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On skewed risks in economic models and experiments

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ABSTRACT

Many of the most significant risks that people face in their lives are left-skewed, i.e., imply large losses with only small probability. I characterize skewness in binary risks, which are widely applied in both economic models and experiments. Moreover, I provide an explicit re-parametrization of binary risks in terms of their first three moments. These results allow for the conducting of comparative statics analysis with regard to skewness, and provide a useful tool for the calibration of lotteries in experiments. I apply them to show that left-skewed background risks give rise to a very strong precautionary saving motive, and to collect additional laboratory evidence on skewness preference and risk-seeking behavior.

1. Introduction

People are generally excited about the small chance of a large gain which comes along with a right-skewed or positively skewed risk. Likewise, they fear the unlikely event of a large loss that left-skewed or negatively skewed risks feature. Evidence for skewness preference is found in asset returns (e.g., Mitton and Vorkink, 2007; Kozhan et al., 2013), in data on horse-race bets (Golec and Tamarkin, 1998), and in the laboratory (Brünner et al., 2011; Ebert and Wiesen, 2011b). Even neuro-economists have used skewness as a stimulus (Wu et al., 2011). The fact that many people gamble in the lottery (seeking positively skewed risk) and buy insurance (avoiding negatively skewed risk) further serves as evidence of skewness preference. The descriptive success of decision theories like cumulative prospect theory (Tversky and Kahneman, 1992) may be attributed in part to the fact that they imply skewness preference.

A large amount of experimental studies on decision making under risk employs binary risks. This is because they are easily understood and tractable, and at the same time they reflect many important features of risk. For the same reasons, they are widely used in economic modeling. For example, Eeckhoudt and Gollier (2005) employ binary risks to study the impact of downside risk aversion on preventive behavior; Barberis and Huang (2008) model stocks as binary risks in an asset pricing model; and Schneider and Spalt (2012) use binary risks to illustrate skewness in an investment decision context.

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Health and labor economists study the binary risks of falling ill or becoming unemployed. Both risks are left-skewed, because the likelihood of the event is small, and the consequences are severe.

But how exactly should we define "skewness" in these settings? This paper answers this question by providing a comprehensive characterization of skewness in binary risks. The more skewed a binary risk is, the more similar it is to a typical lottery ticket that grants a high price with small probability. We show that this intuition perfectly coincides with the common definitions of skewness that refer to the tails or the odd moments of a distribution. This result, a *characterization of skewness in binary risks*, is surprising, as for most distributions such clean equivalences among various and competing skewness measures can hardly be obtained. An implication is that, for binary risks, comparative statics analyses with respect to skewness are unambiguous and easy.

The proof of the skewness characterization makes use of an explicit re-parametrization of binary risks in terms of their first three moments. This *moment characterization of binary risks* is of its own interest as it provides a convenient tool for designing lotteries with mean, variance, and skewness as desired. In particular, one can vary one moment while keeping the two others constant, so as to identify the effect of each moment separately.

The usefulness of the moment and skewness characterization are illustrated through several theoretical applications as well as through an experiment. On the theoretical side, we show that the skewness of the background risk is a crucial determinant of precautionary saving. In particular, left-skewed background risks induce a strong precautionary savings motive. We further study applications for the design of experiments, in particular for the growing empirical literature on higher-order risk preferences (e.g., Deck and Schlesinger, 2010; Ebert and Wiesen, 2011b; Kocher et al., 2012; Noussair et al., forthcoming). Moreover, we point out potential improvements to the methodology in the seminal paper of Golec and Tamarkin (1998) to test for skewness preference using horse-race lotteries.

Based on our theoretical results as well as on those of Chiu (2010), we develop a new method to elicit and disentangle risk aversion and skewness preference in experiments. Chiu (2010) recently showed that preferences over binary risks are well understood in terms of moments, and thus the moment characterization provides a useful tool for designing binary choice tasks. The experiment confirms and extends the growing evidence on skewness preference in several ways. First, we find skewness preference in an investment return frame that allows for the direct conclusion that the celebrated Sharpe ratio performance measure (which considers return per unit of variance) does not predict individuals' investment choices well. Second, the design allows us to test whether receiving right-skew is more important than avoiding left-skew. We find that individuals both like right-skew and dislike left-skew, and we do not find that one is more important than the other. Third, we find evidence for individuals being risk-loving when it comes to increases in risk of right-skewed risks. As will be explained, this observation is conceptually different from the well-known evidence on skewness preference.

After presenting the *moment characterization* and the *skewness characterization* in Sections 2 and 3, respectively, we present theoretical applications and applications to earlier experiments in Section 4. Section 5 describes and analyzes the experiment, and Section 6 concludes.

2. Moment characterization of binary risks

We first clarify our notion of a binary risk.

Definition 1. Let $x_1, x_0 \in \mathbb{R}$, with $x_1 > x_0$. B is a Bernoulli-distributed random variable with parameter $p \in (0, 1)$. A *binary risk (or lottery)* with *payoffs* x_1 and x_0 and *probability parameter* p, denoted by $L = L(p, x_1, x_0)$, is defined as the random variable

$$L = B \cdot x_1 + (1 - B) \cdot x_0.$$

That is, L is simply the binary lottery with probability p assigned to the higher outcome x_1. This definition guarantees uniqueness of representation and excludes degenerate lotteries because the cases $p = 0$, $p = 1$, and $x_1 = x_0$ are excluded.[1] $\mathbb{E}[L]$ and $\mathbb{V}[L]$, respectively, denote the mean and the variance of L. For $n \geq 3$ we denote the nth standardized central moment of L by $\mathbb{M}_n^S(L) := \mathbb{E}[(L - \mathbb{E}[L])^n]/(\mathbb{V}(L))^{n/2}$. Throughout the paper, for $n \geq 3$, we refer to standardized central moments. For example, $\mathbb{M}_3^S(L)$ is just "the third moment." Considering centralized and standardized moments allows us to assess skewness net of mean and variance so as to compare the skewness of lotteries with different means and variance.

[1] We do not distinguish between binary random variables and binary distributions because the distinction is not important for the results in this paper.