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# Climate Risk and Retirement Savings

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## Abstract

Climate change has caused both substantial short and long-term financial impacts on individuals and families. Little research, however, has examined its financial consequences on retirement savings. This study explores the relationship between climate risk (CR) and retirement wealth, and related pathways via risk aversion and regret with 1,438 Dutch respondents. Findings show that CR is positively related to risk aversion and avoidance of regret, and more savings for retirement. The findings indicate that CR is a relevant determinant of savings for retirement, but it is inconclusive that more savings is through precautionary motive or future regret.

**Categories:** Climate Change, Consumer Behavior, Risk Management
**Keywords:** climate change, household finance, retirement savings, precautionary motive, avoidance of regret
**JEL Classifications:** D14, D31, D81, G41, G51

## Introduction

The climate is undoubtedly changing. Increases in longer periods of excessively high temperatures, heavy rains, severe floods, longer droughts, and wildfires are currently occurring more frequently in the US and elsewhere around the world (US Global Change Research Program, 2023). Climate risk (CR), the potential financial loss from this climate change (Haynes, 1895), has inflicted substantial economic damages with a historic 93 billion dollars in 2023 alone in America and will be more severe in the near future than previously expected (US NOAA, 2024).

CR can seriously impact financial problems in retirement savings for individuals and families. Extreme heat, heavy rains, and /or severe winds may cause people to reduce working hours (often associated with income loss), and can further lead to loss of jobs. Moreover, these factors can disrupt supply changes of businesses and damage infrastructures, resulting in increased prices and living expenses. Extreme weather conditions from climate change can also damage properties, leading to increased repair costs and insurance premiums for homes and automobiles, as well as decreased property values, threatening financial security in future consumption as retirement savings as well as current consumption.

Despite potentially serious financial problems stemming from CR, many Americans do not think that climate change is a major threat currently (46%) (Pew Research Center, 2023), and in their own lifetime (55%) (Gallup, 2024). Retirement savings planning requires consideration of various risks such as inflation and health care cost and related preference (Lee and Kim, 2016). However, people tend to overlook the long-term and lingering impact on retirement savings of financial loss and increased expenses due to climate change (Unexpected risks and retirement planning, 2021). Given that savings for retirement are essential in retirement, it is important and timely to examine how people behave in retirement savings under CR.

Previous studies have shed light on the economic loss associated with CRs from extreme heat (Baranyai and Banai, 2022), floods (Flood damage and federally backed mortgages in a changing climate, 2023), hurricanes and wildfires at a macro level (The impact of climate change on American household finances, 2023). Little is known, however, about the impact on household finance, particularly the relationship between CR and retirement savings. The current study can contribute in two ways to the personal and family finance literature. Practically, it can identify how CR relates to savings behaviors for retirement, and conceptually it considers CR as an additional risk related to both income and expenses risk for retirement savings.

This study fills the gap in the literature by answering two questions: (1) What is the financial impact of CR on retirement savings? (2) How does CR affect retirement savings? To answer these questions, (1) we examine the relationship between awareness of climate change and retirement savings, and (2) utilizing mediation models, we test the pathways of this relationship via two motives: a precautionary motive for saving and an avoidance motive of anticipated regret (AR).

### Literature review

*Climate Risk and Retirement Savings*

CR comes from any significant change in climate measures such as temperature, precipitation, or wind that lasts for decades or longer (Clean energy glossary, 2007). CR can affect decisions for retirement savings as an additional risk of labor income loss (income), increase in living cost (expenses) and property damage (The cost of climate change on households and families in the EU, 2023) in personal and family finances. When people make decisions about retirement savings, they have to take into account many risks, and CR is one of them. CR is characterized as background risk that is not under the control of individuals and family, and is independent from the risk involved in the financial decision at hand (Eeckhoudt et al., 1996) (Harrison et al., 2007) such as portfolio choice in investment for retirement savings (portfolio risk). When making financial decisions, people may not simply consider portfolio risk but total risks (portfolio risk and background risk) (Huang and Yang, 2020) such as income risk, consumption risk, or CR.

We are not aware of prior studies examining a direct relationship between CR and retirement savings behaviors. Most of previous studies have examined saving behaviors when people face background risks that are unrelated to CR, such as individual job loss and consumption risks for increased spending in financial decision-making. Overall, these studies found that people decrease current consumption in favor of future consumption, save more, and accumulate more wealth. One study provided a model of optimal consumption and savings for retirement with job loss risk and showed that people with a higher risk of job loss consume less and save more than those with a lower risk of job loss (Saving for retirement with job loss risk, 2013). When people have labor income risk from job loss, they accumulated 1% to 3.5 % more total net worth and 2% to 4.5 % more financial net worth (Lusardi, 1988). Expecting total household income risk, people accumulated net worth by 4% to 6% more (Castaldo and Tirelli, 2025). Consumption risk in the future measured by expectation of consumption growth was also associated with less current consumption and more savings. Confronting consumption risk, people increase future consumption by 1% through saving while decreasing current consumption by 1% (Christelis et al., 2020).

*Channels of Climate Risk to Retirement Savings*

The literature on saving explains why people save more when facing additional risks via the precautionary savings motive. Keynes (Keynes, 1936) conceptually suggested "to build up a reserve against unforeseen contingencies" (precautionary saving motives). People need to insure future consumption against unexpected risks. A theoretical model shows an extra savings demand under income uncertainty (Leland, 1968). When facing additional CRs with income and consumption risk, people will be more risk averse: RA (aversion to uncertainty) and reduce their willingness to take and expose themselves to avoidable risks (Guiso and Paiella, 2008) by saving more for future consumption. Many recent studies have found that natural disasters increased risk aversion (Liebenehm et al., 2024) (Bourdeau Brien and Kryzanowski, 2020) while some research showed that natural disasters decreased risk aversion due to emotional responses (Kahsay and Osberghaus, 2018).

Previous research suggested a possible channel through which additional risks from CR can affect saving behaviors. Empirical studies found evidence of precautionary saving motives when people are confronted with background risks (Lusardi, 1988), (Castaldo and Tirelli, 2025, and (Christelis et al., 2020). Some additional empirical studies found that nursing home risk accounts for 3% of aggregate wealth (Kopecky and Koreshkova, 2024) and about 8% of total wealth in farm households is for precautionary savings due to income risk in addition to portfolio risk (Mishra et al., 2013).

Important for the current goals is that previous research also suggests another possible channel to save more and accumulate wealth more when facing CR, namely the channel through the avoidance motive of AR. Regret theory (Loomes and Sugden, 1982) is the name generally used for the theory that decision-makers anticipate future regret and incorporate this in their decision-making. The theory is broadly based on four simple assumptions. First, decision-makers are assumed to feel emotions such as regret when their obtained outcome is worse than what they would have obtained had they chosen differently. Second, these feelings of regret are assumed to negatively influence the evaluation of the obtained outcome. Third, decision-makers can predict feelings of regret beforehand ("anticipate" them). Fourth and finally, decision-makers are assumed to take this AR into account and choose in such a way to avoid it from happening. There is ample support for these assumptions (Bleichrodt and Wakker, 2015) (Zeelenberg, 2024).

AR is relevant in the context of background risk. Often, in real life, AR leads to risk aversion (Simonson, 1992). Because decision-makers feel regret when a rejected alternative turns out to be better than the chosen one, regret is typically felt when risky decisions are made (Zeelenberg, 1999) (Zeelenberg et al., 1996). If there would be no risk, outcomes would be known beforehand, and the best alternative would be chosen. Hence, research often found that when decision-makers anticipate regret, they, for example, show safer behaviors, such as less driving violation, exercising, and cancer screening (Sandberg and Conner, 2008) (Brewer et al., 2016).

Regret is clearly relevant in the context of retirement decision-making. Gillespie (Gillespie and Rubloff, 2024) surveyed a representative sample of Americans, who were asked via the telephone to list their biggest financial regrets. "Not saving for retirement early enough" was mentioned most frequently. And approximately 58% of people aged 60 to 79 in the US households expressed regret that they did not save more for retirement savings (Börsch Supan et al., 2023). Studies in the Netherlands and Australia found similar regrets on retirement savings (Croy et al., 2015) (Krijnen et al., 2022).

A crucial question in this context is when people anticipate regret, and when their decisions is influenced by it. Because regret stems from comparing "what is" to "that what might have been," it is evident that uncertainty about the future is a condition that elicits feelings of AR (Braun and Muermann, 2004). When deciding now about how much to save for retirement, one has to mentally simulate possible futures, including those in which one has saved too little. This is likely to induce feelings of regret over having saved too little, consistent with the survey finding that these are major financial regrets (Gillespie and Rubloff, 2024) (Börsch Supan et al., 2023).

*Summary of Literature Review*

Previous studies have found that in general, additional risks related to income and consumption significantly impact household financial behaviors, but there is very little research about the additional impact of CR on retirement savings and the mechanism via which this impact may occur. The current study aims to explore the relationship between CR and retirement savings, perhaps the most important and most frequently overlooked in household finance, and test pathways between them.

## Theoretical framework and hypotheses

Major motives for saving have been documented as precautionary (to guard against unexpected events or risks), preparatory (to plan for anticipated life events such as retirement), and bequest motives (Keynes, 1936). In this study, we propose a conceptual model to understand the precautionary saving motive in response to risk, particularly focusing on climate-related risks. The basic framework for explaining individuals' saving and wealth accumulation behavior is the life-cycle theory of saving and consumption (Modigliani and Brumberg, 1980). This theory posits that age is a primary determinant of savings, as individuals aim to smooth consumption over their lifetimes.

However, the basic life-cycle model assumes certainty in individuals' income and does not account for various risks such as unemployment, health shocks, or climate change that can significantly affect income, consumption, and saving behavior. An important extension of this model incorporates risk as an additional determinant of savings, leading to what is known as precautionary saving. Under this extended model, individuals save not only to smooth consumption across predictable life stages but also to build a financial buffer against unforeseen events they cannot control, such as CRs.

Our proposed model integrates precautionary saving within the life-cycle framework (Carroll, 1997) (Lusardi, 1988) and places a stronger emphasis on risk rather than age as a major determinant of saving behavior. As risk increases, particularly climate-related risk, the likelihood of future regret also rises (Loomes and Sugden, 1982) (Braun and Muermann, 2004). This is especially relevant for long-term financial decisions such as retirement savings. When individuals perceive a heightened level of CR, they may anticipate greater regret over saving too little. This AR can, in turn, motivate increased saving behavior as a form of self-protection.

Based on these propositions, the relationship between CR and individual wealth accumulation can be expressed through the following functional relationship (equation 1):

$$W = W(age, CR, X) \text{.....(1)}$$

where W is wealth or savings for retirement, CR is climate risk, and X is household characteristics. According to the prediction of precautionary motive and the results of related empirical studies, this model predicts ( $\delta$W/ $\delta$ CR > 0), and we hypothesize that CR has a positive relationship with wealth (H1). To understand how additional CR may increase savings, we propose a following model (equation 2) based on additional CR making people more risk averse and avoid more future regrets stemming from having saved too little.

$$W = W(\text{age}, RA(CR), AR(CR), X) \text{....(2)}$$

where RA is risk aversion, and AR is avoidance attitude toward AR. Change in wealth from CR is presented (equation 3):

$$\frac{\partial W}{\partial CR} = \left(\frac{\partial W}{\partial RA}\right)\left(\frac{\partial RA}{\partial CR}\right) + \left(\frac{\partial W}{\partial AR}\right)\left(\frac{\partial AR}{\partial CR}\right) \text{.....(3)}$$

This model predicts and $\left(\frac{\partial W}{\partial RA}\right)\left(\frac{\partial RA}{\partial CR}\right) > 0$, and we hypothesize that CR has a positive relationship with risk aversion that relates to more savings (H2); CR has a positive relationship with regret avoidance that relates to more savings (H3). Three hypotheses are presented in Figure *1*.

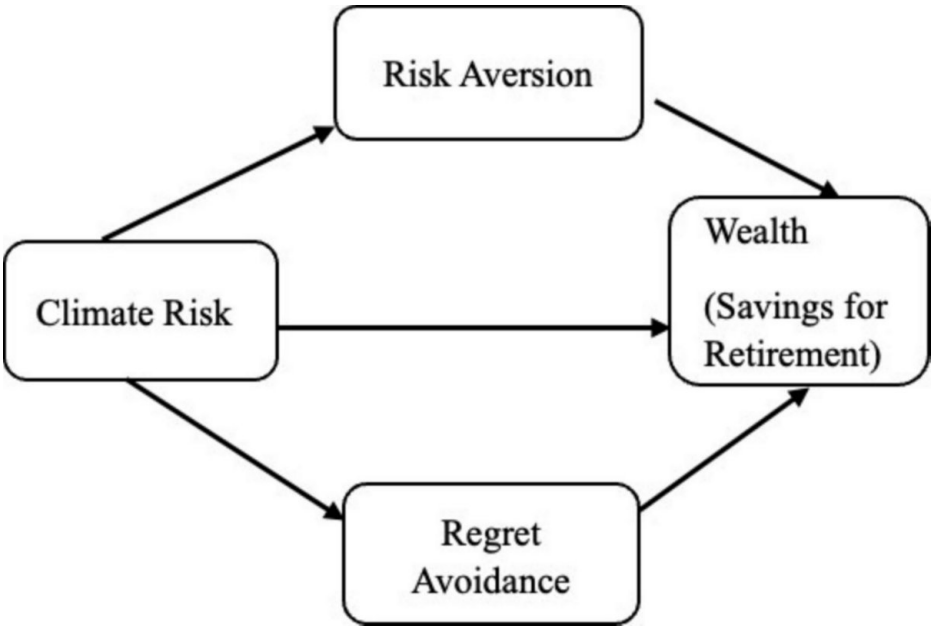


**FIGURE 1: Theoretical framework**

We specify the following empirical models to estimate the relationship between CR and wealth based on the theoretical framework.

$$W = a_1 + a_2 CR + a_3 X + e \text{ .....(4)}$$

$$RA = b_1 + b_2 CR + e_1 \text{ .....(5.1)}$$

$$W = r_1 + r_2 RA + r_3 CR + r_4 X + e_2 \text{ .....(5.2)}$$

$$AR = p_1 + p_2 CR + e_3 \text{ ...(6.1)}$$

$$W = u_1 + u_2 AR + u_3 CR + u_4 X + e_4 \text{ .....(6.2)}$$

The model (equation 4) is to test H1 (Climate risk -->Wealth). The models (equation 5.1) and (equation 5.2) are to test H2 (Climate Risk --> Risk Aversion --> Wealth), and the models (equation 6.1) and (equation 6.2) to test H3 (Climate Risk --> Regret Avoidance --> Wealth) with mediation analysis, respectively.

## Research Method

### Data and participants

We utilized data from the Longitudinal Internet Studies for the Social Sciences (LISS), administered by CentERdata at Tilburg University, the Netherlands (LISS, 2025). The LISS is a rare data set that provides all the relevant variables in this study such as retirement wealth, CR, and regret that make it possible to test hypotheses in this study. The LISS is a nationally representative study of Dutch adults (about 7,500 individuals) to understand social, economic, and behavioral aspects since 2008. Panel members participate in online surveys on a wide range of topics throughout the year. Each participant has a unique ID, allowing researchers to link data across time points. This study utilized the 2020 wave for assessing retirement savings, CR awareness and demographics, the 2018 wave for risk aversion, and the 2012 wave for regret. To construct the sample, we selected participants who had completed all waves that contained the relevant variables for our analysis. Matching this information across the datasets resulted in a final sample of 1,438

participants. However, incorporating the regret variable in the mediation analysis reduced the sample size to 964.

## Measures

*Dependent Variables (DV)*

We used four types of financial outcomes as measures of retirement savings.

Retirement savings: We use participation in work-related pension schemes as a proxy for retirement savings. Participants indicated if they had a retirement savings account by reporting whether they received a pension fund overview in 2019 or 2020, respectively. This refers to overviews from employer-arranged pension funds or insurers, excluding widow/widower pensions, single-premium life insurance policies for investment, bank savings schemes, or private disability insurances. We created a dummy variable set to 1 if the participant received at least one overview, and 0 if not.

Insurance for saving purposes: Participants indicated whether they owned any of the following assets as of December 31, 2019: a single premium life insurance policy, life annuities, or a whole life insurance of endowment insurance (not linked to a mortgage). We created a dummy variable coded as 1 for a "yes" response and 0 otherwise.

Investments: Participants indicated whether they possessed one or more of the following assets on December 31, 2019: mutual funds including growth funds or share funds (e.g., managed funds), bonds, debentures (e.g., a type of bond without collateral), stocks, options, or warrants. We created a dummy variable set to 1 for a "yes" response and 0 otherwise.

Real estates: Participants were asked to indicate whether they possessed one or more of the following assets on December 31, 2019: real estate (including land) not used as their own home, second home, or holiday home. We created a dummy variable coded as 1 for a "yes" response and 0 otherwise.

*Relevant Independent Variable (IV)*

Climate risk awareness: Participants were asked to indicate their agreement with 5 statements about climate change on a scale ranging from 1 (Completely disagree) to 5 (Completely agree). The items were as follows: 1. Climate change will have an impact on my immediate surroundings; 2. The impact of climate change is overstated; 3. Climate change mainly has an impact on faraway countries; 4. Climate change will probably have a great impact on people like me; 5. I am unsure as to whether climate change really exists. A score was calculated by averaging responses to the 5 statements, with statements 2, 3, and 5 reverse-coded and "don't know" responses treated as missing data (Cronbach's $\alpha = .71$).

*Mediating Variables (Med)*

Risk aversion: Participants answered the question: "Generally speaking, are you the kind of person who is willing to take risks or who prefers to avoid risks?" On a scale ranging from 0 (avoid risks) to 10 (fully willing to take risks). For the analysis, scores were reversed to reflect greater risk aversion with higher numbers and recoded to start from 1 instead of 0.

Regret: To assess the disposition to AR, participants were asked to indicate to what extent they agreed with the statements: "I never regret my decisions." On a scale ranging from 1 (Totally disagree) to 7 (Totally agree). For the analysis, scores were reversed so that higher numbers indicated a higher propensity to regret one's decisions.

*Demographic Variables*

We included the following demographic variables as controls: gender (coded 1 for female), age as a continuous variable, age squared, education level in four categories (1 = primary school, 2 = high school, 3 = technical education, 4 = university), marital status (coded 1 for married), origin (coded 1 for Dutch background), personal gross monthly income in euros (log-transformed), and gross monthly household income in euros (log-transformed).

## Analytic approach

Given the binary nature of the dependent variables, we conducted a series of logistic regressions to estimate the main effect of CR awareness on the following outcomes: having a retirement savings account, having investments, holding savings-type insurance, and owning real estate. For the retirement savings model, we controlled for personal income, whereas for the other financial outcomes, we used household income as a control variable. This distinction was made because we expect that decisions around savings-

type insurance, investments, and real estate are influenced by total household income, while retirement savings are likely based solely on personal work-related income. Cases with missing information on the dependent variables were excluded from our analyses.

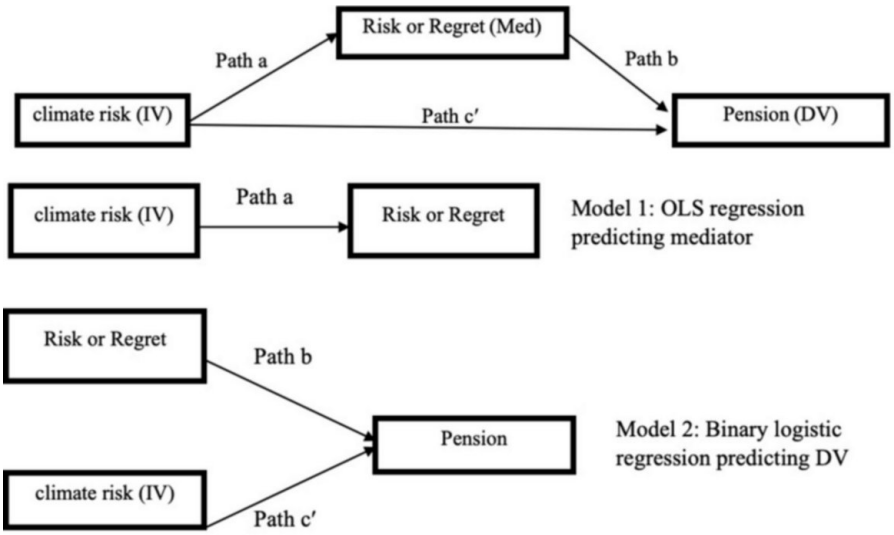


**FIGURE 2: Mediation analysis**

OLS, Ordinary Least Squares; DV, Dependent Variables

We also conducted a mediation analysis to test the hypothesis that the effect of climate change awareness on financial measures is mediated by either risk aversion or regret. A mediation analysis examines whether the effect of an independent variable on an outcome operates indirectly through a third variable (the mediator), with the goal of understanding the underlying mechanism of the relationship (Baron and Kenny, 1986) (Hayes, 2009). Figure *2* presents the mediation models we estimated. The mediation analysis was carried out in three steps. First, we regress the dependent variables (financial measures) on the independent variable (climate change awareness). Second, we test whether the independent variable (climate change awareness) is significantly related to the mediating variable (risk aversion or regret) with Ordinary Least Squares (OLS) regressions. Third, we test whether the mediating variable (risk aversion or regret) is significantly related to the dependent variables (financial measures), controlling for the independent variable (climate change awareness).

# Results

## Descriptive statistics

Table *1* presents the mean scores, standard deviations, and frequencies for all study variables. Half of the participants were female (51%), more than half were married (57%), and the majority were of Dutch origin (83%). The average age was 56 years (ranging from 18 to 102). Most participants owned a home (74%), with an average personal gross monthly income of €2,501. Participants were relatively risk-averse, with a mean score of 7.6 (out of a maximum of 11), and demonstrated relatively high CR awareness, with a mean score of 3.45 (out of 5). Approximately 37% reported having a retirement savings account, 6% held savings-type insurance, about 15% had investments, and around 6% owned real estate. The demographics of our sample closely mirror those of the full LISS panel; however, our sample includes a significantly higher proportion of married participants (57% vs. 42%) and appears to be slightly more educated.

| | Study sample | | | | | LISS panel | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Min | Max | N | Mean | SD | Min | Max |
| Climate risk awareness | 1,220 | 3.45 | 0.67 | 1.4 | 5 | 1,787 | 3.48 | 0.68 | 1.4 | 5 |
| Age | 1,438 | 56.68 | 16.85 | 19 | 102 | 9,263 | 49.36 | 18.77 | 16 | 120 |
| Personal gross monthly income in Euros | 1,366 | 2,501.87 | 1945.56 | 0 | 26,000 | 8,560 | 2,681.08 | 18,795.15 | 0 | 1,662,336 |
| Regret | 964 | 3.86 | 1.44 | 1 | 7 | 5,621 | 3.91 | 1.44 | 1 | 7 |
| Risk aversion | 1,437 | 7.62 | 2.36 | 1 | 11 | 5,551 | 7.62 | 2.40 | 0 | 11 |
| | Study sample | | | LISS panel | | |
| | N | Freq. Yes | Percent | N | Freq. Yes | Percent |
| Pension | 1,438 | 534 | 37.13 | 3,507 | 2,139 | 37.89 |
| Insurance | 1,438 | 131 | 9.11 | 5,849 | 488 | 8.34 |
| Investments | 1,438 | 213 | 14.81 | 5,849 | 800 | 13.68 |
| Real estates | 1,438 | 89 | 6.19 | 5,849 | 361 | 6.17 |
| Female | 1,438 | 734 | 51.04 | 10,875 | 5,533 | 50.88 |
| Married | 1,438 | 821 | 57.09 | 10,875 | 4,607 | 42.36 |
| Dutch | 1,438 | 1,192 | 82.89 | 10,875 | 6,114 | 80.15 |
| Homeowner | 1,437 | 1,066 | 74.18 | 10,875 | 7,863 | 72.30 |
| Education | 1,434 | | | 10,295 | | |
| Primary school | | 68 | 4.74 | | 1,757 | 17.07 |
| High school | | 485 | 33.82 | | 2,839 | 27.58 |
| Technical education | | 349 | 24.34 | | 2,226 | 21.62 |
| University | | 532 | 37.10 | | 3,473 | 33.73 |

**TABLE 1: Sample statistics**

Frequency and percentage values represent the number (and percentage) of participants who responded "yes" to each financial outcome (e.g., "yes" to having insurance) or demographic characteristic (e.g., "yes" to being Dutch).

## Relationship between climate risk awareness and financial outcomes

Table *2* presents the results of a series of logistic regressions examining the impact of CR awareness on the likelihood of having retirement savings, insurance for saving purposes, investments, and real estate. The findings revealed a positive and statistically significant effect of CR awareness on the likelihood of having retirement savings, insurance and real estates. The bottom part of Table *2* presents the estimated marginal effects of the CR awareness on holding each measure of financial outcomes. The marginal effects demonstrate the expected change in the likelihood of holding each financial asset associated with a 1-unit or 1-standard deviation (0.67) increase in CR awareness. On average, a 1-unit increase in CR awareness (e.g., from 1 to 2) raises the likelihood of having a retirement savings account by 4.1 percentage points ($p < .05$), while a 1-standard deviation increase raises it by 2.8 percentage points ($p < .05$). Similarly, a 1-unit increase in CR awareness raises the likelihood of having insurance and real estate by 2.9 ($p < .10$) and 3.0 ($p < .05$) percentage points, respectively, whereas a 1-standard deviation increase raises these likelihood by 1.9 percentage points ($p < .10$) and 1.9 percentage points ($p < .05$), respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Variables | Retirement savings | Insurance | Investments | Real estate |
| | | | | |
| Climate risk awareness | 0.299** | 0.311* | 0.0432 | 0.441** |
| | (0.128) | (0.163) | (0.135) | (0.201) |
| Age | 0.586*** | 0.523*** | 0.0303 | 0.0951 |
| | (0.0491) | (0.111) | (0.0353) | (0.0636) |
| Age Squared | -0.00640*** | -0.00424*** | -0.0000286 | -0.000481 |
| | (0.000492) | (0.000928) | (0.000316) | (0.000536) |
| Log-Pers. income | 0.415*** | | | |
| | (0.158) | | | |
| Log-House. income | | 0.676*** | 0.998*** | 0.987*** |
| | | (0.228) | (0.188) | (0.271) |
| Gender (1 = Female) | -0.0414 | -0.549** | -0.670*** | -0.509* |
| | (0.184) | (0.216) | (0.180) | (0.264) |
| Married (1 = Yes) | -0.100 | 0.134 | -0.604*** | -0.317 |
| | (0.185) | (0.250) | (0.198) | (0.290) |
| Dutch background (1 = Yes) | 0.685*** | 0.420 | 0.302 | 0.0884 |
| | (0.227) | (0.354) | (0.263) | (0.388) |
| Primary school | 0.152 | -0.252 | -1.407* | 0.104 |
| | (0.529) | (0.655) | (0.752) | (0.786) |
| High school | 0.0557 | -0.317 | -0.709*** | -0.301 |
| | (0.222) | (0.260) | (0.218) | (0.336) |
| Technical education | -0.114 | -0.591** | -0.742*** | 0.158 |
| | (0.215) | (0.288) | (0.237) | (0.322) |
| Self-owned dwelling (1 = Yes) | 0.546*** | 0.628* | 0.396 | 1.114** |
| | (0.205) | (0.357) | (0.258) | (0.495) |
| Constant | -17.05*** | -24.95*** | -11.41*** | -17.03*** |
| | (1.699) | (3.744) | (1.905) | (3.079) |
| | | | | |
| Marginal effects - Climate risk awareness | | | | |
| | | | | |
| +1 | 0.041** | 0.029* | 0.005 | 0.030** |
| +SD | 0.028** | 0.019* | 0.004 | 0.019** |
| Observations | 1,077 | 1,112 | 1,112 | 1,112 |

**TABLE 2: The results of logistic regression models**

Note: For the variable Education, the reference category is Higher Education. Estimates are logit coefficients, with standard errors in parentheses. *** p < 0.01,** p < 0.05,* p < 0.1.

## Mediation analysis

Table 2 presents the results of the first step of the mediation analysis explained earlier, which indeed revealed that climate change awareness was positively and statistically significantly related to having retirement savings, insurance, and real estate. Table 3 reports the results of the second step of the mediation analysis using OLS estimation for risk aversion and regret respectively. Climate change awareness was positively and statistically significantly related to risk aversion and regret. Increases in climate change awareness were associated with positive increases in risk aversion and experienced regret.

| | (1) | (2) |
|---|---|---|
| Variables | Risk | Regret |
| | | |
| Climate risk awareness | 0.208** | 0.255*** |
| | (0.103) | (0.0822) |
| Age | 0.0228 | -0.0483* |
| | (0.0258) | (0.0250) |
| Age Squared | -0.0000447 | 0.000391* |
| | (0.000237) | (0.000219) |
| Log-House. income | -0.624*** | 0.183 |
| | (0.140) | (0.116) |
| Gender (1 = Female) | 0.998*** | 0.156 |
| | (0.135) | (0.107) |
| Married (1 = Yes) | 0.377** | -0.0263 |
| | (0.157) | (0.126) |
| Dutch background (1 = Yes) | -0.0785 | 0.0531 |
| | (0.187) | (0.163) |
| Primary school | 0.851** | -0.0432 |
| | (0.368) | (0.273) |
| High school | 0.644*** | 0.144 |
| | (0.167) | (0.136) |
| Technical education | 0.451** | -0.000349 |
| | (0.179) | (0.144) |
| Self-owned dwelling (1 = Yes) | 0.283 | -0.181 |
| | (0.172) | (0.137) |
| Constant | 9.696*** | 2.882** |
| | (1.350) | (1.133) |
| Observations | 1,111 | 749 |
| R-squared | 0.122 | 0.032 |

**TABLE 3: OLS regression analysis predicting the mediator: risk or regret**

Note: For the variable Education, the reference category is Higher Education. Estimates are logit coefficients, with standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. OLS, Ordinary Least Squares.

Table 4 shows the result of the third step of the mediation analysis estimating a series of logistic

regressions. We did not include the independent variable "Investment" in this step since the first step showed no relationship with climate change awareness.

Columns 1, 2, and 3 in Table *4* show that the coefficient for risk aversion was not statistically significant in the model for retirement savings. While risk aversion was statistically significant in the other two models (insurance and real estate), the coefficient was negative. Such cases, where direct and mediated effects display opposite signs, are known in the literature as inconsistent mediation models (Davis, 1985) (MacKinnon et al., 2000). This finding suggests that our mediation hypothesis was not supported. It may indicate that risk aversion plays a different role in the relationship between climate change awareness and financial measures, potentially acting as a confounder rather than solely as a mediator. Additionally, Columns 4, 5, and 6 in Table *4* show that the coefficient for regret was not statistically significant for any financial measure after controlling for climate change awareness. Thus, we found no evidence to support our mediation hypothesis.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Variables | Retirement savings | Insurance | Real estate | Retirement savings | Insurance | Real estate |
| | | | | | | |
| Climate Change Awareness | 0.309** | 0.332** | 0.465** | 0.396** | 0.110 | 0.353 |
| | (0.129) | (0.164) | (0.202) | (0.160) | (0.203) | (0.255) |
| Risk Aversion | -0.0492 | -0.0989** | -0.110* | | | |
| | (0.0364) | (0.0465) | (0.0570) | | | |
| Regret | | | | -0.116 | 0.0923 | 0.0136 |
| | | | | (0.0719) | (0.0901) | (0.112) |
| Age | 0.600*** | 0.523*** | 0.0969 | 0.652*** | 0.683*** | 0.0962 |
| | (0.0499) | (0.111) | (0.0636) | (0.0664) | (0.166) | (0.100) |
| Age Squared | -0.00653*** | -0.00423*** | -0.000476 | -0.00707*** | -0.00570*** | -0.000605 |
| | (0.000499) | (0.000926) | (0.000537) | (0.000659) | (0.00138) | (0.000846) |
| Log-Pers. income | 0.397** | | | 0.378* | | |
| | (0.159) | | | (0.205) | | |
| Log-House. income | | 0.620*** | 0.914*** | | 0.918*** | 0.675* |
| | | (0.230) | (0.275) | | (0.289) | (0.353) |
| Gender (1 = Female) | -0.0186 | -0.432* | -0.373 | -0.127 | -0.766*** | -0.498 |
| | (0.186) | (0.223) | (0.274) | (0.234) | (0.278) | (0.340) |
| Married (1 = Yes) | -0.0979 | 0.154 | -0.297 | -0.392* | 0.0157 | -0.242 |
| | (0.186) | (0.252) | (0.292) | (0.235) | (0.320) | (0.379) |
| Dutch background (1 = Yes) | 0.716*** | 0.432 | 0.0894 | 0.696** | 0.702 | 0.522 |
| | (0.228) | (0.354) | (0.389) | (0.307) | (0.515) | (0.624) |
| Primary school | 0.241 | -0.124 | 0.198 | 0.185 | -0.510 | -0.534 |
| | (0.534) | (0.658) | (0.790) | (0.577) | (0.800) | (1.076) |
| High school | 0.0900 | -0.270 | -0.256 | 0.127 | -0.475 | -0.451 |
| | (0.223) | (0.263) | (0.338) | (0.282) | (0.321) | (0.424) |
| Technical education | -0.0718 | -0.536* | 0.207 | -0.0338 | -1.093*** | -0.220 |
| | (0.217) | (0.289) | (0.323) | (0.277) | (0.374) | (0.421) |
| Self-owned dwelling (1 = Yes) | 0.571*** | 0.656* | 1.158** | 0.433* | 0.106 | 0.530 |
| | (0.206) | (0.359) | (0.498) | (0.258) | (0.401) | (0.523) |
| Constant | -17.03*** | -24.02*** | -15.96*** | -17.82*** | -30.49*** | -13.64*** |
| | (1.729) | (3.770) | (3.135) | (2.252) | (5.392) | (4.110) |
| | | | | | | |
| Observations | 1,076 | 1,111 | 1,111 | 743 | 749 | 749 |

**TABLE 4: Logistic regression analysis with the mediator: risk or regret**

Note: For the variable Education, the reference category is Higher Education. Estimates are logit coefficients, with standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

## Discussion

This study explored the extent to which CR influences retirement savings behavior and how it relates to various types of retirement wealth. We used data from 1,438 respondents in the LISS in the Netherlands. We tested three hypotheses: H1: CR is associated with higher retirement wealth, H2: this relationship is mediated by risk aversion (precautionary saving motive), and H3: it is also mediated by the avoidance of AR.

We found that CR was positively associated with all measures of retirement wealth such as pensions, savings-type insurance and real estate investment except for financial investment. These findings partially supported H1. Quantitatively, a one-unit increase in CR awareness led to a 4.1% increase in retirement pensions , a 2.9% increase in savings-type insurance and a 3.0% increase in real estate investment. Interestingly, personal investments in mutual funds, stocks, or bonds showed no association with CR. This contrasts with previous studies, which found that background risks like climate change influence portfolio choices in retirement savings (Harrison et al., 2007) (Huang and Yang, 2020). In the Netherlands, the retirement pension system is defined benefit (though this is changing in the coming years), meaning that individuals typically receive around 70% of their pre-retirement income with minimal investment risk for their lifetime. Consequently, Dutch individuals may prefer guaranteed options such as additional contributions to employer pension or savings-type insurance. In this investment environment, people may lack detailed knowledge about financial risk, making CR less relevant in personal investment decisions.

However, our findings did not support the other hypotheses: H2 or H3, the proposed pathways linking CR with retirement savings via risk aversion (precautionary motive) or AR (avoidance motive of future regret). Mediation analyses showed that individuals with greater CR awareness had a higher risk aversion and a greater tendency toward regret. Yet, these tendencies did not translate into savings behaviors. One possible explanation is that CR awareness itself may reflect individuals' overall risk attitudes toward retirement savings. Recall that people make investment decisions based not only on portfolio risk but also on total perceived risk including additional background risks like climate change. In our analysis, we used risk aversion as a proxy for portfolio risk, and CR as a background risk. For Dutch individuals with precautionary savings motives, CR may be perceived as equivalent to portfolio risk, which means "risk is risk". This finding may also be influenced by the Dutch pension system, which requires minimal engagement from employees in managing investment risk (i.e., portfolio risk). Future research is needed to further explore this pathway.

Regarding the regret avoidance pathway, one possible explanation may be related to the measure of regret motivation. We used a single-item measure that was unrelated to financial planning or retirement savings. This may have failed to capture relevant financial regret. Additionally, a small number of participants answered this item, limiting statistical power. A better-powered study with a solid financial regret measure is needed to test this pathway more rigorously. In addition to the regression-based mediation framework, we re-estimated the models using structural equation modeling (SEM). The results from the SEM analyses were consistent with our main findings, providing further support for the robustness of the findings presented (the results are available upon request).

### Implications

Our findings suggest that individuals do consider CR when planning for retirement savings. As the frequency and severity of climate-related events increase, people need to prepare for rising living costs including food and shelters especially in the near future. In defined contribution systems for retirement savings in the United States, the burden of retirement savings and investment planning falls largely on individuals, but not employers or governments. Accordingly, in retirement savings planning, individuals may need to both adjust their portfolio risk to deal with CRs and increase their monthly contributions to prepare for future consumption needs.

The association between CR and increased retirement savings offers useful insights for financial education and policy development, enabling people to better understand CR and its consequences for retirement savings. Despite the growing threats of climate change (e.g., heavy rainfall, heatwaves or tornadoes), nearly half of Americans (46%) do not see it as a major threat (Pew Research Center, 2023), and 55% do not believe it will pose a serious threat in their lifetime (Gallup, 2024). Policies could encourage or require employers via tax incentives to provide financial education that incorporates CR when employees make retirement contributions and investment decision, such as in employer-sponsored 401(k) plans.

Financial educators and advisors managing retirement savings and investments also need to proactively address CR in their consultations. Most individuals investing through IRAs or 401(k)s use mutual fund companies. When selecting mutual funds with different portfolio risks and returns, many are advised to choose target date funds (TDFs, a.k.a., life cycle fund), which automatically adjust portfolio risk based on investors' expected retirement date. In fact, TDF participation rose from 45% in 2012 to 68% in 2022 among 401(k) participants (EBRI, 2024). However, TDFs typically do not explicitly consider CR. Since

individuals assess investment risk based on total perceived risk including CR for retirement savings decisions, financial advisors should emphasize climate-related considerations, particularly when recommending TDFs.

### Limitations

Several limitations should be considered when interpreting these findings. First, our sample in this study consisted of Dutch respondents who generally benefit from secure pension systems and job security. These systems differ from those in countries like the US, potentially limiting generalizability. From another perspective, due to these favorable conditions, our findings about the relationship between CR and retirement savings may be robust without concerns about reverse causality although our result is correlational due to cross-sectional data but not causal in nature. It is plausible that people with higher wealth are concerned about CR to protect their wealth. But if most people have stable pensions and jobs, their extra retirement savings may reflect individuals' risk attitude toward CR rather than the other way around.

Second, we measured retirement wealth using binary variables(i.e., whether or not individuals had certain accounts). CR may influence not only whether people save but also how much they save. We attempted a two-part model that included account ownership and savings amounts, but missing variables of the savings amounts (i.e., about 56% of the sample) prevented meaningful analysis of savings amounts. Third, we measured CR as individuals' self-reported awareness of their exposure to the adverse effects of climate change. This may not correspond to actual exposure. Likewise, the measures for risk aversion and regret were proxies with inherent measurement errors. Lastly, some variables that may influence individuals' saving decisions such as financial literacy levels or trust in climate policy were not controlled due to data unavailability. Further studies should examine impacts of CR on broader household finances including extra expenses for living costs or labor income while covering these limitations.

## Conclusions

We tentatively conclude that CR is an emerging factor influencing retirement savings behavior. Individuals who are more aware of climate change are more likely to have additional retirement wealth such as extra private pensions, savings-type insurance, or real estate. However, the mechanisms driving this behavior remain unclear. Our proposed pathways-risk aversion and avoidance of regret-were not supported by the data, possibly due to measurement issues or the existence of alternative motives. Future studies should investigate other potential pathways to better understand how CR shapes retirement planning.

## Additional Information

### Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

**Concept and design:** Hyungsoo Kim, Marcel Zeelenberg

**Drafting of the manuscript:** Hyungsoo Kim, Marcel Zeelenberg, Catalina Estrada-Mejia

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### Disclosures

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## References


1. Baranyai E, Banai Á: Heat projections and mortgage characteristics: evidence from the USA. Climatic Change. 2022, 175:14. 10.1007/s10584-022-03465-1
2. Baron RM, Kenny DA: The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology. 1986, 51:1173-182. 10.1037/0022-3514.51.6.1173
3. Bleichrodt H, Wakker PP: Regret theory: a bold alternative to the alternatives. The Economic Journal. 2015, 125:493-532. 10.1111/ecoj.12200
4. Bourdeau Brien M, Kryzanowski L: Natural disasters and risk aversion. Journal of Economic Behavior & Organization. 2020, 177:818-35. 10.1016/j.jebo.2020.07.007
5. Braun M, Muermann A: The impact of regret on the demand for insurance. The Journal of Risk and Insurance. 2004, 71:737-67.
6. Brewer NT, DeFrank JT, Gilkey MB: Anticipated regret and health behavior: A meta-analysis. Health Psychology. 2016, 35:1264-275. 10.1037/hea0000294
7. Börsch Supan A, Bucher-Koenen T, Hurd MD, Rohwedder S: Saving regret and procrastination. Journal of Economic Psychology. 2023, 94:102577. 10.1016/j.joep.2022.102577
8. Carroll CD: Buffer-stock saving and the life cycle/permanent income hypothesis. The Quarterly Journal of Economics. 1997, 112:1-55.
9. Castaldo S, Tirelli M: Subjective income risk and precautionary saving. Economic Modelling. 2025, 143:106965.
10. Christelis D, Georgarakos D, Jappelli T, van Rooij M: Consumption uncertainty and precautionary saving. The Review of Economics and Statistics. 2020, 102:148-61. 10.1162/rest_a_00819
11. Clean energy glossary. (2007). Accessed: December 28, 2007: https://sor.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&glos....
12. Croy G, Gerrans P, Speelman CP: A mediating role for anticipated regret in predicting retirement savings intention between groups with (without) past behaviour. Australian Journal of Psychology. 2015, 67:87-96. 10.1111/ajpy.12070
13. Davis JA: The Logic of Causal Order. SAGE Publications, Inc., Beverly Hills, CA; 1985.
14. Eeckhoudt L, Gollier C, Schlesinger H: Changes in background risk and risk taking behavior. Econometrica. 1996, 64:683-89. 10.2307/2171866
15. EBRI. (2024). Accessed: April 30, 2024: https://www.ebri.org/content/401%28k%29-plan-asset-allocation--account-balances--and-loan-activity-in-2022.
16. Flood damage and federally backed mortgages in a changing climate. (2023). Accessed: June 29, 2025: https://www.cbo.gov/publication/59753.
17. Gallup. (2024). Accessed: April 22, 2024: https://news.gallup.com/poll/643850/seven-key-gallup-findings-environment-earth-day.aspx.
18. Gillespie L, Rubloff T: Survey: 2 in 5 Americans regret not saving enough for retirement or emergencies. Bankrate. 2024,
19. Guiso L, Paiella M: Risk aversion, wealth, and background risk. Journal of the European Economic Association. 2008, 6:1109-150. 10.1162/jeea.2008.6.6.1109
20. Harrison GW, List JA, Charles T: Naturally occurring preferences and exogenous laboratory experiments: A case study of risk aversion. Econometrica. 2007, 75:433-58. 10.1111/j.1468-0262.2006.00753.x
21. Hayes AF: Beyond Baron and Kenny: statistical mediation analysis in the new millennium. Communication Monographs. 2009, 76:408-20. 10.1080/03637750903310360
22. Haynes J: Risk as an economic factor. The Quarterly Journal of Economics. 1895, 9:409-49. 10.2307/1886012
23. Huang X, Yang T: How does background risk affect portfolio choice: An analysis based on uncertain mean-variance model with background risk. Journal of Banking & Finance. 2020, 111:105726. 10.1016/j.jbankfin.2019.105726
24. Kahsay G A, Osberghaus D: Storm damage and risk preferences: panel evidence from Germany. Environmental and Resource Economics. 2018, 71:301-18. 10.1007/s10640-017-0152-5
25. Keynes JM: The General Theory Of Employment Interest And Money. Macmillan, London; 1936.
26. Kopecky KA, Koreshkova T: The impact of medical and nursing home expenses on savings. American Economic Journal: Macroeconomics. 2024, 6:29-72. 10.1257/mac.6.3.29
27. Krijnen JMT, Zeelenberg M, Breugelmans SM, Van Der Schors A: Intention and action in retirement preparation. Behavioural Public Policy. 2022, 6:191-212. 10.1017/bpp.2018.39
28. Lee JM, Kim KT: The role of propensity to plan on retirement savings and asset accumulation. Family and Consumer Sciences Research Journal. 2016, 45:34-48. 10.1111/fcsr.12179
29. Leland HE: Saving and uncertainty: the precautionary demand for saving. Quarterly Journal of Economics. 1968, 82:465-73. 10.2307/1879518
30. Liebenehm S, Schumacher I, Strobl E: Rainfall shocks and risk aversion: Evidence from Southeast Asia. American Journal of Agricultural Economics. 2024, 106:145-76. 10.1111/ajae.12403
31. Loomes G, Sugden R: Regret theory: an alternative theory of rational choice under uncertainty. The Economic Journal. 1982, 92:805-24. 10.2307/2232669
32. Lusardi A: On the importance of the precautionary saving motive. The American Economic Review. 1988, 88:449-53.
33. LISS. (2025). https://www.lissdata.nl/how-it-works.
34. MacKinnon DP, Krull JL, Lockwood CM: Equivalence of the mediation, confounding, and suppression effect. Prevention Science. 2000, 1:173-81. 10.1023/a:1026595011371
35. Modigliani F, Brumberg R: Utility analysis and the consumption functions: an attempt at integration. The Collected Papers of Franco Modigliani, Volume 2: The Life Cycle Hypothesis of Saving. Abel A (ed): The MIT Press, Cambridge, MA; 1980. 2:128-97.
36. Mishra AK, Uematsu H, Matthew Fannin J: Measuring precautionary wealth using cross-sectional data: the case of farm households. Review of Economics of the Household. 2013, 11:131-41. 10.1007/s11150-011-9139-0
37. Pew Research Center. (2023). Accessed: August 9, 2023: https://www.pewresearch.org/short-

reads/2023/08/09/what-the-data-says-about-americans-views-of-climate-change/.
38. Sandberg T, Conner M: Anticipated regret as an additional predictor in the theory of planned behaviour: A meta-analysis. British Journal of Social Psychology. 2008, 47:589-606. 10.1348/014466607x258704
39. Saving for retirement with job loss risk. (2013). Accessed: June 29, 2025: https://www.richmondfed.org/publications/research/economic_quarterly/2013/q1/grochulski.
40. Simonson I: The influence of anticipating regret and responsibility on purchase decisions. Journal of Consumer Research. 1992, 19:105-18. 10.1086/209290
41. The impact of climate change on American household finances. (2023). Accessed: June 29, 2025: https://home.treasury.gov/system/files/136/Climate_Change_Household_Finances.pdf.
42. The cost of climate change on households and families in the EU. (2023). Accessed: June 29, 2025: https://www.eesc.europa.eu/sites/default/files/files/qe-04-23-897-en-n.pdf.
43. US NOAA: U.S. Billion-dollar Weather and Climate Disasters, 1980 - present (NCEI Accession 0209268). 2024,
44. US Global Change Research Program: Fifth national climate assessment: report-in-brief. The United States Global Change Research Program. 2023,
45. Unexpected risks and retirement planning. (2021). Accessed: June 29, 2025: https://pensionresearchcouncil.wharton.upenn.edu/blog/unexpected-risks-and-retirement-planning/.
46. Zeelenberg M: Regret. Emotion Theory: The Routledge Comprehensive Guide Volume II: Theories of Specific Emotions and Major Theoretical Challenges. Scarantino A (ed): Routledge, London; 2024. 2:332-50. 10.4324/9781003469018-20
47. Zeelenberg M: Anticipated regret, expected feedback and behavioral decision-making. Journal of Behavioral Decision Making. 1999, 12:93-106. 10.1002/(SICI)1099-0771(199906)12:2<93::AID-BDM311>3.0.CO;2-S
48. Zeelenberg M, Beattie J, Van der Pligt J, De Vries NK: Consequences of regret aversion: Effects of expected feedback on risky decision making. Organizational Behavior and Human Decision Processes. 1996, 65:148-58. 10.1006/obhd.1996.0013