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Testing for prudence and skewness seeking

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Testing for prudence and skewness seeking*

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Numerous theoretical predictions such as precautionary saving or preventive behavior have been derived for prudent decision makers. Further, prudence can be characterized as downside risk aversion and plays a key role in preference for skewness. We propose and implement a method to test for prudence in a laboratory experiment. It makes use of a novel graphical representation of compound lotteries which is easily accessible to subjects. We systematically test it for robustness, using a factorial design. Prudence is observed on the aggregate and individual level. We show, theoretically and empirically, that prudence does not boil down to skewness seeking; in the same way that risk aversion does not boil down to variance avoidance. In particular, preferences based on the first three statistical moments can, at most, approximately explain individuals' behavior in the experiment.

Key words: Decision making under risk, precautionary savings, prudence, downside risk, skewness seeking, laboratory experiment

JEL classification: D81, C91

1. Introduction

It is well known that risk aversion only partially captures an individual's risk preferences. An example is the following lottery pair defined by Mao (1970). Lottery M_A pays zero with a probability of $p = \frac{1}{4}$ and 2000 with the counterprobability of $\frac{3}{4}$. Lottery M_B pays 1000 with a probability of $\frac{3}{4}$ and 3000 with a probability of $\frac{1}{4}$. Statistically, these lotteries have the same mean and variance, but M_B is more skewed to the right. While M_A may seem 'riskier', the preference of M_B over M_A is not implied by risk aversion but by prudence.[1]

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[1] Within the expected utility framework, risk aversion can be defined as $u'' < 0$ and prudence as $u''' > 0$.

This was shown by Menezes et al. (1980) who illustrate that M_B exhibits more downside risk and who further characterize prudence as downside risk aversion. They also show that prudence, unlike risk aversion, relates to measures of skewness, in particular to the third central moment and semi-target variance.[2] Thus, prudence plays an important role when considering preference towards downside risks.

Such risks occur frequently in everyday life. For example, most insurance contracts address downside risks similar to M_A (where the arbitrary choice of p is much smaller than 1/4 and refers to the insurance event). Similarly, on the gain side, M_B corresponds to the risk of a typical lottery ticket. The payoff structures of numerous assets exhibit downside risk. For example, the payoff distribution of a (defaultable) bond resembles M_A. Downside risk might be even more crucial both to investors and private individuals than comparable symmetric risks. This is also evidenced by the intensive use of downside risk measures such as value-at-risk. In his seminal study, Mao surveyed business executives' reasons on investments of the type M_A and M_B.

Within the expected utility theory (EUT), numerous important implications of prudence on economic behavior have been shown. To name a few, Kimball (1990) coined the term prudence and showed that it is necessary and sufficient for a precautionary savings motive.[3] Eeckhoudt and Gollier (2005) analyze the impact of prudence on prevention, i.e., the action undertaken to reduce the probability of an adverse effect to occur.

These general concepts find application in various areas of economics and finance. The broad range of applications, provided in the following non-exhaustive list, emphasizes the importance of prudence. In health economics, Courbage and Rey (2006) show that prudence is an important factor in preventive care decisions within a medical decision making context. Esö and White (2004)

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[2] Note that these results are independent of the expected utility theory. Chiu (2005) links prudence to a strong measure of skewness due to van Zwet (1964). See also Chiu (forthcoming) and Ebert (2010) for more on prudence and skewness.

[3] That means the awareness of uncertainty in future payoffs will raise an individual's optimal saving today. The relationship between precautionary savings and the third derivative of the utility function was already recognized by Leland (1968) and Sandmo (1970).

show that there can be precautionary bidding in auctions when the value of the object is uncertain and when bidders are prudent. Likewise, White (2008) analyzes prudence in bargaining. Treich (forthcoming) shows that prudence can decrease rent-seeking efforts in a symmetric contest model. Fagart and Sinclair-Desgagné (2007) investigate prudence in a principal-agent model with applications to monitoring and optimal auditing. Within a standard macroeconomic consumption and labor model, Eeckhoudt and Schlesinger (2008) analyze the impact of prudence on policy decisions such as changes in the interest rate. Other examples are insurance demand (e.g., Fei and Schlesinger 2008) or life-cycle investment behavior (e.g., Gomes and Michaelides 2005). Even in environmental economics prudence plays a decisive role; Gollier (2010) finds an ecological prudence effect when discounting future environmental impacts.

Prudence is also necessary (but not sufficient) for decreasing absolute risk aversion, properness (Pratt and Zeckhauser 1987) and standard risk aversion (Kimball 1993). Further, prudence is exhibited by all the commonly used utility functions (Brockett and Golden 1987), in particular power and exponential utility. Thus, implicitly, prudence is assumed widely in the economics and finance literature.

While preference of M_B over M_A is necessary but not sufficient for prudence, Eeckhoudt and Schlesinger (2006) presented a more general lottery preference which is equivalent to prudence. Given two equally likely future states, a prudent individual prefers to have an unavoidable zero-mean risk in the state where her wealth is higher. Equivalently, she prefers to have the unavoidable harms of a sure loss and a zero-mean risk in different future states rather than in the same state. More generally, Eeckhoudt and Schlesinger define proper risk apportionment of all orders (where prudence corresponds to order 3). This new understanding of risk preferences does not rely on EUT. Further, it can be generalized to the multiattribute case as shown in Eeckhoudt et al. (2007) or Tsetlin and Winkler (2009).

Despite the substantial amount of literature on prudence and the frequency of downside risk in general, there is rather little empirical, i.e., experimental, research on prudence. This is in sharp contrast to other theories of decision making under risk. Theoretical predictions derived from prudence might be no more than an interesting mind game if we cannot test their validity. Currently the share between theoretical and empirical papers, in particular experimental ones, is extremely unbalanced.

Some empirical papers trace prudence via the precautionary savings motive relying on Kimball's (1990) EUT-based model (e.g., Dynan 1993, Carroll 1994 and Carroll and Kimball 2008). To test the theories and behavioral traits based on prudence in a more controlled environment, we need a methodology to test individuals for prudence in the laboratory. The first attempt in this direction was made by Tarazona-Gomez (2004), who finds weak evidence for the existence of prudence. Her experiment relies on a certainty equivalent approach involving tabulated trinomial lotteries. It is based on strong assumptions and approximations within expected utility theory. The only other and much more elegant approach to test for prudence is Deck and Schlesinger (2010). Using six pairs of Eeckhoudt and Schlesinger's lotteries, they find weak evidence for prudence.

The contribution of this paper is as follows. Firstly, we propose a method to test for prudence in a laboratory setting. Some results overlap with those of Deck and Schlesinger, whose research was started independently of ours. However, our methodology allows for a more general implementation of the zero-mean risks in the prudence lotteries. This feature is necessary, because on the theoretical side we show that prudence is not only a preference for high skewness—just as risk aversion is not only a preference for a low variance, but this preference is robust towards different levels of kurtosis. It is the zero-mean risk that drives the statistical properties, in particular the kurtosis, of the prudence lotteries. This makes them different from the simpler lotteries of Mao and from the ones of Deck and Schlesinger, who considered symmetric risks only. As a left-skewed zero-mean risk constitutes more harm to a prudent individual, one could conjecture a greater tendency to 'apportion the harms properly'. Indeed, in the experiment we observe significantly more prudent decisions when the risks to be apportioned are left-skewed. Although our experimental presentation and parameters are different from Deck and Schlesinger, our overall result that 65% of choices are prudent is close to their finding of 61%.

Secondly, we implement lotteries, as in Mao's survey, for the first time in an incentivized experiment. This is done to contrast the rather general Eeckhoudt and Schlesinger lotteries (ES lotteries), equivalent to prudence from simpler lotteries implying *skewness seeking* only. This applies to the lotteries used in the experiments of Tarazona-Gomez and Deck and Schlesinger. Skewness seeking can be motivated by the assumption of third order moment preferences.[4] Although moment preferences, in general, are incompatible with EUT, they are widely assumed in economic and financial modeling due to their simplicity and tractability.[5] Under *moment preferences*, individuals' decisions between two prospects only depend on the first few statistical moments of these prospects. When studying prudence, only prospects with equal mean and variance will be compared, such that *third-order moment preferences* are equivalent to a preference for or against a high third central moment and refer to 'the' skewness of the prospect. That is, in this setting prudence is equivalent to skewness seeking. In the experiment the skewness seeking preference of M_B over M_A is more widely observed than preference over the prudence lotteries. There is also a significant positive correlation between the two and, consistent with theory, most individuals we diagnose as prudent prefer M_B over M_A. However, while skewness seeking has some approximative value in explaining preferences, for a more accurate test of prudence the ES lotteries should be implemented in a more general way. In particular, subjects do respond to differences in their kurtosis which leads us to reject the assumption of third-order moment preferences.

Thirdly, concerning the experimental methodology, we propose a novel graphical representation of compound lotteries in experiments. We also present a convenient method for lottery calibration in terms of their first three statistical moments. In particular, we analyze the statistical moments of the ES and Mao lotteries, where we also complement a result in Roger (forthcoming).

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[4] Tarazona-Gomez (2004) explicitly makes this assumption. In particular, preferences are given by a utility function which is truncated at third order.

[5] For example, they underlie a large number of classical and also modern portfolio choice models, such as Kraus and Litzenberger (1976) or Briec et al. (2007). This is also why this theory is an active area of research. See, for example, Eichner (2008). Brockett and Kahane (1992) and Brockett and Garven (1998) show explicitly that they are incompatible with EUT.

The paper proceeds as follows. Section 2 analyzes the lotteries underlying the experiment, motivates the parameter choices and outlines the novel lottery calibration technique applied in this paper. In Section 3, the research questions are stated. Section 4 describes the experimental design and procedure. In Section 5, results from the experiment are provided and Section 6 concludes.

2. Prudence and skewness seeking

In this section, we first define the lotteries employed in the experiment. Then we analyze and interpret their statistical properties and show how they relate to skewness seeking and prudence. The last subsection is concerned with the calibration of lottery parameters in the experiment.

2.1. Mao's lotteries and Eeckhoudt and Schlesinger's prudence lotteries

Let us start with the definition of binary lotteries in general.

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

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

In recognition of Mao (1970), we define the following class of lotteries and give an example in Figure 1.[6]

Definition 2. Two binary lotteries $L_X = L_X(p_X, x_1, x_0)$ and $L_Y = L_Y(p_Y, y_1, y_0)$ constitute a *Mao lottery pair* or a *Mao pair* if they have equal mean and variances and $p_X = 1 - p_Y$.

Intuitively, for a Mao lottery pair, if L_X has its high payoff associated with the *high* probability, then L_Y has its high outcome associated with the *small* probability, and vice versa.[7] Next, we

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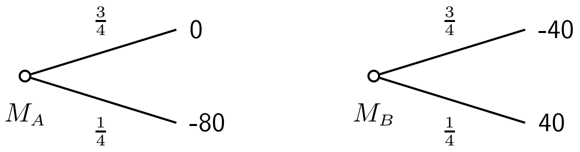
[6] Definition 2 specifies a class of lotteries that characterizes the risks analyzed in Mao's survey. Mao (1970) considered a concrete example of this class that motivated the paper of Menezes et al. (1980).

[7] This actually is how skewness manifests in a binary lottery; see our theorem in Subsection 2.3 and Ebert (2010) for a generalization to higher orders.

Figure 1 Example of a Mao lottery pair (M_A, M_B)



Note. The lotteries above correspond to the Mao pair displayed to subjects in question MAO1 of the experiment. A Mao preferent individual prefers lottery M_B (with a skewness of $+1.15$) over lottery M_A (with a skewness of -1.15).

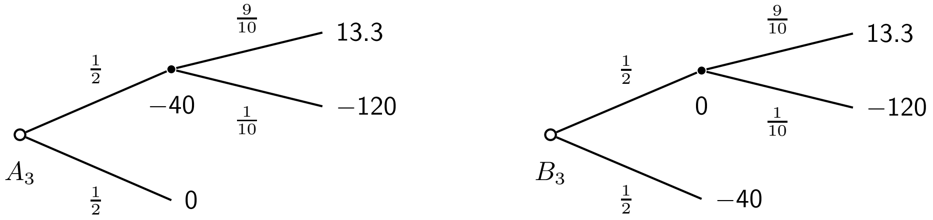
define the prudence lotteries of Eeckhoudt and Schlesinger (2006) and give an example in Figure 2.

Definition 3 (Eeckhoudt-Schlesinger Prudence). Let X be a Bernoulli-distributed random variable with parameter $p = \frac{1}{2}$ and let $k > 0$. Let ϵ be a non-degenerate random variable independent of X with $\mathbb{E}[\epsilon] = 0$. Consider the lotteries

$$A_3 = X \cdot (0) + (1 - X) \cdot (-k + \epsilon) \text{ and } B_3 = X \cdot (-k) + (1 - X) \cdot \epsilon.$$

These two lotteries as a pair are called *(Eeckhoudt-Schlesinger) prudence lottery pair* or *ES pair*. An individual is called *prudent* or said to have the *ES preference* if she prefers B_3 over A_3 for all values of k, for all random variables ϵ and for all wealth levels x.

Figure 2 Example of a prudence lottery pair (A_3, B_3)



Note. The lotteries above correspond to the ES pair displayed to subjects in question ES1 of the experiment. In the example ϵ is left-skewed implying that lottery A_3 has a larger kurtosis than lottery B_3 (see Proposition 3).

For the prudent option B_3 the additional zero-mean risk ϵ (i.e., the second lottery) occurs in the good state of the 50/50 gamble (i.e., in the state whithout the sure reduction in wealth, $-k$), whereas for the imprudent option A_3 the zero-mean risk occurs in the bad state. Intuitively, a prudent choice implies a 'disaggregation of harms' or 'proper risk apportionment'. Eeckhoudt and Schlesinger show that this preference is equivalent to prudence within EUT, i.e., $u''' > 0$. Menezes et al. (1980) define an increase in downside risk and show that prudence is equivalent to downside risk aversion. They reinterpret the results of Mao's survey and show that the lottery M_B has less downside risk than the corresponding lottery M_A.

Proposition 1 **(Menezes, Geiss, Tressler, 1980)**. *Let* (M_A, M_B) *denote a pair of Mao lotteries. Prudence is sufficient (but not necessary) for preferring* M_B *over* M_A.

It is interesting to note that Eeckhoudt and Schlesinger (2006) define proper risk apportionment of all orders n via an iterative nesting process of lotteries. For these lotteries B_n and A_n they then show that preferring B_n over A_n is equivalent to $sgn(u^{(n)}) = (-1)^{n+1}$ within EUT. Risk apportionment of order 4 is called temperance and there is also quite a large amount of theory concerned with the behavioral implications of temperance. Although in this study we focus on prudence, our methodology could be easily adapted to test for temperance. The experiment of Deck and Schlesinger (2010) actually finds some evidence of intemperate decisions.

2.2. Prudence, moments and skewness seeking

We now investigate the statistical features of the Mao and ES (prudence) lotteries in more detail. This will motivate the particular choices of the lottery pairs we implement in the experiment. If not noted otherwise, 'moments' refer to standardized central moments and the n^{th} moment of a random variable Z is given by $\mu_n^S(Z) := \mathbb{E}[(Z-\mathbb{E}[Z])^n]/\left(\mathbb{V}(Z)\right)^{n/2}$. With $\nu(Z) := \mu_3^S(Z)$ and $\kappa(Z) := \mu_4^S(Z)$ we denote the third and fourth moment, respectively.

Proposition 2 **(Statistical Characterization of Mao lottery pairs)**. *Consider a pair of Mao lotteries given by* $L_X = L_X(p, x_1, x_0)$ *and* $L_Y = L_Y(1-p, y_1, y_0)$. *Then for all* $n \in \mathbb{N}$ *it is*

$$\mu_n^S(L_X) = (-1)^n \mu_n^S(L_Y),$$

in particular

$$\nu(L_X) = -\nu(L_Y) \text{ and } \kappa(L_X) = \kappa(L_Y).$$

The following proposition generalizes Proposition 4 in Roger (forthcoming).

Proposition 3. *Consider an arbitrary Eeckhoudt-Schlesinger lottery pair in Definition 3.* A_3 *and* B_3 *have equal expectation and variance and thus* $\mathbb{V}(A_3) = \mathbb{V}(B_3) =: \sigma^2$ *is well-defined. Furthermore,*

$$\begin{aligned} \nu(B_3) - \nu(A_3) &= \frac{3k\mathbb{E}[\epsilon^2]}{2\sigma^3} > 0 \text{ and} \\ \kappa(B_3) - \kappa(A_3) &= \frac{2k\mathbb{E}[\epsilon^3]}{\sigma^4} \text{ can be positive, negative, or zero.} \end{aligned}$$

The third and fourth moments, respectively, are sometimes referred to as 'the' skewness and 'the' kurtosis. However, there are numerous measures for these properties; see MacGillivray (1986) for an overview. In a recent paper, Ebert (2010) generalized our Proposition 3 and showed that $\mu_n^S(B_3) - \mu_n^S(A_3) > 0$ for all n odd. Further, for binary zero-mean risks such as those employed in our experiment, $\kappa(B_3) - \kappa(A_3) < 0 \Longleftrightarrow \mu_n^S(B_3) - \mu_n^S(A_3) < 0$ for all n even.[8] Therefore, while thinking in third- and fourth-order terms will provide the reader with the correct intuition, our arguments actually apply to the very strong notions of skewness and kurtosis that refer to *all* odd and even moments, respectively.[9]

We know that Mao lotteries have equal mean and variance, and have the same kurtosis (see Proposition 2). We say that an individual is *skewness seeking* if she prefers the Mao lottery with the high (positive) skewness over the one with small (negative) skewness, which is well-defined as a consequence of Proposition 2.

Comparing Propositions 2 and Proposition 3, we see that both prudence and the Mao preference imply higher skewness to be beneficial to the individual. Unlike the Mao preference, prudence further requires that the lottery with the higher skewness is preferred no matter whether it has a smaller or higher kurtosis. That is, prudence implies a preference for skewness, but it also requires this preference to be robust towards variations in kurtosis. Ebert (2010) puts this observation on

[8] The assumption of a binary risk is not crucial to his result. For example, the result also holds if the majority of odd moments of ϵ is negative; see Ebert (2010) for details.

[9] For random variables with a compact support, the sequence of (natural) moments characterizes the probability distribution. In the statistics literature, this is known as Hausdorff moment problem (Hausdorff 1921). In this sense, these descriptions of skewness and kurtosis for prudence lotteries are exhaustive.

a more rigorous basis and refers to the "kurtosis robustness feature of prudence."

What is the origin of this additional statistical freedom of the ES lotteries compared to the Mao lotteries? From Proposition 3 we see that the prudent choice has the smaller kurtosis if and only if the zero-mean risk that has to be apportioned is left-skewed. The zero-mean risks of the lotteries employed in the experiment of Deck and Schlesinger (2010) were symmetric. This constantly implies the same kurtosis for the two prudence lotteries. Moreover, Roger (forthcoming) shows that the signs of all moments of ES lotteries with symmetric ϵ's coincide with those we derived in Proposition 2 for the Mao lotteries. Thus, from a statistical point of view, prudence lotteries with symmetric zero-mean risks are much closer to the skewness seeking lotteries of Mao than to the general proper risk apportionment lotteries of Eeckhoudt and Schlesinger (2006). Preference between the former lotteries is solely determined by skewness preference and does not reflect the kurtosis robustness feature of prudence.

In this paper, we not only avoid this restriction, but also evaluate it. This requires a comprehensive experimental presentation of the compound ES lotteries as the skewed risks to be apportioned cannot be presented as a fair coin toss to subjects. In the experiment, subjects will also decide over Mao lotteries to test them for skewness seeking, which theoretically is necessary, but not sufficient to imply prudence.

2.3. Lottery calibration

In order to have the prudence and Mao lotteries in the same parameter range, Mao lottery pairs must be calibrated such that they are close to the prudence pairs.[10] We start with a theorem stating that a binary lottery with non-trivial variance and otherwise arbitrary first three moments always exists and the moments uniquely determine the lottery. It implies that every non-degenerate probability distribution with finite first three moments can be approximated up to the third moment

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[10] This is a general issue in lottery choice experiments and has been shown to be important, for example, in the context of multiple price list formats to elicit risk preferences (see Harrison and Rutström 2008). We will show in Subsection 5.4 that this calibration has an effect on subjects' decisions.

by a binary lottery and this approximating lottery is unique. Binary lotteries are one of the main tools to examine decisions under uncertainty and for testing associated theories like expected utility (see, e.g., Hey and Orme 1994) or prospect theory (Kahneman and Tversky 1979). Therefore, the following theorem might find application in many experiments and, in particular, is useful for calibration issues. The given equations conveniently allow to construct exactly the lottery an experimenter is looking for. Finally, the theorem gives intuition on how skewness manifests in binary lotteries; for more, see also Chiu (forthcoming) and Ebert (2010).

Theorem 1. *For constants $E \in \mathbb{R}$, $V \in \mathbb{R}^*_+$ and $S \in \mathbb{R}$ there exists exactly one binary lottery $L_X = L_X(p, x_1, x_0)$ such that $\mathbb{E}[L_X] = E$, $\mathbb{V}[L_X] = V$ and $\nu[L_X] = S$. Its parameters are given by*

$$p = \begin{cases} \frac{4+S^2+\sqrt{S^4+4S^2}}{8+2S^2} & \text{if } S<0 \\ \frac{1}{2} & \text{if } S=0 \\ \frac{4+S^2-\sqrt{S^4+4S^2}}{8+2S^2} & \text{if } S>0 \end{cases}, \quad x_1 = E + \sqrt{\frac{V\cdot(1-p)}{p}}, \quad x_0 = E - \sqrt{\frac{V\cdot p}{1-p}}.$$

Now we use this theorem to calibrate the Mao and ES pairs to each other. The Mao pair in Figure 1 and the ES pair in Figure 2 are an example. All four lotteries depicted have equal mean and variance and the differences in skewness between the ES pair and the Mao pair are also equal. When an ES pair and a Mao pair are calibrated to each other in this way, we call them *corresponding* lottery pairs. The following proposition gives an existence and uniqueness result for such a calibration.

Proposition 4 **(Calibration)**. *Consider a prudence lottery pair (A, B) with finite first three moments. For every $S > 0$ there exists exactly one Mao lottery pair (M_A, M_B) such that*

$$\mathbb{E}[M_A] = \mathbb{E}[A] \text{ and } \mathbb{E}[M_B] = \mathbb{E}[B],$$
$$\mathbb{V}[M_A] = \mathbb{V}[A] \text{ and } \mathbb{V}[M_B] = \mathbb{V}[B] \text{ as well as}$$
$$\nu[M_A] = -S \text{ and } \nu[M_B] = S.$$

For $S = 0.5(\nu[B] - \nu[A])$ the difference in third moments of the prudence pair equals the difference in third moments of the Mao pair and the quadratic error $\Delta := (\nu[B] - \nu[M_B])^2 + (\nu[A] - \nu[M_A])^2$ is minimized.

3. Research questions

In this paper we propose a method to test for prudence, employ it in an experiment and test it for robustness. A main focus is on whether prudence boils down to skewness seeking or if, on the other hand, we find evidence for the kurtosis robustness feature of prudence. As explained in Section 2, the Mao lotteries are similar in structure to the ones employed in earlier studies (e.g., Tarazona-Gomez 2004) and differ in their skewness, but not in their kurtosis. Thus they help us to investigate the relationship of prudence and skewness seeking.

Research Question 1 *What is the relationship between prudence and the Mao preference?*

Answering Research Question 1 is of particular interest for several reasons. If prudence and the Mao preference are equivalent, skewness seeking seems to characterize prudence sufficiently well. Moreover, this would support moment preferences up to order three in general. If Mao preferent individuals do not exhibit prudence, this implies that prudence is a stronger property, not only in theory, but also in practice. In particular, it is not sufficient then to ask lotteries based on the first three moments to test for prudence. Further, as shown in Subsection 2.3, then no binary lottery can be sufficiently complex to test for prudence.

Eeckhoudt and Schlesinger's definition of prudence (Definition 3) is very broad in scope. That is, the lottery preference must hold for any random variable ϵ, any loss $-k$, any wealth level x and, of course, is robust towards framing of the decision task. This is the reason why a 'simple binary lottery preference' can be equivalent to signing the derivatives of the utility function—looking more closely, the lottery preference is not that simple. In particular, the fact that the zero-mean risks are arbitrary adds a large amount of stochastic freedom to these lotteries. We will test in a systematic way which of these features do significantly influence subjects' decisions.

Concerning the robustness towards framing, we test whether it makes a difference if the task is to add the zero-mean risk ϵ or the fixed amount $-k$ to a state of the 50/50 gamble, given that the other item ($-k$ or ϵ, respectively) is already present in one state. This relates to the intuition of Eeckhoudt and Schlesinger's definition of prudence as 'proper risk apportionment'. Further, Definition 3 of prudence could be adapted such that the loss $-k$ is replaced by fixed gain in wealth

k. The prudent choice then is the one where k and ϵ appear in the *same* state (a prudent individual prefers the unavoidable additional risk when wealth is higher). Further in-depth explanations are provided in Section 4. In short, we state the following research questions.[11]

Research Question 2 *Are individuals' decisions independent of whether the fixed amount k corresponds to a gain or a loss?*

Research Question 3 *Are individuals' decisions influenced by the wealth level x?*

Research Question 4 *Are individuals' decisions influenced by different framing of the decision task – whether they are asked to add the zero-mean risk ϵ or the fixed amount k to a state of the 50/50 gamble?*

Research Question 5 *Are individuals' decisions influenced by the skewness of the zero-mean risk ϵ and, therewith, the kurtosis of the prudence lotteries?*

We also will investigate whether the calibration of lotteries in terms of the first three moments (described in Subsection 2.3) does have an effect on subjects' decisions. Further, we will investigate whether age, gender and risk aversion have an impact on prudence.

4. Experimental design and procedure

The computerized experiment, programmed in z-Tree (Fischbacher 2007), comprises the three stages ES, MAO and RIAV. In total, each subject makes 34 individual choices over lottery pairs. The lottery outcomes are disclosed in Taler, our experimental currency. One Taler is worth €0.15 (about $0.20). Decisions are incentivized by a random-choice payment technique. That means, one out of 34 decisions is randomly drawn to determine solely a subject's payoff.[12] The lottery chosen

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[11] Research Questions 2 to 4 have been addressed to some degree in Deck and Schlesinger (2010). We will compare results in Section 5.

[12] It has become increasingly common in economics experiments to elicit a series of choices from participants and then to pay for only one selected at random; see Baltussen et al. (2010) for a fine overview. The random choice payment technique enables the researcher to observe a large number of individual decisions for a given research budget. However, the important question arises whether subjects behave as if each of these choices involves the

by the individual in the randomly determined decision is actually played out at the end of the experiment.

In stage ES, we test subjects for prudence. Subjects decide over Mao pairs in stage MAO. In stage RIAV, we determine subjects' degree of risk aversion, employing the well-established method by Holt and Laury (2002). A questionnaire comprising demographic questions follows the experiment. We now describe the experimental stages in more detail.

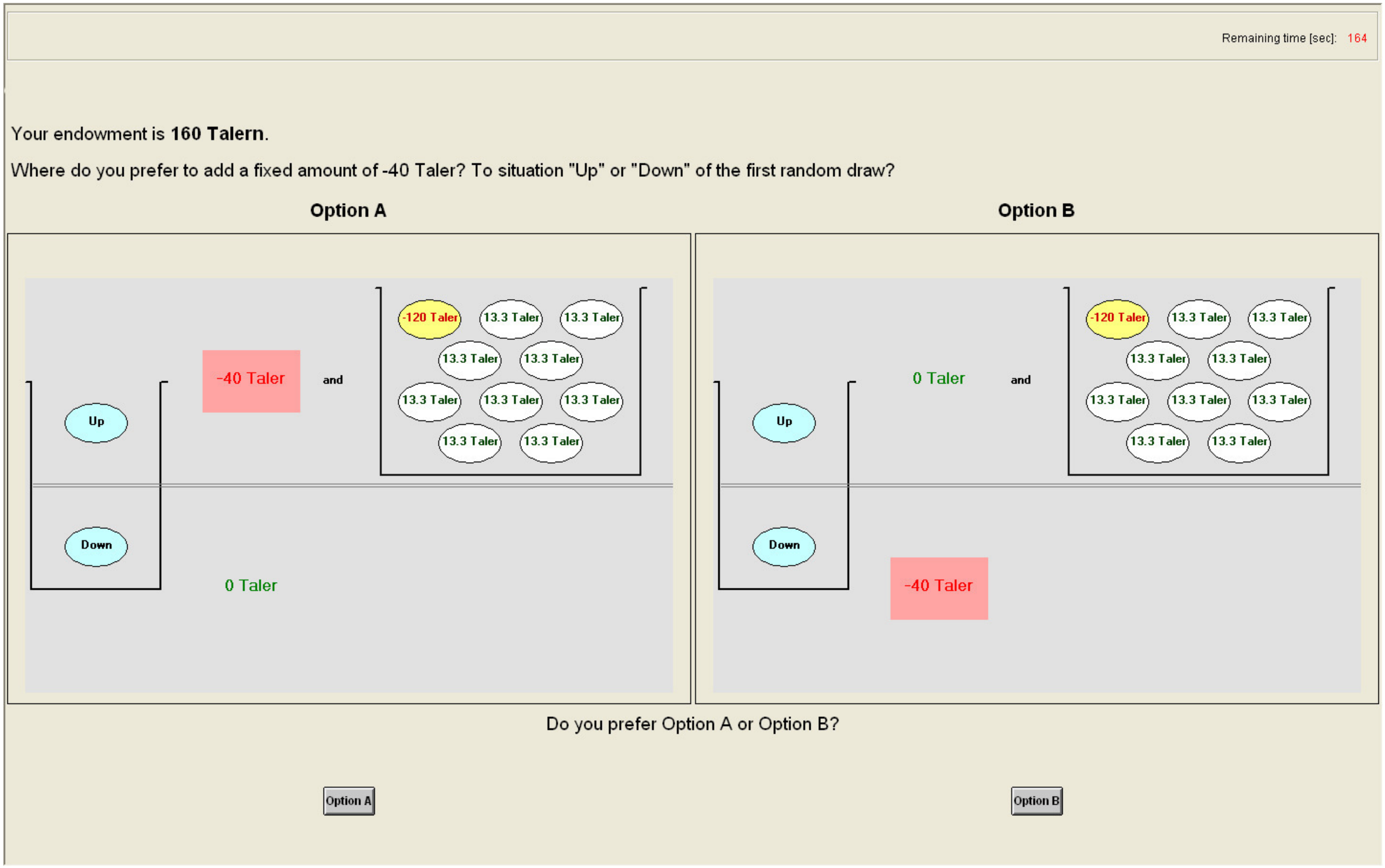
4.1. Prudence test embedded in a factorial design – Stage ES

In stage ES, we test whether individuals are prudent according to Definition 3. To this end subjects are asked to make preference choices over the 16 ES pairs $\text{ES1}, \text{ES2}, \ldots, \text{ES16}$.

We introduce a new ballot box representation to display the compound lotteries of the ES pairs. Figure 3 shows, as an example, how question ES1 (that has already been illustrated more formally in Figure 2) appears on subjects' decision screens. It must be understood as follows: Option A and Option B are displayed in the left and right panel of Figure 3, respectively. For both options the 50/50 gamble is depicted as a ballot box that contains two balls labeled "Up" and "Down". The displays of both Option A and Option B themselves are spatially separated, each into an upper panel containing the "Up-ball", and into a lower panel containing the "Down-ball". Now consider Option A. If the draw from the first ballot box is "Up", then the subject loses 40 Taler and a second lottery (the zero-mean risk ϵ) follows. The zero-mean risk ϵ is also displayed in a ballot box format with 10 balls in total. Balls implying a loss (here: -120 Taler) are colored in yellow on subjects' decision screens and balls implying a gain (here: 13.3 Taler) are colored in white. In situation "Down" no second lottery follows and no loss occurs. For Option B, if the draw from

stated payoffs. This issue has been analyzed, among various other setups, in experiments with pairwise lottery choice problems similar to our experiment. For example, Starmer and Sugden (1991) found clear evidence that under random payment subjects isolate choices as if paid for each task. Similar evidence was reported by Beattie and Loomes (1997) and Cubitt et al. (1998). In a lottery experiment with a multiple price list format, Laury (2005) reports no significant difference in choices between paying for 1 or all 10 decision.

Figure 3 Example of the lottery display in stage ES (Question ES1)



Remaining time [sec]: 164

Your endowment is **160 Talern**.

Where do you prefer to add a fixed amount of -40 Taler? To situation "Up" or "Down" of the first random draw?

Do you prefer Option A or Option B?

the first ballot box is “Up”, no loss occurs and a second lottery follows (the same ϵ as depicted in Option A). If the draw is “Down”, a loss of 40 Taler occurs. The order of subjects’ 16 decision screens is randomized for each subject and also the position of the prudent option being either left or right on the screen has been randomized.

This ballot box representation interlinks decisions on the computer screen with the lottery play at the end of the experiment (see Figure 4). Further, it visualizes asymmetric zero-mean risks and all probabilities in an intuitive way.

Figure 4 Sample of ballot boxes

Note. This photograph shows an example of the ballot boxes used to determine subjects’ payoffs at the end of the experiment from a decision made in stage ES, e.g., ES1 (compare to screenshot in Figure 3).

To test Research Questions 2 to 5, we employ a completely randomized factorial design.[13] The factors are as follows: sign of k (Factor A), wealth level x (Factor B), framing (Factor C) and composition of ϵ (Factor D); see columns 6 to 9 in Table 1 for a complete design layout.

Along the illustration in Figure 3 we now explain how the factors of the factorial design translate

[13] For a detailed description of the factorial design technique, see, e.g., Montgomery (2005).

into subjects' decision screens. When Factor A is at its low level ($k_1 = 40$), the outcomes of the 50/50 gamble are 0 Taler and -40 Taler. That is, the fixed amount added corresponds to a loss. Hence, in the example, the imprudent choice is Option A, as the additional zero-mean risk occurs in the bad state. At the alternative level ($k_2 = -40$) of Factor A the amount 40 Taler is added, which corresponds to a gain and is displayed as a green bill on subjects' screens. With Factor A we test for an experimental framing effect (Research Question 2) and whether individuals really exhibit the intuition of proper risk apportionment. For example, if a subject consistently prefers the option where ϵ is added to outcome 0 Taler (independent of the sign of k) we could conjecture that this is due to framing and conclude that 0 is a so-called focal point.

Factor B tests for a wealth effect according to Research Question 3 and comprises the levels $x_1 = 160$ or $x_2 = 80$ Taler. This test is limited in that wealth levels are presented as endowments to subjects that they receive in order to accommodate possible negative lottery outcomes. However, in some tasks, the wealth effect can actually be quite substantial.[14] The wealth level on subjects' screens is indicated in the upper left corner. In Figure 3, it is set to 160 Taler.

In the example, the decision between the imprudent Option A and the prudent Option B is whether in the up-state or in the down-state a fixed loss of 40 Taler is preferred *given* that the additional risk will be in the up-state. That is, the question on the decision screen is "*Where do you prefer to add a fixed amount of* -40 *Taler? To situation "Up" or "Down" of the first risky event?*" At the other level of Factor C, subjects are asked to which situation—either 0 or $-k$—of the 50/50 gamble to add another risky event (ϵ). Thus, the two levels of Factor C are "add k" (a sure reduction or increase in wealth) or "add ϵ" (a zero-mean random variable). Factor C directly relates to the intuition behind Eeckhoudt and Schlesinger's prudence definition of proper risk apportionment. It purely checks for a framing issue as the lotteries across levels of Factor C are identical in distribution.

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[14] For example, when comparing possible outcomes of prudent and imprudent choices for questions ES4 ($x_1 = 160$) and ES6 ($x_2 = 80$), the difference between subjects' possible payoff varies between 80 and 100 Taler, i.e., € 12 to € 15 (about $ 16 to $ 20).

With Factor D, we test if prudence is invariant under variation of the ϵ's (Research Question 5) or *equivalently*, for the kurtosis robustness feature of prudence. According to Proposition 3 and Ebert (2010), the prudent lottery choice B_3 has always the higher skewness compared to the imprudent choice A_3, i.e., $\mu_n(\epsilon) < 0$ for all n odd. It has the smaller kurtosis, i.e., $\mu_n(B_3) - \mu_n(A_3) < 0$ for all n even, if and only if ϵ is left-skewed. Thus, when varying the zero-mean risks, it is natural to vary their skewness systematically as this is the significant driver of the statistical differences between the prudence lotteries. The skewness of a binary lottery depends on its up-probability.[15] In our example, ϵ is left-skewed, such that the prudent lottery choice has the smaller kurtosis. If ϵ in the example had the signs of the outcomes switched it would be right-skewed and the prudent option had the higher kurtosis. As ϵ has a mean of zero, skewness has the following interpretation. A left-skewed ϵ yields a small gain with high probability and a large loss with a small probability. Further, as we display ϵ as a ballot box containing 10 balls, skewness translates one-to-one to the number of draws implying losses or gains, respectively. Indeed, in the example, ϵ implies a loss of 120 Taler with a 10% chance and a gain of 13.3 Taler with a 90% chance.

We denote the levels of Factor D "$\kappa(B_3) - \kappa(A_3) > 0$" (positive kurtosis difference) and "$\kappa(B_3) - \kappa(A_3) < 0$" (negative kurtosis difference). However, any of the mentioned equivalent interpretations (kurtosis difference, skewness of the zero-mean risk, composition of the ballot box) is captured by Factor D. These practical interpretations of kurtosis difference support our theoretical argument that restricting to symmetric ϵ's is a somewhat severe limitation for a procedure that aims to test for prudence.

To sum up, by specifying the four factors above, we manipulate the requirements in Eeckhoudt and Schlesinger's definition of prudence and for framing issues. We can test which factors have a severe impact on individuals' decisions such that they should be accounted for when testing for prudence. A complete overview of the 16 ES pairs, their statistical properties and the arrangement of factors is provided in Table 1.

[15] For this and the following arguments, see Theorem 1 and its proof in Appendix A.

Table 1 ES pairs with their underlying factors and their statistical properties

	ϵ				Factors				Statistical properties			
ES pair	p	z_1	$1-p$	z_0	A	B	C	D	$\mathbb{E}[A_3]$ $=\mathbb{E}[B_3]$	$\mathbb{V}(A_3)$ $=\mathbb{V}(B_3)$	$\nu(B_3)$ $-\nu(A_3)$	$\kappa(B_3)$ $-\kappa(A_3)$
ES1	0.90	13.33	0.10	−120.00	40	160	add $-k$	$\kappa(B_3)-\kappa(A_3)<0$	−20.00	1,200.00	2.30	−9.48
ES2	0.10	120.00	0.90	−13.33	40	160	add $-k$	$\kappa(B_3)-\kappa(A_3)>0$	−20.00	1,200.00	2.30	9.48
ES3	0.80	12.00	0.20	−48.00	40	160	add ϵ	$\kappa(B_3)-\kappa(A_3)<0$	−20.00	688.00	1.92	−3.50
ES4	0.20	48.00	0.80	−12.00	40	160	add ϵ	$\kappa(B_3)-\kappa(A_3)>0$	−20.00	688.00	1.92	3.50
ES5	0.70	12.00	0.30	−28.00	40	80	add $-k$	$\kappa(B_3)-\kappa(A_3)<0$	−20.00	568.00	1.48	−1.33
ES6	0.30	28.00	0.70	−12.00	40	80	add $-k$	$\kappa(B_3)-\kappa(A_3)>0$	−20.00	568.00	1.48	1.33
ES7	0.60	8.00	0.40	−12.00	40	80	add ϵ	$\kappa(B_3)-\kappa(A_3)<0$	−20.00	448.00	0.60	−0.15
ES8	0.40	12.00	0.60	−8.00	40	80	add ϵ	$\kappa(B_3)-\kappa(A_3)>0$	−20.00	448.00	0.60	0.15
ES9	0.90	13.33	0.10	−120.00	−40	160	add $-k$	$\kappa(B_3)-\kappa(A_3)>0$	20.00	1,200.00	2.30	9.48
ES10	0.10	120.00	0.90	−13.33	−40	160	add $-k$	$\kappa(B_3)-\kappa(A_3)<0$	20.00	1,200.00	2.30	−9.48
ES11	0.80	12.00	0.20	−48.00	−40	160	add ϵ	$\kappa(B_3)-\kappa(A_3)>0$	20.00	688.00	1.92	3.50
ES12	0.20	48.00	0.80	−12.00	−40	160	add ϵ	$\kappa(B_3)-\kappa(A_3)<0$	20.00	688.00	1.92	−3.50
ES13	0.70	12.00	0.30	−28.00	−40	80	add $-k$	$\kappa(B_3)-\kappa(A_3)>0$	20.00	568.00	1.48	1.33
ES14	0.30	28.00	0.70	−12.00	−40	80	add $-k$	$\kappa(B_3)-\kappa(A_3)<0$	20.00	568.00	1.48	−1.33
ES15	0.60	8.00	0.40	−12.00	−40	80	add ϵ	$\kappa(B_3)-\kappa(A_3)>0$	20.00	448.00	0.60	0.15
ES16	0.40	12.00	0.60	−8.00	−40	80	add ϵ	$\kappa(B_3)-\kappa(A_3)<0$	20.00	448.00	0.60	−0.15

Note. This table describes the prudence lottery pairs ES1, ES2, ... ES16 in stage ES. ϵ is the zero-mean risk with its up-state z_1, its down-state z_0 and the respective probabilities p and $1-p$ shown in columns 2 to 5. The explicit arrangement of factors A, B, C and D is given in columns 6 to 9. The remaining columns provide information of the difference in moments of the ES pairs.

4.2. Stage MAO

In this stage, we investigate whether subjects are Mao preferent in order to answer Research Question 1. Applying Proposition 4, we obtain 8 different pairs of Mao lotteries, between which subjects have to state their preference. There are only 8 pairs, as the change in the kurtosis (Factor D) does not affect these lotteries (see Proposition 2). Thus lottery pair MAO1 corresponds to both lottery pairs ES1 and ES2, lottery pair MAO2 corresponds to ES3 and ES4, and so on. As the Mao lotteries imply negative outcomes, subjects are endowed with a certain amount of money equal to the wealth level x in the corresponding ES pairs. The Mao pairs are shown in Table 2.[16]

For the Mao lottery pairs, we choose a graphical representation similar to the one proposed by Camerer (1989). An example of a decision screen can be found in the instructions to stage II in

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[16] Analogous to stage ES, the order of subjects' decision screens is randomly permutated in stage MAO and the position of the Mao preferent option is randomized.

Table 2 Mao pairs and their statistical properties

	M_A				M_B				Statistical properties		
									$\mathbb{E}[M_A]$	$\mathbb{V}(M_A)$	$\nu(M_B)$
Mao pair	p	x_1	$1-p$	x_0	p	y_1	$1-p$	y_0	$=\mathbb{E}[M_B]$	$=\mathbb{V}(M_B)$	$=-\nu(M_A)$
MAO1	0.75	0.00	0.25	−80.00	0.75	−40.00	0.25	40.00	−20.00	1200.00	1.15
MAO2	0.72	−3.48	0.28	−61.64	0.72	−36.52	0.28	21.64	−20.00	688.00	0.96
MAO3	0.67	−3.44	0.33	−54.30	0.67	−36.56	0.33	14.30	−20.00	568.00	0.74
MAO4	0.58	−1.81	0.42	−44.62	0.58	−38.19	0.42	4.62	−20.00	448.00	0.30
MAO5	0.75	40.00	0.25	−40.00	0.75	0.00	0.25	80.00	20.00	1200.00	1.15
MAO6	0.72	36.52	0.28	−21.64	0.72	3.48	0.28	61.64	20.00	688.00	0.96
MAO7	0.67	36.56	0.33	−14.30	0.67	3.44	0.33	54.30	20.00	568.00	0.74
MAO8	0.58	38.19	0.42	−4.62	0.58	1.81	0.42	44.62	20.00	448.00	0.30

Appendix B.

4.3. Stage RIAV

In stage RIAV, we apply the well-known method of Holt and Laury (2002) to test for risk aversion; see the original article for details. We include their test in order to investigate the relationship between risk aversion and prudence.

4.4. Procedural details

The experiment was conducted at the XYZ. Overall 72 students of the XYZ from various fields participated in 9 experimental sessions in December 2008, January and February 2009. The stage order was varied sytematically across sessions. Each session lasted for about 90 minutes. Subjects earned on average €18.50 (about $24.70).

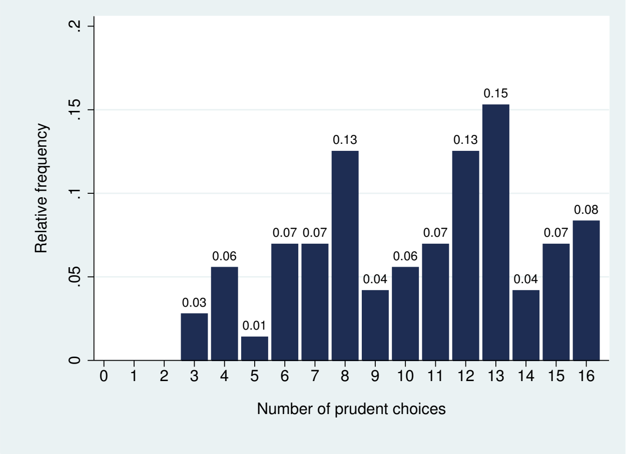
The procedure of the experiment was as follows: firstly, experimenters extensively introduced the decision task and the entire procedure of the experiment to subjects. Secondly, before each experimental stage started, subjects were asked to answer control questions testing their understanding of the decision task. In particular, they were familiarized with the illustration of lotteries and their outcomes as well as probabilities. Only when subjects had answered these questions correctly were they allowed to proceed to the decision stages of the experiment. Then, thirdly, subjects made the decisions in the experimental stages. Afterwards, subjects answered a questionnaire for which they received €4.00 ($5.34) in addition to their earnings from the experiment (comparable to a show-up fee). Finally, each subject's payoff was determined by a random-choice payment technique. To this end, for each subject one ball was chosen out of a set of balls numbered between 1 and 34 from a ballot box referring to a lottery pair from stage ES, MAO or RIAV. The subject's lottery choice in this randomly drawn lottery pair was then actually played out. In stages MAO and ES, the outcome was allocated to the subjects' wealth level in that decision, i.e., subjects could charge the coupon they obtained in the beginning. The ES lotteries were played out using ballot boxes resembling the lotteries displayed on subjects' decision screens (see the photograph in Figure 4). The binary lotteries in stages MAO and RIAV were played out using a ballot box with 100 balls numbered from 1 to 100. If, e.g., the up-state had a likelihood of 90%, a draw of the balls numbered $1, 2, \ldots, 90$ implied the corresponding up-payoff.

5. Experimental Results

5.1. Preliminary analysis

There is evidence for both prudence and Mao preferent behavior at an aggregate level.[17] Figure 5

Figure 5 Distribution of the number of prudent choices by subjects



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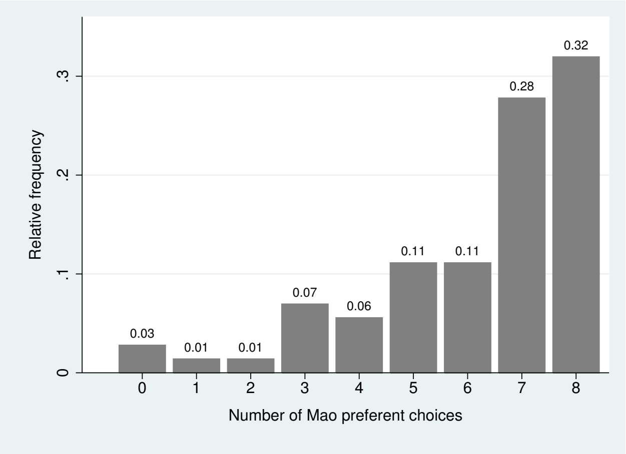
[17] To rule out possible stage order effects, we compare responses from sessions with stage order MAO-ES with responses from sessions with stage order ES-MAO. The null hypothesis that both samples are drawn from the same distribution cannot be rejected (for ES-responses: $p = 0.413$ and for MAO-responses: $p = 1.000$, two-sided two-sample Kolmogorov-Smirnov test).

plots the relative frequencies of subjects' prudent choices. Overall, 65.10% of subjects' responses are prudent. This fraction is slightly higher than the 61% of prudent choices reported by Deck and Schlesinger (2010). In our sample, on average 10.42 of the choices are prudent with a standard deviation of 3.65. The median (mode) of prudent choices is 11 (13). The observed behavior in stage ES differs significantly from arbitrary behavior. Formally, we can reject the null hypothesis that the median of subjects' prudent choices is equal to 8 as it would be for arbitrary choices ($p = 0.0000$, two-sided one-sample Wilcoxon signed-rank test).[18]

In stage MAO, 77.08% of all questions are answered in a Mao preferent way. Figure 6 illustrates the relative frequencies of subjects' Mao preferent choices. Each subject has been, on average, Mao preferent in 6.16 out of 8 questions with a standard deviation of 2.01. The median (mode) of Mao preferent choices is 7 (8). Also, this behavior differs significantly from arbitrary choices ($p = 0.0000$, one-sample Wilcoxon signed-rank test).

Figure 6 Distribution of the number of Mao preferent choices by subjects



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[18] In the following, all statistical tests are *two-sided* if not indicated differently. The Wilcoxon signed-rank procedure assumes, under the null hypothesis, that the sample (of frequencies per individual) is randomly taken from a population, with a symmetric frequency distribution. The symmetric assumption does not assume normality. As an alternative, a two-sided one-sample sign-test, implying the same null and alternative hypothesis (but without the symmetry assumption), would also lead us to reject the null ($p = 0.0004$).

5.2. Within subject analysis

Our preliminary analysis suggests substantial evidence for prudent and Mao-preferent behavior. This subsection is concerned with their relationship at an individual level (Research Question 1). For starters, we observe a significant positive correlation (which is a symmetric measure of association) of $\rho = 0.2844$ between prudent and Mao-preferent choices ($p = 0.0155$, Spearman rank correlation test).

We now show that the actual relationship is asymmetric. To this end, we categorize subjects' responses in stages ES and MAO according to the frequency of prudent and Mao-preferent choices, respectively. These categorizations are somewhat arbitrary. However, the qualitative conclusions stay the same when changing the categorizations by plus or minus one. Subjects who answered 12 or more (4 or less) out of 16 questions prudently are said to be *prudent* (*imprudent*). Those subjects who answered 5 to 11 questions prudently are classified as *indifferent.* Similarly, subjects are classified as *Mao-preferent* (*not Mao-preferent*) if they have answered 7 or 8 (0 or 1) out of 8 questions in favor of the lottery with the positive (negative) skewness. When answering 2 to 6 questions in a Mao-preferent manner, subjects are allotted to the category *indifferent.*

Table 3 cross-tabulates the absolute frequencies of subjects according to the categories. Let us first analyze prudence and the Mao preference separately. 34 (47.22%) of all 72 subjects are prudent, whereas only 6 (8.33%) are imprudent. Note again that this gives a very different picture, compared to looking at the aggregate responses only. Deck and Schlesinger (2010) report that very few subjects always decided imprudently (2%) and only 14% were always prudent in their six decision tasks. The Mao preference is more widely observed than prudence, as 43 (59.72%) of all subjects exhibit it, whereas only 3 (4.17%) do not.[19] This complies with our arguments made in Sections 2 as it shows that, empirically, the Mao preference is a weaker preference than prudence.

Table 3 Contingency table on categories

	Not Mao-preferent	Indifferent	Mao-preferent	Total
Imprudent	0	3	3	6
Indifferent	2	13	17	32
Prudent	1	10	23	34
Total	3	26	43	72

[19] Tarazona-Gomez (2004) finds 63% of the subjects to be 'prudent' under the assumption of third-order moment preferences.

The difference in prudent and Mao-preferent observations immediately indicates that Mao lotteries are indeed not suitable to test for prudence.

The conditional frequency f(Mao-preferent |prudent) that a prudent individual exhibits the Mao preference is 67.65%, whereas f(not Mao-preferent |prudent) is only 2.94%.[20] The chance for a prudent individual to be Mao-preferent is thus about 23 times higher than not being Mao-preferent. The analysis of the reverse statement does not provide such a clear-cut picture. The conditional frequency f(prudent |Mao-preferent) is given by 53.49% whereas f(imprudent |Mao-preferent) equals 6.98%. Thus the chance of being prudent given that an individual is Mao-preferent is about 8 times higher for an individual that is not Mao-preferent. This result, however, is not very reliable as there are only 3 subjects who were not Mao-preferent. In short, we see that knowing about an individual's preference towards the Mao lotteries gives some information about whether the individual is prudent. The result also hints in the 'right' direction as being Mao-preferent increases the probability of being prudent.

Result 1 *Most prudent individuals exhibit the Mao preference whereas Mao-preferent individuals may not be prudent.*

Result 1 shows that the Mao preference is not sufficient to make conclusions whether an individual is prudent. Thus, there seems to be more to prudence than skewness seeking. In particular, it would lead us to reject third-order moment preferences. Result 1 can also be interpreted as a robustness check for our method to test for prudence. Those subjects it diagnoses as prudent, consistently with theory, are Mao-preferent.

5.3. Influences on prudent behavior

We now investigate what types of ES questions are more likely to be answered prudently. In general, we find that the particular choice of the prudence lottery pair has a strong impact on the 72 subjects' decisions. Relative frequencies range from 50.00% to 75.00% with a standard deviation of 8.11.% from the reported mean of 65.10%. In order to determine what particular elements in the definition of prudence cause these differences, we investigate Factors A, B, C and D according to

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[20] If we exclude subjects who were indifferent at least at one stage, these numbers become 95.6% and 4.2%, respectively.

Research Questions 2 to 5.

As formulated in Research Question 2, we are interested whether the fixed amount k being a gain or a loss (Factor A) influences subjects' decisions. When k is a loss, 66.32% of responses are prudent, whereas slightly less responses are prudent (63.89%) when k is a gain. Test statistics of a Wilcoxon signed-rank test and a Fisher-Pitman permutation test for paired replicates in Table 4 show that this difference is insignificant ($p = 0.5253$ and $p = 0.5008$, respectively).

Result 2 *Subjects' decisions are robust towards different outcomes of the 50/50 gamble, i.e., whether the fixed amount k is a gain or a loss. Implicitly, 0 as a focal point did not influence behavior.*

Considering Factor B, 64.76% of choices are prudent if the wealth level x is high ($x_1 = 160$) and 65.45% of choices are prudent if x is low ($x_2 = 80$) which indicates an insignificant difference (see the test results in Table 4).

Result 3 *Subjects' decisions are robust towards different wealth levels.*

Research Question 4 asks whether a framing of the decision task (Factor C) influences subjects' decisions. The level of Factor C influences prudent choices substantially, as 67.36% of the choices are prudent if the level is "add ϵ" and 62.85% if the level is "add $-k$". Test statistics show that differences are weakly significant.

Result 4 *Framing of the decision task influences subjects' decisions. Weakly significant more subjects answer questions prudently if the zero-mean risk (ϵ) has to be added to the 50/50 gamble compared to the fixed amount (k).*

In essence, Result 4 shows that the decision task involving subjects' conscious consideration about another risky event leads to more prudent choices, whereas when asked to add a fixed amount subjects make slightly more imprudent choices. When looking at the interaction of Factors A and C weakly significantly more choices are prudent whenever i) the fixed amount is a loss ($k_1 = 40$) and subjects are asked to "add ϵ" and ii) the fixed amount is a gain ($k_2 = -40$) and they are asked to "add $-k$" ($p = 0.0690$).

In short, our analysis of factors suggests that subjects' decisions are neither influenced by the fixed amount being a gain or a loss nor by the wealth level. These results are in line with behavioral patterns reported by Deck and Schlesinger (2010). They also find that the relative size of the zero-mean risk is not influential. In contrast to their findings, our behavioral data evidence that framing of the decision task weakly influences subjects' choices.

Factor D considered in Research Question 5 is most significant (see Table 4). At its low level (negative kurtosis difference), 68.58% of subjects' choices are prudent. If Factor D is at its high level (positive kurtosis difference), 61.63% of the choices are prudent. For questions ES9 (largest positive kurtosis difference in the experiment) and ES10 (largest negative kurtosis difference, other factors like in ES9), 50.00% and 75.00% of answers are prudent, respectively. Note again that for the prudence lotteries a negative kurtosis difference is equivalent to ϵ being left-skewed, i.e., the ballot box displayed on subjects' screens contains more white balls (implying a small gain) than yellow balls (implying a high loss).

Table 4 Analysis of prudent choices for different factor levels

Factor	Level	Relative frequency of prudent choices	p-value (Fisher-Pitman permutation test)
A	$k_1 = 40$	0.6632	0.5008
	$k_2 = -40$	0.6389	
B	$x_1 = 160$	0.6476	0.8362
	$x_2 = 80$	0.6545	
C	add $-k$	0.6285	0.0677
	add ϵ	0.6736	
D	$\kappa(B_3) - \kappa(A_3) < 0$	0.6858	0.0121
	$\kappa(B_3) - \kappa(A_3) > 0$	0.6163	

Result 5 *The particular choice of the zero-mean risk ϵ strongly influences subjects' decisions. Significantly more subjects decide prudently if ϵ is left-skewed.*

One intuition supporting Result 5 is that a prudent individual may consider a negatively skewed zero-mean risk as a “bigger” harm. Hence, there is a greater tendency for disaggregating the harms of the sure loss and the zero-mean risk. In Section 2, we showed that ϵ being left-skewed implies a smaller kurtosis for the prudent than for the imprudent choice. An interpretation is that in this case the prudent choice implies a smaller likelihood of extreme events to occur. A prudent individual, however, would seek the higher skewness of the prudent lottery choice irrespectively of its kurtosis. She must not deviate from her preference if the additional risk is not too harmful to her. This was shown in the theoretical part of this paper and was referred to as the kurtosis robustness feature of prudence. Thus, Result 5 is a major finding of our experiment as it confirms its relevance empirically. It emphasizes the importance to use several lotteries to test for prudence in order to reflect the statistical diversity which is implicit in Eeckhoudt and Schlesinger’s definition of prudence. As the kurtosis of the prudence lotteries matters, the significance of Factor D also shows that there is more to prudence than skewness seeking.

The above observations are generalized and detailed in Ebert (2010). He shows that a mixed risk averse decision maker[21] has higher utility from proper risk apportionment if ϵ is left-skewed. Thus, our result also gives some support for mixed risk aversion.

5.4. Testing for moment preferences

In this section, we test directly for moment preferences. The Mao pairs were calibrated to the ES pairs according to Proposition 4 in terms of the first three moments. Lottery pair Mao 1 is calibrated to lottery pair ES1 and ES2, Mao 2 is calibrated to ES3 and ES4, and so on. We investigate whether there is a stronger association between subjects’ decisions over such corresponding lottery pairs than to those over the remaining ones.

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[21] An expected utility maximizer is called mixed risk averse if she is nth-degree risk averse of all orders, i.e., $sgn(u^{(n)}) = (-1)^{n+1}$ for all n. All of the commonly used utility functions exhibit mixed risk aversion. In particular, such a decision maker is prudent.

For each ES question—paired with any Mao question—we set up 8 contingency tables. That equals 128 2×2-contingency tables, in total, among which are 16 tables for corresponding Mao and ES pairs. As a measure of association we use the *phi coefficient* (r_ϕ). Each contingency table comprises the four categories i) prudent, Mao-preferent, ii) prudent, not Mao-preferent, iii) imprudent, Mao-preferent and iv) imprudent, not Mao-preferent.

The results shown in Table 5 are that, for 7 out of 16 comparisons, the degree of association between the Mao and the corresponding ES pair is stronger compared to the remaining ones. For 4 out of these 7 associations the difference is weakly significant at a 6% level as indicated by test results of a one-sided Fisher-Pitman permutation test (see last column of Table 5). The probability that the degree of association of a corresponding lottery pair is largest by coincidence is one out of eight. For 7 successes out of 16 observations, the null hypothesis (that the probability of a success on a single trial is 1/8) has to be rejected ($p = 0.0019$, two-sided binomial-test).

Table 5 Correlation (r_ϕ) between Mao and ES pairs

	MAO1	MAO2	MAO3	MAO4	MAO5	MAO6	MAO7	MAO8	p-value
ES1	**0.1491**	0.0087	0.0016	0.0888	0.0262	0.0940	0.1027	0.0170	0.0078
ES2	**0.0028**	0.0194	0.0007	0.0032	0.0045	0.0036	0.0032	0.0005	0.7031
ES3	0.2130	**-0.0510**	0.0400	-0.0041	0.0117	0.2050	0.2273	-0.1544	0.9688
ES4	0.1050	**0.0410**	0.1480	0.0960	-0.1035	0.1478	-0.1409	0.1011	0.5859
ES5	0.1315	0.0127	**0.0974**	-0.0174	-0.0029	0.1229	0.0769	0.0223	0.0547
ES6	0.2800	0.1888	**0.1312**	0.0806	-0.1176	-0.0075	0.1282	0.0133	0.1953
ES7	0.1272	0.0555	0.1654	**0.1120**	-0.0127	0.1692	0.1663	0.0508	0.3750
ES8	0.0836	0.1888	0.1312	**0.0022**	-0.1176	-0.0748	0.1282	0.1501	0.9297
ES9	0.1206	0.1491	-0.0702	0.0361	**0.0342**	0.0000	0.0327	-0.0945	0.3672
ES10	0.0348	0.0861	0.2026	0.0625	**0.0987**	0.0000	0.1322	0.0910	0.3125
ES11	0.1713	0.0385	0.0544	-0.0653	-0.2561	**0.0320**	-0.0253	-0.1383	0.1406
ES12	-0.0940	0.0410	0.1480	0.0166	0.1223	**-0.0569**	0.0030	0.0318	0.9922
ES13	0.2597	0.3107	0.2243	0.2659	0.2537	0.1413	**0.3099**	0.1112	0.0156
ES14	-0.1127	0.0270	-0.0212	0.0022	0.1050	-0.2094	**0.1992**	-0.0551	0.0078
ES15	0.1315	0.0887	0.1689	0.0562	0.0668	-0.0035	0.1435	**-0.2989**	1.0000
ES16	-0.0075	0.1387	0.1654	0.1120	0.1400	0.1000	0.0933	**0.0508**	0.9766

Note: The values on the diagonal in bold face indicate r_ϕ for the corresponding ES and Mao pairs. p-values are shown for a one-sided Fisher-Pitman permutation test for paired replicates.

Result 6 *For a significant number of ES pairs, the number of prudent choices is closest to the number of Mao-preferent choices for the corresponding Mao pair. This indicates that the first three* *statistical moments have some predictive power for prudence.*

The weak correlation between moments and preferences also supports the necessity of appropriate lottery calibration. This way it can be ruled out that measured effects are only due to different parameter ranges among lotteries. Further, the results are in line with theoretical findings of Brockett and Garven (1998) that subjects' decisions in the experiment cannot be explained completely by the first three moments only. In particular, prudence is not perfectly captured by skewness seeking.

5.5. Risk aversion and individual characteristics

According to Eeckhoudt and Schlesinger (2006), prudent individuals can be risk averse, risk neutral or risk loving. This is confirmed by our data where a substantial proportion of subjects is risk averse (87.50%). Among the prudent (non-prudent, i.e., imprudent and indifferent) subjects are 1 (3) risk neutral, 29 (34) risk averse and 3 (1) risk loving. Risk aversion of prudent and non-prudent individuals does not differ significantly ($p = 0.8106$, Mann-Whitney U-test).

The age of the 72 participants is, on average, 24.25 years; the youngest individual is 19, the oldest is 42 years of age. 41 are female and 31 are male. According to Mann-Whitney U-tests, neither age nor gender have a significant influence on the number of prudent answers observed in our experiment.

6. Conclusion

Currently, the share between theoretical and empirical literature on prudence is very unbalanced. Numerous behavioral implications of prudence have been pointed out, but there is very little empirical, i.e., experimental, research on prudence to support the relevance and validity of these theories. To get there, in this paper we propose, implement and check for robustness a method testing for prudence in a laboratory setting.

We constructed a set of 16 prudence lottery pairs (Eeckhoudt and Schlesinger 2006) that not only reflect skewness seeking, but also the kurtosis robustness feature of prudence. As shown, the latter is also a characteristic feature of prudence. Its origin lies in the skewness of the zero-mean risks and we show how to implement such risks in the experiment. To this end, we propose a new ballot box representation of compound lotteries for application in experiments. It is very easy to understand and translates naturally from subjects' decision screens to the real-world draw of the lotteries.

In the experiment, indeed, the choice of the zero-mean risk significantly affects subjects' decisions. Thus, we find that prudence does not boil down to skewness seeking. Prudence is observed on the aggregate as well as at the individual level. 65% of responses are prudent and we classify 47% of individuals as prudent and 8% as imprudent. The number of prudent responses varies substantially from 50% to 75% for different prudence lottery pairs. This should be taken into account when testing for prudence.

Moreover, this paper contains a lottery calibration theorem that allows the researcher to construct binary lotteries with desired first three moments. We illustrate how this theorem can be used to construct lotteries in the desired parameter range. We also present a statistical characterization of the lotteries of Mao (1970) and show that preference between such lotteries is purely determined by the difference in their skewness.

Given the observed presence of prudence, further experimental research could focus on the empirical validation of prudent behavior. For example, the probably most famous prediction that prudent people exhibit larger precautionary saving has received little attention yet. Moreover, the method proposed in this paper could be easily adapted to test for temperance and associated theories.

Appendix A: Proofs

Proof of Proposition 2. Let $n \in \mathbb{N}$ be arbitrary. It is well known that the $\mu_n(\cdot)$-operator is homogeneous of degree n and translation invariant. The assumption $p_X = 1 - p_Y$ is equivalent to $X = 1 - Y$ such that $\mu_n(X) =$

$(-1)^n\mu_n(Y)$ which for $n=2$ just implies $\mathbb{V}(X)=\mathbb{V}(Y)$. Note that we can write $L_X = X\cdot x_1 + (1-X)\cdot x_0 = (x_1-x_0)X + x_0$ and thus $\mathbb{V}(L_X)=(x_1-x_0)^2\mathbb{V}(X)$. Analogously, we have $\mathbb{V}(L_Y)=(y_1-y_0)^2\mathbb{V}(Y)$. Since the Mao lotteries have equal variance we obtain $(x_1-x_0)^2=(y_1-y_0)^2$ and because of the unique representation of binary lotteries (see Definition 1) this is equivalent to

$$x_1 - x_0 = y_1 - y_0. \tag{1}$$

Using once more homogeneity and translation invariance of the $\mu_n(\cdot)$-operator and plugging in yields

$$\mu_n(L_X) = (x_1-x_0)^n\mu_n(X) = ((y_1-y_0))^n(-1)^n\mu_n(Y) = (-1)^n\mu_n(L_Y).$$

Because of the assumed variance equality the claim for $\mu_n^S(\cdot)$ follows immediately. ☐

Proof of Proposition 3. The proof can be done by statistical standard calculations and thus is omitted. A more general version of the proposition is proven as Proposition 1 in Ebert (2010). ☐

Proof of Theorem 1. After calculating expectation, variance and skewness of a binary lottery as in Definition 1 we find that $L_X = L_X(p,x_1,x_0)$ has to suffice the following system of equations

$$E = px_1 + (1-p)x_0 \tag{2}$$

$$V = (x_1-x_0)^2 p(1-p) \tag{3}$$

$$S = \frac{1-2p}{\sqrt{p(1-p)}} \tag{4}$$

with $x_1 > x_0$ and $0 < p < 1$. It is natural to start with solving equation (4) for p. After squaring and some rearrangement one obtains

$$p^2(-S^2-4) + p(4+S^2) - 1 = 0.$$

Setting $\tilde{S} := 4 + S^2$ the solutions to this quadratic equation are given by

$$p_{1/2} = \frac{\tilde{S} \overset{+}{-} \sqrt{\tilde{S}^2 - 4\tilde{S}}}{2\tilde{S}}, \tag{5}$$

where p_1 is the solution associated with the addition. It is easy to see that the expression under the square root is always positive. If $S=0$ there is one solution, namely $p=\frac{1}{2}$. Otherwise there are two solutions. Both these solutions are strictly positive since $\sqrt{\tilde{S}^2 - 4\tilde{S} + 4 - 4} = \sqrt{(\tilde{S}-2)^2 - 4)} \le \tilde{S} - 2$ and thus

$$p_{1/2} \ge p_2 \ge \frac{\tilde{S} - (\tilde{S}-2)}{2\tilde{S}} = \frac{1}{\tilde{S}} > 0.$$

All solutions are smaller than 1 since

$$p_1 < 1 \iff \sqrt{\tilde{S}^2 - 4\tilde{S}} < \tilde{S}$$

what can be shown to be true for all $\tilde{S}$ (and thus for all S) by doing the quadratic expansion as in the previous calculation. Note that equation (4) is a square root equation and thus we have to verify the solutions. Obviously, if $S = 0$ then $p = 0.5$ is the unique solution. Otherwise, from equation (5) it follows that $p_1 > p_2$ and $p_1 + p_2 = 1$, i.e. $p_1 > 0.5$ and $p_2 < 0.5$. If $S < 0$ then p_2 does not solve equation (4) because $1 - 2p_2 > 0$, but p_1 does. Similarly, if $S > 0$ only p_2 solves equation (4). Thus in any case equation (4) has a unique solution in $(0, 1)$ (such that it is a probability) that will be denoted by p in the following.[22]

The remainder of the proof is straightforward. For any p obtained from equation (4) the system of equations (2) and (3) can be solved for a unique solution to obtain the expressions stated in the claim from which finally also $x_1 > x_0$ is evident. ☐

Proof of Proposition 4. By Theorem 1 there exists exactly one binary lottery $L_X \equiv M_A$ with $\mathbb{E}[M_A] = \mathbb{E}[A]$, $\mathbb{V}[M_A] = \mathbb{V}[A]$ and $\nu[M_A] = -S$. By Theorem 1 there also exists exactly one lottery $L_Y \equiv M_B$ whose expectation and variance equal that of M_A and further $\nu[M_B] = +S$. From equation (4) one immediately obtains $p_X = 1 - p_Y$ such that by Definition 2 (M_A, M_B) constitutes a Mao lottery pair that fulfills the requested moment conditions.

For the second part, note that by taking derivatives

$$\Delta = (\nu[B] - S)^2 + (\nu[A] - (-S))^2$$

indeed achieves its maximum at $S = \frac{\nu[B] - \nu[A]}{2}$. The difference in skewness of the Mao pair is $2S$ and as can be seen from the previous equation this indeed equals the skewness difference $\nu[B] - \nu[A]$ of the prudence pair. ☐

Appendix B: Instructions

[*translated from German for session order ES-MAO-RIAV*]

Thank you very much for participating in this decision experiment!

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[22] We can see now how skewness is reflected in a binary lottery. It has zero skewness if and only if both states have equal probability. Otherwise, it is positively (negatively) skewed if the high payoff is associated with the low (high) probability.

General Information

In the following experiment, you will make a couple of decisions. Following the instructions and depending on your decisions, you can earn money. It is therefore very important that you read the instructions carefully.

You will make your decisions anonymously on your computer screen in your cubicle. During the experiment you are not allowed to talk to the other participants. Whenever you have a question, please raise your hand. The experimenter will answer your question in private in your cubicle. If you disregard these rules you can be excluded from the experiment. Then you receive no payment.

During the experiment all amounts are stated in Taler, the experimental currency. At the end of the experiment, your achieved earnings will be converted into Euro at an exchange rate of 1 Taler = € 0.15 and paid to you in cash.

Structure of the Experiment and Your Decisions

In total, you will make 34 decisions throughout the experiment. In each decision you will decide upon which of **two different risky events—either Option A or Option B**—you prefer.

An example of Option A could be as follows: With 50% chance you will lose 10 Taler or with 50% chance you will receive 20 Taler. Option B could be: With 20% chance you will receive 0 Taler and with 80% chance you will receive 10 Taler.

The experiment consists of three stages that will be explained in detail in the following. To determine your payoff in the experiment, one of your decisions will be randomly chosen. This takes place after you have completed all your decisions. To this end, the experimenter picks one of 34 balls, marked with numbers from 1 to 34, out of a ballot box. Each number occurs only once in the ballot box, whereby the draw of a particular number is equally likely. The outcome of the risky event, that you have opted for, at the randomly chosen decision will afterwards be determined by another random draw. This procedure will be explained extensively when the stages of the experiment are described.

Keep in mind that only one of your 34 decisions determines your payoff in the experiment. Therefore each of your single decisions can determine your entire payoff in the experiment.

You make your decisions at the computer screen in the computer lab. For each decision you have a maximum of 3 minutes. After the experiment, the decision relevant for every participants's payoff and the outcome of the risky event will be determined by random draws for each participant in the seminar room. For this the experimenter will call upon participants one by one.

Note that some risky events comprise negative outcomes. For these questions you receive coupons indicating an endowment (in Taler). You can charge the coupons when the outcome of the risky event is determined.

Stage I

In the first stage of the experiment you make 16 decisions. On each of the 16 sequent decision screens you decide which of the two risky events—either Option A or Option B—you prefer. In this stage risky events (may) comprise two random draws.

For each decision one random draw is given. This draw is as follows: With 50% chance the situation "Up" occurs or with 50% chance the situation "Down" occurs.

For your decisions you receive an endowment in Taler, because outcomes of risky events in this stage can also comprise losses. Accordingly, your payoff in this stage consists of two components:

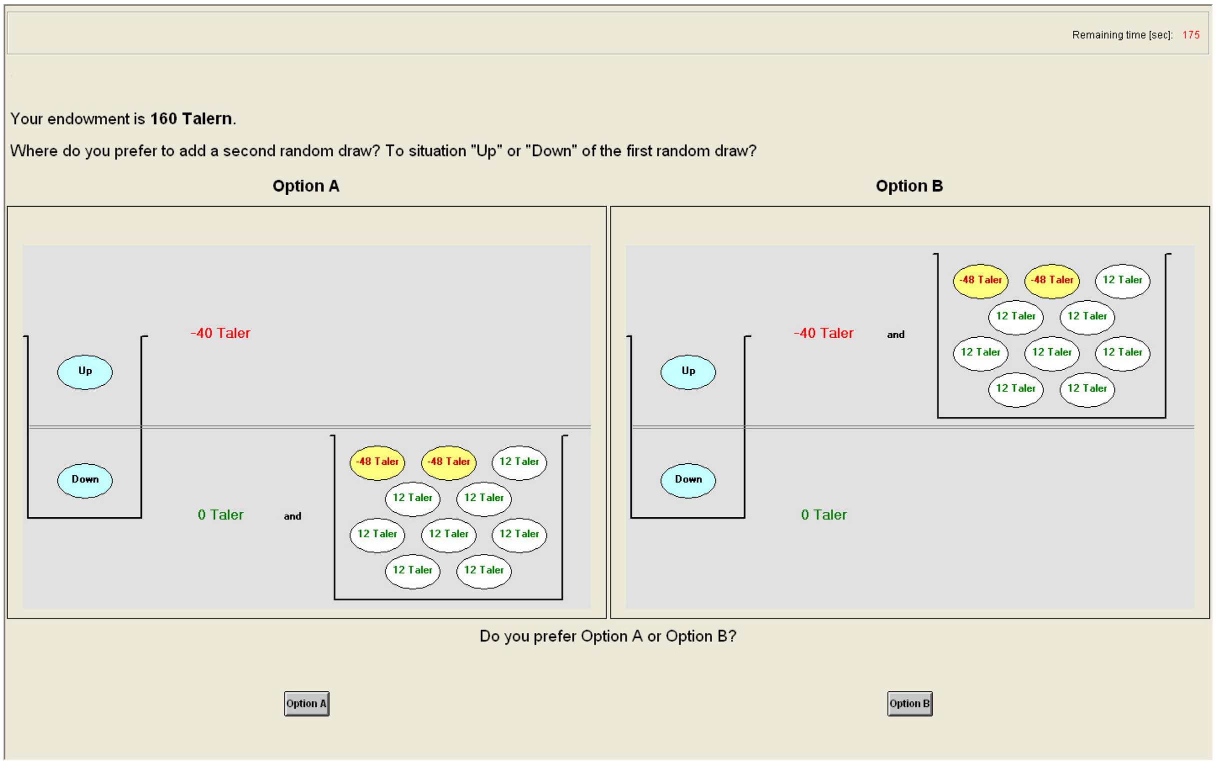
Endowment and **Outcome of the chosen risky event**

How is the outcome of the (chosen) risky event determined in Stage I? For the first random draw there are two balls in a ballot box—one marked with "Up" and the other with "Down". The draw of a particular ball is equally likely. To determine your payoff in this stage **two** random draws may be necessary. At the second random draw one ball is drawn from another ballot box with 10 balls. The balls are either yellow or white. Note that the composition of yellow and white balls may change for different decisions in this stage. But within one decision, i.e. for Option A and Option B, the composition of yellow and white balls remains the same.

Decision type 1

For 8 out of 16 decisions in stage I you are asked the following: Given what situation of the first random draw—either "Up" or "Down"—do you prefer a **second random draw**? An example is provided by the following screen:

In Option A you lose 40 Taler, if situation "Up" occurs in the first random draw. If situation "Down" occurs, you receive 0 Taler and a second random draw succeeds. This second random draw is as follows: With 20%



Remaining time [sec]: 175

Your endowment is **160 Talern**.

Where do you prefer to add a second random draw? To situation "Up" or "Down" of the first random draw?

Option A

Option B

Do you prefer Option A or Option B?

chance you lose 48 Taler and with 80% chance you receive 12 Taler. In Option B, you lose 40 Taler if in the first random draw the situation "Up" occurs and a second random draw succeeds (The second random draw is the same as in Option A). When situation "Down" occurs, you receive 0 Taler. For this decision you are endowed with 160 Taler.

*Now suppose the decision from the example above is randomly drawn to determine your payoff. Suppose you have chosen **Option A**.*

- *If in the first random draw the ball "Up" is drawn, you lose 40 Taler. After allocating your endowment of 160 Taler for this decision to the lottery outcome, your payoff is 120 Taler.*
- *If in the first random draw the ball "Down" is drawn, you receive 0 Taler and a second random draw succeeds.*

— If in the second random draw a yellow ball is drawn, you lose 48 Taler and your payoff after allocating your endowment is 112 Taler.

— If in the second random draw a white ball is drawn, you receive 12 Taler and your payoff after allocating your endowment is 172 Taler.

*Suppose you have chosen **Option B**.*

- *If in the first random draw ball "Up" is drawn, you lose 40 Taler and a second random draw succeeds.*

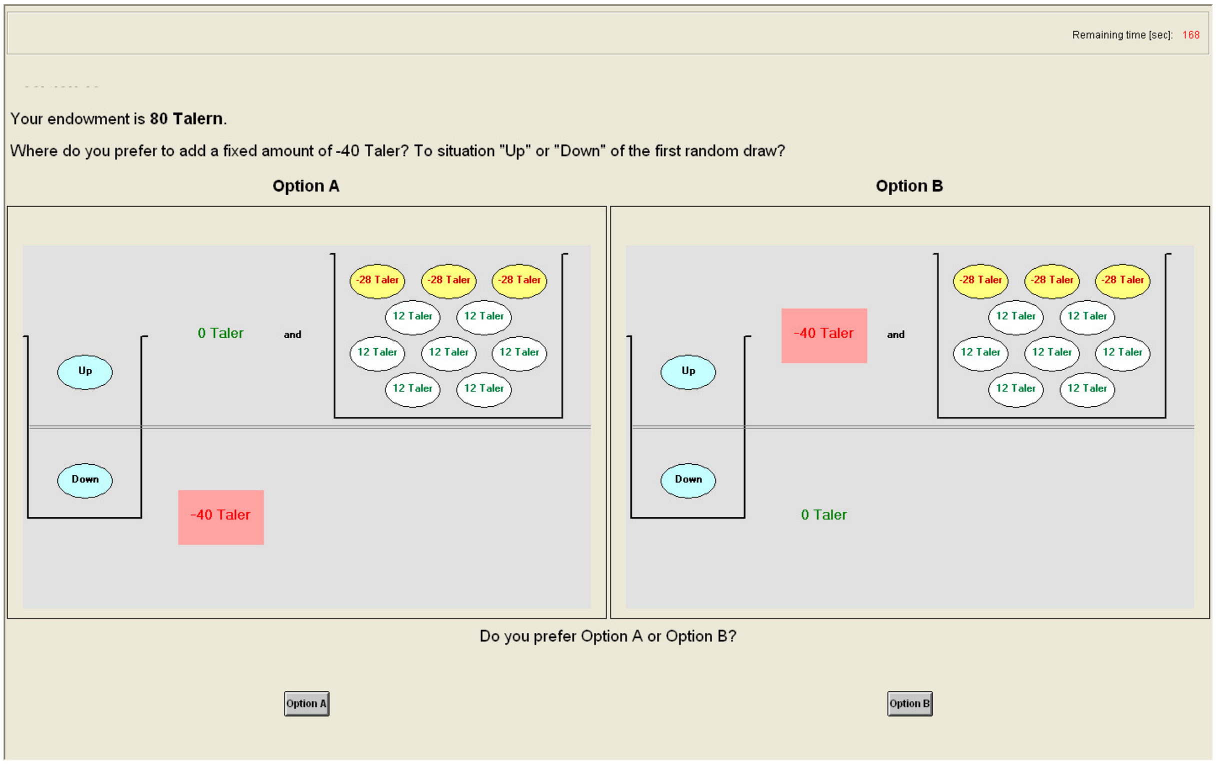
— If in the second random draw a yellow ball is drawn, you lose 48 Taler and your payoff after allocating your endowment is 72 Taler.

— If in the second random draw a <u>*white*</u> *ball is drawn, you receive 12 Taler and your payoff after allocating your endowment is 132 Taler.*

- *If in the first random draw "Down" is drawn, you receive 0 Taler. After allocating your endowment of 160 Taler for this decision to the lottery outcome your payoff is 160 Taler.*

Decision type 2

For the remaining 8 out of 16 decisions in stage I you are asked the following: To what situation do you prefer to add a **(fixed) amount**—either to situation "Up" where a second random draw succeeds or to situation "Down" where no second random draw succeeds. Note that the fixed amount can either be positive or negative. An example is provided by the following screen:



Remaining time [sec]: 168

Your endowment is **80 Talern**.

Where do you prefer to add a fixed amount of -40 Taler? To situation "Up" or "Down" of the first random draw?

Option A **Option B**

Do you prefer Option A or Option B?

In Option A, when situation "Up" occurs in the first random draw you receive 0 Taler and a second random draw succeeds. The second random draw is as follows: With 30% chance you lose 28 Taler and with 70% chance you receive 12 Taler. When situation "Down" occurs in the first random draw, you lose 40 Taler and no second random draw succeeds. In Option B if situation "Up" occurs in the first random draw you lose 40 Taler and a second random draw succeeds (The second random draw is the same as in Option A). When situation "Down" occurs, you receive 0 Taler and no second random draw succeeds. For this decision you are endowed with 80 Taler.

Now suppose the decision from the example above is randomly drawn to determine your payoff. Suppose you *have chosen* ***Option A****.*

- *If in the first random draw the ball "Up" is drawn, you receive 0 Taler and a second random draw succeeds.*

  —If in the second random draw a yellow ball is drawn, you lose 28 Taler and your payoff after allocating your endowment is 52 Taler.

  —If in the second random draw a white ball is drawn, you receive 12 Taler and your payoff after allocating your endowment is 92 Taler.

- *If in the first random draw the ball "Down" is drawn, you lose 40 Taler. After allocating your endowment of 80 Taler for this decision to the lottery outcome your payoff is 40 Taler.*

Suppose you have chosen ***Option B****.*

- *If in the first random draw the ball "Up" is drawn, you lose 40 Taler and a second random draw succeeds.*

  —If in the second random draw a yellow ball is drawn, you lose 28 Taler and your payoff after allocating your endowment is 12 Taler.

  —If in this second a white ball is drawn, you receive 12 Taler and your payoff after allocating your endowment is 52 Taler.

- *If in the first random draw the ball "Down" is drawn, you receive 0 Taler. After allocating your endowment of 80 Taler for this decision to the lottery outcome your payoff is 80 Taler.*

Stage II

In the second stage of the experiment you are asked to make eight decisions. On each of the 8 sequent decision screens you decide which of the two risky events—Option A or Option B—you prefer.

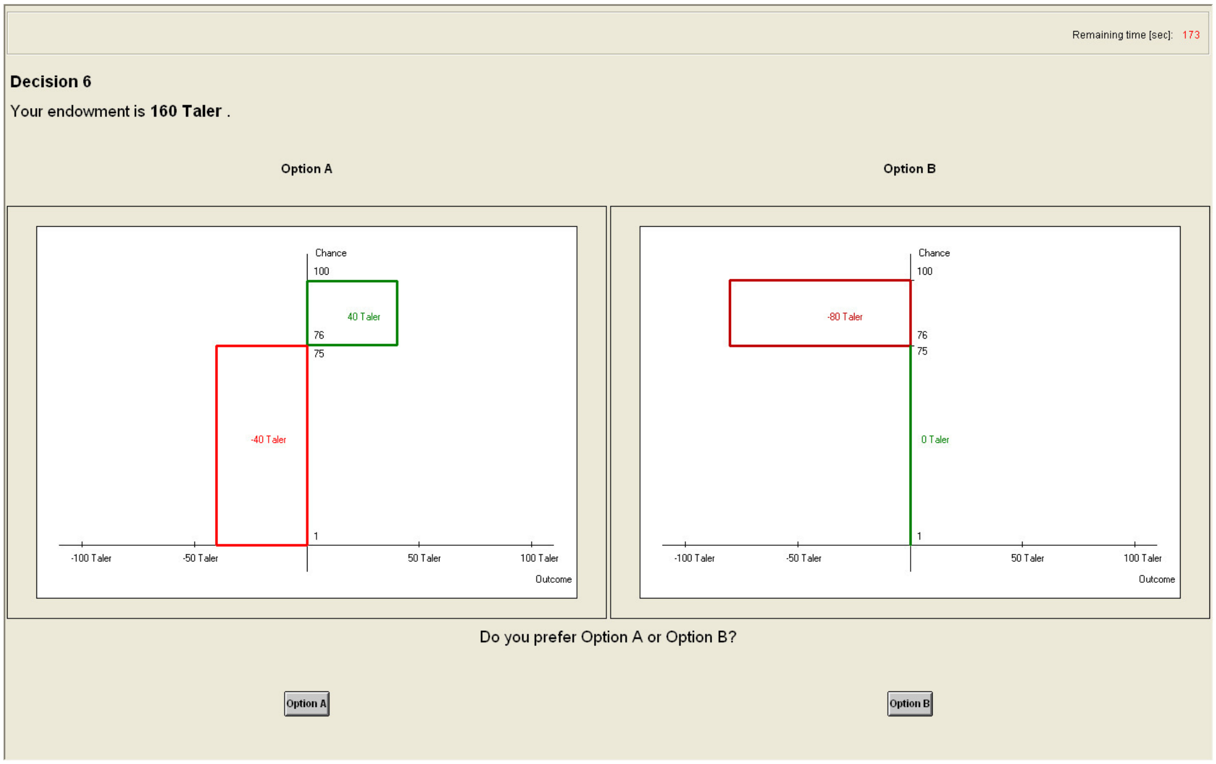
For your decisions you receive an endowment in Taler, because outcomes of risky events in this stage can comprise losses. Accordingly, your payoff in this stage consists of two components:

Endowment and **Outcome of the chosen risky event**

How is the outcome of the (chosen) risky event determined in Stage II? To this end, there is another ballot box. This ballot box contains 100 balls with numbers from 1 to 100. Each number occurs only once, thus the draw of a particular number is equally likely. An example of a decision screen provides the following screen:

In Option A you will lose 40 Taler with 75% chance (balls 1 to 75) or with 25% chance you will receive 40 Taler (balls 76 to 100). In Option B you receive 0 Taler with 75% chance (balls 1 to 75) or you will lose 80 Taler with 25% chance (balls 76 to 100). Your endowment is 160 Taler in this example.

Now suppose that this decision was randomly drawn to determine your payoff.



Remaining time [sec]: 173

Decision 6

Your endowment is **160 Taler** .

Do you prefer Option A or Option B?

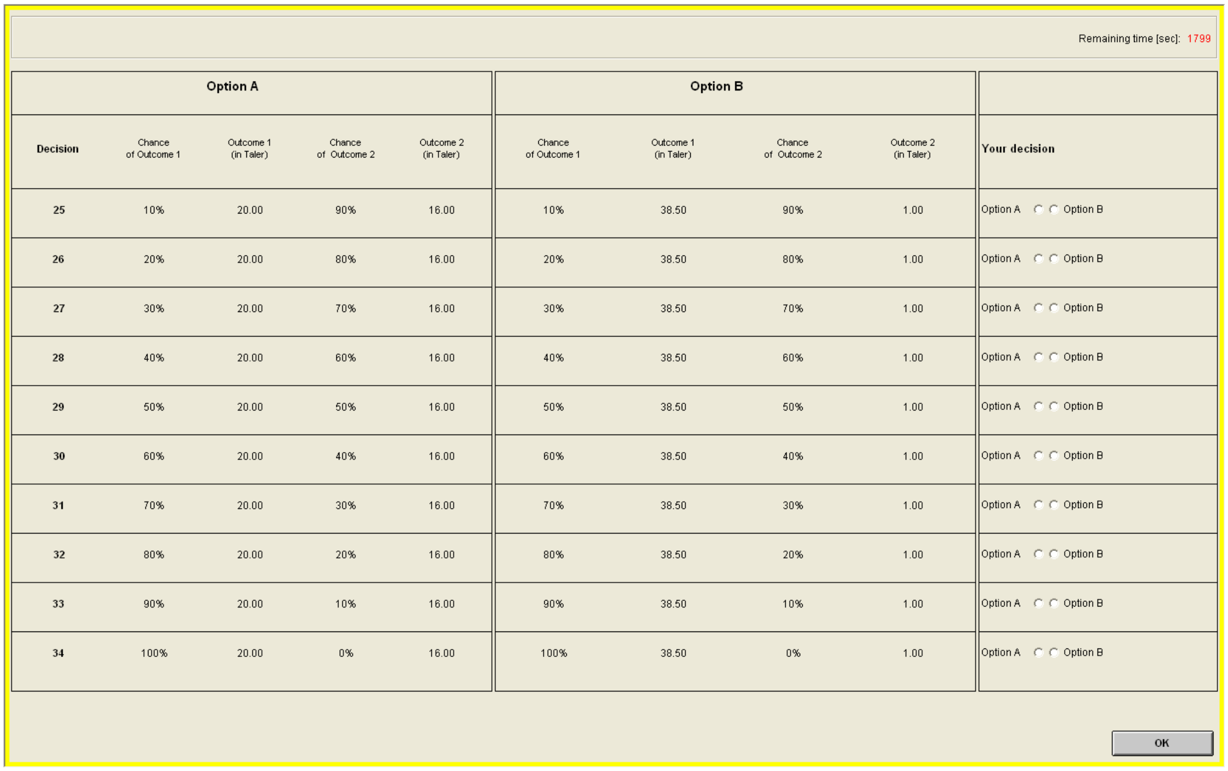
- *Suppose you have chosen **Option A** and assume that a ball is drawn from the ballot box with a number between 1 and 75. That means, you lose 40 Taler. Your resulting payoff, after allocating the endowment of 160 Taler for this decision to the lottery outcome, is 120 Taler. If a ball with a number between 76 and 100 is drawn, you receive 40 Taler. Under consideration of your endowment your payoff is 200 Taler.*
- *Suppose you have chosen **Option B** and assume that a ball is drawn from the ballot box with a number between 1 and 75. That means, you receive 0 Taler. Your resulting payoff after allocating the endowment of 160 Taler for this decision to the lottery outcome is 160 Taler. If a ball with a number between 76 and 100 is drawn, you lose 80 Taler. Under consideration of your endowment your payoff is 80 Taler.*

Stage III

In stage III you are asked to make 10 decisions on a single decision screen. The risky events between you have to decide in this stage are displayed in a table format. In each row of the table you make one decision.

For an illustration see the following figure:
Each risky event comprises two possible outcomes and two corresponding probabilities. You make your decision at the end of each row by indicating the risky event you prefer (either Option A or Option B). When making your decisions you do not have to follow a particular order and you can change your decisions as often as desired within the time permitted.

The outcomes of the risky events in this stage do not comprise losses. Thus, for the decisions in this stage



Remaining time [sec]: 1799

	Option A				Option B				
Decision	Chance of Outcome 1	Outcome 1 (in Taler)	Chance of Outcome 2	Outcome 2 (in Taler)	Chance of Outcome 1	Outcome 1 (in Taler)	Chance of Outcome 2	Outcome 2 (in Taler)	**Your decision**
25	10%	20.00	90%	16.00	10%	38.50	90%	1.00	Option A ○ ○ Option B
26	20%	20.00	80%	16.00	20%	38.50	80%	1.00	Option A ○ ○ Option B
27	30%	20.00	70%	16.00	30%	38.50	70%	1.00	Option A ○ ○ Option B
28	40%	20.00	60%	16.00	40%	38.50	60%	1.00	Option A ○ ○ Option B
29	50%	20.00	50%	16.00	50%	38.50	50%	1.00	Option A ○ ○ Option B
30	60%	20.00	40%	16.00	60%	38.50	40%	1.00	Option A ○ ○ Option B
31	70%	20.00	30%	16.00	70%	38.50	30%	1.00	Option A ○ ○ Option B
32	80%	20.00	20%	16.00	80%	38.50	20%	1.00	Option A ○ ○ Option B
33	90%	20.00	10%	16.00	90%	38.50	10%	1.00	Option A ○ ○ Option B
34	100%	20.00	0%	16.00	100%	38.50	0%	1.00	Option A ○ ○ Option B

you do not receive an endowment. Accordingly, your payoff is as follows:

Outcome of the risky event

How is the outcome of the chosen risky event determined in Stage III? To determine the outcome there is a ballot box with 100 balls marked with numbers from 1 to 100 (analogously to stage II). Each number occurs exactly once in the ballot box, i.e. the draw of a particular number is equally likely.

Before the experiment will start now, please note: You are asked comprehension questions before each stage starts. These questions should familiarize you with the decision task in each stage.

After the experiment, you are asked to answer a questionnaire. For answering the questionnaire you receive independently from your earnings during the experiment €4.

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