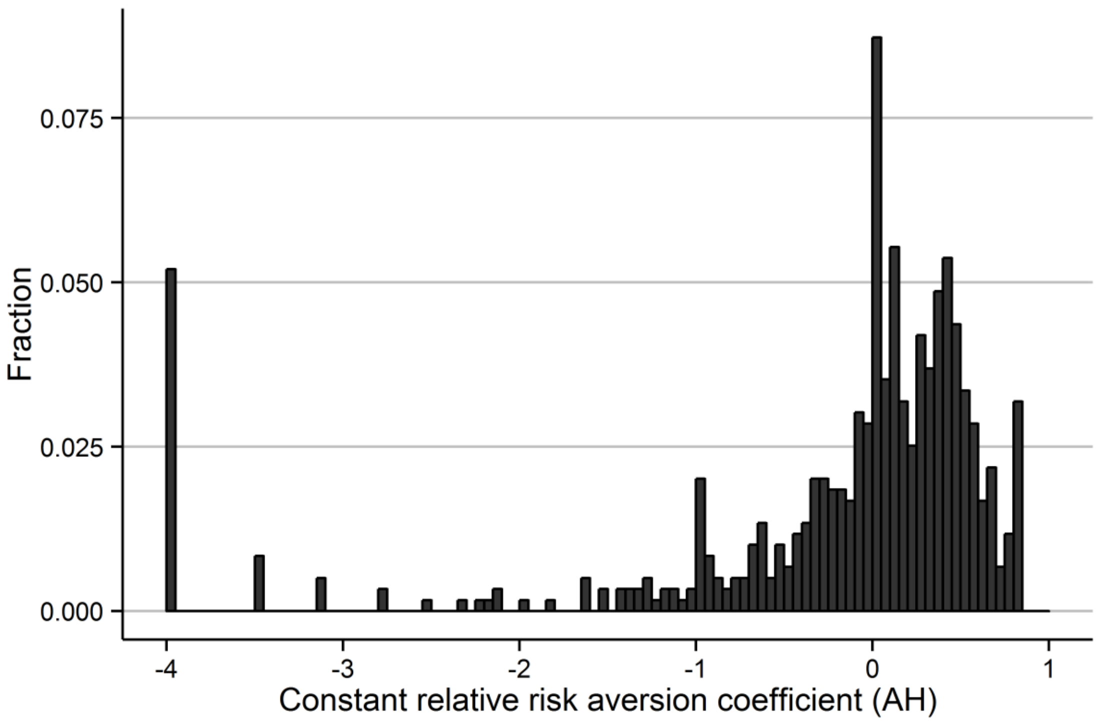

Figure 3. Histogram of CRRA Coefficient *r* in the Andreoni and Harbaugh (AH) Experiment

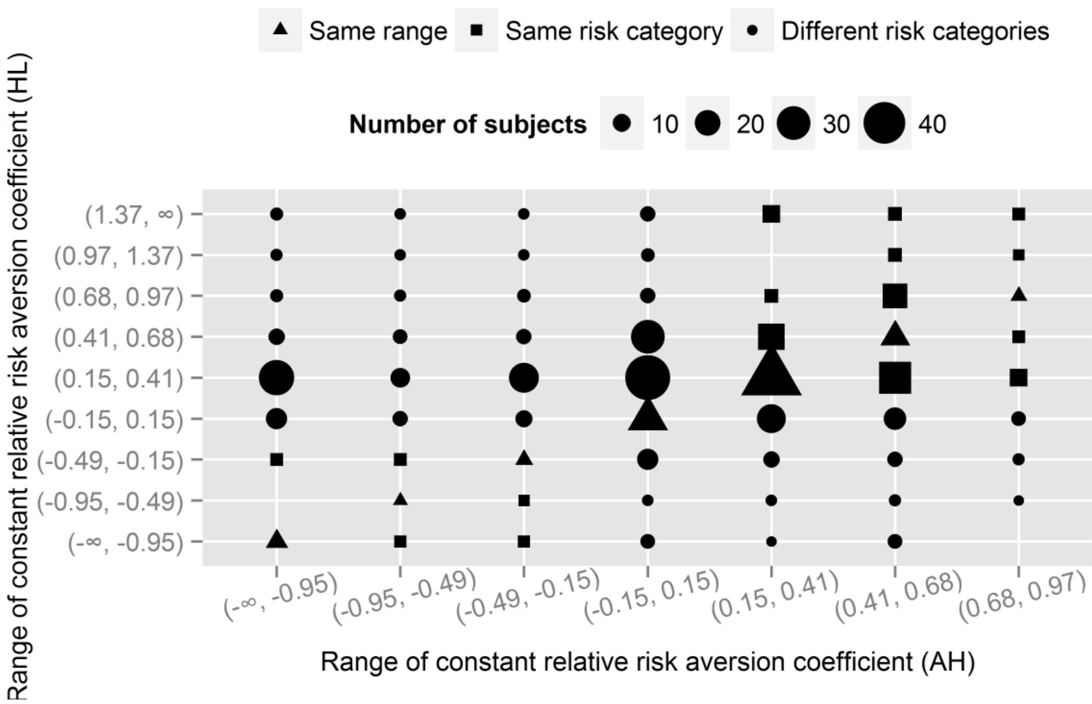

Figure 4. Within-subject Comparison between CRRA Coefficients Estimated in the Haul and Lory (HL) and Andreoni and Harbaugh (AH) Experiments

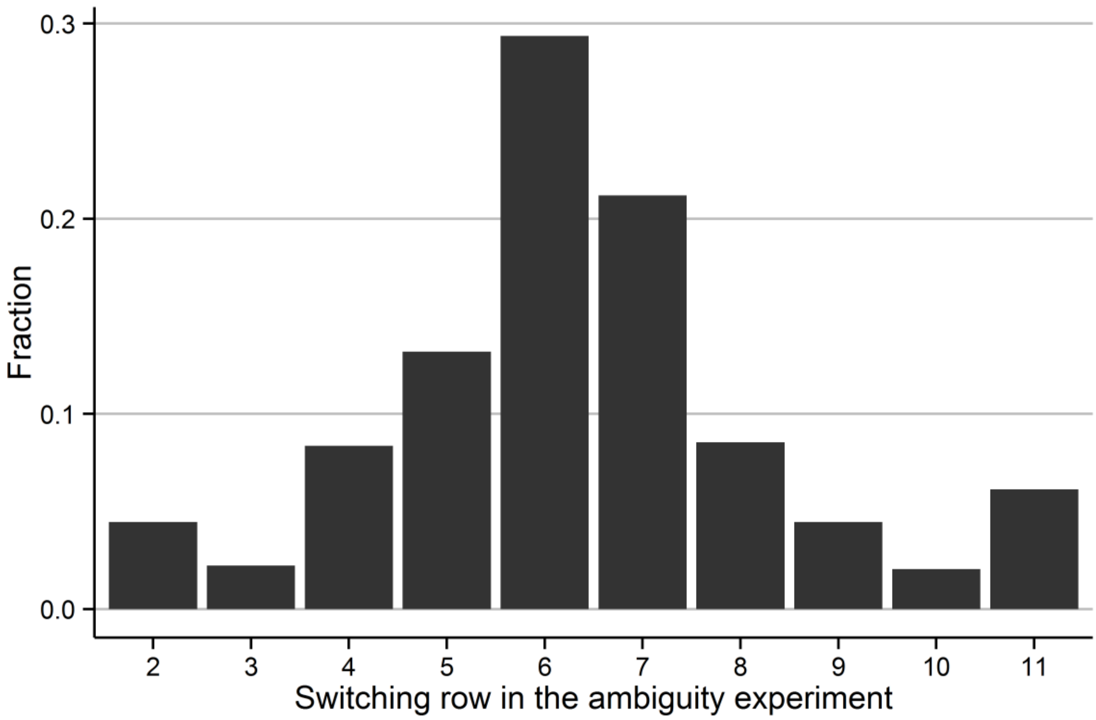

Figure 5. Histogram of Fraction of Subjects Switching Row in the Ambiguity Experiment

Table 1. Descriptive Statistics

	Mean	S.D.
General willingness to take risks	2.936	0.983
Switching row in HL risk experiment	6.067	1.741
CRRA coefficient *r* in AH risk experiment	-0.238	1.118
Switching row in the ambiguity experiment	6.361	2.019
Covariates		
Age (years)	47.540	8.735
Gender (1 = male, 0 = female)	0.735	0.442
Education (years)	9.074	2.188
Working off-farm (1 = yes, 0 = no)	0.540	0.499
Household size	4.444	1.440
Land size (hectare)	0.702	0.318
Household income (CNY 1000)	25.447	16.220
Neuroticism	0	1
Extraversion	0	1
Openness	0	1
Agreeableness	0	1
Conscientiousness	0	1
Locus of control	0	1
Observations	596	

Notes: \$1 ≈ CNY 6; S.D.: standard deviation. "HL" refers to the risk preference measure elicited by the Hault and Lory (2002) task described in section 2.3 while "AH" by the Andreoni and Harbaugh (2010) task described in section 2.4.

Table 2. Hault and Laury (2002) Task

	Option 1				Option 2				Range of relative risk aversion r
	p	*x1*	*1-p*	*x2*	*p*	*x1*	*1-p*	*x2*	
1	1/10	10.5	9/10	8.5	1/10	20	9/10	0.5	$r < -0.95$
2	2/10	10.5	8/10	8.5	2/10	20	8/10	0.5	$r < -0.95$
3	3/10	10.5	7/10	8.5	3/10	20	7/10	0.5	$-0.95 < r < -0.49$
4	4/10	10.5	6/10	8.5	4/10	20	6/10	0.5	$-0.49 < r < -0.15$
5	5/10	10.5	5/10	8.5	5/10	20	5/10	0.5	$-0.15 < r < 0.15$
6	6/10	10.5	4/10	8.5	6/10	20	4/10	0.5	$0.15 < r < 0.41$
7	7/10	10.5	3/10	8.5	7/10	20	3/10	0.5	$0.41 < r < 0.68$
8	8/10	10.5	2/10	8.5	8/10	20	2/10	0.5	$0.68 < r < 0.97$
9	9/10	10.5	1/10	8.5	9/10	20	1/10	0.5	$0.97 < r < 1.37$
10	10/10	10.5	0/10	8.5	10/10	20	0/10	0.5	$1.37 < r$

Notes: x1 and *x2* are the two outcomes of each option; *p* is the probability of receiving outcome *x1*.

Table 3. Andreoni and Harbaugh (2010) Task: Example of Choice Set

	Option 1	Option 2	Option 3	Option 4	Option 5
p	16/100	32/100	48/100	64/100	80/100
x	20	16	12	8	4

Notes: x is the possible outcome of each option with a probability *p*.

Table 4. Nine pairs of the Parameters m and r_1 in Choice Sets of the Andreoni and Harbaugh Task

Choice set	1	2	3	4	5	6	7	8	9
r_1	12.495	18.75	37.5	75	150	25	37.5	75	150
m	12	12	12	12	12	24	24	24	24

Notes: m is the experimental budget, and r_1 is the price of the probability of receiving a certain outcome.

Table 5. Choice Sets in the Ambiguity Task

	Risky option		Ambiguity Option	
	p	*x*	*p*	*x*
1	0/10	10	?	10
2	1/10	10	?	10
3	2/10	10	?	10
4	3/10	10	?	10
5	4/10	10	?	10
6	5/10	10	?	10
7	6/10	10	?	10
8	7/10	10	?	10
9	8/10	10	?	10
10	9/10	10	?	10
11	10/10	10	?	10

Notes: x represents the outcome, and *p* the probability of receiving the outcome *x.*

Table 6. Risk Preferences Elicited via Different Measures at the Aggregate Level

	Risk aversion	Risk neutrality	Risk loving	Total number of subjects
Survey	40%	27%	33%	595
HL	68%	18%	14%	552
AH	55%	7%	38%	596

Notes: "Survey" refers to the self-reported willingness to take risks in general, measured on a 5-point scale. "HL" refers to the risk preference measure elicited by the Hault and Lory (2002) task described in section 2.3 while "AH" by the Andreoni and Harbaugh (2010) task described in section 2.4.

Table 7. Within-subject Comparison between Survey and Experimental Measures

		HL experiment			AH experiment		
		Risk aversion	Risk neutrality	Risk loving	Risk aversion	Risk neutrality	Risk loving
Survey	Risk aversion	**25%**	8%	7%	**22%**	2%	16%
	Risk neutrality	20%	**5%**	3%	14%	**2%**	11%
	Risk loving	23%	6%	**4%**	19%	2%	**11%**

Note: See footnote of Table 6.

Table 8. Determinants of Risk Preferences Elicited via Different Measures

Dependent variable	Willingness to take risks	CRRA coefficient r (HL)		CRRA coefficient r (AH)	
	(1)	(2)	(3)	(4)	(5)
Willingness to take risks			0.027		-0.032
			(0.027)		(0.067)
Age	-0.012**	0.001	0.002	-0.009***	-0.008***
	(0.005)	(0.003)	(0.002)	(0.003)	(0.003)
Gender	0.344***	0.026	0.018	0.031	0.050
	(0.096)	(0.065)	(0.067)	(0.122)	(0.114)
Education	0.056**	0.000	-0.002	-0.008	-0.009
	(0.022)	(0.008)	(0.009)	(0.020)	(0.018)
Working off-farm	-0.144*	0.013	0.014	-0.006	-0.021
	(0.074)	(0.041)	(0.042)	(0.078)	(0.084)
Household size	0.038	-0.002	-0.002	0.008	0.012
	(0.025)	(0.014)	(0.013)	(0.032)	(0.033)
Land size	-0.163	0.091	0.093*	0.095	0.076
	(0.127)	(0.059)	(0.054)	(0.131)	(0.131)
Household income	0.003	-0.002*	-0.002*	-0.006	-0.006
	(0.002)	(0.001)	(0.001)	(0.004)	(0.005)
Neuroticism	-0.046	0.029	0.029	-0.083	-0.093
	(0.049)	(0.028)	(0.029)	(0.062)	(0.059)
Extraversion	0.101**	0.017	0.011	-0.050	-0.057
	(0.040)	(0.015)	(0.016)	(0.049)	(0.046)
Openness	0.066	-0.025	-0.029	0.070**	0.066*
	(0.048)	(0.028)	(0.027)	(0.035)	(0.035)
Agreeableness	0.044	-0.008	-0.013	-0.005	-0.019
	(0.074)	(0.027)	(0.027)	(0.035)	(0.038)
Conscientiousness	0.027	-0.007	-0.008	-0.002	-0.006
	(0.069)	(0.027)	(0.027)	(0.042)	(0.043)
Locus of control	0.009	-0.020	-0.024	-0.068*	-0.080*
	(0.044)	(0.025)	(0.025)	(0.040)	(0.042)
Constant	2.620***	0.216	0.145	0.495	0.575
	(0.387)	(0.145)	(0.113)	(0.334)	(0.419)
Village fixed effects	Yes	Yes	Yes	Yes	Yes
Order effect	Yes	Yes	Yes	Yes	Yes
Observations	578	536	535	579	578

Notes: In column 1, the dependent variable is the willingness to take risks in general measured on a 5-point scale. In columns 2 and 3, the dependent variable is the midpoint of interval of CRRA coefficient estimated in the HL experiment while in columns 4 and 5, the dependent variable is the CRRA coefficient estimated in the AH experiment. Standard errors clustered at the village level are in parentheses. *, **, ***: Significant at the 10%, 5%, and 1% levels, respectively.

Table 9. Marginal Effects of Education on Risk Preferences Consistency

	Survey vs. HL	Survey vs. AH
	(1)	(2)
Education	-0.022 (0.015)	0.007 (0.009)
Village fixed effects	Yes	Yes
Other controls	Yes	Yes
Observations	535	578
Log likelihood	-326.98	-364.61

Notes: The dependent variable is a dummy variable equal to one if subjects have same classified risk preferences across measures, zero otherwise. Other controls include age, gender, working off-farm, household size, land area, and household income. Average probit marginal effects are reported. Standard errors clustered at the village level are presented in parentheses.

Table 10. Marginal Effects of Ambiguity Preferences on Inconsistent Risk Preferences

	Survey vs. HL	Survey vs. AH
	(1)	(2)
Ambiguity aversion (1/0)	0.113** (0.054)	0.129*** (0.049)
Village fixed effects	Yes	Yes
Other controls	Yes	Yes
Observations	335	343
Log likelihood	-164.2	-202.69

Notes: The dependent variable is a dummy variable equal to one if subjects shift from risk loving or risk neutrality in the experiment to risk aversion in the survey, or from risk loving in the experiment to risk neutrality in the survey, and zero if subjects shift towards risk loving, i.e., from risk aversion or risk neutrality in the experiment to risk loving in the survey, or from risk aversion in the experiment to risk neutrality in the survey. Other controls include age, gender, education, working off-farm, household size, land area, and household income. Average probit marginal effects are reported. Standard errors clustered at the village level are presented in parentheses. **, ***: Significant at the 5% and 1% levels, respectively.

Appendix A. Studies Comparing Risk Preference Measures

Table A1 summarizes studies that compare risk preferences elicited via different measures. These studies are often conducted in the laboratory with students (panel A) and in developed countries (for example, USA, Germany, and Australia). Very few studies are conducted in the field with non-student subjects (panel B) and in developing countries. Charness and Viceisza (2012) compare the survey question on willingness to take risks (henceforth, WTR), the HL experimental measure, and the Gneezy and Potters (1997) experimental measure (henceforth, GP). They use a between-subject comparison with a small sample size (91 farmers in Senegal). They find that subjects behave differently in the two experimental measures, and the survey measure is unlikely to reveal accurate risk attitudes. Hardeweg et al. (2013) compare the WTR and adjusted HL measures.[14] They use a within-subject comparison with a large sample size (934 farmers in Thailand). They find that the survey measure can predict subjects' choices in the experiment.

Pairs or groups of different incentivized experimental measures are compared in studies by Harrison (1990), Isaac and James (2000), Berg et al. (2005), Deck et al. (2008b), Bruner (2009), Hey et al. (2009), Dave et al. (2010), Harbaugh et al. (2010), Charness and Viceisza (2012), Reynaud and Couture (2012), Crosetto and Filippin (2013b), Deck et al. (2013), and Dulleck et al. (2013). In particular, Dulleck et al. (2013) compares the HL and AH measures, however, with a small student sample (78 Australian students). Although the experimental measures used differ, all studies report that a considerable number of subjects exhibit inconsistency across experimental measures.

In some of the aforementioned studies (Deck et al., 2008b; Charness and Viceisza, 2012; Reynaud and Couture, 2012; Crosetto and Filippin, 2013b; and Deck et al., 2013), survey measures are also implemented and compared to incentivized experimental measures. Studies that compare just one incentivized experimental measure with survey measures are also listed in Table A1. Insignificant correlations between risk preferences elicited via the survey and incentivized

[14] The adjusted HL design differs with the original HL design in presenting one lottery and one fixed amount instead of two lotteries in a binary choice.

experimental measures are reported in Eckel and Grossman (2002; 2008), Deck et al. (2013), and Lönnqvist et al. (2015). Charness and Viceisza (2012) do not report the correlations, but different patterns in subjects' revealed risk attitudes can be observed in different measures. In other studies, experimental risk preferences are found significantly correlated with risk attitudes in general or in some specific domains. The variance explained, however, is not high: no more than 10% of the variance in experimental choices can be explained by risk attitudes elicited via the survey questions. This suggests that survey measures cannot precisely predict experimental behaviours, even if significant correlations are presented. For instance, Hardeweg et al. (2013) report that the willingness to take risks in general can significantly predict experimental behaviours at the 1% level. A closer investigation, however, shows that roughly 65% of subjects report that they are risk neutral or risk loving in the survey, but only 10% of subjects are revealed to be risk neutral or risk loving in the adjusted HL experiment.

Table A1. Studies Comparing Different Risk Elicitation Measures

Studies	Sample size	Country	Risk elicitation measures: Survey questions	Risk elicitation measures: Incentivized experiments	Results
				Panel A: Student subjects	
Ding et al. (2010)	121	China	WTR, hypothetical lottery question	Adjusted HL	The correlation of risk preferences elicited via the survey and the experiment is significant at the 5% level.
Harrison (1990)	46	USA		First-price auction, BDM	Compared to the first-price auction, BDM reveals a larger level of risk loving.
Isaac and James (2000)	34	-		First-price auction, BDM	Only a few subjects are stable between the two experiments.
Eckel and Grossman (2002; 2008)	261	USA	WTR	EG	The correlation of risk preferences elicited via the survey and the experiment is insignificant.
Kruse and Thompson (2003)	93	USA	WTR	Risk mitigation experiment	Of the total 93 subjects, only 23 subjects are consistent between the survey and the experiment.
Berg et al. (2005)	48	USA		BDM, English clock auction, first-price auction	Subjects are not stable across elicitation measures.
Deck et al. (2008b)	75	USA	WTR, hypothetical investment and risk job questions	HL, DOND	The correlation of risk preferences elicited between different methods is insignificant.
Anderson and Mellor (2009)	239	USA	hypothetical gamble questions	HL	The majority of subjects are not consistent across elicitation methods.
Bruner (2009)	157	USA		MPL (probability variation), MPL (reward variation)	A large number of subjects are inconsistent across methods.
Hey et al. (2009)	24	USA		PC, BID, ASK, BDM	The correlation of risk preferences elicited via different methods is low and insignificant in most cases.
Harbaugh et al. (2010)	96	USA		Choice and price-based lottery tasks	A large number of subjects are inconsistent across elicitation methods.
Crosetto and Filippin (2013b)	444	Germany	WTR	HL, EG, BART, GP, BRET	Elicited risk preferences are inconsistent across methods.
Deck et al. (2013)	203	USA	WTR	HL, EG, DOND, BART	The correlation of risk preferences elicited via different methods is low and insignificant in most cases.
Dulleck et al. (2013)	78	Australia		HL, AH	Only 10% of subjects have the same risk preference intervals in the two experiments.
Lönnqvist et al. (2015)	232	Germany	WTR	HL	The correlation of risk preferences elicited via the survey and the experiment is insignificant.
Vieider et al. (2015)	2939	30 countries	WTR	Adjusted HL	The correlation of risk preferences elicited via the survey and the experiment is significant for most countries.

Table A1. Studies Comparing Different Risk Elicitation Measures (continued)

Panel B: Non-student subjects					
Charness and Viceisza (2012)	91	Senegal	WTR	HL, GP	Subjects fail to understand the HL experiment but not the GP experiment. The risk patterns revealed via the survey and the GP experiment are different.
Hardeweg et al. (2013)	934	Thailand	WTR, hypothetical investment question	Adjusted HL	The correlation of risk preferences elicited via the survey and the experiment is significant at the 1% level.
Pennings and Smidts (2000)	346	Netherlands	WTR	MPL	The correlation of risk preferences elicited via the survey and the experiment is significant at the 1% level.
Dave et al. (2010)	881	Canada		HL, EG	At the aggregate level, subjects are more risk averse in the HL experiment than in the EG experiment.
Dohmen et al. (2011)	450	Germany	WTR, hypothetical investment question	Adjusted HL	The correlation of risk preferences elicited via the survey and the experiment is significant at the 1% level.
Reynaud and Couture (2012)	30	France	WTR	HL, EG	The correlation of risk preferences elicited via the survey and the experiment with low payoffs is weakly significant at the 10% level, the correlation of risk preferences elicited via the survey and the experiment with high payoffs is insignificant.

Notes: Elicitation measures: AH – the Andreoni and Harbaugh (2010) method; ASK – A minimal selling price for lotteries (Hey et al., 2009); BART – the Balloon Analogue Risk Task (Lejuez et al., 2002); BDM – the Becker, Degroot, and Marschack method (Becker et al., 1964); BID – A maximal buying price for lotteries (Hey et al., 2009); BRET – the Bomb Risk Elicitation Task (Crosetto and Filippin, 2013a); DOND – the Deal or No Deal method (Deck et al., 2008a); EG – the Eckel and Grossman (2002) method; GP – the Gneezy and Potters (1997) method; MPL – Multiple Price List; PC – Pairwise Choice of lotteries (Hey et al., 2009); WTR – Willingness to take risks (Blais and Weber, 2006; Dohmen et al., 2011).

Appendix B

Table B1. Andreoni and Harbaugh (2010) Task

For each decision number (1 to 9) below, decide the option you **like most** by checking the corresponding box. Example: In decision 1, if the option you like most is: 16 out of 100 chance of gaining ¥10, you would check the left-most box. Remember to check only one box per decision!						
1	__out of 100 chance	16	32	48	64	80
	of gaining	¥10	¥8	¥6	¥4	¥2
2	__out of 100 chance	11	21	32	43	53
	of gaining	¥10	¥8	¥6	¥4	¥2
3	__out of 100 chance	5	11	16	21	27
	of gaining	¥10	¥8	¥6	¥4	¥2
4	__out of 100 chance	3	5	8	11	13
	of gaining	¥10	¥8	¥6	¥4	¥2
5	__out of 100 chance	1	3	4	5	7
	of gaining	¥10	¥8	¥6	¥4	¥2
6	__out of 100 chance	16	32	48	64	80
	of gaining	¥20	¥16	¥12	¥8	¥4
7	__out of 100 chance	11	21	32	43	53
	of gaining	¥20	¥16	¥12	¥8	¥4
8	__out of 100 chance	5	11	16	21	27
	of gaining	¥20	¥16	¥12	¥8	¥4
9	__out of 100 chance	3	5	8	11	13
	of gaining	¥20	¥16	¥12	¥8	¥4

Notes: The table is designed based on tables used by Andreoni et al. (2013) and Andreoni and Harbaugh (2010). ¥ = CNY.