Individual Preference for Longshots

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Results from studies on risk taking behavior suggest that people tend to be risk seeking when making choices over lotteries that involve longshots: small probabilities of winning sizable payoffs. To investigate preferences over longshots systematically, we conduct an incentivized experiment using state lotteries in China each involving a single prize and fixed winning odds. This enables our construction of single-prize lotteries involving winning odds between 10^{-5} and 10^{-1} and winning prizes ranging from RMB10 (about USD1.60) to RMB10,000,000 across different expected payoffs. For lotteries with the lower expected payoffs of 1 and 10, subjects exhibit heterogeneous preference for longshot: some prefer the smallest winning probability while others favor intermediate winning probabilities. As the expected payoff increases to 100, subjects become predominantly risk averse, even for the lowest winning probability of 10^{-5}. Our findings pose challenges for several non-expected utility models in the literature.

Keywords: longshot risk, gambling, non-expected utility, prospect theory, rank dependent utility, betweenness, experiment

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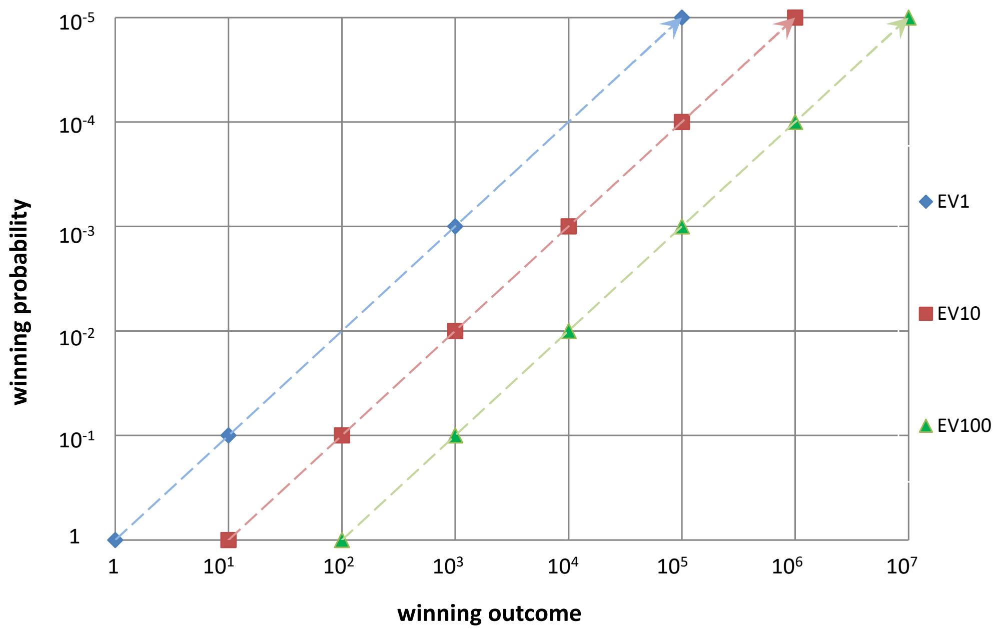
1. Introduction

Individuals exhibit risk seeking behavior when there is a small chance of winning a sizable prize – this is apparent in gambling activities from casino games to racetrack betting. A stylized observation that has emerged from racetrack betting is the favorite-longshot bias (Griffith, 1949). Bettors are inclined to overbet longshots (horses with a small chance of winning) and underbet favorites (horses with a high probability of winning. This general observation is in keeping with the fact that Lotto games, such as Hong Kong's Mark Six and U.S.'s Powerball, have reduced their winning odds over the years and this has been accompanied by disproportionate increases in demand (Baucells and Yemen, 2017). These findings, however, are generally drawn from aggregate data, and provide little systematic information about individuals' preference for longshots (Jullien and Salanié, 2000; Snowberg and Wolfers, 2010). At the individual level, researchers have turned to hypothetical lotteries to avoid the possibility of having to award sizable prizes. Overall, evidence from gambling data and hypothetical experiments suggest that decision makers are risk seeking when facing small probabilities of winning sizable gains. This behavior is regarded as one of the stylized observations in decision making under risk (Tversky and Kahneman, 1992; Wakker, 2010).

Beyond aggregate data and hypothetical choice, we present the first experimental study on individual preferences for longshots with extremely small probabilities and extremely large prizes. Our longshot lotteries are constructed from three fixed-odds-fixed-outcome state lottery products in China, namely, 1D, 3D, and 5D. Respectively, 1D, 3D, and 5D pay out a prize of RMB10 with probability 10^{-1}, RMB1,000 with probability 10^{-3}, and RMB100,000 with probability 10^{-5}. For instance, we can create a lottery that pays RMB10,000,000 with winning probability of 10^{-5} by purchasing 100 5D tickets all with the same winning number. The full range of single-prize lotteries are constructed under one of three expected payoffs: RMB1, 10, or 100, and have explicit winning odds of 10^{-1} to 10^{-5} and explicit prizes of RMB10 to RMB10,000,000 (see Figure 1 below). This construction affords us a wide array of lotteries with small probabilities of winning sizable prizes; and further allows us to finely characterize the individuals' preference over longshot risks. We conduct the experiment with a sample size of 836 participants in China to make choices between pairs of lotteries that have the same expected payoffs.

Figure 1. Structure of lotteries used in our experiment



Note. Illustration of lotteries grouped under *EV (expected value) = 1*, *EV = 10*, and *EV = 100* involving the probabilities of 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, and 10^{-5} and winning outcomes (in RMB) of 10, 10^2, 10^3, 10^4, 10^5, 10^6, and 10^7, using different combinations of 1D, 3D, and 5D tickets. Preferences for longshots can be investigated for a given expected value, and for different expected value with either a fixed winning probability or a fixed winning outcome.

We find strong support for longshot preference at expected payoffs of 1 and 10, but not 100. Moreover, we observe considerable heterogeneity in longshot preferences: monotonic longshot preference that favor the smallest winning probability of 10^{-5}, and single-peak longshot preference that favor intermediate winning probabilities such as 10^{-3} and 10^{-1}. As the winning probability gets smaller at a specific expected payoff, risk attitude may not converge. The intuition of favorite-longshot bias suggests that the smaller the winning probability, the higher the value of the lottery. Yet, the decision maker may consider the winning probability to be negligible at some point and end up favoring a lottery with an intermediate winning probability.[1] . In this regard, Kahneman and Tversky (1979) observe that "*Because people are limited in their ability to comprehend and evaluate extreme probabilities, highly unlikely events are either ignored or overweighed…*"

As expected payoffs increase from 1 to 100, we observe a general tendency to switch from being risk seeking to risk averse in the following ways. First, the favored winning probability tends to increase as the expected payoff increases. Second, this tendency to switch remains regardless whether the winning probability or the winning outcome is fixed or when

[1] Decades after Bernoulli's original paper in 1728, Buffon (1777) suggests that the St. Petersburg paradox could be resolved if people ignore small probabilities. Morgenstern (1979) suggests that expected utility was not intended to model risk attitude for very small probabilities.

the same ratio of winning probabilities is maintained across pairs of lotteries with the same winning outcomes. The latter switch in risk attitude corresponds to a form of common-ratio Allais behaviour as illustrated in Kahneman and Tversky's (1979): Subjects exhibit a preference for a 90 percent chance of winning 3,000 over a 45 percent chance of winning 6,000, but an 'opposite' preference for a 0.2 percent chance of winning 3,000 over a 0.1 percent chance of winning 6,000.

Our observed behavioral patterns shed light on several non-expected utility models, including rank-dependent utility (Quiggin, 1982) and betweenness-conforming models such as weighted utility (Chew, 1983) and disappointment averse utility (Gul, 1991). Under these models, preference over longshots depends on the interplay between the concavity of utility function and the overweighting of winning probability. When the winning outcome is sufficiently large, the tendency towards risk aversion from the concavity of the utility function would dominate the tendency towards risk seeking from the overweighting of small probability. This can lead to a preference for intermediate winning probabilities over the smallest winning probability and a switch from being risk seeking to being risk averse as expected payoff increases. In Section 4, we show that these models can exhibit the full range of longshot related choice behavior using a concave utility function displaying eventually decreasing elasticity coupled with their respective forms of overweighting of winning probabilities.

The paper proceeds as follows. Section 2 presents our experimental design. Properties involving longshot preferences are defined in Section 3. Section 4 derives conditions under which different utility models may exhibit specific preference properties. Section 5 presents the experimental results in terms of observed choice patterns among lotteries with the same expected payoffs and across different levels of expected payoffs. We discuss in Section 6 and conclude in Section 7.

2. Experimental Design

We develop an experimental design using three kinds of single-prize fixed-odds state lotteries in China known as 1D, 3D and 5D. A 1D ticket pays *RMB10* if the buyer chooses a one-digit number between *0* and *9* that matches a single winning number. Similarly, for 3D tickets, a buyer chooses a three-digit number from *000* to *999* and wins *RMB1,000* if the number matches a single winning number. Likewise, a 5D ticket pays *RMB100,000* if the buyer's five-digit number matches the winning number. The digit lottery tickets cost *RMB2* each, and are on sale daily, including weekends, through authorized outlets by two state-owned companies. The China Welfare Lottery sells the 1D lottery and the China Sports Lottery sells both 3D and 5D lotteries. The winning numbers for each lottery are generated using Bingo blowers by independent government agents and this process is telecast live daily at 8 p.m. Buyers may pick their own numbers or have a computer generate random numbers at the sales outlet. Winning tickets are cashed out at the lottery outlets.

Figure 1 in the Introduction presents the parametric structure of the single-prize lotteries with different levels of winning probabilities and expected payoffs of 1, 10 and 100. We construct lotteries with expected values 10 and 100 using different combinations of tickets. For example, a lottery with 10^{-3} chance of winning 10^{5} can come from 100 3D tickets with same numbers while a lottery with 10^{-4} chance of winning 10^{5} corresponds to ten 5D tickets with 10 different numbers.[2] Notice that the combination of lotteries does not work for lotteries with expected payoffs of 1, and we are limited to using 10^{-1}, 10^{-3}, and 10^{-5} as the winning probabilities for lotteries with expected payoffs of 1. We summarize the details of these lottery products and how we generate the lotteries used in the experiment in Table A1 in Appendix B. Overall, we include *four* lotteries with expected payoffs of 1, *ten* lotteries with expected payoffs of 10, and *ten* lotteries with expected payoffs of 100. The preference relation is elicited by pairwise comparison among lotteries with the same expected payoffs. This leads to a total of 96 binary choice comparisons: six at expected payoff 1, 45 at expected payoff 10, and 45 at expected payoff 100. We also include four comparisons in which one choice stochastically dominates the other to test for subjects' engagement or attentiveness. (see Table A2 in Appendix B for details).

In order to incentivize choices, ten percent of the subjects were randomly selected to be compensated by receiving their chosen lottery from a randomly selected choice out of *100* choices made. The lottery was randomly chosen in the following ways. We add the subject's birthday (year, month, and date—eight numbers in total) to obtain its trailing digit. If this digit is the same as the trailing digit from the sum of the winning number in the 3D Welfare lottery on Feb 28, 2013, the subject will receive the additional compensation. Each randomly chooses a number between *1* and *100*, which determines the specific decision to be received whether it is a sure amount of money or a lottery, in which case the subject will receive the corresponding combination of lottery tickets purchased from a state lottery store. The theoretical and empirical validity of this random lottery incentive has been a subject of debate (see, e.g., Starmer and Sugden, 1991; Wakker, 2007; Freeman, Halevy, and Kneeland, 2015, for related discussions).

[2] These combinations of different lottery tickets do not lead to compound lotteries (Halevy, 2007; Dean and Ortoleva, 2014; Gillen, Snowberg, and Yariv, 2015), as the uncertainty is resolved in one stage. Moreover, after they are explained how combinations work, to reduce complexity, subjects only see the winning probabilities and winning outcomes when making choices.

We adopt this incentive method in our current study because it is relatively simple and it offers an efficient way to elicit subjects' preferences thereby enabling the analysis of choice behavior at the individual level.

The experiment is conducted in an internet-based setting. Running experiments online has become increasingly common in experimental economics research. For example, Von Gaudecker et al. (2008) compare laboratory and internet-based experiments, and show that the observed differences arise more from sample selection rather than the mode of implementation. Moreover, they find virtually no difference between the behavior of students in the lab and that of young highly educated subjects in the internet-based experiments. Running an internet-based experiment is convenient for collecting large samples, which could be helpful when conducting individual level analysis. In our experiment, each choice is displayed separately on each screen, as shown in Appendix D. We randomize the order of appearance of the 100 binary comparisons as well as the order of appearance within each comparison. At the end of the experiment, subjects answer questions about their demographics.

The potential subjects are Beijing-based university students ($N = 1{,}282$) whom we recruited earlier for a large study. These subjects have previously received compensation from participating in our experiments in both classroom and online settings, they are likely to have greater trust in receiving their compensations for participating in our study. Email invitations were sent and followed by two reminders over a two-month period. We ended up with a sample of *836* subjects (*50.0* percent females; average age = *21.8*) with a response rate of *65* percent. On average, subjects spent *19.3* minutes in the experiment. Each subject received RMB20 for participating in the experiment. For reference, the students' average monthly expenses were about RMB1,200 based on survey data.

3. Properties involving Longshot Preferences

In our design, subjects choose between pairs of equal-mean lotteries $(m/q, q)$ and $(m/r, r)$ with $q > r$, where (x, p) denotes a single-prize lottery paying x with probability p and paying 0 with probability $1 - p$. Receiving an amount x with certainty is denoted by $[x]$. We refer to a preference for $(m/q, q)$ over $(m/r, r)$, denoted by $(m/q, q) \succ (m/r, r)$, as being risk averse, and the opposite preference for $(m/r, r)$ over $(m/q, q)$, denoted by $(m/q, q) \prec (m/r, r)$, as being risk seeking. We refer to a preference for $[m]$ over $(m/q, q)$ as risk averse towards $(m/q, q)$, and a preference for $(m/q, q)$ over $[m]$ as risk seeking towards $(m/q, q)$.

First, we are interested in the way risk attitudes may vary when the winning probability p shrinks while the expected payoff is maintained at m. This idea is related to the favorite longshot bias at an individual level in which the decision maker will increasingly value $(m/p, p)$ as p decreases towards 0 (Chew and Tan, 2005). We state this property formally below.

Property M. A decision maker exhibits *monotonic longshot preference* at m over $(0, q]$ if $(m/q, q) \succ [m]$ and $(m/p, p) \succ (m/p', p')$ with $0 < p < p' < q$.

In our experimental setting, should the decision maker be risk seeking towards a lottery with 10^{-1} winning probability, the monotonic longshot preference property implies a preference for the lottery with 10^{-5} winning probability over the lottery with 10^{-3} winning probability, which is in turn preferred to the lottery with 10^{-1} winning probability, when all three lotteries have the same expected payoff. Alternatively, the decision maker may have a favored winning probability of p^* at expected payoff m in being increasingly risk seeking as the winning probability decreases from q to p^*, and then switch to being increasingly risk averse as the winning probability further decreases from p^*. We state this single-peak property below.

Property SP. A decision maker exhibits *single-peak longshot preference* at m over $(0, q]$ if $(m/q, q) \succ [m]$ and there is a *favored winning probability* p^* such that $(m/p, p) \succ (m/p', p')$ for $p^* < p < p' < q$ and $(m/p', p') \succ (m/p, p)$ for $0 < p < p' < p^*$.

In the limit, as p^* tends towards 0, single-peak longshot preference becomes *monotonic longshot preference*, which relates to favorite longshot bias at the individual level. In our experiment, single-peak longshot preference over $(0, 10^{-1}]$ is compatible with four choice patterns: (i) one with 10^{-1} as the favored winning probability: $(m/10^{-5}, 10^{-5}) \prec (m/10^{-3}, 10^{-3}) \prec (m/10^{-1}, 10^{-1})$; (ii) two with 10^{-3} as the favored winning probability: $(m/10^{-5}, 10^{-5}) \prec (m/10^{-1}, 1^{-1}) \prec (m/10^{-3}, 10^{-3})$ and $(m/10^{-1}, 10^{-1}) \prec (m/10^{-5}, 10^{-5}) \prec (m/10^{-3}, 10^{-3})$; and (iii) one with 10^{-5} as the favored winning probability: $(m/10^{-1}, 10^{-1}) \prec (m/10^{-3}, 10^{-3}) \prec (m/10^{-5}, 10^{-5})$. Notice that case (iii) is observationally indistinguishable from monotonic longshot preference over $(0, 10^{-1}]$.

We say that a decision maker exhibits longshot preference at m over $(0, q]$ if her preference is either monotonic or single-peaked. We next investigate the potential tendency towards risk aversion when the stake in terms of expected payoff increases. We examine this tendency in three ways: (i) when the winning probability is fixed; (ii) when the winning outcome is fixed; and (iii) when winning outcomes of pairs of lotteries are fixed so that the ratio of winning probabilities remain the same. We state these tendencies formally as properties below.

Property SA (*Scale aversion*). (i) The decision maker exhibits *outcome scale aversion* at probability q if there is an m^* such that $(m/q, q) \succ [m]$ for $m < m^*$ and $(m/q, q) \prec [m]$ for $m > m^*$. (ii) The decision maker exhibits *probability scale aversion* at outcome x if there is an m^* such that $(x, m/x) \succ [m]$ for $m < m^*$ and $(x, m/x) \prec [m]$ for $m > m^*$. (iii) The decision maker exhibits *common-ratio scale aversion* at outcomes $H > L$ if there is an m^* such that $(H, m/H) \succ (L, m/L)$ for $m < m^*$ and $(H, m/H) \prec (L, m/L)$ for $m > m^*$.

Relatedly, the intuition behind scale aversion suggests that the favored winning probability itself would increase as the expected payoff increases. In our setting, a decision maker who is risk seeking towards lottery $(10^3, 10^{-3})$ may become risk averse towards lottery $(10^5, 10^{-3})$ due to outcome scale aversion, or become risk averse towards lottery $(10^3, 10^{-1})$ arising from probability scale aversion. On the other hand, a decision maker who is risk seeking towards $(m/q, q)$ would need to remain risk seeking towards $(m'/q, q)$ for $m' > m$. For example, if the decision maker is risk seeking towards $(10^3, 10^{-1})$, the decision maker will also be risk seeking towards lottery $(10^3, 10^{-3})$ as well as lottery $(10, 10^{-1})$. Notice that pure risk aversion or pure risk seeking for our three levels of expected payoffs is observationally indistinguishable from outcome scale aversion or probability scale aversion.

From the definition of common-ratio scale aversion above, comparing risk attitude towards two pairs of equal-mean lotteries with the same ratio L/H of winning probabilities, i.e., $(L, m/L)$ and $(H, m/H)$ versus $(L, m'/L)$ and $(H, m'/H)$ with $m' > m$ yields four possible choice patterns: (i) risk seeking for both pairs; (ii) risk averse for both pairs; (iii) risk seeking for the lower expected payoff comparison and risk averse for the higher expected payoff comparison; (iv) risk averse for the lower expected payoff comparison and risk seeking for the higher expected payoff comparison. Expected utility is compatible with the first two patterns but not the third pattern, commonly known as the common-ratio Allais paradox, and the fourth pattern referred to as reverse Allais behavior. For example, being risk seeking between $(10^3, 10^{-3})$ and $(10^5, 10^{-5})$ coupled with being risk averse between $(10^3, 10^{-1})$ and $(10^5, 10^{-2})$ represents an instance of common-ratio Allais behaviour.

4. Implications of Utility Models

In this section, we investigate the conditions under which different utility models can exhibit the various properties of longshot preference. It is known that the expected utility model (EU) cannot exhibit Allais behavior arising from common-ratio scale aversion, and also cannot exhibit preference for longshots when concave utility function is imposed. We consider several commonly used non-expected utility models in the literature including rank-dependent utility (RDU – Quiggin, 1982) and two forms of betweenness utility: weighted utility (WU – Chew, 1983) and disappointment aversion utility (DAU – Gul, 1991).

For a lottery $(m/p, p)$ paying outcome m/p with probability p, its RDU is given by $w(p)u(\mathrm{m/p})$, where u is a continuous and increasing utility function and w is a continuous and increasing probability weighting function which maps [0, 1] to [0,1] such that $w(0) = 0$ and $w(1) = 1$. We list below several forms of w functions in the literature:

$p^c/[p^c+(1-p)^c]^{1/c}$	Tversky and Kahneman (1992)
$\tau p^d/[\tau p^d+(1-p)^d]$	Goldstein and Einhorn (1987)
$exp\{-\beta[-ln\ p]^{\alpha}\}$	Prelec (1998)

To model longshot related preference properties in conjunction with a concave utility function, the probability weighting function is initially concave and overweights small probabilities.[3]

DAU and WU both belong to the class of preferences satisfying the betweenness axiom which represents an important weakening of the independence axiom. In our setting of single-prize lotteries, the DAU of (x, p) is given by $pu(x)/(p + \lambda(1\text{-}p))$. This coincides with RDU using the Goldstein-Einhorn (1987) probability weighting function with $\tau = 1/\lambda$ and $d = 1$ (see Abdellaoui and Bleichrodt, 2007). It follows that DAU exhibits longshot related preference properties which are similar to RDU. The WU of a single-prize lottery $(m/p, p)$ is given by $ps(m/p)u(x)/[ps(m/p) + 1 - p]$, where s is a continuous and positive valued salience function defined over outcomes. The winning probability is overweighted, when s is increasing. In contrast with RDU, the degree of overweighting of the winning probability increases with the magnitude of the winning outcome when s is an increasing function.

Under the models discussed, the preference for single-prize longshots depends on the interplay between the concavity of the utility of large winning prize and overweighting of small winning probability. Table 1 displays the conditions under which these two utility models can

[3] The special case where $d = 1$ reduces to the form of probability weighting function in Rachlin, Raineri, and Cross (1991) given by $(1 + \delta(1-p)/p)^{-1}$ with $\delta = 1/\tau$ being interpreted in terms of hyperbolic discounting of the odds $(1-p)/p$ against yourself winning. See Section 7.2 of Wakker (2010) for a comprehensive review of different forms of probability weighting functions.

exhibit the various longshot related preference properties using a concave *u* function with eventually declining elasticity coupled with appropriate conditions. Specifically, RDU and WU can each exhibit monotonic as well as single-peak longshot preference in which the favored winning probability is increasing with expected payoff, along with scale aversion in both outcome and probability.

The limiting case of a power utility function with constant elasticity merits special attention. In this case, RDU can exhibit single-peak longshot preference but the corresponding favored winning probability is independent of the expected payoff. While it implies constant relative risk aversion and is compatible with probability scale aversion, yet it is not compatible with outcome scale aversion. By comparison, WU can exhibit the full range of longshot related preference properties except for outcome scale aversion given that *s* is an increasing function. The derivation of the conditions summarized in Table 1 are provided in the appendix A.

Table 1. Conditions on utility models to exhibit longshot preference related properties

Property	RDU		WU	
	Eventually decreasing u-elasticity	*Constant u-elasticity*	*Eventually decreasing u-elasticity*	*Constant u-elasticity*
Monotonic longshot	Y	N	Y	Y
Single-peak longshot	Y	Y[a]	Y	Y
Outcome scale aversion	Y	N	Y	N[b]
Probability scale aversion	Y	Y	Y	Y
Common-ratio scale aversion	Y	Y	Y	Y

Note. **a**. favored winning probability is fixed. **b**. Incompatible with an increasing *s* function.

5. Results

In this section, we report the observed choice behavior among lotteries with the same expected payoffs of *1*, *10*, and *100* as well as comparisons of risk attitudes elicited at different expected payoffs. Table 2 presents the aggregate proportions of risk seeking choice at the three levels of expected payoffs. At expected payoff *1*, subjects are generally risk seeking, except for being risk averse between 10^{-3} and 10^{-5}. In particular, the winning probability of 10^{-3} seems favored since $(10^3, 10^{-3})$ tends to be chosen over *[1]*, $(10, 10^{-1})$, and $(10^5, 10^{-5})$. At expected payoff *10*, subjects are generally risk seeking relative to receiving the expected payoff with certainty and risk averse between pairs of lotteries. At expected payoff *100*, subjects are predominantly risk averse.

Table 2. Proportion of risk seeking choice at each level of expected payoff.

Winning probability		Proportion of risk seeking choice (%)		
Higher	Lower	EV = 1	EV = 10	EV = 100
1	10^{-1}	*75.8*	*60.2*	*19.6*
1	10^{-2}	-	*55.0*	*18.5*
1	10^{-3}	*80.3*	*55.3*	*16.0*
1	10^{-4}	-	*52.8*	*14.5*
1	10^{-5}	*79.8*	*51.9*	*14.5*
10^{-1}	10^{-2}	-	*33.3*	*24.7*
10^{-1}	10^{-3}	*61.5*	*35.2*	*17.6*
10^{-1}	10^{-4}	-	*31.3*	*19.3*
10^{-1}	10^{-5}	*63.3*	*32.3*	*17.8*
10^{-2}	10^{-3}	-	*29.7*	*28.6*
10^{-2}	10^{-4}	-	*27.5*	*24.5*
10^{-2}	10^{-5}	-	*28.5*	*24.5*
10^{-3}	10^{-4}	-	*37.8*	*38.0*
10^{-3}	10^{-5}	*40.3*	*39.1*	*32.8*
10^{-4}	10^{-5}	-	*43.8*	*41.1*

Note. Column 1 (2) presents the winning probability for the lottery with the higher (lower) probability. Columns 3, 4, and 5 display the proportions of risk seeking choice under the three levels of expected payoffs of EV = 1, EV = 10, and EV = 100 respectively.

At the aggregate level, observe that subjects tend to be risk seeking for lotteries with smaller expected payoffs and switch to being risk averse as expected payoff increases. This leads us to organize our results in two ways: First, when expected payoff is fixed, we examine the extent to which subjects may possess monotonic or single-peak longshot preference. Second, we study subjects' switching behavior from being risk seeking to being risk averse as expected payoff increases.

5.1. *Preference within the same expected payoff*

For each of expected payoffs of *1*, *10*, and *100*, Figure 2 displays the corresponding frequencies of different choice patterns: single-peak longshot behavior at 10^{-5}, 10^{-3} and 10^{-1}, purely risk averse choice behavior, and other transitive patterns classified as "transitive-others" alongside those exhibiting intransitive choice. To facilitate comparisons with the observed choice frequencies, we present the corresponding chance rate for each type of choice pattern.[4] At

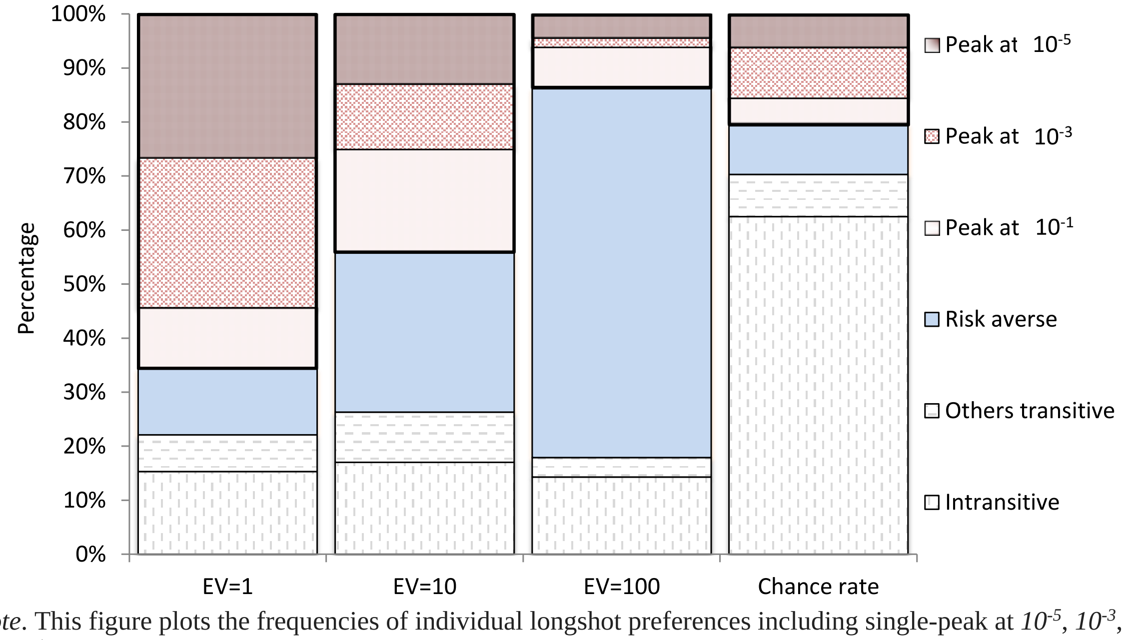
[4] To compare across three levels of expected payoffs, we focus on choice patterns involving probabilities *1*, 10^{-1}, 10^{-3}, and 10^{-5}, and denote the transitive choice patterns in an ascending order (e.g., 1053 refers to $10^{-3} \succ 10^{-5} \succ 1 \succ 10^{-1}$) (see Table A3 in Appendix B for the list). For each level of expected payoff, more than 80% of the subjects exhibit transitive choice patterns (see Appendix C for detailed discussions on intransitive choice patterns). Of twenty four transitive choice patterns, thirteen are single-peak, including seven over $(0, 10^{-1}]$, four over $(0, 10^{-3}]$, and two over $(0, 10^{-5}]$. Six are purely risk averse—1350, 1530, 3150, 3510, 5130, and 5310. For the remaining five patterns under "Others", 10^{-3} is worse than 10^{-1} as well as 10^{-5}. We test whether the observed frequency is significantly different from the chance rate in Table A4 in Appendix B.

expected payoff *1*, *65.6* percent of the subjects exhibit single-peak longshot preference patterns while only *12.3* percent are purely risk averse. Among those with single-peak preferences, the observed frequency is higher than the corresponding chance rate for each favored winning probability at 10^{-5}, 10^{-3} and 10^{-1} (proportion test, $p < 0.001$). At expected payoff *10*, *44.0* percent exhibit single-peak preferences while *29.7* percent are purely risk averse. Among those with single-peak preferences, the observed frequency is higher than the corresponding chance rate for each of the favored winning probabilities of 10^{-5} and 10^{-1} (proportion test, $p < 0.001$). At expected payoff *100*, a substantial majority of *68.3* percent are purely risk averse while only *13.8* percent have single-peak preferences. Among those with single-peak preferences, the observed frequency remains significantly higher than the corresponding chance rate only for the favored winning probability of 10^{-1} (proportion test, $p < 0.001$).[5]

Summarizing, we have the following overall observation of longshot preferences involving equal-mean comparisons.

Observation 1. *Subjects exhibit significant incidences of both single-peak longshot preference and monotonic longshot preference for lower expected payoffs, and they exhibit less longshot preference as expected payoffs increase.*

Figure 2. Frequencies of individual longshot preferences



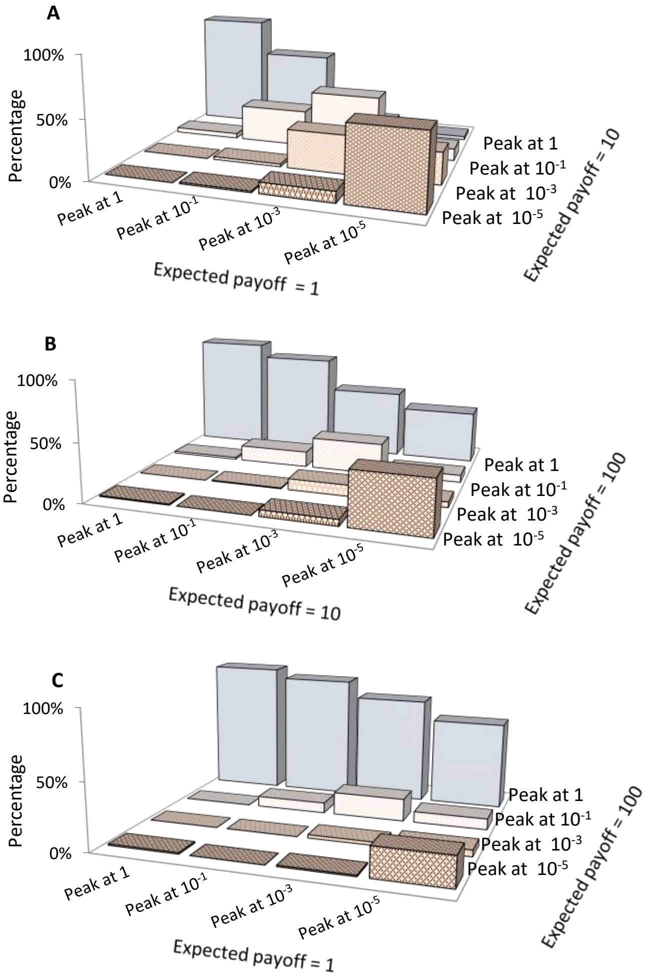
Note. This figure plots the frequencies of individual longshot preferences including single-peak at 10^{-5}, 10^{-3}, and 10^{-1} (delineated with thickened borders), purely risk averse choice, other transitive choice, and intransitive choice across expected payoffs (EV) of *1*, *10*, and *100*, compared to the chance rate.

[5] We include an additional analysis with 10^{-2}, and 10^{-4} lotteries. Observe that the proportions of subjects with transitive preference is 38.16% for EV10 and 54.78% for EV100. This supports the observed low frequency of intransitivity relative to the chance rate of 97.8%. Observe also that the proportions of risk averse subjects are 20.57% for EV10 and 48.33% for EV100. These are consistent with the switch from being risk seeking to being risk averse as expected payoff increases. Proportions which are too small to be displayed in Figure 2 are presented in Table A5 in the Appendix.

5.2. *Preferences across expected payoffs*

This subsection investigates the following longshot properties as the expected payoff increases (i) migration pattern of favored winning probabilities; (ii) outcome scale aversion and probability scale aversion; and (iii) common-ratio scale aversion.

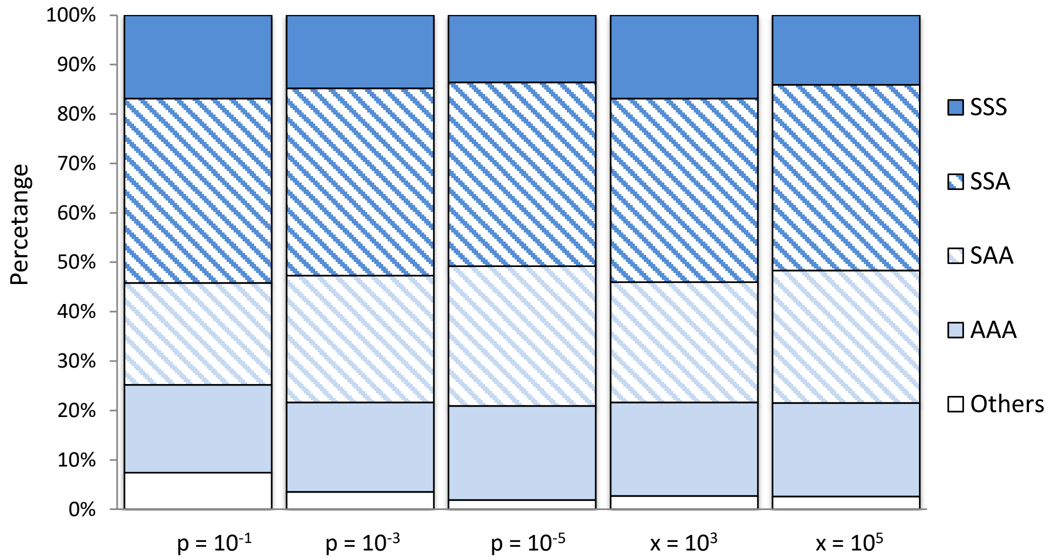
Figure 3. Migration of favored winning probabilities across expected payoffs



Note. Panel A shows the migration pattern of subjects migrating from being risk averse, denoted by "*Peak at 1*", or having single-peak longshot preference at 10^{-1}, 10^{-3}, or 10^{-5} at expected payoffs of *1* to being risk averse, or have single-peak longshot preference at 10^{-1}, 10^{-3}, or 10^{-5} at expected payoffs of *10*. Panel B and Panel C show the corresponding migration patterns from expected payoffs of *10* to expected payoffs of *100*, and from expected payoffs of *1* to expected payoffs of *100*, respectively.

Migration pattern of favored winning probabilities. To investigate the migration pattern of favored winning probabilities as the expected payoff increases, we examine the behaviors for those subjects who either are purely risk averse or have single-peak longshot preferences. Figure 3 presents the migration pattern across expected payoffs of *1* and *10* (Panel A), across expected payoffs of *10* and *100* (Panel B), and across expected payoffs of *1* and *100* (Panel C). More specifically, of *165* subjects who favor 10^{-3} at expected payoff 1, only about one third continue to do so at expected payoff *10.* A strong majority switch to the higher winning probability of 10^{-1} or become risk averse. Of *86* subjects favoring 10^{-1} at expected payoff *1*, majority of them become risk averse at expected payoff *10*. By contrast, for the *99* subjects who are risk averse at expected payoff *1,* almost all of them remain risk averse at expected payoff *10.* Similar patterns are observed between expected payoffs 10 and 100, as well as between expected payoffs 1 and 100. Overall, we observe that the favored winning probabilities increase as expected payoffs increase (see Table A6 in Online Appendix B for details).

Figure 4. Switching towards risk aversion as the expected payoff increases



Note. This figure displays the percentages of different scale averse choice patterns across the three levels of expected payoffs: SSS (risk seeking at all three levels of expected payoffs), SSA (risk seeking at expected payoffs of *1* and *10*, and risk averse at expected payoff *100*), SAA (risk seeking at expected payoff *1*, and risk averse at expected payoffs of *10* and *100*), and AAA (risk averse at all three levels of expected payoffs), and “Others” (the other four patterns), when fixing the winning probability as 10^{-1}, 10^{-3}, and 10^{-5}, as well as fixing the winning outcome as 10^3 and 10^5, respectively.

Outcome scale aversion and probability scale aversion. To examine the property of outcome scale aversion, we examine risk attitudes relative to expected payoffs while fixing the winning probability across the three levels of expected payoffs successively. In parallel, to examine the property of probability scale aversion, the winning outcome is fixed at 10^3 and 10^5 as the winning probability varies between 10^{-5} and 10^{-1}. In each case, there are eight possible choice patterns given that there are three comparisons between a lottery and receiving its expected payoff with certainty. Of these, four are compatible with the tendency of a switch from being risk seeking to being risk averse as the expected payoff increases: (i) risk seeking across all three levels of expected payoffs; (ii) risk seeking at expected payoffs of *1* and *10*, and risk averse at expected payoff 100; (iii) risk seeking at expected payoff *1*, and risk averse at expected payoffs of *10* and *100*; and (iv) risk averse across all three levels of expected payoffs. The four remaining patterns, grouped under "Others", allow for the opposite tendency to switch from being risk averse to being risk seeking as expected payoff increases. The proportion of each choice pattern is summarized in Figure 4, which is derived from Table A7 in Appendix B. We see that the bulk of our subjects tend to switch from being risk seeking to being risk averse as expected payoff increases—*57.9* percent (with $p = 10^{-1}$), *63.4* percent (with $p = 10^{-3}$), *65.5* percent (with $p = 10^{-5}$), *61.5* percent (with $x = 10^{3}$), and *64.4* percent (with $x = 10^{5}$).

Common-ratio scale aversion. We examine common-ratio Allais behavior (relating to common-ratio scale aversion as defined in section 3) and their corresponding frequencies for 14 instances (see Table 3 for details). The observed incidence of Allais choice pattern ranges from *13.6* percent to *27.4* percent.[6] We investigate whether the observed patterns of EU violations are systematic using Conlisk's (1989) test which takes expected utility as the null hypothesis, and compares the frequencies of Allais and reverse Allais behavior. Taking the 14 comparisons in Table 3 together, we find Allais violations to be more pronounced than reverse Allais behavior ($Z = 27.17, p < 0.001$). For these 14 comparisons, the proportion of each Allais pattern is significant at $p < 0.003$, suggesting that violations of expected utility are pervasive for longshot lotteries.

We further test for the possible presence of a certainty effect (Kahneman and Tversky, 1979) by comparing the incidence of Allais behavior in the presence of a sure outcome with its incidence without a sure outcome. Across the expected payoffs of 100 and 10, we find that the incidence of 20.1% for Allais behaviour involving *100* as sure outcome (Items 3 – 6) is significantly higher ($D = 1.93, p < 0.03$) than the incidence of 16.4% for Allais behavior not involving sure outcomes (Items 8 – 13). Focusing instead on expected payoffs of *10* and 1, we find that the incidence of 16.4% for Allais behaviour involving *10* as sure outcome (Items 1 and 2) is not significantly different ($D = -1.19, p > 0.1$) from the incidence of 18.5% for Allais behavior not involving sure outcomes (Item 7).

[6] This is in line with what is reported in the literature based generally on moderate probabilities (i.e., Conlisk, 1989; Cubitt, Starmer and Sugden, 1998; List and Haigh, 2005; Huck and Muller, 2012; Nebout and Dubois, 2014). For instance, Conlisk (1989) observes that the proportion of individual-level Allais pattern is *43.6* percent for his basic treatment and *10.8* percent for his three-step treatment. List and Haigh (2005) find the proportion of such patterns to be *43* percent among student subjects and only *13* percent among professional traders. More recently, with a sample of *1424*, Huck and Muller (2012) report the proportion of Allais behavior to be *49.4* percent in a high hypothetical-payoff treatment, *19.6* percent in a low hypothetical-payoff treatment, and *25.6* percent in a low real-payoff treatment

Table 3. Incidence of common-ratio Allais choice behavior

Item	High EV	Low EV	Allais	Reverse Allais
1	$[10]$ vs $(10^3,10^{-2})$	$(10,10^{-1})$ vs $(10^3,10^{-3})$	*15.6%*	*9.1%*
2	$[10]$ vs $(10^5,10^{-4})$	$(10,10^{-1})$ vs $(10^5,10^{-5})$	*17.1%*	*6.6%*
3	$[10^2]$ vs $(10^3,10^{-1})$	$(10^2,10^{-1})$ vs $(10^3,10^{-2})$	*20.7%*	*7.1%*
4	$[10^2]$ vs $(10^4,10^{-2})$	$(10^2,10^{-1})$ vs $(10^4,10^{-3})$	*20.9%*	*4.3%*
5	$[10^2]$ vs $(10^5,10^{-3})$	$(10^2,10^{-1})$ vs $(10^5,10^{-4})$	*18.3%*	*3.0%*
6	$[10^2]$ vs $(10^6,10^{-4})$	$(10^2,10^{-1})$ vs $(10^6,10^{-5})$	*20.3%*	*2.5%*
7	$(10^3,10^{-2})$ vs $(10^5,10^{-4})$	$(10^3,10^{-3})$ vs $(10^5,10^{-5})$	*18.5%*	*5.7%*
8	$(10^3,10^{-1})$ vs $(10^4,10^{-2})$	$(10^3,10^{-2})$ vs $(10^4,10^{-3})$	*15.0%*	*10.0%*
9	$(10^3,10^{-1})$ vs $(10^5,10^{-3})$	$(10^3,10^{-2})$ vs $(10^5,10^{-4})$	*15.7%*	*5.7%*
10	$(10^3,10^{-1})$ vs $(10^6,10^{-4})$	$(10^3,10^{-2})$ vs $(10^6,10^{-5})$	*15.1%*	*6.0%*
11	$(10^4,10^{-2})$ vs $(10^5,10^{-3})$	$(10^4,10^{-3})$ vs $(10^5,10^{-4})$	*18.5%*	*9.3%*
12	$(10^4,10^{-2})$ vs $(10^6,10^{-4})$	$(10^4,10^{-3})$ vs $(10^6,10^{-5})$	*20.7%*	*6.1%*
13	$(10^5,10^{-3})$ vs $(10^6,10^{-4})$	$(10^5,10^{-4})$ vs $(10^6,10^{-5})$	*13.6%*	*7.9%*
14	$(10^3,10^{-1})$ vs $(10^5,10^{-3})$	$(10^3,10^{-3})$ vs $(10^5,10^{-5})$	*27.4%*	*4.7%*

Note. The first column numbers the common-ratio Allais cases. The next two columns present the pairs of high expected payoff and low expected payoff lotteries. The last two columns display the corresponding rates of Allais and reverse Allais behavior. The first six common-ratio comparisons each involve a sure outcome for the high expected payoff lottery while the remaining eight comparisons all do not involve any sure outcomes.

Summarizing, we have the following overall observation.

Observation 2. *Subjects switch from being risk seeking to being risk averse as expected payoff increases.* (**A**) F*or subjects exhibiting single-peak longshot preference, the favored winning probability tends to increase with an increase in the expected payoff;* **(B)** *Subjects exhibit outcome scale aversion and probability scale aversion in switching from being risk seeking to being risk averse as the expected payoff increases when* <u>*either*</u> *the winning outcome* <u>*or*</u> *the winning probability is fixed;* **(C)** *Subjects exhibit systematic equal-mean common-ratio Allais behavior for small probabilities.*

6. Discussion

Theoretical Implications. The two observations summarized above help discriminate among possible specifications of the different utility models in choice under risk. Using a concave utility function with decreasing elasticity, both RDU and WU can account for the main observations of our experiment through different approaches to overweighting of the winning probability. RDU overweighs directly with a probability weighting function which is initially concave. For WU, the higher the winning outcome, the more WU overweighs the winning probability given an increasing salience function defined on outcomes. In the limiting case of a power utility function with constant elasticity, these two models differ in their implications. Here, RDU is compatible with outcome scale aversion but not with probability scale aversion. While RDU can exhibit single-peak longshot preference, the favored winning odds being fixed does not accord well with the migratory pattern. By contrast, WU can exhibit a fuller range of longshot preference behavior; however, WU is not compatible with outcome scale aversion when the salience function is increasing.

Preference for longshots in gambling. Our results shed light on the understanding of gambling behavior and the working of gaming markets. Since Griffith (1949), one of the most well-known phenomena in betting market is the favorite longshot bias in which the expected return from betting on favorites exceeds the expected return from betting on longshots (see Sobel and Ryan, 2008 for a recent review). Despite its extensive occurrence in the literature, there are some exceptions. For example, Busche and Hall (1988) find no evidence for favorite longshot bias using data from racetracks in Hong Kong. Subsequently, Busche (1994) identifies a reverse favorite longshot bias in Japanese and Hong Kong racetrack markets, which have much more sizable betting volumes than those in US and Europe. Moreover, there is no known evidence for favorite longshot bias in Asian markets. Taken together, these findings point to a potential cultural difference in preference towards longshots, which is of interest for future studies.

To account for the phenomenon of favorite-longshot bias, researchers have offered theoretical accounts based on asymmetric information (Ali, 1977; Shin, 1991), heterogeneity in bettors' behavior (Hurley and McDonough, 1995; Ottaviani and Sørensen 2006), misperception of winning probability and probability weighting (Griffith, 1949; Jullien and Salanié, 2000; Snowberg and Wolfers, 2010), and bettors being generally risk seeking (Quandt, 1996; Golec and Tamarkin, 1998). Barseghyan, Molinari, and O'Donoghue (2013) note that the estimation of winning odds relies on aggregate data, and cannot differentiate between estimating the winning probability versus weighting the winning probability. In our experimental setting, using fixed-odds-fixed-outcome lotteries enables a focus on nonlinear probability weighting rather than an estimation of probability in accounting for the observed choice behavior.

Our findings of a greater incidence of single-peak longshot preference over monotonic longshot preference suggests a limit to the favorite-longshot bias phenomenon. This may conceivably be reflected in the design of racetrack betting in terms of the number of horses in a typical race and the range of winning odds available. The presence of 1D, 3D, and 5D lottery tickets in China also reveals heterogeneity in the demand for lottery products in terms of favorite winning probabilities. Interestingly, based on a report on sales of lottery products in China from Caitong Consultancy, a lottery research institute of sina.com, the 2015 annual sales for 3D lottery tickets is RMB*20.5* billion compared to RMB*3.2* billion for 5D lottery tickets, suggesting that many lottery purchasers do not favor 10^{-5}. Moreover, while the rules for Powerball in the U.S. have been gradually changed towards drastically smaller winning odds, the odds for the jackpot were increased slightly to *1: 175,223,509*, with a decrease in the number of red balls from *39* to *35* in 2012. This development corroborates the idea of a limit to the reach of the favorite-longshot bias, with lottery commissions settling for a less extreme longshot probability of winning the jackpot. Relatedly, the strong incidence of longshot preference at expected payoffs of *1* and *10* but not *100* corroborates a general observation about lottery ticket pricing. Lottery tickets tend to be priced low; scaling up the price together with their prizes may not pay.

Preference for longshots in other markets. In financial markets, it has been suggested that a positively skewed security can be “overpriced” and earn a negative average excess return (see, e.g., Kraus and Litzenberger, 1976). Moreover, the preference for skewed securities may be related to a number of financial phenomena such as the low long-term average return on IPO stock and the low average return on distressed stocks (Barberis and Huang, 2008). In the insurance market, it has been commonly suggested that the demand for insurance could be driven by the overweighting of small probabilities of large losses. Kunreuther and Pauly (2003) argue that people often ignore extremely small probabilities, leading to underpurchasing of insurance for disasters. Relatedly, McClelland, Schulze, and Coursey (1993) propose that some people fully ignore small probabilities while other people overweight them. The literature further suggests that people tend to be more pessimistic as stakes increase (see, e.g., Etchart-Vincent, 2004; Barseghyan, Molinari, and O'Donoghue, 2013). It is natural to ask whether we may observe the counterparts in these settings, especially when the losses are extremely large (Kahneman and Tversky, 1979; Barberis, 2013). Would we find single-peak preference in insuring longshot hazards? Is there a stake-size effect in attitude towards longshot in financial markets? Further research towards addressing these questions may help shed light on the understanding of investment behavior and the design of insurance policies.

7. Conclusion

Using state lotteries in China, we conduct an incentivized experiment, and arrive at two observations. First, for lotteries with lower expected payoffs, subjects exhibit heterogeneous preference for longshots: some prefer the smallest winning probability while others favor intermediate winning probabilities. Second, subjects tend to switch from being risk seeking at low expected payoff to being risk averse at high expected payoff. These two observations contrast with the existing literature that people tend to be risk seeking when facing longshots, and that there is a further tendency within this group to favor bets with smaller winning probabilities for the same expected payoff. Overall, our study suggests that the tendency towards risk aversion from the overall concavity of the utility function over sizable outcomes can dominate eventually the tendency towards risk seeking from the overweighting of small probability.

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Appendix A. Derivations for Claims in Table 1

This appendix provides details and derivations of the conditions on the class of u functions with decreasing elasticity shared between RDU and WU and on the w and s functions for the respective models to exhibit monotonic versus single-peak losngshot preference and scale aversion in outcome and in probability as illustrated in Table 1. The case of a power u function with constant elasticity is treated separately for both models.

Rank-dependent Utility (RDU)

To derive the condition for properties relating to longshot preference over probabilities between $(0, q]$, consider the following maximization problem for RDU:

$$\max_{p\in(0,q]} w(p)u(m/p). \qquad (1)$$

Monotonic longshot preference. It is straightforward to verify that the maximand in (1) is strictly decreasing if the utility elasticity $\varepsilon_u(m/p)$ given by $(m/p)u'(m/p)/u(m/p)$ always exceeds the probability weighting elasticity $\varepsilon_w(p)$ given by $pw'(p)/w(p)$. For example, the elasticity ρ of a power utility function x^ρ may be uniformly greater than the elasticity of a piecewise linear $\pi = a + bp$, which increases from 0 to $b/(a + b)$.

Single-peak longshot preference. The first-order condition for (1) is given by the equality between the probability weighting elasticity $\varepsilon_w(p)$ and the utility elasticity $\varepsilon_u(m/p)$. This yields a sufficient condition for the solution p^* to be unique over $(0, q]$: $\varepsilon_w(p)$ is decreasing in p and $\varepsilon_u(m/p)$ is increasing in p, corresponding to $\varepsilon_u(y)$ being decreasing in y, e.g., an exponential utility. To obtain a comparative statics condition so that the favored winning probability p^* increases as expected payoff m increases, we apply Topkis' (1998) theorem which requires the cross partial derivative of the maximand $w(p)u(m/p)$ to be positive. This corresponds to requiring $\frac{\partial}{\partial p}\varepsilon_u(m/p)$ to be positive which is part of the sufficient condition for the first-order condition already assumed. Note that a number of w functions in the literature, e.g., Goldstein and Einhorn (1987) and Tversky and Kahneman (1992), have decreasing elasticity for p near 0. By contrast, the w function in Prelec (1998) has increasing elasticity for the usual case of the α parameter being less than 1 when w overweights small probabilities.

Scale Aversion. Consider the difference $u(px)/u(x) - w(p)$. With utility elasticity $\varepsilon_u(x)$ being decreasing so that $u(px)/u(x)$ is increasing in x, it follows that RDU exhibits outcome scale aversion as long as $u(px)/u(x)$ exceeds $w(p)$ for a sufficiently large x. RDU also exhibits probability scale aversion as long as $u(px)/u(x) > w(p)$ as p increases. This would be the case for the more usual reverse S-shape w function which lies below the identity line for moderate probabilities.

Power uitility. The case of a power u function x^{ρ} with constant utility elasticity ρ which also corresponds to constant relative risk aversion merits further attention. This specification can exhibit monotonic longshot preference as long as the probability weighting elasticity ε_w is bounded from above by the utility elasticity ρ. While it can exhibit single-peak longshot preference at $\varepsilon_w(p^*) = \rho$, the favored winning probability p^* does not depend on expected payoff. In relation to scale aversion in outcome and in probability, the relevant comparison between $u(px)$ and $w(p)u(x)$ yields $(p^{\rho} – w(p))x^{\rho}$. It follows that this specification can exhibit probability scale aversion at the same probability at which p^{ρ} exceeds $w(p)$ regardless of the outcome x. Moreover, this specification cannot exhibit outcome scale aversion – once it is risk seeking at some probability for some winning outcome, it would remain risk seeking at that probability regardless of the magnitude of the outcome. Interestingly, the condition of utility elasticity $xu'(x)/u(x)$ being decreasing which underpins outcome scale aversion does not appear to be directly related to the property of increasing relative risk aversion which corresponds to $xu''(x)/u'(x)$ being increasing.

<u>Weighted Utility (WU)</u>

Consider the maximization problem below:

$$\max_{p\in(0,q]} ps(m/p)u(m/p)/[ps(m/p) + 1 - p]. \tag{2}$$

Monotonic longshot preference. Should the maximand in (2) be increasing over $(0, q]$, WU would exhibit monotonic longshot preference. This is shown in Chew and Tan (2005) for WU under constant absolute risk aversion with a negative exponential u function and an increasing exponential s function. More generally, monotonic longshot preference corresponds to the maximand in (2) being decreasing in p over $(0, q]$. This yields the following condition:

$$u'(m/p, p)/u(m/p, p) > [1 – (m/p – m)s'(m/p)/s(m/p)]/[ms(m/p)+y – m],$$

for p over $(0, q]$. For the above inequality to be satisfied, it is sufficient that the inequality below holds once it holds at some outcome m/p with respect to expected payoff m.

$$s'(m/p)/s(m/p) \geq 1/(m/p – m). \tag{3}$$

Single-peak longshot preference. The first-order condition to (2) is given by:

$$p/(1 – p) = [1 – \varepsilon_s(m/p) – \varepsilon_u(m/p)]/[s(m/p)\varepsilon_u(m/p) – 1], \tag{4}$$

where $\varepsilon_s(y) = ys'(y)/s(y)$ is the elasticity of the salience function *s*. Since $p/(1-p)$ is increasing in *p,* a sufficient condition for the solution p^* to be optimal is for RHS of (4) to be decreasing over $(0, q]$. It follows that p^* increases in *m* since this term is increasing in *m*. We further note that the condition on RHS of (4) being decreasing for *p* near *0* holds if $\varepsilon_s(m/p)$ and the product $s(m/p)\varepsilon_u(m/p)$ are both increasing in *p* while the numerator and the denominator are both positive. We can verify that this condition holds for $u = ln(1+x)$ with $\varepsilon_u(x) = x/[(1+x)ln(1+x)]$ and s = $1 + bx^\gamma$ with $\varepsilon_s(x) = b\gamma x^\gamma/(1 + bx^\gamma)$.

Scale Aversion. Consider the difference between the utility ratio and the decision weight given by:

$$u(px)/u(x) - ps(x)/[ps(x) + 1 - p]. \tag{5}$$

Under the condition of decreasing utility elasticity, it is apparent that WU can exhibit scale aversion at probability *p* as long as both *u* and *s* are bounded. In this case, $u(px)/u(x)$ tends to *1* while the ratio $ps(x)/[ps(x) + 1 - p]$ tends to $[1+(1-p)/ps^*]^{-1} < 1$, where s^* is the limit of $s(x)$ as *x* increases. To see that WU can exhibit scale aversion with fixed outcome *x*, observe that (5) becomes positive as *p* increases towards *1* as long as the slope of the right-hand term of (5) at $p = 1$ given by $u(x)/u'(x)$ exceeds $s(x)$. This latter inequality is easily satisfied with a bounded utility function. We can verify that WU also exhibits both outcome and probability scale aversion when its *u* function is a negative exponential function and its weight function *s* is a power function.

Power utility. As with RDU, we discuss the case of a power *u* function with elasticity ρ separately. From the preceding discussion, it follows that WU can exhibit both monotonic given that condition (3) does not involve the utility function. It can also exhibit single-peak longshot preference since the decreasingness of RHS of (4) is not affected by utility elasticity being constant. In terms of scale aversion, the relevant comparison yields $p^\rho - s(x)/[ps(x) +1 - p]$. It follows that WU can exhibit probability scale aversion with a judicious choice of its salience function *s*, e.g., the form of s = $1 + bx^\gamma$ considered above. However, WU with a power *u* function cannot exhibit outcome scale aversion when *s* is an increasing function.

Appendix B: Supplementary Tables

Table A1. Lotteries used in the experiment.

Outcome	EV = 1		EV = 10		EV = 100	
x	p	Lottery	p	Lottery	p	Lottery
1	*1*	Cash	-	-	-	-
10	10^{-1}	1D	*1*	Cash	-	-
10^2	-	-	10^{-1}	Same 1D	*1*	Cash
10^3	10^{-3}	3D	10^{-2}	Different 3D	10^{-1}	Different 3D
2×10^3	-	-	5×10^{-3}	*5* same 3D	-	-
5×10^3	-	-	2×10^{-3}	*2* same 3D	-	-
10^4	-	-	10^{-3}	Same 3D	10^{-2}	*10 x 10* 3D
2×10^4	-	-	-	-	5×10^{-3}	*50* same 3D
5×10^4	-	-	-	-	2×10^{-3}	*20* same 3D
10^5	10^{-5}	5D	10^{-4}	Different 5D	10^{-3}	Same 3D
2×10^5	-	-	5×10^{-5}	*5* same 5D	-	-
5×10^5	-	-	2×10^{-5}	*2* same 5D	-	-
10^6	-	-	10^{-5}	Same 5D	10^{-4}	*10 x 10* 5D
2×10^6	-	-	-	-	5×10^{-5}	*50* same 5D
5×10^6	-	-	-	-	2×10^{-5}	*20* same 5D
10^7	-	-	-	-	10^{-5}	Same 5D

Note. Besides the lotteries listed in Figure 1, this table lists an additional eight lotteries involving winning probabilities of 2×10^{-3}, 5×10^{-3}, 2×10^{-5}, and 5×10^{-5}. The choice frequencies of the additional lotteries under the three levels of expected payoffs – EV = 1, EV =2, and EV =3 – appear similar to those corresponding to the adjacent lotteries. Column 1 displays the winning outcome. Columns 2, 4, and 6 display the winning probabilities under the three expected payoffs respectively. Columns 3, 5, and 7 display our implementation of the individual lotteries using different combinations of 1D, 3D, and 5D tickets for the three expected payoffs respectively.

Table A2. Comparisons involving stochastic dominance

1A	1/100,000 chance receiving RMB100,000 and 99,999/100,000 chance of receiving 0.
1B	1/100,000 chance receiving RMB10,000 and 99,999/100,000 chance of receiving 0.
2A	1/10,000 chance receiving RMB100,000 and 9,999/10,000 chance of receiving 0.
2B	1/100,000 chance receiving RMB100,000 and 99,999/100,000 chance of receiving 0
3A	50/1,000 chance receiving RMB980,500/1,000 chance of receiving RMB98,and 450/1,000 chance of receiving 0
3B	50/1,000 chance receiving RMB9,800,500/1,000 chance of receiving RMB980,and 450/1,000 chance of receiving 0
4A	10/100,000 chance receiving RMB1,000,000, 5000/100,000 chance of receiving RMB1,000,and 94,990/100,000 chance of receiving 0.
4B	5/100,000 chance receiving RMB1,000,000, 5000/100,000 chance of receiving RMB1,000,and 94995/100,000 chance of receiving 0 Yuan

Note. The table presents four pairs of lotteries in which one option dominates the other option in terms of first order stochastic dominance. One product, 2D, paying RMB98 rather than RMB100 at 1 percent chance, is used in constructing four binary comparisons to detect violations of stochastic dominance in this table.

Table A3. Frequencies of the twenty four transitive choice patterns

Small-probability risk attitude	Transitive choice patterns	Favored winning probability	Frequencies in %		
			EV = 1	EV = 10	EV = 100
SP over $(0, 10^{-1}]$	0 5 3 1	10^{-1}	*8.7****	*9.7****	*1.70*
	5 0 3 1	10^{-1}	*1.40*	*3.8****	*0.60*
	5 3 0 1	10^{-1}	*1.10*	*5.4****	*5.3****
	0 1 5 3	10^{-3}	*21.1****	*7.8****	*0.50*
	0 5 1 3	10^{-3}	*3.5****	*2.9****	*0.60*
	5 0 1 3	10^{-3}	*0.40*	*0.40*	*0.10*
Monotonic	0 1 3 5	10^{-5}	*23.6****	*11.6****	*3.2****
SP over $(0, 10^{-3}]$	1 0 5 3	10^{-3}	*2.6***	*0.008*	*0.50*
	1 5 0 3	10^{-3}	*0.10*	*0.20*	*0.00*
	5 1 0 3	10^{-3}	*0.10*	*0.00*	*0.00*
	1 0 3 5	10^{-5}	*2.8****	*0.014*	*0.70*
SP over $(0, 10^{-5}]$	3 1 0 5	10^{-5}	*0.00*	*0.00*	*0.10*
	1 3 0 5	10^{-5}	*0.20*	*0.00*	*0.50*
Purely Risk Averse	5 3 1 0	1	*8.6****	*20.3****	*47.2****
	3 5 1 0	1	*1.30*	*5.7****	*14.0****
	5 1 3 0	1	*0.50*	*1.00*	*2.8****
	1 5 3 0	1	*0.50*	*0.00*	*0.50*
	1 3 5 0	1	*1.20*	*2.20*	*2.8****
	3 1 5 0	1	*0.20*	*0.50*	*1.00*
Others	0 3 5 1	-	*3.0****	*4.2****	*0.60*
	3 5 0 1	-	*0.70*	*2.3**	*1.70*
	3 0 5 1	-	*0.60*	*1.00*	*0.50*
	0 3 1 5	-	*2.3**	*0.016*	*0.80*
	3 0 1 5	-	*0.20*	*0.20*	*0.00*
		Total	*84.4****	*82.9****	*86.7****

Note. The table presents the frequencies of the twenty four transitive choice patterns. They include thirteen single-peak (SP) choice patterns, six purely risk averse choice patterns, and five choice patterns under "Others". Each choice pattern lists the four options in ascending order of preference, e.g., 1053 means that *$(10^3, 10^{-3}) \succ (10^5, 10^{-5}) \succ [1] \succ (10, 10^{-1})$*. Against a chance rate of *1.6* percent (*1* out of *64* possible patterns), the per cell threshold frequencies for the three levels of significance *10%, **5%, ***1% are 2.3 percent, 2.5 percent, and 2.8 percent, respectively.

Table A4. Frequencies of longshot preferring and risk averse choice patterns

Small-Probability Risk Attitude	Chance Rate	Frequency (%)		
		EV = 1	EV = 10	EV = 100
Single-peak over (0, 10^{-1}]	7/64	*59.5****	*41.6****	*12.0*
Single-Peak@10^{-1}	3/64	*11.2****	*19.0****	*7.6****
Single-Peak@10^{-3}	3/64	*25.0****	*11.0****	*1.2*
Single-Peak@10^{-5}	1/64	*23.3****	*11.6****	*3.2***
Single-peak over (0, 10^{-3}]	4/64	*5.7*	*2.5*	*1.2*
Single-Peak@10^{-3}	3/64	*2.9*	*1.1*	*0.5*
Single-Peak@10^{-5}	1/64	*2.8**	*1.4*	*0.7*
Single-peak over (0, 10^{-5}]	2/64	*0.2*	*0.0*	*0.6*
Purely risk averse	6/64	*12.3****	*29.7****	*68.3****
Others	5/64	*6.8*	*9.2*	*3.6*
Total Transitive	24/64	*84.6*	*82.9*	*86.7*

Note. The table summarizes the frequencies of single-peak and purely risk averse choice patterns in Table A4 along with “Others” under the three levels of expected payoffs (EV =1, EV =2, and EV = 100). We test whether the observed frequency is significantly higher than the chance rate at three levels of significance—10 percent, 5 percent, and 1 percent—indicated by *, **, and *** using the proportion tests.

Table A5. Frequencies of choice patterns including 10^{-2} and 10^{-4}

	Chance		EV10		EV100	
Pattern	N	Percent	N	Percent	N	Percent
Risk Aversion	120	0.37%	172	20.57%	404	48.33%
Single-Peak@10^{-1}	5	0.02%	76	9.09%	27	3.23%
Single-Peak@10^{-2}	30	0.09%	11	1.32%	7	0.84%
Single-Peak@10^{-3}	100	0.31%	5	0.60%	2	0.24%
Single-Peak@10^{-4}	120	0.37%	6	0.72%	3	0.36%
Single-Peak@10^{-5}	120	0.37%	0	0.00%	0	0.00%
Others	225	0.69%	49	5.86%	15	1.79%
transitive	720	2.20%	319	38.16%	458	54.78%

Note. The table summarizes the frequencies of single-peaked and purely risk-averse choice patterns, from 10^{-1} to 10^{-5}. With 6 lotteries, there are 15 binary choices leading to 32768 (= 2^{15}) possibilities. Among them, 720 (= 6!) patterns are transitive, resulting in a chance rate of 2.2%.

Table A6. Migration of favored winning probabilities across expected payoffs

	Panel A: Expected payoffs 1 and 10					
		Expected payoff 10				
		1	10^{-1}	10^{-3}	10^{-5}	Total
Expected payoff 1	1	*95*	*4*	*0*	*0*	*99*
	10^{-1}	*57*	*26*	*2*	*1*	*86*
	10^{-3}	*18*	*79*	*53*	*15*	*165*
	10^{-5}	*4*	*14*	*37*	*86*	*141*
	Total	*174*	*123*	*92*	*102*	*491*
	Panel B: Expected payoffs 10 and 100					
		Expected payoff 100				
		1	*10^{-1}*	*10^{-3}*	*10^{-5}*	*Total*
Expected payoff 10	1	*231*	*4*	*0*	*2*	*237*
	10^{-1}	*127*	*20*	*1*	*0*	*148*
	10^{-3}	*43*	*20*	*7*	*4*	*74*
	10^{-5}	*29*	*4*	*3*	*29*	*65*
	Total	*430*	*48*	*11*	*35*	*524*
	Panel C: Expected payoffs 1 and 100					
		Expected payoff 10				
		1	10^{-1}	10^{-3}	10^{-5}	Total
Expected payoff 1	1	*96*	*0*	*0*	*1*	*97*
	10^{-1}	*83*	*7*	*0*	*0*	*90*
	10^{-3}	*161*	*34*	*5*	*2*	*202*
	10^{-5}	*96*	*12*	*7*	*32*	*147*
	Total	*436*	*53*	*12*	*35*	*536*

Note. Panel A shows the counts for subjects who migrate from being either risk averse, denoted by "*1*", or having single-peak longshot preference at 10^{-1}, 10^{-3}, or 10^{-5} at expected payoff of *1* to being either risk averse, or having single-peak longshot preference at 10^{-1}, 10^{-3}, or 10^{-5} at expected payoff of *10*. Panel B (resp: Panel C) shows the corresponding migration counts for subjects from expected payoff of *10* (resp: *1*) to expected payoff of *100*. Pearson's chi-squared tests are highly significant ($p < 0.001$).

Table A7. Proportion (%) of scale-averse behavior as expected payoff increases

Panel A: Fixed winning probability					
Probability	SSS	SSA	SAA	AAA	Others
10^{-1}	16.9	37.3	20.6	17.8	7.4
10^{-3}	14.8	37.9	25.7	18.1	2.3
10^{-5}	13.6	37.2	28.3	19.0	1.8
Panel B: Fixed winning outcome					
Outcome	SSS	SSA	SAA	AAA	Others
10^{3}	16.9	37.1	24.4	18.9	3.8
10^{5}	14.1	37.6	26.8	18.9	2.6

Note. Panel A presents the percentage of choice patterns across the three levels of expected payoffs keeping the winning probability constant. Panel B presents the percentage of choice patterns across the three levels of expected payoffs keeping the winning outcome constant. SSS (risk seeking at all three levels of expected payoffs), SSA (risk seeking at expected payoffs of *1* and *10*, and risk averse at expected payoffs of *100*), SAA (risk seeking at expected payoffs of *1*, and risk averse at expected payoffs of *10* and *100*), and AAA (risk averse at all three levels of expected payoffs).

Table A8. Frequencies of single-peak and risk averse choice patterns

Small-Probability Risk Attitude	Chance Rate	With Violation (%)			Without Violation (%)		
		EV = 1	EV = 10	EV = 100	EV = 1	EV = 10	EV = 100
Single-peak over (0, 10^{-1}]	7/64	*58.4*	*40.7*	*14.4*	*60.5*	*42.3*	*9.6*
Single-Peak@10^{-1}	3/64	*9.6*	*14.1*	*8.3*	*12.9*	*23.7*	*6.7*
Single-Peak@10^{-3}	3/64	*21.5*	*11.5*	*1.4*	*28.2*	*10.5*	*0.9*
Single-Peak@10^{-5}	1/64	*27.2*	*15.1*	*4.5*	*19.4*	*8.1*	*1.9*
Single-peak over (0, 10^{-3}]	4/64	*6.5*	*2.9*	*1.4*	*4.8*	*2.1*	*0.9*
Single-Peak@10^{-3}	3/64	*2.6*	*1.4*	*0.7*	*3.1*	*0.7*	*0.2*
Single-Peak@10^{-5}	1/64	*3.8*	*1.4*	*0.7*	*1.7*	*1.4*	*0.7*
Single-peak over (0, 10^{-5}]	2/64	*0.2*	*0.0*	*1.0*	*0.2*	*0.0*	*0.2*
Purely risk averse	6/64	*9.3*	*24.6*	*60.5*	*15.3*	*34.7*	*78.2*
Others	5/64	*7.4*	*10.3*	*4.3*	*6.2*	*8.1*	*2.8*
Total Transitive	24/64	*81.8*	*78.5*	*81.5*	*87.1*	*87.3*	*91.8*

Note. The table summarizes the frequencies of single-peak and purely risk averse choice patterns in Table A4 along with “Others” for those with and without violations of first-order stochastic dominance.

Table A9. Effect of violation of stochastic dominance on choice across expected payoffs

Probability	Choice Pattern	With Violation		Without Violation	
		Panel A: Fixed winning probability			
		Mean	Std. Dev.	Mean	Std. Dev.
10^{-1}	AAA	*15.6*	*1.8*	*20.1*	*2.0*
	SAA	*19.4*	*1.9*	*21.8*	*2.0*
	SSA	*37.1*	*2.4*	*37.6*	*2.4*
	SSS	*19.4*	*1.9*	*14.4*	*1.7*
	Others	*8.6*	*1.4*	*6.2*	*1.2*
10^{-3}	AAA	*14.8*	*1.7*	*21.3*	*2.0*
	SAA	*25.1*	*2.1*	*26.3*	*2.2*
	SSA	*37.3*	*2.4*	*40.9*	*2.4*
	SSS	*18.9*	*1.9*	*10.8*	*1.5*
	Others	*3.8*	*0.9*	*0.7*	*0.4*
10^{-5}	AAA	*15.1*	*1.8*	*23.0*	*2.1*
	SAA	*25.8*	*2.1*	*30.9*	*2.3*
	SSA	*37.6*	*2.4*	*36.8*	*2.4*
	SSS	*18.7*	*1.9*	*8.6*	*1.4*
	Others	*2.9*	*0.8*	*0.7*	*0.4*

Outcome	Choice Pattern	With Violation		Without Violation	
		Panel B: Fixed winning outcome			
		Mean	Std. Dev.	Mean	Std. Dev.
1,000	AAA	*15.6*	*1.8*	*20.6*	*2.0*
	SAA	*23.4*	*2.1*	*25.4*	*2.1*
	SSA	*36.6*	*2.4*	*37.6*	*2.4*
	SSS	*20.6*	*2.0*	*13.2*	*1.7*
	Others	*3.8*	*0.9*	*3.3*	*0.9*
100,000	AAA	*15.6*	*1.8*	*22.2*	*2.0*
	SAA	*24.9*	*2.1*	*28.7*	*2.2*
	SSA	*38.0*	*2.4*	*37.1*	*2.4*
	SSS	*18.2*	*1.9*	*10.0*	*1.5*
	Others	*3.3*	*0. 9*	*1.9*	*0.7*

Note. Panel A presents the mean and standard deviation of the incidence (in %) of choice patterns across the three levels of EVs keeping the winning probability constant for those with and without violations of first-order stochastic dominance. Panel B presents the mean and standard deviation (in %) of the incidence of choice patterns across the three levels of EVs keeping the winning outcome constant for those with and without violations. SSS (risk seeking at all three EVs), SSA (risk seeking at EV = 1 and EV = 10, and risk averse at EV = 100), SAA (risk seeking at EV = 1, and risk averse at EV = 10 and EV = 100), and AAA (risk averse at all three EVs). Using multinomial logistic regression, we find that no-violation subjects tend to exhibit more AAA and less SSS, suggesting that they are generally more risk averse (10^{-1}, $p < 0.103$; 10^{-3}, $p < 0.001$; 10^{-5}, $p < 0.001$; 10^{3}, $p < 0.039$; 10^{5}, $p < 0.002$). The overall single-switch behaviors for both groups appear similar.

Table A10. Effect of violation of stochastic dominance on Allais behavior

Allais Behavior	With violation		Without violation	
	Mean	Std. Dev.	Mean	Std. Dev.
EV = 1 vs. EV =10	*17.5*	*24.1*	*16.3*	*23.5*
EV = 10 vs. EV = 100	*21.0*	*17.8*	*14.9*	*16.6*
EV = 1 vs. EV = 100	*29.9*	*45.8*	*249*	*43.3*

Note. The table lists the mean and standard deviation (in %) of the incidence of Allais behavior for those with violations (columns 2 and 3), those with violations (columns 4 and 5). The overall proportions of Allais behavior for these two groups appear similar. While subjects without violations exhibit a significantly lower incidence of Allais behavior for EV = 10 vs EV = 100 than those with violations, we do not observe a significant difference between EV = 1 and EV = 10, and between EV = 1 and EV = 100.

Appendix C. Intransitive Choice and Violation of Dominance

This appendix examines the incidence of intransitive choice and violation of first order stochastic dominance observed in the data. At all three levels of expected payoffs, subjects exhibit high rates of transitive choice—*84.4* percent for expected payoff *1, 82.9* percent for expected payoff *10,* and *86.7* percent for expected payoff *100*—exceeding the chance rate of *24/64* in each case ($p < 0.001$) with *61.5* percent exhibiting transitivity across all three levels of expected payoffs. This suggests that subjects' choices are mostly transitive even when the winning probabilities are extremely small at 10^{-3} and 10^{-5} regardless of the level of expected payoff.

We relate the observed intransitive choices to violation of stochastic dominance in terms of four binary choices in which one lottery stochastically dominates another (Table A2). In terms of stochastic dominance, *50* percent of our subjects show no violation, *31* percent have *one* violation, *15* percent have *two* violations, *4* percent have *three* violations, and the remaining *1* percent have *four* violations. Subjects are divided into two groups—one without violations and another with at least one violation. For those without violations of dominance, the proportion of transitive patterns is between 87.1 percent and 91.9 percent, which is significantly higher than those with violations of dominance (between 78.5 percent and 81.8 percent) ($p < 0.001$). The association between violation of stochastic dominance and preference intransitivity suggests that the observed intransitive choice may be linked to inattention or lack of effort in participating in our experiment.

We further make use of the observed degree of violation, which may reflect the subjects' level of attentiveness and effort in participating in our experiment, to test whether this factor influences the observed choice behavior. The proportion of longshot preference at (0, 10^{-1}] is similar for those with violations of dominance and those without violations of dominance (58.4 percent versus 60.5 percent for expected payoffs of *1*; 40.7 percent versus 42.3 percent for expected payoffs of *10*; 14.4 percent versus 9.6 percent for expected payoffs of *100*). Overall, those without violations of dominance are more risk averse than those with violations (*9.3* percent versus 15.3 percent for expected payoffs of *1*; 24.6 percent versus *34.7* percent for expected payoffs of *10*; 60.5 percent versus 78.2 percent for expected payoffs of *100*).

For scale aversion, the proportion of risk aversion across the three levels of expected payoffs for those without violations of dominance is between 21 percent and 23 percent for either fixed winning probability or fixed winning outcome, which is significantly larger than those with violations of dominance (about 15 percent) ($p < 0.001$), while the proportion of risk seeking across the three levels of expected payoffs for those without violations of dominance is between 10 percent and 15 percent, which is significantly smaller than those with violations of dominance (between 18 percent and 21 percent) ($p < 0.001$). The overall proportions of Allais behavior for these two groups appear similar. While subjects without violations exhibit a significantly lower incidence of Allais behavior for expected payoffs across *10* and *100* relative to those with violations ($p < 0.001$), we do not observe a significant difference in the incidence of Allais behavior for expected payoffs across *1* and *10* ($p > 0.584$), and for expected payoffs across *1* and *100* ($p > 0.104$). We report the details in Tables A7, A8, and A9. In sum, while there are some observed differences for subjects who are more prone to violations of stochastic dominance, the qualitative features of the observed longshot preference behavior, the switching behavior in risk attitudes across expected payoffs, and the equal-mean common-ratio Allais behavior remain robust.

Appendix D: Experimental Instructions

Thank you for participating in this study on decision making. Please read the following instructions carefully before you make any decisions.

<u>Tasks</u>: In this study, you will make a number of binary choices as illustrated in the following two examples.

Example 1. Which of the following two options will you choose?

A. 1/1000 chance of receiving 2000 Yuan, 999/1000 chance of receiving 0 Yuan

B. 1/100,000 chance of receiving 200,000 Yuan, 99,000/100,00 of receiving 0 Yuan

Choosing A means that you have 1/1000 chance of receiving 2000 Yuan and 999/1000 chance of receiving 0 Yuan. Choosing B means that you have 1/100,000 chance of receiving 200,000 Yuan and 99,000/100,000 chance of receiving 0 Yuan.

Example 2. Which of the following two options will you choose?

A. 1/1000 chance of receiving 100,000 Yuan, 999/1000 chance of receiving 0 Yuan

B. receiving 100 Yuan for sure

Choosing A means that you have 1/1000 chance of receiving 100,000 Yuan and 999/1000 chance of receiving 0 Yuan. Choosing B means that you receive 100 Yuan for sure.

In each round, you choose between two options, and there are 100 rounds in total. The probability and amount of money may be different in each round. We will use lotteries with different combinations of probability and amount of money.

<u>Details of Rules for the Lottery</u>: Three types of lotteries are used in this study, i.e., "Array 3" and "Array 5" of China Sports Lottery, and "3D" of China Welfare Lottery. You may refer to the detailed rules of these three lotteries. Below is a brief introduction of these three types of lotteries.

Array 3. Buyers can choose a three-digit number from 000 to 999. If the number chosen by the buyer is the winning number (same digits in the same order), the buyer of the lottery wins 1000 Yuan. That is, the probability of winning 1000 Yuan is 1/1000 for a randomly chosen number. For example, if the winning number is 543 and you have ten lotteries with the number 543, you will receive 10,000 Yuan. That is, you have 1/1000 chance to win 10,000 Yuan with ten lotteries of the same number.

Array 5. Buyers can choose a five-digit number from 00000 to 99999. If the number chosen by the buyer is the winning number (same digits in the same order), the buyer of the lottery wins 100,000 Yuan. That is, the probability of winning 100,000 Yuan is 1/100,000 for a randomly chosen number.

For example, if the winning number is 54321 and you have ten lotteries with the number 54321, you will receive 1000,000 Yuan. That is, you have 1/100,000 chance to win 1000,000 Yuan with ten lotteries of the same number.

3D. 3D is similar to Array 3. Buyers can bet on a three-digit number from 000 to 999. If the number chosen by the buyer is the winning number (same digits in the same order), the buyer of the lottery wins 1000 Yuan. That is, the probability of winning 1000 Yuan is 1/1000 for a randomly chosen number. Lottery 3D has another two ways of betting.

"2D" Betting: Buyers can bet on the first two digits, last two digits, or the first and last digit of a three-digit number from 000 to 999. The chosen two digits should have the same order and be in the same position as the winning number. The winning amount is 98 Yuan for each ticket.

"1D" Betting: Buyers can bet on the ones, tens, and hundreds of a three-digit number from 000 to 999. The chosen digit should have the same order and be in the same position as the winning number. The winning amount is 10 Yuan for each ticket.

Detailed rules for "Array 3" in China Sports Lottery:

http://www.lottery.gov.cn/news/10006630.shtml

Detailed rules for "Array 5" in China Sports Lottery:

http://www.lottery.gov.cn/news/10006657.shtml

Detailed rules for "3D" in China Welfare Lottery:

http://www.bwlc.net/help/3d.jsp

We will implement the corresponding probability and the amount by combining different types of lotteries. In Option A of Example 1, you have 1/1000 chance of receiving 2000 Yuan with two "Array 3" lotteries with the same number. In Option A of Example 2, you have 1/1000 chance of receiving 100,000 Yuan with 100 "Array 3" with the same number.

In a similar manner, you will get lottery combinations with different probabilities of winning various amounts. In this experiment, all the numbers of the lotteries are generated randomly by a computer. We will buy these lotteries from lottery stores.

Payment: Every participant in the experiment will get 20 Yuan as a base payment. You have a ten percent chance of receiving an additional payment, which is randomly chosen in the following way. We will add your birthday (year, month, and date—eight numbers in total) to get a one-digit number (0-9). If this number is the same as the sum of the "3D" Welfare lottery on Feb 28, 2013, you will receive the additional payment. That is, you have approximately a ten percent chance of receiving an additional payment.

The amount of the additional payment is decided in the following way. You will be asked to randomly choose one number between 1 and 100, which determines one decision out of your

100 decisions. Your payment will depend on the decision you made on that particular round. If your choice on that round is a certain amount of money, you will get that amount of money. If your choice on that round is a lottery, then your payment is through the lottery.

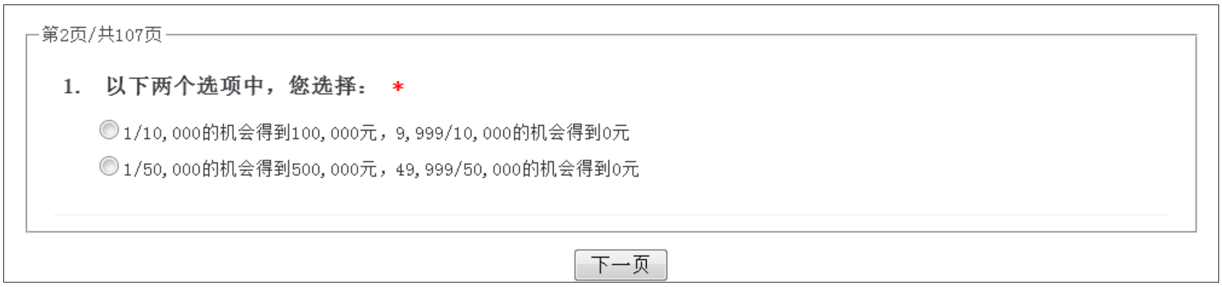
<u>Time for payment</u>: The payment will be implemented around March to April, 2013. The specific date will be announced later.

Summary for Rules:

1. You will be asked to decide between two options in each of the 100 rounds.
2. The probabilities and amounts of money in each decision can be realized by different combinations of lotteries.
3. Each participant will get 20 Yuan as a base payment.
4. Ten percent of participants will be randomly chosen to receive additional payment; the payment will be based on one randomly chosen decision out of the 100 decisions made.

If you have any questions about this experiment, please feel free to email us at b2ess@nus.edu.sg. If you are clear about the instructions, you may start and make your decisions now.

Sample Screen of Choice.


第2页/共107页

1. 以下两个选项中，您选择： *

1/10,000的机会得到100,000元，9,999/10,000的机会得到0元

1/50,000的机会得到500,000元，49,999/50,000的机会得到0元

下一页

Note. The translation of the sample screen is as follows. Page 2 of 107 Pages: 1. In the following two options, which one will you choose? *1/10,000 chance of receiving 100,000 Yuan, 9,999/10,000 chance of receiving 0; *1/50,000 chance of receiving 500,000 Yuan, 49,999/50,000 receiving 0 Yuan.