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Risk, Ambiguity and Efficient Liability Rules: An experiment[§]

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Abstract

We conduct experiments to study the incentive effects of strict liability by comparing both regimes, unlimited and limited liability in the domain of risk and ambiguity. We assume that the firm's activities cause a risk of technological disaster and can invest in prevention to reduce the likelihood of accident. We assess Lampach and Spaeter's theoretical predictions. We find on average high levels of investment under limited liability in the domain of risk, consistent with the theory, but lower level of investment in prevention in the domain of ambiguity. We do not find that subjects' degree of optimism affect the decision choice albeit we demonstrate strong evidence in favor of inequity aversion, fairness and risk preferences.

Keywords: Strict liability; Technological disaster; Experiment; Risk; Ambiguity; Optimism
JEL Classification: K13; C91; D81

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1 Introduction

Technological disasters not only trigger human losses and endanger environmental ecosystems but also impact economic stability and growth. In the past tense, several technological accidents occurred, such as toxic waste water spills from mining activities in Spain (1999) and Romania (2000), the Golf of Mexico deep water oil spill (2010), Fukushima disaster (2011) and Bangladesh textile factory collapse (2013). Those incidents have reshaped the industrial organization by public policy calling for stronger prevention measures, efficient compensation mechanism, building sound environmentally technologies and adoption of management of disaster risk reduction. A recent report from the European Environmental Agency (EEA) stresses that in the period 1998-2009 nearly 100 000 fatalities impacted more than 11 million people and caused economic losses of about EUR 150 billion (European Environmental Agency, 2011). In the meanwhile the rapid growing industrialization of contemporary societies and new technologies might produce new potential hazards.

In recent years, public policy has witnessed an increased pace of technological progress that nevertheless challenges the governance of new emerging risks. In this context new emerging technologies (e.g. Nano- and biotechnology, shale gas exploitation, deep sea mining, tar sand extraction) pose potential health and environmental risks and are unequivocally associated with scientific uncertainty. In the meanwhile, the obstacle to design an efficient legal regime for uncertain risks related to new technologies highlights the fact that the regulatory systems need to be flexible and sufficiently balanced. In this context, a legal framework is needed which is predictable enough for operating decision makers albeit should not jeopardize public consent (World Economic Forum, 2015).

In the European Union, the Environmental Liability Directive (ELD) 2004/35/EC[1] and in the United States, the Comprehensive Environmental Response, Compensation and Liability Act[2] (CERCLA) encourage industrial operators to hold appropriate financial security to remedy environmental damage. Nevertheless, the legislative provisions also seek to prevent contamination of future sites by designating strict liability. Public policies pursue to establish efficient environmental instruments, as for instance liability rules, to give injurers an incentive to internalize the social cost of their taken actions (Brown, 1973; Calabresi, 1970; Dari-Mattiacci and De Geest, 2005; Faure, 2010). In general, liability rules engage injurers to restore or compensate for damages caused by their activities. The liability rule that caps the financial liability of the injurer to the value of her net assets at the moment of the accident is called limited liability. In contrast, (strict) unlimited liability is often considered as the rule that shall induce full compensation of victims whatever the firm's assets. It is the intend of this article to pinpoint to strict liability as it remains an open question in the existing literature due to lack of empirical evidence Hansmann and Kraakman (1991); Leebron (1991); Grundfest (1992) whether the regime of limited or unlimited applies as the most suitable and effective liability rule.

[1] Directive 2004/35/EC of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage.

[2] The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601–9675), commonly known as "Superfund law," consists of Public Law 96–510 (Dec. 11, 1980).

For this reason, among others, the incentive effects of tort law is a major focus of technological disaster prevention efforts and understanding firm's behavior in ambiguous situation is crucial for anticipating future paths in decision making and designing effective policy. This paper studies which liability regime (strict) unlimited or limited liability induces the potential injurer (firm) to invest optimally in prevention in the domain of risk and ambiguity. Furthermore, we explore the underlying determinants influencing the decision choice to invest in prevention. We consider in this paper a basic unilateral accident model (Shavell, 1980). We assume that the potential injurer's (firm) activities cause a risk of technological disaster and can invest in prevention to reduce the likelihood of accident. We consider in this paper ambiguity as a situation in which the potential injurer does not know the actual probabilities due to paucity of information[3]. We purport that the lack of information stems from the existence of insufficient scientific evidence about the risks of new emerging technologies. Our theoretical predictions are derived from Lampach and Spaeter (2016). To test these theoretical predictions, we conduct laboratory experiments.

Thus far, there exist solely a few theoretical papers in the literature on law and economics considering the question of ambiguity in civil liability under tort law (Teitelbaum, 2007; Mondello, 2013; Chakravarty and Kelsey, 2016; Jacob, 2015; Lampach and Spaeter, 2016; Pannequin and Ropaul, 2015). Moreover, experimental studies on law and economics in the field of behavioral economics are scarce. Kornhauser and Schotter (1990) analyze the incentive effects of strict liability and negligence rule. King and Schwartz (2000) explore how legal regimes affect the social welfare. Koch and Schunk (2013) compare the effect of limited and unlimited liability in the context of risk and ambiguity for auditors. Pannequin and Ropaul (2015) investigate the effects of liability regimes on the demand for both insurance and self-insurance. Our experiment is close to Angelova et al. (2014) who study the effect of liability rules for managing environmental disaster. The main difference between our experimental framework and theirs is that we introduce ambiguity and focus on the strict liability rule (unlimited and limited). Besides, we allow for the occurrence of possible losses, which will be compensated at the end of the experiment by a show-up fee. To the best of our knowledge, this is the first experiment that examines the performance of strict but limited liability in an ambiguous environment. A further novel aspect of our experimental study is that we adopt the modified dictator game (MDG) according to Blanco et al. (2011) to elicit subjects' fairness preferences in the domain of losses (Zhou and Wu, 2011).

In line with theory, our experimental results show that underinvestment in prevention under limited liability in the domain of risk does not systematically occur. It also appears from this research that subjects invest more under unlimited liability in the domain of ambiguity compared to risk. Still, we find two results inconsistent with the theoretical predictions. We do not observe on average higher levels of investment in prevention under limited liability in the domain of ambiguity and subject's degree of optimism does not affect the decision choice. Finally, we find strong evidence related to inequity aversion, fairness and risk preferences

[3] Dequech (2000) discusses the fundamental distinction between ambiguity and uncertainty.

The remainder of this article is organized as follows. Section 2 presents the theoretical predictions. Section 3 outlines the experimental design and procedures. Section 4 presents the empirical results by comparing the different treatments through non-parametric statistical tests. Moreover, we summarize the results of panel data estimation. Section 5 concludes and discusses several limitations of the study. Proofs, additional material and the questionnaire can be found in the appendices A, B and C.

2 Economic Theory and Predictions

We consider the theoretical predictions given by a simple accident model in which the activity of a party involves a risk of accident. The model is based on the unilateral accident model proposed by Shavell (1980). There are two agents, a potential injurer[4] and a representative victim. The legal rule defines who, in Society, shall bear the loss. Under strict liability, the potential injurer is required to compensate the third party regardless of the behavior that has led to the damage. Two regimes are at stake. Under the regime of unlimited liability, the injurer has to pay *ex post* for all the damage caused by her activity whatever her level of prevention and level of assets. Under the regime of strict but limited liability, the injurer's compensation payment is limited to her net value, which can never be negative under this regime; otherwise the firm enters into bankruptcy. In what follows, we consider a risky - and subsequently an ambiguous activity. We follow Lampach and Spaeter's theoretical predictions.

2.1 Strict liability and risk

When an accident occurs, the loss for Society is $l > 0$. We denote as d the payment made by the injurer to the victim if an accident occurs: We have $0 < d$ in case of strict liability, and $d = 0$ in case no liability rule is put in place. Hence, in the absence of liability all accident losses fall on the victim and no compensation fee will be paid by the injurer. The probability π of an accident, with $\pi \in [0, 1]$, depends on the monetary amount x invested by the injurer in prevention, with $x \in [0, \bar{x}]$ and $\bar{x} > 0$. We assume $\pi^{'}(x) < 0$ and $\pi^{''}(x) \geq 0$. The potential injurer makes a net, fixed and exogenous benefit b over production. To consider bankruptcy, we assume that $b < l$ even with no investment at all in prevention, the firm can make negative profits in the case of an accident, depending on the liability regime at stake, as formalized below.

Following Shavell (1980), we assume risk neutrality for both parties, the potential injurer and the potential victim[5]. The social optimal level of prevention x^S is the solution of the program:

$$\max_{x} E(\tilde{W^S}) = b - \pi(x)l - x \tag{1}$$

- **Strict and unlimited liability**

[4] A firm whose activity is risky for Society for instance.

[5] The theoretical results hold for risk neutrality and risk aversion.

Under strict and unlimited liability (UL), the damage needs to be fully compensated by the injurer even if it exceeds her net wealth. The private program is

$$\max_x E(\tilde{W_{UL}^P}) = b - \pi(x)d - x, \qquad \text{with} \quad d = l,$$

fitting with the social program (1). As a consequence, well known in the literature, the optimal private level of prevention x_{UL}^P equals the social one x^S. It satisfies the first order condition

$$-\pi^{'}(x_{UL}^P)l = 1, \tag{2}$$

where the left (right)-hand-side term being the expected marginal benefit (cost) of one additional unit of prevention.

- **Strict but limited liability**

Under strict but limited liability (LL), the injurer's maximum payment, denoted as $\hat{d}$ is limited to her net value, which can never be negative under this regime. Hence, $\hat{d} = b - x < l$. Thus, the injurer obtains value only in the non-accident state (which occurs with probability $1-\pi(x)$) and the bankruptcy level $\hat{d}$ is endogenous to the model and depends on x. In such a situation, the injurer considers the private program

$$\max_x E(\tilde{W_{LL}^P}) = (1 - \pi(x))\hat{d}(x),$$

and the private solution x_{LL}^P satisfies the following first-order-condition:

$$-\pi'(x_{LL}^P)\hat{d}(x_{LL}^P) = 1 - \pi(x_{LL}^P) \tag{3}$$

By comparing 3 with (2), we conclude that both the expected marginal benefit and the marginal cost are impacted by the judgment proof property displayed by limited liability. And it is not true, contrary to what is often argued in the literature (Summers (1983), Shavell (1986), Shavell (1987) and Brander and Spencer (1989)), that LL induces always less prevention than UL. These authors stress that the potential for bankruptcy implies a reduction in prevention levels under limited liability, as the potential injurer do only care about the costs she has to pay.

We summarize the results for risk and strict liability in Proposition 1 derived from Lampach and Spaeter (2016) hereafter.

Proposition 1 *Let us assume that the injurer is an expected utility maximizer and that the bankruptcy threshold $\hat{d}$ is endogenous, with $\hat{d} = b - x$.*
(i) Under unlimited liability, the injurer invests optimally in prevention. Formally $x_{LL}^P = x^S$.
(ii) Under limited liability, the injurer can invest either more or less in prevention than the social optimal level. Formally $x_{LL}^P \lesseqgtr x^S$ in optimum.

As a part $(l - \hat{d})$ of the loss is externalized toward the victims, both the expected marginal benefit and marginal cost of prevention decrease (compare (3) to (1)). There are two relevant points for the firm to invest either more or less in prevention. Hence part of the cost of prevention is recovered by the potential injurer since they are deduced from her assets before compensation. As a direct consequence, it could be profitable for her to invest even more in prevention than the social optimum. This result was obtained earlier by Beard (1990) and Lipowski-Posey (1993). Furthermore, Dionne and Spaeter (2003) also find this result by considering limited liability for the potential injurer and extended liability for the bank[6] which finances the potential injurer. In these three papers the firm is financed by an outside lender, contrary to what is considered in Lampach and Spaeter (2016), where the prevention investment is financed by the exogenous benefits coming from production. Here, victims have to bear part of the loss which can be seen as extending the (financial) liability toward them[7].

Finally, contrary to the first intuition, limited liability does not systematically imply underinvestment in prevention: Whenever the marginal cost declines more rapidly than the expected marginal benefit, the potential injurer invests more in prevention than the social level. We implicitly assess this result in section 4.

2.2 Modeling ambiguity of civil liability

Following Lampach and Spaeter (2016), we use the NEO-expected utility (NEO-EU) model axiomatized by Chateauneuf et al. (2007) to include ambiguity in the basic unilateral accident model. NEO-EU is a special case of Choquet expected utility model (Gilboa, 1987; Schmeidler, 1989) with a Non-Extreme-Outcome ,additive (NEO-additive) capacity.

The injurer is a NEO-EU maximizer whose beliefs about the "preliminary" probability π of an accident announced by the regulator can be represented by a behavior-additive capacity (Chateauneuf et al., 2007). The injurer behaves in such a situation in the sense as if she had an additive probability distribution but questions whether this distribution is the true one (Dominiak and Lefort, 2013). More precisely, she believes that this so-called preliminary probability π is the true probability with a degree of confidence δ, with $\delta \in [0, 1]$. Nevertheless, another level of risk shall be considered by the potential injurer with a degree of confidence $1 - \delta$. This other level of risk is a subjective and personal belief denoted $q(\alpha, x)$. More precisely, Lampach and Spaeter (2016) suppose that the subjective belief depends on the injurer's degree of optimism, denoted α with $\alpha \in [0, 1]$, and her investment in prevention x. The injurer is optimistic when $\alpha > 0.5$, pessimistic when $\alpha < 0.5$ and ambiguity neutral when $\alpha = 0.5$. The authors suppose that $q_\alpha < 0, q_x \leq 0$ and $q(\alpha, 0) \lesseqgtr \pi(0)$ for $\alpha \lesseqgtr 0.5$.

This assumption on $q(\alpha, x)$ differs, to a certain extent, from Teitelbaum (2007) and Mondello (2013). Indeed in their setting, the subjective belief only depends on the degree of optimism albeit not on prevention.

[6]The bank must pay for the extra damage whenever the potential injurer is pushed into bankruptcy and cannot fully compensate the victims.

[7]See also Dari-Mattiacci and De Geest (2006).

- **Strict and unlimited liability**

Under strict and unlimited liability, the injurer computes the following program:

$$\max_x E(\widetilde{W_{UL}^{amb}}) = \delta[\pi(x)(b-x-l) + (1-\pi(x))(b-x)] + (1-\delta)[q(\alpha,x)(b-x-l) + (1-q(\alpha,x))(b-x)]$$
$$= b - x - [\delta\pi(x) + (1-\delta)q(\alpha,x)]l \quad (4)$$

We summarize hereafter the theoretical results of Lampach and Spaeter (2016) that we assess afterwards.

Proposition 2 *(Lampach and Spaeter, 2016) Let us assume that the injurer is a NEO-EU maximizer*
i) If the beliefs she builds on the accident state in the non-confident scenario is independent on her level of prevention, then she always invests less in prevention than in the risky, non-ambiguous environment. Formally if $q_x = 0$ then $x_{UL}^{amb} < x_{UL}^{P} = x^S$. This results holds whatever her degree of optimism α and degree of confidence δ.
ii) In the case $q_x < 0$, the injurer invests more in prevention than the social optimum if the probability of accident announced by the regulator is less sensitive to prevention than her own subjective belief. This result holds whatever her degree of confidence in the regulator's announcement. Formally we have $x_{amb}^{UL} \lesseqgtr x^S$ iff $\left|\pi'(x^S)\right| \gtreqless \left|q_x(\alpha, x^S)\right|$, $\forall\delta < 1$.
iii) The more (less) optimistic the injurer, the higher (lower) her private level of prevention if and only if $q_{x\alpha} < 0$ (> 0).

Point i) is rather immediate and has also been obtained by Teitelbaum (2007) and Mondello (2013). The subjective belief of the injurer is not interfered by prevention. Thus the only probability that can be impacted by prevention is the one announced by the regulator, namely π. But its effect is only considered by the regulator with a degree of confidence $\delta < 1$, so that the marginal benefit of prevention is lower than the marginal benefit obtained in the setting only with risk.

Point ii) is more interesting and considers the possibility for the injurer to affect her personal and subjective belief by investing in prevention. The level that she will invest in optimum depends on the relative efficiency of prevention on the probability $\pi(.)$ and the weight $q(\alpha, .)$. Two important points shall be noticed. This result does not depend on her degree of confidence δ. Indeed even if the injurer is highly confident (high δ) in the announcement π made by the regulator, she will underinvest in prevention if her personal belief q (considered with a degree of confidence $1-\delta$) is relatively insensitive to prevention. The explanation is straightforward: In the first scenario[8] (Risk) the announcement of π made by the regulator is considered as identical to the scenario under risk. Thus, this first scenario yields the same unit marginal benefit and unit marginal cost as in the situation with risk. The changing point is that a second scenario emerges in the ambiguity case: The possibility that the injurer considers alternatively a subjective belief q of accident. In this second scenario, she compares the sensitivity of q to x with the

[8]For more details see Lampach and Spaeter (2016).

sensitivity of π to x whatever her degree of confidence over this second scenario. In particular, she will invest more whenever she believes that her prevention better controls "her" probability q compared to the marginal impact π_x considered by the regulator.

From point iii), we deduce that optimism plays an important role. Indeed, if a more optimistic injurer believes that she has more control (Is more effective in reducing q) on the probability of occurrence than a less optimistic injurer ($q_{\alpha x} < 0$) then prevention becomes more profitable. As a result, she decides to invest more in prevention albeit it does not mean that she invests more than the social optimal level. This will depend on the property reported in point ii).

- **Strict but limited liability**

Under strict but limited liability, the injurer's maximization program writes

$$\begin{aligned} E(\widetilde{W_{LL}^{amb}}(x)) &= \delta[(1-\pi(x))\hat{d}(x)] + (1-\delta)[(1-q(\alpha,x))\hat{d}(x)] \\ &= [(1-\delta)(1-q(\alpha,x)) + \delta(1-\pi(x))]\hat{d}(x), \end{aligned} \tag{5}$$

with $\hat{d}(x) = b - x$. In this expected wealth, only the no accident state matters since no wealth is available in the accident state: all the assets are confiscated for compensation as previously in the risky environment. Consider the following notation:

$$j(\alpha,\delta,x) = \delta(1-\pi(x)) + (1-\delta)(1-q(\alpha,x)) \tag{6}$$

Function $j(\alpha,\delta,x)$ plays the role of a synthetic weight put on the no-accident state by the injurer. It depends on personal trait such as α, personal beliefs δ, and individual decision x. For an interior solution x_{LL}^{amb}, the first-order-condition of Program (5) writes:

$$j_x(\alpha,\delta,x_{LL}^{amb})\widehat{d}(x_{LL}^{amb}) = j(\alpha,\delta,x_{LL}^{amb}) \tag{7}$$

Recall the first-order-condition (3) that holds in case of risk and limited liability and write it

$$\left|\pi'(x_{LL}^P)\right| \hat{d}(x_{LL}^P) = 1 - \pi(x_{LL}^P) \tag{8}$$

In both first-order-conditions, (7) and (8), the left-hand-side term is the expected marginal benefit of prevention, while the right-hand-side term is the expected marginal cost of prevention. In both cases, the expected marginal cost of one unit invested in prevention is no longer one. Indeed, this one unit of expense impacts the available wealth of the injurer only in the no accident state, which occurs with probability $(1-\pi(x))$ in the risky situation, while it is weighted by the subjective synthetic weight $j(\alpha,\delta,x)$ in the model with ambiguity. As a direct consequence, the variation of the expected marginal cost of prevention when moving from risk to risk and ambiguity depends simultaneously on the injurer's degree of optimism α and degree of confidence δ in the regulator's announcement. In the meantime, the expected marginal benefit (left-hand-side term) in case of ambiguity is also affected by the degree of confidence and the ambiguity attitude of the injurer, but not only. The efficiency of the prevention technology also matters. This is captured by $j_x(\alpha, \delta, x_{LL}^{amb})$ in (7) and it also matters in risk: it is captured by $\left|\pi'(x_{LL}^{P})\right|$ in (8). Finally, several different configurations are at stake when considering the injurer's ambiguity attitude, her degree of confidence and her belief in her ability to make change through prevention and the subjective probability of accident she builds in the non-confident scenario.

Proposition 3 *(Lampach and Spaeter, 2016) Let us assume that a regime of limited liability holds and that the injurer is a NEO-EU maximizer.*

It is not possible to conclude about the optimal level of prevention under ambiguity compared to risk, whatever the agent's degree of confidence and degree of optimism, even though $j_x(\alpha, \delta, .)$ and $|\pi'(.)|$ can be ranked.

As in the unlimited liability case, we are not able to conclude in the theoretical model about the sign of the difference between the optimal level of prevention in risk and ambiguity. We test some specific hypotheses in the experiments hereafter.

2.3 Hypotheses

In summary, the economic theory predicts rather ambiguous results in the domain of ambiguity as well as in risk. We are particularly interested in some specific cases for which we need to adjust the parameters of our experimental design to test the following hypotheses (Lampach and Spaeter, 2016).

Hypothesis 1:. *Under limited liability, a potential injurer will invest more in prevention than under unlimited liability in the domain of risk (Proposition 1 i)).* Hence, we test this theoretical prediction that a potential injurer will invest more in prevention under limited liability compared to the social optimal level.

Hypothesis 2:. *Under unlimited liability, a potential injurer will invest more in prevention in the domain of ambiguity than in the domain of risk (Proposition 2 ii)).* We test this theoretical prediction under some specific conditions while setting the parameters of the experiment to satisfy the required condition.

Hypothesis 3:. *Under limited liability, a potential injurer will invest more in prevention in the domain of ambiguity than in the domain of risk (Proposition 3).* As the result is ambiguous, we cannot even test a theoretical prediction under specific condition. As a consequence, we claim that the potential injurer will invest on average higher levels of investment under limited liability in the domain of ambiguity compared to risk.

Hypothesis 4:. *Under ambiguity, an optimistic injurer will invest more in prevention than a pessimistic injurer (Proposition 2 iii).* We test this theoretical prediction under some condition while adjusting our parameters to satisfy the required condition.

Furthermore, we aim to identify the underlying determinants (inequity aversion, risk aversion, degree of optimism and degree of confidence) affecting the decision choice to invest in prevention.

3 Experimental Design

We run four different games for the same sample size of experimental subjects and employ a between subject design. The experiment comprises two parts. The first part of the experiment encompasses three distinct tasks to elicit subject's attitudes toward advantageous inequity, risk and ambiguity. The second part of the experiment features the main experiment.

3.1 Procedure

We conduct two sessions per treatment and run a total of 8 sessions[9], with 20 subjects in each session, in the Economic Experimental Laboratory at the University of Strasbourg (France). The subject pool consists of 160 undergraduate students from the University of Strasbourg which participate in November 2015 in the experiment. Subjects are recruited through ORSEE[10]. We are also interested in whether subjects have an economic background. Out of those taking part in the sessions, the majority (70%) study a quantitative subject such as Economics, Chemistry, Biology, Life Sciences, Engineering or Mathematics while others study a non-quantitative subject such as Psychology, Political Science, History or Language. All experiments are run on personal computers and the experiment is programmed in *EconPlay*[11].

The payoffs are denominated in a fictitious currency called Experimental Currency Unit (ECU) for Task 4 and convert into Euros at the end of the experiment at rate known by subjects. On average subjects earn €26 and the experiment lasts a maximum of 1 hour and 15 minutes, excluding payment.

Subjects arrive at the laboratory and are randomly assigned to a cubicle. In total, subjects receive four sets of instructions[12] consecutively. Subjects are allowed to read the instructions by their own pace and are also read aloud by an experiment administrator. Subjects have the opportunity to ask questions and the administrator answers any question individually. The experiment administrator ensures that everyone has understood the four different tasks. The corresponding computer screen is displayed and subjects submit their decisions. Once all participants have entered their decisions in for each task, the instructions for the following task are distributed. Upon completion of the fourth instruction task, subjects answer clarifying questions[13].

[9] We have four treatments and repeat each one twice.

[10] A web-based Online Recruitment System for Economic Experiments developed by Greiner (2015).

[11] The program of this experiment has been designed by Kene Boun My with the web platform EconPlay (`www.econplay.fr`).

[12] Experimental protocols can be found in Appendix C.2.

[13] Subjects complete a quiz compromising in total 10 questions. Four out of the ten questions refer to the calculation of the earnings.

3.2 Task 1 - Elicitation of advantageous inequity aversion

We employ the MDG[14] (Task 1), according to Blanco et al. (2011), to elicit subjects fairness preferences[15] in the domain of losses (Zhou and Wu, 2011). All subjects initially undertake the first task and are presented with a list of 10 pairs of payoff vectors. They are asked to choose sequentially one of the two payoff vectors of the corresponding line. This game is known in the literature as the MDG in which the dictator (Player A) has to decide about how much of the initial amount he is willing to sacrifice to Player B (advantageous inequity aversion) to attain equal distribution of payoffs (Blanco et al., 2011). The left payoff vector[16] is always (€0,€-10) and the right payoff vector contains equally payoffs varying from (€-10,€-10), (€-9,€-9) throughout to (€0, €0). Subjects receive an endowment of €10. Each subject made a choice as to the role of the dictator (Player A). At the end of the experiment, subjects are randomly assigned to player A or B and one of the 10 payoff vector pairs is randomly chosen by the computer to determine the payment.

3.3 Task 2 & 3 - Elicitation of risk and ambiguity aversion

According to Chakravarty and Roy (2009), we apply the multiple price list (Holt and Laury, 2002) in the domain of losses to elicit subject's attitudes toward risk (Task 2) and ambiguity (Task 3). Before starting with the task, subjects are asked to choose the color blue or yellow (The chosen color constitutes the winning color and remains the same for the subsequent tasks.). In task 2 (Risk task) and task 3 (Ambiguity task), subjects are provided with a series of binary choices in the domain of losses. Each task table comprises 2 options (Left or Right) for a path of 10 decisions. The Right option is represented by losing a sure amount of money varying between €-10, €-9 all the way to €0. The left option in the domain of risk (Risk task) is captured by losing a one in two chance, with known probability, €0 or €-10. The left option in the domain of ambiguity (Ambiguity task) is sketched by losing with unknown probability €0 or €-10. Subjects are instructed to report their risk and ambiguity preferences by choosing sequentially one of the two options, Left and Right, for the course of the 10 decision choices.

3.4 Task 4 - Main Experiment

According to Angelova et al. (2014) and Blanco et al. (2011), the experiment consists of MDG, in which subjects face individual decisions for a sequence of ten rounds. In the fourth task, we apply four distinct treatments in the experiment. Table 1 briefly sketches the different treatments. They differ in the liability regime (UL, LL) and in the presence of risk (RK) and ambiguity (AMB).

[14] In the experimental literature, the term "Modified Dictator Game" is well established and used in different context. See for further details Andreoni and Miller (2002); Fisman et al. (2007); Heinrich and Weimann (2013).

[15] We refer to Fehr and Schmidt (1999) model of inequity aversion by meaning that individuals do not only care about their own payoffs but also care about other's payoffs. Advantageous inequity implies that an individual harms another part.

[16] The first (second) element of the payoff vector is associated to player A's (player B's) payoff.

Table 1: Treatment

	Strict and unlimited liability	Strict but limited liability
Risk	RK-UL	RK-LL
Ambiguity	AMB-UL	AMB-LL

Recall that both liability regimes differ in whether the injurer could fully (UL) or partially (LL) compensate the victim. At the beginning of the ten rounds, subjects are randomly assigned to roles (X and Y) and X-Y[17] pairs. In line with Angelova et al. (2014), one can think of player X as the potential injurer and player Y as the victim. During the 10 rounds, player Y is affected by the decision of player X but cannot anticipate (stays passive). Subjects face individual decisions in a non-strategic set-up. Hence, we recompose randomly the groups for each round so that the probability of being re-matched with the same person is exactly zero[18]. All subjects decide as if they would be assigned to role X.

In each of the 10 rounds, with a probability of $\pi(x) = \frac{(a-x)}{(b+x)}$ in the RK and $q_i(\alpha, x) = \frac{a_i - x}{b_i + x^{2\alpha}}$ in AMB treatment, an event would occur and lead to a loss of endowment by both, X and Y. Note that we are determining the parameter $a = 98$ and $b = 113$ in RK treatment. For the AMB treatment, we determine $\alpha = 0.5$ (degree of optimism/pessimism), $a_i = 104, 101, 98, 95, 92$ and $b_i = 107, 110, 113, 116, 119$ with $i = A, B, C, D, E$. In this way, we specify five different probability functions based on the variation of the parameter a and b and presenting them to the subjects, named as "Urn A", "Urn B", "Urn C", "Urn D" and "Urn E".

According to Attanasi et al. (2014), we use a two-stage lottery to represent ambiguity to subjects. In the first stage, the 100-ball small urn is generated from an opaque big urn containing 100 small urns of urn A, urn B, urn C, urn D and urn E in an unknown composition. We randomly draw one 100-ball small urn from the big urn. In the second stage, we randomly pick one ball from the drawn urn comprising 100 balls of blue and yellow balls in a precisely known composition.

At the beginning of Task 4, subjects receive the information that "Urn C" will have a higher chance to be drawn than the other four urns. Nevertheless, the information does not have any effect on the five different probability/urn configurations. Subjects were free to believe whether the supplementary information is true or not. We introduce this information due to Lampach and Spaeter (2016) theoretical framework, who are modelling ambiguity with NEO expected utility model. Recall that an injurer in an ambiguous environment believes with a certain degree of confidence that the probability announced by the regulator will be the true one. Hence, this requires us to add additional information to adjust our experimental design to the theoretical model. In overall one probability configuration in RK and five probabilities in AMB treatment are at the issue.

We provide subjects in the RK treatment with an easily understandable payoff table. In AMB treatment, we supply subjects with a simulator, which returns the number of balls of their chosen color

[17] To avoid a framing effect, we intentionally name both roles differently than those in Task 1.
[18] (Morton and Williams, 2010, p230) define perfect stranger matching as "in which researchers make sure that subjects always face a new set of other players and the contamination from previous play is not possible".

in the urns and payoffs of player X and Y according to the amount of investment. Furthermore, we explain to the subjects that payoffs in each round will depend on two random draws.

Player X is endowed with two pockets. It is such as if the potential injurer's *partner* pocket is endowed by the shareholder's capital, which is protected under limited liability (but not under unlimited liability) and the *benefit* pocket is endowed by the benefit from the production of a new innovative product.

Table 2 indicates the initial endowment of player X and Y for the different treatments.

Table 2: Endowment

	Strict and unlimited		Strict but limited	
	Partner pocket*	Benefit pocket	Partner pocket*	Benefit pocket
X : The potential injurer	100 ECU	80 ECU	100 ECU	80 ECU
Y : The potential victim	90 ECU		90 ECU	

*Note: Experimental Currency Unit (ECU); *: Show-up fee*

Subject X receives a one-time show up fee of 100 ECU which compensates potential losses. During each round, subject X receives an endowment of 80 ECU and subject Y receives an endowment of 90 ECU. Note that 10 ECU worth 1 Euro. In case an event occurs the victim will face a loss of her entire wealth but will be compensated by the injurer. Under UL treatment, subject X will have to fully compensate the victim (Player X's payoff can be negative). Under LL treatment, subject X can solely compensate subject Y up to their net endowment (Endowment minus investment cost). In this case, player X's payoff cannot be negative. In each round subject X is asked to decide whether she wants to reduce the probability of an event by investing the amount of 0, 20, 40, 60 or 80 ECU. In the RK and AMB treatment, it is explained to subjects that a higher amount of investment will cause that a higher number of balls of their chosen color (winning color) will be in the urn (See Appendix B.1 for more details). Table 3 sketches player X and Y's payoffs for unlimited and limited liability in the domain of risk and ambiguity.

Table 3: Payoffs

Unlimited Liability	Decision choice				
	0 ECU	20 ECU	40 ECU	60 ECU	80 ECU
Winning color	(80; 90)	(60; 90)	(40; 90)	(20; 90)	(0; 90)
Other color	(−10; 90)	(−30; 90)	(−50; 90)	(−70; 90)	(−90; 90)

Limited Liability	Decision choice				
	0 ECU	20 ECU	40 ECU	60 ECU	80 ECU
Winning Color	(80; 90)	(60; 90)	(40; 90)	(20; 90)	(0; 90)
Other color	(0; 80)	(0; 60)	(0; 40)	(0; 20)	(0; 0)

Note that: Player X and Y's payoffs are given in parentheses

Furthermore, subjects respond to a detailed post-questionnaire[19] consisting of 44 questions related to socio-economic status, altruism and risk preferences. Furthermore, we aim to gauge information about subject's degree of inequity, confidence, optimism and trust by using questions from psychology literature. More precisely, subjects are asked to express their agreement with 8 items regarding subject's fairness preferences according to the belief in justice world scale (Lucas et al., 2013). The first set of questions refers to subject's fairness preferences with respect to others (Distributive Justice for Others) and next set of questions with respect to themselves (Distribute Justice for Self). Subjects were asked to express their agreement on a 7-point Likert-type scale ranging from 1 (Strongly Agree) to 7 (Strongly Disagree). Furthermore, we ask subjects to express their level of confidence (Keller et al., 2011), optimism (Wimberly et al., 2008; Vautier et al., 2003; Scheier and Carver, 1992) and trust[20] (Yamagishi, 1986; Yamgishi and Sato, 1986) using a value between 1 (Strongly Agree) to 5 (Strongly Disagree).

3.5 Discussion of the design

We decide not to allow multiple switching[21] in task 1, task 2 and task 3. We are simply telling subjects directly that we are interested in the amount for which they switch from preferring to gamble (by playing the lottery) or to receive the sure amount of money. To suppress any order effects, we are modifying the sequence of task 2 and task 3. Subjects receive an endowment of €10 for each of the

[19] See Appendix C.3 for details and further information about the post-questionnaire.

[20] It is important to bear in mind that the referents of trust are characterized by agents and the referents of confidence are characterized by objects or systems (Keller et al., 2011). More explicitly, trust is associated with values and intentions and confidence is associated with performance (Rotter, 1967). We deem that both, confidence and trust are relevant measures to disentangle the degree of ambiguity.

[21] In the literature, there still lacks a compliance whether multiple switching may be indicative of indifference or whether subjects do not understand the task. For this reason, we decide to allow subjects to switch solely once (Vieider et al., 2015; Charness et al., 2013).

three tasks to compensate potential losses. At the beginning of the first part of the experiment, we inform subjects that the computer randomly selects one decision for each of the three tasks.

In Task 4, we do not inform subjects until the end of the ten rounds about their role. We acknowledge that subjects could expect to have a one in two chance to be at the end of the experiment player Y. Accordingly this might affect subject's behavior. In a trust game it appears that playing both roles has an effect on trust and reciprocity (Burks et al., 2003). Furthermore, Brandts and Charness (2011) reviews the literature whether the strategy method leads to different results. They conclude that more studies find no differences than studies that do. According to the literature, we decide to apply this well established design (Blanco et al., 2011; Angelova et al., 2014) owing to probe treatment effects. Moreover, this approach permits to increase the sample size and thus to enhance the predictive power of statistical tests and panel regression analysis. Furthermore, we decide to include repetition in this task. The main reason for this was due to the mainly complex representation of ambiguity to subjects. Our fear was that in a once repeated one-shot game, subjects would make random decision choices when they do not understand the game. We are of the opinion that in our case repetition amplifies the comprehension of the game, specifically for the ambiguity treatment.

Furthermore, the novel aspects in our design are that we introduce a two pocket endowment and allow for potential losses being compensated at the end of the task. This is different from Angelova et al. (2014) as we include a framing effect that subjects could feel potential losses, which are compensated at the end of the game. Nonetheless, we are convinced that our experimental design captures a realistic depiction of both liability regimes by embedding a two pocket mechanism.

We implement a twofold feedback mechanism. First, during each round subjects are informed about their decision choice, whether their winning color has been drawn and the payoffs of player X and Y. Second, at the end of the 10 rounds, subjects are informed about their ten decision choices, whether their winning color has been drawn, the payoffs of player X and Y and the urn drawn in the case of AMB treatment[22] and actual role.

We adopt the random payment incentive mechanism as payment method in this experiment. When subjects face a sequence of decision choices, the main problem is that earnings on the previous periods may influence behavior in the later periods. Davis and Holt (1993) propose to apply a random selection of the payment to control for wealth effects. Furthermore, if subjects know that they will be paid for a random round, thus they treat each decision with care (See for further detail Charness and Genicot (2009)). For instance, once subjects have made all their decisions, we have randomly chosen one subject to pick at random a number between 1 and 10 indicating the round of task 4 which will be paid out. After completing the questionnaire, subjects randomly choose one row of task 1, task 2, and task 3 for which they will be paid out. All random draws are independent from each other. We used the computer to simulate the draws in the four tasks.

[22] We were not given any feedback information during each round about which small urn has been picked among the five to suppress any revision of subject's beliefs in the AMB treatment.

4 Results

To present our results, we proceed as following. First, we will investigate our hypothesis while comparing the investment in prevention under both liability regimes (unlimited and limited) and both domains (risk and ambiguity). Second, we compare our theoretical predictions (Optimal level) with subject's actual decision choices. With respect to our theoretical framework, we grasp whether optimists are chiefly investing higher levels in prevention compared to pessimists. Third, we will discuss the "learning effect" and "end-game effect" which might affect subject's choices of investment in prevention. Finally, we apply Random Effects Ordered Probit (REOP) estimations to analyze accurately which underlying determinants are affecting the investment in prevention.

4.1 Empirical results

For a general overview of the results, Table 4 summarizes the descriptive statistics for the average investment in prevention within each treatment. We need to emphasize that we are running two sessions per treatment as a consequence we pool the data within each treatment.

Table 4: Aggregated (pooled) average investment per treatment

	Risk & Unlimited	Risk & Limited	Ambiguity & Unlimited	Ambiguity & Limited
Average investment (SD)	23.40 (12.46)	33.00 (11.25)	28.85 (11.30)	28.50 (12.46)

Note: With N=1600 observations

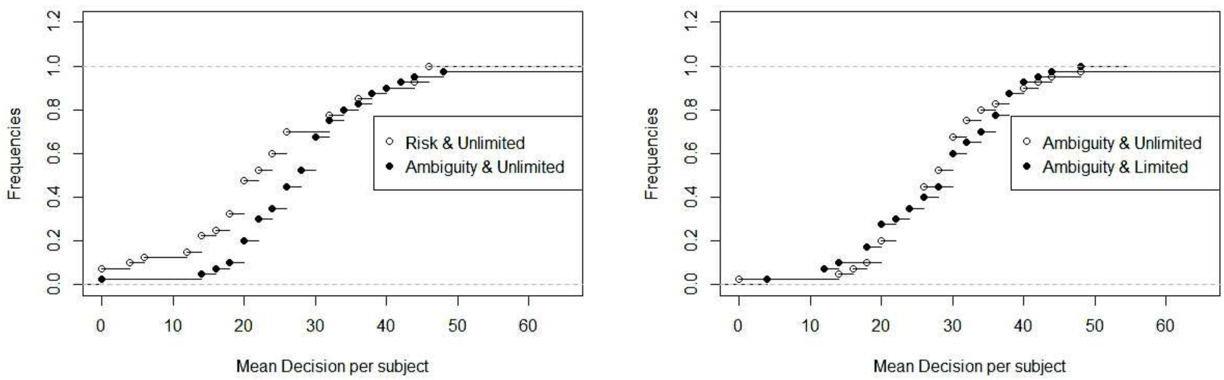
The results reported in Table 4 show that the average investment in prevention is the highest under RK-LL, lower under AMB-LL, lower under AMB-UL and the lowest under RK-UL. We investigate a one-tailed Kolmogorov-Smirnov (KS hereafter) test[23] test to assess whether the differences in treatment are significant by comparing pairwise the cumulative distribution function of the average investment across treatments. We apply a bootstrap[24] version of KS test to generate reliable results. To verify the robustness of the statistical test, we perform alternatively Mann-Whitney (MW hereafter) test.

Figures 1a and 2b illustrate that the cumulative distribution function of the average investment under RK-LL is significant higher than under RK-UL (KS test $p = 0.001$ and MW test $p = 0.000$) and under AMB-LL (KS test $p = 0.082$ and MW test $p = 0.023$). The first result is consistent with our model prediction (Hypothesis 1): The aggregated level of investment in prevention is higher under the regime of limited compared to unlimited liability in the domain of risk. Hence, we show that underinvestment

[23]We are in favor of applying KS test due to the hypotheses which are not based in a measure of central tendency (mean, median). Besides, the hypotheses of the KS test essentially relate to the equality of the two distribution functions. For a review on non-parametric tests, see Siegel and Castellan (1988).

[24]Bootstrapping allows for robust estimation of sampling variances, standard errors and confidence intervals by resampling a given data set a specified number of times.

in prevention under limited liability does not systematically occur. Moreover, figure 2a shows that the cumulative distribution function of the average investment under AMB-UL is significant higher than under RK-UL (KS test $p = 0.049$ and MW test $p = 0.019$). This result confirms our Hypothesis 2 that the investment in prevention in the domain of ambiguity is higher compared to the domain of risk under the regime of unlimited liability. Moreover, it stresses that subjects are sensitive to ambiguity under unlimited liability and tend to increase their investment levels.



(a) Risk: Comparing UL and LL

(b) Ambiguity: Comparing UL and LL

Source: Own calculations

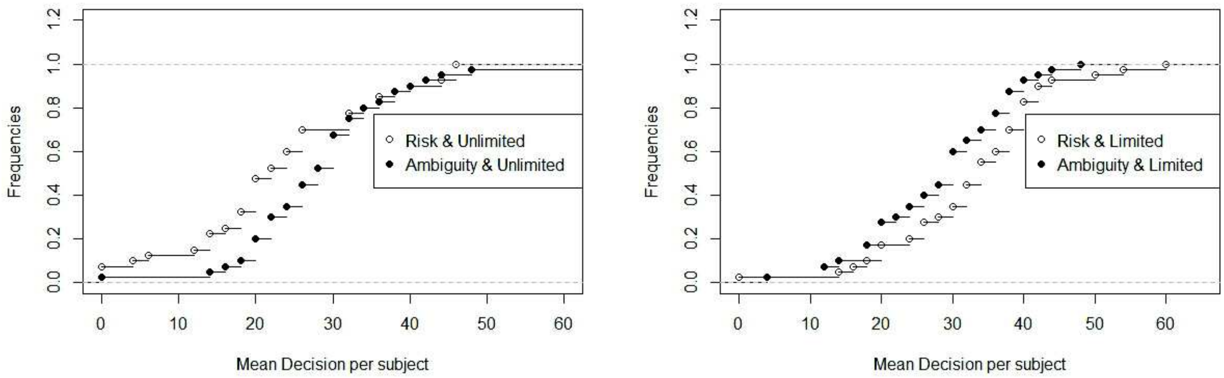
Figure 1: Graphical assessment of the aggregated average investment in prevention by comparing unlimited and limited liability while fixing the domain

However, the third result is inconsistent with Hypothesis 3. While shifting to the domain of ambiguity, it does not lead on average to higher levels of investment in prevention under the regime of limited liability. Interestingly, subjects tend to invest lower levels of prevention in the domain of ambiguity compared to the regime of limited liability in the domain of risk. A possible explanation might be that ambiguity and limited liability cause an effect of underinvestment in prevention compared to the domain of risk. Since ambiguity generates specific noise in the decision making and limited liability triggers in specific situations that less value of endowment is confiscated, it might be desirable for subjects to invest lower levels of prevention. However, if we compare the cumulative distribution function of average decision under limited liability in the domain of ambiguity to the baseline (RK-UL), we observe that investment levels are rather high under limited liability in the domain of ambiguity[25].

For the sake of completeness, we test additionally whether there are differences in distributions of AMB-UL and AMB-LL (See figure 1b). Nonetheless, we do not find any significant effect (KS test $p = 0.670$ and MW test $p = 0.403$). One possible reason could be that ambiguity causes a high amount

[25] We additionally compare the cumulative distribution function of the average investment under RK-UL (baseline) with AMB-LL and have found a significant differences (KS test $p = 0.027$ and MW test $p = 0.027$), which clearly shows that subjects tend to invest higher levels of prevention under ambiguity than compared to the baseline. See Figure 7 in appendix B.2.

of noise or further ambiguity hampers the decision making under both liability regimes in a similar way that we are not able to disentangle any effect.



(a) UL: Comparing Risk and Ambiguity (b) LL: Comparing Risk and Ambiguity

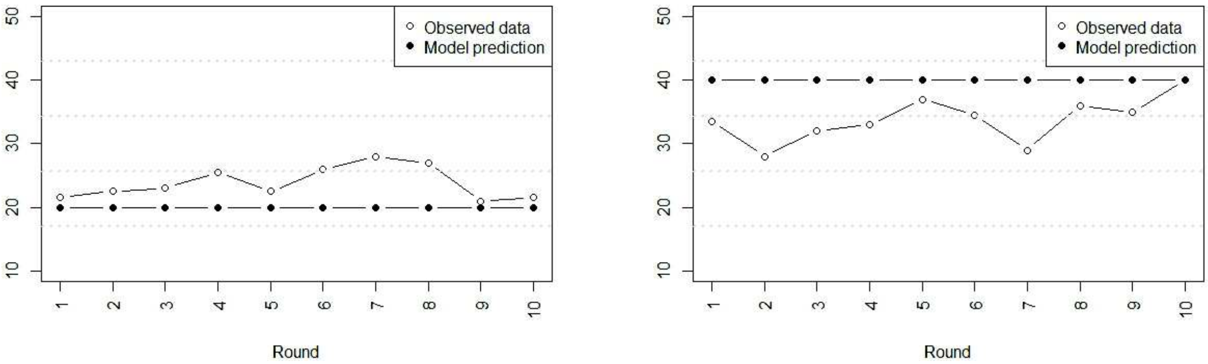
Source: Own calculations

Figure 2: Graphical assessment of the aggregated average investment in prevention by comparing the domain of risk and ambiguity while fixing the liability regime

Furthermore, we compare our model predictions with the observed data for each treatment. Figure 3 and figure 4 depict subject's actual investment choices and the optimal level of investment predicted by the model round per round for each of the four treatments. Under RK-UL treatment, subjects invest slightly more than what is predicted by the model (Optimal investment level equals 20 ECU). In contrast, in case of RK-LL treatment, subjects start out by choosing moderate investment levels and increase these levels until those predicted by the theory (Optimal investment levels equals 40 ECU[26]). In the domain of ambiguity[27] subjects start out by choosing slightly higher investment level and lower these until the optimum level predicted by the theory (Optimal investment level equals 22.5 ECU). Subjects choose investment level for most of the time very close to the prediction (Optimal investment level equals 25.5 ECU) under limited liability in the domain of ambiguity. In overall, we observe that subject's actual choices are mostly consistent with point predictions.

[26]Furthermore, we need to stress that the optimal investment level under limited liability might be considered as a focal point. We include a question by asking subjects at the end of the experiment (Before payment) on a four item scale (1 =*"Never"* to 4 =*"Always"*) to report their investment decision on the following question *"Have you chosen the investment level 40 ECU, because you didn't know which level of investment to select to maximize your potential earnings?"*. We find that 3 out of 160 subjects (2%) responded with *"Always"* and 14 out of 160 subjects (9%) responded with *"Often"*.

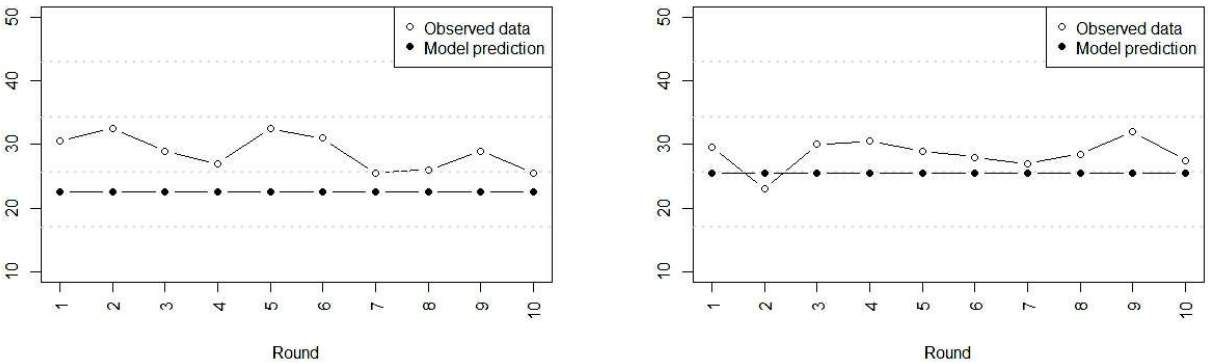
[27]It was not possible to calculate *ex ante* the optimal level of investment in the domain of ambiguity owing to the lack of information about the individuals degree of confidence and optimism.



(a) Risk: Unlimited Liability (b) Risk: Limited Liability

Source: Own calculations

Figure 3: Graphical assessment of the observed versus predicted mean decision per round in the domain of risk for both unlimited and limited liability



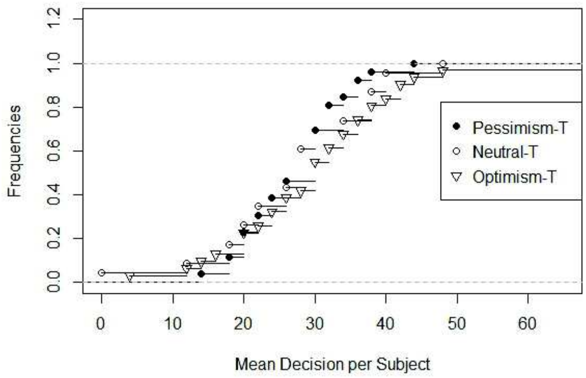
(a) Ambiguity: Unlimited Liability (b) Ambiguity: Limited Liability

Source: Own calculations

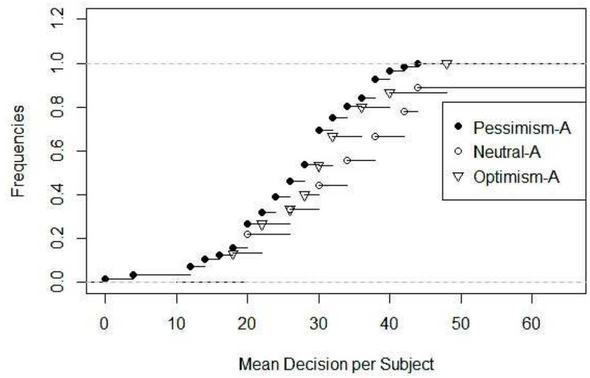
Figure 4: Graphical assessment of the observed versus predicted mean decision per round in the domain of ambiguity for both unlimited and limited liability

Next, we report the comparative results of the cumulative distribution function of subjects optimism index[28] and their average investment level pooled for both treatments in the domain of ambiguity (See Figure 5).

[28]We distinguish between both elicitation methods, Ask (Multiple price list) and Task (Psychology scale) to compare properly our results. In the task approach, we determine the optimism index as such that subjects switching before the fifth row are in the group Pessimism-T, exactly at the fifth row are in the group Neutral-T and above the fifth row are in the group Optimism-T. In the Ask task, we determine the groups alike by setting the reference point of the optimism scale at 18.



(a) Task: Optimism Index in AMB



(b) Ask: Optimism Index in AMB

Source: Own calculations

Figure 5: Ask versus Task: Cumulative distribution function between average investment in prevention and optimism index aggregated for both liability regimes in the domain of ambiguity

In figure 5a and 5b, we see that in both cases (Task and Ask) subjects being in the group of optimism choose slightly higher mean levels of investment compared to the group of pessimism. However, we find contradictive results among statistical tests between both groups: task (KS test $p = 0.628$ MW test $p = 0.084$) and ask (KS test $p = 0.284$ and MW test $p = 0.039$). Hence, the Mann-Whitney test confirms our Hypothesis 4 that optimistic subjects choose on average higher levels of investment compared to pessimistic subjects in the domain of ambiguity. Since KS test does not support these results, we need to be carefully with the interpretation. We find statistical differences in the medians of both samples but no differences can be found among the distribution of both groups. We infer that these findings partially support Hypothesis 4.

We further discuss the effect of learning[29] on subject's decision choice over rounds. Figure 6 illustrates the proportions of investment decision by treatment over time. Therefore, we aggregate the investment decision per round and per treatment to investigate the hypothesis that the investment in mean are equal in the first and last round across all four treatments. To assess whether the members of a pair differ in size, we employ a non-parametric statistical test, the Wilcox Signed Rank Test. While pairwise comparing the first and last round for each treatment (Unlimited Liability & Risk $p = 1.000$; Limited Liability & Risk $p = 0.875$; Unlimited Liability & Ambiguity $p = 0.214$; Limited Liability & Ambiguity $p = 0.836$) confirms that they have identical distributions. Thus, we conclude that we do not observe in particular a learning effect, which is in line with the results of Angelova et al. (2014).

As can be seen graphically (Figure 6), we observe similar pattern across treatments. If we compare the first and last round for each treatment, we see that there are no significant differences across treatments. While subjects in the RK-UL treatment appear to choose rather lower level of investment

[29]We stress that we are not able to distinguish whether subjects are learning in terms of gaining a better understanding of the experimental task or in terms of altering their decision choice due to acquiring learning from previous rounds.

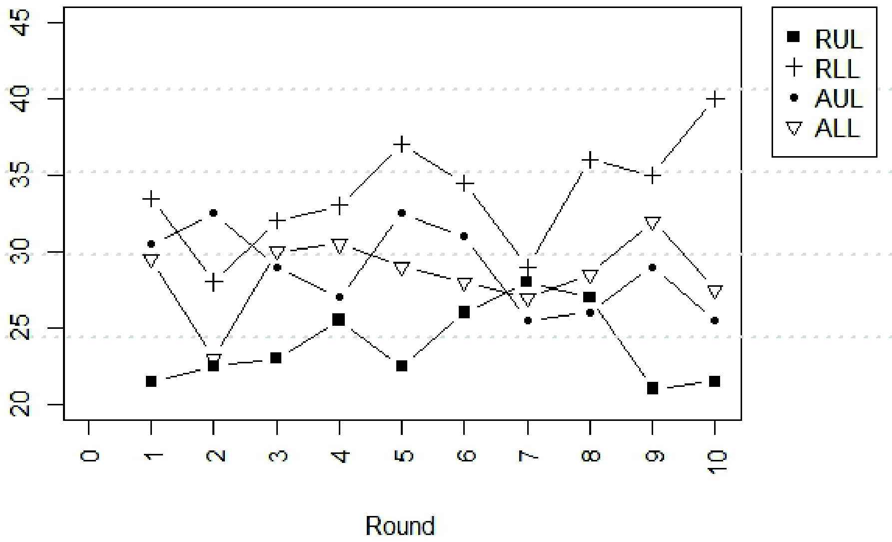


Figure 6: Aggregated average investment per round per treatment (pooled)

Note: RUL: Risk & Unlimited Liability; RLL: Risk & Limited Liability; AUL: Ambiguity & Unlimited Liability; ALL: Ambiguity & Limited Liability

compared to AMB-UL treatment, subjects in RK-LL treatment start out choosing higher investment level compared to subjects in AMB-LL treatment. It is of great interest to find out why subjects invest higher under the regime of limited liability in the domain of risk compared to the domain of ambiguity. To better understand subject's individual investment decision, we deploy panel regression analysis.

4.2 Factors affecting the investment in prevention

In general, several factors might influence subject's investment decision. Our database allows us to control for treatment effects, personal traits[30], socio-demographic variables and specific preferences that can intervene with the liability rules. To present our experimental results, we apply panel regression analysis in which the dependent variable is the individual investment decision choice per round across treatments. We employ specifically balanced panel data and estimate[31] our parameters by applying REOP model estimation (Kuklys, 2005; Pfarr et al., 2011). Table 9 in appendix B.1 presents the estimated results (two model specification) of REOP estimator and reports cluster robust standard errors to correct for individual heterogeneity across treatments (Cameron and Miller, 2015). The first column summarizes the estimated results of Model (a) and respectively the second column presents the estimated results of Model (b).

The REOP coefficients in panel estimation differ by a scale factor, thus we cannot interpret the magnitude of the coefficients, but rather we report the average (or mean) marginal effects of the explanatory

[30] In appendix B.1, we provide the results of the reliability of the test scales by reporting alpha Cronbach.

[31] The estimation of the results has been programmed in R Software. Data and Code are available in the online appendix.

variable. Thus, we chiefly summarize the average marginal effects for the five outcomes (Recall that the individual investment per round is an ordinal variable; 0 ECU = Outcome 1, 20 ECU = Outcome 2, 40 ECU = Outcome 3, 60 ECU = Outcome 4, 80 ECU = Outcome 5). Table 5 presents the average marginal effects of REOP model estimation using balanced panel data and the explanatory variables may be divided into four groups: treatment variables, individual characteristics from TASK (Parameters from the first three tasks), socio-demographic variables and individual characteristics from ASK (Questionnaire). Furthermore, we include a lagged variable *Event lag* to control for the results from the previous round indicating whether the winning color was drawn. We especially control for the effect that the previous result from the draw might influence the decision choice. Table 9 in appendix B.1 demonstrates that we have strong treatment effects even when we control for the variable *Event lag* in the model specification.

Table 5: Average marginal effects from ordered probit model estimation

Dependent variable: Individual investment per round					
	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5
Treatment Risk & Unlimited	Baseline	Baseline	Baseline	Baseline	Baseline
Treatment Risk & Limited	-0.124***	-0.063***	0.103***	0.062***	0.022***
	(0.012)	(0.004)	(0.010)	(0.004)	(0.006)
Treatment Ambiguity & Unlimited	-0.079***	-0.041***	0.066***	0.040***	0.014***
	(0.010)	(0.003)	(0.006)	(0.005)	(0.005)
Treatment Ambiguity & Limited	-0.647***	-0.033***	0.054***	0.033***	0.012***
	(0.015)	(0.006)	(0.013)	(0.005)	(0.004)
Inequity aversion (TASK)	0.011***	0.006**	-0.010**	-0.005**	-0.002***
	(0.004)	(0.003)	(0.004)	(0.002)	(0.000)
Risk aversion (TASK)	0.001	0.001	-0.001	-0.001	-0.000
	(0.007)	(0.004)	(0.005)	(0.003)	(0.001)
Ambiguity aversion (TASK)	-0.004	-0.002	-0.003	0.002	0.001
	(0.006)	(0.003)	(0.005)	(0.003)	(0.001)
Age	-0.008	0.004	-0.007	-0.004	-0.001*
	(0.005)	(0.003)	(0.005)	(0.003)	(0.001)
Gender	0.023	0.012	-0.019	-0.011	-0.004
	(0.026)	(0.013)	(0.021)	(0.014)	(0.005)
Religion	-0.001	-0.000	0.000	0.000	0.000
	(0.003)	(0.001)	(0.002)	(0.001)	0.000
Risk attitudes Q21 (ASK)	0.010**	0.005*	-0.008*	-0.005*	-0.002***
	(0.005)	(0.003)	(0.005)	(0.003)	(0.001)
Risk attitudes Q22.1 (ASK)	-0.002	-0.001	0.002	0.001	0.000
	(0.007)	(0.003)	(0.006)	(0.004)	(0.001)
Risk attitudes Q22.2 (ASK)	-0.012**	-0.006**	0.010**	0.006**	0.002***
	(0.005)	(0.003)	(0.005)	(0.003)	(0.001)
Risk attitudes Q22.3 (ASK)	-0.012**	-0.006**	0.010*	0.006**	0.002*
	(0.006)	(0.003)	(0.05)	(0.003)	(0.001)

Risk attitudes Q22.4 (ASK)	0.006**	0.003**	-0.005**	-0.003**	-0.001**
	(0.003)	(0.001)	(0.002)	(0.001)	(0.000)
Risk attitudes Q22.5 (ASK)	0.013*	0.007*	-0.011*	-0.007*	-0.002
	(0.008)	(0.004)	(0.006)	(0.003)	(0.002)
Risk attitudes Q22.6 (ASK)	-0.010	-0.005*	0.008	0.005*	0.002
	(0.006)	(0.003)	(0.005)	(0.003)	(0.001)
Risk attitudes Q23 (ASK)	0.006	0.003*	-0.005*	-0.003*	-0.001
	(0.004)	(0.002)	(0.003)	(0.002)	(0.001)
Altruism towards others (ASK)	0.011	0.006	-0.010	-0.006	-0.002
	(0.009)	(0.005)	(0.008)	(0.005)	(0.002)
Altruism toward my-self (ASK)	-0.004	-0.002	0.004	0.0022	0.001
	(0.016)	(0.008)	(0.013)	(0.008)	(0.003)
Inequity attitudes toward to others (ASK)	-0.005***	-0.002**	0.004**	0.002**	0.001***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.000)
Inequity attitudes toward my-self (ASK)	0.003***	0.002**	-0.003**	-0.002**	-0.001***
	(0.001)	(0.007)	(0.001)	(0.001)	(0.000)
Degree of optimism	-0.002	-0.001	0.002	0.001	0.000
	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)
Degree of confidence	-0.001	-0.001	0.001	0.000	0.000
	(0.003)	(0.002)	(0.003)	(0.002)	(0.001)
Degree of trust	0.003	0.001	-0.002	-0.001	-0.000
	(0.004)	(0.002)	(0.004)	(0.002)	(0.001)
Event lag	-0.023***	-0.012***	0.020***	0.012***	0.004***
	(0.004)	(0.002)	(0.003)	(0.003)	0.001

Note: *p<0.1; **p<0.05; ***p<0.01; N=1440
Cluster robust standard errors are given in parentheses

The estimation results show that all treatment variables *Treatment Risk & Limited*, *Treatment Ambiguity & Unlimited*, *Treatment Risk & Limited* are significant at 1-percent level for the five outcomes.

For instance, the average marginal effects of the variable *Treatment Risk & Limited Liability* compared to the baseline indicates that individuals are 12.4% less likely to have chosen Outcome 1, 6.3% less likely to have chosen Outcome 2, 10.3% more likely to have chosen Outcome 3, 6.2% more likely to have chosen Outcome 4 and 2.2% more likely to have chosen Outcome 5. Moreover, we find significant effects for the variables *Inequity aversion (Task)*. This means that subjects with a lower degree of inequity aversion are more likely to invest lower levels in prevention.

While controlling for specific individual characteristics reported by subjects in the questionnaire, we find that the variables *Risk Attitudes Q21* (General) and *Risk Attitudes Q22.2* (Financial matters), *Risk Attitudes Q22.3* (Sports), *Risk Attitudes Q22.4* (Occupation), *Inequity attitudes toward to others (Ask)*, *Inequity attitudes toward my-self (Ask)* are significant at least at 10-percent level. Furthermore, we find that individuals with a higher risk perception related to financial matters and during leisure and sport have a higher probability to invest more in prevention. Contrary, the results show that individuals with higher risk perception related to their occupation are less likely to invest more in prevention. Furthermore, the variable *Risk attitudes Q23* (Investment risks), perception of risk in the domain of losses, is significant at least at 10-percent level (Column 2 to 4), except for Outcome 1 and 5. In other words, subjects with a higher risk aversion in the domain of losses are more likely to invest less in investment. Next, one unit increase in *Inequity towards to others (Ask)* is associated with being 0.5% less likely to have chosen outcome 1, 0.2% less likely to have chosen Outcome 2, 0.4% more likely to have chosen Outcome 3, 0.2% more likely to have chosen Outcome 4 and 0.1% more likely to have chosen Outcome 5. More precisely, we find that subjects reporting higher fairness preferences toward to other (Ask) have a higher probability to invest higher levels in prevention. In contrast, subjects reporting higher fairness preferences toward to oneself (Ask) have a lower probability to invest more in prevention. Besides, we do not find any significant effect for the variables *Degree of optimism*, *Degree of confidence* and *Degree of trust*. Finally, the result of the draw of a blue or yellow ball from the previous round impacts the investment decision. The average marginal effect for the variable *Event lag* reports that individuals are 2.3% less likely to choose Outcome 1, 1.2% more likely to choose Outcome 2, 2.0% more likely to choose Outcome 3, 1.2% more likely to choose Outcome 4 and 0.4% more likely to choose Outcome 5. This finding shows that subjects are influenced from their previous result of the random draw. In fact, subjects whose winning color has not been drawn tend to invest higher levels in prevention compared to those whose winning color has been drawn. Nevertheless, one could argue that this issue features a potential drawback of our experimental design, albeit we find very strong and robust treatment effects.

4.3 Behavioral strategy

Since the variable *Event lag* is highly significant in our estimation analysis, we wonder whether subject's investment behavior has altered during the ten rounds of Task 4. It might be worth discussing the effect of strategic behavior in repeated games to rule out potential bias. We perform REOP estimation by correcting with cluster robust standard errors to assess the underlying determinants affecting the investment behavior. The dependent variable is a lag variable indicating subject's variation of investment choice within a range from -80 ECU (Outcome 1) to 80 ECU (Outcome 8) of round r compared to $r-1$. For the sake of brevity, we are solely discussing the estimation results rather than reporting explicitly the marginal effects (See Table 16 in appendix B.1). The main results of the estimation can be summarized as following. First, we do not find any significant effect for the treatment effects, meaning that subject's choice varies independently of the treatments. This confirms that the strategic behavior do not diverge across treatments and support our previous results. Second, the behavioral variation is higher (from -80 to -60 to -40 to -20 to 0 to 20 to 40 to 80) with lower age, for women (compared to men), lower risk aversion related to occupation, higher risk aversion related to the faith in other people, higher level of altruism towards themselves, higher inequity aversion and for the draw of the wrong color. We are not able to avert that the draw of a ball of the previous round is affecting the decision choice. We confess that our experimental design reveals some shortcomings regarding this issue with the wisdom of hindsight. Finally, we could not find any significant effect neither for ambiguity aversion nor for the degree of optimism.

5 Concluding Remarks

This paper studies whether strict liability is performing efficiently in the domain of risk and ambiguity. Specifically, we test Lampach and Spaeter (2016) theoretical predictions by setting carefully the parameters to satisfy the specific conditions in experimental tasks. In particular, we are interested to verify whether individuals overinvest in prevention for both liability regimes in an ambiguous environment and for a specific case under limited liability in the domain of risk. We assess these theoretical predictions to provide new insights on empirical validity to the literature on tort law and policymakers involved in dealing with new emerging technologies related to technological disasters or any external loss.

Our results are consistent with the theoretical predictions in that limited liability leads significantly to higher investment levels in prevention compared to unlimited liability in the domain of risk. However, Angelova et al. (2014) could not find any significant differences by comparing whether individuals were able to fully compensate victim's losses. They conclude that agents do not invest more in prevention even when losses to third parties increase. Here, we do not manipulate the size of liability[32] albeit we allow for potential losses to occur under unlimited liability. This could be one possible reason why we find significant differences between both liability regimes in the domain of risk. On the other side, it is possible that this finding is unique due to our parameters setting, nevertheless we demonstrate for a specific case that underinvestment is not systematically observed in the domain of risk. In addition, we show that individuals significantly invest higher levels of prevention under unlimited liability in the domain of ambiguity compared to risk. In contrast to theory, we find that limited liability in the domain of ambiguity leads on average to lower levels of investment in prevention compared to domain of risk. Moreover, we do not find any significant effect of neither individual's degree of optimism reported in the questionnaire nor from task affecting the decision choice to invest in prevention. On the other hand, we find from REOP estimation strong evidences that individual with a higher inequity aversion, higher fairness and risk preferences incline to invest higher levels in prevention.

Several limitations of this research should be stressed. It is undisputable that our design mirrors specific drawbacks. As already mentioned, we acknowledge that the modified dictator game might influence subject's decision behavior. Nonetheless, we argue that it remains essentially hypothetical and we decide to apply this well-established design (Andreoni and Miller, 2002; Fisman et al., 2007; Blanco et al., 2011; Heinrich and Weimann, 2013; Angelova et al., 2014) owing to probe treatment effects. Furthermore, we deem that our design aims to represent the decision problem as realistic as possible by

[32] Koch and Schunk (2013) also manipulate the size of liability in their experiment and found that both risk aversion and ambiguity aversion are higher and positively correlated under unlimited liability compared to limited liability.

including third parties and considering that the injurer could suffer from potential losses. Finally, we seek to combine approaches from both, economics and psychology literature to elicit subject's degree of optimism through conducting multiple price list tasks and using psychological measurement. Another possibility would be to disentangle both ambiguity parameters by measuring the degree of ambiguity (Degree of confidence) and ambiguity attitudes (Degree of optimism) in a specific task (Eichberger and Kelsey, 2014). For instance, Kilka and Weber (2001) propose a two stage approach, similar to the method by Tversky and Craig (1995), to measure the degree of ambiguity and ambiguity attitudes. Moreover, Baillon et al. (2015) suggest a method to decompose ambiguity attitudes into pessimism and likelihood sensitivity.

These experimental findings can be useful for public policy in the context of governing new emerging technologies to design better regulations and foster knowledge on how the legal regimes are performing. It might be challenging to reason general conclusions from experiments due to lacking of external validity. However, the lessons we can learn from our experiment are that subjects show on average high levels of investment under both unlimited and limited in the domain of ambiguity. This means that the liability rules are not efficient and lawmakers might plead to revise the existing legal basis to address an efficient incentive mechanism for new emerging technologies. Moreover, the results derived from laboratory experiments create a baseline to subsequently conduct field experiments. We admit that undergraduate students as subject pool are not representative for firms, albeit our results give a direction and valuable insights about the efficiency of tort law in an ambiguous environment.

To conclude, more empirical evidence is needed to obtain a better understanding of the driven factors influencing the decision making under risk and ambiguity to establish efficient liability rules. Future research could seek to use previous empirical findings to build and adjust economic models for the governance of new emerging risks.

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A Proofs

All proofs are derived from Lampach and Spaeter (2016).

Proof of Proposition 2

A partial derivate of (4) with respect to x yields the following first order condition for an interior solution x_{UL}^{amb}

$$1 = -[\delta\pi^{'}(x_{UL}^{amb}) + (1-\delta)q_x(\alpha, x_{UL}^{amb})]l \tag{9}$$

If $q_x(\alpha, .) = 0$, it reduces to $1 = -\delta\pi^{'}(x^S)l$. With $\delta < 1$, Point i) is immediate.

If $q_x(\alpha, .) < 0$, then the right-hand-side term may be either lower or higher than $-\pi^{'}(x^S)l$. Precisely, by comparing the social marginal benefit $-\pi^{'}(x^S)l$ obtained with risk with the private marginal benefit under ambiguity $-[\delta\pi^{'}(x_{UL}^{amb}) + (1-\delta)q_x(\alpha, x_{UL}^{amb})]l$, we obtain that:

$$\begin{aligned} x_{UL}^{amb} \gtreqless x^S &\Leftrightarrow (1-\delta)\left[\pi^{'}(x^S) - q_x(\alpha, x^S)\right] \gtreqless 0 \\ &\Leftrightarrow \left|q_x(\alpha, x^S)\right| \gtreqless \left|\pi^{'}(x^S)\right| \end{aligned}$$

This is Point ii). Now write (9) as follows:

$$\frac{\partial W_{amb}^P}{\partial x} = -1 - [\delta\pi^{'}(x_{UL}^{amb}) + (1-\delta)q_x(\alpha, x_{UL}^{amb})]l = 0 \tag{10}$$

Point iii) is obtained thanks to appropriate total differentiations applied to (10). We have:

$$\frac{dx_{UL}^{amb}}{d\alpha} = \frac{l(1-\delta)q_{x\alpha}}{\frac{\partial W_{UL}^{amb}}{\partial x \partial x}}$$

The denominator corresponds to the expression of the second order conditions. With $\pi_{xx} > 0$ and $q_{xx} > 0$ by assumptions, there are satisfied so that $\frac{\partial W_{UL}^{amb}}{\partial x \partial x} < 0$. The numerator is strictly positive (strictly negative, equal to zero) if and only if $q_{x\alpha} > 0 (< 0, = 0)$. This is Point iii). Proposition 2 is demonstrated. ♦

Proof of Proposition 3

Let us subtract the first-order-condition under risk and limited liability (8) from the first-order-condition under ambiguity and limited liability (7), and let us evaluate this difference at point x_{LL}^P. We have

$$[(j_x(\alpha, \delta, x_{LL}^P) - \left|\pi'(x_{LL}^P)\right|)]\widehat{d}(x_{LL}^P) \gtreqless j(\alpha, \delta, x_{LL}^P) - (1 - \pi(x_{LL}^P) \Leftrightarrow x_{LL}^{amb} \gtreqless x_{LL}^P \tag{11}$$

The left-hand-side term in (11) is the difference between the expected marginal benefits under risk and under ambiguity evaluated at the private risky optimum x_{LL}^P, while the right-hand-side term is the difference in the expected marginal costs. Let us denote the former as ΔB and the latter as ΔC.

For $\alpha \geq 0.5$ we have, by assumption, $j(\alpha, \delta, 0) - (1 - \pi(0)) > 0$. If $j_x(\alpha, \delta, x) < |\pi'(x)|$ for any x, then we are not able to conclude about the sign of $j(\alpha, \delta, x_{LL}^P) - (1 - \pi(x_{LL}^P))$. For $\alpha < 0.5$ we have, by assumption, $j(\alpha, \delta, 0) - (1 - \pi(0)) < 0$ and the same problem holds if $j_x(\alpha, \delta, x) > |\pi'(x)|$ for any x. Proposition 3 is demonstrated. ⧫

B Tables and Figures

B.1 Tables

Table 6: Decision choice for the RK treatment

	Decision variable [ECU]				
	0	20	40	60	80
Probability of an event [%]	87	59	38	22	9

Source: Own compilation

Table 7: Decision choice for the AMB treatment

	Decision variable [ECU]				
	0	20	40	60	80
Probability A [%]	97	66	44	26	13
Probability B [%]	92	62	41	24	11
Probability C [%]	87	59	38	22	9
Probability D [%]	82	55	35	20	8
Probability E [%]	77	52	33	18	6

Source: Own compilation

Table 8: Descriptive Statistics of experimental data

	Min	Max	Mean	Std. Deviation	Sample size
Decision choice	0	80	28.55	20.51	1600
Inequity aversion (TASK)	1	10	5.96	2.44	1600
Risk aversion (TASK)	3	10	5.92	1.61	1600
Ambiguity aversion (TASK)	1	10	5.38	1.84	1600
University degree	0	2	0.42	0.58	1600
Studies	0	5	2.11	1.45	1600
Age	18	34	21.45	2.94	1600
Gender	0	1	0.5	0.50	1600
Nationality	0	1	0.77	0.42	1600
Sister	0	3	0.89	0.96	1600
Brother	0	3	0.88	0.92	1600
Couple	0	1	0.18	0.38	1600
Religion	0	8	1.68	2.25	1600
Participation	0	1	0.84	0.36	1600
Altruism towards others (ASK)	1	6	3.89	1.20	1600
Altruism toward my-self (ASK)	0	6	2.77	1.32	1600
Inequity attitudes toward to others (ASK)	0	20	12.03	3.88	1600
Inequity attitudes toward my-self (ASK)	4	24	15.44	4.07	1600
Degree of optimism	8	28	19.23	3.69	1600
Degree of confidence	6	27	15.57	4.43	1600
Degree of trust	11	25	17.46	2.88	1600

Table 9: Estimation results applying ordered probit model

Dependent variable: Individual investment per round		
	Model (a)	Model (b)
Coefficient		
Treatment Risk & Unlimited	Baseline	Baseline
Treatment Risk & Limited	0.567***	0.498***
	(0.012)	(0.030)
Treatment Ambiguity & Unlimited	0.316***	0.319***
	(0.008)	(0.027)
Treatment Ambiguity & Limited	0.321***	0.261***
	(0.0017)	(0.053)
Inequity aversion (TASK)	-0.047**	-0.043**
	(0.023)	(0.019)
Risk aversion (TASK)	0.009	-0.004
	(0.017)	(0.028)
Ambiguity aversion (TASK)	-0.003	0.015
	(0.020)	(0.025)
Age		-0.033
		(0.023)
Gender		-0.091
		(0.107)
Religion		0.002
		(0.011)
Risk attitudes Q21 (ASK)		-0.040*
		(0.020)
Risk attitudes Q22.1 (ASK)		0.010**
		(0.029)
Risk attitudes Q22.2 (ASK)		0.047**
		(0.021)
Risk attitudes Q22.3 (ASK)		0.049**
		(0.025)
Risk attitudes Q22.4 (ASK)		-0.025**
		(0.010)
Risk attitudes Q22.5 (ASK)		-0.053*
		(0.031)
Risk attitudes Q22.6 (ASK)		0.042*

		(0.025)
Risk attitudes Q23 (ASK)		-0.024*
		(0.014)
Altruism towards others (ASK)		-0.044
		(0.038)
Altruism toward my-self (ASK)		0.018
		(0.067)
Inequity attitudes toward to others (ASK)		0.019***
		(0.007)
Inequity attitudes toward my-self (ASK)		-0.012***
		(0.005)
Degree of optimism		0.008
		(0.010)
Degree of confidence		0.004
		(0.013)
Degree of trust		-0.011
		(0.017)
Event lag		0.096***
		(0.016)
$\kappa 1$	-0.939***	-1.565
	(0.318)	(1.130)
$\kappa 2$	0.170	-0.491
	(0.264)	(1.105)
$\kappa 3$	1.424***	0.739
	(0.212)	(1.023)
$\kappa 4$	2.229***	1.593*
	(0.127)	(0.929)
Individual level variance component		
σ_u	0.437	0.379
	(0.125)	(0.094)
Number of observations	N=1600	N=1440
Log pseudolikelihood	-2090.41	-1892.77

Note: *p<0.1; **p<0.05; ***p<0.01; N=1440

Table 10: Distributive Justice (Others) Scale

	Observation	Sign	Average Correlation	Alpha Crombach
Q7.	160	+	0.2929	0.5541
Q8.	160	+	0.2938	0.5551
Q9.	160	+	0.2851	0.5447
Q10.	160	+	0.3949	0.6619
Test scale			0.3167	0.6496

Table 11: Distributive Justice (Myself) Scale

	Observation	Sign	Average Correlation	Alpha Crombach
Q11.	160	+	0.4509	0.7113
Q12.	160	+	0.5530	0.7877
Q13.	160	+	0.4968	0.7476
Q14.	160	+	0.5401	0.7789
Test scale			0.5102	0.8065

Table 12: Revised Orientation Test (R-LOT)

	Observation	Sign	Average Correlation	Alpha Crombach
Q24.	160	+	0.3870	0.7163
Q26.	160	-	0.3440	0.6772
Q30.	160	-	0.2909	0.6214
Q32.	160	-	0.2966	0.6278
Q33.	160	+	0.3127	0.6454
Test scale			0.5102	0.7077

Table 13: General Confidence Scale

	Observation	Sign	Average Correlation	Alpha Crombach
Q24.	160	+	0.5609	0.8363
Q26.	160	+	0.5238	0.8148
Q30.	160	+	0.5223	0.8139
Q32.	160	+	0.4928	0.7954
Q33.	160	-	0.5865	0.8502
Test scale			0.5373	0.8531

Table 14: Trust Scale

	Observation	Sign	Average Correlation	Alpha Crombach
Q24.	160	+	0.2033	0.5051
Q26.	160	+	0.2437	0.5631
Q30.	160	+	0.2870	0.6169
Q32.	160	-	0.2276	0.5410
Q33.	160	+	0.2815	0.6104
Test scale			0.2486	0.6233

Table 15: Frequency of choosen investment level using panel data

	Higher	Equal	Less
Frequency	383	670	387
Percentage	26.6	46.53	26.88

Sample size: N=1440

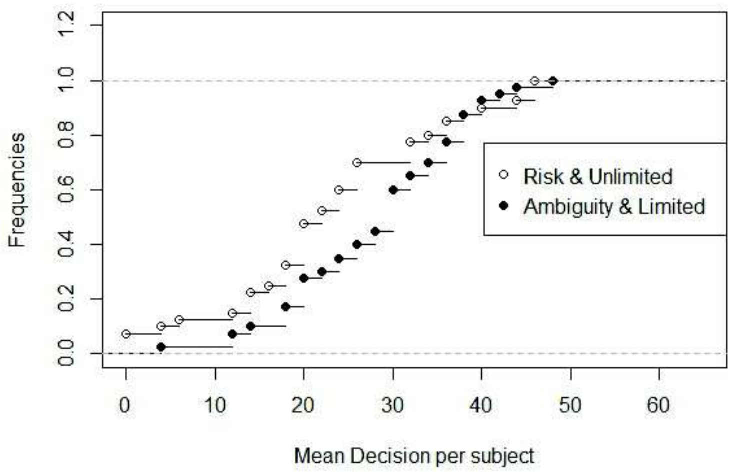
Table 16: Estimation of the behavioral variation by applying random effects ordered probit model

	Dependent variable: Behavioral change (lag)	
	Coefficient	Cluster Robust Std. Err.
Treatment Risk & Unlimited	Baseline	Baseline
Treatment Risk & Limited	-0.002	(0.013)
Treatment Ambiguity & Unlimited	-0.010	(0.010)
Treatment Ambiguity & Limited	-0.025	(0.024)
Inequity aversion (TASK)	-0.004	(0.003)
Risk aversion (TASK)	-0.018	(0.006)
Ambiguity aversion (TASK)	0.013	(0.019)
Age	-0.006***	(0.002)
Gender	-0.031*	(0.018)
Religion	-0.004	(0.004)
Risk attitudes Q21 (ASK)	-0.002	(0.011)
Risk attitudes Q22.1 (ASK)	0.006	(0.008)
Risk attitudes Q22.2 (ASK)	0.008	(0.009)
Risk attitudes Q22.3 (ASK)	0.004	(0.007)
Risk attitudes Q22.4 (ASK)	-0.008**	(0.003)
Risk attitudes Q22.5 (ASK)	-0.005	(0.007)
Risk attitudes Q22.6 (ASK)	0.009*	(0.005)
Risk attitudes Q23 (ASK)	-0.006	(0.012)
Altruism towards others (ASK)	-0.030	(0.019)
Altruism toward my-self (ASK)	0.020**	(0.010)
Inequity attitudes toward to others (ASK)	0.000	(0.004)

Inequity attitudes toward my-self (ASK)	0.005**	(0.002)
Degree of optimism	-0.003	(0.002)
Degree of confidence	0.001	(0.001)
Degree of trust	-0.004	(0.006)
Event lag	0.702***	(0.057)
$\kappa1$	-2.327***	(0.311)
$\kappa2$	-1.872***	(0.250)
$\kappa3$	-1.327***	(0.175)
$\kappa4$	-0.569***	(0.160)
$\kappa5$	0.747***	(0.112)
$\kappa6$	1.544***	(0.093)
$\kappa7$	2.123***	(0.127)
$\kappa8$	2.568***	(0.895)
Individual level variance component		
σ_u	0.000	(0.000)
Number of observations	N=1440	
Log pseudolikelihood	-2156.4	

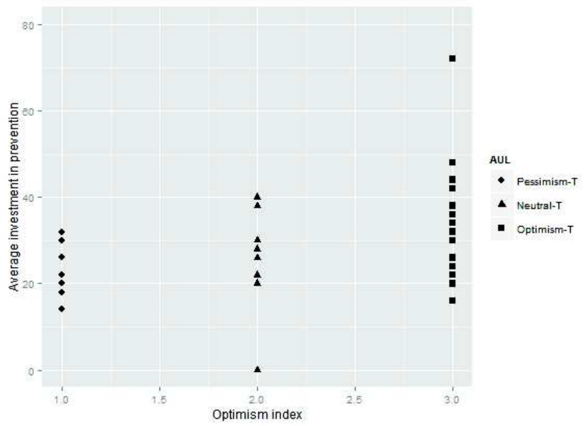
Note: *p<0.1; **p<0.05; ***p<0.01

B.2 Figures

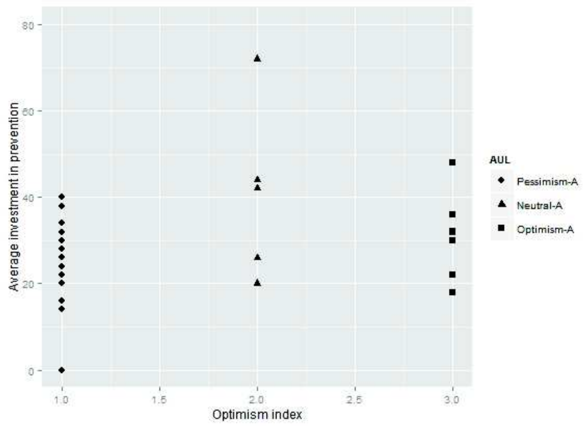


Source: Own calculations

Figure 7: Graphical assessment of the aggregated average investment in prevention by comparing the baseline with limited liability in the domain of ambiguity



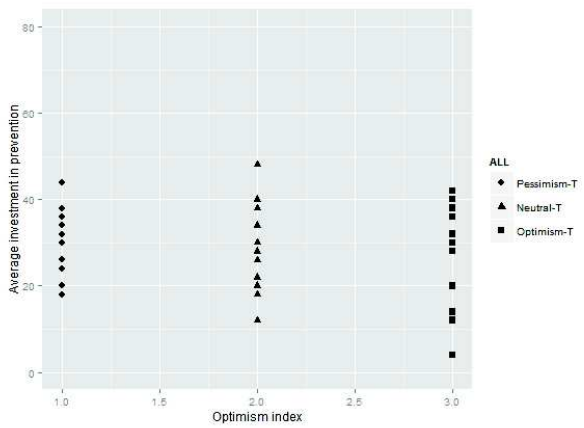
(a) Task: Optimism Index in AUL



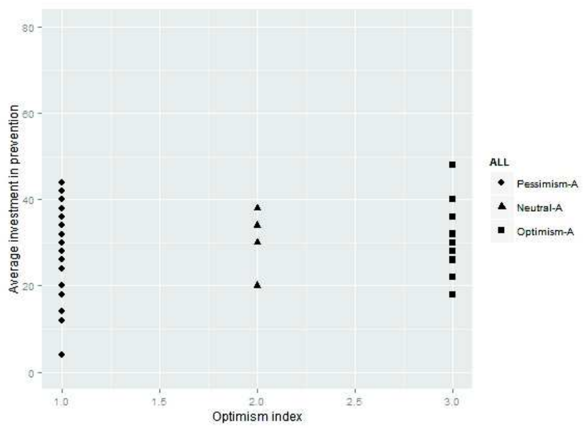
(b) Ask: Optimism Index in AUL

Source: Own calculations

Figure 8: Ask versus Task: Relationship between Optimism Index and average investment in prevention under unlimited liability in the domain of ambiguity



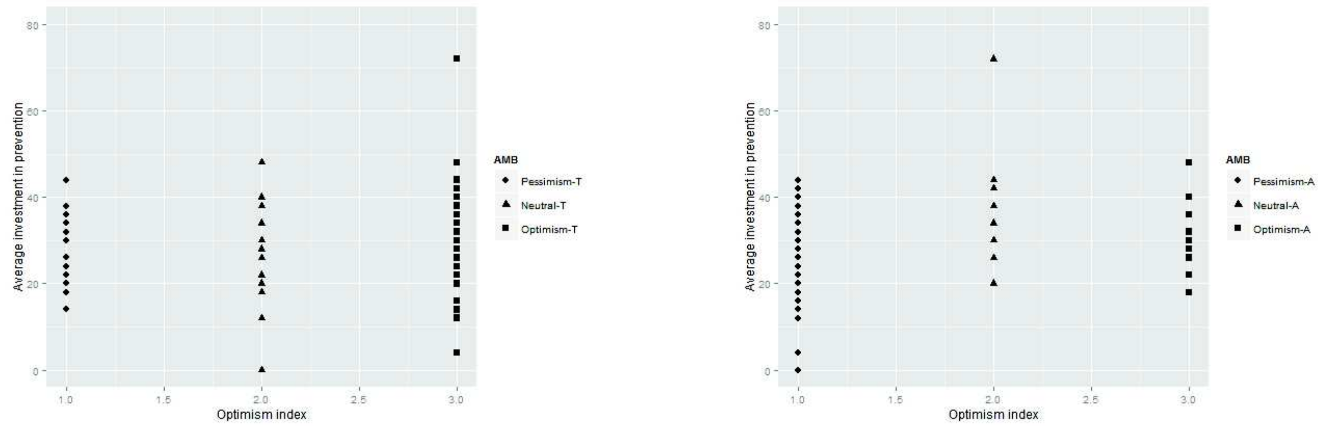
(a) Task: Optimism Index in ALL



(b) Ask: Optimism Index in ALL

Source: Own calculations

Figure 9: Ask versus Task: Relationship between Optimism Index and average investment in prevention under limited liability in the domain of ambiguity

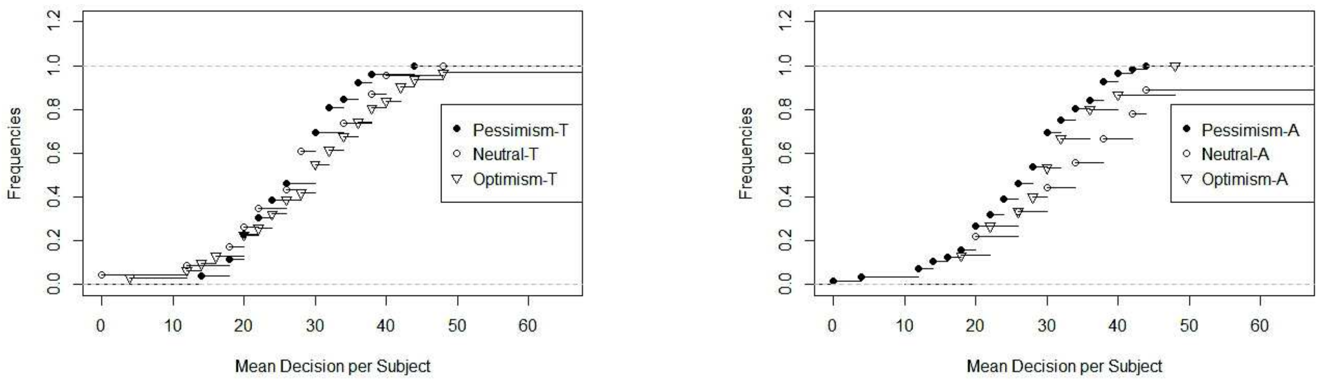


(a) Task: Optimism Index in AMB

(b) Ask: Optimism Index in AMB

Source: Own calculations

Figure 10: Ask versus Task: Relationship between Optimism Index and average investment in prevention aggregated for both liability regimes in the domain of ambiguity



(a) Task: Optimism Index in AMB

(b) Ask: Optimism Index in AMB

Source: Own calculations

Figure 11: Ask versus Task: Cumulative distribution function between average investment in prevention and optimism Index aggregated for both liability regimes in the domain of ambiguity

C Materials and Information

C.1 Screenshots of the experimental tasks

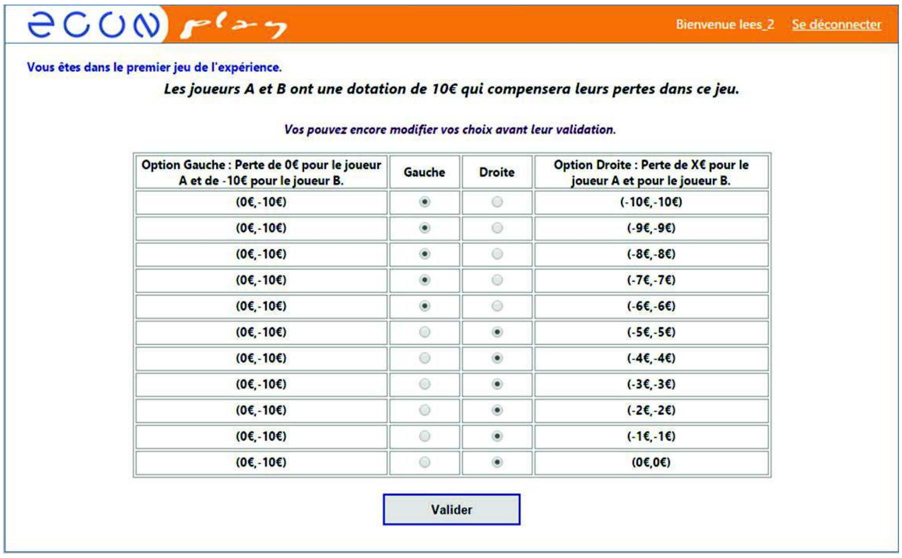


Figure 12: Screenshot of Task 1: Modified dictator game to elicit subject's attitudes toward advantageous inequity aversion

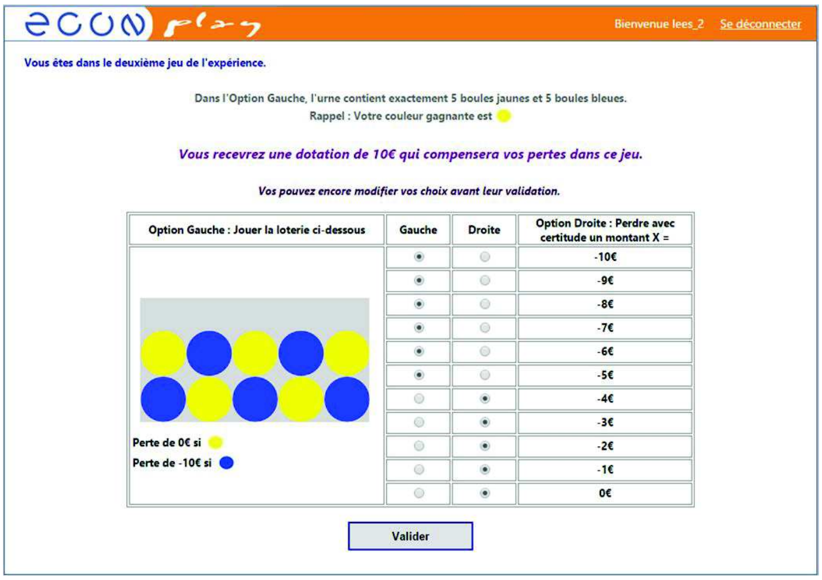


Figure 13: Screenshot of Task 2: MPL to elicit subject's attitudes toward risk aversion

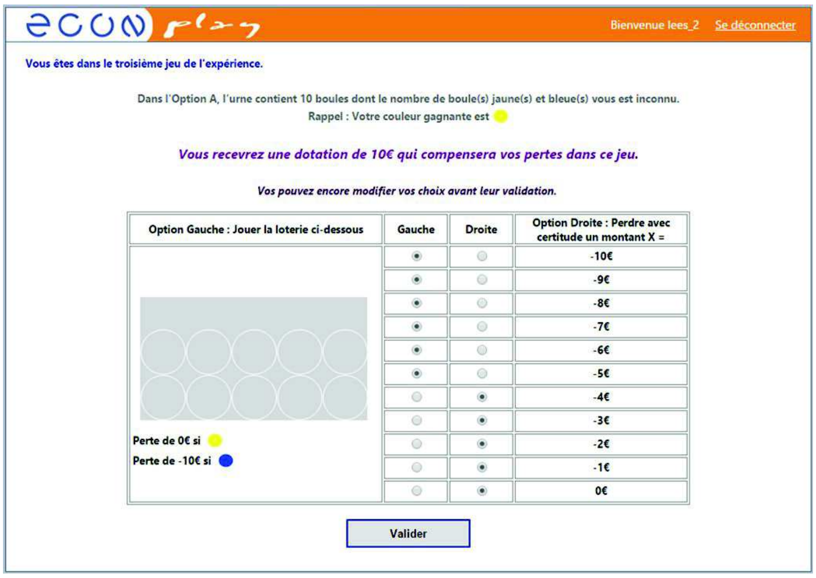


Figure 14: Screenshot of Task 3: MPL to elicit subject's attitudes toward ambiguity aversion

Figure 15: Screenshot of subject's decision choice in RK treatment under unlimited liability

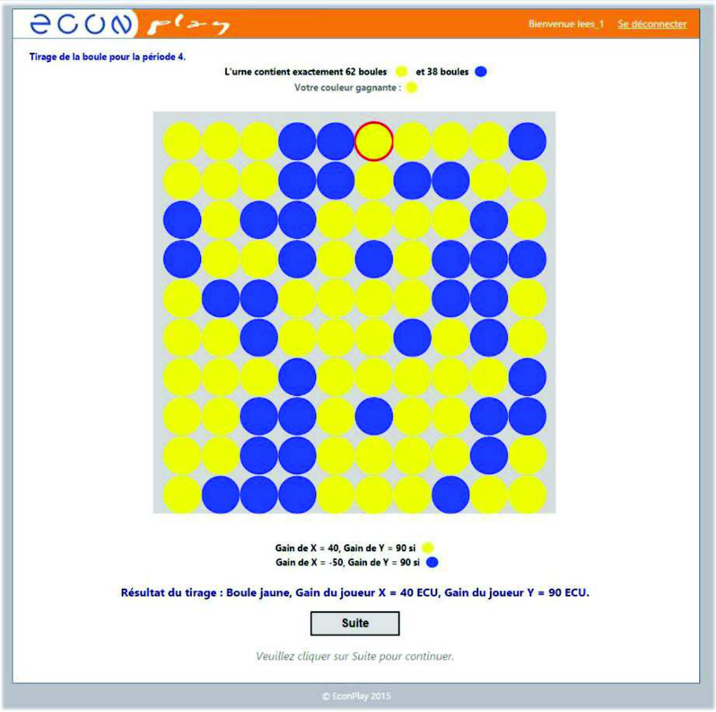


Figure 16: Screenshot of the draw of a blue or yellow ball in RK treatment under unlimited liability

Figure 17: Screenshot of the feedback table during round 4 in RK treatment under unlimited liability

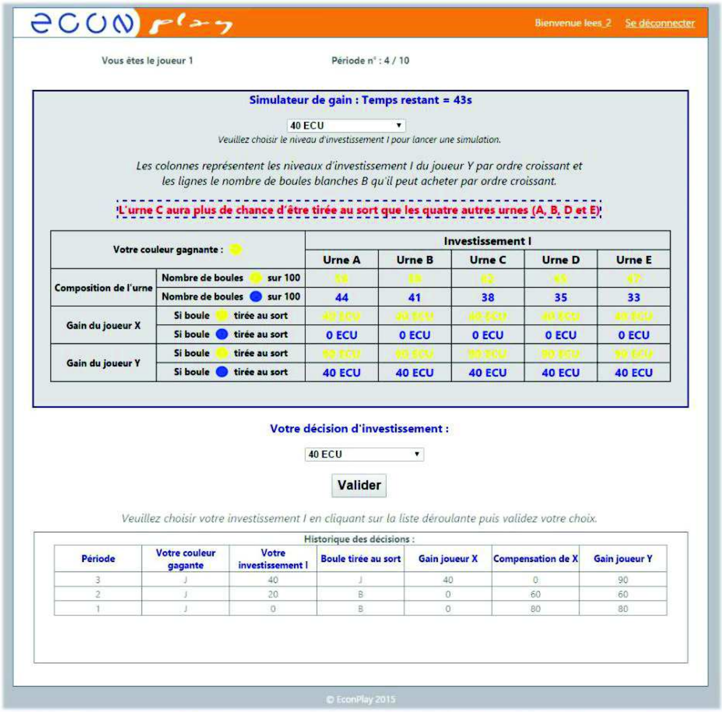


Figure 18: Screenshot of subject's decision choice in AMB treatment under limited liability

Figure 19: Screenshot of the first draw of an urn in AMB treatment under limited liability

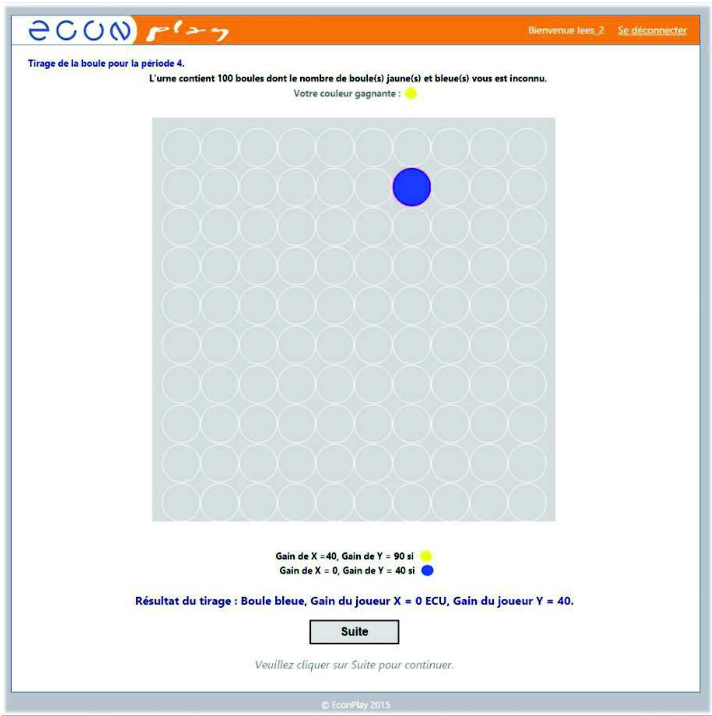


Figure 20: Screenshot of the second draw of a yellow or blue ball from the drawn urn in AMB treatment under limited liability

Figure 21: Screenshot of the feedback table during round 4 in AMB treatment under limited liability

Vous êtes le joueur 1

L'ordinateur vous a désigné comme joueur X

Le tableau ci-dessus rappelle l'ensemble de vos décisions en tant que joueur X ainsi que les gains des joueurs X et Y.

Rappel : En tant que joueur X, vous recevez une allocation d'un montant de 100 ECU pour ce jeu 4.

Nous allons procéder au tirage au sort de la période gagante.

Historique des décisions :

Période	Couleur gagante	Investissement I	Urne tirée au sort	Nombre de boules jaunes	Nombre de boules bleues	Boule tirée au sort	Gain joueur X	Compensation de X	Gain joueur Y
1	J	0	B	8	92	B	0	80	80
2	J	20	C	41	59	B	0	60	60
3	J	40	D	65	35	J	40	0	90
4	J	40	A	56	44	B	0	40	40
5	J	20	B	38	62	B	0	60	60
6	J	40	D	65	35	B	0	40	40
7	J	40	C	62	38	J	40	0	90
8	J	20	C	41	59	B	0	60	60
9	J	0	D	18	82	B	0	80	80
10	J	0	D	18	82	B	0	80	80

Figure 22: Screenshot of feedback table at the end of the experiment in AMB treatment under limited liability

C.2 Sets of Instructions

[Translated from French to English]

Welcome in our laboratory.

You are about to participate in an experiment in decision making. If you carefully follow the instructions and you make good decisions you may earn a nice payment which will be given to you at the end of the experiment. All subjects have identical instructions. Do not hesitate to ask questions during the experiment.

Your payment during this experiment will partially depend on your decision choices, the decision of others and the results of random draw.

- **General framework**

The experiment comprises four tasks.

The instruction for the first task will be directly handed out.
The instruction for the second task will be handed out after the first task.
The instruction for the third task will be handed out after the second task.
The instruction for the fourth task will be handed out after the thrid task.

Each task will be paid out. Your payment is the sum of the pay-offs of the four tasks. We inform you about the pay-offs of the four tasks at the end of the experiment. You will receive your payment in cash.

- **First task of the experiment (TASK 1)**

Your task will be to choose between two alternatives: "Left" and "Right". The alternative will determine the allocation of a certain amount between you (Player A) and another subject (Player B) present in this room.

The alternatives:

- Alternative Left will pay you €0 and player B €-10
- Alternative Right will pay you and player B an equally amount of €X. Notice that the amount X increases from one line to the next.

Les joueur A et B ont une dotation de 10€ qui compensera leurs pertes dans ce jeu.

Veuillez choisir entre l'Option Gauche qui fait perdre 0€ au joueur A et -10€ au joueur B et l'Option Droite qui fait perdre -X€ aux 2 joueurs.

Option Gauche : Perte de 0€ pour le joueur A et de -10€ pour le joueur B.	Gauche	Droite	Option Droite : Perte de X€ pour le joueur A et pour le joueur B.
(0€,-10€)	●	○	(-10€,-10€)
(0€,-10€)	○	○	(-9€,-9€)
(0€,-10€)	○	○	(-8€,-8€)
(0€,-10€)	○	○	(-7€,-7€)
(0€,-10€)	○	○	(-6€,-6€)
(0€,-10€)	○	○	(-5€,-5€)
(0€,-10€)	○	○	(-4€,-4€)
(0€,-10€)	○	○	(-3€,-3€)
(0€,-10€)	○	○	(-2€,-2€)
(0€,-10€)	○	○	(-1€,-1€)
(0€,-10€)	○	●	(0€,0€)

Figure 23: Information table

Remark: You are not allowed to make inconsistent decisions during this task. More precisely, in case you prefer alternative "Left" for a certain line (amount €X), the computer imposes you the same alternative for the lines lower than X. Similarly, if you prefer alternative "Right" for a certain line (€X), the computer imposes you the same alternative for the adjacent lines higher than X. Furthermore, the computer requires you to choose alternative "Left" for the amount X equal to €0 and alternative "Right" for the amount X equal to €10.

Pay-offs :

At the end of the experiment, the computer assigns you randomly to player A or B. If you are assigned as player A, the computer will randomly draw a line (€X). Given the result of the random draw, your pay-off depends on your decision choice. In the case you have chosen the alternative "Right", the pay-offs of both players will be €X. In case you have chosen alternative "Left", player A's pay-off will be €10 and Player B's pay-off will be €0.

If you are assigned as player B, your pay-off will depend on player A's decision choice and the random draw of the line (€X). In the case player A has chosen the alternative "Right", the pay-offs of both players will be €X. If player A has chosen alternative "Left", your pay-off will be €0.

The random draws are performed individually.

- **Second task of the experiment (TASK 2)**

Your task will be to choose between two alternatives: "Left" and "Right". The computer asks you whether you like to choose the color, blue or yellow, as your winning color. The chosen color remains your winning color throughout the experiment.

You receive an endowment of 10 Euro to compensate potential losses during this task.

The alternatives:

- Alternative "Left" contains the draw of a ball from an urn comprised with a known numbers of blue and yellow balls. The urn is composed exactly with 5 blue and 5 yellow balls. In case the ball drawn from the urn is the same color as your winning color, then you will incur a loss of €0, otherwise you will incur a loss of €-10.
- Alternative "Right" incur with certainty a loss of amount X. The amount X varies within a range from €-10 to €0.

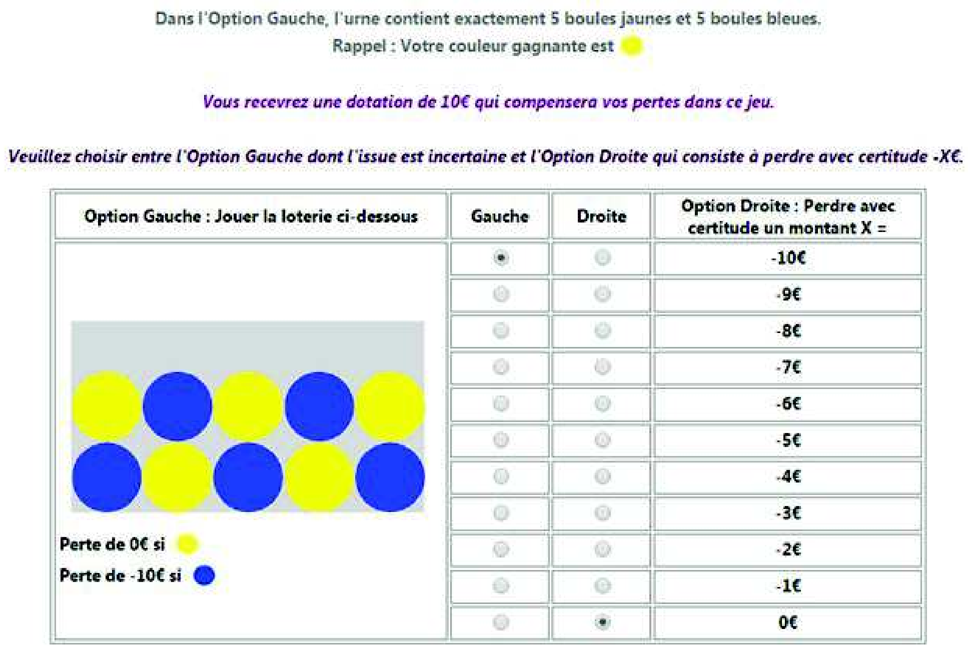


Figure 24: Information table

Remark: You are not allowed to make inconsistent decisions during this task. More precisely, in case you prefer alternative "Left" for a certain line (amount €X), the computer imposes you the same alternative for the lines lower than X. Similarly, if you prefer alternative "Right" for a certain line (€X), the computer imposes you the same alternative for the adjacent lines higher than X. Furthermore, the computer requires you to choose alternative "Left" for the amount X equal to €-10 and alternative "Right" for the amount X equal to €0.

Pay-offs :
At the end of the experiment, the computer determines randomly a line X.
If you choose alternative "Left", a ball will be drawn from the urn. If the color of the ball corresponds to your winning color, your pay-off will be €10 (Endowment minus the loss of €0), otherwise your pay-off will be €0 (Endowment minus the loss of €10). If you choose alternative "Right", your pay-off will be equal to the endowment minus the loss of €X.

The draw is performed on an individual basis during this task.

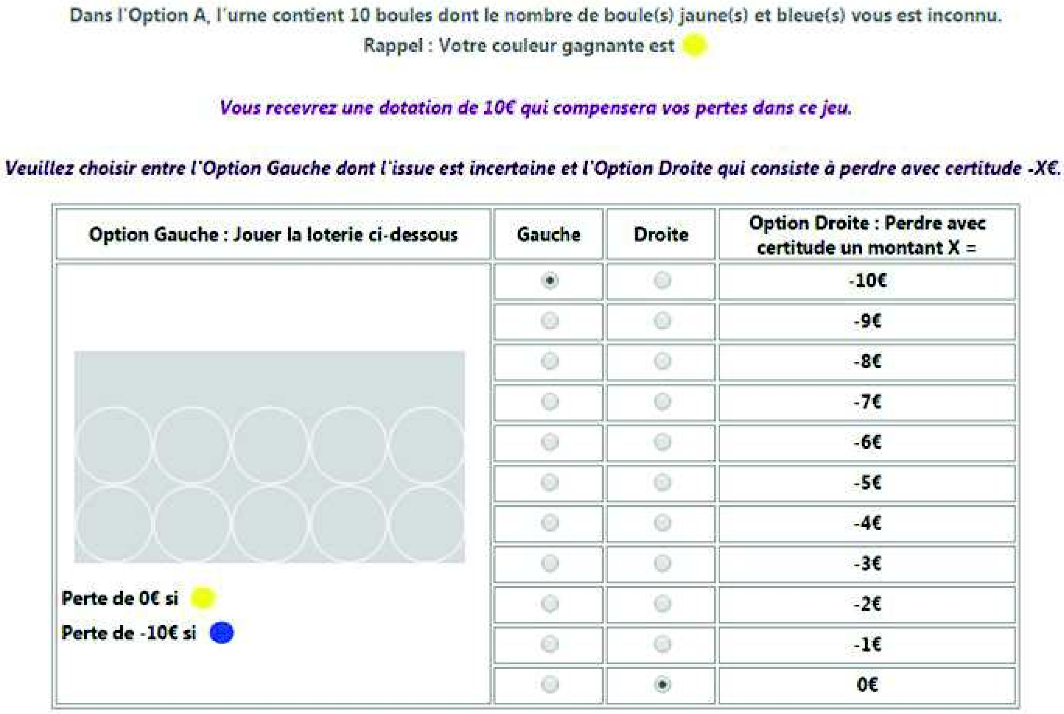
- **Third task of the experiment (TASK3)**

Your task will be to choose between two alternatives: "Left" and "Right". Your winning color from previous tasks remains the same during this task.

You receive an endowment of 10 Euro to compensate potential losses during this task.

The alternatives:

- Alternative "Left" contains the draw of a ball from an urn comprised with 10 balls in which the number of blue and yellow is unknown. The unknown urn may consist of 0 until 10 blue balls and 0 until 10 yellow balls. In case the ball drawn from the urn corresponds to your winning color, then you will incur a loss of €0, otherwise you will incur a loss of €-10.
- Alternative "Right" incur with certainty a loss of amount X. The amount X varies within a range from €-10 to €0.



Dans l'Option A, l'urne contient 10 boules dont le nombre de boule(s) jaune(s) et bleue(s) vous est inconnu.
Rappel : Votre couleur gagnante est

Vous recevrez une dotation de 10€ qui compensera vos pertes dans ce jeu.

Veuillez choisir entre l'Option Gauche dont l'issue est incertaine et l'Option Droite qui consiste à perdre avec certitude -X€.

Option Gauche : Jouer la loterie ci-dessous	Gauche	Droite	Option Droite : Perdre avec certitude un montant X =
Perte de 0€ si Perte de -10€ si			-10€
			-9€
			-8€
			-7€
			-6€
			-5€
			-4€
			-3€
			-2€
			-1€
			0€

Figure 25: Information table

Remark: You are not allowed to make inconsistent decisions during this task. More precisely, in case you prefer alternative "Left" for a certain line (amount €X), the computer imposes you the same alternative for the lines lower than X. Similarly, if you prefer alternative "Right" for a certain line (€X), the computer imposes you the same alternative for the adjacent lines higher than X. Furthermore, the computer requires you to choose alternative "Left" for the amount X equal to €-10 and alternative "Right" for the amount X equal to €0.

Pay-offs :

At the end of the experiment, the computer determines randomly a line X.

If you choose alternative "Left", a ball will be drawn from the urn. If the color of the ball corresponds to your winning color, your pay-off will be €10 (Endowment minus the loss of €0), otherwise your pay-off will be €0 (Endowment minus the loss of €10). If you choose alternative "Right", your pay-off will be equal to the endowment minus the loss of €X.

The draw is performed on an individual basis during this task.

C.2.1 Risk & Unlimited Liability

General framework:

This task comprises 10 rounds. In each round you are asked to make a decision choice as player X. At the end of the experiment, you will be informed about your role whether you have been assigned to player X or Y. You do not know your role before the end of the experiment.

Your role does not change during the 10 rounds. In case you are player X, you will be linked with a different player Y in each round. Similarly, in case you are player Y, you will be linked with a different player X in each round. It is impossible that you play twice with the same player Y or X.

Player X receives a show-up fee of 100 ECU to compensate potential losses. This show-up fee does not apply to player Y.

Player X faces a decision choice for the pair XY. Both player's pay-off will depend on player X's decision choice. At the beginning of each round, player X receives an endowment of **80 ECU**. Player Y receives **90 ECU**.

13 ECU are equivalent to 1 Euro.

The course of instruction details player X's decision choice.

During the 10 rounds, player X and Y's pay-offs depend on:

- The investment level I chosen by player X
- Result of the random draw of a ball from an urn comprising 100 balls of color blue and yellow of a known composition

Your winning color from previous tasks remains the same during this task.

Investment level of player X:

In each round, player X decides whether to invest 0, 20, 40, 60 or 80 ECU. The level of investment will determine the number of blue and yellow balls in the urn (See for further details figure 15 below). The higher the level of investment, the higher the number of balls with your winning color will be in the urn. The investment incurs a cost which is equal to the level of investment for player X .

Player X and Y's pay-offs:

- In case the ball drawn from the urn correspond to your winning color, player Y will lose her initial endowment of 90 ECU. However this loss will be fully compensated by player X. Player X pay-off will be equal to her initial endowment less the investment cost less the compensation fee transferred to player Y (80 ECU $-I$ – 90 ECU).
- In case the ball drawn from the urn correspond to your winning color, player X's pay-off will be equal to her initial endowment less the investment cost (80 ECU $-I$) and player Y pay-off will be 90 ECU.

		Investment *I*				
		0 ECU	**20 ECU**	**40 ECU**	**60 ECU**	**80 ECU**
Your winning color is Yellow	**Composition of the urn**					
	Number of yellow balls upon 100 balls	13	41	62	78	91
	Number of blue balls upon 100 balls	87	59	38	22	9
Player X's payoffs	***If a yellow ball is drawn***	*80 ECU*	*60 ECU*	*40 ECU*	*20 ECU*	*0 ECU*
	If a blue ball is drawn	*-10 ECU*	*-30 ECU*	*-50 ECU*	*-70 ECU*	*-90 ECU*
Player 's payoffs	***If a yellow ball is drawn***	*90 ECU*	*90 ECU*	*90 ECU*	*90 ECU*	*90 ECU*
	If a blue ball is drawn	*90 ECU*	*90 ECU*	*90 ECU*	*90 ECU*	*90 ECU*

Figure 26: Information table

Example:

Assume that your winning color is YELLOW.

In case you invest **0 ECU**, thus the urn comprises 13 yellow and 87 blue balls. The probability of drawing one yellow ball from the urn is 13% and one blue ball from the urn is 87%.

In case a blue ball will be drawn, thus player X pay-off will be negative and will be equal to -10 **ECU**. This amount corresponds to the initial endowment of player X less the investment cost less the compensation fee transferred to player Y (-10 ECU = 80 ECU -0 ECU -90 ECU). Player Y pay-off will be 90 **ECU**.

In case a yellow ball will be drawn, thus player X pay-off will be **80 ECU**. This amount corresponds to the initial endowment of player X less the investment cost (80 ECU = 80 ECU -0 ECU). Player Y pay-off will be **90 ECU**.

Note that all rounds and draws will be independent from each other.

Feedback during the game:

At the beginning of each round, you are provided with a feedback table indicating for each previous round: your level of investment, the result of the draw as well as player X and Y's pay-off.

Summary of the task:

- Each participant will decide as player X and does not know his/her role (X or Y) until the end of the game.
- Player X receive a show-up fee of 100 ECU to compensate potential losses. This show-up fee does not apply to player Y.
- In each round, player X receives an initial endowment of 80 ECU and player Y receives an initial endowment of 90 ECU.
- Player X decision choice determines player X and Y's pay-off.
- Player X's level of investment determines the number of blue and yellow balls in the urn.
- The higher the level of investment, the higher the number of balls of your winning color will be in the urn.
- In case the ball drawn from the urn corresponds to your winning color, thus player X's pay-off will be equal to her initial endowment less the investment cost (80 ECU $-I$). Player Y pay-off will be 90 ECU.
- In case the ball drawn from the urn does not correspond to your winning color, player X pay-off will be equal to her initial endowment less the investment cost less the compensation fee transferred to player Y (80 ECU $-I$ – 90 ECU). Player Y pay-off will be 90 ECU.

Payment:

At the end of the fourth task, the computer informs you whether you have been assigned to player X or Y. A participant present in the room will randomly choose a round which will determine the payment for this task. He/she announces the selected round to the other participants.

In case you are assigned as player X, thus your pay-off depends on your decision choice of the selected round. In case you are assigned as player Y, thus your pay-off will depend on player X's (With which you have been linked in the selected round) decision choice.

Your total pay-off for this experiment will be the sum of pay-offs of task one, two, three and four.

Before the task starts, you will participate in a quiz to verify your understanding about the instructions.

C.2.2 Ambiguity & Limited Liability

General framework:
This task comprises 10 rounds. In each round you are asked to make a decision choice as player X. At the end of the experiment, you will be informed about your role whether you have been assigned to player X or Y. You do not know your role before the end of the experiment

Your role does not change during the 10 rounds. In case you are player X, you will be linked with a different player Y in each round. Similarly, in case you are player Y, you will be linked with a different player X in each round. It is impossible that you play twice with the same player Y or X.

Player X receives a show-up fee of 100 ECU to compensate potential losses. This show-up fee does not apply to player Y.

Player X faces a decision choice for the pair XY. Both player's pay-off will depend on player X's decision choice. At the beginning of each round, player X receives an endowment of **80 ECU**. Player Y receives **90 ECU**.

13 ECU are equivalent to 1 Euro.

The course of instruction details player X's decision choice.

During the 10 rounds, player X and Y's pay-offs depend on:

- The investment level I chosen by player X
- Result from the first random draw of an urn from a big urn comprising 100 different urns; "urn A", "urn B", "urn C", "urn D" and "urn E" in an unknown composition
- Result from the second random draw of a ball from the urn (previously drawn) comprising 100 balls of the color blue and yellow in a known composition

Your winning color from previous tasks remains the same during this task.

The random draws:

Player X and Y's pay-offs depend on two random draws:

- The draw of an urn from a big urn comprising 100 urns in which the number of urn A, urn B, urn C, urn D and urn E is. The big urn can contain from 0 to 100 urns A, 0 to 100 urns B, 0 to 100 urns C, 0 to 100 urns D and 0 to 100 urns E.
- The draw of a ball from the previously drawn urn of the big urn.

Each of the five urns compromise 100 balls of color blue and yellow in an known composition. The number of blue and yellow balls will be different for each urn.

A first random draw will determine the urn. The second random draw of the previously drawn urn will determine whether the ball correspond or not to your winning color.

You receive an information regarding urn C. You will be free to believe whether this information is true. The information will not influence the composition of the different urns (A, B, C, D and E) in the big urn. It is up to you to believe whether you are confident about the information.

Investment of player X:
In each round, player X decides whether to invest 0, 20, 40, 60 or 80 ECU. The level of investment will determine the number of blue and yellow balls in the urn (See for further details figure 15 below). The higher the level of investment, the higher the number of balls with your winning color will be in the urn. The investment incurs a cost which is equal to the level of investment for player X .

Player X and Y's pay-offs:

- In case the ball drawn from the urn corresponds to your winning color, player X pay-off equals to her initial endowment less the investment cost (80 ECU $-I$). Player Y pay-off will be 90 ECU.
- In case the ball drawn from the urn does not correspond to your winning color, player Y will lose her initial endowment of 90 ECU. In this case, player X is required to compensate partially player Y's losses. The compensation amount need to be paid by player X will be equal to her/his initial endowment less the investment cost (80 ECU $-I$). Player Y pay-off equals the compensation fee transferred from player X. Player X pay-off will be 0 ECU.

Table 27 (At the end of the instruction) illustrates an example by considering yellow as the winning color. The table presents player X and Y's pay-off depending on player X's chosen level of investment.

Example:

Assume that your winning color is YELLOW.

In case player X chooses the level of investment of **0 ECU**, thus urn A comprises 3 yellow and 97 blue balls, urn B comprises 8 yellow and 92 blue balls, urn C comprises 13 yellow and 87 blue balls, urn D comprises 18 yellow and 82 blue balls and urn E comprises 23 yellow and 77 blue balls. The corresponding probabilities that a yellow ball will be randomly drawn are 3%, 8%, 13%, 18% and 23% if urn A, B, C, D or E will be drawn respectively. Similarly, the corresponding probabilities that a blue ball will be randomly drawn are 97%, 92%, 87%, 82% and 77% if urn A, B, C, D or E is drawn respectively.

In case a blue ball will be randomly drawn, player X pay-off will be **0 ECU**. Player Y will lose his/her initial endowment which needs to be partially compensated by player X. The amount of compensation equals the player X's initial endowment less the investment cost. Player Y pay-off will be **80 ECU** (80 ECU = 80 ECU $-$0 ECU).

In case a yellow ball will be randomly drawn, player X pay-off will be **80 ECU**. This amount corresponds to her/his initial endowment less the investment costs (80 ECU = 80 ECU $-$0 ECU). Player Y pay-off will be **90 ECU**.

Note that all rounds and draws will be independent from each other.

Feedback during the game:

At the beginning of each round, you are provided with a feedback table indicating for each previous round: your level of investment, the result of the draw as well as player X and Y's pay-off.

Summary of the task:

- Each participant will decide as player X and does not know his/her role (X or Y) until the end of the game.
- Player X receives a show-up fee of 100 ECU to compensate potential losses. This show-up fee does not apply to player Y.
- In each round, player X receives an initial endowment of 80 ECU and player Y receives an initial endowment of 90 ECU.
- Player X decision choice determines player X and Y's pay-off.
- Player X's level of investment determines the number of blue and yellow balls in the urn.
- The number of blue and yellow balls will be different in each urn.
- The higher the level of investment, the higher the number of balls of your winning color will be in the urn.
- Player X and Y's pay-offs depend on two random draws.
- One urn will be randomly drawn from a big urn comprising 100 urns in which the number of urn A, urn B, urn C, urn D and urn E are unknown.
- You will receive an information regarding urn C.
- You will be free to believe whether this information is true.
- The information will not influence the composition of the different urns (A, B, C, D and E) in the big urn.
- In case the ball drawn from the previously drawn urn corresponds to your winning color, player X's pay-off will be equal to her/his initial endowment less the investment cost (80 ECU $-I$). Player Y pay-off will be 90 ECU.
- In case the ball drawn from the previously drawn urn does not correspond to your winning color, player X pay-off will be 0 ECU. Player Y's pay-off will be equal to player X's initial endowment less the investment cost (80 ECU $-I$).

Payment:

At the end of the fourth task, the computer informs you whether you have been assigned to player X or Y. A participant present in the room will randomly choose a round which will determine the payment for this task. He/she announces the selected round to the other participants.

In case you are assigned as player X, thus your pay-off depends on your decision choice of the selected round. In case you are assigned as player Y, thus your pay-off will depend on player X's (With which you have been linked in the selected round) decision choice.

Your total pay-off for this experiment will be the sum of pay-offs of task one, two, three and four.

Before the task starts, you will participate in a quiz to verify your understanding about the instructions.

Your winning color is Yellow		Investment *I*														
		0 ECU					20 ECU					40 ECU				
		Urn A	Urn B	Urn C	Urn D	Urn E	Urn A	Urn B	Urn C	Urn D	Urn E	Urn A	Urn B	Urn C	Urn D	Urn E
Composition of the urn	Number of yellow balls upon 100 balls	3	8	13	18	23	34	38	41	45	48	56	59	62	65	67
	Number of blue balls upon 100 balls	97	92	87	82	77	66	62	59	55	52	44	41	38	35	33
Player X's pay-off	***If a yellow ball is drawn***	*80 ECU*					*60 ECU*					*40 ECU*				
	If a blue ball is drawn	*0 ECU*					*0 ECU*					*0 ECU*				
Player Y's pay-off	***If a yellow ball is drawn***	*90 ECU*					*90 ECU*					*90 ECU*				
	If a blue ball is drawn	*80 ECU*					*60 ECU*					*40 ECU*				

Votre couleur gagnante est le JAUNE		Investment *I*										
		60 ECU					80 ECU					**Player X receives a show-up fee of 100 ECU. This show-up fee does not apply to player Y.**
		Urn A	Urn B	Urn C	Urn D	Urn E	Urn A	Urn B	Urn C	Urn D	Urn E	
Composition of the urn	Number of yellow balls upon 100 balls	74	76	78	80	82	87	89	91	92	94	
	Number of blue balls upon 100 balls	26	24	22	20	18	13	11	9	8	6	
Player X's pay-off	***If a yellow ball is drawn***	*20 ECU*					*0 ECU*					
	If a blue ball is drawn	*0 ECU*					*0 ECU*					
Player Y's pay-off	***If a yellow ball is drawn***	*90 ECU*					*90 ECU*					
	If a blue ball is drawn	*20 ECU*					*0 ECU*					

Figure 27: Information table

C.3 Questionnaire

We would like to ask you to fill out some socio-demographic questions about yourself.

- Q1. Age:

- Q2. Years of study:

- Q3. Gender:
  - Men
  - Women

- Q4. Your study:
  - Economic, Economic & Mathematics, Management
  - Quantitative Science (e.g. Life Sciences, Engineering, Biology, Chemistry)
  - Qualitative Science (e.g. Political Science, Psychology, etc.)
  - Languages
  - Literature and Philosophy
  - Other

- Q5. Do you have a French nationality?
  - Yes
  - No

- Q6. If no, which is your nationality?

- Q7. How many siblings older than you do you have?

- Q8. How many siblings younger than you do you have?

- Q9. Do you live in a couple?

- Q10. Your religion?
  - Agnostic
  - Catholic
  - Protestant

  - Orthodox
  - Muslim
  - Jew
  - Hinduism
  - Buddhism
  - Other

- Q11. Would you say that most of the time people try to help others or only follow their own interests? (0=help others; 6=follow their own interests)

- Q12. Would you say that most of the time you try to help others or only follow your own interests? (0=help others; 6=follow your own interests)

  In this first set of questions we are interested in your perception of fairness with respect to OTHERS. Please mark your level of agreement using the 7-point scale shown below.

- Q13. I feel that people generally earn the rewards and punishments that they get in this world

- Q14. People usually receive the outcomes that they deserve

- Q15. People generally deserve the things that they are accorded

- Q16. I feel that people usually receive the outcomes that they are due

  In this next set of questions we are interested in your perception of fairness with respect to YOURSELF. Please mark your level of agreement using the 7-point scale shown below.

- Q17. I feel that I generally earn the rewards and punishments that I get in this world

- Q18. I usually receive the outcomes that I deserve.

- Q19. I generally deserve the things that I am accorded.

- Q20. I feel that I usually receive the outcomes that I am due.

- Q21. How do you see yourself: Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please tick a box on the scale, where the value 0 means: "risk averse" and the value 10 means: "fully prepared to take risks". You can use the values in between to make your estimate

- Q22. How do you see yourself: Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please tick a box on the scale, where the value 0 means: "risk averse" and the value 10 means: "fully prepared to take risks". You can use the values in between to make your estimate

  - Q22.1 while driving?
  - Q22.2 in financial matters?
  - Q22.3 during leisure and sport?
  - Q22.4 in your occupation?
  - Q22.5 with your health?
  - Q22.6 your faith in other people?

- Q23. Please consider what you would do in the following situation: Imagine that you had won 100,000 Euros in the lottery. Almost immediately after you collect the winnings, you receive the following financial offer from a reputable bank, the conditions of which are as follows: There is the chance to double the money within two years. It is equally possible that you could lose half of the amount invested. You have the opportunity to invest the full amount, part of the amount or reject the offer. What share of your lottery winnings would you be prepared to invest in this financially risky, yet lucrative investment?

  - 100.000 Euros
  - 80.000 Euros
  - 60.000 Euros
  - 40.000 Euros
  - 20.000 Euros
  - Nothing, I would decline the offer

  In this next set of questions we are interested in your degree of optimism. Please mark your level of agreement using the 5-point scale shown below.

- Q24. In uncertain times, I usually expect the best.

- Q25. It's easy for me to relax

- Q26. If something can go wrong for me, it will [Reversed]

- Q27. I'm always optimistic about my future
- Q28. I enjoy my friends a lot
- Q29. It's important for me to keep busy
- Q30. I hardly ever expect things to go my way [Reversed]
- Q31. I don't get upset too easily
- Q32. I rarely count on good things happening to me [Reversed]
- Q33. Overall, I expect more good things to happen to me than bad

In this next set of questions we are interested in your degree of confidence. Please mark your level of agreement using the 5-point scale shown below.

- Q34. In the future, society will be functioning as well as today
- Q35. Our society is well equipped to solve future problems
- Q36. The future safety and security of our population is assured
- Q37. Our society has a bright future
- Q38. Nowadays, things seem to be getting more and more out of control [Reversed]
- Q39. Altogether, we live in a safe and secure time.

In this next set of questions we are interested in your degree of trust. Please mark your level of agreement using the 5-point scale shown below.

- Q40. Most people tell a lie when they can benefit by doing so
- Q41. Those devoted to unselfish causes are often exploited by others

- Q42. Some people do not cooperate because they pursue only their own short-term self-interest. Thus, things that can be done well if people cooperate often fail because of these people

- Q43. Most people are basically honest [Reversed]

- Q44. There will be more people who will not work if the social security system is developed further