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Abstract

This study investigates individual differences in catastrophic risk perception using Cumulative Prospect Theory (CPT) through a laboratory experiment. The choice of CPT allows us to introduce a basic "addendum" to traditional EUT evaluations of these kinds of risks. We analyze the drivers of risk perception through a laboratory measure of CPT based on experimental data, where possible drivers include sociodemographic factors, psychological characteristics, and psychometric variables such as past experience. We define in this setting an interesting aspect that is a peculiar characteristic of extreme risks: the so-called shared burden effect, where individuals perceive the same risks as less severe if they affect a larger share of the collectivity. External validity is provided by examining whether laboratory-elicited risk perception predicts real-world extreme risk assessments.

Keywords: risk perception, catastrophic risk, prospect theory, experimental economics, shared burden effect
JEL Codes: D81, C91

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1 Introduction

Catastrophic events, such as pandemics, nuclear risks, and large-scale natural disasters, are low-probability but high-impact occurrences. Despite their rarity, these events have captured significant attention, especially in recent years, because of their profound societal and individual relevance. For example, during the COVID-19 pandemic, individuals exhibited significantly different responses to measures such as lockdowns and vaccination campaigns, as well as varying attitudes toward infection risks, leading to heterogeneity in compliance and beliefs about the restrictions (Cipolletta et al., 2022). Additionally, individual attitudes and trust were significantly affected, with lockdown experiences influencing prosocial behaviors such as fairness and cooperation(Buso et al., 2020).

Similarly, public discourse surrounding the war in Ukraine revealed considerable variation in nuclear risk perception, with some individuals dismissing the possibility of nuclear escalation and others exhibiting heightened concerns (Lauriola et al., 2024).

The existing literature shows that risk perception is inherently subjective and shaped by a complex interaction of multiple factors, including cognitive biases, past experiences, personality, cognitive, and sociodemographic factors (Slovic, 2000), and extensive empirical evidence documents systematic deviations from EUT predictions, particularly for low-probability, high-impact risks (Kahneman and Tversky, 1979).

Individuals often exhibit biases when evaluating such probabilities, particularly in the context of extreme events. For instance, many people irrationally fear rare but catastrophic events such as airplane crashes, shark attacks, or acts of terrorism, despite their statistical improbability. This can lead to excessive risk-avoidance behaviors, such as individuals refusing to fly after hearing about a plane crash, even though driving is objectively far more dangerous. Conversely, other individuals enthusiastically participate in lotteries, greatly overweighting the tiny probability of winning a large jackpot. The same optimism bias may lead other individuals to systematically underestimate their own exposure to catastrophic risks. Smokers, for example, frequently believe that they are personally less likely than others to suffer from lung cancer, even when faced with clear epidemiological evidence. Moreover, people often exhibit loss aversion, feeling the pain of losses more acutely than the pleasure of gains. This is evident when investors hold onto losing stocks hoping for a rebound, or when individuals overpay for insurance to avoid potential losses. Additionally, their preferences show different curvature for gains and losses, meaning they are risk-averse for gains but risk-seeking for losses. For example, they might prefer a sure gain over a risky gain of the same expected value, but prefer a risky loss over a sure loss of the same amount.

These cognitive distortions illustrate the complex and sometimes contradictory ways in which humans process probability and loss. Cumulative Prospect Theory (CPT) provides a more accurate framework to capture these behavioral occurrencies by incorporating probability distortion, differential sensitivity to gains and losses, and loss aversion (Tversky and Kahneman, 1992). Unlike EUT, CPT accounts for the fact that individuals misperceive probabilities, exhibit asymmetric risk preferences, and value losses more than equivalent gains. Recent studies have increasingly linked risk perception and decision-making under uncertainty to CPT, particularly in the context of rare but high-impact events Goda and Hong (2021); Yang et al. (2022); Moon and Chang (2018).

CPT is particularly well-suited for modeling catastrophic risk perception given the definition of risk perception in ISO 31010 Risk Management Guidelines, which conceptualizes risk perception as the severity of outcomes weighted by subjective probability assessments. This definition aligns with CPT's structure, that accounts for probability distortion and loss aversion.

Despite all the well-documented cognitive biases, there remains a lack of experimental measures that directly quantify catastrophic risk perception using CPT-derived parameters. While previous studies have examined risk attitudes in natural disasters or financial markets, no experimental framework has systematically elicited individual CPT parameters to construct a personalized measure of catastrophic risk perception.

This study aims to fill the gap in the literature by developing an experimental measure of catastrophic risk perception using CPT-derived parameters and testing the shared burden effect. This shared burden effect refers to the phenomenon where individuals discount the severity of a risk when it is shared among a group, compared to when it affects them individually. This effect is underexplored and its definition and conceptualization is a key novelty of this study, building on insights into diffused responsibility in the context of risk perception (Böhm and Pfister, 2008); Loewenstein et al., 2013. This study seeks to test it through a controlled laboratory experiment, thus addressing three main research questions.

First, What individual factors shape catastrophic risk perception, and how do cognitive abilities, personality traits, sociodemographic characteristics, and past experiences contribute to its heterogeneity?

Second, to what extent do these determinants differentially influence the two key components of risk perception—perceived outcome severity and probability?

And third, does a shared burden effect lead individuals to perceive collectively borne risks as less severe than identical risks faced individually, and what underlying mechanisms drive this phenomenon?

These questions are addressed in a controlled laboratory experiment that consists of three phases. The first phase involves the elicitation of individual CPT parameters using the method developed by Abdellaoui (2008). Participants complete a series of certainty equivalent tasks designed to recover their probability weighting and value function parameters, providing measures of probability distortion, curvature for gains and losses, and loss aversion. These parameters are used to construct an individual measure of catastrophic risk perception.

The second phase examines willingness to pay (WTP) for risk reduction in a controlled decision scenario. Participants face an adverse event with a five percent probability of eliminating their accumulated earnings and must state their maximum WTP to cancel this probability. Two conditions allow for a test of the shared burden effect: an individual risk condition, where only the participant is affected, and a shared risk condition, where the same event will have the same realization for all participants. A random-cost mechanism ensures incentive compatibility. A systematic reduction in WTP under the shared condition would provide evidence that individuals perceive collective risks as less severe, despite identical probabilities and outcomes.

The third phase consists of a survey assessing subjective perceptions of real-world risks, including pandemics, nuclear war, and natural disasters. The survey also collects data on cognitive ability, personality traits, and sociodemographic factors, including social identity proxies such as place of origin. This allows for an analysis of how these characteristics shape risk attitudes and the shared burden effect. The CPT-based risk perception measure is used as a predictor of subjective risk assessments in real-world domains, providing insight into its external validity. This real life scenarios are selected by using catastrophic events affecting people both individually and collectively.

By constructing an experimental measure of catastrophic risk perception based on CPT, this study provides a laboratory-based quantification of probability weighting and loss aversion in the context of extreme risks. Additionally, by testing the shared burden effect, it offers new insights into whether individuals perceive collective risks as less severe, an area of research that remains underexplored in risk perception studies.

The rest of the paper is structured as follows. Section 2 reviews the relevant literature on risk perception and decision-making under uncertainty, focusing on CPT and its empirical applications in the context of extreme risks. Section 3 outlines the experimental design, detailing the elicitation of CPT parameters, the simulation of both shared and individual risk scenarios, the real life risk assessment and the final questionnaire. Section 4 details the empirical methodology implemented to analyze individual differences in risk perception, the shared burden effect and its determinants. Section 5 presents the results, and section 6 concludes by summarizing the study's contributions and discussing the implications for policy and future research.

2 Literature Review

The study of risk perception, particularly in the context of catastrophic events, has been extensively explored across multiple disciplines, including economics and psychology. While Expected Utility Theory (EUT) provides a normative model of decision-making under risk, empirical research has long demonstrated that individuals systematically deviate from EUT predictions when assessing rare, high-impact events (Kahneman and Tversky, 1979; Quiggin, 1993). This has led to the adoption of alternative models, like Cumulative Prospect Theory (CPT) (Tversky and Kahneman, 1992), as frameworks for modeling behavior in this contexts. CPT accounts for well-documented behavioral anomalies, such as probability distortion, loss aversion, and different utility curvature for losses, which are particularly relevant in the study of catastrophic risk perception.

Empirical applications of CPT in disaster economics confirm that probability distortions significantly influence preparedness behavior. In the domain of earthquake risk, example, Goda and Hong (2021) show that individuals systematically overweight small probabilities, leading to higher willingness to pay (WTP) for risk reduction. Similarly, Chou et al. (2022) find that when individuals are presented with explicit probability information, their risk attitudes deviate systematically from rational Bayesian updating, with probability misperception playing a key role in driving insurance demand and mitigation efforts. These distortions extend to other contexts, such as flood insurance decisions (Botzen et al., 2015) and pandemic response (Cipolletta et al., 2022), where individuals react disproportionately to media coverage rather than objective risk statistics.

Another key component of CPT, loss aversion, has been widely documented as a major determinant of risk behavior in extreme contexts. The notion that losses loom larger than gains (Kahneman et al., 1991) explains why individuals often display stronger reactions to potential catastrophic losses than predicted by standard economic models. In financial markets, loss aversion contributes to excessive demand for catastrophe insurance (Kunreuther and Michel-Kerjan, 2013), while in disaster preparedness, it explains why individuals overpay for risk-mitigation measures even when expected value calculations would suggest otherwise (Bocquého et al., 2014).

Recent research has shown that loss aversion is not uniform across individuals but varies depending on experience, personality, and social context. Studies indicate that prior exposure to disasters can both amplify or attenuate loss aversion: individuals who have previously suffered catastrophic losses tend to develop greater risk sensitivity, while those exposed repeatedly to near miss events may become desensitized and exhibit lower precautionary behavior (Wachinger et al., 2013). Moreover, cultural differences influence the extent to which individuals exhibit loss aversion in risk perception. For example, Eastern societies, which emphasize collectivist risk mitigation strategies, tend to display higher loss aversion than Western societies, where individualistic decision-making dominates (Wang et al., 2017; Gierlach et al., 2010).

A growing body of research explores individual characteristics that influence risk perception across various disaster contexts, with different main factors shaping individual differences:

First, direct disaster experience, but this effect varies by context. Some studies suggest that first-hand exposure increases perceived vulnerability (Cerase et al., 2023), while others indicate that repeated exposure can lead to desensitization (Wachinger et al., 2013).

Second, cultural values and local beliefs, especially affect trust on efficacy of collective action (Gierlach et al., 2010), (Buso et al., 2020), (Bodas and Adini, 2022).

Third, trust in authorities. Individuals with high trust in government institutions tend to adopt stronger precautionary measures, whereas distrust leads to risk minimization and reluctance to comply with mitigation efforts (Wachinger et al., 2013), (Loewenstein et al., 2013).

Finally geographic factors. Residents of earthquake-prone regions perceive risks differently than those living in areas with lower objective exposure (Cerase et al., 2019), (de la Maza et al., 2018). However, long-term residents in high-risk areas may develop a normalization bias, underestimating the true likelihood of a disaster (Rufat, 2015).

Beyond these primary factors, risk literacy, cognitive biases, and temporal distance from past events also contribute to heterogeneity in risk perception. Studies indicate that individuals with higher education and numeracy skills tend to evaluate risks more rationally, whereas those with lower risk literacy exhibit greater reliance on heuristics and media narratives (Stolero et al., 2024) (Nyandwi et al., 2023).

A key yet underexplored phenomenon in catastrophic risk perception is referred in this paper as the shared burden effect, which suggests that individuals systematically discount the severity of same risks when they are collectively shared rather than personally borne.

Emerging evidence suggests that when catastrophic risks are framed as collective threats, individuals exhibit lower WTP for mitigation measures. Studies on earthquake insurance indicate that people are less willing to purchase coverage when risks are described as affecting an entire community rather than themselves individually (Chou et al., 2022), (Moon and Chang, 2018). Similarly, research on flood preparedness finds that collective framing reduces perceived urgency to take action, as individuals assume that governments or other community members will intervene (Asgari and Levy, 2015), (Botzen et al., 2015).

While existing research on public goods and social dilemmas has established that diffusion of responsibility leads to lower individual contributions to risk mitigation (Feldman and Hazlett, 2016), (Darley and Latané, 1968), no study has systematically tested in a laboratory context whether people perceive catastrophic risks as less severe when they affect a group rather than an individual. And while CPT has been widely applied to decision-making under uncertainty, few studies have developed experimental measures that elicit individual probability weighting and loss aversion parameters in the context of extreme risks (Bocquého et al., 2014), (Barseghyan et al., 2013). Existing work has primarily relied on survey-based approaches rather than controlled laboratory experiments. This study addresses these gaps by constructing an experimental measure of catastrophic risk perception using elicited CPT parameters and testing for the shared burden effect in a controlled experimental design, linking CPT-based experimental findings to real-world risk assessments.

3 Experiment Design

This section outlines the experimental design and the general framework employed to investigate catastrophic risk perception and the shared burden effect. The study is structured to elicit individual risk preferences, examine behavioral responses to catastrophic risk scenarios, and link experimental findings to real-world risk assessments. The first phase elicits CPT parameters (probability distortion, value function curvature for gains and losses and loss aversion) using the elicitation task from Abdellaoui (2008) to construct an individual measure of catastrophic risk perception. The second phase tests for the shared burden effect measuring wiilingness to pay (WTP) for risk reduction under different framing conditions, distinguishing between individual and collective risk. In the third phase, participants complete a survey assessing their perceptions of real-world catastrophic risks, personality traits, cognitive ability, and sociodemographic characteristics. This survey data evaluates the external validity of the experimental measures and provides control variables for the analysis.

3.1 Theoretical Framework of CPT

Cumulative Prospect Theory (CPT) posits that decision-making under risk follows a weighted valuation of outcomes, where probabilities are transformed by a probability weighting function $w(p)$, and outcomes are evaluated relative to a reference point using a value function $v(x)$. Empirical applications typically assume zero as the reference point, particularly in experimental settings where gains and losses are explicitly framed (Abdellaoui et al., 2007; Köbberling and Wakker, 2005). The two principal components are:

1. Probability Weighting Function: Individuals tend to overweight small probabilities and underweight large probabilities, leading to probability distortion. This is modeled as $w(p)$, where

$$w(p) = \frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}}, \tag{1}$$

with parameter γ capturing the curvature of the probability weighting function.

2. Value Function: The valuation of outcomes follows a convex shape for gains and a concave shape for losses, reflecting diminishing sensitivity, and incorporates loss aversion λ:

$$v(x) = \begin{cases} x^\alpha, & x \geq 0 \\ -\lambda(-x)^\beta, & x < 0 \end{cases} \tag{2}$$

where α and β control the curvature of the value function and λ measures loss aversion.

3.2 Phase 1: Eliciting CPT Parameters Using Abdellaoui's Method

The first phase aims to elicit individual risk preferences under Cumulative Prospect Theory (CPT) to construct a personalized measure of catastrophic risk perception. CPT describes decision-making under risk through a probability weighting function $w(p)$ that transforms probabilities and a value function $v(x)$ that evaluates outcomes relative to a reference point, set at zero in this experimental context (Abdellaoui et al., 2007; Köbberling and Wakker, 2005). This phase adapts the semi-parametric method from Abdellaoui (2008), which employs fixed probabilities and certainty equivalents (CEs) to estimate probability distortion, value function curvature, and loss aversion.

Unlike Abdellaoui (2008) original approach, which uses choice-based bisection with probabilities fixed at $p_g = 1/2$ and $2/3$ for gains and $p_\ell = 1/2$ and $1/3$ for losses, this study fixes the probability at 5% across all tasks to reflect the low-likelihood nature of catastrophic risks and elicits CEs via direct statements rather than iterative choices.

The method comprises three stages, using stated CEs for two-outcome prospects to derive CPT parameters.

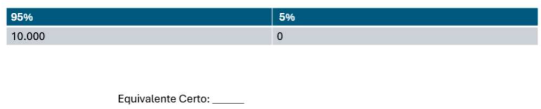
Table 1: Potential Gains and Losses for CPT Elicitation

Outcome Index i	1	2	3	4	5	6
Gains: x_i ()	2,000	4,000	6,000	10,000	10,000	10,000
Gains: y_i ()	0	0	0	0	6,000	8,000
Losses: x_i ()	-2,000	-4,000	-6,000	-10,000	-10,000	-10,000
Losses: y_i ()	0	0	0	0	-6,000	-8,000

Table 1 lists the potential gains and losses, adapted from Abdellaoui (2008), used across these stages:

1. **Elicitation in the Gain Domain**
   Participants state CEs for six gain prospects of the form $(x_i, 0.05; y_i)$, where $x_i > y_i \geq 0$ and the probability of x_i is fixed at 5% (thus 95% is the probability of y_i). Outcomes align with Table 1: x_i ranges from 2,000 to 10,000, and y_i from 0 to 8,000. For each prospect $(x_i, 0.05; y_i)$, the CE G_i is expressed such that $(G_i, 1; 0) \sim (x_i, 0.05; y_i)$. An example task is shown in Figure 1, where participants state the sure amount equivalent to a 5% chance of 10,000 versus 0.

   Figure 1: Example Gain Prospect: Participants state the certain amount G_i equivalent to a 5% chance of 10,000 versus 0.

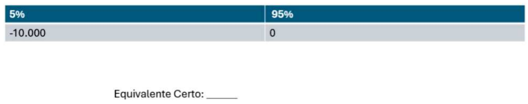
   Assuming a power value function $v(x) = x^\alpha$ for $x \geq 0$, and given i indifference equations

   $$v(G_i) = w^+(0.05)[v(x_i) - v(y_i)] + v(y_i) \tag{3}$$

   α (curvature for gains) and $w^+(0.05)$ (probability weight at 5%) are estimated through non linear least squares.

2. **Elicitation in the Loss Domain**
   CEs are elicited for six loss prospects of the form $(x_i, 0.05; y_i)$, where $0 \geq y_i > x_i$, with the probability fixed at 5%. Outcomes mirror Table 1: x_i ranges from -2,000 to -10,000, and y_i from 0 to -8,000. The CE L_i is determined such that $(L_i, 1; 0) \sim (x_i, 0.05; y_i)$. Figure 2 illustrates an example, asking for the sure amount equivalent to a 5% chance of -10,000 versus 0.

Figure 2: Example Loss Prospect Task: Participants state the certain amount L_i equivalent to a 5% chance of -10,000 versus 0.



Assuming $v(x) = -\lambda(-x)^\beta$ for $x < 0$, the indifference equations

$$v(L_i) = w^-(0.05)[v(x_i) - v(y_i)] + v(y_i) \tag{4}$$

yields estimates of β (curvature for losses) and $w^-(0.05)$ (probability weight at 5%).

3. **Loss Aversion Estimation**
This stage links gains and losses to estimate the loss aversion coefficient λ. A mixed prospect $(G^*, 0.05; L^*)$ is presented, where,$G^* > 0 > L^*$, and L^* choosed by the participant such that $(G^*, 0.05; L^*) \sim 0$. Then the equation

$$w^+(0.05)v(G^*) + w^-(0.95)v(L^*) = 0 \tag{5}$$

is solved. With $w^+(0.05)$, $w^-(0.05)$, $v(G^*)$, and $v(L^*)$ known, and $w^-(0.95) = 1 - w^-(0.05)$ under CPT, λ is derived as

$$\lambda = -\frac{w^+(0.05)v(G^*)}{w^-(0.95)v(L^*)}. \tag{6}$$

Approximately 13 elicitations (six per stage + one per loss aversion) are conducted, estimated to take around 20 minutes. Outcomes represent catastrophic risks (e.g., earnings losses in thousands), ensuring contextual relevance. Incentives are not implemented, consistent with Abdellaoui (2008)'s stance (p. 252, 261) that real incentives are neither necessary nor feasible for losses and mixed prospects. Hypothetical outcomes suffice, supported by evidence showing no systematic incentive effects for such tasks (e.g., Beattie and Loomes, 1997; Camerer and Hogarth, 1999), and real losses pose ethical and practical challenges, particularly in a laboratory setting.

This method retains the efficiency of Abdellaoui (2008) approach by fixing the probability (here 5%), requiring only one weight per domain, and avoids full assumptions on $w(p)$.

3.3 Phase 2: Testing the shared burden effect with Willingness to Pay

The second phase examines the shared burden effect in a controlled decision scenario. The shared burden effect posits that individuals perceive risks affecting a group collectively as less severe than identical risks affecting them individually. This phase uses fixed earnings of 20 provided to each participant at the end of phase 1 as the stake at risk.

Participants face an adverse event represented by a random variable with a 5% probability of occurring (resulting in the loss of 20) and a 95% probability of not occurring (retaining 20). Two conditions are presented to test the shared burden effect:

- **Individual Risk Condition**
  In this scenario, the realization of the random variable is independent for each participant. Each individual faces a unique draw: with 5% probability, their 20 earnings are lost, and with 95% probability, they are retained. Participants state their maximum WTP to eliminate this risk, ensuring their earnings are preserved regardless of the outcome.

- **Collective Risk Condition**
  In this scenario, the realization of the random variable is identical for all participants. A single draw determines the outcome for the group: with 5% probability, all participants lose their 20 earnings, and with 95% probability, all retain them. Participants state their maximum WTP to eliminate this collective risk, securing their earnings if successful.

Participants provide WTP values for both scenarios in a single session, with one scenario (individual or collective) randomly selected for implementation. A random-cost mechanism, ensures incentive compatibility: a random cost between 0 and 20 is drawn, and if the participant's WTP exceeds this cost, the risk is eliminated, and they pay the cost; otherwise, the risk remains, and the outcome depends on the random variable's realization. This approach incentivizes truthful WTP statements.

Two WTP elicitations (one per condition) are conducted, taking approximately 5–10 minutes. The WTP data enable testing the shared burden effect by comparing differences between the collective and individual conditions with those that will be observed in Phase 3's real-world catastrophic risk assessments, conducted under both individual and collective risk framings. A systematically lower WTP in collective scenarios, mirrored by similar patterns in real-world perceptions, would indicate that shared risks are perceived as less severe across experimental and real-world settings, despite identical probabilities and outcomes.

3.4 Phase 3: Assessing Real-World Risk Perceptions and Individual Characteristics

The third phase assesses perceptions of real-world catastrophic risks and collects data on individual characteristics. These assessments test the external validity of the measure constructed with CPT parameters - as outlined in the next section - and the findings of the shared burden effect from Phases 1 and 2, while individual characteristics (sociodemographics, IQ, personality and past experience) serve as covariates in regression models to understand their impact on risk perception. This survey-based approach examines whether the shared burden effect—lower perceived severity and WTP for collective risks— extends beyond the laboratory to naturalistic settings, while exploring cognitive, psychological, and sociodemographic influences on catastrophic risk attitudes.

Participants complete a structured survey with the following components:

1. **Perceived Risk Severity**
   Participants rate the perceived severity of five catastrophic risks—fatal accident, mortal illness, pandemic, nuclear total war, and natural disaster—on a scale from 1 (minimal risk) to 10 (extreme risk). Each risk is assessed as it naturally occurs: individual for personal events (e.g., fatal accident, mortal illness) and collective for group-wide events (e.g., pandemic, nuclear war, natural disaster), enabling comparison with Phase 2's WTP differences based on inherent scenario characteristics.

2. **Past Experience with Extreme Risks**
   A binary question (yes/no) asks whether participants have experienced an extreme risk event (e.g., natural disaster, severe illness), providing a covariate to assess experiential influences on risk perception.

3. **Willingness to Pay for Risk Mitigation**
   Participants state their WTP to insure against two specific risks—nuclear total war and fatal illness—assuming a 100,000 endowment. Nuclear total war, inherently a collective risk, is assessed as "How much would you pay to eliminate nuclear war risk?" while fatal illness, inherently individual, is assessed as "How much would you pay to eliminate fatal illness risk?" This leverages the natural distinction between these real-life scenarios to compare with Phase 2's lab-based shared burden effect, where individual and collective conditions were experimentally manipulated.

4. **Personality and Cognitive Ability**
   The Big Five personality traits (openness, conscientiousness, extraversion, agreeableness, neuroticism) are measured using a validated 10-item short-version test. Cognitive ability is assessed with a 10-question short-form IQ test (UNIT test), providing standardized scores. These measures explore psychological and cognitive drivers of risk perception variability.

5. **Sociodemographic Data**
   Age, gender, and place of origin are collected as covariates to analyze demographic influences on risk attitudes and the shared burden effect.

The survey comprises approximately 35–40 questions: 5 risk severity ratings, 1 past experience question, 2 WTP elicitations, 10 personality items, 10 IQ questions, and 3–5 sociodemographic items. Administered post-Phases 1 and 2, it takes an estimated 20 minutes. Participants receive a 3 euro show up fee in addition to their earnings from phase 2.

This phase facilitates testing the shared burden effect by comparing Phase 2's WTP differences (individual vs. collective conditions) with Phase 3's real-world assessments, where nuclear war is collective and fatal illness individual. A lower WTP and severity for nuclear war versus fatal illness, aligning with Phase 2, would confirm the effect's external validity. Phase 3 data, combined with Phase 1's CPT parameters, will construct a catastrophic risk perception measure (detailed in the next section) and assess its ability to explain real-world risk perception variations, while regression models with Phase 3 covariates clarify how individual traits shape these perceptions.

4 Data and Methodology

4.1 Data

The dataset was collected through an experimental session conducted at the CESARE laboratory at LUISS Guido Carli University, Rome. Participants were recruited primarily among LUISS students using the ORSEE recruitment system. A total of 98 participants took part in the experiment; however, 7 participants were excluded due to incomplete or inconsistent responses, resulting in a final sample of 91.

Table 2 presents descriptive statistics for key variables, including CPT parameters and participant characteristics. The sample was predominantly male (58.24%), with a majority of participants originating from Southern (32.9%) and Central Italy (36.2%), while fewer came from Northern Italy (12.09%) or abroad (18.68%). Participants completed a standardized Big Five personality questionnaire (Rammstedt and John, 2007), with scores for each personality item ranging from 1 to 5. Participants scored moderately high on conscientiousness (mean = 3.64, SD = 0.65) and openness (mean = 3.25, SD = 0.75), whereas neuroticism exhibited big variability (mean = 3, SD = 0.94). Approximately 17.5% of the sample reported previous direct experience with catastrophic events (e.g., severe illness).

Table 2: Summary Statistics of CPT Parameters and Covariates

Variable	Mean	Median	Std. Dev.	Min	Max
λ	1.99	2.15	0.87	0.55	3.46
α	0.98	1.00	0.02	0.81	1.01
β	0.98	1.00	0.05	0.75	1.03
$w^{-}(0.05)$	0.16	0.11	0.16	0.02	0.60
Percent Male	58.24%	-	-	-	-
Percent Female	41.76%	-	-	-	-
Percent North	12.09%	-	-	-	-
Percent Center	36.26%	-	-	-	-
Percent South	32.97%	-	-	-	-
Percent Out of Italy	18.68%	-	-	-	-
Big Five: Extraversion	3.15	3.00	0.81	1.00	5.00
Big Five: Agreeableness	2.86	3.00	0.77	1.00	4.50
Big Five: Conscientiousness	3.64	3.50	0.65	2.00	5.00
Big Five: Neuroticism	3.00	3.00	0.94	1.00	5.00
Big Five: Openness	3.19	3.00	0.76	1.00	5.00
Percent with Past Experience	17.58%	-	-	-	-

Key experimental variables included CPT-derived parameters: loss aversion (λ), curvature of the value function for gains (α), curvature for losses (β), and probability weighting for rare losses ($w^{-}(0.05)$). These parameters were estimated using non-linear least squares, as specified in the experimental design and in line with Abdellaoui's method.

As shown in the table, the distributions of these parameters reveal substantial heterogeneity. Loss aversion (λ) exhibited considerable variability, ranging from 0.55 to 3.46 with a mean of 1.99, aligning closely with standard values found in behavioral economics literature, typically between 1.5 and 2.25 (Tversky and Kahneman, 1992; Abdellaoui et al., 2007).

Probability weighting for rare losses ($w^{-}(0.05)$) showed a pronounced overweighting of low-probability outcomes, with a mean of 0.16 and significant dispersion, consistent with cumulative prospect theory's prediction that individuals overweight small probabilities (Kahneman and Tversky, 1979; Gonzalez and Wu, 1999).Parameters α and β displayed relatively low variance around values slighlty lower than 1, suggesting limited individual variation in curvature sensitivity for low-probability prospects. While the observed values of β align closely with existing studies, α is not significantly lower as often observed in the literature (Desmoulins-Lebeault et al., 2016), potentially reflecting a context-specific effect where participants perceive gains with reduced diminishing sensitivity, possibly due to the high stakes and structured environment of the experiment.

To identify potential multicollinearity and interdependencies among CPT parameters, a correlation analysis was conducted. Moderate correlations emerged, notably between loss aversion (λ) and probability distortion ($w^{-}(0.05)$), suggesting that while these are conceptually distinct constructs—emotional aversion versus cognitive distortion—there is a meaningful interdependence, and individuals prone to overweight probabilities might also experience heightened loss sensitivity. The possible interactions and implications will be discussed more deeply in the next sections.

Initial data processing involved exclusion of incomplete responses (7 participants) and standardization of psychological variables (Big Five scores, IQ) to facilitate clear interpretation in subsequent regressions.

4.2 Constructing and Analyzing Catastrophic Risk

The remainder of this section outlines the empirical strategy used for analyzing catastrophic risk perception (CRP) within the CPT framework. The analysis begins with the construction of an individual CRP measure based on elicited CPT parameters. Its validity is then assessed by examining its predictive power for real-world risk assessments. Next, the determinants of CRP are investigated, followed by a decomposition of its components to separately evaluate the roles of probability distortion and loss aversion. Finally, the presence of the shared burden effect is tested both in laboratory conditions and through willingness-to-pay (WTP) assessments in the survey, with an analysis of its potential drivers. Results will be then presented and discussed in the next section.

The Catastrophic Risk Perception (CRP) measure is constructed based on the cumulative prospect theory (CPT) framework, using the parameters elicited from the participants in Phase 1 of the experiment. Specifically, the CRP measure for each participant is computed as the average of the CPT value function evaluated across all six elicited loss amounts x_i:

$$\mathrm{CRP}_i = \frac{1}{6}\sum_{i=1}^{6} w_i^{-}(0.05) \cdot v_i(-x_i), \tag{7}$$

where $w_i^{-}(0.05)$ represents the probability weighting function evaluated at the low-probability level ($p = 0.05$), and $v_i(x)$ is the value function under CPT for losses, defined as:

$$v_i(x) = -\lambda_i \cdot (-x)^{\beta_i}, \tag{8}$$

with λ_i capturing individual loss aversion, and β_i representing the curvature of the value function for losses. Evaluating the CRP across multiple elicited amounts rather than at an arbitrary single point ensures robustness and a consistent reflection of participants' catastrophic risk evaluations over a relevant range of loss magnitudes.

4.3 External Validation with Real-World Risk Assessments

To test the external validity of the CRP measure, individual risk scores from Phase 3—specifically participants' ratings (1–10) for four separate real-world risks (fatal accident, mortal illness, pandemic, and nuclear war)—are individually regressed on the standardized CRP measure (z-score normalization applied to the measure defined in previous subsection). The choice to use separate ordinary least squares (OLS) regressions for each risk without additional covariates is deliberate, as the objective here is not to establish causality, but rather to verify whether the variation in the CRP measure alone meaningfully explains variation in participants' real-world risk assessments. A significant positive correlation in these regressions would confirm that the constructed CRP measure effectively captures real-world catastrophic risk perception differences among participants. Formally, each regression is specified as:

$$\text{RiskScore}_{r,i} = \alpha_0 + \alpha_1 \text{CRP}i + u_{r,i} \tag{9}$$

where $\text{RiskScore}_{r,i}$ represents participant 's perceived severity (scale 1–10) for risk r. A statistically significant positive coefficient would suggest CRP effectively captures individual variation in perceived risk.

4.4 Determinants of Catastrophic Risk Perception

To analyze the determinants of CRP, a comprehensive OLS regression is initially estimated:

$$\text{CRP}_i = \beta_0 + \beta_1 \text{Gender}_i + \sum_{j=1}^{3} \phi_j \text{Origin}_{j,i} + \sum_{k=1}^{5} \gamma_k \text{Big Five}_{k,i} + \delta \text{IQ}_i + \theta \text{PastExp}_i + \epsilon_i. \tag{10}$$

This full specification includes demographic variables (gender and place of origin), psychological traits (Big Five personality dimensions from Rammstedt and John (2007)), cognitive ability (IQ), and past experience with catastrophic events.

However, the sample size (91 participants) is relatively modest for reliably estimating all covariates simultaneously, potentially causing issues related to statistical power and multicollinearity. Indeed, preliminary analyses revealed that while some variables (e.g., gender and place of origin) appeared marginally significant or nearly significant when analyzed individually or with fewer predictors, their significance diminished considerably in the presence of the full set of psychological and cognitive covariates. This loss of significance in the full model likely stems from multicollinearity (i.e., correlation among predictors, especially personality traits) and reduced degrees of freedom given the relatively small sample size.

To mitigate this issue, a reduced-form regression is subsequently estimated, retaining sociodemographic variables (gender and place of origin) and past experience, but excluding personality traits and IQ. The rationale for this decision is based on results from previous literature and on the fact that personality and cognitive variables demonstrated consistently high p-values in the comprehensive model, suggesting limited individual explanatory power, while sociodemographic characteristics such as gender and geographical origin showed relatively lower p-values and theoretical relevance, justifying their retention in the reduced specification. This selective approach enhances statistical power and clarity in identifying key demographic and experiential determinants of CRP.

To further disentangle the channels through which past experience affects catastrophic risk perception, separate regressions are estimated with loss aversion (λ_i) and probability distortion

($w_i^-(0.05)$) as dependent variables. These analyses allow for the identification of whether past experiences influence catastrophic risk perception primarily by altering the perception of outcome severity (via loss aversion) or by affecting perceived likelihood (via probability distortion). Interaction terms between past experience and these parameters explicitly test these distinct psychological pathways.

4.5 Disentangling the Channels of Drivers on Risk Perception

As discussed in the introduction, the two components of catastorphic risk perception are subjective probability and outcome severity, represented in this framework by probability distortion and loss aversion. Therefore, each driver could potentially impact risk perception differently in his two components. Past experience, for instance, can shape risk perception through distinct cognitive mechanisms. First, past exposure to catastrophic events may influence the perception of likelihood, leading individuals to distort probability weighting. This occurs when personal experience makes rare events feel more probable than objective statistical frequencies suggest. Second, past experience can alter the perception of loss severity. On one hand, frequent exposure to extreme events may reduce sensitivity to losses, therefore decreasing loss aversion. On the other hand, particularly traumatic past experiences may heighten the psychological weight of losses, increasing loss aversion. These distinct channels require separate empirical analysis to isolate their effects.

To examine the influence on probability weighting, the following regression is estimated:

$$w_i^-(0.05) = \rho_0 + \rho_1 \text{PastExp}_i + \mathbf{X}_i' \boldsymbol{\rho} + \varepsilon_i, \tag{11}$$

where $w_i^-(0.05)$ is participant i's probability weighting at $p = 0.05$, and PastExp_i is the same binary variable representing past experience with catastrophic risks. The control vector $\mathbf{X}_i$ is the covariates vector including sociodemographics, IQ and personality.

The impact of the covariates on sensitivity to losses is then analyzed by estimating:

$$\lambda_i = \theta_0 + \theta_1 \text{PastExp}_i + \mathbf{X}_i' \boldsymbol{\theta} + \xi_i, \tag{12}$$

where λ_i represents loss aversion. A negative θ_1 would suggest that repeated exposure to loss-related events reduces sensitivity (habituation effect), whereas a positive coefficient would indicate heightened aversion due to traumatic reinforcement. In contrast to the CRP specification, a reduced-form model is not reported here, as additional analysis indicated that excluding covariates neither altered the main results nor revealed any additional significant explanatory variables.

4.6 Shared Burden Effect

The shared burden effect, a term coined in this paper to encapsulate the tendency for individuals perceive as less severe collective risks compared to individual ones, builds on insights into diffused responsibility and risk perception (Böhm and Pfister, 2008); Loewenstein et al., 2013. This subsection analyzes this behavioral anomaly across both laboratory and the naturalistic settings presented in Phase 2 and Phase 3.

Paired t-tests are performed to analyze WTP disparities across settings. In Phase 2, WTP_{ind} (individual risk) is tested against WTP_{coll} (collective risk) for a 5% chance of losing 20:

$$H_0 : \text{WTP}_{\text{ind}} = \text{WTP}_{\text{coll}}$$
$$H_1 : \text{WTP}_{\text{ind}} > \text{WTP}_{\text{coll}}$$

In Phase 3, $\text{WTP}_{\text{fatal illness}}$ (personal threat) contends with $\text{WTP}_{\text{nuclear war}}$ (collective catastrophe) from a 100,000 endowment, probing:

$$H_0 : \text{WTP}_{\text{fatal illness}} = \text{WTP}_{\text{nuclear war}}$$
$$H_1 : \text{WTP}_{\text{fatal illness}} > \text{WTP}_{\text{nuclear war}}$$

To explore the potential drivers behind this effect, an OLS regression dissects the Phase 2 WTP gap:

$$\Delta\text{WTP}_i = \phi_0+\phi_1\lambda_i+\phi_2 w_i^-(0.05)+\phi_3\beta_i+\phi_4(\lambda_i\times\text{Past Experience}_i)+\phi_5\text{Past Experience}_i+\mathbf{Z}_i'\boldsymbol{\phi}+\nu_i$$

where $\Delta\text{WTP}_i = \text{WTP}_{\text{ind,i}} - \text{WTP}_{\text{coll,i}}$, Past Experience$_i$ ($1 =$ experienced fatal illness, $0 =$ no), and $\mathbf{Z}_i$ includes age, gender, place of origin, Big Five traits, and IQ. This difference in the perception of collective and individual risk may be influenced by cognitive and personality traits. In particular, personality factors such as conscientiousness and agreeableness may shape the extent to which individuals rely on collective decision-making rather than personal risk assessment. Additionally, cognitive ability (IQ) could modulate the ability to accurately process probabilities and assess risk severity, potentially mitigating or amplifying the shared burden effect. Socio-demographic factors may also play a role by affecting collective responsibility norms. These relationships will be further explored in discussed in the results section. A significant drop in collective WTP across both phases will confirm the shared burden effect's strength, connecting lab results to real-world meaning. This will prove the effect is a solid behavioral trend and shows how CPT explains it, offering a new way to understand collective risk valuation.

5 Results

5.1 External Validity of Catastrophic Risk Perception

To validate the external relevance of the experimentally-derived Catastrophic Risk Perception (CRP) measure, four separate linear regressions are estimated—one for each self-reported risk rating collected in the post-experimental survey: fatal disease, nuclear war, pandemic, and extreme accident. Each regression uses the standardized CRP score as the sole predictor, allowing for a clean reduced-form assessment of whether variation in risk perception measured under laboratory conditions explains heterogeneity in real-world risk assesments.

The regression results are reported in Table 3.

Table 3: External Validity: Regressions of Risk Severity Ratings on Standardized CRP

Dependent Variable	**CRP$_z$ Coef.**	**SE**	***p*-value**
Fatal Disease Risk	0.574***	0.208	0.007
Nuclear War Risk	0.594***	0.215	0.007
Pandemic Risk	0.323	0.225	0.155
Extreme Accident Risk	0.448**	0.175	0.012

For both disease and nuclear risks, the CRP measure significantly and positively predicts the severity ratings, supporting its external validity. A one standard deviation increase in CRP is associated with an increase of approximately 0.57–0.59 points in the perceived risk severity on a 1–10 scale. The relationship is also significant for extreme accidents, though with a slightly smaller coefficient. Positive coefficient but no statistically significant association for pandemic-related risk is found, suggesting a potential context-specific variation in how laboratory risk preferences translate into real-world concerns. This lack of significance for pandemic-related risk may also reflect confounding effects of recent collective experience with COVID-19, which could homogenize responses or interact with unobserved emotional or contextual factors, attenuating the explanatory power of individual-level CRP. Overall, the results provide empirical support for the CRP measure as a meaningful proxy for catastrophic risk perception.

5.2 Determinants of Catastrophic Risk Perception

The determinants of catastrophic risk perception (CRP) are then examined through regression analyses to identify the factors significantly associated with individual variations in CRP. Initially, a full regression model was estimated, incorporating demographic variables, past experience, personality traits (Big Five), and gender as predictors. Results from the full model are reported in Table 4.

Table 4: Regression Results: Full Model of CRP Determinants

Variable	Estimate	Std. Error	t-statistic	p-value
Intercept	0.864	0.870	0.993	0.324
Past Experience	0.704**	0.242	2.912	0.005
Gender (Male)	-0.266	0.207	-1.288	0.202
North	0.125	0.335	0.373	0.710
Center	0.151	0.277	0.544	0.588
South	0.407	0.272	1.493	0.140
Extraversion	-0.097	0.119	-0.816	0.417
Agreeableness	-0.152	0.125	-1.217	0.227
Conscientiousness	-0.065	0.140	-0.463	0.645
Neuroticism	-0.012	0.110	-0.112	0.912
Openness	-0.061	0.122	-0.505	0.615
IQ	-0.005	0.050	-0.098	0.922

As shown in Table 4, among the psychological traits assessed through the Big Five personality framework, none emerged as significantly associated with CRP. Extraversion (estimate = -0.097, $p = 0.417$), agreeableness (estimate = -0.152, $p = 0.227$), conscientiousness (estimate = -0.065, $p = 0.645$), neuroticism (estimate = -0.012, $p = 0.912$), and openness (estimate = -0.061, $p =$ 0.615) displayed non-significant relationships. Similarly, IQ showed no significant association with CRP (estimate = -0.005, $p = 0.922$). The only significant predictor appears to be Past Experience, enhancing perception of risk.

Given these results and the relatively modest sample size, as discussed before, a reduced-form model excluding the psychological traits and IQ was estimated to enhance statistical power, clarity, and interpretability of the results. An additional justification for emphasizing sociodemographic variables is their significant role in separate analyses examining loss aversion, as showed in the next subsection, suggesting these factors systematically shape individuals' sensitivity to catastrophic losses.

Results from the reduced-form regression model are presented in Table 5.

Table 5: Regression Results: Reduced Model of CRP Determinants

Variable	Estimate	Std. Error	t-statistic	p-value
Intercept	-0.385	0.188	-2.046	0.044
Past Experience	0.715***	0.199	3.594	0.001
Gender (Male)	-0.269*	0.155	-1.736	0.086
North	0.010	0.271	0.039	0.969
Center	0.161	0.220	0.728	0.468
South	0.405*	0.215	1.886	0.063

Notably, the origin from Southern Italy reached statistical significance (estimate = 0.405, $p =$ 0.063), suggesting underlying regional differences in catastrophic risk perception (CRP) that align with previous research on distinct behavioral patterns across Italian regions. Prior studies have consistently documented that Southerners exhibit more pessimistic beliefs about cooperation, lower trust, and stronger aversion to social risk, reflecting deep-rooted cultural and social identities shaped by historical institutions and socioeconomic structures (Bigoni et al., 2017, 2018). Such regional behavioral heterogeneity may contribute to differences in individual evaluations of catastrophic risk, as pessimistic and risk-averse beliefs could amplify perceived severity and likelihood of rare extreme events.

A specific example linking regional experience and catastrophic risk perception emerges from studies showing that Southern Italy's frequent exposure to severe natural disasters, such as earthquakes, increases risk aversion, negatively impacting entrepreneurial activity and economic decisions (De Blasio and Di Addario, 2018), and therefore also potentially affecting risk perception through the channel of past experience. Previous experience emerged in fact as strongly significant (estimate=0.715, $p < 0.001$), confirming the expectation that individuals with prior exposure to catastrophic events exhibit an increased perception of those risks. However, it remains unclear from this analysis whether this increased perception is primarily due to an exaggerated subjective assessment of event likelihood (probability distortion) or to greater sensitivity to potential negative outcomes (loss aversion), or how these two potential mechanisms interact. As outlined in the methodology, further analysis disentangling these two cognitive components — probability weighting and loss aversion — will clarify how precisely past experience shapes catastrophic risk perception. Overall, the results indicate that catastrophic risk perception (CRP) is primarily driven by sociodemographic and experiential factors. Prior experience with catastrophic events shows a robust and significant association with higher CRP, highlighting the influence of personal exposure on risk sensitivity. Gender also emerges as a relevant factor: females tend to exhibit higher CRP levels, consistent with well-documented gender differences in risk perception and aversion. Additionally, origin from Southern Italy is marginally significant, suggesting that regional cultural identity may shape individual attitudes toward catastrophic risk in ways that align with broader evidence on social trust, cooperation, and financial behavior. In contrast, cognitive ability and personality traits—including the Big Five dimensions—do not display meaningful explanatory power in this context. These findings reinforce the importance of focusing on social background and lived experience, rather than dispositional traits, when analyzing how individuals perceive and respond to catastrophic risk.

5.3 Disentangling the Cognitive Channels: Probability Distortion and Outcome Severity

To understand the cognitive mechanisms underlying the significant predictors of catastrophic risk perception (CRP) identified earlier, separate regressions analyze the impact of individual characteristics on two distinct components of cumulative prospect theory: loss aversion (λ) and probability distortion ($w^{-}(0.05)$). Tables 6 and 7 present these results, respectively.

Loss Aversion (λ). Table 6 reports that past catastrophic experience, gender, and regional origin significantly influence loss aversion. Specifically, individuals who experienced catastrophic events exhibit substantially higher loss aversion (estimate = 0.554, $p < 0.001$). This finding aligns with the heightened CRP observed earlier, suggesting that past exposure predominantly increases the psychological weight of losses. Gender differences also emerge strongly: male participants exhibit significantly lower loss aversion compared to females (estimate = -1.157, $p < 0.001$), consistent with the earlier finding that females perceive catastrophic risks more severely. Regional variation shows that respondents from Southern Italy have notably higher loss aversion (estimate = 0.449, $p = 0.016$), reinforcing earlier findings linking regional cultural identity to increased CRP. Conversely, respondents from Northern Italy have significantly lower loss aversion (estimate = -0.642, $p = 0.005$). These patterns reinforce the interpretation that observed CRP differences due to sociodemographic factors arise mainly through sensitivity to loss severity rather than probability distortion.

Table 6: Regression Results: Determinants of Loss Aversion (λ)

Variable	Estimate	Std. Error	p-value
Intercept	2.471	0.581	< 0.001
Past Experience	0.554***	0.161	< 0.001
Male (Gender)	-1.157***	0.138	< 0.001
North (Region)	-0.642***	0.224	0.005
Center (Region)	-0.015	0.185	0.934
South (Region)	0.449**	0.182	0.016
Extraversion	0.079	0.079	0.321
Agreeableness	0.009	0.083	0.913
Conscientiousness	-0.109	0.093	0.248
Neuroticism	0.047	0.074	0.521
Openness	0.027	0.081	0.741
IQ	-0.011	0.033	0.734
Observations	91		
Adjusted R-squared	0.625		

Robust standard errors reported.

Probability Distortion ($w^{-}(0.05)$). The analysis of probability distortion yields substantially weaker results, with no significant predictors emerging (Table 7). Neither psychological nor demographic factors such as gender or region significantly influence the subjective distortion of rare-event probabilities. Past experience shows a marginally significant positive association with probability distortion ($p = 0.086$), suggesting a slight increase in subjective likelihood; however, its primary and stronger impact remains on loss aversion ($p < 0.001$).

Table 7: Regression Results: Determinants of Probability Distortion ($w^{-}(0.05)$)

Variable	Estimate	Std. Error	p-value
Intercept	0.201	0.115	0.083
Past Experience	0.055	0.032	0.086
Male (Gender)	0.033	0.027	0.222
North (Region)	0.002	0.044	0.962
Center (Region)	0.038	0.036	0.303
South (Region)	0.012	0.036	0.737
Extraversion	-0.006	0.016	0.691
Agreeableness	-0.029	0.016	0.082
Conscientiousness	-0.012	0.018	0.533
Neuroticism	0.011	0.015	0.439
Openness	-0.004	0.016	0.800
IQ	-0.003	0.007	0.680
Observations	91		
Adjusted R-squared	0.071		

Robust standard errors reported.

Overall, the disentangling analyses underscore that past catastrophic experience, gender, and regional origin primarily influence catastrophic risk perception by shaping the psychological sensitivity to outcomes (loss aversion), rather than by altering probability distortion. These findings clarify that observed variations in catastrophic risk preferences are driven predominantly by differences in perceived loss severity rather than subjective probability assessments.

5.4 Shared Burden Effect: WTP Comparisons and Regression Analysis

As explained in the Methodology section, paired-sample t-tests have been conducted to compare participants' stated willingness to pay (WTP) between individual and collective in Phase 2 (laboratory settings) and Phase 3 (real-life risks scenarios). Phase 2 is particularly relevant for assessing the existence of the shared burden effect since the risk in the two scenarios is exaclty the same with same probability (and in a controlled laboratory environment) and the only difference is that the realization of the random risky event is the same for everyone in the collective risk scenarios. The analysis in Phase 3 is useful to confirm external validity and robustness. A significant difference is found: WTP under collective risk was significantly lower than WTP in the individual risk scenario (paired t-test, $p < 0.05$; see Table 8). In Phase 3, participants stated their WTP for an insurance against an individual fatal disease versus an insurance against a nuclear accident (representing a collective fatal risk). Here too the difference was significant: WTP for nuclear accident insurance was lower than WTP for fatal disease insurance (paired t-test, $p < 0.01$; Table 8).

Table 8: Paired t-test results comparing mean willingness-to-pay (WTP)

Comparison	Mean WTP_1	Mean WTP_2	$t(df)$	p
Phase 2: Individual vs. Collective	2.21	1.92	$t_{99} = 2.787$	0.003
Phase 3: Disease vs. Nuclear	54479.11	41712.09	$t_{99} = 5.11$	0.008

These findings robustly support the existence of the shared burden effect, indicating that individuals perceive risks differently when they affect larger groups rather than themselves only. The lower WTP observed in collective scenarios suggests a psychological discounting effect, where the responsibility and psychological impact of bearing a catastrophic loss are diluted among group members. This result aligns with behavioral economics theories on responsibility diffusion and risk-sharing mechanisms, suggesting that individuals derive some comfort from collective exposure, potentially underestimating their personal vulnerability within a group context.

Moreover, the consistently lower valuation of collective risks across both laboratory and naturalistic settings strengthens external validity and underscores that the shared burden effect persists irrespective of the scale of hypothetical losses involved. This has relevant implications for public policy and risk communication, highlighting the necessity to consider psychological biases in collective risk management and insurance market design, for example in contexts such as disaster preparedness, public health interventions or, as increasingly present in public debate, deterrence of international conflicts.

To further investigate individual differences in this shared burden effect, factors that may predict the magnitude of the WTP change between conditions are analyzed. We define ΔWTP as the difference in an individual's willingness to pay between the two paired scenarios in Phase 2 (laboratory settings). Table 9 presents the detailed regression results, incorporating socio-demographic factors, past experience, psychological traits, and CPT parameters.

The analysis indicates a limited general explanatory power, with an adjusted R-squared slightly below zero. Among all predictors, only the probability distortion parameter approached statistical significance (estimate $= -1.678$, $p = 0.053$), with its significance increasing in the reduced forms, suggesting that participants who distort probabilities to a greater extent exhibit a smaller shared burden effect. This finding implies that individuals prone to overestimate low probabilities may perceive catastrophic risks similarly in both individual and collective contexts, thus reducing the discrepancy between their willingness to pay individually versus collectively.

Other predictors, including past catastrophic experiences, socio-demographic factors (gender and region), and psychological traits (Big Five personality dimensions and IQ), showed no significant relationships with the shared burden effect. Even when replicating the logic employed previously for the CRP determinants by estimating a reduced-form model excluding psychological and cognitive variables, no meaningful additional insights emerged. The persistence of non-significance suggests that the shared burden effect is not strongly driven by sociodemographic or experiential variables considered here but rather may be shaped by more subtle psychological or contextual factors not captured in this study.

Overall, the results emphasize the complex nature of the shared burden effect, The marginal significance of probability distortion highlights its potential relevance, but further targeted studies with larger samples or different experimental contexts are needed to better understand the psychological mechanisms behind this newly defined phenomenon.

Table 9: Regression Analysis of Drivers of shared burden effect (Δ WTP)

Variable	Estimate	Std. Error	t-statistic	p-value
Intercept	3.680	3.469	1.061	0.292
Past catastrophic experience	0.244	0.323	0.755	0.452
Male gender	0.046	0.360	0.128	0.899
North region	-0.093	0.395	-0.237	0.814
Central region	0.137	0.308	0.444	0.658
South region	-0.267	0.322	-0.828	0.410
Probability distortion ($w^{-}(0.05)$)	-1.678*	0.855	-1.962	0.053
Loss curvature (β)	-1.806	3.035	-0.595	0.554
Loss aversion (λ)	-0.108	0.220	-0.493	0.623
Extraversion	-0.053	0.141	-0.378	0.707
Agreeableness	0.091	0.139	0.656	0.514
Conscientiousness	-0.256	0.159	-1.614	0.111
Neuroticism	-0.014	0.123	-0.111	0.912
Openness	0.026	0.136	0.192	0.848
IQ	-0.069	0.056	-1.216	0.228
Observations	91			
Adjusted R-squared	-0.011			

* $p < 0.1$; robust standard errors reported.

6 Discussion and Conclusion

This study aimed to enhance the understanding of catastrophic risk perception, with the mechanisms and drivers shaping it, and examine how it translates into economic valuations for risk mitigation, with a particular focus on what has been defined in this paper as the shared burden effect, i.e. the mechanisms for which same risks are perceived as less severe when shared among the collectivity. To achieve this, an index for individual catastrophic risk perception (CRP) was developed, capturing individual sensitivity to low-probability, high-impact events in a controlled laboratory setting. This measure demonstrated strong internal consistency and successfully predicted real-world assessments of various extreme risk scenarios, affirming its external validity.

Several key findings emerged from our analysis. First, through regression analyzes, the CRP index was robust in predicting individual differences in risk perception, reaffirming its practical importance. Across sociodemographic variables, gender emerged as a mildly significant predictor: women consistently reported a higher perception of risk and demonstrated a stronger response to risk framing. Additionally, regional background played a role, with Southern Italians exhibiting heightened risk sensitivity, consistent with prior studies on regional disparities in attitudes towards risk and uncertainty. But the most important driver appeared to be previous experience: individuals that already had to deal with an extreme event were perceiving risk highly. Further analyses sought to disentangle the cognitive channels behind these differences in CRP—specifically, loss aversion (severity perception) and probability distortion.

Interestingly, the main drivers of CRP (past catastrophic experience, gender, and regional origin) predominantly influenced outcome severity perceptions rather than subjective probability assessments. Individuals with prior catastrophic experiences, women, and Southern Italians exhibited significantly heigher loss aversion. Probability distortion, although mildly influenced by past experience, played a comparatively minor role in shaping overall catastrophic risk perception suggesting that these drivers shape catastrophic risk perception mainly through loss aversion.

Second, participants displayed a pronounced shared burden effect: their willingness to pay (WTP) to mitigate catastrophic risks was significantly lower when costs were collectively borne compared to individual scenarios. This effect was consistently observed both in the controlled laboratory experiment (with an endowment of 20 at stake) and in the survey-based real-world scenarios (with a hypothetical endowment of 100,000). Such findings underline the importance of risk sharing psychological mechanisms in social and economics decisions regarding risk mitigation.

In exploring the drivers behind the shared burden effect (the gap between individual and collective WTP), the analysis revealed limited explanatory power for sociodemographic and psychological traits. Only the subjective probability weighting parameter approached marginal significance, suggesting individuals who subjectively amplify the probability of rare events are more impacted and therefore less willing to mitigate their perception when the risk is shared by the collectivity. These findings provide valuable insights for policymakers, especially given the psychological bias captured by our findings: participants expressed a significantly lower willingness to pay for collective catastrophic risks, such as nuclear threats, compared to individual health-related risks like severe diseases. This suggests the public tends to fear and prioritize immediate, personally relevant threats over more abstract, collective dangers. Consequently, redirecting resources from healthcare towards defense spending—particularly amid discussions about rearmament due to geopolitical tensions—could appear particularly troubling to citizens, as it directly conflicts with their expressed preferences and perceived risk priorities. Effective communication and policy strategies must therefore carefully justify such reallocations, clearly demonstrating how collective security investments do not undermine individual-level protections, especially in sensitive areas such as health and social care.

Moreover, recognizing sociodemographic and experiential drivers of catastrophic risk perception—such as prior exposure to severe events, gender differences, and regional identity—can help tailor policies and communication efforts. For example, targeted informational campaigns addressing regional disparities or prior experiences could enhance the effectiveness of policies by addressing specific psychological and social determinants of risk perception, increasing societal resilience amid ongoing international tensions and other extreme risks.

Several limitations should be acknowledged. The sample size was modest and largely student-based, potentially limiting generalizability. Additionally, hypothetical scenarios, although carefully constructed, may introduce biases into stated WTP values. Further research should utilize larger, diverse, and representative samples, incorporating real economic stakes to enhance external validity. Moreover, longitudinal studies could further clarify the stability and dynamics of CRP over time, particularly after real catastrophic events.

In conclusion, this study advances the understanding of catastrophic risk perception by demonstrating its cognitive and social foundations and highlighting critical drivers. The newly developed CRP index provides a robust measure of individual catastrophic risk perceptions, demonstrating strong external validity through its predictive power for real-world risk evaluations. Analysis of its determinants highlights the critical roles of sociodemographic characteristics and past experiences, particularly in shaping sensitivity to losses.

Moreover, the identification of a novel shared burden effect, revealing a systematic decrease in individual willingness-to-pay under collective cost-sharing scenarios compared to individual ones, significantly advances our understanding of how social context influences economic behavior towards catastrophic risks. Together, these findings offer policymakers actionable insights for promoting public cooperation, aligning resource allocation with citizens' risk preferences, and improving institutional trust through targeted risk communication strategies.

7 Disclosure Statement

The author reports there are no competing interests to declare.

8 Data Availability Statement

The data that support the findings of this study are openly available in "figshare" at https://doi.org/10.6084/m9.figshare.28697372.v1

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