"Prevent or Cure"? Trading in the face of left-skewed binary lotteries

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Abstract

This paper focuses on the individual's trade-off between a reduction in the probability of occurrence of a negative event and a reduction in its magnitude for a risk averse decision-maker. For that purpose, we propose a theoretical model based on left-skewed binary lotteries with lottery A associated to a lower damage and a higher probability of occurrence than B. We show that the main determinant of the individual's choice is the expectations of the lotteries. When the expectations of A is higher or equal to the one of B, then any risk averse decision-maker will prefer A to B due to second-order stochastic dominance. However, when the lottery B is associated to a higher expectation than A, then additional assumptions on individual's prudence and temperance are required. We also test experimentally our theoretical predictions. Finally, we provide three possible applications, and draw related policy recommendations.

Keywords: Left-skewed risk, binary lotteries, prudence, temperance.

JEL codes: C91, D81.

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1 Introduction

This paper aims explaining the drivers of individuals' decisions in face of *left-skewed binary lotteries*. Indeed, there are increasing evidences in the literature about skewness preference: people enjoy the small chance to win a large gain (right-skewed risk), but they fear a (even very low) likelihood to suffer a large loss (left-skewed risk). This can explain why people buy insurances, and also why they gamble in lotteries, bet in horse races (Golec and Tamarkin [24]), or even why they have under-diversified portfolios (Mitton and Vorkink [25], Kozhan *et al.* [20]). In addition, binary risks are also widespread. Especially, risks of accident are binary ones: only two events can occur (accident, or no accident). It is the same for the risk of illness. So, facing a risk of accident (or a risk of disease) is equivalent to face a *left-skewed binary lottery*.

Few papers analyze binary and skewed lotteries. Foncel and Treich [13] studied how much an agent is ready to pay for avoiding a risk of losing her entire wealth (risk of ruin), thus highlighting the role of the fear of ruin coefficient firstly introduced by Aumann and Kurz [2]. To our knowledge, only two papers study preferences over binary lotteries. The first one is written by Chiu [4], and it provides a characterization of binary lotteries by their three first moments and makes a link between these moments and preferences over the lotteries, which allows to build model-free preference criteria. The second one, by Ebert [8], goes further and provides formula to design binary and skewed lotteries, what is particularly convenient to set experiments.

Although very few analyzed, left-skewed binary lotteries have a reality. Several fields of application can be enumerated like public regulation of accident through civil liability, therapeutic decisions or production ones[1]. Civil liability is a legal provision that compels any injurer to repair the damage she causes by the payment of damages. It is indeed the main public policy tool for regulating risky activities: because of the threat of having to pay damages in case of accident, the agent driving a risky activity has incentives to make effort in prevention, to reduce the probability that an accident occurs. There are two rules of enforcement of liability: the strict liability rule, and the rule of negligence[2]. Shavell [30], [31] shows that a rule of negligence induces higher efforts in risk prevention than strict liability, thus leading to a lower probability of accident. But victims are not compensated in case of damage. On the contrary, strict liability always ensure a partial compensation, but it provides fewer incentives for care than negligence: the probability of accident is higher. So, each rule can be associated with a left-skewed binary lottery, one with a high probability of a low loss (strict liability), the other one with a low probability of a high loss (negligence), thus highlighting a trade-off between probability and magnitude of loss. To the best of our knowledge, this litterature has focused on the analysis of incentives provided by the legal system, but the question of the *global* desirability of the regulation has been put aside: what are the victims' choice in the face of the trade-off between probability and magnitude of loss? Our paper aim to shed light on this issue, which is of high interest for welfare concerns.

[1] In the introduction, we give some insights on the first field, the two other ones will be introduced in the discussion.

[2] In case of strict liability, the injurer has to repair the victim independently from her behavior in terms of risk prevention. In case of a negligence rule, the injurer can be exempted from liability when it is proved before the Court that she has complied with a due standard of care.

To date, empirical analysis on liability rules are very scarce. They rely on experimental economics and, as the theoretical analysis, they mainly focus on the incentives to implement prevention. Kornhauser and Schotter compare strict liability and negligence in unilateral settings [18] and bilateral settings [19]. Angelova *et al.* [1] also compare these two rules, while focusing on the effect of potential insolvency. Pannequin and Ropaul [28] examine the effects of risk and ambiguity under these two rules, and Lampach, Boun My and Spaeter [21] compare the incentives for prevention provided by limited and unlimited liability under ambiguity. Dopuch *et al.* [7] address the issue of multiple torfeasors, but focus on the incentives to settle before trial, and Wittman *et al.* [34] compare strict liability and negligence in their abilities to induce (good) equilibria.

To sum up, this paper proposes to study how a decision-maker trades off between two left-skewed binary lotteries, one characterized by a high loss associated with a low probability of occurrence, and the other one characterized by a lower loss but associated with a higher probability of occurrence. Our problem is different and more general than the one of Foncel and Treich [13] in the sense that we compare two different situations of risk which have the same best outcome (the "no loss" -or no accident- event) but different worst outcomes (the "loss" event, with different magnitudes of loss across the lotteries). Also, by focusing on left-skewed binary lotteries having a similar best outcome, we study a particular (but widespread) case which is not taken into account by Chiu [4] or Ebert [8].

Beyond contributing to the theory of decision, our paper aims to find applications, especially in tort law analysis where our model allows to answer the question: *if they could* choose, would the victim prefer to reduce the magnitude of loss (thanks to a strict liability rule), or to reduce the probability that a damage occurs (thanks to a negligence rule)? Answering this question allows to open the analysis of civil liability to widen welfare concerns.

We find that any risk-averse decision-maker which faces a trade-off between probability and magnitude of loss should tilt in the favor of the lowest magnitude of loss (at the expense of a higher probability of loss) as soon as this option provides a higher or similar expected outcome than the other alternative (Proposition 1). When the lottery providing the lowest probability of loss (but the highest magnitude of loss) is associated with the highest expected outcome, then theoretical results prove that none of the lottery stochastically dominates the other one (Proposition 2). However, we prove that individual characteristics about prudence and temperance play a role: sufficiently prudent and temperant decision-maker should prefer the lottery providing the lowest probability of loss (Proposition 3). The experiment allows testing these theoretical predictions. We show that the result is different function of the expectations of the lotteries. Then, Proposition 1 is verified only when the expectation of A is higher than the one of B. Propositions 2 and 3 are not verified. These results are then discuss in terms of public policy issue.

The paper is organized as follows. In Section 2, we build a theoretical analysis of the determinants of individual's decision when facing two left-skewed binary lotteries. In Section 3, we empirically test for the robustness of our theoretical predictions through a lab experiment. Section 4 presents the results while Section 5 proposes a discussion and Section 6 concludes.

2 Theoretical analysis

In this section, we first introduce the assumptions of the model before to analyze the determinants of the choice between the two left-skewed binary lotteries that we consider.

2.1 Basic assumptions

Consider an expected utility maximizer whose preferences are represented by a von Neumann-Morgenstern utility function $U(x)$, with $U'(x) > 0$ and $U''(x) < 0$. The initial wealth is noted W, with $W > 0$. She has to choose between two binary lotteries, $\tilde{L}_A \equiv (p_A, 1 - p_A; -D_A, 0)$ and $\tilde{L}_B \equiv (p_B, 1 - p_B; -D_B, 0)$. p_i, with $i = A, B$, takes a value in $]0,1[$ and denotes the probability of the worst event (*i.e.*, losing D_i, with $D_i > 0$, $i = A, B$). We pose the following properties:

- $p_B < p_A$
- $D_B > D_A$
- $D_B \leq W$

$E[\tilde{L}_i] = -p_i D_i$ is the expected loss associated with the lottery $\tilde{L}_i$.
In terms of final wealth, when choosing a lottery $i = A, B$, the agent faces a probability p_i to earn $W - Di$ (loss state), and a probability $(1 - p_i)$ to keep W (no loss state).

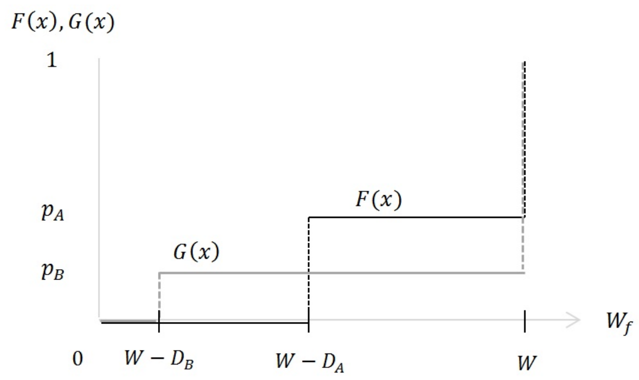
With these two lotteries, the agent can only suffer losses (in the best event, she only keeps unchanged her initial wealth W, but she didn't earn any additional gain). Such "only-lose" lotteries are left-skewed. The assumptions indicate that the probability of loss is lower with the lottery $\tilde{L}_B$ and the outcome in case of loss is higher with the lottery $\tilde{L}_A$. In such a context, we wonder whether an agent prefers to reduce the probability of loss but to suffer from a lower outcome in case of loss (lottery $\tilde{L}_B$), or to enjoy a lower loss but to suffer from a higher probability to face a loss (lottery $\tilde{L}_A$).

Recalling the application in tort law, the lottery $\tilde{L}_A$ can be seen as the enforcement of a strict liability rule while the lottery $\tilde{L}_B$ corresponds to a rule of negligence.

2.2 Choosing between two left-skewed lotteries

When facing such lotteries, two cases have to be distinguished: when the lottery $\tilde{L}_A$ leads to a higher (or similar) expected payoff than the lottery $\tilde{L}_B$, or when the lottery $\tilde{L}_A$ is associated with a lower expected payoff than the lottery $\tilde{L}_B$. The Figure 1 below draws the cumulative probability distributions of the final wealth (denoted W_f) associated with the two lotteries: $F(x)$ for the lottery $\tilde{L}_A$, $G(x)$ for the lottery $\tilde{L}_B$.

Figure 1: Cumulative distributions of the final wealth



2.2.1 First case: $E[W+\tilde{L}_A] \geq E[W+\tilde{L}_B]$

In this first case, when the two lotteries have the same expectation: $E[W+\tilde{L}_A] = E[W+\tilde{L}_B]$, then: $W - p_A D_A = W - p_B D_B$.
It is easy to check that no first-order stochastic dominance holds because cumulative probability distributions of the two lotteries cross each other (see Figure 1). However, by looking at the cumulative probability distributions of the final wealth, we can show that lottery $\tilde{L}_A$ stochastically dominates the lottery $\tilde{L}_B$ at the second-order. Denoting x an outcome of the final wealth W_f, the lottery $\tilde{L}_A$ stochastically dominates the lottery $\tilde{L}_B$ at the second-order iff:

$$\int_{W-D_B}^{t} F(x)dx \leq \int_{W-D_B}^{t} G(x)dx, \forall t \in [W-D_B, W] \tag{1}$$

It is easy to check that the area under the cumulative function $F(x)$ is equal to $p_A D_A$, and the area under the cumulative function $G(x)$ is equal to $p_B D_B$ (*i.e.*, the absolute value of expectations of $\tilde{L}_A$ and $\tilde{L}_B$ respectively). Because the lowest outcome of $\tilde{L}_B$ is lower than the lowest outcome of $\tilde{L}_A$, the condition (1) is satisfied for $E[W+\tilde{L}_A] = E[W+\tilde{L}_B]$.

When the lottery $\tilde{L}_A$ is associated with a higher expectation than the lottery $\tilde{L}_B$ (*i.e.*, $E[W+\tilde{L}_A] > E[W+\tilde{L}_B] \Rightarrow W - p_A D_A > W - p_B D_B \Rightarrow p_A D_A < p_B D_B$), the stochastic second-order domination of the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$ also holds. We obtain the following result.

Proposition 1. *Consider two binary left-skewed lotteries $\tilde{L}_A \equiv (p_A, 1-p_A; -D_A, 0)$ and $\tilde{L}_B \equiv (p_B, 1-p_B; -D_B, 0)$, with $p_A > p_B$ and $D_B > D_A$. Consider the case where the lottery $\tilde{L}_A$ provides a higher (or similar) expected outcome than the lottery $\tilde{L}_B$ (i.e., $-p_A D_A \geq -p_B D_B$).*

The lottery $\tilde{L}_A$ stochastically dominates the lottery $\tilde{L}_B$ at the second-order. So, any risk-averse decision-maker ($U'' < 0$) prefers the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$, whatever the level of initial wealth W.

Note that in the case where the two lotteries have the same expectation, the lottery

$\tilde{L}_A$ is a mean-preserving contraction[3] of the lottery $\tilde{L}_B$. Note also that this proposition is independent of the level of the wealth, and then, any risk-averse decision-maker prefers lottery $\tilde{L}_A$ to lottery $\tilde{L}_B$, whatever the level of wealth.

2.2.2 Second case: $E[W + \tilde{L}_A] < E[W + \tilde{L}_B]$

In this second case, we analyze the individual's preference between the two lotteries when the lottery $\tilde{L}_B$ leads to a higher expected outcome than the lottery $\tilde{L}_A$: $E[W+\tilde{L}_A] < E[W+\tilde{L}_B]$.

In that case, again, no first-order stochastic dominance holds since the cumulative distributions cross each other. Second-order stochastic dominance has to be questioned. Again, the lottery $\tilde{L}_A$ dominates (is dominated by) the lottery $\tilde{L}_B$ iff:

$$\int_{W-D_B}^{t} F(x)dx \leq (\geq) \int_{W-D_B}^{t} G(x)dx, \forall t \in [W - D_B, W]$$

We question both possibilities. Consider first the case of a dominance of the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$. Since the worst outcome of the lottery $\tilde{L}_B$ is lower than the one of the lottery $\tilde{L}_A$, the condition cannot be satisfied. Then, regarding the dominance of the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$, we know: $E[W + \tilde{L}_A] < E[W + \tilde{L}_B] \Rightarrow W - p_A D_A < W - p_B D_B \Rightarrow p_A D_A > p_B D_B$. As a consequence, the area under the function $F(x)$ is, over the whole range of values of x, higher than the one under the function $G(x)$: the condition is not satisfied. As already established in the literature (Gollier [14], p 43, and Levy and Sarnat [15], p 198), we find that a lottery cannot stochastically dominate another one at the second-order if it is associated with the lowest expected outcome.

We then investigate for the presence of higher order stochastic dominances. Third-order stochastic dominance was introduced by Whitmore [33], and higher order stochastic dominances (fourth to nth order) are developed by Fishburn [11]. By synthesizing their contributions, we can say that for an uncertain prospect $F(x)$ to stochastically dominates another uncertain prospect $G(x)$ at the nth-order (with $n \geq 2$), the two following conditions have to be simultaneously satisfied:

$$F^n(x) \leq G^n(x), \forall t \in [W - D_B, W] \tag{2}$$

$$\int_{W-D_B}^{W} F(x)dx \leq \int_{W-D_B}^{W} G(x)dx \tag{3}$$

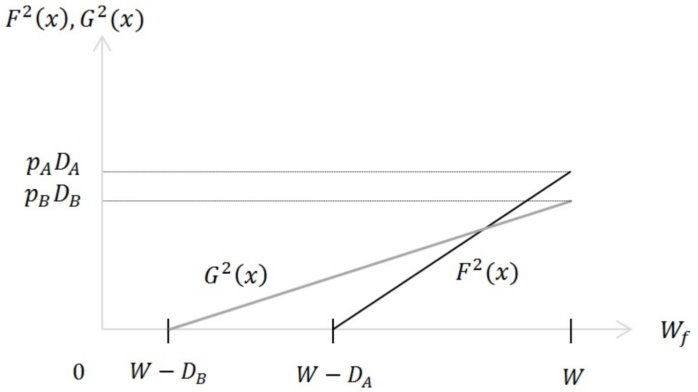
with $F^n(x) = \int_{W-D_B}^{t} F^{n-1}(x)dx$, and $G^n(x) = \int_{W-D_B}^{t} G^{n-1}(x)dx$, both being defined on $[W - D_B, W]$, $n \geq 2$, $F^1(x) = F(x)$, $G^1(x) = G(x)$.

According to the condition (3), for a lottery to stochastically dominates another one at the nth-order, it is necessary for this lottery to provide the highest expected outcome. This

[3] Lottery $\tilde{L}_A$ is a mean-preserving contraction of the lottery $\tilde{L}_B$, but the lottery $\tilde{L}_B$ is not a downside risk increase of the lottery $\tilde{L}_A$. Indeed, $-p_A D_A = -p_B D_B$ implies the variance of the lottery $\tilde{L}_A$ (which is $p_A(1 - p_A)D_A^2$) to be lower than the variance of the lottery $\tilde{L}_B$ (which is $p_B(1 - p_B)D_B^2$). Yet, a downside risk increase (in the sense of Menezes *et al.* [23]) consists in a transfer of risk from the right to the left of the distribution, mean and variance being unchanged.

is the case for the lottery $\tilde{L}_B$ (stochastic domination of the lottery $\tilde{L}_A$ is thus excluded). However, the condition (2) teaches us that, for the lottery $\tilde{L}_B$ to stochastically dominates the lottery $\tilde{L}_A$ at the nth-order, it is necessary that the area under the function $G^{n-1}(x)$ is, for each outcome x, lower than the area under the function $F^{n-1}(x)$ (see the Figure 2 below for the case of the third-order stochastic dominance). Because the lottery $\tilde{L}_B$ is associated with the worst outcome, this condition can never be satisfied.

Figure 2: $F^2(x)$ and $G^2(x)$ when the lottery $\tilde{L}_A$ has the lowest expected outcome



This leads to the following result.

Proposition 2. *Consider two binary left-skewed lotteries $\tilde{L}_A \equiv (p_A, 1-p_A; -D_A, 0)$ and $\tilde{L}_B \equiv (p_B, 1-p_B; -D_B, 0)$, with $p_A > p_B$ and $D_B > D_A$. Consider the case where the lottery $\tilde{L}_A$ provides a lower expected outcome than the lottery $\tilde{L}_B$ (i.e., $-p_A D_A < -p_B D_B$).*
No lottery stochastically dominates the other one, at any order.

Because stochastic dominance is not conclusive when the lottery $\tilde{L}_B$ is associated with a higher expected payoff than the lottery $\tilde{L}_A$, we make a comparative analysis based on the properties of utility functions. The analysis is based on comparisons of risk and precautionary premiums, and so it only holds for "small risks" in the sense of Arrow-Pratt.

We proceed in two steps. In each step, we consider values of p_A, p_B, D_A and D_B as given and responding to the constraint: $-p_B D_B > -p_A D_A$, which follows from $E[W + \tilde{L}_B] > E[W + \tilde{L}_A]$.

In the first step, we consider an individual with a given initial wealth W, who has to choose between the two lotteries: we highlight the conditions, on her utility function, for which she will prefer one lottery to the other one.

Then, in a second step, we analyze how these preferences are robust to a variation in the level of initial wealth W: for which conditions these preferences still hold when the value of W increases (p_A, p_B, D_A and D_B keep unchanged)?

Our analysis leads to the following result. Proof is presented in Appendix A.

Proposition 3. *Consider a risk-averse decision-maker, endowed with a given initial wealth W, who faces the two lotteries $\tilde{L}_A \equiv (p_A, 1-p_A; -D_A, 0)$ and $\tilde{L}_B \equiv (p_B, 1-p_B; -D_B, 0)$, with $p_A > p_B$ and $D_B > D_A$. Consider the case where the lottery $\tilde{L}_A$ provides a lower expected outcome than the lottery $\tilde{L}_B$ (i.e., $-p_A D_A < -p_B D_B$). "Small risks" in the sense of Arrow-Pratt hold.*

(i) If the decision-maker is "sufficiently" prudent ($U^{'''} > 0$) and "sufficiently" temperant ($U^{''''} < 0$), she prefers the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$. Moreover, this preference is robust to an increase in the level of initial wealth.

(ii) If the decision-maker is "sufficiently" imprudent ($U^{'''} < 0$) and "sufficiently" untemperant ($U^{''''} > 0$), she prefers the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$. Moreover, this preference is robust to an increase in the level of initial wealth.

This means that when $-p_A D_A < -p_B D_B$, the individual's choice can not be explained only by risk attitude. In this case, assumptions about the size of risk is needed (*i.e.*, "small risks" in the sense of Arrow-Pratt) and attitudes towards prudence and temperance are required. The concepts of prudence and temperance were developped by Kimball ([16]; [17]). A prudent decision-maker is characterized by $U''' > 0$, while a temperant one is represented by $U'''' < 0$. Eeckhoudt and Schlesinger [10] proposed a more behavioural definition of these concepts. Then, a prudent individual has a preference for adding an unavoidable zero-mean risk ("bad" event) to a state in which income is high ("good" event), rather than adding it to a state in which income is low ("bad" event). In a way, we can say that a prudent decision-maker prefers combining "bad with good" rather than combining "bad with bad". Temperate individuals have a preference for disaggregating two independent zero-mean risks across different states, rather than facing them both in a single state (Noussair *et al.* [26]).

The Proposition 3 teaches us that only a sufficiently high degree of prudence ensures a risk-averse decision-maker to prefer the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$, for a given level of W (and a sufficiently high degree of temperance ensures the precautionary premium to decrease with W, thus ensuring the preference to be quite robust for any increase in W). The rationale underlying this result lies in the application of the "*I like to combine good with bad*" principle. Indeed, lotteries $\tilde{L}_A$ and $\tilde{L}_B$ can be expressed as respective combinations of each other with additional lotteries (details are provided in section A.4 of Appendix A). In the case where $E[\tilde{L}_A] < E[\tilde{L}_B]$, the lottery $\tilde{L}_B$ can be expressed as a combination of the lottery $\tilde{L}_A$ with a positive-mean lottery on her worst event (losing D_A). So it combines a "good" event (positive-mean lottery) with a "bad" event (to suffer a loss). The lottery $\tilde{L}_A$ can be expressed as a combination of the lottery $\tilde{L}_B$ with two other lotteries: a negative-mean lottery on her best event (keeping W), and a positive-mean lottery on her worst event (losing D_B). Again, good events are combined with bad events. An increase in the value of $E[\tilde{L}_B] - E[\tilde{L}_A]$ requires the negative-mean lottery (which is combined with $\tilde{L}_B$ to lead to $\tilde{L}_A$) to have a higher weight, so that a sufficiently prudent decision-maker would prefer the lottery $\tilde{L}_A$ (that adds a good event - a positive-mean lottery - to a bad one).

3 Experimental test

In this section, we detail the experiment following a classical approach consisting in the describing of the design, the order issues, the participants and incentives.

3.1 The design

The objective of the experiment is to test the theoretical predictions summarized in Table 1 and their robustness to an increase in wealth.

Table 1: Theoretical predictions

Proposition 1	$-p_A D_A \geq -p_B D_B$	$\tilde{L}_A \succ \tilde{L}_B$
Propositions 2 and 3	$-p_A D_A < -p_B D_B$	$\tilde{L}_A \succ \tilde{L}_B$ if $U''' < 0, U'''' > 0$ $\tilde{L}_B \succ \tilde{L}_A$ if $U''' > 0, U'''' < 0$

To address our research questions on the individual's trade-off between reduction in probability *versus* magnitude, we designed an experiment composed with three steps (see Appendix B for the experimental instructions). The first step is devoted to the measurement of risk aversion, prudence and temperance, in order to test for Proposition 3. In the second step, participants are exposed to lottery choices, corresponding to the lotteries A and B of the theoretical part, allowing to test for Propositions 1 and 2. All our participants answered the same series of lottery choices but for some participants, the wealth is low while for other the wealth is high, *i.e.*, two treatments. The last step gathers questions on the individual's characteristics of the participants (age, gender, study level).

3.1.1 Step 1: Risk aversion, prudence and temperance

In this first step, we characterize the participant's attitude towards risk, prudence and temperance. This first step allows us to ensure that our participants are risk averse, and also allows eliciting prudence and temperance to test for Proposition 3. Indeed, following this proposition, the measures of risk aversion, prudence and temperance are potential explanatory variables to justify the participant's lottery choice (A or B), when the Lottery B provides a higher expected outcome than Lottery A. In this context, we use a methodology recently proposed by Noussair *et al.* [26][4], and based on the intuitive definitions provided by Eeckhoudt and Schlesinger [10]. These authors stipulate that "a prudent individual has a preference for adding an unavoidable zero-mean risk to a state in which income is high, rather than adding it to a state in which income is low; and a temperant individual has a preference for disagreggating two independant zero-mean risks across different states, rather than facing them both in a single state" (Noussair *et al.* [26]).

The method proposed by Noussair *et al.* [26] is model-free but allows to make the link between the theoretical model and the experiment. Indeed, maintaining the expected utility

[4]See the Appendix C of Noussair *et al.* [26] for a comparison of the methods and findings of other existing studies trying to measure prudence and temperance.

assumption, as in our theoretical model, leads to classify agents as prudent and temperate function of the sign of the derivatives of their utility functions ($U''' > 0$ for prudent, and $U'''' < 0$ for temperant).

Consequently, we assume the same choice tasks as in Noussair *et al.* [26] presented in Table 2.

Table 2: Choice tasks

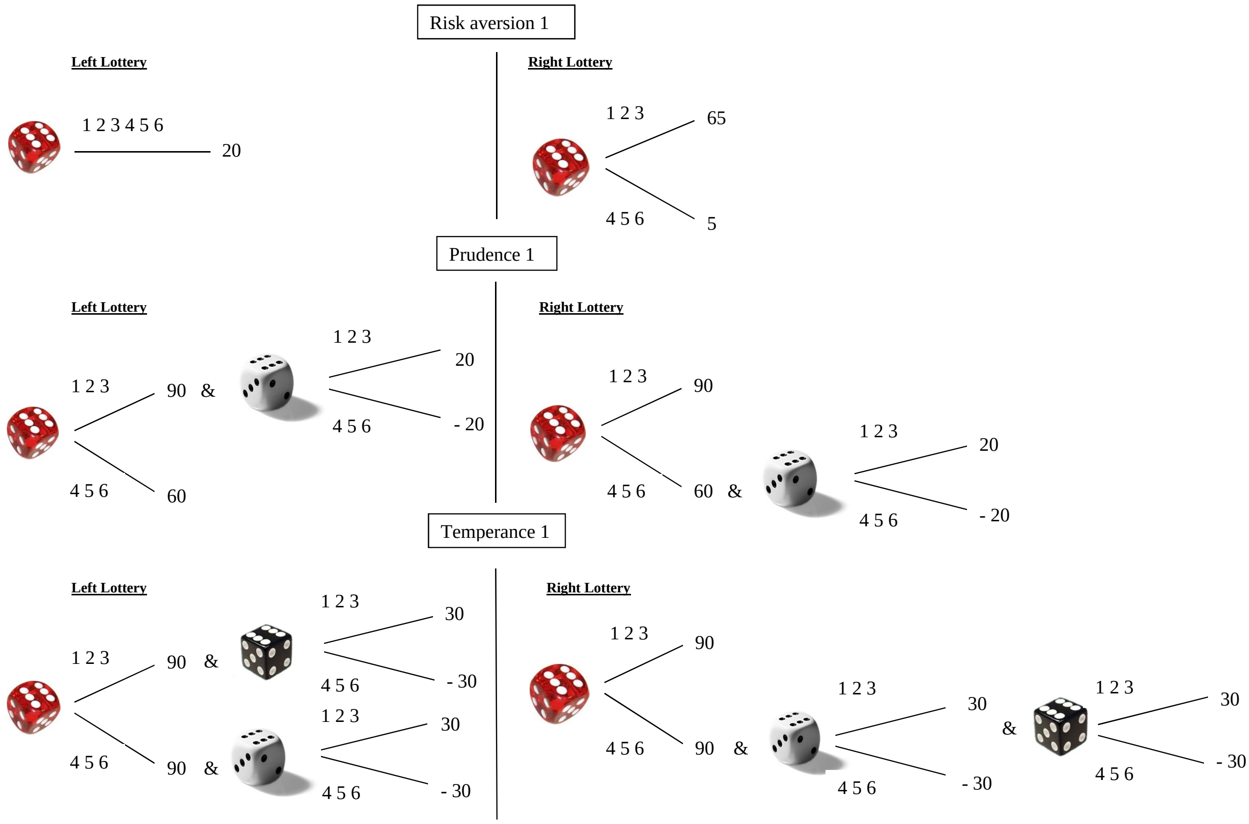
	Left Lottery	Right Lottery
Risk Aversion 1	20	[65_5]
Risk Aversion 2	25	[65_5]
Risk Aversion 3	30	[65_5]
Risk Aversion 4	35	[65_5]
Risk Aversion 5	40	[65_5]
Prudence 1	[(90+[20_-20])_60]	[90_(60+[20_-20])]
Prudence 2	[(90+[10_-10])_60]	[90_(60+[10_-10])]
Prudence 3	[(90+[40_-40])_60]	[90_(60+[40_-40])]
Prudence 4	[(135+[30_-30])_90]	[135_(90+[30_-30])]
Prudence 5	[(65+[20_-20])_35]	[65_(35+[20_-20])]
Temperance 1	[(90+[30_-30])_(90+[30_-30])]	[90_(90+[30_-30]+[30_-30])]
Temperance 2	[(90+[30_-30])_(90+[10_-10])]	[90_(90+[30_-30]+[10_-10])]
Temperance 3	[(90+[30_-30])_(90+[50_-50])]	[90_(90+[30_-30]+[50_-50])]
Temperance 4	[(30+[10_-10])_(30+[10_-10])]	[30_(30+[10_-10]+[10_-10])]
Temperance 5	[(70+[30_-30])_(70+[30_-30])]	[70_(70+[30_-30]+[30_-30])]

Then, subjects had five lottery choices to realize for risk aversion, five for prudence and five for temperance, *i.e.*, 15 lottery choices. Each lottery is an equiprobable lottery with a 50% chance that each outcome occurs. We present the lottery as compound lottery for the subject. In addition, we present the lotteries graphically to the participants by means of three differently coloured dice in order to emphasize the independance of the risks, as presented in Figure 3.

Figure 3 presents the first choice task for risk aversion, prudence and temperance. In this Figure 3, and following Noussair *et al.* [26], the choice of the Left lottery indicates risk aversion, prudence, and temperance, respectively. In addition, Figure 3 allows to clearly observe the definition of prudence and temperance proposed by Eeckhoudt and Schlesinger [10]. Indeed, a prudent individual always chooses the Left lottery over the Right one because she prefers to associate a zero-mean risk to a good state of the world rather than to a bad state. In the same vein, a temperant individual always selects the Left Lottery because she prefers to disagreggate two independent zero-mean risks across two states of the world, rather than facing them in the same state. Consequently, the measure of the participant's risk aversion corresponds to the number of safe choices she realized among the five decisions presented in Table 2. In the same vein, the measure of prudence (temperance) is equal to the number of prudent (temperant) choices realized among the corresponding five decisions. The higher the number, the higher the strength of the individual's preferences[5]. Finally,

[5]The use of the number of binary decisions consistent with prudence and temperance, as measures of the strength of these attitudes, follows Deck and Schlesinger [6], Ebert and Wiesen [9] and Noussair *et al.* [26].

Figure 3: Examples of choice tasks



subjects were presented with one lottery choice at a time for a total of 15 choices for each participant.

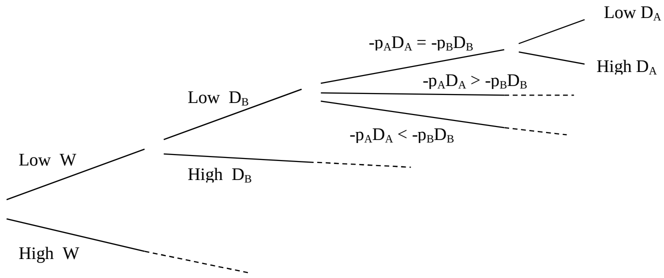
3.1.2 Step 2: Lottery choices

As indicated before, the objective of this second step is to test for Propositions 1 and 2. This second step is represented in Figure 4.

The participants are either in the High wealth treatment or in the Low wealth treatment (between-subject variable). These two treatments allow us to test the robustness of our theoretical results to a wealth increase. Indeed, Propositions 1, 2 and 3 are still true when wealth raises. Then, in the High wealth treatment, the wealth is two times higher than in the Low wealth treatment. Each treatment is composed with several within-subject variables.

First, all the participants are exposed to two levels of partial damage in case of risk occurrence in Lottery B, Low D_B and High D_B. The theoretical predictions hold whatever

Figure 4: Experimental design



the level of the damage in case of risk occurrence in Lottery B (with $D_B > D_A$). Then, it seems interesting to look whether, empirically, the individual behaves in the same manner when facing a low partial damage or a high one.

Second, for each level of partial damage in case of risk occurrence in Lottery B (low or high), each participant is exposed to the three conditions considered in the theoretical part as regard to the expectations of the two lotteries: Lottery A and Lottery B as the same expectation value ($-p_AD_A = -p_BD_B$), the expectation of Lottery A is higher than those of Lottery B ($-p_AD_A > -p_BD_B$) and the opposite ($-p_AD_A < -p_BD_B$).

Finally, for each level of expectation, two different values for the damage in case of risk occurrence in Lottery A are considered, as regard to the damage of Lottery B in case of risk occurrence. Indeed, the theoretical part imposes restriction on the value of the damage in case of risk occurrence in Lottery A, *i.e.*, D_A must be lower than D_B. However, there is no other restrictions, so that D_A can take several potential values. In order to ensure the robustness of our experimental results, we test for two different values of D_A: low ($D_A < 1/2D_B$) and high ($D_A > 1/2D_B$).

In this context, for each branch of the tree, we ask participants to take four lottery choices. Subjects were presented with one lottery choice at a time. Figure 5 presents an example of these four lottery choices for the first branch of the tree, *i.e.*, Low wealth treatment ($W = 100$), Low D_B ($D_B = 40$), $-p_AD_A = -p_BD_B$, Low D_A ($D_A = 10$).

Proposition 1 indicates that a risk-averse participant should choose Lottery A for the four lotteries presented in this example. Each participant has to take 48 sequential decisions in this second step.

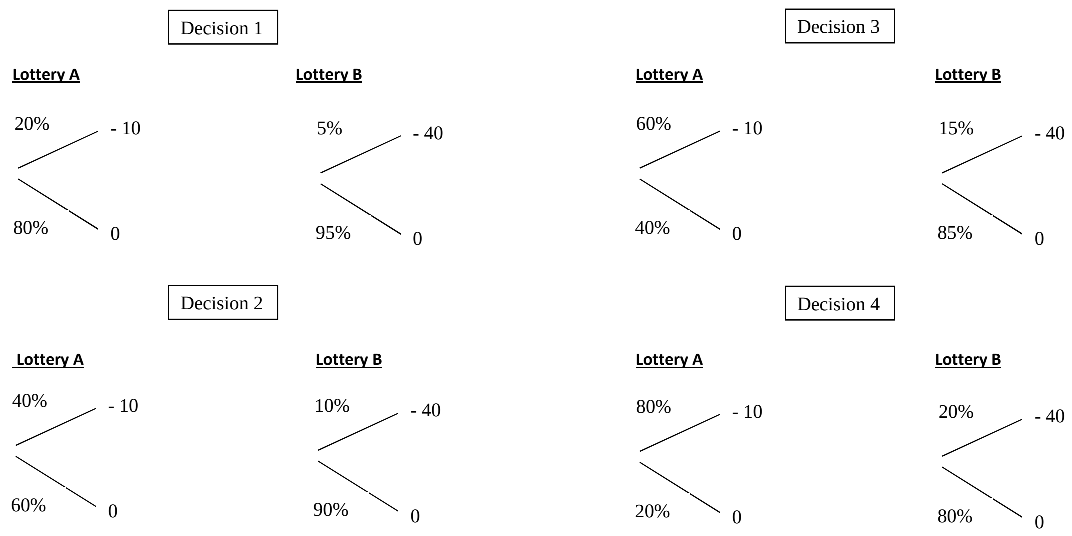
3.2 Order effect issues

The order of the three steps is always the same during the experiment.

In step 1, the order of presentation is always the same, the choice tasks are ordered as in Table 2, aversion, prudence and then temperance.

In step 2, the subjects always begin with the loteries having the same expectations ($-p_AD_A = -p_BD_B$), after with the loteries where $-p_AD_A > -p_BD_B$ and then finished with

Figure 5: Example of lottery choices



the loteries characterized by $-p_A D_A < -p_B D_B$. The order of the presentation is changed for Low/High D_B and for Low/High D_A, so that we have four different modalities.

In step 3, the order of the questions is always the same.

3.3 Participants and incentives

The experiment takes place at the Economic Experimental Laboratory of the University of Strasbourg in november 2016. 246 students were recruited from different study programmes (hard sciences, law, economics and management, sociology, literature). Among these 246 students we retain the 195 of them who are risk averse for our final sample[6]. 12 sessions were run, so that each treatment, Low and High wealth, contained respectively 97 and 98 participants. Each session lasted approximately one hour and ended with a demographic survey including questions about the participants' age, sex and study level. Consequently, the sample is composed with 117 women and 78 men, the average age is 20.93 years and 77.4% of the students have a License degree, other have a Bachelor degree (20%) or a Master degree (2.6%).

The participants realized the different steps of the experiment knowing that, at the end of the session, one task in step 1 and one task in step 2 would be randomly drawn and the decision takes by the participants for these tasks would be implemented and paid. Such a random selection of the payment has been proposed by Davis and Holt [5] to control for wealth effect. In addition, such a random selection mechanism ensures that the subjects treat each decision with some care (Charness and Genicot [3]). The payoffs are denominated in a fictitious currency called Experimental Currency Unit (ECU) and convert into Euros at

[6]As Noussair *et al.* [26], we consider as risk averse a subject who realized 2 or more non-risky choices. Those opting for 0 non-risky choices are characterized as risk seeking and those with only 1 non-risky choices are risk seeking/neutral.

the end of the experiment at a rate known by the subjects (€1 = 15 ECUS). The payments of the subjects varied between €10 and €28 with an average of €19.89.

Note that the step 2 of the experiment takes place in the loss domain. In such a case, as traditionally done, the subject has an endowment. This endowment corresponds to the wealth W of the theoretical model, and each participant receives the same endowment within a treatment (Low W *versus* High W).

4 Experimental Results

In this section, we present the results from the experimental test of each theoretical proposition.

4.1 Results for step 1: risk aversion, prudence and temperance

As indicated previously, the measure of the participant's risk aversion, prudence and temperance corresponds to the number of safe, prudent and temperant choices she realized among the corresponding five decisions. Then, Table 3 presents the average number of safe, prudent and temperant choices.

Table 3: Average number of safe, prudent and temperant choices

	Nb of choices A
Risk aversion	3.40 [1.04]
Prudence	2.82 [1.49]
Temperance	3.41 [1.57]

Standard deviation in [.]

These average are significantly different from 2.50 at the 1% level, so that in our sample, the subjects are on average characterized by risk aversion, prudence and temperance, as in Noussair et al. [26]. Indeed, Noussair *et al.* [26] obtained that, on average in their sample, the individuals make 3.38 non-risky choices, 3.45 prudent choices and 3.0 temperant choices, allowing to characterize them as significantly risk averse, prudent and temperant individuals.

4.2 Test of Proposition 1

Proposition 1 indicates that a risk averse individual should always prefer lottery A to lottery B if $-p_A D_A \geq -p_B D_B$.

Recall that for each case, four decisions (choices between lottery A and lottery B) had to be made. From Table 4, it appears that on average, subjects prefer lottery B to lottery A ($2.40 > 1.60$) when the two lotteries have the same expected value. In addition, the difference is significant both between the number of choices for A and B, and between number A choices and 2 (which would represent an indifference between the two lotteries). Consequently, Proposition 1 is not verified for $-p_A D_A = -p_B D_B$. Nevertheless, it is verified

Table 4: Average number of lottery A choices

	Nb of choices A
$-p_A D_A = -p_B D_B$	1.60 [1.214]
$-p_A D_A > -p_B D_B$	3.36 [0.957]
$-p_A D_A < -p_B D_B$	0.97 [1.209]

Standard deviation in [.] .

for $-p_A D_A > -p_B D_B$ because on average, the subjects realized 3.36 choices A (and only 0.64 choices B). The difference is also significant both between the number of choices for A and B, and between number A choices and 2. As a consequence we obtain:

Result 1.

When the lottery A provides a higher expected outcome than the lottery B, risk averse individuals significantly prefer the lottery A over the lottery B. This validates Proposition 1 for this case.

However, when the two lotteries provide the same expected outcome, risk averse individuals significantly prefer the lottery B over the lottery A. This violates Proposition 1 for this case.

Let us have a more detailed look with Table 5.

Table 5: Number of Lottery A and B choices

			Low wealth Nb of A choices N = 97	High wealth Nb of A choices N = 98
Low D_B	$-p_A D_A > -p_B D_B$	Low D_A	3.37 [0.893]	3.47 [0.840]
		High D_A	2.91 [1.164]	2.99 [1.188]
	$-p_A D_A = -p_B D_B$	Low D_A	1.38 [1.303]	1.70 [1.270]
		High D_A	1.45 [1.041]	1.46 [1.159]
	$-p_A D_A < -p_B D_B$	Low D_A	1.26 [1.301]	1.18 [1.279]
		High D_A	0.54 [0.914]	0.49 [0.944]
High D_B	$-p_A D_A > -p_B D_B$	Low D_A	3.67 [0.625]	3.59 [0.771]
		High D_A	3.40 [0.954]	3.45 [0.839]
	$-p_A D_A = -p_B D_B$	Low D_A	1.35 [1.225]	1.57 [1.332]
		High D_A	1.91 [1.155]	1.94 [1.082]
	$-p_A D_A < -p_B D_B$	Low D_A	1.28 [1.337]	1.36 [1.394]
		High D_A	0.86 [1.070]	0.80 [1.015]

Standard deviation in [.]

Having a quick look at this Table, we can highlight two trends in the results. First, it appears that very few differences may be observed between the last two columns (Low wealth, High wealth), which means that the level of the wealth seems to have few impact on the individuals' choices. Second, differences in choices clearly appear depending on the expectations of the two lotteries: the number of choices A is higher when $-p_A D_A > -p_B D_B$ than when

$-p_A D_A = -p_B D_B$, and it is lower when $-p_A D_A < -p_B D_B$ than when $-p_A D_A = -p_B D_B$.

In order to deepen the analysis, we ran a 2 (wealth levels) $\times$ 4 (Order) $\times$ 2 (D_B levels) $\times$ 3 (expectation levels) $\times$ 2 (D_A levels) ANOVA on the average number of Lottery A choices, with repeated measurements on the last three factors because they are within-subjects variables, whereas the other two factors are between-subjects variables.

Before analyzing the results of the ANOVA, keep in mind that the design of the lotteries is made in a way to obey to a given ranking between their expectations: we consider cases where the lottery A has a higher/lower/similar expected value than the lottery B. As a consequence, when regarding the effect of switching, for instance, from a Low D_i to a High D_i case (for a given ranking in the expected values of lotteries, and a given Low/High D_j case, $i = A, B$, $j = A, B$, $i \neq j$), our design cannot allow us providing the "other things being equal" effect associated with the change in this variable D_i[7]: a change in D_i may be associated with changes in p_j and/or D_j. However, our design allows us analyzing the effect of an increase in both levels of damage, D_A and D_B simultaneously, all other parameters being constant: to do that, we have to compare Low D_B to High D_B cases, for a given level of D_A.[8]

The results of the ANOVA analysis reveal that the number of A choices is impacted significantly and positively when switching from Low to High D_B (F = 47.380, p = 0.000), when switching from Low to High D_A (F = 21.315, p = 0.000), and by the three possible levels of expectations (F = 848.010, p = 0.000)[9]. The crossed variable $D_A \times D_B$ is also significant and positive (F = 22.042, p = 0.000). Finally, the level of wealth (Low/High Wealth) is not significant (F = 0.504, p = 0.479), and there is no significant order effect (F = 1.450, p = 0.230).

We also perform several additional tests, which confirm those provided by the ANOVA. First, as the ANOVA reveals that the level of expectation seems to be of interest, we realize two-by-two comparisons for paired sample between the three levels of expectations. The results showed that the average number of A choices is significantly smaller when $-p_A D_A = -p_B D_B$ (1.60) as compared to $-p_A D_A > -p_B D_B$ (3.36) (t = -35.239, p = 0.000) and significantly higher when $-p_A D_A = -p_B D_B$ (1.60) as compared to $-p_A D_A < -p_B D_B$ (0.97) (t = 13.259, p = 0.000). In addition, comparing the number of A choices when $-p_A D_A > -p_B D_B$ (3.36) and $-p_A D_A < -p_B D_B$ (0.97) indicates a significant and positive difference in favors of the scenario where $-p_A D_A > -p_B D_B$ (t = 49.537, p = 0.000).
Second, the ANOVA reveals that switching from Low D_B to High D_B has a significant impact on the number of choices in favor of lottery A. Recall that, given our design, it means that increasing both values of D_A and D_B increases the number of choices in favor of lottery A.

[7]Indeed, to ensure the relative expectations between lotteries to be unchanged, when we compare Low D_A and High D_A cases, probabilities associated with lottery B are different between these two cases. Also, when we compare Low D_B and High D_B cases, the level of D_A changes between these two cases in order to ensure the ratio between D_A and D_B to be unchanged.

[8]For instance we compare (Low D_B, High D_A) to (High D_B, High D_A), for a given relative level of expectations.

[9]Mauchly's sphericity test indicated that the variance-covariance matrix of the dependent variable is not spherical for the three possible levels of expectations (Mauchly's W = 0.951, p = 0.009), so that the reported F and p values are adjusted (Greenhouse-Geisser).

Except for two cases[10] (among the twelve we have), we observe that when the amount of loss of the two lotteries increases simultaneously the number of choices for lottery A increases ; these differences being all statistically significant when the level of D_A is high (High D_A), but not when the level of D_A is initially low (Low D_A). This suggests that the effect of an increase in the level of losses is not linear.

Result 2.
When the amounts of loss of both lotteries, D_A and D_B, increase, risk averse individuals make a higher number of choices in favor of lottery A.

This result has an impact in terms of political recommendations, that we will discuss in the Discussion section.

4.3 Test of Propositions 2 and 3

Recall that Proposition 2 teaches us that there is no stochastic dominance between the two lotteries when the lottery A has a lower expectation than lottery B (*i.e.*, $-p_A D_A < -p_B D_B$). So, risk aversion is not sufficient to explain the ranking between lotteries A and B when $-p_A D_A < -p_B D_B$. As a consequence, Proposition 3 investigates the role of prudence (and temperance): when $-p_A D_A < -p_B D_B$, a risk averse individual who is sufficiently prudent should choose more often lottery B than lottery A, and this ordering is robust to any increase in W when the individual is sufficiently temperant. Consequently, we first have a look on the role of prudence.

On that point, Table 4 lets appeared that, when $-p_A D_A < -p_B D_B$, on average the number of A choices (0.97) is always lower than the number of B choices (3.03), whatever the scenario in terms of levels of wealth, D_B or D_A. The question is now to know if this trend is explained (or not) by the individual's preferences towards prudence. In order to answer this question, we run an ordinal logit on the number of B choices, because the dependant variable (number of B choices) is ordinal, from 0 to 4. The regression equation is:

$$y_i^* = X_i \beta + \epsilon_i$$

with y_i^* stands for the number of B choices of individual i, X_i corresponds to the vectors of explanatory variables of the number of B choices (y_i), *i.e.*, number of prudent choices.

The results are presented in Table 6. Keep in mind that we only consider choices made in cases where $-p_A D_A < -p_B D_B$, which corresponds to 780 observations[11]. The regression

[10] There are twelve cases for which both D_A and D_B increase, other things being equal. When going from (Low D_B, Low D_A) to (High D_B, Low D_A), and when going from (Low D_B, High D_A) and (High D_B, High D_A), for each ranking of expected values, and for each treatment Low/High W. The two only cases for which the number of choices for lottery A decreases are when going from (Low D_B, Low D_A) to (High D_B, Low D_A), with the two lotteries having similar expected values, for both Low and High W. But these differences are not statistically significant.

[11] Over the two treatments (Low W and High W), we have 195 (risk averse) individuals. In each treatment, an individual had to make 4 (series of 4) decisions associated with the case $-p_A D_A < -p_B D_B$: one in case of (Low D_B, Low D_A), one when (Low D_B, High D_A), one when (High D_B, Low D_A), and one when (High D_B, High D_A). To sum up, there are 195 individuals who make $195 \times 4 = 780$ series of decisions (each series is synthesized by a score, from 0 to 4, in terms of number of A choices, as in Table 5).

equation is estimated both for the two treatments (columns "All treatments"), and for each treatment separately (columns "Low W treatment" and "High W treatment"). The Pseudo R^2 of McFadden are very low because we only consider prudence as explanatory variables while clearly, other variables may explain the number of B choices. However, note that the Pseudo R^2 are higher for regressions considering the level of wealth (0.017 for the Low wealth treatment and 0.019 for the High one), suggesting the interest of such separate regressions, as compared to the regression "All treatments".

Table 6: Estimation's results for the ordinal logit

	All treatments		Low W treatment		High W treatment	
Variable	Estimation [Std Dev.]	N	Estimation [Std Dev.]	N	Estimation [Std Dev.]	N
Prud. 0	.204 [.292]	68	.641 [.399]*	44	.357 [.492]	24
Prud. 1	.365 [.270]	92	1.305 [.402]***	52	-.252 [.379]	40
Prud. 2	-.511 [.231]**	144	.146 [.345]	84	-.798 [.328] ***	60
Prud. 3	-.291 [.217]	204	.744 [.339]**	104	-.989 [.292]***	100
Prud. 4	.083 [.232]	156	.863 [.371] **	64	-.337 [.302]	92
Prud. 5 (ref)		116		40		76
Pseudo R^2 McFadden	.009		.017		.019	

Standard deviation in [.]; Significance level: * 10%, ** 5%, *** 1%.

Table 6 highlights the impact of the degrees of prudence on the number of B choices: for instance, for "All treatments", $-.511$ associated with Prud. 2 means that individuals with a degree of prudence of 2 make less choices in favor of lottery B than individuals with a degree of prudence of 5. This result is in line with Proposition 3, as the fact that individuals with a degree 3 of prudence make less B choices than individuals with a degree 5 of prudence. But this last observation is not significant, and choices of individuals with degrees 0, 1 and 4 of prudence are not in line with Proposition 3.

Then, we also distinguish our analysis depending on the treatment Low/High W. More variables are statistically significant but, especially for the treatment Low W, data do not validate Proposition 3: in the treatment Low W, all individuals with a lower degree of prudence than a degree of 5 make, on average, more B choices than individuals with a degree 5 of prudence. In the treatment High W, individuals with degrees of prudence of 1, 2, 3 and 4 make, on average, less B choices than individuals with a prudence of degree 5 (and this is statistically significant for degrees 2 and 3). This is in line with Proposition 3, but the reverse hold for individuals with a degree 0 of prudence.

Finally, remark that the ordinal logit analyzes the impact of the degree of prudence whatever the degree of risk aversion. This is in line with Proposition 3 which states that, in theory, from the moment that the decision-maker is risk averse (and whatever her degree of risk aversion), the higher her degree of prudence the more she should choose the lottery B. To be complete, we also analyze the impact of prudence on the choices for lottery B, for given degree of risk aversion (see Tables 10, 11, and 12 in Appendix C): we observe no increasing trend in the average number of choices for lottery B with the degree of prudence (for a given degree of risk aversion).

All these observations lead to the following result.

Result 3.

When the lottery B provides the highest expected outcome, she is more often chosen than the lottery A but prudence does not seem to explain the preference for lottery B.

As a consequence, Proposition 3 is not validated.

Finally recall that, according to Proposition 3, the role of prudence in the choice (for lottery B) when $-p_A D_A < -p_B D_B$ only consists in making this choice (which should depend on prudence) robust to any increase in W. However our data invalidate the role of prudence in the choice for lottery B, for two different values of W. So we do not present any investigation on the impact of temperance[12].

5 Discussion

In this section, we discuss about the policy recommendations that we can make from our results. We first focus on the case of the regulation of risk of accident by the mean of civil liability, as evoked in the introduction. We also discuss interpretations in the domains of therapeutic decisions and production decisions.

5.1 Regulation of risks of accident

In introduction we mention the fact that our setup, with left-skewed binary lotteries, is relevant for modeling risks of accidents. Especially the comparison between our two lotteries A and B is convenient for studying the regulation of these risks by the means of civil liability rules. We introduced the trade-off which can exist between probability and magnitude of damage: strict liability is associated with a lower magnitude of damage, but a higher probability of accident than negligence. In our setup, strict liability thus corresponds to lottery A and negligence to lottery B.

Taking the perspective of the economic analysis of tort law, three of our results have policy implications.

First, our Result 1 shows that when the lottery A provides the highest expected outcome, most risk averse individuals prefers the lottery A over the lottery B. For the economic analysis of tort law, it means that potential victims of accident prefer the strict liability rule over the negligence rule when the former provides a higher expected outcome than the latter. In that case, victims arbitrate in favor of a better compensation (and against a lower probability of accident). But the reverse holds whenever the negligence rule provides a similar (or a higher) expected outcome as (than) strict liability.

This result shed a new light on the comparison between strict liability and negligence. The economic analysis of tort law mainly focuses on the comparison of rules with respect to the incentives for care they provide. In case of injurer's potential insolvency, there is a consensus on the virtues of negligence in providing strong incentives for care. But the impact of the absence of compensation for victims is neglected. Result 1 shows that victims give also value to compensation (against having a low probability of harm), when compensation allows for a higher expected outcome. It means that allowing compensation in case of negligence, with an additional policy tool (as a compensation fund) could be welfare improving.

[12] For the sake of completeness, we check the role of temperance: it has no significant impact on choices.

Second, our Result 3 shows that an increase in the level of damage (all other things being equal) leads the lottery A to become more attractive (relatively to lottery B). This reinforces our first policy recommendation about the importance of the victims' compensation, for the case of the most potentially harmful activities[13].

Third, our analysis highlights an additional result which has implications for the economic analysis of tort law. Consider only cases where the two lotteries A and B provide similar expected outcomes. Consider the two following cases: (High D_B, High D_A), and (High D_B, Low D_A) ; gathered in the following Tables[14].

Table 7: Comparisons of lotteries - case (High D_B, Low D_A)

	Lottery A				Lottery B				Expectations	
Decision	p_A	Outcome	$1-p_A$	Outcome	p_B	Outcome	$1-p_B$	Outcome	$E[\tilde{L}_A]$	$E[\tilde{L}_B]$
Decision 1	0.2	-20	0.8	0	0.05	-80	0.95	0	-4	-4
Decision 2	0.4	-20	0.6	0	0.10	-80	0.90	0	-8	-8
Decision 3	0.6	-20	0.4	0	0.15	-80	0.85	0	-12	-12
Decision 4	0.8	-20	0.2	0	0.20	-80	0.80	0	-16	-16

$W = 100$, $D_A = 30$, $D_B = 80$

Table 8: Comparisons of lotteries - case (High D_B, High D_A)

	Lottery A				Lottery B				Expectations	
Decision	p_A	Outcome	$1-p_A$	Outcome	p_B	Outcome	$1-p_B$	Outcome	$E[\tilde{L}_A]$	$E[\tilde{L}_B]$
Decision 1	0.2	-60	0.8	0	0.15	-80	0.85	0	-12	-12
Decision 2	0.4	-60	0.6	0	0.30	-80	0.70	0	-24	-24
Decision 3	0.6	-60	0.4	0	0.45	-80	0.55	0	-36	-36
Decision 4	0.8	-60	0.2	0	0.60	-80	0.40	0	-48	-48

$W = 100$, $D_A = 60$, $D_B = 80$

When you compare choices in Table 8 with those in Table 7, you can see that "going from Table 8 to Table 7" leads to an increase in the expected outcome. Now, depending on the lottery you choose in each case, the improvement in the expected outcome can be characterized: (i) by a decrease in the amount of damage when you always chooses lottery A ; (ii) by a decrease in the probabilities to be injured but an increase in the amount of loss when you switches from lottery A to lottery B ; (iii) by a decrease in the amount of loss but an increase in the probabilities to be injured when you switches from lottery B to lottery A ; (iv) by a decrease in the probabilities to be injured when you always choose lottery B.

Our experimentation highlights the following results:

Recall that these values are the number of choices for lottery A (among the four lotteries choices, in each case). We can see that, whatever the treatment, going from (High D_B, High

[13]Fleming [12], p. 97, highlights that strict liability is increasingly used for regulating the most hazardous activities. Shavell [32] explains it by the need to provide incentives to make non observable and/or non standardized efforts (*i.e.*, efforts that cannot be regulated by a negligence rule because of the inability to set and/or observe a (due) level of care). The victims' need for a minimum compensation could thus provides an additional argument in favor of this policy measure.

[14]Recall that in the Step 2 of the experiment, four lotteries decisions were proposed in each given case.

Table 9: Comparisons of choices, from (High D_B, High D_A) to (High D_B, Low D_A)

Treatment	Case: (High D_B, High D_A)	Case: (High D_B, Low D_A)	Comparison
Low W	1.91 [1.155]	1.35 [1.225]	$(t = 3.725, p = 0.000)$
High W	1.94 [1.082]	1.57 [1.332]	$(t = 2.607, p = 0.011)$

Standard deviation in [.]

D_A) to (High D_B, Low D_A) leads to a significant decrease in the number of choices in favor of the lottery A. In other words, still considering the application for the economic analysis of accident law, we can see that when the potential injured have the possibility to lessen their expected losses, they arbitrate in favor of a decrease in the probabilities to be injured against a better compensation (for both improvements leading to the same decrease in the expected loss). This result is however less salient in cases of Low D_B.

To sum up, the three main policy recommendations which can be made, from our results, for the regulation of risks of accident by the mean of civil liability are:

(i) *Potential injured prefers strict liability to negligence when the latter allows providing a lower expected loss than the latter. In the opposite case, the reverse holds.*

(ii) *An increase in the potential harm increases the value of strict liability for potential injured people.*

(iii) *But in case of high damage, the potential victims prefer improving their expected outcome through a decrease in the probability of accident (e.g. by enforcing more severe standards of care) instead of through a decrease in damage (e.g. via a better compensation).*

5.2 Therapeutic decisions

The trade-off, that we deal with in this paper, between probability and magnitude can also be encountered in case of therapeutic decisions. Indeed, some new treatments improve the likelihood to achieve remission (*i.e.*, higher probability to be in the best state of Nature) but can also be associated with complications, so that when these new treatments fail people are worse off than in case of failure with conventional treatments, for which the probability to get healthy is lower (see Leclercq, Roudière and Viard [22] for the case of antiretroviral treatments against HIV, or Ricard *et al.* [29] for the case of new brain tumor therapies).

Given our setup, new treatments are represented by the lottery B (low probability of loss - or high probability of being in the best state of Nature - but high potential damage) while the conventional ones are represented by the lottery A (higher probability of loss - or lower probability of being in the best state - but low potential damage).

Here, we focus on two results: (i) ceteris paribus, when the two potential damages D_i ($i = A, B$) increase, risk averse individuals more frequently choose the lottery A (*i.e.*, our Result 3) ; (ii) when they have the possibility to decrease their expected loss, risk averse individuals prefer reducing the probability to be harmed than to reduce the magnitude of the potential harm.

In the specific context of therapeutic decision described above, this leads to the following statements:

(i) *for a given utility of remission (which is similar in both treatments) and for given probabilities, a deterioration in health status in case of complication (by a similar factor in both cases) leads a risk-averse-VNM-patient to more frequently prefer the conventional treatment (lottery A) to a new one (lottery B).*

(ii) *However, a risk-averse-VNM-patient would more often prefer to improve the efficiency of her medical therapy by improving the probability of remission than by improving her utility in case of complication.*

To sum up, a risk-averse-VNM-patient having the possibility to improve her expected welfare prefers improving the probability to get wealthy again, but when facing the threat of being worse in case of complications, he more often arbitrates in favor of a mean to decrease harm in case of complication. As a result, depending on the nature of the evolution (*i.e.*, an improvement, or a deterioration), revisions in decisions about probability / magnitude trade-off are not the same.

5.3 Production decisions

Finally, a last interpretation of our results relates to the domain of the choice of production technology in agricultural sectors.
To illustrate, consider the case of a farmer who has to choose between two farming practices for producing her agricultural goods: a conventional practice, which requires the use of chemicals (fertilizers, pesticides, ...), and a biological one which bans the use of any chemical. We pose the two following assumptions: (i) in the best state of Nature, the two practices provide the farmer with the same outcome[15], (ii) the two types of farming methods are impacted by the same extent in case of climatic hazard. As a consequence, the payoff in the best state of Nature, W, is an expected outcome which takes into account climatic hazards.
These assumptions being posed, we can see our lottery A as representing the "bio" practice, while the lottery B represents the conventional one. Indeed, "bio" technologies are associated with a high probability for the harvest to be harmed by biotic factors[16] (such as pests, because of the absence of pesticides), while conventional methods are associated with lower probabilities of harms, but these harms can be of a much larger magnitude (e.g. human diseases because of long term exposition to some chemical substances).

Comparing (High D_B, High D_A) to (High D_B, Low D_A), or comparing (Low D_B, High D_A) to (Low D_B, Low D_A), allows seeing the impact of a decrease in D_A. Our data[17] clearly

[15]This is not a too strong assumption, to the extent that biological way of producing can be more costly, but the strength of the demand for "bio" products allows producers to increase their amount of sales.

[16]A study about potential losses occuring in the absence of pests control management procedures is provided in [27].

[17]A decrease in D_A, other parameters staying unchanged, leads to an increase in the expected outcome of lottery A, $E[\tilde{L}_A]$, relatively to the one of lottery B, $E[\tilde{L}_B]$. Look at Table 5. Consider cases where

show that such a decrease in D_A leads to a higher number of choices for lottery A.

In this framework, a decrease in D_A corresponds to a decrease in harm resulting from the absence of the use of chemicals in bio farmer practices. From the farmer's point of view, such a decrease in harm could be made possible by receiving, for instance, a public support in case of realization of biotic hazards. In this way, our result indicates that a public support for farmers against biotic hazards could incite them to adopt bio farming methods, if this support allows improving the relative expected outcome of this farming practice. This result is quite intuitive, but another one is more interesting.

If you consider the effect we highlighted in Table 9, we can see that, if they faced such a choice, risk-averse-VNM-farmers would prefer to decrease the probability of conventional farming methods to cause harms[18] (decrease p_B) than decreasing the amount of losses associated with bio farming methods (decrease in D_A).

To sum up, in the specific context of choice of farming methods, our experiment leads to the following statements:

(i) Providing public support to reduce the risk-averse-VNM-farmers' losses in case of biotic hazards, in a way to improve the relative expected outcome of bio farming methods, provides farmers with incentives to adopt these farming methods (instead of conventional ones).

(ii) Risk-averse-VNM-farmers prefer improving their expected outcome by reducing the probability of loss related to conventional methods, than by reducing the amount of losses associated with "bio" methods.

6 Conclusion

In this paper, we propose the first theoretical and experimental analysis on the trade-off between a reduction in the probability of occurrence of a negative event and a reduction in its magnitude for a risk averse decision-maker.

Our analysis is based on the comparison of two left-skewed binary lotteries: the lottery A exhibits a higher probability of loss than the lottery B, but a lower magnitude of loss than lottery B.

Our theoretical analysis shows that any risk-averse-VNM decision-maker should prefer lottery A when it provides a higher (or a similar) expected outcome than lottery B. So, such a decision-maker arbitrates in favor of a low magnitude of loss (against a low probability

$E[\tilde{L}_A] = E[\tilde{L}_B]$, in a way to obtain $E[\tilde{L}_A] > E[\tilde{L}_B]$ after decreasing the value of D_A. We can see that switching from (High D_B, High D_A) to (High D_B, Low D_A) leads the number of A choices to evolve from 1.91 or 1.94, to 3.67 or 3.59 (depending on whether low W or high W, respectively). When we consider the switching from (Low D_B, High D_A) to (Low D_B, Low D_A), we observe the number of A choices to grow from 1.45 or 1.46, to 3.37 or 3.47 (low W, high W).

[18] We illustrate losses related to conventional farming methods by harms on human health. A farmer will suffer such a loss in case of harm on consumers, and if the farmer's liability is established (so that he is obliged to pay damages to consumers). In this way, reducing the probability to get losses can also be interpreted by reducing the probability to be held liable / increasing the chances of winning the trial thanks to a good defence.

of loss). But when lottery B provides the highest expected outcome, sufficiently prudent decision-maker should prefer lottery B.

Our experimental results partially validate the theoretical ones: lottery A is preferred to lottery B when it provides the highest expected payoff, but in case of similar expected outcome the lottery B is more frequently chosen. When the lottery B provides the highest expected outcome, we find the most prudent decision makers to choose more often the lottery B (than least prudent ones), but only when their level of wealth is high.

Additional effects have been analyzed, as the effect of a variation in the magnitude of loss or variation in probabilities. When facing an increase in losses (for both lotteries), the individuals arbitrate in favor of the lottery which provides the lowest amount of loss. However, when having the possibility to improve their expected welfare (by either decreasing the probability to suffer a loss, or by decreasing the magnitude of loss), individuals opt for reducing the probability to suffer a loss.

Finally, we provide three applications of our results, in the regulation of risks of accident (by the mean of civil liability), for therapeutic decision making, and in the choice of farming methods. We draw (first) recommendations, which could be more deeply investigated through more domain-specific models.

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A Proof of Proposition 3

As mentioned in the body of the article, we first compare the two lotteries $\tilde{L}_A \equiv (p_A, 1-p_A; -D_A, 0)$ and $\tilde{L}_B \equiv (p_B, 1-p_B; -D_B, 0)$ for given values of p_A, p_B, D_A, D_B and initial wealth W. Recall that we only consider the case where $E[W+\tilde{L}_B] > E[W+\tilde{L}_A]$, and that such a study only hold for small risks in the sense of Arrow-Pratt.

We first suppose that the decision-maker prefers the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$, and we analyze the conditions for which this preference holds. Then we make a similar work by supposing a preference for the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$.

In each case, we first study the preference for a given value of W, and then we analyze how the preference evolves when the value of W increases.

A.1 The decision-maker prefers $\tilde{L}_B$ over $\tilde{L}_A$

For a given value of W, the decision-maker prefers the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$ iff:

$$
\begin{aligned}
& E[U(W+\tilde{L}_B)] > E[U(W+\tilde{L}_A)] \\
& \Rightarrow U(W+E[\tilde{L}_B]-\pi_B) > U(W+E[\tilde{L}_A]-\pi_A) \\
& \Rightarrow U(W-p_BD_B-\pi_B) > U(W-p_AD_A-\pi_A)
\end{aligned}
$$

with $\pi_i \simeq -\frac{\sigma_i^2}{2}\left[\frac{U''(W+E[\tilde{L}_i])}{U'(W+E[\tilde{L}_i])}\right]$, the risk premium (in the sense of Arrow-Pratt) which is associated with the lottery $i = A, B$. σ_i^2 is the variance of the lottery $i = A, B$.
Because $U(.)$ is an increasing function, preference for the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$ requires:

$$
\begin{aligned}
& W-p_BD_B-\pi_B > W-p_AD_A-\pi_A \\
& \Rightarrow W-p_BD_B-(W-p_AD_A) > \pi_B-\pi_A
\end{aligned} \tag{4}
$$

Because $p_BD_B < p_AD_A$, a sufficient condition for (4) to hold is π_i to decrease with the level of final wealth (and so to have $\pi_B - \pi_A < 0$).
The derivative of π_i with respect to the final wealth is:

$$
-\frac{\sigma_i^2}{2}\left[\frac{U'''(W+E[\tilde{L}_i]).U'(W+E[\tilde{L}_i]) - [U''(W+E[\tilde{L}_i])]^2}{[U'(W+E[\tilde{L}_i])]^2}\right] \tag{5}
$$

This derivative is negative if $U'''(W+E[\tilde{L}_i]).U'(W+E[\tilde{L}_i]) - [U''(W+E[\tilde{L}_i])]^2 > 0$. This requires $U'''(.)$ to be "sufficiently" positive. Recall that $U'''(.) > 0$ characterizes prudent decision-makers. As a result, only a "sufficient" degree of prudence leads to a preference for lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$.

A.2 The decision-maker prefers $\tilde{L}_A$ over $\tilde{L}_B$

Similarly, the decision-maker prefers the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$ iff:

$$\begin{aligned}
&E[U(W+\tilde{L}_B)] < E[U(W+\tilde{L}_A)] \\
&\Rightarrow U(W+E[\tilde{L}_B]-\pi_B) < U(W+E[\tilde{L}_A]-\pi_A) \\
&\Rightarrow U(W-p_BD_B-\pi_B) < U(W-p_AD_A-\pi_A) \\
&\Rightarrow W-p_BD_B-\pi_B < W-p_AD_A-\pi_A \\
&\Rightarrow W-p_BD_B-(W-p_AD_A) < \pi_B-\pi_A \qquad (6)
\end{aligned}$$

For (6) to hold, it is necessary for π_i to (sufficiently) increase with the level of final wealth (in order to have $\pi_B - \pi_A >> 0$). So, (5) has to be positive. It is positive as soon as: $U^{'''}(W+E[\tilde{L}_i]).U^{'}(W+E[\tilde{L}_i]) - [U^{''}(W+E[\tilde{L}_i])]^2 < 0$. $U^{'''}(.) < 0$ is a sufficient condition. As a result, $U^{'''}(.) < 0$, which characterizes an imprudent decision-maker, is a sufficient condition for (5) to be positive. But the degree of imprudence has to be "sufficiently" strong for (6) to hold.

A.3 Stability as regard to an increase in W

We analyze the stability of these preferences with an increase in the level of initial wealth W (the other parameters, relative to the lotteries, remain unchanged).

First consider a decision-maker who prefers the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$. Suppose her initial wealth W increases. The decision-maker still continues to prefer the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$ iff:

$$E[U^{'}(W+\tilde{L}_B)] < E[U^{'}(W+\tilde{L}_A)]$$

Indeed, $U^{'}(.)$ being a decreasing function (because of risk-aversion), having $E[U^{'}(W+\tilde{L}_B)] < E[U^{'}(W+\tilde{L}_A)]$ ensures that $E[U(W+\tilde{L}_B)] > E[U(W+\tilde{L}_A)]$ still holds.
From $E[U^{'}(W+\tilde{L}_B)] < E[U^{'}(W+\tilde{L}_A)]$ we deduce:

$$\begin{aligned}
&E[U^{'}(W+\tilde{L}_B)] < E[U^{'}(W+\tilde{L}_A)] \\
&\Rightarrow U^{'}(W+E[\tilde{L}_B]-\phi_B) < U^{'}(W+E[\tilde{L}_A]-\phi_A) \\
&\Rightarrow U^{'}(W-p_BD_B-\phi_B) < U^{'}(W-p_AD_A-\phi_A)
\end{aligned}$$

with $\phi_i = -\frac{\sigma_i^2}{2}\left[\frac{U^{'''}(W+E[\tilde{L}_i)}{U^{''}(W+E[\tilde{L}_i)}\right]$, the prudence premium (in the sense of Kimball [16]) which is associated with the lottery $i = A, B$. σ_i^2 is the variance of the lottery $i = A, B$.
Since $U^{'}(.)$ is a decreasing function, the preference for lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$ is still ensured if

$$\begin{aligned}
&W-p_BD_B-\phi_B > W-p_AD_A-\phi_A \\
&\Rightarrow W-p_BD_B-(W-p_AD_A) > \phi_B-\phi_A \qquad (7)
\end{aligned}$$

Because $p_BD_B < p_AD_A$, a sufficient condition for (7) to hold is ϕ_i to decrease with the level

of final wealth ($\phi_B - \phi_A < 0$).
The derivative of ϕ_i with respect to the final wealth is:

$$-\frac{\sigma_i^2}{2}\left[\frac{U^{''''}(W+E[\tilde{L}_i]).U^{''}(W+E[\tilde{L}_i]) - [U^{'''}(W+E[\tilde{L}_i])]^2}{[U^{''}(W+E[\tilde{L}_i])]^2}\right] \tag{8}$$

This derivative is negative if $U^{''''}(W+E[\tilde{L}_i]).U^{''}(W+E[\tilde{L}_i]) - [U^{'''}(W+E[\tilde{L}_i])]^2 > 0$. This requires $U^{''''}(.)$ to be "sufficiently" negative. Recall that $U^{''''}(.) < 0$ characterizes temperant decision-makers (Kimball [17]). As a result, only a "sufficient" degree of temperance allows the preference for lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$ to still hold when the value of W increases.

Similarly, consider now a decision-maker who initially prefers the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$. Suppose her initial wealth W increases. The decision-maker still continues to prefer the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$ iff

$$\begin{aligned}
&E[U^{'}(W+\tilde{L}_B)] > E[U^{'}(W+\tilde{L}_A)]\\
&\Rightarrow U^{'}(W+E[\tilde{L}_B]-\phi_B) > U^{'}(W+E[\tilde{L}_A]-\phi_A)\\
&\Rightarrow U^{'}(W-p_BD_B-\phi_B) > U^{'}(W-p_AD_A-\phi_A)\\
&\Rightarrow W-p_BD_B-\phi_B < W-p_AD_A-\phi_A\\
&\Rightarrow W-p_BD_B-(W-p_AD_A) < \phi_B-\phi_A
\end{aligned} \tag{9}$$

For (9) to hold, it is necessary for ϕ_i to (sufficiently) increase with the level of final wealth. So, (8) has to be positive. It is positive as soon as: $U^{''''}(W+E[\tilde{L}_i]).U^{''}(W+E[\tilde{L}_i]) - [U^{'''}(W+E[\tilde{L}_i])]^2 < 0$. $U^{''''}(.) > 0$ is a sufficient condition. As a result, $U^{''''}(.) > 0$, which characterizes an untemperant decision-maker, is a sufficient condition for (8) to be positive. But the degree of untemperance has to be "sufficiently" strong for (9) to hold.

To sump up, we find that a preference for the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$ holds when the decision-maker is "sufficiently" prudent ($U^{'''} > 0$), and this preference is robust to an increase in W when the decision-maker is "sufficiently" temperant $U^{''''} < 0$. This is Point (i) of the Proposition.

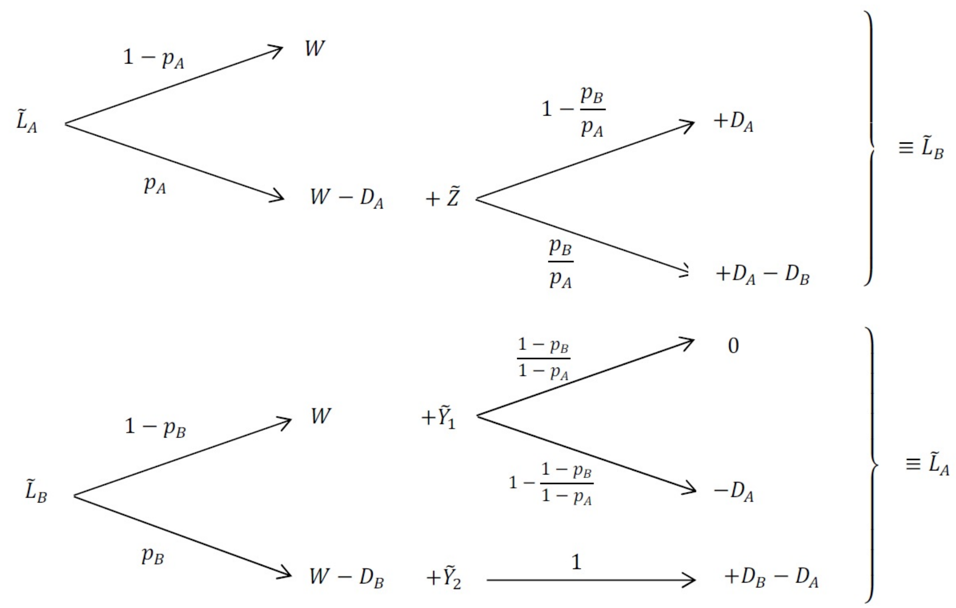
We also find that a preference for the lottery $\tilde{L}_A$ over the lottery $\tilde{L}_B$ holds when the decision-maker is "sufficiently" imprudent ($U^{'''} < 0$), and this preference is robust to an increase in W when the decision-maker is "sufficiently" untemperant $U^{''''} > 0$. This is Point (ii) of the Proposition.

A.4 More details for the interpretation of Proposition 3

The proposition 3 teaches us that only a sufficiently high degree of prudence ensures a risk-averse decision-maker to prefer the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$, for a given level of W (and a sufficiently high degree of temperance ensures the precautionary premium to decrease with W, thus ensuring the preference to be quite robust for any increase in W). The intuition behind this result is not obvious, and merits more attention. Look at the Figure 6 below.

It depicts the lottery $\tilde{L}_B$ as a composition of lottery $\tilde{L}_A$ and another lottery Z, and the

Figure 6: Lotteries A and B as combinations of each other



lottery $\tilde{L}_A$ as a composition of lottery $\tilde{L}_B$ and two another lotteries Y_1 and Y_2.

First, consider the case where $E[\tilde{L}_A] = E[\tilde{L}_B]$, so that any risk averse decision-maker prefers $\tilde{L}_A$ over $\tilde{L}_B$ because $\tilde{L}_A$ stochastically dominates $\tilde{L}_B$ at the second-order. Consider that adding Z to $\tilde{L}_A$ does not change the expected outcome of $\tilde{L}_A$, and adding Y_1 and Y_2 to $\tilde{L}_B$ does not change the expected outcome of $\tilde{L}_B$. However, when adding Z the lottery $\tilde{L}_A$ becomes equivalent to the lottery $\tilde{L}_B$, and when adding Y_1 and Y_2 the lottery $\tilde{L}_B$ becomes equivalent to the lottery $\tilde{L}_A$, so that the preference is reversed.
In that case, the lottery Z is a zero-mean lottery which is added to the lottery $\tilde{L}_A$; and more precisely to the "bad event" of the lottery $\tilde{L}_A$ (losing D_A). Regarding the lotteries Y_1 and Y_2, they are respectively a strictly negative-mean lottery added to the "good event" of the lottery $\tilde{L}_B$ (no loss) and a strictly positive-mean (and degenerated) lottery added to the "bad event" of the lottery $\tilde{L}_B$ (losing D_B). Applying the "*I like to combine good with bad*" principle allows explaining the preference reversal: considering any zero or negative-mean lottery as a "bad" event (while a positive-mean lottery could be seen as a "good event" - or at least a "not so bad" event), adding Z is "combining bad with bad" while adding Y_1 and Y_2 responds to "combining good with bad". So, when adding Z to the lottery $\tilde{L}_A$ the risk-averse decision-maker becomes relatively worse-off.

Consider now the case where $E[\tilde{L}_A] < E[\tilde{L}._B]$. This case requires: $E[\tilde{Z}] > 0$, for the lottery $\tilde{L}_A$ to becomes the lottery $\tilde{L}_B$ (which has a higher expected outcome), and the decrease in the expectation of the lottery Y_1 (with $E[\tilde{Y}_1] < 0$) to offset any positive variation in the expectation of the lottery Y_2 (with $E[\tilde{Y}_2] > 0$). As a consequence, by comparison with the previous case we note that: (i) Z becomes a "good" (or "not so bad" event) which is combined with the "bad event" of lottery $\tilde{L}_A$ to become the lottery $\tilde{L}_B$; (ii) Y_1 becomes a "very bad" event, the weight of which becoming more important than the weight of Y_2 (in order to decrease the overall expected outcome when transforming the lottery $\tilde{L}_B$ into lottery $\tilde{L}_A$). So, for a sufficiently high degree of prudence (*i.e.*, a strong preference for combining good with bad), the "*I like to combine good with bad*" principle allows explaining the preference for the lottery $\tilde{L}_B$ over the lottery $\tilde{L}_A$ when $E[\tilde{L}_A] < E[\tilde{L}_B]$.

B Experimental instruction

This experience is intended for the study of decision-making in a risky situation. You will be confronted with 78 individual decisions that will be divided into two steps, a third step will be a questionnaire on your personal characteristics.

In Step 1, you will make 30 decisions[19]. These decisions will concern choices between two options, called "Option A" and "Option B". The options will be displayed visually using dice of different colors. Gains / losses associated with these options will be expressed in a virtual currency called ECU (Experimental Currency Unit).

Let us consider three examples of options to understand how this first step works.

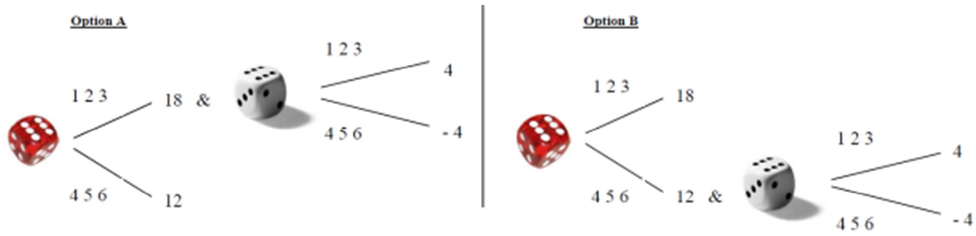
Example 1: You can choose between option A and option B:

- **Option A**: get 4 ECUS with certainty (with 6 chances out of 6).
The red dice and the numbers indicated are interpreted as follows: imagine that a dice is thrown, if the numbers 1, 2, 3, 4, 5 or 6 appeared then you would get 4 ECUS.

- **Option B**:
• Get 13 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 1, 2 or 3 appeared then you would get 13).
• Get 1 ECU with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 1).

Example 2: You can choose between option A and option B:
- **Option A**:
• Get 12 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 12).
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 1, 2 or 3 appeared then you would get 18) and get 4 ECUS more with 1 chance out of 2 (if the white dice was thrown and the numbers 1, 2 or 3 appeared then you would get 4).

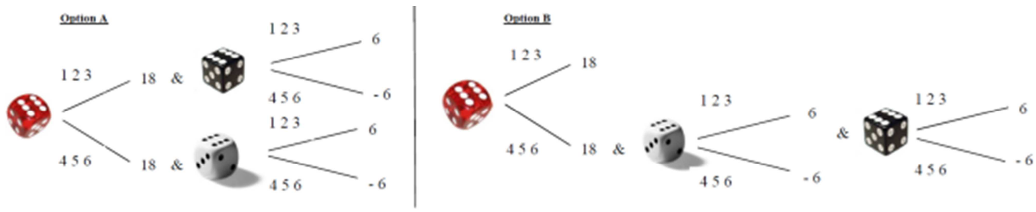
[19] During the experiment, the participants realized the task of Noussair et al. [26] both in the gain and loss domain, *i.e.* 15 choices two times. The results presented in this paper are only about the gain domain.



• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 1, 2 or 3 appeared then you would get 18) and lose 4 ECUS with 1 chance out of 2 (if the white dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 4).

- **Option B**:
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 1, 2 or 3 appeared then you would get 18).
• Get 12 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 12) and get 4 ECUS more with 1 chance out of 2 (if the white dice was thrown and the numbers 1, 2 or 3 appeared then you would get 4).
• Get 12 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 12) and lose 4 ECUS with 1 chance out of 2 (if the white dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 4).

Example 3: You can choose between option A and option B:



- **Option A**:
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 1, 2 or 3 appeared then you would get 18) and get 6 ECUS more with 1 chance out of 2 (if the black dice was thrown and the numbers 1, 2 or 3 appeared then you would get 6).
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 1, 2 or 3 appeared then you would get 18) and lose 6 ECUS with 1 chance out of 2 (if the black dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 6).
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 18) and get 6 ECUS more with 1 chance out of 2(if the black dice was thrown and the numbers 1, 2 or 3 appeared then you would get 6).
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 18) and lose 6 ECUS with 1 chance out of 2 (if the black dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 6).

- **Option B**:
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 1, 2 or 3 appeared then you would get 18).

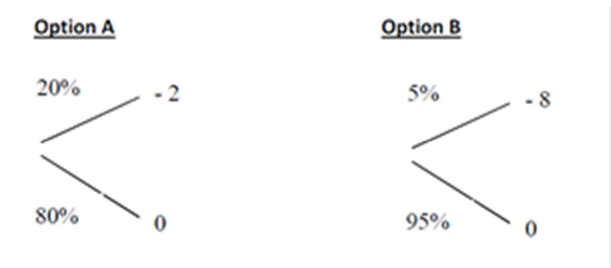
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 18), get 6 ECUS more with 1 chance out of 2 (if the white dice was thrown and the numbers 1, 2 or 3 appeared then you would get 6), and get 6 ECUS more with 1 chance out of 2 (if the black dice was thrown and the numbers 1, 2 or 3 appeared then you would get 6).
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 18), get 6 ECUS more with 1 chance out of 2 (if the white dice was thrown and the numbers 1, 2 or 3 appeared then you would get 6), and lose 6 ECUS with 1 chance out of 2 (if the black dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 6).
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 18), lose 6 ECUS with 1 chance out of 2 (if the white dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 6), and get 6 ECUS more with 1 chance out of 2 (if the black dice was thrown and the numbers 1, 2 or 3 appeared then you would get 6).
• Get 18 ECUS with 1 chance out of 2 (if the red dice was thrown and the numbers 4, 5 or 6 appeared then you would get 18), lose 6 ECUS with 1 chance out of 2 (if the white dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 6), and lose 6 ECUS with 1 chance out of 2 (if the black dice was thrown and the numbers 4, 5 or 6 appeared then you would lose 6).

In each of the situations represented, you will be asked to make a choice: which option do you prefer? These three examples will be reproduced 10 times each with different amounts for gains and losses, so that you will make 30 choices of this type in step 1 of this experiment.

In Step 2, you will make 48 decisions. These decisions will concern choices between two options, called "Option A" and "Option B". The gains/losses associated with these options will be expressed in a virtual currency called ECU (Experimental Currency Unit).

Let us take an example to understand how this second step works.

You can choose between option A and option B:



- **Option A**:
• Lose 2 ECUS with 1 chance out of 5 (20%);
• Do not lose anything and get nothing with 4 chances out of 5 (80%).

- **Option B**:
• Lose 8 ECUS with 1 chance out of 20 (5%);
• Do not lose anything and get nothing with 19 chances out of 20 (95%).

You will have to make 48 such choices, the amounts of gains and losses, and the probabilities associated with these gains and losses varying for each choice.

In step 3, you will answer questions about your personal characteristics (age, gender, studies, etc.).

On a regular basis, instructions will appear on your screen. You must take the time necessary to choose the answers that actually match your preferences. There is no right or wrong answer, just different behaviors to observe. You also do not have time constraints, you have all the time you need. At the end of the experiment, a choice of step 1 and a choice of step 2 will be randomly drawn by the computer to determine your reward for participating. This reward will be a sum of money. The ECU (Experimental Currency Unit) will be converted at the rate of 15 ECUS = €1.

For the purposes of the experiment, you must answer all the questions. Your answers will be recorded by the computer network and processed anonymously. The confidentiality of the information contained in this questionnaire is ensured by the anonymity of the respondent. Your answers will therefore remain completely confidential. The results will be presented in synthetic form in scientific publications, scrupulously respecting the anonymity of the answers. The lack of communication between the participants is a guarantee of success. We ask you not to discuss with the other participants.

During the experiment do not hesitate to ask questions to the organizers. They are at your disposal.

C Average numbers of choices for lottery B, for a given degree of risk aversion, depending on the degree of prudence

Table 10: All treatments

	Risk aversion 2		Risk aversion 3		Risk aversion 4		Risk aversion 5	
Degree of prudence	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)
Prud. 0	3.833333333	3	3.333333333	3	2.55	5	3.25	3
Prud. 1	3.3	10	3.65625	8	3	2	2.833333333	3
Prud. 2	2.826923077	13	2.979166667	12	2.416666667	6	2.65	5
Prud. 3	2.611111111	9	3.222222222	18	2.697368421	19	3.2	5
Prud. 4	3.666666667	6	3	15	3.090909091	11	3.071428571	7
Prud. 5	3.666666667	3	3.464285714	7	2.65	5	2.875	14

Table 11: Low W treatment

	Risk aversion 2		Risk aversion 3		Risk aversion 4		Risk aversion 5	
Degree of prudence	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)
Prud. 0	3.75	2	3.5	2	3.75	1	3	1
Prud. 1	2.5	2	3.666666667	6	2	1	3.25	1
Prud. 2	2.65625	8	3.5	4	2	1	2.5	2
Prud. 3	2.15	5	3.05	10	2.5	9	3.75	1
Prud. 4	3.9375	4	3.045454545	11	3	6	2.25	2
Prud. 5	3.666666667	3	3.6	5	3	3	3.15625	8

Table 12: High W treatment

	Risk aversion 2		Risk aversion 3		Risk aversion 4		Risk aversion 5	
Degree of prudence	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)	Nb of B (average)	N (indiv.)
Prud. 0	4	1	3.25	4	2.25	4	3.375	2
Prud. 1	3.5	8	3.625	2	4	1	2,.625	2
Prud. 2	3.1	5	2.71875	8	2.5	5	2.75	3
Prud. 3	3.1875	4	3.4375	8	2.875	10	3.0625	4
Prud. 4	3.125	2	2.875	4	3.2	5	3.4	5
Prud. 5	n.a.	0	3.125	2	2.125	2	2.5	6