Measuring Group Selection Effects on Attitudes toward Uncertainty: Experimental Evidence from Bangladesh†

Ahsanuzzaman[1], Asad Karim Khan Priyo[2], Kanti Ananta Nuzhat[2]

Abstract

We address two broad issues in the paper – we (*i*) measure the effects of communication on risk and ambiguity aversions, and (*ii*) investigate the role selection of own group members plays in one's attitudes toward uncertainty. In the process of addressing the above two broad objectives, we first measure farmers' risk and ambiguity aversions when subjects make decision alone. We investigate the subjects' attitudes toward uncertainty with different winning probabilities (p=0.3, 0.5, and 0.7) for risk experiments only as probabilities of winning are unknown for ambiguity experiments. Secondly, in order to measure the effects of communication, we conduct all these variations of experiments allowing farmers to make decisions in groups of three. We measure the influence of group-member selection on attitudes toward uncertainty by allowing half the subjects to form groups of three on their own and random peering of equal group size for the remaining subjects. Experiments using 206 farmers in Jessore district of Bangladesh provide results with five notable features. *First*, farmers in our study are, on average, moderate-to-highly risk averse but ambiguity neutral to mildly ambiguity averse. Women tend to be more risk and ambiguity averse than men. *Second*, farmers exhibit higher risk and ambiguity aversions when they make choices in groups compared to when they choose alone. *Third*, male farmers tend to make more extreme choices than females all cases: making choices alone, and in groups of both types. *Fourth*, farmers are less risk averse when group members are self-selected relative to when they are randomly assigned which is more relevant for males than females. This implies that the (male) birds of same feather flock together even in uncertain prospects when more controlled attitudes are needed. *Finally*, farmers are more ambiguity averse when making decisions in consultation with self-selected peers compared to when making decisions in consultation with randomly assigned group members. The opposite selection effects suggest that Bangladeshi farmers in general view and act differently when probability distribution of uncertain prospect is known compared to a scenario when the probability distribution is unknown. This clearly suggests the need for different policy prescriptions with regard to choices that have both risk and ambiguity features such as technology adoption.

Keywords: Risk aversion; Ambiguity aversion; social influence; selection effect

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[1]Post-Doctoral Researcher, Center for Experimental and Applied Economics, Department of Applied Economics and Statistics, University of Delaware, Newark, DE 19716, USA. Email: ahsanmi@udel.edu

[2]Assistant Professor, Department of Economics, North South University, Dhaka, Bangladesh. Email: asad.priyo@northsouth.edu

[2]Assistat Professor, Department of Economics, North South University, Dhaka, Bangladesh. Email: kanti.nuzhat@northsouth.edu

1. Introduction

There is a rich literature focusing on the role of individuals' risk aversion as an important behavioral factor in certain choices such as technology adoption (Ahsanuzzaman and Norton, 2014; Liu, 2013; Ward and Singh, 2014; Barham *et. al*., 2013; Alpizar *et. al*., 2011; Feder *et al*., 1985; Feder, 1980; Srinivasan, 1972). The role of ambiguity aversion, a second type of uncertainty that implies that an individual has preference for a known risk over an unknown risk, in individuals' decision-making is less studied on developing countries perspective. Analyzing risk attitudes is relevant when outcome is uncertain with known distribution, and investigating ambiguity attitudes becomes important when not only the outcome is uncertain but also the distribution of outcomes is unknown. Decisions such as adoption of brand new technology certainly involves risk and ambiguity attitudes as both the outcome and the distribution of outcome of the new technology are unknown to the decision makers prior to using it. Potential omitted variable bias problem can arise if only risk attitude is included in the adoption model whereas the ambiguity attitude is also an inherent component of the choice. Conclusion based on such biased estimate may lead to wrong policy recommendations and formulation.

Furthermore, economic agents in the real world can communicate among themselves when making a choice which may affect their attitudes toward uncertainty, ambiguity in particular which is mainly the subjective belief, and in turn can alter their adoption decision. The issue is more important as individuals' attitudes may change in a certain direction depending on who they communicate with. The literature also demonstrates that subjects' communication among themselves prior to decision- making changes their risk and ambiguity aversions on choices over uncertain prospects (Fershtman and Segal, 2018; Ahsanuzzaman and Norton, 2016; Alpizar *et al.*, 2011; Engle *et al.*, 2013; Chung *et al.*, 2014). Sometimes, the behavior of others influences own decisions (Fershtman and Segal, 2018; Jackson, 2014; Brunette *et al.*, 2014) due to, among other factors, whom the agents choose to communicate to leading to a group members' selection effect on individuals' attitudes toward uncertainty. Consequently, it is also important to investigate and measure the impact of selection of groups on individuals' attitudes toward uncertainty. A thorough investigation of group selection effects may be helpful in formulating policy and designing interventions for any specific groups of people to attain the desired outcome.

Building on the above-mentioned issues, we address two broad issues in the paper – we (*i*) measure the effects of communication on risk and ambiguity aversions, and (*ii*) investigate the role selection of own group members plays one's attitudes toward uncertainty. In the process of addressing the above two broad objectives, we first measure farmers' risk and ambiguity aversions when subjects make decision alone. We investigate the subjects' attitudes toward uncertainty with different winning probabilities (p=0.3, 0.5, and 0.7) for risk experiments only as probabilities of winning are unknown for ambiguity experiments. Secondly, in order to measure the effects of communication, we conduct all these variations of experiments allowing farmers to make decisions in groups of three. We measure the influence of group members' selection on attitudes toward uncertainty by allowing half the subjects to form groups of three on their own and random peering of equal group size for the remaining subjects.

Experiments using 206 farmers in Jessore district of Bangladesh provide results with five notable features. *First*, farmers in our study are, on average, moderate-to-highly risk averse but ambiguity neutral to mildly ambiguity averse. Women tend to be more risk and ambiguity averse than men. *Second*, farmers exhibit higher risk and ambiguity aversions when they make choices in groups compared to when they choose alone. *Third*, male farmers tend to make more extreme choices than females all cases: making choices alone, and in groups of both types. *Fourth*, farmers are less risk averse when group members are self-selected relative to when they are randomly assigned which is more relevant for males than females. This implies that the (male) birds of same feather flock together even in uncertain prospects when more controlled attitudes are needed. *Finally*, farmers are more ambiguity averse when making decisions in consultation with self-selected peers compared to when making decisions in consultation with randomly assigned group members. The opposite selection effects suggest that Bangladeshi farmers in general view and act differently when probability distribution of uncertain prospect is known compared to a scenario when the probability distribution is unknown. This clearly suggests the need for different policy prescriptions with regard to choices that have both risk and ambiguity features such as technology adoption.

2. Literature Review

Since excluding measuring risk preferences from a study involving choice can potentially pose an omitted variable bias problem, inclusion of risk preference in technology adoption study is a solution to the problem. The technology adoption literature considering risk aversion as an important factor can be traced as back as Sandmo (1971), Srinivasan (1972), and Feder (1980). Binswanger (1980, 1981) are among the experimental studies measuring risk aversion of farmers in developing countries. Binswanger (1980) used both response behavior of Indian farmers from a hypothetical questionnaire and incentive-compatible experiments to compare results from the two methods. Studies focusing on risk preferences differ in methods for data collection that include analyses based on experimental lotteries as well as the analysis of production decisions based on data collected from household surveys. Among studies using experimental lotteries, some have been based on hypothetical lotteries (Hill, 2009; de Brauw and Eozenou, 2014), some on real lotteries (Miayata, 2003; Wik *et. al*., 2004; Liu, 2013; Yesuf and Bluffstone, 2009; Tanaka *et al*,. 2010; Harrison *et al*., 2010), and some on both (Binswanger, 1981; Holt and Laury, 2002; Mosley and Verschoor, 2005). In addition to differences in experimental set up, the conceptual framework for characterizing risk preferences varies from expected utility theory (EUT) to prospect theory (PT).

Among studies using experimental lotteries, designs of the experiments vary for measuring attitudes toward uncertainty. The designs include lotteries that hold outcome probabilities constant and vary payouts (Binswanger, 1980, 1981; Miayata, 2003; Barr, 2003; Wik *et al*., 2004) or that use a multiple price list (MPL) approach in which probabilities vary with payouts held constant (Holt and Laury, 2002; Eckel *et al*., 2002; Harrison *et al*., 2005; Harbaugh *et al*., 2002). In the MPL approach, participants are shown certain lottery pairs at once (i.e., on a sheet or computer screen, similar to Table A1 in the appendix), and are asked to mark their preferences (lottery A or lottery B) in each row.

Though less common, studies investigating attitudes toward ambiguity have conducted experiments using college student populations in developed countries. There are few experimental studies that measure attitudes toward ambiguity in farming societies in developing countries that include Henrich and McElreath (2002), Akay*et al.*, (2012), Ward and Singh (2015), and Engle-Warnick *et al*., (2011). Another small but growing strand of literature focuses on measuring the attitudes toward uncertainty in the presence of social exchanges. The idea behind including social exchanges among subjects in experiments is that individuals often coordinate among themselves in the real world before making a decision. By doing so, they attempt to reduce ambiguity as well as cost that are related to gathering information (Alpizar *et al*., 2011). This strand of literature argues that communication among individuals prior to making choices over uncertain prospects might change risk and ambiguity preferences ((Fershtman and Segal, 2018; Ahsanuzzaman and Norton, 2016; Alpizar et al., 2013; Chung et al., 2014). In a real-world decision-making on choices that has both risk and ambiguity features such as adoption of a brand-new technology, individuals have scopes to communicate with their peers or someone whose advice they find reliable before making adoption decision. Sometime farmers mimic other farmers' farming practices if they are convinced that those are better practices and hence generates higher profits. Thus, the decision-making in a group-setting might be such that the decision others influences own choices (Fershtman and Segal, 2018; Jackson, 2014; Brunette et al., 2014) due to, among other factors, whom the agents choose to communicate to, leading *group members selection effects*. It is important to examine both the extent and the direction, if any, of effects of communication among individuals on their attitudes toward uncertainty.

3. Experimental Design and Procedure

Much of the literature on risk elicitation procedures follows either the pioneering work of Binswanger (1980) or of Holt and Laury (2002). Our instrument, presented in appendix table A2 is different from the one employed by those authors. We follow the approach similar to those of Akay *et al.,* (2012), Capon (2009), and Barham *et al*., (2014) and ask respondents to directly compare certain amounts and lotteries. By making 21 choices, as shown in Table A2, subjects reveal certainty equivalents (CE) for the lotteries. A CE is the payment such that the subject is indifferent between receiving the prospect or the sure amount. The elicited CEs are then used to measure the coefficients of relative risk aversion for each subject. CEs allow risk preferences across respondents to be compared as well. The same exercise was conducted with subject groups of 3 to investigate the behavioral pattern of the subject alone and in groups of peer farmers.

Table 1: Summary of all experiments conducted

Game No.	Probability of winning	Gain only (G) or Loss included as well	Number of player(s)	Risk (R) or ambiguity (A) experiment
1	50	G	1	R
2	50	G	3	R
3	30	G	1	R
4	30	G	3	R
5	70	G	1	R
6	70	G	3	R
7	50	L	1	R
8	50	L	3	R
9	70	L	1	R
10	70	L	3	R
11	30	L	1	R
12	30	L	3	R
13		G	1	A
14		G	3	A
15		L	1	A
16		L	3	A

At the beginning of the experiments, participants were provided with a house money of BDT 500. Participants were provided 21 choices between a certain payoff and the risky prospect with the certain payoff increasing in 50 BDT increments from 0 BDT to 1000 BDT (see Table A2 in appendix). There are two types of uncertain prospects in different experimental sessions based on gain and loss domains of the experiments. In gain domain, the lottery is between winning 1000 BDT and nothing (0 BDT), which is between winning 1000 BDT and losing 500 BDT for loss domain. There are 3 different probability distribution (p=0.3; p=0.5; and p=0.7) of two outcomes in uncertain prospect in risk experiments where subjects participated in each type of risk experiments twice – facing the uncertain prospects alone and in groups of 3. The probability distribution is unknown for ambiguous experiments and hence subjects participated in ambiguous experiments twice for both gain and loss domain – facing uncertainty alone and in groups of 3.

In summary, each subject participates in 12 experiment sessions as shown in Table A2 for risk experiment and 4 ambiguous experimental sessions. Table 1 summarizes the total number of sessions each subject faced during the whole experiment period. *G* in Table 1 represents gain domain, while *L* indicates the loss domain; when number of players is 3 implies subjects made decisions in groups of 3. There are two types of groups each experiment day. Fifty percent of subjects formed groups of 3 members selected by themselves, while the remaining subjects have been formed groups of 3 by random assignment of their group members. In order to eliminate order effects, each subject faced the 16 sessions in Table 1 at random order.

The experiment is designed to elicit the participant's *certainty equivalents* for both the risky and ambiguous prospects. There are two types of experimental sessions based on two different uncertain prospects: one risky and the other ambiguous. The risky prospect allows the participant to bet on the color of a ball drawn from a bag containing 3 pink and 7 green balls for p=0.3; 5 pink and 5 green balls for p=0.5; and 7 pink and 3 green balls for p=0.7[2] in three different chance mechanisms (30%, 50%, and 70%) to win the prize (see table A2). The ambiguous prospect, on the other hand, allows participants to bet on the color of a ball drawn from a bag containing 10 balls. The combination of pink and green balls in the bag can be any such that it sums up to 10 and hence the probability of winning is unknown to the subject (see table A2). The participant can win 1000 Bangladeshi Taka (BDT) by predicting the color correctly[3]. A choice list is used to elicit each participant's certainty equivalence at switching points for the two prospects. For small certain payments, it is expected that most participants prefer to play the lottery. However, when the certain payoff is large, it is expected that participants will opt to take the payment instead of playing the lottery. Given this expectation, participants' risk preferences should be revealed at the point where

[2] This may be very simple game, but it is reasonable to get their behavior elicited provided that the farmer group has little to no formal education. With sophisticated lotteries, it might be difficult for farmers to understand the situation and hence to elicit their true attitude.
[3] The daily wage for an unskilled labor in this region is BDT 250-400 depending on the season.

they switch from playing a lottery to the sure thing. Hence, participants had an opportunity to leave the experiment station earning as low as 0 BDT and as much as 1500 BDT depending on their decision-making in each experiment session. Hence, the design of the experiment provides an incentive-compatible environment so that subjects reveal their true preferences on uncertain prospects.

Following Eggert and Lokina (2007), and Akay *et al*., (2012), the CE for each participant in each game is calculated as the midpoint between the lowest certain payoffs for which the participant chooses the sure thing and the highest certain payment for which (s)he chooses to play lottery. A constant relative risk aversion (CRRA) utility function is assumed for the agents, i.e., $u(x) = x^{1-\gamma}$ where γ is the coefficient of the relative risk aversion. The ambiguity aversion can be estimated using the elicited certainty equivalent for both the risk and ambiguous situations using the following formula (Akay *et al*., 2012).

$$Ambiguity\ aversion\ (\theta) = \frac{CE_R - CE_A}{CE_R + CE_A} \qquad (1)$$

where CE_R = Certainty equivalent amount of money for the risky prospect, and CE_A = Certainty equivalent amount of money for the ambiguous prospect. This measure ranges from -1 (ambiguity loving) to 0 (ambiguity neutrality) to 1 (ambiguity averse). Similar to Engle *et al*., (2013), our experimental design provides the scope for measuring ambiguity aversion based on switchover points in both risky and ambiguous lotteries. The relative location of the switch-over point in the ambiguity instrument as compared to the switch-over point in the risk instrument reveals the subject's ambiguity preferences.

In the experiment, we at first form the groups of 3 members. The following decisions then are randomly made for each group: whether subjects will face te prospects alone first or in group first. If individual decisions are randomly chosen for a certain group, for an example, each person faces sessions 1, 3, 5, 7, 9, 11, 13, and 15 in Table 1 at random order. Once individual decisions are made for that group, members are allowed to communicate before making each person's choice separately. In this stage, each group faced the uncertain prospects of sessions 2, 4, 6, 8, 10, 12, 14, 16 of Table 1 at random order. While individuals were allowed communication in groups, we tell them, however, that each of the participants in a group can make their own choices separately and the choices of each participant in the group may be same as or different from the choices of the other participants. However, they were told that we encourage each person to make one's choice such that it represents their preferences the choices involve potential earnings at the end of the experiments. In summary, each farmer faces 336 choices in the three rounds. In order to ensure incentive compatibility, we randomly choose 10 percent of total farmers in each experiment day for real payment outside the house money. It is important that the presence of the loss domain provides that any participant part of real payment has a chance of losing the house money. This helps address an important issue in this type of experiment – house money effect in lab-type experiments. The literature often claims that subjects in these types of experiments sometimes behave irrationally or in a more extreme direction because of the house money they get by participating in the experiment. For each chosen farmer, we randomly pick a session for payment (which delivers very similar results to the alternative procedure of paying each subject with probability 1 (Laury, 2006). Finally, from the selected round, a choice from the choice list is randomly picked for payment. If anyone of those selected farmers chose the sure payout in the selected session, we gave him/her that amount. Otherwise, she received the amount based on the result of the bet. In this way, we provide a monetary incentive to participants to elicit their attitudes toward uncertain situations.

4. Data Description and Results

Farmers were recruited by inviting Total 206 farmers from Jessore district of Bangladesh participated in our experiments in 5 Table 2 reports descriptive statistics on some important variables. Our sample of 206 farmers includes individuals with a wide array of varying attributes. The farmers' age ranges between 17 and 80 with the average being 37 years. Eighty four percent of the respondents are male and 57% can read and/or write. The farmers on average have 4.7 years of schooling. The respondents vary greatly in terms of farming experience ranging from a few months[4] to 65 years, with the average being 17 years. 84% of the respondents are married and the average family consists of approximately 5 members. Only 33% of the farmers have a bank account and each on average owns about 50 decimals of land.

Table 2: Descriptive Statistics

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
Age (years)	204	37.29	12.31	17	80
Gender (1 = Male, 0 = Female)	205	0.84	0.37	0	1
If the person can read and/or write (1 = can, 0 = can't)	205	0.57	0.50	0	1
Education (Years of schooling)	124	4.65	4.94	0	16
Years of experience	189	17.15	11.48	0	65
Number of family members	205	4.89	1.74	1	11
Marital status	205	0.84	0.36	0	1
If the spouse can read and/or write (1 = can, 0 = can't)	189	0.56	0.51	0	1
If the person has a bank account (1 = has, 0 = doesn't have)	205	0.33	0.47	0	1
Land ownership (in decimal)	201	50.34	82.91	0	600

[4] Experience of less than 6 months is rounded down to 0 in the table.

4.1 Risk Aversion

Table 3 reports risk aversion coefficients both when farmers make decisions alone and when they make decisions after discussing with 2 other members in group. Coefficients for female respondents are reported separately. Table 4 reports distribution of risk aversion coefficients of Bangladeshi farmers compared to various estimates in the literature. Combining the results from the two tables, it's clear that Bangladeshi farmers are risk averse in general. In fact, among the six risk experiments reported in Table 3 (the bottom 6 rows), 61% to 96% of the farmers belong to the category of risk averse (risk aversion coefficient between 0.41 and 0.68) or highly risk averse (risk aversion coefficient greater than 0.68). In terms of individual decision making, risk aversion decreases with probability of winning. When deciding alone, male farmers tend to exhibit extreme risk loving behavior as reflected by the large negative minimum coefficient values. Such extreme behavior results in the mean risk aversion to be negative. Women are more risk averse than men and prone to less extreme behavior.

Comparing our risk aversion measures with other studies, it seems that Bangladeshi farmers' risk behavior as a whole differs quite a bit from participants in the developed world (rows 1 and 2 of Table 4). If we consider individual decision making with a 30% probability of winning (row 9 of Table 4), then Bangladeshi farmers' risk aversion behavior looks almost identical to the Ethiopian farmers (row 8 of Table 4) as reflected in the distribution of risk aversion measures. However, the distribution changes for the other risk experiments (rows 10 – 14 of Table 4).

Table 3: Risk aversion coefficients

		Individual decision making			Group decision making		
		p=0.3	p=0.5	p=0.7	p=0.3	p=0.5	p=0.7
Whole sample	Mean	-0.64	-1.8	-1.77	0.89	0.93	0.88
	Median	0.81	0.73	0.73	0.50	0.50	0.50
	Min.	-26.37	-26.37	-26.37	-1.41	-1.41	-1.41
	Max.	0.81	0.81	0.81	4.11	4.11	4.11
Female	Mean	0.65	0.34	-0.49	0.75	0.82	0.74
	Median	0.81	0.81	0.81	0.50	0.50	0.50
	Min.	-0.76	-2.60	-26.38	0.50	0.50	0.50
	Max.	0.81	0.81	0.81	1.69	1.85	1.44

Note: p denotes probability of winning

Table 4: Distribution of CRRA parameters of Bangladeshi farmers compared to estimates in literature

	Risk Neutral/loving	Mildly risk averse	Risk averse	Highly risk averse
Study	$\gamma^* \leq 0.15$ (%)	$0.15 < \gamma \leq 0.41$ (%)	$0.41 < \gamma \leq 0.68$ (%)	$\gamma > 0.68$
(1) Dutch students (n=79)	19	35	44	1
(2) U.S. students (n=93)	19	19	23	39
(3) Bangladeshi students (n=194)	20	4	6	70
(4) Bangladeshi students (n=194)	15	13	7	65
(5) Bangladeshi farmers (n=104)	11	30	43	16
(6) Bangladeshi farmers (n=104)	27	17	32	24
(7) Bangladeshi farmers (n=104)	8	23	47	22
(8) Ethiopian Farmers (n=92)	22	11	10	58
(9) Bangladeshi farmers (n=206, p=.3) [a]	22	10	10	58
(10) Bangladeshi farmers (n=206, p=.5) [a]	30	6	14	50
(11) Bangladeshi farmers (n=206, p=.7) [a]	33	6	10	51
(12) Bangladeshi farmers (n=206, p=.3) [b]	4	0	55	41
(13) Bangladeshi farmers (n=206, p=.5) [b]	4	0	49	47
(14) Bangladeshi farmers (n=206, p=.7) [b]	5	0	50	45

*γ denotes CRRA coeeficient; [a] When farmers make decisions alone; [b] When farmers make decisions in group

Table 5 reports risk aversion coefficients for group decision making including results for randomly formed groups and self-selected group while Table 6 reports the group effects and the selection effects.[5] As per the total group effects reported in Table 6, both men and women become more risk averse when making decision in a group as opposed to deciding alone. The group effects are significantly larger for men. Overall, for both men and women group effects increase with probability of winning. Average risk aversion increases as the presence of group members curtails the tendency towards extreme behavior (see the minimum values in Table 3).

Table 5: Risk aversion coefficients when decisions are made in groups: random vs. self-selected group formation

			p=0.3	p=0.5	p=0.7
Whole sample	Group: overall	Mean	0.89	0.93	0.88
		Median	0.50	0.50	0.50
	Group: randomly assigned members	Mean	0.96	0.96	0.96
		Median	0.50	0.50	0.50
	Group: self-selected members	Mean	0.84	0.89	0.78
		Median	0.50	0.50	0.50
Female	Group: overall	Mean	0.75	0.82	0.74
		Median	0.50	0.50	0.50
	Group: randomly assigned members	Mean	0.74	0.88	0.79
		Median	0.50	0.50	0.50
	Group: self-selected members	Mean	0.76	0.76	0.67
		Median	0.50	0.50	0.50

Note: p denotes probability of winning

As reported in Table 6, selection effects for both men and women are mostly negative implying farmers are less risk averse when group members are self-selected relative to when they are randomly assigned. This indicates that when making decisions in consultation with self-selected

[5] Total group effect = Risk aversion when deciding in group - Risk aversion when deciding alone; Selection effect = Risk aversion when deciding in self-selected group - Risk aversion when deciding in randomly formed group

peers who are likely to be friends and/or neighbors, farmers tend to take more risks than when making decisions in consultation with randomly assigned group members. Overall, the negative selection effects are larger for men than women.

Table 6: Group effects and group selection effects on risk aversion

		Whole Sample		Female	
Probability of winning		Mean	Median	Mean	Median
p=0.3	Total group effect*	1.54	-0.31	0.10	-0.31
	Selection effect**	-0.12	0	0.02	0
p=0.5	Total group effect	2.73	-0.23	0.48	-0.31
	Selection effect	-0.07	0	-0.12	0
p=0.7	Total group effect	2.65	-0.23	1.23	-0.31
	Selection effect	-0.18	0	-0.12	0

* Total group effect = Risk aversion when deciding in group - Risk aversion when deciding alone

** Selection effect = Risk aversion when deciding in self-selected group - Risk aversion when deciding in randomly formed group

4.2 Ambiguity Aversion

Table 6 reports ambiguity aversion coefficients both when farmers make decisions alone and when they make decisions in group. Coefficients for female respondents are reported separately. The results suggest that Bangladeshi farmers – both men and women – mostly exhibit mild ambiguity averse to ambiguity neutral behavior, which is consistent with studies that investigate ambiguity aversion (see, e.g., Engle-Warnick et al., 2007; Alpizar et al., 2011; Akay et al., 2012; Ross et al., 2012, and Ahsanuzzaman and Norton, 2016).

Table 7: Ambiguity aversion coefficients

		Individual decision making			Group decision making		
		p=0.3	p=0.5	p=0.7	p=0.3	p=0.5	p=0.7
Whole sample	Mean	0.10	0.08	-0.005	0.10	0.11	0.02
	Median	0	0	0	0	0	0
Female	Mean	0.13	0.10	-0.09	0.04	0.09	-0.03
	Median	0	0	0	0	0	0

Note: p denotes probability of winning; Ambiguity aversion = $\frac{CE_R - CE_A}{CE_R + CE_A}$, where CE denotes certainty equivalent and subscripts R and A indicate Risk and Ambiguity experiments, respectively.

Table 8: Ambiguity aversion coefficients when decisions are made in groups: Random vs. Non-Random group formation

			p=0.3	p=0.5	p=0.7
Whole sample	Group: overall	Mean	0.10	0.11	0.02
		Median	0	0	0
	Group: randomly assigned members	Mean	0.08	0.09	-0.01
		Median	0	0.14	0.00
	Group: self-selected members	Mean	0.12	0.00	0.05
		Median	0	0	0
Female	Group: overall	Mean	0.05	0.09	-0.03
		Median	0	0	0
	Group: randomly assigned members	Mean	0.05	0.08	-0.10
		Median	0	0	0
	Group: self-selected members	Mean	0.01	0.10	0.05
		Median	0	0	0

Note: p denotes probability of winning

Table 8 reports ambiguity aversion coefficients for group decision making including measures for randomly formed groups and self-selected group and Table 9 reports the group effects and the selection effects.[6] Overall, farmers tend to show slightly more ambiguity aversion when deciding in groups than when deciding alone. However, as Table 9 suggests, the group effects in case of

[6] Total group effect = Ambiguity aversion when deciding in group - Ambiguity aversion when deciding alone; Selection effect = Ambiguity aversion when deciding in self-selected group - Ambiguity aversion when deciding in randomly formed group

ambiguity aversion are considerably smaller than observed in case of risk aversion. For women, group effects in fact are negative (i.e., ambiguity aversion decreases when deciding in group compared to when deciding alone) when probabilities of winning are 30% and 50% while group effect is positive when winning probability is 70%. The group effects for women are also much smaller than the group effects measured in risk experiments.

As reported in Table 9, as opposed to risk aversion scenario, selection effects in the case of ambiguity aversion for both men and women are mostly positive – the effects overall being larger for men. This implies that farmers become more ambiguity averse when making decisions in consultation with self-selected peers compared to when making decisions in consultation with randomly assigned group members. The opposite selection effects suggest that Bangladeshi farmers in general view and act differently when probability distribution of uncertain prospect is known compared to a scenario when the probability distribution is unknown.

Table 9: Group effects and group selection effects on ambiguity aversion

		Whole Sample		**Female**	
Probability of winning		Mean	Median	Mean	Median
p=0.3	Total group effect*	0	0	-0.09	0
	Selection effect**	0.04	0	-0.04	0
p=0.5	Total group effect	0.03	0	-0.01	0
	Selection effect	-0.09	0	0.02	0
p=0.7	Total group effect	0.02	0	0.06	0
	Selection effect	0.15	0	0.06	0

* Total group effect = Ambiguity aversion when deciding in group - Ambiguity aversion when deciding alone

** Selection effects = Ambiguity aversion when deciding in self-selected group - Ambiguity aversion when deciding in randomly formed group

5. Conclusion

Previous experimental literature focuses mostly in measuring risk attitudes among individuals and groups. Less studies have been conducted on the other type of uncertainty measurement, such as, ambiguity measurement, especially in the context of developing countries. Our study therefore focuses on rural farmers from Bangladesh in adopting new technological advancement where it measures the two types of uncertainty attitudes, such as, risk and ambiguity, and its impact on adopting new technology. Unlike risk attitude, in ambiguity attitude both the outcomes and the distribution of the outcomes are unknown. Technology adoption by farmers involves both risk and ambiguity aversion and dropping one of these leads to omitted variable biasness. Therefore, a thorough investigation on individual and group effects have been conducted to measure the two uncertainties that arise in adoption of new technology.

In this study we introduce some interesting features such as twenty-one lotteries vs. incrementally-increasing-certain outcome choices with varying probabilities of winning (p=0.3, 0.5, and 0.7) and allowing farmers to make decisions alone and in groups of three – both self-selected groups and randomly selected groups – to capture different attitudes towards uncertainty. The study also assesses whether male and female farmers vary in their attitudes toward uncertainty.

We find several interesting results. We find that while most Bangladeshi farmers exhibit moderately to highly risk averse behavior, they tend to show ambiguity neutral to mildly ambiguity averse behavior. Women are generally more risk and ambiguity averse than men. Farmers exhibit considerably greater risk and mildly higher ambiguity aversions when they make choices in groups compared to when they choose alone. They are less risk averse when group members are self-selected as opposed to when they are randomly assigned. We also find that farmers are more ambiguity averse when making decisions in consultation with self-selected peers compared to when making decisions in consultation with randomly assigned group members. The opposite selection effects suggest that Bangladeshi farmers generally behave differently when probability distribution of uncertain prospect is known compared to a scenario when the probability distribution is unknown.

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Appendix

Table A1. The ten binary choice tasks used in the experiments, patterned after Holt and Laury (2002)

Order in which tasks were shown				
Forward Order	Revised Forward Order	Reverse Order	**Lottery A** – "Safe" choice[a]	**Lottery B** – "Risky" choice[a]
	1		$1.11 with **p=0**, $0.67 with **p=1.0**	$1.78 with **p=0**, $0.22 with **p=1.0**
1	**2**	10	$1.11 with **p=0.1**, $0.67 with **p=0.9**	$1.78 with **p=0.1**, $0.22 with **p=0.9**
2	**3**	9	$1.11 with **p=0.2**, $0.67 with **p=0.8**	$1.78 with **p=0.2**, $0.22 with **p=0.8**
3	**4**	8	$1.11 with **p=0.3**, $0.67 with **p=0.7**	$1.78 with **p=0.3**, $0.22 with **p=0.7**
4	**5**	7	$1.11 with **p=0.4**, $0.67 with **p=0.6**	$1.78 with **p=0.4**, $0.22 with **p=0.6**
5	**6**	6	$1.11 with **p=0.5**, $0.67 with **p=0.5**	$1.78 with **p=0.5**, $0.22 with **p=0.5**
6	**7**	5	$1.11 with **p=0.6**, $0.67 with **p=0.4**	$1.78 with **p=0.6**, $0.22 with **p=0.4**
7	**8**	4	$1.11 with **p=0.7**, $0.67 with **p=0.3**	$1.78 with **p=0.7**, $0.22 with **p=0.3**
8	**9**	3	$1.11 with **p=0.8**, $0.67 with **p=0.2**	$1.78 with **p=0.8**, $0.22 with **p=0.2**
9	**10**	2	$1.11 with **p=0.9**, $0.67 with **p=0.1**	$1.78 with **p=0.9**, $0.22 with **p=0.1**
10	**(11)[d]**	1	$1.11 with **p=1.0**, $0.67 with **p=0**	$1.78 with **p=1.0**, $0.22 with **p=0**

Notes:[a]Winnings were not cash; participants won "1-prize" notes and selected from prizes worth approximately Rs. 10 (US$0.22). [b]The interpretation choose Lottery A in all rows above and continues choosing Lottery B in all subsequent games. As discussed in the text, this interval is more difficult to who switch multiple times. [c]A participant who chooses Lottery B in this row has misunderstood the task, since it involves no uncertainty and the prize were not presented with this task in "revised forward" order. It is labeled as Task 11 because all task were standardized to his order for analysis.

Table A2: 21 binary choice tasks used in the experiments

Turn	Option One: Urn (P(Payoffs))	Option Two: Certain amount (BDT)	Switching-Point from 1 to 2	CE at Switching-Point (BDT)
1	p(1000),(1-p)(0)	0		0
2	p(1000),(1-p)(0)	50	1 to 2	25
3	p(1000),(1-p)(0)	100	2 to 3	75
4	p(1000),(1-p)(0)	150	3 to 4	125
5	p(1000),(1-p)(0)	200	4 to 5	175
6	p(1000),(1-p)(0)	250	5 to 6	225
7	p(1000),(1-p)(0)	300	6 to 7	275
8	p(1000),(1-p)(0)	350	7 to 8	325
9	p(1000),(1-p)(0)	400	8 to 9	375
10	p(1000),(1-p)(0)	450	9 to 10	425
11	p(1000),(1-p)(0)	500	10 to 11	475
12	p(1000),(1-p)(0)	550	11 to 12	525
13	p(1000),(1-p)(0)	600	12 to 13	575
14	p(1000),(1-p)(0)	650	13 to 14	625
15	p(1000),(1-p)(0)	700	14 to 15	675
16	p(1000),(1-p)(0)	750	15 to 16	725
17	p(1000),(1-p)(0)	800	16 to 17	775
18	p(1000),(1-p)(0)	850	17 to 18	825
19	p(1000),(1-p)(0)	900	18 to 19	875
20	p(1000),(1-p)(0)	950	19 to 20	925
21	p(1000),(1-p)(0)	1000	20 to 21	975

p is the probability of winning 1000 BDT which is 0.3, 0.5, or 0.7 in different risk experiments. For ambiguity experiments, *p* is unknown.