Risk in the Background: How Men and Women Respond

Alexandra van Geen (Harvard University)*

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Abstract

This study experimentally tests the gender-specific effect of risky environments on subsequent risk taking. Many decisions take place in the presence of unrealized risk, frequent income fluctuations and realizations of risk, but the effect of these factors is poorly understood. This study finds stark differences in how females and males take risks in response to these stimuli. Females increase risk taking after an increase in income and in the presence of a positive-outcome unrealized risk, but there are no such effects for males. Males increase risk taking after winning a lottery, while females do not.

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1 Introduction

When considering risks in isolation, lab and field studies find that females have higher baseline risk aversion; they are generally less inclined to accept a risky prospect than males (e.g.,Eckel and Grossman, 2008; Croson and Gneezy, 2009). However, decisions to take on risk typically do not occur in isolation, rather they occur in the presence of a risky environment. Decision makers will have had previous exposure to risks of which they have since learned the outcome, and may simultaneously face risks of which the outcome is not yet revealed. For example, an investment banker deciding whether to purchase $300 million of stocks, may moments before have made the deal of his lifetime. An engineer who is considering to undergo a risky surgery, may at the same time be burdened by whispers of a looming reorganization at her company. Even when the fortunate realization of the investment banker's previous investment does not objectively alter the odds of the stock investment, this 'realized risk' may still impact his willingness to buy. Similarly, even though the potential layoff does not affect her medical outlook, the presence of this 'unrealized risk' may still influence the engineer's likelihood to opt for surgery. In order to have a true grasp of the gender differences in risk attitudes, we will therefore need to allow for these interactions with the decision environment.

In this paper I use laboratory experiments to test whether there are gender differences in how the presence of- independent and exogenous- realized and unrealized risks affect subsequent risk attitudes. The design also allows me to establish whether this sensitivity is driven by the income associated with these risks. Decision models such as Expected Utility Theory or Prospect Theory allow for an effect of realized and unrealized risk on subsequent risk attitudes through the income associated with their outcomes. However, realized and unrealized risk may also impact risk attitudes through non-income channels. The experience of winning after the realization of risk may for example give rise to altered emotional or hormonal states, or affect expectations on the odds of subsequent risky prospects. Similarly, the experience of the stochastic element associated with an unrealized risk may create a state of suspense that directly affects risk attitudes.

I find that an increase in income increases risk taking in females, but does not increase risk taking in males. Positive-outcome unrealized risk also tends to increase risk taking in females but not in males, and this effect appears to be mostly driven by the income associated with the potential outcomes of the lottery. The size of the increase in risk taking is significant, and eliminates the initial gender difference in risk attitude. The income effect appears transient, and females eventually return to baseline risk preferences. The experience of winning after the realization of risk increases risk taking in males but does not have this effect for females.

The income-driven effect of unrealized risk for females is consistent with the commonly used isoelastic utility function. For this function increased sensitivity to income is implied by the higher baseline risk aversion of females. The temporary nature of the effect of income is consistent with decision models that feature reference point dependence, including prospect theory.

The observed winning effect for males is conform the observations by Wall Street trader turned neuroscientist John Coates, who reports how past profitable trades appeared to increase risk taking in male Wall Street traders to an irrational and dangerously high magnitude, an effect he attributes to winning-induced surges in testosterone (Coates, 2012).

The findings of this study support a more integrated view on risk attitude. This paper joins ranks with other studies that stress the importance of the riskiness of the decision environment: Cameron and Shah (2013) find that the experience of an earthquake or flood reduces risk taking in lottery-based elicitation tasks by about 50%. Malmendier and Nagel (2011) find that the generation who experienced the Great Depression has a lower willingness to take financial risk. Provincial level GDP growth variability and variable business income have also been found to reduce risk taking (Guiso and Paiella, 2008; Heaton and Lucas, 2000)

This paper proceeds as follows. Section II discusses the ways through which realized and unrealized risk can affect risk attitudes. In the conceptual framework of Section III, I derive the testable conditions that enable me to estimate gender-specific effects. Section IV describes the experimental design, Section V reports the experimental results and Section VI concludes.

2 Theory and Evidence

2.1 Sensitivity to Realized Risk: the Income or the Experience?

The realization of a risk can affect the risk attitude towards subsequent, unrelated, risks because of the *income* associated with the realization of the risk, and also through the associated *experience*. Income effects feature heavily in decision models such as (Cumulative) Prospect Theory (CPT) and Expected Utility Theory (EUT.) In true EUT, the assumptions of wealth integration and decreasing absolute risk aversion imply increased risk taking after increased income. However, experimentalists have increasingly moved away from this model to explain risk taking in laboratory studies. Rabin (2000) observes that the assumption of total wealth integration dictates that subjects should be risk neutral over the small stakes that are typically used in lab experiments, and this assumption is therefore irreconcilable with the facts. Many studies have since rejected the assumption of (full) wealth integration (Heinemann, 2008; Barberis et al., 2006). The evidence of lack of wealth integration is consistent with the concept of 'narrow framing' where people make investment decisions without taking into account their total portfolio. A version of EUT, where subjects partake in narrow framing and integrate only the earnings that fall within the frame (e.g., their earlier experimental earnings), does allow for income effects on the restricted domain that the laboratory experiment provides.[1] In the remainder of this paper whenever I discuss the income effects of 'EUT', I refer to this narrow framing version of EUT. Although the CPT

[1]The assumption of integration of experimental income is susceptible to similar criticism as the assumption of asset integration in EUT. Any theory of decision making under risk that relies on diminishing marginal utility of wealth to explain risk attitude, regardless if they specify full, partial or no asset integration, is susceptible to a version of the Rabin critique (Cox et al., 2007; Cox and Sadiraj, 2008).

model does not feature asset integration, because of the slope of the value function, income associated with the realization of risk may still temporarily affect risk taking if people fail to update their reference points.

These decision models do not allow for a direct effect from the experience of the realization of risk. When the outcome of the realized risk is fortunate and the decision maker 'wins,' the experience of winning may directly impact risk preferences. For example, winning may create certain emotions that in turn affect risk preferences. Good mood has been shown to increase optimism, and stock markets do better on sunny days (e.g., Wright and Bower, 1992; Hirshleifer and Shumway, 2003). Hormones are also affected by winning: Winning increases testosterone in men and increases their risk taking (Apicella et al., 2014). Winning may also affect beliefs. For example, it may give rise to hot-hand beliefs: After a string of successes, individuals have been shown to believe they are on a winning streak and give subjective probabilities of winning that exceed the objective probabilities (Croson and Sundali, 2005). In contrast, winning may give rise to the gambler's fallacy and reduce the perceived likelihood of winning a subsequent, independent, risk.

Although I am not aware of incentivized and controlled experiments that feature both genders, there is some research that suggests increased risk taking after past wins. Traders at the Taiwan Stock Exchange take above average risks after gains in prior trading outcomes (Liu et al., 2010). In a study by Thaler and Johnson (1990), participants were presented with a list of hypothetical statements in the form "you have won/lost X." Following a hypothetical win, participants were more likely to take a gamble. In their study with male subjects, Apicella et al. (2014) find that risk taking increases after winning the rock-paper-scissors game.

2.2 Sensitivity to Unrealized Risk: the Income, or the Anticipation?

An independent and uninsurable 'background risk' can affect the willingness to take on subsequent risk in two ways. Firstly, the income associated with the potential outcomes of background risks may affect risk taking. Within the EUT model, the assumption of asset integration ensures that the income associated with the potential outcomes of the background risk affects subsequent risk taking (Gollier and Pratt, 1996; Quiggin, 2003). For *undesirable* background risks, utility functions that satisfy proper risk aversion (Pratt and Zeckhauser, 1987), standard risk aversion (Kimball, 1993) and the more general risk vulnerability (Gollier and Pratt, 1996) all imply increased (absolute) risk aversion, and these conditions are met by a quite plausible set of assumptions. When it comes to *desirable* risks, the effect on risk attitude is less straightforward as there are two opposite forces. The increased riskiness may increase risk aversion for future risk in risk-vulnerable subjects, but the increased utility may reduce it (Gollier, 2001). Non-stochastic reference-point-based models such as CPT can also allow for an effect on risk attitude. If an individual's reference points are not updated after the introduction of background risk, the income associated with the background risk can affect risk taking through the effect of the induced gain- or loss-domain.

In a behavioral model, a second potential source of reactivity to unrealized risk is the sensitivity to the "risk component" of the background risk. The state of anticipation implies a presence of suspense that may change reference points or induce cognitive load and emotions; all of these have been shown to affect risk attitudes ((Loewenstein et al., 2001; Deck and Jahedi, 2013)). The model of Koszegi and Rabin (2006) allows for stochastic reference point distributions. It represents the notion that the risk component of unrealized risk affects tolerance to subsequent risks through the adjustment of the referent of what constitutes 'normal' risk. Sprenger (2013) shows that this model can result in an endowment effect for risks where the exposure to background risks makes a person more tolerant towards subsequent risks

There have been few studies that feature true experimental tests of the effect of background risk on risk taking, and none have studied gender differences. Results of the studies are conflicting. The low-stake lab-based experiments of Lusk and Coble (2008), and the low-stake field experiment with collector coins by Harrison et al. (2007), suggest a small reduction in risk taking in the presence of negative-outcome background risk and mean-reserving spreads. On the other hand, research on narrow bracketing finds that when selecting multiple risks, subjects appear to make decisions as if the risks are isolated (e.g., (Kahneman and Lovallo, 1993; Rabin and Weizsaecker, 2009)). Samuelson (1963) finds that offering multiple risks increases risk taking, a phenomenon he termed the "fallacy of large numbers." Sprenger (2013) also reports an increase in risk tolerance after endowing people with risks.

3 Conceptual Framework

3.1 Determining Income Effects for Men and Women

We define the absolute risk aversion at initial wealth level w as ***baseline risk aversion***. Decreasing absolute risk aversion implies a negative income effect after an increase in income by x because it causes a reduction from baseline risk aversion, i.e., $AR(w) < AR(x,w.)$

Definition. The ***income effect*** of income x on absolute risk aversion at wealth level w is defined as $IC(x, w) = AR(x, w) - AR(w)$.

Consider the risk represented by the lottery $L^*(X) = (p; b, c)$ with $b>c>0$. Decreasing absolute risk aversion implies a larger reduction in risk aversion if outcome b is realized than if outcome c is realized. Therefore, the income effect of b is more negative, i.e., $IC(b, w) < IC(c, w)$.

This inequality applies for EUT with narrow framing, in which case b and c refer to the earlier-obtained income within the narrow frame. It also applies for models with reference-point dependence, such as CPT if reference points have not been updated and b and c refer to the distance as compared to the reference point w. This inequality may not hold if people more crudely respond to the gain (or loss) frame that the income induces, because in that case there may not be level effects of income on risk attitude.

The realization of risk may come with a larger income effect for females because they have higher baseline risk aversion (i.e., $AR^f(w_f) > AR^m(w_m)$. To see this, If at any wealth level w, agent i is more risk averse than decision maker j, then it holds that $u_i(w) = g \diamond u_j(w)$ for some concave function g. It can be derived that $AR^i(w) = AR^j(w) - f(w)$ where $f(w) = \frac{g''(u_j(w)))}{g'(u_j(w))} u_j'(w)$ and $f(w) < 0$. Therefore, the income effects for agent i after the realization of the lottery can be written as:

$$IC^i(x,w) = (AR^j(x,w) - f(w+x)) - (AR^j(w) - f(w)) = IC^j(x,w) - (f(w+x) - f(w).)$$

For f increasing in w, the income effect after the assignment of a positive-outcome realized risk would reduce risk aversion more for agent i than it would for agent j. This condition can easily be verified for the commonly used power utility function $u(w) = \frac{w^{1-\rho}}{1-\rho}$. For this function, $RR = \rho$ is the coefficient of relative risk aversion. Absolute risk aversion is decreasing, with $AR = \frac{\rho}{w}$. If females have higher relative risk aversion than males (i.e., $RR^f = \rho^f = \rho^m + c$), they thus have higher baseline absolute risk aversion $AR^f = \frac{\rho^m + c}{w}$. Since $AR^f = AR^m - f(w)$ it must hold that $f(w) = -\frac{c}{w}$ with $f' > 0$. Therefore, in this family of functions, income will increase risk taking more for agents with higher baseline risk aversion.[2]

Similar to the effect of a certain change in income, unrealized risk also can affect risk aversion. Allowing for a stochastic element in wealth in the form of random variable $\tilde{k}$, and making use of the indirect utility function (Kihlstrom et al., 1981), it holds for all w that $v(w) = Eu(w + \tilde{k})$. Since $v^{[n]}(w) = Eu^{[n]}(w + \tilde{k})$ (Gollier, 2001), it holds that:

$$AR(w, \tilde{k}) = -\frac{v''(w)}{v'(w)} = -\frac{Eu''(w + \tilde{k})}{Eu'(w + \tilde{k})}$$

Next let $\tilde{x}$ denote the random variable associated with the unrealized risk represented by lottery $L^*(X) = (p; b, c)$ with $b > c$. Since $Ev(w + \tilde{x}) = p(v(w + b) + (1 - p)v(w + c)$, it follows

[2] If the observed gender difference in risk attitude is driven by lower initial wealth levels/lower reference points for females ($w_f < w_m$,) but they have otherwise identical DARA preferences, this could also explain the higher risk aversion of females. An increase in income by x then comes with a larger reduction in risk aversion for females as long as $IC' > 0$, which is satisfied for the power utility function, as for this function $IC' = \frac{\rho}{w^2} - \frac{\rho}{(w+x)^2} > 0$.

that:

$$AR(w,\tilde{k},\tilde{x}) = -\frac{Ev''(w+\tilde{x})}{Ev'(w+\tilde{x})} = -\frac{pv''(w+b)+(1-p)v''(w+c)}{pv'(w+b)+(1-p)v'(w+c)}$$

This implies:

$$AR(w,\tilde{k},\tilde{x}) = sAR(w,\tilde{k},b) + (1-s)AR(w,\tilde{k},c) \tag{1}$$

with $s = \frac{1}{1+\frac{1-p}{p}\frac{v'(c+w)}{v'(b+w)}}$. Note that $s>0.5$ for $c>b$. This can also be shown to hold for non-stochastic reference-point models such as CPT.[3]

The income effect of the background risk can thus be written as:

$$IC(w,\tilde{k},\tilde{x}) = sIC(b.w) + (1-s)IC(c,w.)$$

For $b>c>0$ and with DARA preferences risk aversion would therefore also reduce in the presence of background risk.

The theoretical implications for gender differences in income effects are similar for unrealized risk as they were for realized risk. For stochastic income in the form of lottery $L^*(X)$, it holds that $IC^f(\tilde{x},w) = s(IC^m(b,w) - f(w+b)) + (1-s)(IC^m(c,w) - f(w+c)$ and thus for f increasing in wealth, the income effect after the assignment of a positive-outcome unrealized risk would reduce risk aversion more for a female with higher baseline risk aversion than it would for a male with lower baseline risk aversion. This results in both of the following empirically testable predictions:

(1) Receiving positive income reduces aversion for subsequent risks, i.e., $IC < 0$.

[3] Within non-stochastic reference-point-based decision models such as CPT, there would only be an (income) effect of unrealized risk on risk attitudes if people fail to update their reference point. For a background risk with strictly positive outcomes that is not included in the reference point, condition (1) would still hold, although behavioral probability weighting would affect the weighting(s). Intuitively, because the outcomes of the risk are strictly positive, and risk preferences are still derived from the slope of the (concave) value function, the same results hold as before. Specifically, for a behavioral value function (denoted u*(x)), the indirect value function in the presence of unrealized risk can be set as $v(.) = Eu^*(\tilde{x}) = w(p)u^*(b) + (1-w(p))u^*(c)$.

(2) Females will be more prone to reduce their risk aversion after an unrealized or realized risk with strictly positive outcomes, i.e., $IC^f < IC^m$.

3.2 Determining Winning Effects for Men and Women

Realized risks can affect risk attitude through non-income channels when people are affected by the experience of 'winning' or 'losing.' In order to define the winning effect associated with the realization of risk, we denote $\mathcal{L}$ the set of simple lotteries on the finite outcome set X. A lottery L in $\mathcal{L}$ is a fn $L : X \rightarrow \mathbb{R}$ that has $L(x) \geq 0 \, \forall x \in X$ and $\sum_{x \in X} L(x) = 1$. Let for any x ∈ X δ_x denote the degenerate lottery that has $L(x) = 1$. Next, refer to $\mathcal{L}_x \supset (\mathcal{L} \backslash \delta_x)$ as the set of non-degenerate lotteries that have positive support on x. Then denote the set of outcome-generating processes for outcome x as $Q_x = \{\mathcal{L}_x, \delta_x\}$. When assuming that risk attitudes are not sensitive to the way in which the income comes about (i.e., no consequentialism), it holds that $AR(w, x, q_x) = AR(w, x)$, and thus $AR(w, x|\delta_x) = AR(w, x|L_x)$. If in contrast, people are sensitive to the experience that comes with the realization of risk, this condition will not hold. Letting x* be the highest possible outcome of lottery $L_{x*} \in \mathcal{L}_{x*}$, the ***winning*** of lottery L_{x*} implies the outcome x=x*.

Definition. For the lottery L_x the ***winning effect*** of winning x on absolute risk aversion, at wealth level *w,* is defined as $WN(w, x, L_x) = AR(w, x, |L_x) - AR(w, x|\delta_x)$.

The absolute risk aversion after winning x* in lottery L_{x*} can then be written as $AR(w, x* |L_{x*}) = AR(w) + IC(w, x*) + WN(w, x*, L_{x*})$. Conventional decision theories do not suggest a role for the experience of winning, resulting in the following testable condition:

(3) Both males and females are not sensitive to the effect of winning after a fortunate realization of a risk, i.e., $AR(w, x * |L_{x*}) = AR(w) + IC(w, x*)$.

3.3 Determining Anticipation Effects for Men and Women

If the presence of unrealized risk affects risk attitudes through channels other than income, condition (1) will not hold.

Definition. For random variable $\tilde{x}$ associated with lottery L_x, the ***anticipation effect*** on absolute risk aversion at wealth level w is defined as $ANT(w, x) = AR(w, \tilde{x}) - s(AR(w, b)) + (1 - s)(AR(w, c))$.

The anticipation effect can also be written as $ANT(w, \tilde{x}) = AR(w, \tilde{x}) - s(IC(w, b) + AR(w)) + (1 - s)((IC(w, c) + AR(w)$. If there are no income effects, this reduces to $ANT(w, \tilde{x}) = AR(w, \tilde{x}) - AR(w)$. As the conventional decision theories do not allow for an effect of anticipation, they make the following prediction:

(4) Females and males are not sensitive to an effect of anticipation, i.e., $AR(w, \tilde{x}) = s(AR(w, b)) + (1 - s)((AR(w, c))$.

4 Experimental Design

The experiments were run at the Harvard Decision Science Laboratory in the summer of 2013 with a total of 160 subjects. All subjects were students, 50% were male, about 2/3 were American, average age was 21-22 years, and a bit more than half were Caucasian. All subjects were identified by code numbers and remained anonymous. The experiments were programmed and conducted with the software Z-Tree (Fischbacher, 2007).

The experiment consists of four parts. The first part involves a filler task: All subjects started the experiment by completing a 45-minute questionnaire for which they received \$15. This task was designed to prevent a house-money effect associated with the earning of \$15. The second part of the experiment was designed to measure the effect of unrealized risk. Each subjects was either in a background-risk treatment, a fixed-sum treatment or a control treatment (see Table 1). The 75 subjects in the *Background Risk* treatment were provides with a dice and were informed that an experimenter would come to roll this dice later in the experiment and that they would earn \$30 when the dice turned up 1, 2, or 3, and \$2 otherwise. Subjects in the *High-Fixed Sum* treatment were notified that they received \$30, and subjects in the *Low-Fixed Sum* treatment were notified that they received \$2. Subjects in the *Control* treatment received nothing. Thereafter, subjects participated in a lottery-

Table 1: Treatments for the Effect of Unrealized Risk

	High Sum (N)	Low Sum (N)	Control (N)
Unrealized Risk	Background Risk (75)	Background Risk (75)	
Assigned Sum	High Fixed Sum (29)	Low Fixed Sum (25)	Control (23)

Table 2: Treatments for the Effect of Realized Risk

	High Sum (N)	Low Sum (N)	Control (N)
Realized Risk	High Realized Risk (36)	Low Realized Risk (39)	
Assigned Sum	High-Fixed Sum (29)	Low-Fixed Sum (25)	Control (23)

based risk attitude elicitation task (*Lottery List Task*). During this task, subjects in the background-risk treatment were reminded of the assigned risk through a heading bar at the top of their computer screens, and subjects in the high- and low-fixed-sum treatments were reminded of their assigned fixed sums. The elicitation method is similar to Abdellaoui et al. (2011) with the exception that I also include mixed-outcome and negative-outcome lotteries. Subjects could earn a maximum of $15 and lose a maximum of $15. The task comprises 15 lists of 7 decisions, each list being associated with one particular lottery. In each of the 7 decisions, the lottery is contrasted with a different fixed sum. The lowest fixed sum equals the lowest possible lottery outcome, and the highest fixed sum equals the highest possible outcome. After subjects make their decisions, one of the 15x7 decisions is randomly selected for payment. (See Figure 1 for a screenshot of one of the lottery lists in the lottery list task.) This method is found to be more tractable and less sensitive to the bias that is associated with procedures that rely on comparing non-degenerate lotteries, (Abdellaoui et al., 2011; Bosch-Domenech and Silvestre, 2013).

Part three of the experiment measured subjects' sensitivity to realized risk. Subjects in all

Figure 1: Lottery List Decision Task

treatments were informed about the selected decision in the Lottery List Task, the outcome of the associated lottery, and their payoffs. Then, in the Background-Risk treatments, an experimenter came by to roll the dice for each subject. Depending on the outcome of the dice roll, subjects received either the low outcome (*Low-Realized Risk*) or the high outcome (*High-Realized Risk*). (See Table 2.) Next, all subjects answered a standard incentivized risk elicitation task on the positive domain, similar to Holt and Laury (2002) but with quadrupled payoffs. This task is displayed in Table 3.[4] One of the 10 decisions was randomly selected for payment. In part 4, subjects filled out a short demographic questionnaire (most importantly for us indicating their gender) –and received their payoffs. The total experiment took about 1.5 hours.

Table 3: HL Decision Task

Decision	Option A		Option B	
1	10% chance of \$8	90% chance of \$6.4	10% chance of \$15.4	90% chance of \$ 0.4
2	20% chance of \$8	80% chance of \$6.4	20% chance of \$15.4	80% chance of \$ 0.4
3	30% chance of \$8	70% chance of \$6.4	30% chance of \$15.4	70% chance of \$ 0.4
4	40% chance of \$8	60% chance of \$6.4	40% chance of \$15.4	60% chance of \$ 0.4
5	50% chance of \$8	50% chance of \$6.4	50% chance of \$15.4	50% chance of \$ 0.4
6	60% chance of \$8	40% chance of \$6.4	60% chance of \$15.4	40% chance of \$ 0.4
7	70% chance of \$8	30% chance of \$6.4	70% chance of \$15.4	30% chance of \$ 0.4
8	80% chance of \$8	20% chance of \$6.4	80% chance of \$15.4	20% chance of \$ 0.4
9	90% chance of \$8	10% chance of \$6.4	90% chance of \$15.4	10% chance of \$ 0.4
10	100% chance of \$8	0% chance of \$6.4	100% chance of \$15.4	0% chance of \$ 0.4

Table 4: Number of Choices Favoring the Safe Option in the Lottery List Task

	Control	Background Risk	Fixed Sum	Fixed Sum & Background risk	Low-Fixed Sum	High-Fixed Sum
Female	57.77	50.31	52.59	51.20	51.43	53.85
	(N=13)	(N=42)	(N=27)	(N=69)	(N=14)	(N=13)
Male	49.54	51.80	51.80	51.80	51.58	49.54
	(N=13)	(N=35)	(N=30)	(N=65)	(N=12)	(N=18)

5 Results

5.1 The Effect of Unrealized Risk

The decisions in the lottery list task in the first part of the experiment enable us to estimate the effect of unrealized risk. I apply the approach outlined in the conceptual framework on the number of safe choices in this task, since this number is a positive monotonic transformation of the coefficient of absolute risk aversion. Table 4 describes the number of safe choices per treatment by gender.

In the control treatment (Column 1), I replicate the often-reported finding that females

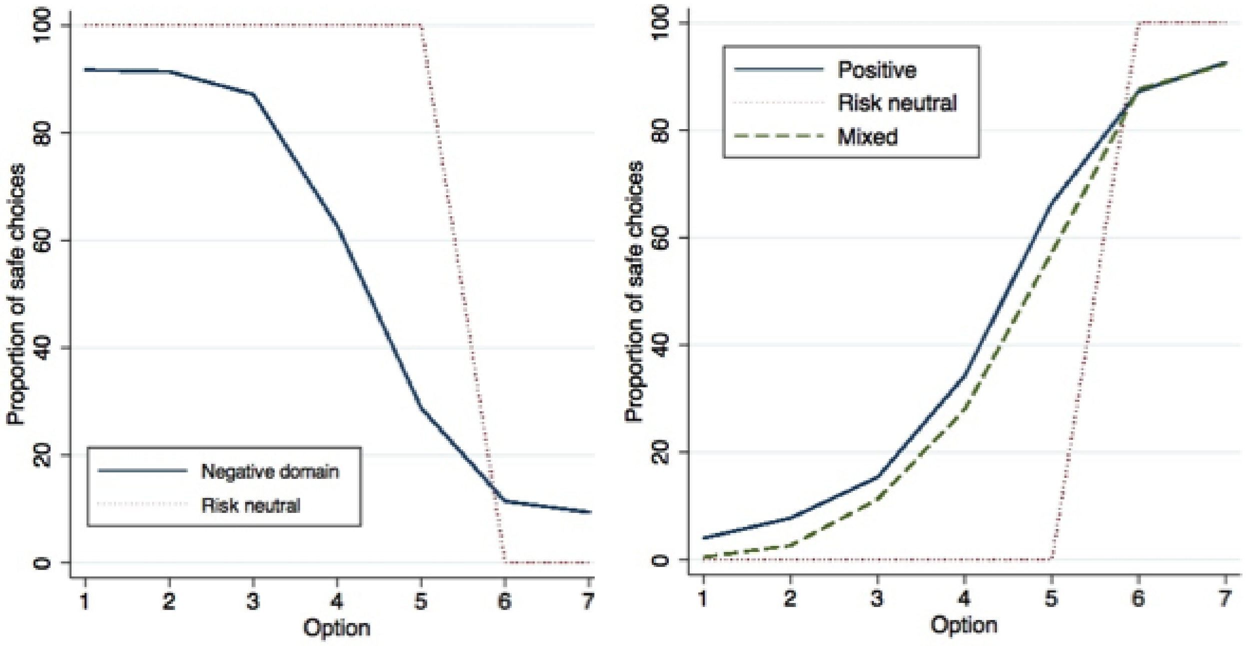
[4] I excluded 8 subjects from the analysis of the second part of the experiment because they had received incorrect information.

have significantly higher baseline risk aversion than males. Females are about 16.6% more likely to select the safe option than males (p=0.02, Wilcoxon rank sum test). However, the introduction of background risk (Column 2) eliminates this common result; the difference is no longer significant (p=0.81, Wilcoxon rank sum test). The driver behind this result is that unrealized risk significantly increases risk taking by females. Compared to the control treatment, the average number of safe choices in the background-risk treatment for females is about 13% lower (p=0.04, Wilcoxon rank sum test). In contrast, the introduction of background risk does not have an economic or statistically significant effect on the risk preferences of males (p=0.60, Wilcoxon rank sum test).

I next explore the mechanisms behind this increase in risk taking for females and examine the respective roles of income and anticipation. An income effect of background risk is conditional on an income effect of assigned non-stochastic income (*Equation 1.*) When comparing the number of safe choices in the fixed-sum treatments (Column 3), I find that income also succeeds in eliminating the gender difference in risk aversion (Wilcoxon rank sum test, p=0.75). Compared to the control treatment (Column 1), risk taking of females is increased by about 9% in the fixed-sum treatments, and an effect of non-stochastic income is therefore directionally supported. A Wilcoxon rank-sum test, however, fails to reject the null hypothesis of equal distribution and central tendency (p=0.12). A Kolmogorov Smirnov test does find a difference in distribution (p=0.08). Comparing the decisions of females in the low-fixed-sum treatment (Column 5) with their choices in the high-fixed-sum treatment (Column 6), I do not find a statistically significant effect of the level of income because the risk attitudes in the fixed-sum treatments do not significantly differ (Wilcoxon rank sum test, p=0.40 and Kolmogorov Smirnov test, p=0.63).

Comparing females' choices in the fixed-sum treatments (Column 3) with their choices in the background-risk treatment (Column 2), there is a 4 percentage points higher increase in risk aversion in the background-risk treatments. This is not significant (Wilcoxon rank sum test, p=0.36), thus it cannot be rejected that the effect of background risk on females'

Figure 2: Distributions of Risk Preference in the Lottery List Task by Lottery Domain



risk attitude is fully driven by income effects. As expected because of the earlier finding that unrealized risk does not affect males' risk preferences, I find no effect of non-stochastic income on male risk preferences (Wilcoxon rank sum test, p=0.50 and Kolmogorov Smirnov test, p=0.60).

Figure 2 reports the risk attitudes in the lottery list elicitation task in more detail and displays the decisions by lottery domain. The left panel of Figure 2 displays the average percentage of choices for the fixed-sum treatment for the 5 negative outcome lotteries. The value of the fixed sum increases over each decision, with decision 1 having a safe value that equals the highest (least negative) outcome of the lottery, and the fixed sum of decision 7 having the lowest (most negative) outcome. The dotted line in the figure depicts the risk-neutral decision for each option. Risk neutrality would imply choosing the risky choice in decisions 6 and 7 only. The actual choices for decisions 1 through 5 is suggestive of the risk-seeking behavior that is often observed in the loss domain. A large proportion of people prefer the risky lottery to the safe choice with higher expected value. For decisions 6 and 7, more than 90% of people select the gamble, which now has a higher expected value than the fixed sum. The remaining 10% of choices for the fixed sum may be the product of risk averse preferences for a portion of the subject pool, or the result of a stochastic choice process.

The panel on the right of Figure 2 shows the distribution for the mixed- and the positive-domain lottery questions. The value of the fixed sum is now increasing over the 7 decisions, with the fixed sum of decision 7 equaling the highest lottery outcome. Risk neutrality would imply a preference for the safe option in decisions 6 and 7. The large proportion of choices for the safe option for options 1 through 5 in both types of lotteries is indicative of risk aversion. In the mixed domain, the preference for the safe choice appears slightly lower than in the positive domain. A possible reason for this reduction in risk aversion is that the safe choice for the first 4 decisions can now be a certain loss, which may induce a preference for risk taking in those questions. In questions 6 and 7, about 10 % keep selecting the gamble, even though it has lower expected value. This may be the result of a stochastic choice process or a very strong preference for risk for a small proportion of subjects.

To more closely examine the effect of unrealized risk and allow for a differential sensitivity to gain and loss frames, I proceed with a regression analysis of the effect of unrealized risk on the coefficient of relative risk aversion. This offers the additional advantage of allowing for the effect of individual characteristics and individual differences in the precision of estimates.

Table 5 presents the regression results of an Expected Utility Model, assuming a CRRA power utility function of $u(x) = x^{\alpha}$ (corresponding with a CRRA coefficient of *1-a*.) The results in the first 4 columns use only the questions on the positive domain, and columns (5) through (8) report the negative domain lottery decisions. The results are robust to a Fechner specification of stochastic errors in the latent choice process (not shown). Column (1) reports this model for females only, and Column (2) for males only. Comparing the estimates of α (*Constant*) for females (*0.55*) and males (*0.74*) suggest increased risk aversion for females in the positive domain. For females, there are significant treatment effects for the low fixed sum and the high fixed sum; for males, there are not. These estimates of α are in line with

Table 5: EUT Specification for the Lottery List Elicitation Task

	Positive Domain (α)				Negative Domain (β)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Background risk	0.10	-0.02	0.10	0.088*	-0.17**	0.09	-0.17**	-0.23**
	(0.065)	(0.070)	(0.065)	(0.049)	(0.076)	(0.090)	(0.076)	(0.070)
Low-fixed sum	0.14*	0.05	0.14*	0.11*	-0.11	0.01	-0.11	-0.11
	(0.083)	(0.105)	(0.082)	(0.066)	(0.093)	(0.106)	(0.093)	(0.073)
High-fixed sum	0.16*	-0.10	0.16**	0.15**	-0.18*	0.08	-0.18*	-0.14
	(0.067)	(0.079)	(0.067)	(0.063)	(0.107)	(0.075)	(0.107)	(0.088)
Male			0.18**	0.15**			-0.14*	-0.17**
			(0.082)	(0.072)			(0.083)	(0.076)
Background risk x Male			-0.12	-0.12			0.27**	0.37***
			(0.096)	(0.085)			(0.118)	(0.100)
Low fixed sum x Male			-0.19	-0.15			0.12	0.04
			(0.133)	(0.117)			(0.140)	(0.148)
High fixed sum x Male			-0.26**	-0.26**			0.26**	0.18
			(0.103)	(0.102)			(0.130)	(0.121)
Cognitive reflection test				0.06***				0.10***
				(0.016)				(0.022)
Age				-0.01				-0.01
				(0.008)				(0.012)
Constant	0.55***	0.74***	0.55*	0.77***	0.68***	0.55***	0.68***	0.66**
	(0.056)	(0.058)	(0.056)	(0.188)	(0.060)	(0.058)	(0.060)	(0.269)
Observations	2870	2730	5600	5600	2870	2730	5600	5600

Notes: Subject-clustered standard errors in brackets. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

the existing estimates in the literature (e.g., (Harrison and Rutstrom, 2008)). In Columns (3) and (4), I allow for potential gender differences in the effects of income and background risk and include interactions with gender and the treatment indicators. In Column (4), I also allow for the effect of age and cognitive reflection, based on the score in the Cognitive Reflection Test developed by Frederick (2005) that measures both cognitive capacity and attributes such as impulsivity. Columns (3) and (4) show, as expected, that males have significantly lower baseline risk aversion. Females significantly increase risk taking in the low-fixed sum, the high-fixed sum and–after controlling for age and cognitive reflection–in the background risk treatment. The increase in risk taking by females in the fixed-sum and the background-risk treatments is considerable, as the effects negate most of the initial gender difference in risk attitude: Tests do not reject that females have the same risk preference as males in the low-sum treatment ($\chi^2(1) = 0.77, p = 0.38,$) or the background-risk treatment ($\chi^2(1) = 0.57, p = 0.45$) and they are significantly less risk averse in the high-fixed-sum treatment ($\chi^2(1) = 5.07, p = 0.02$). The effect of background risk on females' risk attitude can be fully explained by the income effect, as the equality between the three treatment indicators cannot be rejected ($\chi^2(2) = 1.46, p = 0.48$). Those who are older are more risk averse, but not significantly. Those who score better on the Cognitive Reflection Test are significantly less risk averse, a finding consistent with Frederick(2005), who reports more risk taking in the gain domain for those with high cognitive reflection scores.

Next I consider the negative domain lottery decisions in Columns (5)-(8). For the negative domain, I assume the power utility function $u(x) = -(-x)^{\beta}$ so that β <1 implies convexity in the negative domain. In Column (5), I estimate the model for females only, and in Column (6), for males only. The estimate of β for females (*0.68*) and males (*0.55*) suggests that both are risk seeking in the negative domain, but males take more risk. For females, the background risk and the high-fixed-sum treatments significantly increase risk taking, for males they do not. In Columns 7 and 8, I allow for gender interaction effects with the treatment indicators. In the baseline, males are significantly less risk averse. The background-risk and the high-fixed-sum treatments increase risk taking for females, the increase of risk taking in the low-fixed-sum treatment is not significant. Tests cannot reject that females and males have equal risk preferences in the low-fixed-sum treatment ($\chi^2(1) = 0.59, p = 0.74$) and the high-fixed-sum ($\chi^2(1) = 2.43, p = 0.12$) and females are significantly less risk averse than males in the background risk($\chi^2(1) = 5.56, p = 0.002$). The effect of the fixed sums is of a similar order of magnitude as the findings in the positive domain. The effect of unrealized risk appears to increase risk taking more in the negative domain than it did in the positive domain, but tests cannot reject equality of the treatment indicators ($\chi^2(2) = 0.59, p = 0.74$) and the effect of the background risk can thus still be fully explained by income. In Column (8), I allow for the effect of Cognitive Reflection and age. In contrast to the positive domain, Cognitive Reflection now is associated with a reduction in risk taking. This is consistent with Frederick (2005), who also finds that high cognitive reflection increases the likelihood that people accept a sure loss to avoid playing a lottery with lower expected value. The effect of background risk increases after the introduction of these variables, but tests can still not reject the equality across treatments ($\chi^2(2) = 2.10, p = 0.35$.)

In summary, unrealized risk reduces relative risk aversion for females, both in the negative and the positive domains. Income is also associated with an increase in risk taking for females and the strength of income and unrealized risk on risk taking cannot be distinguished. For men, there is no effect of unrealized risk or fixed income, except in the negative domain where receiving the high-fixed sum reduces their risk-seeking behavior.

5.2 The Effect of Realized Risk

To study the effect of realized risk, I focus on the answers to the Holt and Laury task in the second part of the experiment. Figure 3 plots the percentage of choices for the safe lottery for each of the 10 decisions presented. As outlined by the dotted line in the figure, risk neutrality would suggest a switching point after decision 4. The fact that a large number

Figure 3: Percentage of Safe Choices in Holt and Laury Task

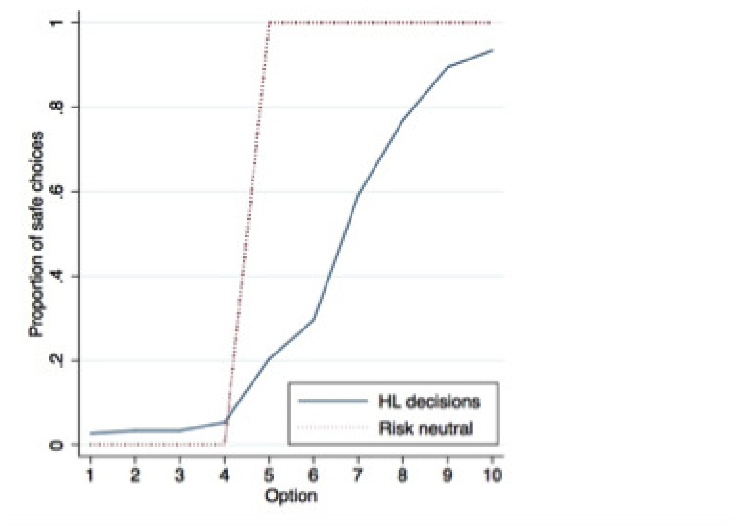


Table 6: Number of Choices Favoring the Safe Option in the Holt and Laury Task

	Control	High-Realized Risk	Low-Realized Risk	Fixed Sum	Low-Fixed Sum	High-Fixed Sum	Total
Female	6.40	6.82	6.20	6.23	6.43	6.00	6.42
	(N=10)	(N=22)	(N=20)	(N=26)	(N=14)	(N=12)	(N=104)
Male	5.77	5.21	5.68	6.46	6.82	6.24	5.91
	(N=13)	(N=14)	(N=19)	(N=28)	(N=11)	(N=17)	(N=102)

of subjects switch later on is indicative of risk aversion.

Table 6 displays the number of choices for the risky lotteries across treatments by gender. On average, males choose the safe option 5.91 times, significantly less than the average 6.41 safe choices by females, (Wilcoxon rank sum test, $p = 0.05$). This is not driven by the fixed-sum treatments; as previously shown in the lottery list elicitation task, women take more risk in these treatments, although not significantly more (Wilcoxon rank sum test, $p=0.78$). When looking at the effect of winning after the realization of risk, I find that the difference across genders increases. In the control treatment, females take 15% less risk than males; in the high-realized risk treatment, females take over 33% less risk than males. In the low-background-risk treatment, where people receive \$2 and "lose" the realized risk, there does not appear to be an effect on the gender gap in risk attitudes.

The first part of the experiment ruled out an income effect for males. In this part, I also do not find a significant income effect for males when comparing the risk attitudes in the fixed-sum treatment and the control treatment (Wilcoxon rank sum test, p=0.22). This implies that any potential increase in risk taking after the positive realization of risk can be attributed to the winning effect. The positive realization of risk increases risk taking by about 22% (Wilcoxon rank sum test, p=0.10). For females, the income effect is no longer significant when comparing the fixed-sum treatments and the control treatment (Wilcoxon rank sum test, p=0.77). This points at a transient effect of income, consistent with the readjustments of reference points and the recency effects that are often observed in the literature (e.g., Erev & Haruvy, 2013). The gains of $30 and $2 are old news once the second risk attitude method is implemented and, therefore, may not affect female's decision making as much. When comparing risk taking in the *High Realized Risk* treatment to risk taking in the fixed-sum treatments and the control treatment, I do not find an effect from winning on females (Wilcoxon rank sum test, p=0.39). This is unexpected because of the income associated with winning $30, which is $14 higher than the expected value of the lottery and an income effect would then increase risk taking. This suggests that there is a counter factor that actually reduces their desire for risk.

This comparison across treatments obscures the income differences within treatments because of the profits obtained in the lottery list elicitation task in the experiment's first part. In addition, it does not allow for individual variation. I will, therefore, proceed with regression analyses. I estimate interval-censored models, using the interval-censored relative risk aversion (rr) as a dependent variable, assuming a CRRA power utility function of $u(x) = x^{(1-rr)}/(1-rr)$ (Table 7). The results are robust to other specifications, including a simple regression on the number of safe choices (not reported.) Of the original 152 subjects, a good amount (127) show the conventional behavior; they start off choosing the lotteries described under option A in the left of Table 3 and have a single switching point to the riskier lotteries described under option B. For 23 of the 25 subjects who deviated from this behavior, I could still calculate an interval by using the lower bound associated with the first risky choice as the lower bound, and using the upper bound associated with the last risky choice as the upper bound. Two subjects made a risky choice in the first row and a safe choice in the last; thus, I could not narrow the interval and excluded them from the analysis. To allow for the treatment induced income effect, I include the indicators *Get30* and *Get2*. *Get30* reflects the subjects who are in the high-fixed-sum treatment *and* the subjects in the background-risk treatment who won \$30 after realization of the risk. *Get2* reflects the subjects who were in the \$2 fixed-sum treatment, and those who received \$2 after realization of the risk. The indicators *High-Realized Risk* and *Low-Realized Risk*, reflect the subjects in the background-risk treatment who only received \$30 or \$2 after the dice were rolled.

In Column (1), I estimate the model for females, and in Column 2 for males. High-realized risk increases risk taking for males and reduces risk taking for females, but the effect is not significant for either gender. Once I control for interactions between gender and treatment effects (Columns (3)-(6)), I find that males significantly reduce their risk aversion after winning and receiving the high-realized risk ($\chi^2(1) = 2.70, p = 0.10$) and this effect is many magnitudes stronger than the effect that being male has on baseline risk attitude ($\chi^2(1) = 2.88, p = 0.09$). Females in contrast, do not increase risk taking after winning. In Column (4), I allow for the effect of profits in the lottery list elicitation task. Because these profits are dependent on the risk attitudes displayed in this task, I also control for the number of choices the subject made for the safe option in this task (*LLT*.) As expected, the subjects that make fewer risky decisions in the lottery list task are also significantly more risk averse in the Holt and Laury task. In Column (5), I allow for gender-specific income effects of the earnings in the lottery list elicitation task, and find that higher profits in this task cause females to significantly increase their risk attitude; for males there is no such effect.

To sum up, winning after the realization of risk increases risk taking in males, but does

Table 7: Interval Censored Models for Holt and Laury Task

	(1)	(2)	(3)	(4)	(5)	(6)
rr						
Get30	-0.22	0.15	-0.15	-0.12	-0.11	-0.16
	(0.318)	(0.173)	(0.271)	(0.256)	(0.250)	(0.250)
Get2	-0.01	0.30*	0.15	0.16	0.15	0.19
	(0.262)	(0.170)	(0.152)	(0.143)	(0.141)	(0.140)
High-realized risk	0.31	-0.34	0.31	0.33	0.32	0.35
	(0.265)	(0.241)	(0.260)	(0.249)	(0.247)	(0.234)
Low-realized risk	-0.07	-0.32**	-0.19	-0.16	-0.15	-0.18
	(0.186)	(0.150)	(0.122)	(0.114)	(0.114)	(0.111)
Male			-0.11	-0.09	-0.13	-0.12
			(0.101)	(0.096)	(0.100)	(0.1000)
Male x Get30			0.25	0.22	0.22	0.29
			(0.294)	(0.278)	(0.273)	(0.275)
Male x High-realized risk			-0.66*	-0.64*	-0.67**	-0.76**
			(0.357)	(0.339)	(0.337)	(0.339)
LLT				0.01**	0.01**	0.02**
				(0.005)	(0.005)	(0.005)
LLT Profits				-0.01	-0.01**	-0.01**
				(0.004)	(0.006)	(0.006)
LLT Profits x male					0.01*	0.01*
					(0.008)	(0.008)
Age						0.05**
						(0.021)
CRT						-0.02
						(0.045)
Constant	0.72***	0.49***	0.65***	-0.10**	-0.09	-1.23**
	(0.208)	(0.106)	(0.133)	(0.279)	(0.284)	(0,584)
lnsigma						
Constant	-0.57***	-0.73***	-0.64***	-0.68***	-0.69***	-0.71***
	(0.159)	(0.164)	(0.113)	(0.113)	(0.115)	(0.115)
Observations	760	740	1500	1500	1500	1500

Notes: Subject-clustered standard errors in brackets. *** Significant at the 1% level. ** Significant at the 5% level.
* Significant at the 10% level.

not increase risk taking in females. Risk preferences of females are no longer significantly affected by earnings they made earlier in the experiment, but are affected by the more recent earnings that they made in the previous lottery list elicitation task.

6 Discussion and Conclusions

This paper shows that there are stark gender differences in the way men and women respond to a risky environment. I find that a positive outcome background risk temporarily increases risk taking in females but not in males. Although baseline risk aversion for females exceeds that of males, the introduction of background risk eliminates this difference. A potential effect of anticipation cannot be completely discarded, but the results suggest that this is driven by the effect of income, to which males are not sensitive. In contrast, once the outcome of the background risk is revealed and subjects 'win' the risk and receive the high outcome, risk taking increases in males but not in females.

Increased sensitivity to income for females is consistent with the predictions of utility functions such as the isoelastic utility function. For these functions, the higher baseline risk aversion of females implies higher sensitivity to previous earnings. This result is applicable to EUT models with narrow framing, and –as long as reference points have not been updated to take these earnings into account– reference-point dependent models such as CPT. However, the complete lack of response to income by males suggests that they are not affected by their previous experimental earnings. Their behavior is consistent with a decision model such as Expected Utility over Income (EUI). This model stipulates a scenario of even 'narrower' framing in which people only consider the potential earnings of a prospect, and are not affected by *any* previous earnings.

The increase of risk taking in males after the experience of winning the lottery is in line with studies on all-male subjects that find an increase in risk taking after the experience of a win (Apicella et al., 2014). The reason that females do not increase risk taking after a win is potentially driven by a different emotional or hormonal response (testosterone has been suggested to be a major driver of the winner's effect). Winning may also affect beliefs on the likelihood of winning subsequent risks differently for females; they may be less prone to hot-hand beliefs, or be more prone to the gambler's fallacy and believe that their luck ran out after the recent win.

It is left to future research to replicate these findings, to study the effects of negative-outcome risks, and to more closely investigate the drivers behind these gender differences. It is possible that the genders are by nature differently disposed towards risk, but the differences may also be socially constructed, or be a consequence of special circumstances that vary across gender. For example, females may have lower expected incomes, or lower reference points of income; this may be a driver in the gender differences in baseline risk attitude as well as their increased sensitivity to income.

The finding that the exposure to past and current risks affects decision-making supports a more dynamic view of risk taking, and can be a motivation for policy interventions to mitigate this threat to optimal judgment and decision-making. The winning effect and the income effect may also be used to induce changes in risk taking. In cases where increases in risk taking are not desirable, such as in a financial-trading setting, withholding the outcomes of previously acquired risks may improve decision-making in males. In instances where increases in risk taking by females is desirable, such as in a micro-finance setting, repeated stimuli may induce the desired effect.

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