The Love of Risk: Misperception or Preference?

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November 7, 2016

Abstract

The stability of risk preference has been extensively studied in the literature. Most previous studies focus on how contexts or experience could alter risk preference. We examine the possible inconsistency of risk preference in an context-free setting by focusing on the effect of a possible loss. Using a survey study in the context of housing price, we show that respondents are less risk averse (or more risk loving) when a possible adverse outcome is in presence. A controlled laboratory experiment was then conducted to further investigate the role of possible adverse outcome on risk preference and the experimental results confirm the phenomenon. In addition, a structural analysis using the experimental data demonstrates that the commonly used utility functions (CRRA and Expo – Power) also show lower risk aversion level when a negative outcome is possible. We discuss explanations that could potentially explain the phenomenon and relevant policy implications.

1 Introduction

People make decisions – whether to purchase a house without knowing its exact future price or whether to invest in a company's stock without knowing its exact future performance – to cope with different risks. Inadequate perception of risks may lead to irrational decisions. The heated housing markets in the near past in cities such as Las Vegas, Miami and Phoenix have been described as good examples of risk misperception. "Investors are prepared to buy houses they will rent out at a loss, just because they think prices will keep rising – the very definition of a financial bubble."[1] Even midlevel managers in the Wall Street were not fully aware of the risks in the housing market and engaged in excessive exposure to housing before the burst of the bubbles Cheng et al. (2014). Nonetheless, if the Wall Street managers had correct perception of the risks in the housing market, would they make "rational" decisions in their own housing transactions?

In most economic theories, it is assumed that people make rational decisions based on their inherent risk preferences given that they have correct risk perceptions. However, recent studies have shown that individual risk preference is likely to be inconsistent in different contexts. For example, Guiso et al. (2014) conducted a repeated survey before and after the recent global financial crisis and found that investors' risk aversion substantially increased after the financial crisis. In a lab setting, Cohn et al. (2015) suggested that financial professionals were more risk averse in a bust scenario and less so in a boom, where fear might play an important role in driving such difference. Other papers, such as He and Hong (2014), also suggested that individual risk preferences depend on past experience even the experience does not have realized monetary consequence.

By examining the literature on risk misperception and context-dependent risk preference, a more fundamental question arises. That is, do home buyers or investors, without risk misperception, have consistent risk preference in a context-neutral setting? We believe this is an important question that has not been fully answered: if people do not possess a consistent or stable risk preference in their decision process, such inconsistency should be taken care of when modeling individual risk preferences and making policy advise. Regardless of the importance of this question, it is almost impossible to distinguish behavior induced by risk misperception and behavior induced by inconsistent risk preference using observational data (Barseghyan et al., 2013). In this paper, we

[1] See the Economist: http://www.economist.com/node/4079027.

first look into individuals' response to hypothetical risks associated with housing purchase in a randomized survey study, and then test the same idea in an incentivized laboratory experiment.

We study decision makers' risk attitudes when making buying or investment decisions. Unlike Fafchamps et al. (2015) that studied the effect after a loss and He and Hong (2014) that studied exposure to high volatility, we focus on the change in risk preference when a possible loss is *simultaneously* presented to decision makers. To achieve this goal, we first conducted a randomized survey in the streets in Beijing with 268 valid responses in total. The respondents had to provide their maximum willingness to pay in 14 different risky scenarios, which are combinations of different housing values in the baseline period and probabilities of housing price appreciation. Respondents were randomly assigned into either control or treatment group. In the control group, there is no probability associated with housing price depreciation. In the treatment group, respondents were asked exactly the same questions except that housing price could potentially fall. By comparing the responses with the same baseline housing value and the same probability of housing price appreciation in both groups, we find that the respondents in the treatment group, where an odd of price depreciation was present, failed to make sufficient downward adjustment to their willingness to pay. Such finding provides preliminary evidence that individuals may underweight the downside risk associated with housing values. Given that the probabilities of possible future outcomes are always revealed to respondents, any bias in their decision making should not be due to incorrect perceptions of the risk itself. Rather, it is due to their inconsistent risk preference in the gain and loss domains.

Moreover, in analyzing the data, we follow Kechelmeier and Shehata (1992) to use a nonparametric measure of risk aversion which is the certainty equivalent/expected value ratio to show the change in risk preference. We believe that this is a less theory dependent measure of risk aversion when compared with the Arrow–Pratt measure (Pratt, 1964). Similar approach was also adopted by other researchers such as Holm et al. (2013). Because all the responses we received from the survey study are answers to hypothetical questions, we then designed a controlled laboratory experiment to simulate the same idea in an economic laboratory where subjects were paid real money determined by the decisions they made in the experiment. The findings in the laboratory experiment also confirm the survey results. Specifically, both the within– and between–subject designs suggest that individuals are significantly less risk averse in the presence of a 10% probability of adverse outcome. A structural analysis shows that both the often used Constant Relative Risk Aversion(CRRA) and the more flexible Expo–power utility function have lower level of risk aversion when a loss is possible. This suggests that if the EUT framework is used to model behavior, adjustments to the risk aversion parameters are necessary.

Our contribution to the literature is mainly on the stability of risk preference. There are many previous studies that examined how risk preference changes along time (Andersen et al., 2008); how different events affect risk preference; and how risk preference can vary in different contexts (e.g. Binswanger (1980)). Chuang and Schechter (2015) provides a thorough review of the relevant studies in both the lab and the field. Our study adds to this literature by asking the question that whether risk preference is an inherently coherent measure of risk attitudes even in a context free setting. We find that individuals are less risk averse with mixed prospects. Because risk preference parameter is critical in most economic models that concern decisions under risk and uncertainty or inter-temporal decisions[2], correctly specifying this parameter will help to improve the explanatory and perdition power. In addition, our conclusion is also relevant to policy making. Investors are likely to take excessive risk, thus demand lower risk premium in a booming market with downside risks, which generate excessive demand in such a market. Therefore, even if investors are fully aware of the downside risk in the market, the policy makers should still watch closely on the prices and implementing policies curbing speculative demand due to increasing appetite of risks from investors.

The rest of the paper is organized as follows. In section 2, we explain our study design, including the survey and laboratory experiment, in details. Section 3 reports reduced form analysis of the results followed by a structural estimation. In section 4, we briefly discuss the results and provide some possible explanations. Lastly, section 5 concludes the paper.

2 Research Design

Because we motivate our research from investor risk misperception and risk preference inconsistency in the housing market, we framed our survey questions in the context of making investment decisions in housing market. We provide various scenarios of price change in the near future and ask the

[2] These models consist a major portion of economic models. In fact, even for models that do not aim to describe behavior under risk and uncertainty such as auction, risk preference is also an important component.

respondents about their willingness to pay, so that we can elicit their risk preferences. We then carry out an incentivized lab experiment using lotteries to elicit individuals' risk preference with both within–subject and between–subject designs.

2.1 Survey Study

The survey study was conducted in year 2014 in Beijing, which is a major metropolitan area in China. Researcher approached people in the streets including both adults and university students. In total, we collected 268 valid responses for both the control and treatment groups. For control group, 106 responses were from adults while 26 responses were from students. For the treatment group, 108 responses were from adults while 28 from students. By checking all the demographic variables collected, we confirm that a balanced sample between control and treatment groups were obtained[3].

To examine their risk attitudes, the respondents were asked the maximum amount they would pay to buy an apartment in different scenarios (different probability of price increase). Panel B in Table 1 shows all the treatments that we had in the survey study. Within each treatment, the probability of housing price appreciation was varied[4].

Respondents were randomly assigned into either control or treatment groups. The baseline housing value was either 2 million or 5 million *yuan*. In the next 3 years, the housing value could either get doubled, remain the same, or cut by half. In the control group, there is no probability associated with housing price depreciation. In the treatment group, respondents were asked exactly the same question except that housing price could potentially fall. For respondents in both groups, they have to provide their maximum willingness to pay for 14 scenarios, which are combinations of different housing values in the baseline period and probabilities of housing price appreciation.

For example, the following is one of the scenarios in the questionnaire for control group.

Scenario 1 (control group): You are considering buying an apartment. If housing price will be rising steadily in the next 3 years, the property will worth 4 million yuan in 3 years, otherwise 2 million yuan (no other possibilities). Now, a reliable private information source releases the

[3] Demographic variables include gender, age, occupation, employment status, education, household size, monthly consumption, and housing purchase experience and plan.

[4] The probabilities we used were 10%, 20%, 30%, 50%, 70%, 80%, and 90%. For the treatment group, there was also a probability associated with the possible housing price depreciation. The probability was always 10%.

following information to you: "The property will be worth 4 million yuan in 3 years with a probability of 10%, otherwise it will be worth 2 million yuan."

Respondents' willingness to pay are then elicited with a table that can be found in the appendix. Correspondingly, the treatment group is:

Scenario 1 (treatment group): You are considering buying an apartment. If housing price will be rising steadily in the next 3 years, the property will be worth 4 million yuan in 3 years; if housing price depreciation happens, the property will be worth 1 million yuan in 3 years; otherwise 2 million yuan (no other possibilities). Now, a reliable private information source releases the following information to you: "The property will be worth 4 million yuan in 3 years with a probability of 10%, 1 million yuan in 3 years with a probability of 10%, otherwise it will be worth 2 million yuan."

Because all the responses we received from the survey study were answers to hypothetical questions, it would be important to study how people respond to the presence of adverse outcome under real incentives. We then designed a laboratory experiment to simulate the same idea in an economic laboratory.

2.2 Laboratory Experiment

This experiment was designed to examine how possible adverse outcome affects risk attitudes. We employed *both* within–subject and between–subject design in our experiment for two reasons. Firstly, within–subject design allows us to control for individual characteristics. However, such design may have some carry over effect across different treatments. Secondly, there is a major drawback of using within–subject design: decision makers rarely come across the questions described in different treatments either simultaneously or consecutively in reality. Hence, it is necessary to compare the results from the within–subject sessions with the between–subject sessions to observe the gap between theory and reality.

We define the four different treatments in this paper. A *simple gain prospect*(SGP) is a simple lottery $(x, p; 0, 1-p)$ that wins amount x with probability p and nothing with probability $1-p$; a *simple mixed prospect*(SMP) is a lottery $(x, p; -y, q; 0, 1-p-q)$ that wins amount x with probability p, loses amount y with probability q and nothing with probability $1-p-q$. A *compound gain prospect*(CGP) shares the same form with the *simple gain prospect* except that it adds another layer of risk. There is a $\frac{1}{3}$ chance of playing the lottery $(x, p-r; 0, 1-p+r)$, $\frac{1}{3}$ chance of playing $(x, p; 0, 1-p)$ and another $\frac{1}{3}$ chance of playing $(x, p+r; 0, 1-p-r)$. The *compound mixed prospect*(CMP) is defined in a similar way. Participants have $\frac{1}{3}$ chance to play $(x, p-r; -y, q; 0, 1-p+r)$, $\frac{1}{3}$ chance to play $(x, p; -y, q; 0, 1-p-q)$ and $\frac{1}{3}$ chance of playing $(x, p+r; -y, q; 0, 1-p-r)$. x and y are positive dollar amounts. p, q, and r are probabilities so $0 \leq p, q, r \leq 1$. In each treatment, we divide the probability range from 0 to 1 into 10 equal intervals and p takes the values $p_1 = 0.1$, $p_2 = 0.2$, $\ldots p_9 = 0.9$; $q_1 = q_2 = \ldots = q_9 = q = 0.1$. Panel A of Table 1 shows all the treatments we had in both the within–subject sessions and between–subject sessions. The mixed prospects (SMP and CMP) are designed to examine the effect of possible negative outcome. The compound lotteries are designed to test the linear probability assumption in EUT [5]. Note that the between–subject design only applies to the comparison between SGP and SMP as well as CGP and CMP because T1 was always paired with T3 while T2 was always paired with T4.

All the experimental sessions were conducted at a major research university in Beijing with undergraduate students as main subject pool. In each treatment of the experiment (SGP, SMP, CGP, or CMP), there are 9 different lottery tickets. Subjects were asked to reveal their certainty equivalents through the iterative Multiple Price List (iMPL) method (Andersen et al., 2006). For each different amount, subjects simply indicate a "yes" or "no" answer. Based on the answers in the first iteration, the computer program further divides the interval into smaller intervals and subjects answer the "yes/no" questions again in the second iteration. For example, if a subject indicates that she chooses the lottery ticket over \$2 but chooses the fixed payment of \$3 over the lottery, the computer program further asks if she would choose the lottery ticket or the fixed amount for ten different amounts between \$2 and \$3[6]. One of the displayed amounts was then randomly drawn by a participant. Answers to that particular amount was implemented (i.e. if lottery ticket was chosen, then the lottery would be played out; if the fixed amount was chosen, the subject would receive the dollar amount). Subjects were also told that only one randomly selected lottery would be played out but they should treat each one as if it was chosen. Details can be found in the appendix.

The experiment consists two waves. In the first wave, the within–subject design was employed.

[5]We use the EUT framework in our analysis as most studies that examine risk preference. Adding compound lotteries help us to judge the magnitude of probability weighting.

[6]The ten different amounts increase at \$0.1.

Participants were asked to complete all four treatments in a random order within a single session. After each treatment, a lottery ticket was randomly selected to be played out and subjects were informed their earnings in the treatment. They then completed some survey questions before proceeding to the next treatment. In the second wave, the between–subject design was used. In a single session, subjects only completed two treatments (either SGP and CGP, or SMP and CMP). This was to make the difference between prospects without negative outcome and prospects with negative outcome less salient to subjects. Of course, one cannot make individual level comparisons with these data.

Experimental participants were recruited through emails and posters. When participants arrived at the laboratory, they were firstly directed to a preparation room where the instructor carefully went through the instruction with Microsoft PowerPoint and answered any question the participants might have. Participants were told not to talk with each other during the experiment before they were assigned to individual computer stations. The experimenter then started the session and participants made their decisions at their own pace.

3 Results

In this section, we firstly present survey results and then turn to experimental data. In the last subsection, we discuss risk preference in the context of EUT and fit our experimental data to different specifications of the utility function.

It is easy to tell whether a decision maker is risk averse, risk neutral, or risk loving based on the definition of risk aversion. However, it becomes less clear when we need to tell "how risk averse" an individual is. This judgment often relies on the utility function' specific functional form (Pratt, 1964). We hope to compare risk aversion levels without assuming a specific utility function so we follow Kechelmeier and Shehata (1992) to calculate the ratio of a subject's certainty equivalent for a particular lottery to the same lottery's expected value as a non–parametric measure of risk preference. For example, an individual is indifferent between a lottery ticket that has 50% probability of winning 20 *yuan* and a fixed amount of 8 *yuan*, then the calculated ratio is 8/(20*50%)=0.8 in this case.

3.1 Regression analysis using survey data

Table 2 presents the simple descriptives for the respondents' willingness to pay in different housing baseline values and risky prospects. It can be shown from the data that the respondents did not make sufficient downward adjustments when the odd of an adverse outcome is present (i.e., the SMP case). Such phenomenon is especially pronounced for the relatively lower housing value.

Figure 1 shows the ratios by different risky prospects and baseline housing values in the survey study. For the two groups with a relatively lower baseline housing value (2 million *yuan*), the ratios for the observations with mixed prospects are dominantly higher than the observations with simple gain prospects under all probabilities. In addition, the SMP group exhibits risk loving patterns under smaller probabilities (0.1, 0.2, 0.3, 0.4 and 0.5). In the two groups with a relatively higher baseline housing value (5 million *yuan*), the respondents are more risk averse on average as indicated by the lower ratios. This is consistent with the literature that higher wealth level is associated with higher level of risk aversion. Similar to the groups with lower housing values, the ratios for the observations with mixed prospects are higher than the observations with simple gain prospects, with smaller gaps though.

With the collected survey data, we run a simple linear regression. The detailed specification can be found in Equation 1.

$$\begin{aligned}(CE/EV)^i_{jk} =& \alpha_{SMP} D^i_{SMP} + \beta_j Probability_j + \gamma_{SMP,j} D^i_{SMP} \times Probability_j \\ &+ \delta_k Value_k + \eta_{SMP,k} D^i_{SMP} \times Value_k + Constant + \epsilon^i_{jk}\end{aligned} \tag{1}$$

where i denotes individual survey respondent, j denotes the price scenario in the survey question, and k denotes the value of the target house. D_{SMP} is a treatment dummy variable. Its value equals 1 for respondents in the treated group. $Probability$ is the probability that the house's market value will appreciate. $Value$ is the baseline housing price. ϵ is an error term that follows a normal distribution.

Table 3 shows the survey study results using regression analysis. We regress the ratios and the log ratios of certainty equivalent to expected values on a dummy for the SMP group, dummies for each probability (p=0.1 as the baseline group), an interaction between the SMP dummy and each probability, the baseline housing value (2 million or 5 million), and an interaction between housing value and the SMP dummy. The coefficient on SMP dummy is significantly positive, indicating that the respondents in the SMP group are significantly more risk loving than the SGP group. Such significant difference is especially pronounced for small probabilities, as indicated from the significantly positive interaction terms between SMP and small probabilities (p=0.2, 0.3 and 0.5). In addition, higher housing value is significantly associated with higher risk aversion, especially for the group with mixed prospects.

3.2 Regression analysis using lab data

Table 4 presents the simple descriptives for the subjects' certainty equivalents for different prospects in different treatments. One can tell from the table that subjects did not make sufficient downward adjustments when a loss became possible (i.e., the SMP and CMP cases). This pattern is consistent with what we observed from the survey data though at a smaller magnitude. Another important observation is that the comparison between simple prospects and compound prospects does not reveal probability weighting in the sense of an inverse S-shaped curve [7]. Given this observation, we pool SGP and CGP, SMP and CMP in our analysis [8]. Figure 2 shows the ratios from the four different treatments in our laboratory experiment. The top panel plots results from the within–subject sessions while the bottom panel plots the between–subject sessions. Points above the reference line represent risk loving and points below reference line are risk averse. One immediate observation is that the degree of risk aversion increases along with the increment in probability of winning. Second observation is that SMP is the least risk averse treatment especially under smaller probabilities. We also conduct the following linear regression that is similar to Equation 1.

[7] The utility one receives from a simple gain prospect is $\pi(p)u(20)$ and the counterpart of the compound prospect is$\pi(\frac{1}{3})\pi(p-0.05)u(20)+\pi(\frac{1}{3})\pi(p)u(20)+\pi(\frac{1}{3})\pi(p+0.05)u(20)$. If the probability weighting function is an inverse S-shaped curve which is flatter in the middle and steeper at the ends, we should observe the CEs to be smaller from the CGP treatment when probability is small and to be larger when probability is big. The experimental data is not consistent with this prediction.

[8] CEs for CGP are not statistically different from CEs for SGP.

$$
\begin{aligned}
(CE/EV)_j^i = & \alpha_{SMP} D_{SMP}^i + \alpha_{CGP} D_{CGP}^i + \alpha_{CMP} D_{CMP}^i + \beta_j Probability_j + \\
& \gamma_{SMP,j} D_{SMP}^i \times Probability_j + \gamma_{CGP,j} D_{CGP}^i \times Probability_j + \\
& \gamma_{CMP,j} D_{CMP}^i \times Probability_j + Constant + \epsilon_j^i \qquad (2)
\end{aligned}
$$

The rule of notation is the same as in the regression equation for the survey data except that we have more treatment dummy variables for the laboratory data.

Table 5 shows regression results from random–effects model to further examine these patterns[9]. It is worth noting that the presence of possible negative outcome on risk preference only exists for small probabilities[10]. This can be observed from both Figure 2 and Table 5. This result is similar to the ones documented in Kechelmeier and Shehata (1992) except that we are examining the effect of presenting a possible negative outcome to subjects. It is also important to emphasize that we employed the iMPL method as Holt and Laury (2002) while Kechelmeier and Shehata (1992) used Willingness To Accept (WTA) values as the certainty equivalents. WTA values has long been associated with the endowment effects (Kahneman et al., 1990; Thaler, 1980) which could possibly bias the certainty equivalents[11]. Therefore, we believe that our elicitation method is more of a neutral environment and is less vulnerable to bias induced by endowment effects.

It is also worth noting that the difference in CE/EV ratios with and without possible negative outcome only exists in small probabilities (i.e. p=0.1, 0.2). As the probability of the positive outcome increases, the gap between the ratios diminishes. It should not be surprising that the difference in risk preference becomes more prominent when the probability of a positive outcome is small. When the probability of positive outcome is large enough, the CE values are also large, so the downward adjustment in the presence of negative outcome becomes proportionally smaller. Compared with the same ratios calculated using the survey data, we found the difference in risk aversion (gain prospects versus mixed prospects) is less prominent in the lab data. We suspect

[9] We conduct Hausman test to confirm the appropriateness of using the random–effects model. The test resulted in a p value of 1 suggesting that a random–effects model is appropriate.

[10] For the within–subject sessions, F test on the regression coefficients result in p value of 0.0054 and 0.1630 when the probabilities of winning are 10% and 20% respectively. For the between–subject sessions, the two p values are 0.0000 and 0.0309.

[11] There are theories that can reconcile the WTA–WTP difference while explaining risk preference including prospect theory. They are not the focus of this paper.

two possible explanations. Firstly, the survey data are collected using hypothetical questions and the lab data are collected using incentivized tasks. Subjects may respond with more care and rely more on deliberative thinking instead of their intuitions. Secondly, the context of housing market may also play an role. If subjects have positive feelings on the housing market as investment opportunities, they may also ignore the downside risk.

3.3 Structural analysis

Most of the analyses of risk preference are conducted under the EUT framework. In other words, the expected utility are assumed to be linear in probabilities and any risk preference is explained by the curvature of the Bernoulli utility function. In this subsection, we follow the literature to estimate two structural models in the EUT family and show that the results are consistent with the ones reported in the reduced form analysis.

One of the two models we estimate has the Constant Relative Risk Aversion (CRRA) utility function that many employ in empirical work (shown in Equation 3). The second model features the Expo–power utility function which is more flexible and nest the first one as a special case (Saha, 1993) (shown in Equation 4).

$$u(x) = x^{1-r} \tag{3}$$

$$u(x) = \frac{1 - e^{-\alpha x^{1-r}}}{\alpha} \tag{4}$$

Depending on the values of the parameters, the Expo–power utility function can be of increasing, constant or decreasing absolute/relative risk aversion. Regarding relative risk aversion,

$$\frac{-u''(x)x}{u'(x)} = r + \alpha(1-r)x^{1-r} \tag{5}$$

It is easy to see that it reduces to CRRA when $\alpha \to 0$ and to Constant Absolute Risk Aversion(CARA) when $r \to 0$. Combining the Expo–power utility function and linearity in probability, we can then derive the decision rules for our experimental subjects.

$$pu(w+x) + qu(w-y) + (1-p-q)u(w) = u(w+CE) \tag{6}$$

where p is the probability of positive outcome while q is the probability of negative outcome. Note that w is defined as initial wealth level in EUT but in most of previous studies especially experiment studies, researchers used income as the argument of the utility function. We argue that, given our experimental design, $w = 10$ which was the fixed payment given to all subjects at the beginning of the experiment[12]. Unlike previous studies (Holt and Laury, 2002), we elicited certainty equivalents in our experiment so we employ a different estimation technique. The estimation follows the same procedure of Yan (2016). Essentially, we assume subjects can "calculate" their certainty equivalents but there is a random error when they make their choices. In particular the theoretical certainty equivalents can be expressed as the following under CRRA and Expo-power utility functions respectively

$$CE_{CRRA} = (\sum_{i=1}^{n} p_i (w + x_i)^{1-r})^{\frac{1}{1-r}} - w \tag{7}$$

$$CE_{Expo-power} = (\frac{log(\sum_{i=1}^{n} p_i exp(-\alpha(w + x_i)^{1-r}))}{-\alpha})^{\frac{1}{1-r}} - w \tag{8}$$

The elicited valuations are $Val = CE + \epsilon$ where $\epsilon \sim Normal(0, \sigma)$. The likelihood function follows naturally from this specification.

Estimated structural parameters from maximum likelihood estimation are shown in Table 6. Column (1) is the result from the CRRA model while column (2) is the result from the Expo–power model. Consistent with the results in the reduced–form analysis, with both CRRA and Expo-power models, decisions on the mixed prospects show a lower level of risk aversion (or a higher level or risk loving). In addition, the Expo-power specification is also able to capture the fact that subjects are risk loving under small probabilities for both simple prospects and mixed prospects. For a more straightforward examination of the estimation results, Figure 3 plot the utility functions implied by the estimated parameters with top panel being the CRRA utility function while bottom panel being the Expo–power utility function. With both CRRA and Expo-power utility functions, the implied Relative Risk Aversion (RRA) by the estimated parameters are lower from MP treatments than from GP treatments. Under CRRA specification, RRA is given in Table 6. Under Expo-power

[12] We cannot let subjects lose money in the experiment so their overall expected payoffs from any experimental session were always positive. Therefor, mathematically, it is equivalent to paying subjects 10 yuan or 30 yuan in the gain only treatments, and paying them 0 yuan, 10 yuan, or 30 yuan in the mixed treatments.

specification, RRA changes when wealth level w changes. At $w = 10$, the RRA is -1.0228 for GP versus -1.3324 for MP[13].

The presence of possible negative outcome does alter the risk preference within EUT framework. Admittedly, both CRRA and Expo–power are just two special functional forms but they are also frequently used in the literature. The consistency between our structural analysis and reduced-form analysis confirms that people behave differently in terms of risk preferences with and without possible loss. In the next section, we briefly discuss some possible explanations of this phenomenon.

4 Discussions

4.1 Possible explanation

The observed change in risk preference from both the reduced form analysis and structural estimation is consistent with observations that people sometimes omit downside risks in the real world. This observed change in risk preference is not readily explained by any theory in economics. Prospect theory (PT) is a descriptive theory that is arguably more precise than EUT in explaining behaviors under risk and uncertainty. Through a simple calculation, we show that the value function in PT needs to be extremely convex in the loss domain to explain such changes.

Considering the cumulative version of prospect theory (Tversky and Kahneman, 1992), value of the four different prospects from the four different treatments can be calculated as in Equation 9.

$$\begin{aligned} V_{SGP} = v(CE_{SGP}) &= \pi^+(p)v(x) \\ V_{SMP} = v(CE_{SMP}) &= \pi^+(p)v(x) - \pi^-(q)\lambda v(-y) \\ V_{CGP} = v(CE_{CGP}) &= [\pi^+(\frac{1}{3}(p-r)) + \pi^+(\frac{1}{3}p) + \pi^+(\frac{1}{3}(p+r))]v(x) \\ V_{CMP} = v(CE_{CMP}) &= [\pi^+(\frac{1}{3}(p-r)) + \pi^+(\frac{1}{3}p) + \pi^+(\frac{1}{3}(p+r))]v(x) - \pi^-(q)\lambda v(-y) \end{aligned} \quad (9)$$

V represents the value of a specific prospect and v is the value function in prospect theory. $\pi^+(\cdot)$ and $\pi^-(\cdot)$ are the probability weighting functions in the gain and loss domains respectively. Note, for V_{CGP} and V_{CMP}, we assume no combining process[14]. Table 7 shows the calculated CE

[13] Because we conducted our estimation at $w = 10$, it is not quite meaningful to extrapolate the RRA to a wealth level far from $w = 10$. See Rabin and Thaler (2001) for details.

[14] Otherwise, we would have $V_{CGP} = V_{SGP}$ and $V_{CMP} = V_{SMP}$.

using functional forms and parameters in (Tversky and Kahneman, 1992). It is easy to see from the table that CE_{SMP} and CE_{SGP} are quite different from each other. Quantitatively,

$$(CE_{SGP} - CE_{SMP})^{\alpha} > CE_{SGP}^{\alpha} - CE_{SMP}^{\alpha} = \pi^{-}(q)\lambda(-y)^{\beta} \tag{10}$$

Thus, β needs to be sufficiently small to guarantee this holds. This also implies the value function is extremely convex in the loss domain and such a conclusion contradicts existing empirical evidence on prospect theory.

As discussed above that prospect theory does not provide a quantitatively reasonable explanation, one may instead argue that some underlying psychological factors could lead to such changes in risk preference. If downside risk is less salient in some context (e.g. a booming real estate market), some individuals may ignore it. This is also consistent with our results. In the survey study, risk preferences are quite different under gain only prospects and mixed prospects while in the lab experiment, the magnitude is much smaller.

4.2 Gender differences

In the next step, we are interested in the potential heterogeneity by different demographic groups. As surveyed in Eckel and Grossman (2008), females are generally more risk averse than males. Therefore, we interact a dummy for gender (1 if male) with all the regressors in Equation 1. Table 8 shows the survey results. Interestingly, the coefficients on "male" dummy is positive and significant at the 0.1 level. The result suggests that males are more risk loving on average which is consistent with the literature about the gender differences in risk preference. In addition, the interaction of male and the dummy for "SMP" tends to be negative but insignificant. Such negative sign is in line with the previous findings that female is likely to be less rational in decision making. Table 9 further displays the results from the lab experiments. It turns out that gender does not play a significant role in determining the certainty equivalent to expected value ratio. However, the signs on gender-related coefficients are expected in most of the regressions. For example, three out of four coefficients on "male" have positive coefficients, suggesting that male respondents are on average more risk loving than female respondents, statistically insignificant though. In addition, three out of four coefficients for the interaction term between “SMP” and “male” are negative, indicating that female respondents display more risk loving with negative risk prospect.

5 Conclusion

This paper presents results from a survey study and a controlled laboratory experiment. In both tasks subjects were requested to provide certainty equivalents to different risky prospects. The study design allows us to identify the role of risk preference in valuing different risky prospects. Both studies show that people are less risk averse when a possible adverse outcome is in presence. This observation suggests that people hold different risk preferences when valuing prospects with and without adverse outcome(s). It further suggests that one set of parameters of the Bernoulli utility function cannot simultaneously explain behavior in both scenarios. On the one hand, we found existing economic theories including prospect theory do not provide quantitatively sound explanations. On the other hand, we argue this phenomenon can be explained by other psychosocial factors such as salience.

In the controlled laboratory experiment, we find that people are less risk averse when a possible adverse outcome is in presence. We argue that the results can be generalized to a broader cohort. A main reason is that the lab experiment is context-neutral, incentive-compatible with small stakes, which is likely to induce less irrationality as compared to investment decisions in the real world. Indeed, we find that the magnitude of the effect is much larger in the survey results than the lab results. In addition, it is also worth noting that the decisions made by working professionals and university students were statistically indifferent in the survey (see Table 10). Therefore, the concern on the external validity of the experiment results can be mitigated.

We believe that this result has important policy implications. Researchers and policy makers often attribute bubbles in the housing or financial market to risk misperception and hence believe that better informed individuals are capable to make better decisions. However, if decision makers' intrinsic risk preferences are different when valuing gain only prospects and mixed prospects, they may naturally fail to adjust their strategies in buying or investing decisions. Based on our findings, investors are likely to take excessive risk, thus demand lower risk premium in a booming market with downside risks, which generate excessive demand in such a market. Therefore, even if investors are fully aware of the downside risk in the market, the policy makers should still watch closely on the prices and implementing policies curbing speculative demand due to increasing appetite of risks from investors.

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Figure 1: Certainty Equivalent to Expected Value Ratios in Survey Study

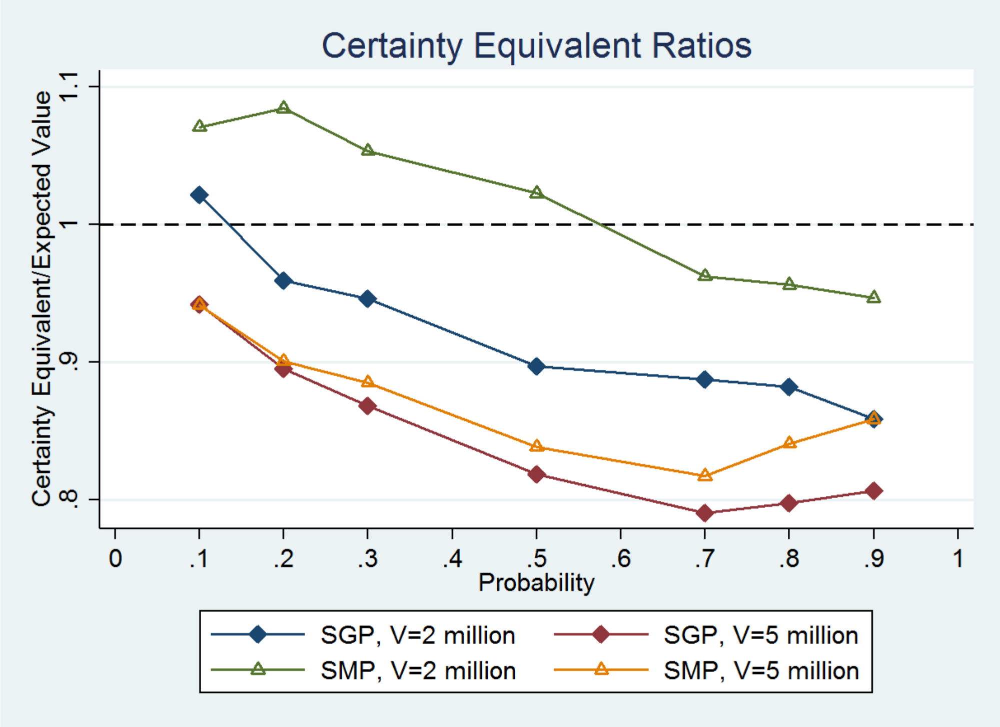


Figure 2: Certainty Equivalent to Expected Value Ratios in Lab Experiment

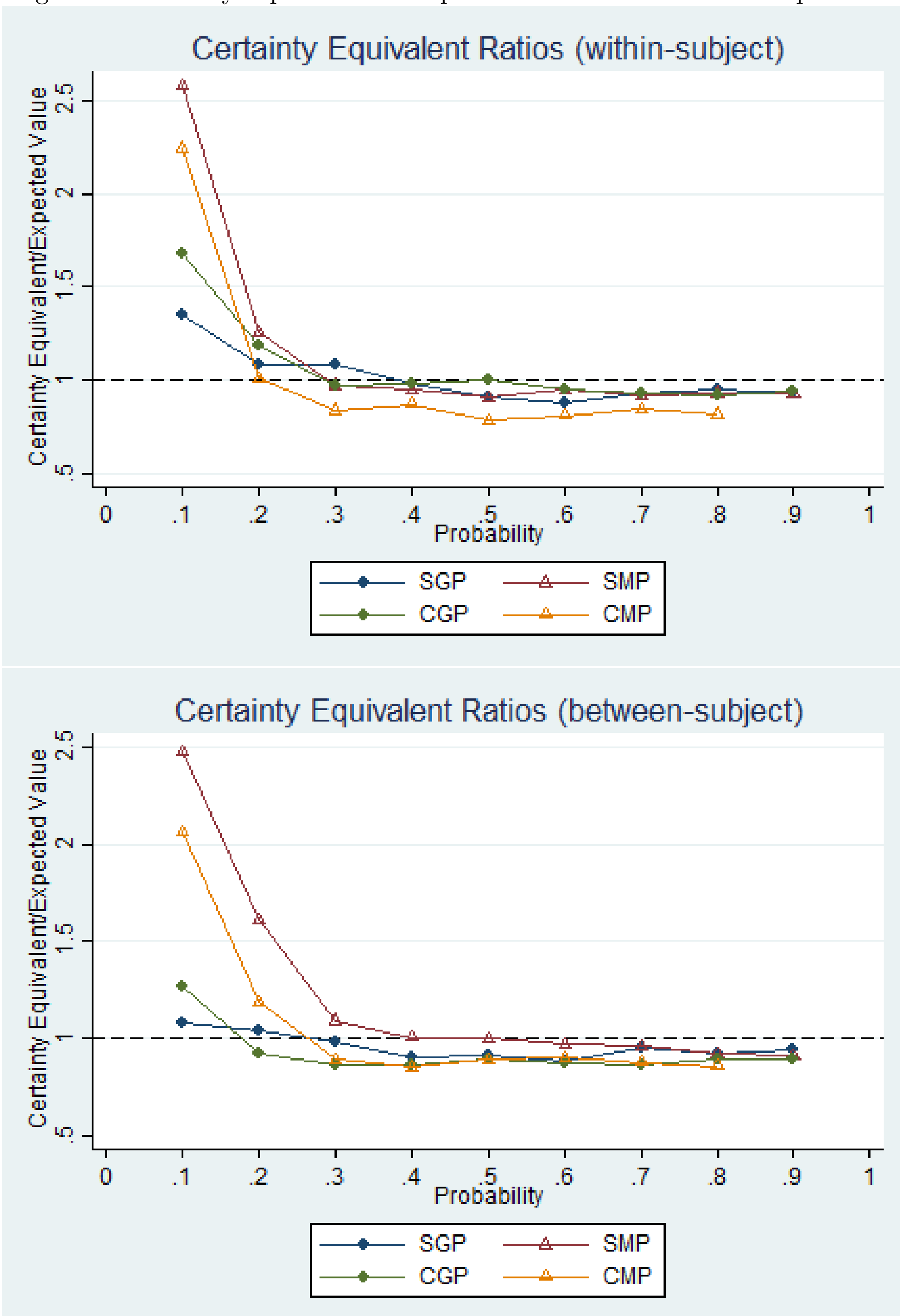
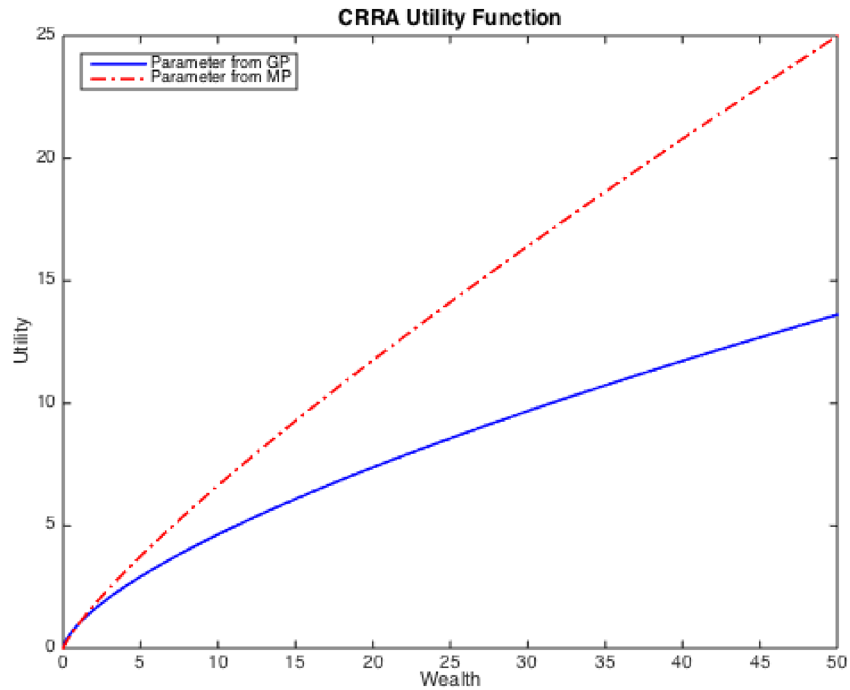


Figure 3: Utility Functions Implied by Parameters Estimated from Experimental Data



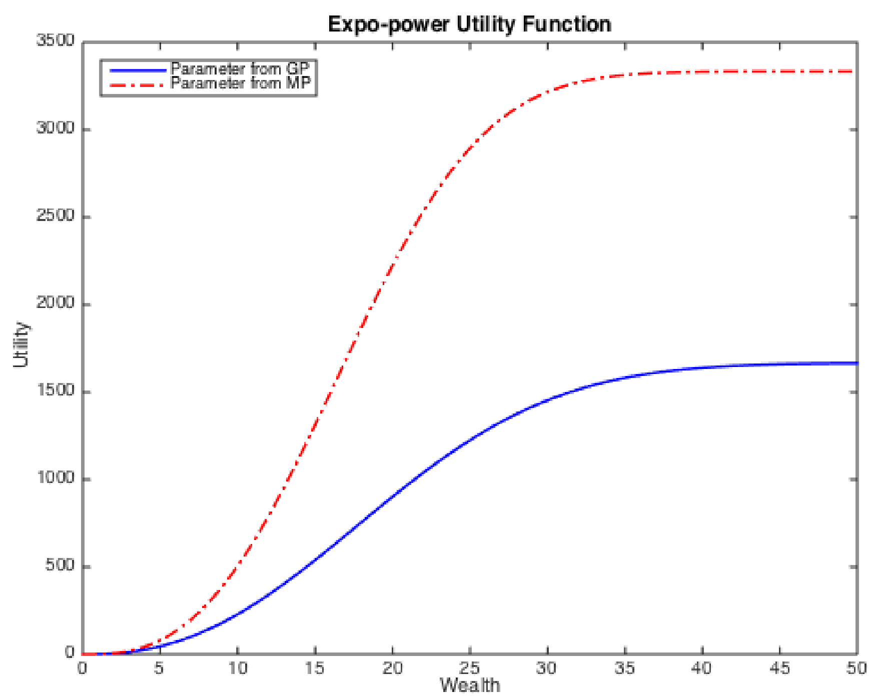


Table 1: Summary of Treatments

Treatment	No. of subject	Possible gain (*yuan*)	Possible loss (*yuan*)
	Panel A: incentivized lab experiment		
Within-subject design			
T1: simple gain prospect (SGP)	40	20	0
T2: simple mixed prospect (SMP)	40	20	10
T3: compound gain prospect (CGP)	40	20	0
T4: compound mixed prospects (CMP)	40	20	10
Between-subject design (T1 paired with T3 and T2 paired with T4)			
T1: simple gain prospect (SGP)	40	20	0
T2: simple mixed prospect (SMP)	40	20	10
T3: compound gain prospect (CGP)	40	20	0
T4: compound mixed prospects (CMP)	39	20	10
	Panel B: randomized field survey (hypothetical)		
Between-subject design–2 million property value			
T1: simple gain prospect (SGP)	132	2 million	0
T2: simple mixed prospect (SMP)	136	2 million	1 million
Between-subject design–5 million property value			
T1: simple gain prospect (SGP)	132	5 million	0
T2: simple mixed prospect (SMP)	136	5 million	2.5 million

Table 2: Mean and Standard Errors of Willingness To Pay from Survey Responses

	Value = 2M			Value = 5M		
Probability	EV	SGP	SMP	EV	SGP	SMP
0.1	220; 210	224.773	203.419	550; 525	517.955	447.206
		(4.739)	(4.328)		(11.384)	(12.426)
0.2	240; 230	230.265	227.684	600; 575	537.273	472.868
		(5.121)	(4.779)		(11.048)	(12.233)
0.3	260; 250	245.909	242.279	650; 625	564.242	508.971
		(5.887)	(5.243)		(12.831)	(12.462)
0.5	300; 290	269.015	276.103	750; 725	614.091	565.956
		(6.091)	(5.462)		(14.012)	(11.547)
0.7	340; 330	301.629	298.309	850; 825	671.894	633.382
		(6.719)	(6.023)		(14.590)	(14.604)
0.8	360; 350	317.614	315.478	900; 875	718.182	693.750
		(6.777)	(5.972)		(15.963)	(16.418)
0.9	380; 370	326.326	331.250	950; 925	766.212	751.324
		(6.895)	(6.092)		(15.657)	(17.439)

Notes: SGP and SMP are Willingness To Pay for gain prospect and mixed prospect respectively. EV is expected value of the gain prospect(before semi–colon) and mixed prospect(after semi–colon). Probability is the odd that housing price will be doubled. For mixed prospects, there is a 10% probability that the housing price will be half. Standard errors of means are in parentheses.

Table 3: Explaining Risk Preference (Certainty Equivalent/Expected Value) in Survey Study

	(1) CE/EV		(2) Log(CE/EV)	
SMP	0.104***	(0.0347)	0.0839**	(0.0421)
P=0.2	-0.0543***	(0.00746)	-0.0606***	(0.00689)
P=0.3	-0.0748***	(0.00962)	-0.0872***	(0.00929)
P=0.5	-0.124***	(0.0108)	-0.143***	(0.0112)
P=0.7	-0.143***	(0.0125)	-0.166***	(0.0136)
P=0.8	-0.142***	(0.0139)	-0.166***	(0.0154)
P=0.9	-0.149***	(0.0158)	-0.171***	(0.0174)
(P=0.2) X SMP	0.0407**	(0.0126)	0.0615**	(0.0190)
(P=0.3) X SMP	0.0380**	(0.0170)	0.0597**	(0.0239)
(P=0.5) X SMP	0.0484**	(0.0189)	0.0747***	(0.0242)
(P=0.7) X SMP	0.0266	(0.0212)	0.0484*	(0.0264)
(P=0.8) X SMP	0.0340	(0.0233)	0.0641**	(0.0292)
(P=0.9) X SMP	0.0456	(0.0257)	0.0751**	(0.0323)
Value	-0.000254***	(0.0000382)	-0.000254***	(0.0000470)
Value X SMP	-0.000229***	(0.0000587)	-0.000204***	(0.0000686)
Constant	1.071***	(0.0237)	0.0436	(0.0281)
Observations	3752		3723	

Notes: Random effects model with standard error clustered by respondents. Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01

Table 4: Mean and Standard Errors of Certainty Equivalents from Laboratory Experiments

Probability	EV	SGP	SMP	CGP	CMP
			Within–Subject		
0.1	2; 1	2.713	2.590	3.356	2.273
		(0.507)	(0.626)	(0.516)	(0.563)
0.2	4; 3	4.340	3.770	4.718	3.063
		(0.384)	(0.516)	(0.510)	(0.598)
0.3	6; 5	6.508	4.845	5.805	4.220
		(0.543)	(0.368)	(0.419)	(0.563)
0.4	8; 7	7.790	6.615	7.838	6.100
		(0.449)	(0.497)	(0.436)	(0.585)
0.5	10; 9	9.080	8.130	9.938	7.033
		(0.422)	(0.406)	(0.422)	(0.428)
0.6	12; 11	10.483	10.388	11.349	8.888
		(0.467)	(0.483)	(0.373)	(0.556)
0.7	14; 13	12.945	11.915	12.933	10.915
		(0.414)	(0.432)	(0.333)	(0.542)
0.8	16; 15	15.183	13.933	14.723	12.220
		(0.337)	(0.463)	(0.550)	(0.676)
0.9	18; 17	16.758	15.725		
		(0.408)	(0.480)		
			Between–Subject		
0.1	2; 1	2.165	2.563	2.636	2.208
		(0.263)	(0.339)	(0.462)	(0.560)
0.2	4; 3	4.200	3.710	4.897	3.603
		(0.392)	(0.292)	(0.640)	(0.461)
0.3	6; 5	5.875	5.205	5.487	4.487
		(0.427)	(0.312)	(0.553)	(0.409)
0.4	8; 7	7.248	6.930	7.051	5.982
		(0.323)	(0.316)	(0.567)	(0.422)

0.5	10; 9	9.105	8.910	8.954	8.013
		(0.426)	(0.379)	(0.420)	(0.432)
0.6	12; 11	10.610	10.430	10.656	9.890
		(0.442)	(0.395)	(0.547)	(0.574)
0.7	14; 13	13.353	12.098	12.413	11.380
		(0.494)	(0.517)	(0.609)	(0.586)
0.8	16; 15	14.670	14.200	13.772	12.818
		(0.501)	(0.610)	(0.657)	(0.672)
0.9	18; 17	16.918	16.060		
		(0.489)	(0.623)		

Notes: SGP, SMP, CGP, and CMP are certainty equivalents of simple gain prospect, simple mixed prospect, compound gain prospect, and compound mixed prospect respectively. EV is expected value of the gain prospect(before semi–colon) and mixed prospect(after semi–colon). Probability is the odd of winning 20 *yuan*. For mixed prospects, there is always a 10% odd to lose 10 *yuan*. Standard errors of means are in parentheses.

Table 5: Explaining Risk Preference (Certainty Equivalent/Expected Value) in Lab Experiment

	Within–Subject				Between–Subject			
	(1) CE/EV		(2) Log(CE/EV)		(3) CE/EV		(4) Log(CE/EV)	
SMP	1.234***	(0.444)	0.233	(0.223)	1.480***	(0.259)	0.712***	(0.134)
CGP	0.308*	(0.171)	0.218	(0.135)	0.235	(0.268)	0.190	(0.216)
CMP	0.916**	(0.403)	0.349	(0.236)	1.125*	(0.579)	0.522**	(0.257)
P=0.2	-0.271	(0.178)	-0.0312	(0.116)	-0.0325	(0.117)	0.113	(0.0884)
P=0.3	-0.272	(0.237)	0.0320	(0.136)	-0.103	(0.130)	0.0696	(0.110)
P=0.4	-0.383*	(0.217)	0.00177	(0.131)	-0.177	(0.114)	0.00241	(0.0948)
P=0.5	-0.448*	(0.234)	-0.0513	(0.154)	-0.172	(0.110)	0.0138	(0.103)
P=0.6	-0.483**	(0.239)	-0.0866	(0.153)	-0.198	(0.124)	-0.0252	(0.115)
P=0.7	-0.432*	(0.244)	-0.00701	(0.153)	-0.129	(0.121)	0.107	(0.112)
P=0.8	-0.407	(0.249)	0.0326	(0.157)	-0.166	(0.127)	0.0552	(0.112)
P=0.9	-0.425*	(0.256)	0.0107	(0.167)	-0.143	(0.130)	0.109	(0.120)
(P=0.2) X SMP	-1.062***	(0.366)	-0.148	(0.182)	-1.293***	(0.252)	-0.545***	(0.141)
(P=0.2) X CGP	-0.227	(0.160)	-0.111	(0.122)	-0.0611	(0.174)	-0.134	(0.151)
(P=0.2) X CMP	-0.980***	(0.334)	-0.650***	(0.225)	-0.974**	(0.474)	-0.517***	(0.164)
(P=0.3) X SMP	-1.349***	(0.428)	-0.380*	(0.212)	-1.418***	(0.232)	-0.642***	(0.130)
(P=0.3) X CGP	-0.439**	(0.179)	-0.295**	(0.134)	-0.300	(0.221)	-0.282	(0.189)
(P=0.3) X CMP	-1.157***	(0.367)	-0.608**	(0.258)	-1.207**	(0.525)	-0.559***	(0.208)
(P=0.4) X SMP	-1.263***	(0.430)	-0.380*	(0.229)	-1.396***	(0.261)	-0.648***	(0.141)
(P=0.4) X CGP	-0.316*	(0.179)	-0.231*	(0.131)	-0.260	(0.226)	-0.174	(0.184)
(P=0.4) X CMP	-1.019***	(0.358)	-0.569**	(0.274)	-1.177**	(0.547)	-0.599***	(0.208)
(P=0.5) X SMP	-1.238***	(0.444)	-0.258	(0.232)	-1.400***	(0.265)	-0.601***	(0.137)
(P=0.5) X CGP	-0.236	(0.173)	-0.140	(0.142)	-0.251	(0.242)	-0.171	(0.189)
(P=0.5) X CMP	-1.043**	(0.415)	-0.567*	(0.304)	-1.145**	(0.566)	-0.533**	(0.231)
(P=0.6) X SMP	-1.163***	(0.444)	-0.163	(0.230)	-1.416***	(0.265)	-0.597***	(0.140)
(P=0.6) X CGP	-0.250	(0.167)	-0.148	(0.134)	-0.232	(0.262)	-0.142	(0.209)
(P=0.6) X CMP	-0.982**	(0.395)	-0.510**	(0.260)	-1.110**	(0.565)	-0.484**	(0.234)
(P=0.7) X SMP	-1.242***	(0.440)	-0.251	(0.224)	-1.503***	(0.256)	-0.767***	(0.140)

(P=0.7) X CGP	-0.323*	(0.169)	-0.239*	(0.140)	-0.303	(0.259)	-0.273	(0.205)
(P=0.7) X CMP	-1.001**	(0.396)	-0.491*	(0.256)	-1.204**	(0.569)	-0.631***	(0.234)
(P=0.8) X SMP	-1.254***	(0.444)	-0.271	(0.228)	-1.450***	(0.262)	-0.695***	(0.137)
(P=0.8) X CGP	-0.351*	(0.179)	-0.317*	(0.177)	-0.292	(0.260)	-0.249	(0.205)
(P=0.8) X CMP	-1.050***	(0.405)	-0.625**	(0.288)	-1.188**	(0.585)	-0.608**	(0.247)
(P=0.9) X SMP	-1.240***	(0.437)	-0.249	(0.225)	-1.475***	(0.261)	-0.737***	(0.143)
Constant	1.356***	(0.257)	-0.0967	(0.165)	1.083***	(0.132)	-0.196	(0.134)
Observations	1352		1330		1343		1313	

Notes: Random effects model with standard error clustered by subjects. Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01

Table 6: Estimation of Structural Parameters

	(1)	(2)
	CRRA	Expo–power
r(GP)	0.3325	-1.3929
	(0.0446)	(0.0987)
r(MP)	0.1773	-1.7399
	(0.0205)	(0.0561)
α(GP)		0.0006
		(0.0002)
α(MP)		0.0003
		(0.00005)
σ	3.1723	3.0786
	(0.0421)	(0.0418)
Observations	318	318

Notes: Standard errors in parentheses. (GP) represents gain only prospects; (MP) represents mixed prospects.

Table 7: Certainty Equivalents under Prospect Theory

Probability of Gain	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
CE of Gain Prospect	3.35	5.10	6.53	7.84	9.10	10.38	11.75	13.33	15.36
CE of Mixed Prospect	-0.14	1.14	2.38	3.55	4.71	5.90	7.19	8.68	10.61
CE of Mixed Prospect (without LA)	1.62	3.26	4.63	5.88	7.10	8.35	9.69	11.23	13.22

Table 8: Explaining Risk Preference by Gender in Survey Study

	(1) CE/EV		(2) Log(CE/EV)	
SMP	0.124*	(0.049)	0.115	(0.060)
Male	0.0979*	(0.046)	0.126*	(0.052)
SMP X Male	-0.0439	(0.068)	-0.0717	(0.081)
P=0.2	-0.0614***	(0.010)	-0.0677***	(0.010)
P=0.3	-0.0774***	(0.014)	-0.0919***	(0.014)
P=0.5	-0.126***	(0.014)	-0.150***	(0.015)
P=0.7	-0.135***	(0.016)	-0.165***	(0.019)
P=0.8	-0.129***	(0.018)	-0.161***	(0.021)
P=0.9	-0.138***	(0.019)	-0.164***	(0.022)
Value	-0.000245***	(0.000)	-0.000230***	(0.000)
SMP X Value	-0.000289***	(0.000)	-0.000271**	(0.000)
Male X Value	-0.0000203	(0.000)	-0.0000577	(0.000)
Other Interaction Terms as Controls				
Constant	1.029***	(0.033)	-0.00985	(0.042)
Observations	3752		3723	

Notes: Random effects model with standard error clustered by respondents. Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01

Table 9: Explaining Risk Preference by Gender in Lab Experiment

	Within–Subject				Between–Subject			
	(1) CE/EV		(2) Log(CE/EV)		(3) CE/EV		(4) Log(CE/EV)	
SMP	1.273***	(0.466)	0.265	(0.280)	1.830***	(0.444)	0.925***	(0.262)
CGP	0.429*	(0.237)	0.137	(0.165)	0.267	(0.359)	0.217	(0.316)
CMP	1.210***	(0.422)	0.524**	(0.241)	1.644*	(0.948)	0.577	(0.386)
Male	0.601	(0.714)	-0.000299	(0.381)	0.251	(0.211)	0.18	(0.207)
SMP X Male	0.119	(1.174)	-0.171	(0.515)	-0.636	(0.720)	-0.477	(0.444)
CGP X Male	-0.36	(0.357)	0.178	(0.304)	-0.0726	(0.463)	-0.14	(0.389)
CMP X Male	-0.603	(1.000)	-0.448	(0.452)	-1.076	(1.009)	-0.0601	(0.414)
P=0.2	-0.508	(0.499)	0.0221	(0.283)	-0.000198	(0.234)	-0.0294	(0.185)
P=0.3	-0.776	(0.638)	-0.0803	(0.318)	-0.176	(0.261)	-0.0497	(0.228)
P=0.4	-0.578	(0.616)	0.0375	(0.318)	-0.216	(0.224)	-0.122	(0.195)
P=0.5	-0.546	(0.642)	0.0942	(0.338)	-0.247	(0.218)	-0.168	(0.213)
P=0.6	-0.519	(0.657)	0.116	(0.343)	-0.227	(0.246)	-0.133	(0.233)
P=0.7	-0.548	(0.684)	0.0789	(0.357)	-0.236	(0.239)	-0.156	(0.226)
P=0.8	-0.575	(0.692)	0.0385	(0.367)	-0.275	(0.250)	-0.195	(0.232)
P=0.9	-0.581	(0.703)	0.0337	(0.377)	-0.319	(0.254)	-0.243	(0.235)
				Other Interaction Terms as Controls				
Constant	1.106***	(0.171)	-0.0935	(0.165)	0.953***	(0.122)	-0.266	(0.168)
Observations	1258		1238		1284		1259	

Notes: Random effects model with standard error clustered by subjects. Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01

Table 10: Test of External Validity with Survey data

	(1)		(2)	
	CE/EV		Log(CE/EV)	
SMP	0.0863**	(0.0400)	0.0493	(0.0462)
Student	-0.0680	(0.0666)	-0.114	(0.0900)
SMP X Student	0.0578	(0.0884)	0.118	(0.114)
P=0.2	-0.0530***	(0.00910)	-0.0583***	(0.00833)
P=0.3	-0.0714***	(0.0113)	-0.0830***	(0.0103)
P=0.5	-0.129***	(0.0123)	-0.147***	(0.0126)
P=0.7	-0.142***	(0.0141)	-0.162***	(0.0155)
P=0.8	-0.139***	(0.0162)	-0.159***	(0.0177)
P=0.9	-0.150***	(0.0177)	-0.169***	(0.0192)
(P=0.2) X SMP	0.0517***	(0.0146)	0.0728***	(0.0238)
(P=0.3) X SMP	0.0445**	(0.0201)	0.0701**	(0.0296)
(P=0.5) X SMP	0.0606***	(0.0212)	0.0958***	(0.0285)
(P=0.7) X SMP	0.0332	(0.0229)	0.0629**	(0.0294)
(P=0.8) X SMP	0.0405	(0.0250)	0.0764**	(0.0327)
(P=0.9) X SMP	0.0566**	(0.0275)	0.0943***	(0.0363)
Other Interaction Terms as Controls				
Constant	1.091***	(0.0255)	0.0765***	(0.0258)
Observations	3598		3573	

Notes: Random effects model with clustered standard error by respondents. Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01